Utilization of the Vacuum-energy:

Theoretical fundament and Explanation of a ZPE-motor

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The fundamental Principle of the Conversion of the Zero-point-energy of the Vacuum

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Abstract

The mechanism of the conversion of zero-point-energy is now understood. This is the basis, on which zero-point-energy converters can be constructed systematically. Here are the details.

Nowadays the existence of the zero-point-energy of the vacuum is recognized in several disciplines within physics (as for instance Astrophysics and Quantum Electrodynamics), and the verification is done, that this energy can be converted into classical types of energy in the laboratory (see Casimir-effect and others). Also the possibility of its utilization for practical energy-technology is proven in the laboratory.

After the zero-point-energy of the vacuum is made manifest in such way, the task arises to clarify the fundamental principles of physics, which explain the conversion of the zero-point-energy into any other (classical) type of energy, such as for instance electrical or mechanical energy. These fundamental basics of Physics are now understood and described in the present article. Based on this theoretical fundament, the article also explains, how the construction of zero-point-energy converters can be done systematicially for practical engineering purpose. This is the first time, when a practical method for the systematic construction of zero-point-energy converters is found. The article gives guidelines for the development dynamic Finite-Element-Algorithm (DFEM), which will enable us to construct zero-point-energy converters systematically.

Simple models of zero-point-energy-converters can be developed with this method rather easy. But more complex realistic engines require remarkable effort for computation.

The train of thoughts of this article is rounded up by the explanation of some examples for consequences of the zero-point-energy and its conversion within everyday life even now, as for instance the existence of electric charge and the stability of atoms.

1. Zero-point-energy in several disciplines of Physics

According to our modern and generally accepted Standard-model of Astrophysics (see [Teg 02], [Rie 98], [Efs 02], [Ton 03], [Cel 07] and many others), our universe consists of

- approx. 5 % well-known particles, visible matter, planets, creatures, black-holes,…
- approx. 25…30 % invisible matter, such as unknown elementary-particles,
- approx. 65…70 % zero-point-energy.

This statement is based on measurements of the accelerated expansion of the universe, which are based on the Doppler-shift of characteristic spectral lines of atoms in stellar and interstellar matter. However, from these measurement, the unsolved question arises, why the expansion of the universe is accelerating as function of time [Giu 00]. This experimental finding contradicts to the theoretical expectations of the Standard-model of Cosmology, according to which the expansion should slow down continuously as a function of time, because of Gravitation, which is an attractive interaction between all matter within our universe (visible matter as well as the invisible matter). And this attraction should decrease the velocity of the expansion of our universe. If we take the zero-point-energy of the vacuum into account, this question can also be solved rather easily, as we will see later in our article. (The background is the conversion of zero-point-energy into kinetic energy of the expansion of the universe.) Not only from this aspect we can see, why the disciplines of Astrophysics and Cosmology not only accept the zero-point-energy of the vacuum but they even demand its existence (see measuring-results mentioned above).

And also in microscopic physics, the zero-point-energy is accepted and claimed, as for instance in Quantum Theory. Richard Feynman needs it for Quantum Electrodynamics, namely by introducing vacuum-polarization into theory. (By the way: This was the theory, which brought the author of a preceding article to his work on the zero-point-energy of the vacuum.) Vacuum-polarization describes the fact, that spontaneous virtual pair production of particle-antiparticle-pairs occurs in the empty space (i.e. in the vacuum), which annihilate after a distinct amount of time and distance (see for instance [Fey 49a], [Fey 49b], [Fey 85], [Fey 97]). Of course, these particles and anti-particles have a real mass (such as for instance electrons and positrons, resulting from electron-positron pair-production). This means, that they contain energy according to the mass-energy-equivalence ($E = m \cdot c^2$). Although this matter and antimatter disappears (annihilates) soon after its creation within the range of Heisenberg's uncertainty relation, it contains energy, for which there is no other source than the empty space, from which these particles and anti-particles are created. This means that the empty space contains energy, which we nowadays call zero-point-energy. (The notation "zero-point-energy" goes back to the knowledge of its origin, which we nowadays have). It is said that this energy "from the empty space" has to disappear within Heisenberg's uncertainty relation because of the law of energy conservation. But this does not contest the fact that this energy is existing – namely as zero-point-energy of the vacuum.

The energy of the empty space (vacuum-energy) should be paid more attention, and there is still much investigation to be done for its utilization. The knowledge about vacuum-polarization describes only a very small part of this vacuum-energy. Thus it is clear that vacuum-energy contains several components completely unknown up to now. Among all these components of vacuum-energy there is also this one, which we call zero-point-energy, and which describes the energy of the zero-point oscillations of the electromagnetic waves of the quantum-vacuum. This special part of the vacuum-energy has the following background:
From Quantum-theory we know, that a harmonic oscillator never comes to rest. Even in the ground-state it oscillates with the given energy of $E = ½\hbar\omega$ (see for instance [Mes 76/79], [Man 93]). This is one of the fundamental findings of Quantum-theory, which is of course valid also for electromagnetic waves. The consequence is that the quantum-vacuum is full of electromagnetic waves, by which we are permanently surrounded.
If this concept is sensible, it should be possible to verify the existence of these zero-point-waves, for instance by extracting some of their energy from the vacuum. If it would be different, Quantum-theory would be erroneous. But in reality Quantum-theory is correct and its conception is sensible. Historically the first verification for the extraction of zero-point-energy from the quantum-vacuum comes from the Casimir-effect. Hendrik Brugt Gerhard Casimir published his theoretical considerations in 1948, suggesting an experiment with two parallel metallic plates without any electrical charge. The energy of the electromagnetic zero-point-waves should cause an attractive force between those both plates, which he calculated quantitatively on the basis of the spectrum of these zero-point-waves [Cas 48]. Because of experimental reasons (the metallic plates have to be mounted very close to each other, and the force is very small), the experimental verification of his theory was very difficult ([Der 56],

[Lif 56], [Spa 58]). Thus Casimir was not taken serious for a rather long time, although his verification of the zero-point-energy is not less than a test of quantum-theory at all. Only in 1997, this is nearly half a century after Casimir's theoretical publication, Steve Lamoreaux from Yale University [Lam 97] was able to verify the Casimir-forces with a precision of ±5%. Since this result, Casimir is taken serious and his Casimir-effect is accepted generally. Before the Lamoreaux-verification, the scientific community ignored the discrepancies between zero-point-energy and Quantum-theory simply without comment. Only since Lamoreaux's measurement, the scientific community understood that Casimir solves many problems and he answers many open questions between vacuum-energy and Quantum-theory.

Since 1997, the existence of vacuum-energy is verified not only in astrophysics, but also in a terrestric laboratory. And since this time, vacuum-energy is accepted by the scientific community. Only few years later, the industrial production of semiconductor circuits for microelectronics applications needed to take the Casimir-forces into account, in order to control the practical production of their miniaturized products.

Although the research field of vacuum-energy as well as its sub-discipline of zero-point-energy (of the electromagnetic waves of the quantum-vacuum) is a very young, the scientific work in this area is very urgent because of its extremely important applications. The point is that this research field opens the door for utilization of this absolutely clean energy, which can be used as a source of energy, free from any environmental pollution. And moreover, this source of energy is inexhaustible, because it is as large as the universe itself. Mankind will have to use this energy soon, if we want to keep our planet as our habitat.

The possibility to utilize this vacuum-energy is already theoretically established and also experimentally verified [Tur 09]. But the experiment could only produce a machine power of 150 NanoWatts. This is really not very much, but it is enough for a principal proof of the fundamental scientific discovery. Thus this work, done in 2009 not yet presents a technical engine, but only the basic scientific verification of the zero-point-energy of the vacuum. Consequently it should be expected, that the next step now will be to build prototypes of this engine for practical engineering techniques with larger machine power. Nevertheless, there is a better way to process, namely as following.

If we look into the available literature, we find that there is already an amazingly large number of existing approaches, to convert vacuum-energy into some classical type of energy. A good overview about the work already available can be found at the book [Jeb 06]. There we read, that successful work is done by laymen as well as by honourable institutes such as Massachusetts Institute of Technology (MIT). Some work is even done by military and secret services ([Hur 40], [Nie 83], [Mie 84]). If we dedicate our attention to available reports, we immediately see, that there are already existing zero-point-energy-converters with a machine power of many orders of magnitudes larger than mine with only 150 NanoWatts. Obviously mankind already managed to take zero-point-energy converters into operation, with handy dimensions and a machine-power of several Watts or sometimes even several KiloWatts.

Even if the utilization of the clean, pollution-free and inexhaustible vacuum-energy is not yet known by everybody, because the intellectual hurdle for its discovery is rather high, it is already clear that this is the energy technology of the upcoming third millennium. It will gain the energy-market within a foreseeable number of years, because mankind needs it to survive [Sch 10], [Ruz 09]. And it will bring a new industrial boom, because all the energy-consuming industry will have enough energy without limitation, as well as private people will have. Similar as the reduction of the prices of semiconductors increased the business of semiconductor-industry, the reduction of the prices of energy will increased the business also of the energy-producing industry. We can be glad about all these practical engineers, who construct vacuum-energy-converters from their intuition, because they help us to find our way towards clean energy. Nevertheless we face the necessity to develop a proper physical theory for the understanding of such converters. The necessary scientific work will not only give us the possibility to understand the fundamental basics of zero-point-energy and its conversion into classical energy, but it would also give us the possibility to perform a systematic construction and optimization of such engines. A contribution to this scientific knowledge was developed by the author of the preceding article in [Tur 09]. But the article here presents the understanding of the principles of zero-point-energy conversion in a way, that it will be possible to develop method to calculate zero-point-energy converters in a way, that the systematic technical construction of these engines will be possible in not too far future.

2. The Energy-circulation of the Fields of the Interactions

We begin our considerations with a remembrance of the energy-circulation of the electric and the magnetic fields, which is described in [Tur 07a] und [Tur 07b]:
As we know, every electric charge emits an electric field, of which the field-strength can be determined by Coulomb's law [Jac 81]. This field contains field energy, which can be determined from the field-strength.
The field-strength of the electric is

$\vec{E}(\vec{r}) = \frac{1}{4\pi\varepsilon_0} \cdot \frac{Q}{r^3} \cdot \vec{r}$ with $Q =$ electrical charge,
$\vec{r} =$ distance from the charge,
$\varepsilon_0 = 8.854187817 \cdot 10^{-12} \frac{A \cdot s}{V \cdot m} =$ electrical field-constant [Cod 00]. (1)

The energy density is determined as

$$u = \frac{\varepsilon_0}{2} \cdot \left|\vec{E}\right|^2 = \frac{\varepsilon_0}{2} \cdot \left(\frac{1}{4\pi\varepsilon_0} \cdot \frac{Q}{r^2} \right)^2 = \frac{Q^2}{32\pi^2 \varepsilon_0 r^4} . \qquad (2)$$

We know that the field contains energy, depending (among others also) on the amount of space, which is filled by the field. Furthermore we know from the Theory of Relativity as well as from the mechanism of the Hertz'ian dipole-emitter, that electric fields (same as magnetic fields, AC-fields as well as DC-fields) propagate with the speed of light (see [Goe 96], [Pau 00], [Sch 02], and others). Thus every electric charge as the source of the field permanently emits field-energy. This is a feature of the field-source and the field. (The property to be a field source is calculated mathematically by the use of the Nabla-operator, as written for instance in Maxwell's equations.)

But from where does the charge (being the field-source) receive its energy, so that it can permanently provide the field energy ?

The answer again goes back to the vacuum-energy, namely to the above mentioned energy-circulation: On the one hand, every charge in the empty space is supported permanently with energy, and because this is also the case if the charge is only in contact with the empty space (the vacuum), the energy can only be provided by the vacuum. On the other hand, the field gives a certain amount of energy during its propagation through the empty space back to the vacuum. This conception was developed in [Tur 07a] and it was proven in [Tur 07b]. This means that the charge converts vacuum-energy into field-energy, and the field gives back this energy to the vacuum, during its propagation into the space. This is the energy-circulation mentioned above. The functioning-mechanism behind this type of "back and forth" energy-conversion (circulation) is not yet completely clarified.

It should be mentioned that this type of energy-circulation is recognized not only for the electric field, but also for the magnetic field. This is also theoretically proven in [Tur 09]. Furthermore, the electromagnetic interaction is not the only one in nature, which can be described by an appropriate potential (a scalar-potential Φ or a vector-potential $\vec{A}$). Consequently each of the four fundamental interactions of nature should have its own basic interaction-field, which can be derived by appropriate mathematical operations from its potential. This leads us to the following systematic:

● Table 1: Electric interaction and other fundamental interactions

Interaction	Potential	Field-strength	Energy density
Electrostatic interaction	$\Phi_{El}(\vec{r}) = \frac{-1}{4\pi\varepsilon_0} \cdot \frac{Q}{r}$ (following Coulomb)	$\vec{E}(\vec{r}) = \frac{1}{4\pi\varepsilon_0} \cdot \frac{Q}{r^3} \cdot \vec{r}$ (following Coulomb)	$u_{El} = \frac{\varepsilon_0}{2} \cdot \left\|\vec{E}\right\|^2$
Electromagnetic interaction	vector-potential $\vec{A}(\vec{r})$ with $\vec{B}(\vec{r}) = \vec{\nabla} \times \vec{A}(\vec{r})$	$d\vec{H}_i = dq_i \cdot \frac{\vec{v}_i \times (\vec{s}_i - \vec{r})}{4\pi \cdot \left\|\vec{s}_i - \vec{r}\right\|^3}$ (Biot-Savart)	$u_{Mag} = \frac{\mu_0}{2} \cdot \left\|\vec{H}\right\|^2$
Gravitation (static interaction)	$\Phi_{Gr}(\vec{r}) = -\gamma \cdot \frac{m}{r}$	$\vec{G}(\vec{r}) = \gamma \cdot \frac{m}{r^3} \cdot \vec{r}$	$u_{Grav} = \frac{1}{8\pi\gamma} \cdot \left\|\vec{G}\right\|^2$
Gravimagnetic interaction	vector-potential $\vec{N}(\vec{r})$ with $\vec{K}(\vec{r}) = \vec{\nabla} \times \vec{N}(\vec{r})$	$d\vec{K}_i = dm_i \cdot \frac{\vec{v}_i \times (\vec{s}_i - \vec{r})}{4\pi \cdot \left\|\vec{s}_i - \vec{r}\right\|^3}$ (see Thirring-Lense)	$u_{GM} = \frac{\beta}{2} \cdot \left\|\vec{K}\right\|^2 = \frac{2\pi\gamma}{c^2} \cdot \left\|\vec{K}\right\|^2$
Strong interaction [Pau 10]	$V = -\frac{\alpha \hbar c}{r}$		
Weak interaction [Wik 10]	Potential of the Higgs-Field $V = -\mu \phi^\dagger \phi + \lambda \left(\phi^\dagger \phi\right)^2$		

Following symbols and constants are used (numerical values according to [Cod 00]):

$Q =$ electrical charge

$m =$ mass (for the interaction of gravitation)

$\vec{r} =$ position vector of the point, at which the field strength is to be determined

$\vec{s} =$ position vector and $\vec{v} =$ velocity of the infinitesimal charge elements in motion

$q_i =$ infinitesimal charge elements in motion

$m_i =$ infinitesimal mass elements in motion

$\Phi_{El} =$ scalar-potential corresponding to the electrical field-strength $\vec{E}$

$\Phi_{Gr} =$ scalar-potential corresponding to the gravitational field-strength $\vec{G}$

$\vec{H} = \int d\vec{H}_i =$ electromagnetic field-strength

$\vec{K} = \int d\vec{K}_i =$ gravimagnetic field-strength

electrical field-constant: $\frac{1}{4\pi\varepsilon_0} = 8.987551788 \cdot 10^9 \frac{N \cdot m^2}{C^2}$ (weil $\varepsilon_0 = 8.854187817 \cdot 10^{-12} \frac{A \cdot s}{V \cdot m}$)

magnetic field-constant: $\mu_0 = 4\pi \cdot 10^{-7} \frac{N \cdot s^2}{C^2}$. It is: $\mu_0 \cdot \varepsilon_0 = \frac{1}{c^2} \Rightarrow \frac{\mu_0}{\frac{1}{4\pi\varepsilon_0}} = \frac{4\pi}{c^2}$

gravitational field-constant: $\gamma = 6.6742 \cdot 10^{-11} \frac{N \cdot m^2}{kg^2}$

gravimagnetic field-constant: $\beta = \frac{4\pi}{c^2} \cdot \gamma = 9.3255 \cdot 10^{-27} \frac{N \cdot s^2}{kg^2}$ It is: $\frac{\beta}{\gamma} = \frac{4\pi}{c^2}$

It should be mentioned that there are several possible descriptions of the fundamental interactions (besides this one given here) within the theory. The most widespread alternative description uses exchange particles – for each fundamental interaction an individual type of exchange particles. (For further details, please see section 6 of the present article.)

We now want to calculate, how much power (energy per time) the field-source of the electric field (i.e. the electric charge) respectively the field source of the gravitational fields (i.e. the ponderable mass) emits.

● As an example for the first mentioned interaction, we regard the electron as a source of the electric field, and thus we begin our calculation with the energy density of the electric field at the surface of the electron:

$$u_{El} = \frac{\varepsilon_0}{2} \cdot \left|\vec{E}\right|^2 = \frac{\varepsilon_0}{2} \cdot \left|\frac{1}{4\pi\varepsilon_0} \cdot \frac{Q}{R_e^2}\right|^2 = 1.45578 \cdot 10^{29} \frac{J}{m^3} \tag{3}$$

For the determination of the numerical value of the field strength at the surface of the electron, that classical electron's radius of $R_E = 2.818 \cdot 10^{15} m$ (according to [COD 00]) was used.

When the field-energy is flowing out of the electron with this energy-density (and with the speed of light), we can calculate the amount of energy per time, which passes an infinitesimal thin spherical shell on the surface of the electron. This is the amount of energy being emitted by the electron. For this calculation, let s be the thickness of this spherical shell and c be the speed of light, with which the field flows through the shell. Then a given field-element will pass the shell within the time $t_x = \frac{s}{c}$. Thus, the amount of energy being emitted with the time-interval t_x is $W_{El} = u_{El} \cdot s \cdot A$. This is the amount of energy, which passes the electron's surface A within the time-interval t_x.

This leads to an emitted power of $P_{El} = \frac{W_{El}}{t_x} = \frac{u_{El} \cdot s \cdot A}{s/c} = u_{El} \cdot A \cdot c$ (4)

Putting the electron's surface $A = 4\pi \cdot R_E^2$ into this expression, and further using (3), we derive

$$P_{El} = u_{El} \cdot A \cdot c = \frac{\varepsilon_0}{2} \cdot \frac{Q^2}{16\pi^2 \varepsilon_0^2 R_e^4} \cdot 4\pi \cdot R_E^2 \cdot c = \frac{c \cdot Q^2}{8\pi^2 \varepsilon_0 R_e^2} = 4.355 \cdot 10^9 \frac{Joule}{\sec.} \tag{5}$$

This is a tremenduously large power with regard to this very tiny particle of a single electron. This means that every electron emits GigaWatts. In order to illustrate this amount of energy and power, we want to convert this energy-rate into a mass-rate following $E = mc^2$, so that we see, how much mass would have to be converted into energy, to provide this machine power:

$$\frac{P_{El}}{c^2} = \frac{1}{c^2} \cdot 4.355 \cdot 10^9 \frac{Joule}{\sec.} = 4.8456 \cdot 10^{-8} \frac{kg}{\sec.}$$

This is the amount of mass, which the classical electron converts into field energy per second.

If we remember that the electron has a mass of only $m_{El} = 9.1094 \cdot 10^{-31} kg$, we see that the complete electron would be used up for the production of its field-energy within the time of

$$\frac{m_{El}}{P_{El}/c^2} = \frac{9.1094 \cdot 10^{-31} kg}{4.8456 \cdot 10^{-8} \frac{kg}{\sec.}} = 1.88 \cdot 10^{-23} \sec.$$

For we know that this is not the case (because the electron does not disappear so quickly), the electron is obviously being supported with energy from some source. It is clear that we again face the energy-circulation described above, where the vacuum (the empty space) supports the electron (the field-source) with energy. **This demonstrates, that the existence of electrically charged particles and bodies is possible by principle only because of the vacuum-energy.**

● But also our second example, the field of gravitation, can be estimated numerically, rather easy. Let us a regard our earth as a source of a field of gravitation, and let us perform the calculation of the field-energy per time being emitted.
We take the energy density of this field from table 1 and put the numerical values of our earth into this formula:

$$u_{Grav} = \frac{1}{8\pi\gamma} \cdot \left|\vec{G}\right|^2 = 5.75177 \cdot 10^{10} \frac{J}{m^3} \tag{6}$$

for the energy density of the field of gravitation on the surface of the earth,
where the field strength is generally known to be $\left|\vec{G}\right| = 9.81 \frac{m}{s^2}$.
Let us again calculate the emitted power according to (4) as $P_{El} = u_{El} \cdot A \cdot c$. Thus we come to

$$P_{Grav} = u_{Grav} \cdot A \cdot c = u_{Grav} \cdot 4\pi R_E^2 \cdot c = 5.75177 \cdot 10^{10} \frac{J}{m^3} \cdot 4\pi \cdot \left(6371 \cdot 10^3 m\right)^2 \cdot 3 \cdot 10^8 \frac{m}{s} = 8.795 \cdot 10^{33} \frac{Joule}{\sec.}. \tag{7}$$

With $E = mc^2$ we derive the mass being converted into field-energy per time to be
$\frac{P_{Grav}}{c^2} = 9.786 \cdot 10^{16} \frac{kg}{\sec.} = 1.287 \cdot 10^{23} \frac{kg}{Jahr}$.
With regard to the mass of the earth of $m_{Erd} = 5.9736 \cdot 10^{24} kg$, this is 2.154% of the earth, which is converted to into its field of gravitation every year. After less than 47 years the earth would be used up completely. Everybody knows that this is not the case. This demonstrates that the earth must be supplied from somewhere with energy. For the Earth is moving within the empty space (the vacuum), the vacuum is the only source, from where the Earth can get this energy.
Now we see that not only the electric charge converts vacuum-energy into electrical field-energy, but also every ponderable mass converts vacuum-energy into the field-energy of the field of gravitation. This is absolutely clear now. Missing is only the clarification about the mechanism behind this energy-conversion. As we will see in section 6, all four fundamental interactions of nature undergo a similar circulation of energy, converting vacuum-energy into field-energy and then back into vacuum-energy.

We should not be surprised that electrically charged bodies convert much more energy per time into the electric field, then ponderable masses convert into the field of gravitation. As we know, the electromagnetic interaction is regarded to be much stronger than the interaction of gravitation. For a relative comparison of the interaction-strength (of those both interactions), we could calculate the relation of the converted power, as it is

$$\frac{P_{El}}{P_{Grav}} = \frac{8.795 \cdot 10^{33} \frac{Joule}{\sec.}}{4.355 \cdot 10^{9} \frac{Joule}{\sec.}} \approx 2 \cdot 10^{24}.$$

This result is a rather similar to values of the comparison of the interaction-strength, as it is done within the standard-model of elementary-particle-physics [Hil 96].

3. The Stability of Atoms

An unsolved enigma of atomic physics, which is often mentioned even in high-schools, is the stability of atoms. Rather often this problem is described in the form of a question:

Why do the electrons of the shell not fall down into the nucleus ?

This question has the following background:
If the electrons run along their given orbits around the nucleus (no matter whether we regard them classical or within the usual model of quantum mechanics), the electrons experience a centripetal-acceleration. If they would not feel this acceleration, they would fly away tangentially from their orbit. Obviously they do not fly away like this, so it is clear that the centripetal-acceleration is really occurring.
According to electrodynamics, accelerated electrical charge does emanate electromagnetic waves, as it is used for instance for the production of X-rays, or as we know it from the functioning-mechanism of the Hertz'ian dipole-emitter. Electrons in the atomic shell should thus emit permanently electromagnetic waves, and these waves transport energy. This loss of energy should make the electron fall down into the atomic nucleus. But as we know, atoms can be stable – and stable atoms have electrons which do not fall into the nucleus. We all consist of such stable atoms. And we do not observe that all atoms permanently emit electromagnetic fields (besides thermal radiation, as long as our temperature is not at zero Kelvin).

In the usual standard-model of physics, this open question is simply ignored. Electrons circulate around the nucleus without flying away tangentially and without falling into the nucleus. We simply accept this without explanation and without understanding. Just we say, that it is like this.

The explanation is coming from vacuum-energy. It is already indicated in literature [Val 08], and it is absolutely clear, if we come back to the above mentioned energy-circulation between vacuum-energy and field-energy:
Of course the electrons feel centripetal-acceleration along their orbit around the nucleus, so it is clear that they emit electromagnetic-waves. But the electrons are permanently supported from vacuum with energy, and this makes it possible that they keep their energy-level. The discreet levels, as we know them from quantum mechanics, are exactly those levels, on which the support with vacuum-energy is in equilibrium with the emission of electromagnetic waves. (This is not a thesis, but it is proven soon.) But the field energy emitted by the accelerated electrons will be re-converted into vacuum-energy within a very short distance, so that we can not see any radiation even after a very short distance away from the electron. This is again a closed energy-circulation respecting the law of energy-conservation. In order to demonstrate that this explanation of the stable energy-levels of the electrons in atomic shell, which is an alternative to the explanation of quantum theory, is not some strange or grotesque train of thoughts, it must be mentioned, that there is the theory of Stochastic Electrodynamics, with many publications in highly respected physic's journals, which uses exactly this alternative train of thoughts as a basis for the calculation of all well-known results of Quantum-mechanics, without using any formalism of Quantum-mechanics at all (for a long list of literature please see [Boy 66..08], but also see the information at [Boy 80], [Boy 85]). A respected scientific group (Calphysics Institute) does remarkable work in the field of the vacuum-energy on the basis of Stochastic Electrodynamics and the support of circulating electrons with zero-point-energy [Cal 84..06]. (This is one of several aspects of their work.)

The only basic assumption of the theory of Stochastic Electrodynamics is the postulate, that the zero-point-oscillations of electromagnetic waves exist (although these waves have been originally discovered within Quantum-theory). Within Stochastic Electrodynamics, the spectrum of these zero-point-waves define the ground state of the electromagnetic radiation of the empty space, this is the vacuum-level. From their interactions with the electrons in the atomic shell, the energy-levels of the electrons are determined. Further assumptions of Quantum-theory are not necessary within Stochastic Electrodynamics.

If we regard the interaction between these zero-point-waves (of the vacuum) and the matter in our world, we see that all particles of matter absorb and re-emit such waves, because all elementary particles permanently carry out zero-point-oscillations. On the basis of this conception, Stochastic Electrodynamics is capable to derive all phenomena, which we know from Quantum-theory, without using Quantum-theory at all.

Historically the first result of Stochastic Electrodynamics was: The black body radiation with its characteristic spectrum as a function of temperature results from the movement of the elementary-particles of which the body consists, and which perform zero-point oscillations. The next result of Stochastic Electrodynamics was the photo-effect. In the history of Quantum-mechanics, one of the prominent results was the explanation of the energy levels of the electrons in atomic shell. In the formalism of Stochastic Electrodynamics, stable states (at which electrons can stay) are achieved when the energy being emitted from the electrons because of their circulation around the nucleus, is identically compensated by the energy which they absorb from the zero-point radiation of the vacuum. (This contains an explanation, why the electrons do not fall into the nucleus because they lose energy due to their circulation. There is some analogy with Bohr's first and third postulate, according to which stable states of shell-electrons are only possible for constructive interference of the electron-waves.) And finally it should be said, that the equilibrium between absorbed and emitted radiation (in Stochastic Electrodynamics) leads to the same discrete energy-levels as we know them from Quantum-mechanics.

Not only the results of Quantum-mechanics but also the results of Quantum-Electrodynamics are reproduced with the formalism of Stochastic Electrodynamics, for instance such as the Casimir-effect, van der Waals- forces, the uncertainty principle (which has been derived the first time by Heisenberg) and many others.

For the sake of completeness it should be remarked, that Stochastic Electrodynamics of course explains the phenomena of nature on its own, not trying to reproduce the mathematical structure of Quantum-theory and even not in connection with the formalism of Quantum-theory. So for example the famous Schrödinger-equation, as a typical formula of Quantum-theory can not be derived with the means of Stochastic Electrodynamics, because such a formula simple is not a topic of Stochastic Electrodynamics. In the same way, formulas of Stochastic Electrodynamics can not derived within Quantum-theory. In this sense, Stochastic Electrodynamics and Quantum-theory are two independent concepts, which describe the same phenomena of nature, but which have totally different philosophical background.

It is known that Stochastic Electrodynamics is not as widespread as Quantum-theory. But it is in complete confirmation with all nowadays known phenomena of nature. Thus it is sensible to accept it for further considerations of "how to extract energy from the zero-point-oscillations", which can lead to interesting results, because new thoughts might emerge. The zero-point-oscillations and the zero-point-waves are the central fundament of Stochastic Electrodynamics.

In this sense, we could describe the relationship between Stochastic Electrodynamics and Quantum Mechanics a little bit provocative, but with logical consequence:
The fundamental of phenomenon of nature, which is described by both theories, is the existence of the electromagnetic zero-point-waves in the vacuum, which we see as a part of the whole vacuum-energy. On the basis of these waves, it is possible to establish two different mathematical formalisms, independently of each other. One formalism is known as Stochastic Electrodynamics and the other one as Quantum Mechanics. Both of them have the same capability to explain the phenomena of nature. Both of them accept and the need vacuum-energy. Vacuum-energy is the only common feature of both theories. Thus vacuum-energy is to be regarded as the real fundament. Both theories are mathematical structures, which use vacuum-energy and draw their conclusions from it. Stochastic Electrodynamics is explicitly conscious of this fact, whereas Quantum Mechanics has this consciousness only implicitly somewhere in background. Because Quantum Theory would not work without vacuum-energy, it is also based on vacuum-energy.

This is the moment for a short intermediate recapitulation of the sections 1-3:
1. The dominant part of our universe is vacuum-energy (even if we don't see it directly).
2. Physical entities as we know them from everyday's life, such as electrical charges and ponderable masses, can only exist because of vacuum energy. Vacuum-energy is the fundament of all interactions between all particles which we know.
3. Also the existence of atoms is only possible because of vacuum-energy, and the theory of atoms is based finally on vacuum-energy.

4. A fundamental understanding of the term "field"

In [Tur 08] the author of this article presented the following explanation for electrical (as well as magnetic) fields, which shall be recapitulated in short terms here:
The empty space (i.e. the vacuum) contains zero-point-waves. They have their continuous spectrum of wavelengths inside the space without field. But if a field is applied, the wave-lengths are reduced in comparison to the wavelengths without field. The fundament of this conception is a work done by Heisenberg and Euler, in which they develop the Lagrangeian of electromagnetic waves within electric and magnetic fields, and they analyze the influence of the fields on the speed of propagation of those waves [Hei 36]. They come to the result, that the speed of light in space containing field is slower, than the speed of light in the space without field. (The latter one is the vacuum speed of light as being used in the Theory of Relativity.) This old work by Heisenberg has been confirmed and further developed by [Bia 70] and by [Boe 07], who quantitatively calculate the reduction of the speed of propagation of electromagnetic waves as a function of the applied field strength.

From there we know, that the speed of electromagnetic waves is reduced by electric and magnetic DC-fields, and we postulate that also the waves in the ground-state (i.e. the zero-point-waves) follow this behaviour. The feature to reduce the speed of waves is a feature of the fields themselves.

On this basis, the field's energy is understood in the terms of a reduction of the wavelengths of the zero-point-waves (which makes them run slower). From there we understand figure 1. On the left side we see an electrical charge "Q", producing an electrostatic field. In the middle there is a metallic plate, shielding the field, so that there is no field on the right side of the plate. Thus the wavelengths of the zero-point-waves are reduced only on the left side containing field, but they are not reduced on the right side which does not contain any field.

On the right side the zero-point-waves have the wavelengths of the field free vacuum. The field's energy, which is flowing from the charge "Q" is stored within the enhanced frequency of the zero-point-waves. This energy-flux goes onto the left side of the metallic plate, is absorbed by the metal-plate and thus causes the attractive force, which pulls the plate towards the charge "Q". This is known within Classical Electrodynamics, where the attractive force is calculated with the use of the image-charge-method [Bec 73].

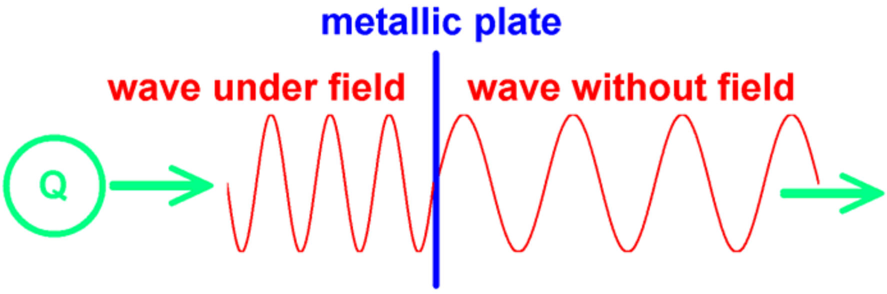

Fig. 1: Conception of the electric field reducing the wavelengths of the zero-point-waves in the quantum – vacuum.

By the way, it should be mentioned, that the influence of the DC-fields on the speed of propagation of the electromagnetic (zero-point-)waves (which are responsible for the interaction) is very tiny. According to [Boe 07] the alteration of the speed of propagation of electromagnetic waves, due to applied magnetic field is

$$\Delta n_{magn} = 1 - \frac{v}{c} = a \cdot \frac{\alpha^2 \hbar^3 \varepsilon_0}{45 m_e^4 c^3} \cdot \left|\vec{B}\right|^2 \cdot \sin^2(\theta) = \begin{cases} 5.30 \cdot 10^{-24} \frac{1}{T^2} \cdot \left|\vec{B}\right|^2 \cdot \sin^2(\theta) \text{ für } a = 8, \parallel\text{–Modus} \\ 9.27 \cdot 10^{-24} \frac{1}{T^2} \cdot \left|\vec{B}\right|^2 \cdot \sin^2(\theta) \text{ für } a = 14, \perp\text{–Modus} \end{cases}$$

$$\left(\text{mit } \left|\vec{B}\right| \text{ in Tesla}\right),$$

$$\Rightarrow \quad \Delta n_{Cotton-Mouton} = \left(1 - \frac{v}{c}\right)_{\perp} - \left(1 - \frac{v}{c}\right)_{\parallel} = 3.97 \cdot 10^{-24} \frac{1}{T^2} \cdot \left|\vec{B}\right|^2 \cdot \sin^2(\theta) \tag{8}$$

with θ being of the angle between the direction of propagation of the photons and the direction of the magnetic field. These both directions define a plane. With regard to this plane, the polarization leads to $a = 8$ for the $\parallel$ – Modus and to $a = 14$ for the $\perp$ – Modus.

According to [Rik 00] and [Rik 03], the effect of an electric field causes

$$\Delta n_{Kerr} = \left(1 - \frac{v}{c}\right)_{\perp} - \left(1 - \frac{v}{c}\right)_{\parallel} \approx 4.2 \cdot 10^{-41} \frac{m^2}{V^2} \cdot \left|\vec{E}\right|^2 \text{, which is also very tiny.} \tag{9}$$

In principle, the field of gravitation can be treated in analogous way, on the basis of the zero-point-waves of gravitation in the quantum vacuum. The field of gravitation would then have an influence on the wavelengths of the (postulated) zero-point-waves of gravitation. This conception of "fields reducing the zero-point-waves of their individual interaction" can be applied to all fundamental interactions in physics, as we will discuss in section 6. The only exception is the Strong interaction, which can not be transferred directly one by one into this model. But this is not the large problem, because the Strong interaction is said to be not completely understood in the Standard model of elementary particle physics (see section 6).

What I also want to mention, is the difference between static fields (such as the electrostatic field and static field of gravitation) and magnetic fields (such as the electromagnetic field and the gravimagnetic field). The existence of the electromagnetic field is generally known. The existence of the gravimagnetic field, is also known by theory [Thi 18] and verified experimentally [Gpb 07], but the knowledge is not widespread among everybody. In history of physics it was derived from the Theory of General Relativity.

The question is now: Static fields reduce the wavelength of the zero-point-waves, but magnetic fields do something very similar. There is a difference between the effects of those both types of fields, the static and the magnetic fields. How can we understand this ?

The answer is surprisingly simple: The difference is a coordinate-transformation, namely the Lorentz-transformation. If an observer is in rest with regard to the field source (for instance an electric charge) the observer will only see the static field. But if the observer is moving with regard to the field source, he will additionally see an electric current (due to the motion of the electric charge), and he will have to calculate additionally the magnetic field produced by this current. This calculation can be done on the one hand by the classical formulas for magnetic fields within classical Electrodynamics, but on the other hand this calculation can be done by taking the relativistic length-contraction of the wavelengths of the zero-point-waves (due to the movement) into account [Dob 03]. Both ways of calculation lead to the same force of interaction and to the same field's energy.

With regard to our concept of the reduced wavelengths of the zero-point-waves, this means: If an observer is moving relatively to the field source, relativistic length-contraction additionally reduces the wavelength of the zero-point-waves. And this additional reduction can be described in terms of a magnetic field.

But now, please focus your attention to the finite speed of propagation of the zero-point-waves, and to the alteration of this speed of propagation due to an applied DC-field. An illustration for a further very important aspect is to be found in figure 2:

Let us start our considerations with the very first line on top of this figure. There we see a sphere on the left side of the drawing, which is drawn with green colour. The sphere does not carry any electrical charge in the first line. The electromagnetic zero-point-waves of the quantum vacuum (in red colour) are flowing without any influence of any field. They propagate with the vacuum speed of light, such as they always do it in the space without any field.

The time is represented in steps from line to line with increasing time from the top to the bottom.

In the next (second) line of figure 2, an electrical charge "Q" is brought onto the green sphere. This causes a reduction of the wavelengths of the electromagnetic zero-point-waves which come into the electrostatic field. They also propagate into the space. But they (i.e. the "blue waves") are propagating a little bit slower than the "red" waves. This difference of speed of propagation causes a small gap between the "blue" and the "red" wave trains.

As long as the electrical charge "Q" is present on the green sphere, the electromagnetic zero-point-waves will propagate with the reduced wavelength, as we see it also in line number 3.

In line 4 the electric charge "Q" is taken away from the green sphere, so that the electromagnetic zero-point-waves now again propagate with the wavelengths of the vacuum without field. This causes, that we now again see the emission of the "red" waves, which propagate with the vacuum speed of light. For the "red" waves propagate a little bit faster than the "blue" ones, the "red" waves begin to overtake. During time, this difference of the speed of propagation will lead to a more and more increasing overlap between the "red" and the "blue" waves, as we can see in lines number 5 and 6. On the one hand the "red" waves coming from behind will overtake the blue waves, but on the other hand the "red" waves, which are running in front of the "blue" waves will make a gap between the red and the blue waves, which is also grows during time.

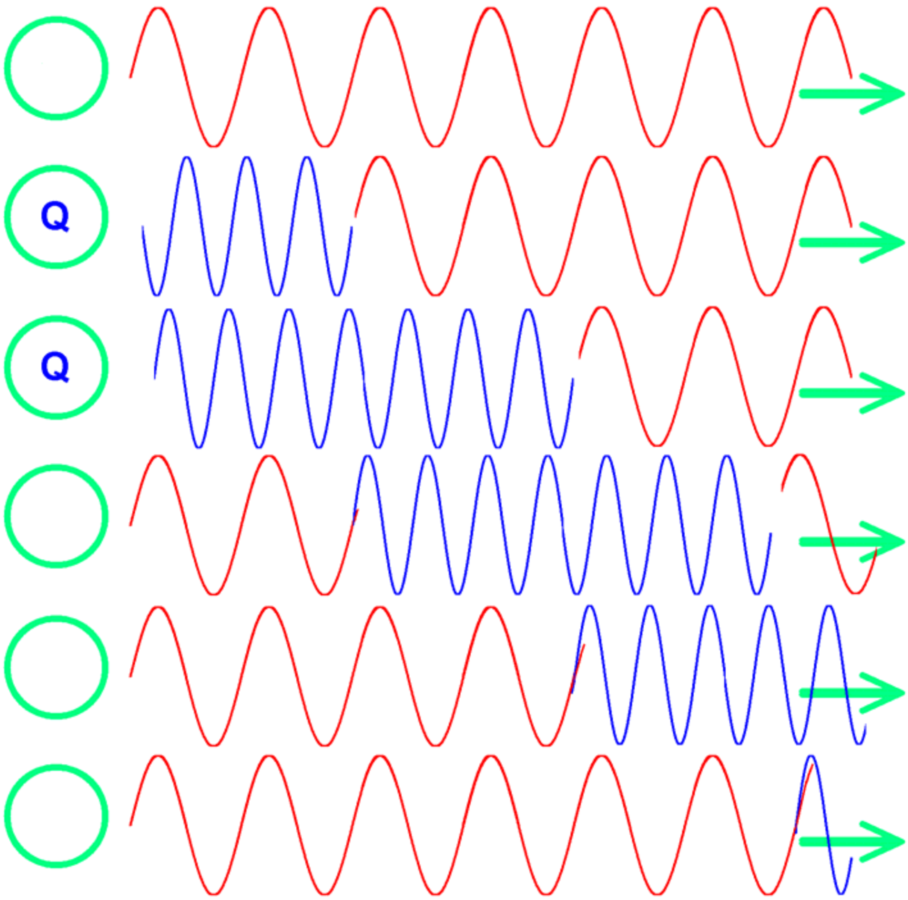

Fig. 2:

Illustration of the propagation of an electric field through the space as a function of time.

In the direction of the abscissa, we see one spatial dimension (into which the field propagates), in the direction of the negative oordinate (from top to bottom), we see the increasing time (in discrete steps).

Please notice, then the **overlap** as well as the **gap** between the fast "red" (emitted without field) and the slow "blue" waves (emitted with field) permanently increases during time, because the waves propagate with different speed. This situation can be compared with cars in traffic which overtake each other.

The crucial consequence of this situation is the conclusion, that there are time intervals, during which there is no effect of the emitted field-energy on an observer (the observer is represented by green arrows on the right side of the figure). This is the case, when the gaps between the "blue" and the "red" waves arrive at the observer. And there are time intervals, during which the observer sees the double amount of zero-point-waves, which is the case when the overlaps between the "blue" and the "red" wave arrives at the observer.

- During the last mentioned time-intervals of twice as many zero-point-waves (overlap), it is possible to take an enhanced amount of energy out of the zero-point-field of the quantum vacuum. This leads to an enhanced force of interaction. At these moments, it is possible to move magnets or electrical charges with enhanced interacting force.
- During the first mentioned time-intervals of the gaps, there is no field-force acting on the observer. At these moments, it is possible to move magnets or electrical charges without any interacting force.

This should open the way to a practical utilization of the zero-point-waves for the conversion of vacuum energy – as soon as we will be able, to build a machine, which always does the right type of movement in the right (appropriate) moment. And example for this mechanism could be the following:

■ During the phase of the **overlap** of the zero-point-waves (simultaneous arrival of both waves), we allow the parts of the machine converting vacuum-energy to follow the Coulomb-force (or magnetic force), so that the force is an enhanced because of the overlap. In the case of an attractive force, the parts of the engine should move towards each other. This very special movement gains more energy, then we can expect from the simplified laws of classical Electrodynamics, which do not take the finite speed of propagation of the fields into account.

■ During the phase of the **gap** between the zero-point-waves (missing interaction-force within the gap) we have to perform the opposite direction of the movement of the parts of the machine converting vacuum-energy, this is the direction against the Coulomb-force (or magnetic force). In the case of an attractive force, the parts of the engine should move away from each other. During this very special movement, the distance between attractive parts of the machine can be enhanced without a force – different then we can expect from the simplified laws of Electrodynamics, which do not take the finite speed of propagation of the fields into account.

By this means it must be possible, to construct closed cycles of movement, along which the attractive direction gains more energy than the repulsive direction consumes.

This explanation describes the fundamental principle, according to which electric and magnetic vacuum-energy-converters can operate.

Up to now, several inventors are known, who constructed vacuum-energy converts by intuition, finding an functioning machine by „trial and error“. But none of them has a clear idea about the theoretical working-principle behind his machine. And none of them is capable to optimize his machine systematically on the basis of such a theory. They all do the optimization by „trial and error“ (and the have success nevertheless).

Many of them report about high frequency impulses, and this is not surprising, if we look to the small differences in propagation-time between the “red” and the “blue” zero-point-waves.

With the concept presented here, the fundamental functioning principle of vacuum-energy converters is found. This is the basic fundament for the construction of vacuum-energy converters at all. It is now the task to apply this knowledge and to build vacuum-energy converters on this principle, and to optimize these devices systematically.

5. Practical methods for the construction of vacuum-energy converters

In order to construct a new vacuum-energy converter, or to calculate the functioning of existing one, the following steps define a scheme of operation.

1. step: Preparation by a classical FEM-computation

The geometry of the machine and especially of its field sources (i.e. magnets or electric charges) has to be modelled with a computer. A possible instrument therefore is the method of finite elements (FEM). But a classical FEM-program can only take this model of the machine and calculate the forces between the different parts of the engine without taking the speed of propagation of the fields into account [Ans 08].

Even if the theory behind such an FEM-algorithm is called electrodynamics, we regard the computation as a static one, because the time-dependency of the propagation of the fields during the space is neglected.

For typical engines made by mankind in the laboratory or in industrial production, this simplified static Theory is absolutely sufficient, because the distances between those parts of the engine, which interact with each other, is so small, that the time for the propagation of the fields don't play a serious role. For example, if an electric engine is a smaller than one meter, the propagation-time for the magnetic fields with the speed of light is less than $t=\frac{v}{s}\leq\frac{1m}{3\cdot10^{8}\frac{m}{s}}=3.\overline{3}\ Nano\,Seconds$, to propagate from one end of the engine to the opposite end. For the practical construction of classical engines (not for zero-point-energy converters) such small time-intervals are absolutely not important. For such engines, the static Theory of classical Electrodynamics is fully sufficient. This is different from zero-point-energy converters, whose principle is based on the dynamic time-dependency of the propagation of the fields.

2. step: Supplement of a real dynamic of the field-propagation to the FEM-method

(2.a.) Practical aspects for the production:
If a zero-point-energy converter shall be constructed, the principles of section 4 have to be taken into account, which are based on the finite speed of propagation of the fields. For the setup to be constructed, the time-intervals for the propagation of the fields with the speed of light, have to be dissected precisely (taking the necessary effort). This makes it necessary to build the machines in such a way, that the motions of its parts are short and fast enough, that the parts of the engine can feel the overlaps and the gaps between the “blue” and the “red” waves of figure 2. Because these gaps and overlaps depend on the speed of light, it is necessary to work with rather high speed of revolution and with rather high frequency of the signals and/or pulses as well as high frequency fields.

(2.b.) Computing method:
In order to realize the described construction, it is necessary to add the real dynamics of the time-dependency of the propagation of the fields to the Finite-Element-Method. Thus it is not enough to register all positions of all components of the machine as it was done under (2.a.), But it is additionally necessary to register fully all components of the machine with their complete motion in space and time. This means: In addition to the three spatial dimensions of the static Theory of classical Electrodynamics, we now have to add the dimension of time. And there is even more additional work to be done: This is necessary not only for all mechanical and electromagnetic components of the machine, but also (and this is very important) for all fields of interaction, which have to be treated as individual parts of the machine. The propagation of these fields must be taken into account, same as the motion of all other parts of the engine. Every hardware component of the machine emits a field during the consecutive time t_1, and this field starts its propagation at the position $\vec{r}_1=(x_1,y_1,z_1)$, from where it is emitted at the time t_1. And from this moment on, the field propagates all over the machine, so that it will reach an other component of the machine at the time t_2 at the position $\vec{r}_2=(x_2,y_2,z_2)$. And there it will cause a force of interaction (independently from the question, to which position the field-emitting hardware has been moving in the meantime). For the operation of the engine, the motion of all of its active components as a function of time t_1 … t_2 has to be taken into account, so that we know their positions

$\vec{r}_1(t)=(x_1(t),y_1(t),z_1(t))$ and $\vec{r}_2(t)=(x_2(t),y_2(t),z_2(t))$, … $\vec{r}_n(t)=(x_n(t),y_n(t),z_n(t))$, where the machine consists of ***n*** components. But additionally the dynamic-FEM simulation (DFEM) on the computer needs the behaviour of all fields of interaction in the same way, these are the data

$\vec{E}_1(x,y,z,t)$, $\vec{E}_2(x,y,z,t)$, …, $\vec{E}_k(x,y,z,t)$ for the dynamic propagation of the electric fields, and $\vec{B}_1(x,y,z,t)$, $\vec{B}_2(x,y,z,t)$, …, $\vec{B}_k(x,y,z,t)$ for the dynamic propagation of the magnetic fields.

Only if the motion of all hardware components of the machine during space and time, **and** the motion of all fields during space and time is completely included into the simulation, the computation of a vacuum-energy-converter is possible. This condition is absolutely necessary, because the finite speed of propagation of the fields and the alteration of the speed of propagation of the zero-point-waves is the basis of the conversion of vacuum-energy. Only if we take the time of the propagation-speed of the zero-point-waves into account, we are capable to extract energy from these waves.

In view of the DFEM-computation, the most uncomplicated type of vacuum-energy-converter is the so called „motionless-converter", which does not contain any hardware-parts in motion. For this type of converter, the only parts in motion are the fields (see for example [Bea 02], Coler [Hur 40], [Nie 83], [Mie 84], and [Mar 88-98]…, just to mention a few examples). It is empirically observed, that these motionless devices convert vacuum-energy, but up to now there was no theoretical understanding, how a machine without any moving parts can gain energy from the vacuum. This understanding is now clear on the basis of the different speeds of propagation of the electromagnetic zero-point-waves, as it is explained in section 4 of the present article. And such motionless converters can be simulated with the computer on the basis of the explanations of section 5. The fundamental theory is Electrodynamics with the supplement of the finite speed of propagation of electric and magnetic fields and the different speeds of propagation of the zero-point-oscillations within these fields.

Let us summarize with few words: For the understanding of a machine converting vacuum-energy, all its moving components have to be taken into account with their movements in space and time. These components are not only the hardware-parts of the engine, but also the fields, by which those hardware parts interact with each other. At those positions and times, where the fields meet active hardware parts of the machine, the forces of interaction have to be calculated and taken into account.

FEM-programs, as they are up to now, are not designed to do this. Classical methods for the construction of machines can not do this as well, because this is not part of the established methods. Even if it is a lot of work to develop a DFEM-algorithm, such a program is not dispensable, because from the logical point of view, this is the way, to understand the conversion of vacuum-energy. With regard to systematic construction of vacuum-energy converters, this type of DFEM-algorithm must be developed.

Crucial question: What has to be arranged in order to make vacuum-energy converters work ?

Answer: A vacuum-energy converter works, it the distances of the components of the machine and the propagation-time of the fields are adjusted to each other in such way, that the energy-consuming (endotherm) part of the movement meets the gap between the "blue" and the "red" wave, whereas the energy-producing (exotherm) part of the movement meets the overlap between the "blue" and the "red" wave (in figure 2).

If the field has attractive character (as for instance between two electrical charges with different algebraic sign), a closed cycle has to be prepared in a way, that that the overlap (of the "blue" and the "red" wave) will occur during the phase, when the components of the machine approach to each other, but the gap will occur during the phase, when the components of the machine enhance the distance between each other. This adjustment intensifies the attractive forces, which accelerate the motion, and it reduces the repulsive forces, which decelerate the motion. The consequence is, that the machine will gain more energy during the phase of acceleration, than it will lose during the phase of deceleration.

If the field has repulsive character (as for instance between two electrical charges with the same algebraic sign), the principle has to be applied in analogous manner, just with reverse direction. This means that the energy-producing, repulsive part of the motion has to be done during the phase of overlap (of the "red" and "blue" waves) in order to intensify the forces, whereas the energy-consuming, attractive part of the motion has to be done during the gap in order to reduce the forces.

Of course we face the question, whether it will be possible to simulate real existing machines with all their complexity with a DFEM-algorithm (which will have to be developed for this purpose). At every position and at every moment of the machine, we have a special spectrum of the fields and of the frequencies of the zero-point-waves, which contains many frequency-components, because the zero-point-waves propagate into a all three-dimensional directions within the machine. For classical engines without vacuum-energy conversion, as they have been produced in the industry since many years, the zero-point-waves have a spectrum, which does not cause any resonant stimulation according to section 4. But for machines with vacuum-energy conversion, this is totally different. They only work because of the resonant stimulation according to section 4. And this requests an exact adjustment of the overlaps and the gaps of the "red" and the "blue" waves with the geometry and the motion of the machine.

For a simple system, consisting of few electrical charges or few magnets in motion, it should not be very difficult, to develop a **Dynamic Finite-Element-Algorithm** (DFEM). But for more complicated and more sophisticated machines, the DFEM-method suggested here, should lead to a rather large expenditure of computation.

6. The Range of the fundamental Interactions

Gravitation and Electromagnetic interaction have infinite range, but Strong and Weak interaction have finite range. These features have to be explained also in accordance with energy-circulation of the energy of the zero-point-waves.

All four fundamental interactions of nature act with a distinct distance between the interacting particles. This distance can reach from microscopically small up to astronomically large. The fact, that the interactions work without bringing the interacting partners into contact, demands without any doubt, that there must be something, which creates the distant interaction. And this "something" can be described in the term of fields, or alternatively it can be described in the terms of interaction-quanta (i.e. exchange-particles). In both cases it is clear, that the particles interacting with each other have to emit energy, i.e. the energy of the fields or alternatively the energy of exchange-particles.

This brings us inevitably back to the energy-conservation and energy-circulation as discussed above, which requires the existence of vacuum-energy: If any interacting partner is in contact only with the void (the empty space), its supply with energy for the production of the field reps. of the exchange-particles can only come from the void. And during their propagation, the fields resp. the exchange-particles have to give back some of their energy to the void.

For Gravitation and Electromagnetic interaction we know, that the fields as well as the exchange-particles are absorbed only partly not completely by the vacuum, so that the interaction will never disappear fully, even for infinite distances. The absorption of field energy by the space is partly and continuous, and it leads to a continuous decrease of the field-strength. For the Strong and for the Weak interaction, the behaviour is totally different. They have finite range. This means that their fields (as well as the exchange-particles) have to be absorbed completely by the vacuum within a finite distance.

For the fundamental concept, we can assume the model, that each of the four fundamental interactions of nature has its own type of zero-point-waves in the quantum-vacuum:

Fundamental interaction	zero-point-waves in quantum-vacuum (in wave-representation)	interaction-quanta (exchange-particles) (in particle-representation)	Range
Gravitation	Gravitation-waves	Gravition	Infinite
Electromagnetic interaction	Electromagnetic waves	Photon	Infinite
Strong interaction	„Strong waves“ (hypothetically ?)	Gluon	Finite
Weak interaction	„Weak waves“ (hypothetically ?)	w^{+}, w^{-}, z^{0} – Bosons	Finite

Obviously each of the four fundamental interaction needs its individual type of the zero-point-waves in the quantum vacuum, because it is impossible to explain Gravitation with Electromagnetic waves, or Strong interaction with Gravitational waves, and so on…

For the explanation of the range of the interactions, we can use the concept which we know from the explanation of the range of Weak interaction. This can be adapted to all fundamental interactions accepts the Strong interaction, which is not yet fully understand (as is said in literature).

Before we will discuss this concept soon, we want to dedicate our attention the Strong interaction, which is responsible for the explanation of forces within the atomic nucleus. These forces are attributed to the exchange of Gluons, which are exchanged between colour-charged particles like quarks. Colour-neutral quark-combinations (such as protons and neutrons) only can see the colour-charges of their partners of interaction, if they are close enough to each other, because for larger distance, they would not dissolve the colour-charge details of each other. Only for very short distances, (below 10^{-15} meters) quark-bags can recognize different colour-charges of each other [Stu 06].

For a discussion of the problems of the understanding of Strong interaction within the Standard-model of elementary-particle physics is not necessary in the article here, we restrict ourselves to the explanation of the range of

- Gravitation
- Electromagnetic interaction and
- Weak interaction.

The finite range of Weak interaction is normally traced back to the rest-mass of the interaction-quanta (W^+, W^-, Z^0 – bosons): These interaction-quanta are taken out of the quantum vacuum (in the Standardmodel of elementary-particle physics same as in the energy-circulation of the preceding article here), and they have to be given back to the quantum vacuum within the limit of Heisenberg's uncertainty relation, in order to respect energy-conservation. This means that the Standardmodel, same as the energy-circulation presented here, assumes the creation of interaction-quanta, whose existence is restricted to a time-interval, due to the energy-time-variant of Heisenberg's uncertainty relation. Especially for the Weak interaction this leads to the consequence:

Rest-mass of the interaction-quantum: $m = \frac{91.1876\,MeV}{c^2} = \frac{1.460986 \cdot 10^{-8}\,J}{\left(299792458\,\frac{m}{s}\right)^2} = 1.6256 \cdot 10^{-25}\,kg$

Uncertainty relation $\Delta E \cdot \Delta t \gtrsim h \;\Rightarrow$ Decay time $\Delta t \approx \frac{h}{\Delta E} \approx \frac{6.6260693 \cdot 10^{-34}\,J \cdot s}{1.460986 \cdot 10^{-8}\,J} \approx 4.53534 \cdot 10^{-26}\,\text{sec.}$

For the interaction-quanta can by principle not be faster than the speed of light, their range is restricted by their life-time to a maximum of

$\Delta x \lesssim \Delta t \cdot c \approx 4.53534 \cdot 10^{-26}\,\text{sec.} \cdot 299792458\,\frac{m}{s} = 1.36 \cdot 10^{-17}\,Meter = 1.36 \cdot 10^{-15}\,cm$.

If we want to apply this conception in full logical consequence to photons and gravitons, which do not have a rest-mass, we come to the following situation, if we change our point of view from the particle-representation to the wave-representation:

Electromagnetic waves have a wavelength of λ and thus they carry an energy of $E = h \cdot \frac{c}{\lambda}$.

This corresponds to a (moving-) mass of the photon of $E = h \cdot \frac{c}{\lambda} = m \cdot c^2 \;\Rightarrow\; m = \frac{h}{c \cdot \lambda}$.

Because the quantum vacuum contains a continuous spectrum of electromagnetic waves, the (moving-) mass of the photons (as interaction-quanta), has a continuous spectrum, and we apply Heisenberg's uncertainty relation as following:

$$\Delta E \cdot \Delta t \gtrsim h \;\Rightarrow\; m \cdot c^2 \cdot \Delta t \gtrsim h \;\Rightarrow\; \frac{h}{c \cdot \lambda} \cdot c^2 \cdot \Delta t \gtrsim h \;\Rightarrow\; \frac{c}{\lambda} \cdot \Delta t \gtrsim 1 \;\Rightarrow\; c \cdot \Delta t \gtrsim \lambda$$

After a photon (as interaction-quantum of the electromagnetic interaction) is taken out of the quantum vacuum by an electric charge (which plays of the roll of a field source), the photon has to be given back to the quantum vacuum within the limit of Heisenberg's uncertainty relation, same as the interaction-quanta of Weak Interaction, which we discussed before. Because the photon propagates with the speed of light, it has to be given back to the quantum vacuum within the distance of propagation of $s = c \cdot \Delta t \approx \lambda$.

This has the consequence, that the range of the Electromagnetic interaction corresponds to the wavelength of the photon as the interaction-quantum, which are the wavelengths of the electromagnetic zero-point-waves of the quantum vacuum. Because the quantum vacuum contains a continuous spectrum of electromagnetic zero-point-waves, and the wavelengths go up to infinity, the range of the interaction has the same length, this is infinity. (Side-remark: A cutoff-radius of the wavelengths of the zero-point-waves for short wavelengths in the order of magnitude of the Planck-length is under discussion, in order to eliminate divergence-problems with the determination of the zero-point-energy of the quantum vacuum. A cutoff-radius for long wavelengths is not necessary and thus it was never under discussion [Whe 68].)

By the way: The concept presented for Electromagnetic interaction can be transferred to Gravitation identically. It is just necessary to replace the electromagnetic zero-point-waves by gravitational zero-point-waves and the photons by gravitons.

7. Solution of the discrepancy of the rest-mass of the field-sources

During time (during centuries) the fields permanently spread out into the space (the universe). This is not the case for the Strong interaction and for the Weak interaction, because their range is finite, and after a short distance, they completely disappear, being fully re-absorbed by the vacuum. But Gravitation and Electromagnetic interaction propagates over infinite distance into the space. Thus their energy can be re-absorbed only partly but never completely by the vacuum. The consequence is, that the amount of field-energy (of the gravitational field, the magnetic field and the electric field) is permanently increasing during time. Due to energy-conservation, their counterpart, the vacuum-energy must decrease permanently during time. If we would know the amount and the distribution of electrical charges and ponderable masses in the universe, we could determine the amount of increasing field-energy and decreasing vacuum-energy as a function of time. This tells us that the information, that our universe consists of about two thirds of vacuum-energy is only a picture of the moment of observation - with regard to cosmological time-intervals.

If we could observe the propagation of the fields for an infinite time-interval, we would come to the total field-energy, as known from literature. The prominent example for this calculation can be found in the widespread beginner's-textbook by Richard Feynman, in which he demonstrates the determination energy and the mass of the electric field of the electron:
From the electric field of the electron and its energy-density recording to our equations (1) and (2), Feynman determines the field-energy in the outside of the electron, using the classical electron's radius of $R_E = 2.818 \cdot 10^{15} m$ (according to [COD 00]) as following:

$$u = \frac{\varepsilon_0}{2} \cdot \left|\vec{E}\right|^2 = \frac{\varepsilon_0}{2} \cdot \left(\frac{1}{4\pi\varepsilon_0} \cdot \frac{Q}{r^2} \right)^2 = \frac{Q^2}{32\pi^2 \varepsilon_0 r^4}$$

$$\Rightarrow \ E_{Feld} = \int_{R_E}^{\infty} u(\vec{r})\, dV = \int_{\varphi=0}^{2\pi} \int_{\vartheta=0}^{\pi} \int_{R_E}^{\infty} \frac{Q^2}{32\pi^2 \varepsilon_0 r^4} \cdot r^2 \cdot \sin(\vartheta)\, dr\, d\vartheta\, d\varphi$$

$$= \frac{Q^2}{32\pi^2 \varepsilon_0} \cdot \underbrace{\int_{R_E}^{\infty} \frac{1}{r^2} dr}_{\left[\frac{-1}{r}\right]_{R_E}^{\infty} = \frac{1}{R_E}} \cdot \underbrace{\int_{\vartheta=0}^{\pi} \sin(\vartheta) d\vartheta}_{2} \cdot \underbrace{\int_{\varphi=0}^{2\pi} d\varphi}_{2\pi} = \frac{Q^2}{32\pi^2 \varepsilon_0} \cdot \frac{4\pi}{\mathrm{R_E}} = \frac{Q^2}{8\pi\varepsilon_0 \cdot \mathrm{R_E}} = 8.1871 \cdot 10^{-14} Joule$$

$$\Rightarrow \ \frac{E_{Feld}}{c^2} = 9.109 \cdot 10^{-31} \text{ kg}$$

But there is a contradiction: From scattering-experiments we know, that the electron has to be treated as punctiform particle in reality (with a radius, which is for sure smaller than the classical electron's radius, and even for sure smaller than $r_{streu} < 10^{-18} m$, see for instance [Loh 05], [Sim 80]). This means, the field-energy of the electron is remarkably larger then the value given above. With other words: The field-energy of the electron is much larger than the ponderable mass of the electron would allow. This problem is regarded as an unsolved discrepancy in literature.

This discrepancy led into several discussions among physicists, because we see an unsolved contradiction of several orders of magnitude. Namely, the problem is as following: If we want to move the electron in space, we have to move the field of the particle together with the electron – if we assume an instantaneous propagation of the field, as classical Electrodynamics does, with infinite speed of propagation (not taking the finite speed of propagation of the fields into account). If we want to move the complete field (together with the electron), we have to overcome the inertia of its large ponderable mass, which is connected to the field-energy (due to $E=mc^2$). In the conception of classical Electrodynamics the complete field is fixed rigidly to the field source of the electron. This is a contradiction not only to the Theory of Relativity (because of the infinite speed of propagation of the field strength, which would allow the transformation of information with infinite speed), but this is also in contradiction to the ponderable mass of the electron in comparison with the field-energy of the electron.

The solution of this discrepancy is rather simple: It is just necessary to dissolve the misunderstanding, which is behind this discrepancy, namely the rigid fixation of the field to the field-source with immediate infinite expansion of the field. This point of few is simply erroneous (because of the reasons explained above). In reality the field is not fixed rigidly to the electron, and thus we do not have to move the complete field, when we want to move the electron. In reality, the electron emits its electromagnetic field, and as soon as the field is emitted, it is released from the electron. So the field propagates through the universe, following the way how it was emitted, not knowing what is happening to the electron, after the field has left its source. The field propagates into the space with the speed of light, without being coupled to the field-source. There is no interaction between the field source and the field being emitted before the moment of observation, so that the field does not give any action back to the electron from which it originates. Consequently, the field has no means to act onto the inertia of the electron. This solves the discrepancy between the classical electron's radius, the electron's radius from scattering experiments, the ponderable mass of the electron and ponderable mass of the electron's field. The electron has its ponderable mass, which is independent from the energy of its field. (The discussion of the ponderable mass of the electron is a different topic, which shall not be under discussion here, because this is not necessary for our consideration dealing with the conversion of vacuum-energy.)

This is one more example, from which we see, how the finite speed of propagation of the field (as a logical consequence of the Theory of Relativity) helps to solve old problems. After decades of years without any solution, the problem fell into oblivion – and here is the solution.

8. Microscopic vacuum-energy conversion

This section has the purpose to demonstrate, that the conversion of vacuum-energy is not something exotic, which can only be achieved with hard effort and after overcoming many difficulties. In reality, the conversion of vacuum-energy is something very normal, which we observe every day in our normal life. In section 3 we saw, that every atom is a vacuum-energy-converter, and we know atoms from everyday's life. We want to support this knowledge about the conversion of vacuum-energy by regarding the electrons in the atomic shell now, namely by demonstrating the connection between these shell-electrons and the vacuum-energy with a little calculation.

Without the conversion of vacuum-energy, atoms could not exist by principle. From the theory of Stochastic Electrodynamics, we know that atoms convert vacuum-energy extremely efficient. We also know from section 2, that single electrons convert vacuum-energy very efficient. Without being supplied by vacuum-energy, electrons would decay within a tiny part of a second.

Of course, this brings us to the question, why microscopic particles can convert vacuum-energy so extremely efficient, much more efficient than macroscopic engines. In search of an answer to this question, we try to find some common criteria, which the microscopic particles have in common. Rather easy, we can realize that the mentioned microscopic particles, have their very fast motion in common. The electron itself is gyrating with a rather high frequency (causing its magnetic moment). And the electron in the atomic shell is a running with a rather high frequency (in the range of 10^{15} Hz) around the nucleus, as can be estimated with regard to the very simple example of the electron of the hydrogen-atom:

According to Bohr's atomic model, the electron circulates around the atomic nucleus, with Coulomb's force delivering the centripetal-force, which is necessary to keep the electron on its orbit.

$$F_{El} = F_Z \Rightarrow \frac{e^2}{4\pi\varepsilon_0 r^2} = \frac{m_e v^2}{r}$$

From Bohr's postulates, from which we know that the electron can only be kept on distinct orbits, we also know the speed of the electrons and the radii of their orbits:

$$v = \frac{n \cdot \hbar}{m_e \cdot r} \qquad \text{and} \qquad r = n^2 \cdot \frac{4\pi\varepsilon_0 \cdot \hbar^2}{m_e \cdot e^2}$$

From there it is not difficult, to derive the frequency of the circulation of the electron along the first orbit (quantum number n=1):

$$f = \frac{v}{2\pi r} = \frac{\frac{n \cdot \hbar}{m_e \cdot r}}{2\pi \cdot n^2 \cdot \frac{4\pi\varepsilon_0 \cdot \hbar^2}{m_e \cdot e^2}} = \frac{m_e \cdot e^4}{32\pi^3 \cdot \varepsilon_0^2 \cdot \hbar^3 \cdot n^3} = 6579683942351511 \text{ sec}^{-1} = 6579684\,GHz$$

We can imagine, that the electromagnetic zero-point-wave of such a high frequency has enough energy, to supply the electron in such way, that it will be kept on its orbit. This means, that we can imagine, that the electromagnetic zero-point-waves are responsible for keeping the electron on a stable orbit. This imagination is confirmed for sure, if we calculate the energy of the electromagnetic zero-point-wave, of this frequency:

$$W = h \cdot f = 6.6260693 \cdot 10^{-34} Js \cdot 6579683942351511 \text{ s}^{-1} = 4.3597 \cdot 10^{-18} J = 27.2114 \text{ eV} = 2 \cdot 13.6\,eV$$

Surprisingly, we found: This is exactly the potential-energy of the electron on its orbit.

Indeed, Bohr's atomic model determines the potential energy, the kinetic energy and the total energy of the electron in the field of the nucleus as

$$\left.\begin{array}{l} E_{Pot} = \dfrac{-m_e \cdot e^4}{4\varepsilon_0^2 \cdot n^2 \cdot h^2} \\ E_{Kin} = \dfrac{1}{2} m v^2 = \dfrac{-m_e \cdot e^4}{8\varepsilon_0^2 \cdot n^2 \cdot h^2} = -\dfrac{1}{2} E_{Pot} \end{array}\right\} \Rightarrow E_n = E_{Kin} + E_{Pot} = \frac{1}{2} E_{Pot} = \frac{+m_e \cdot e^4}{8\varepsilon_0^2 \cdot n^2 \cdot h^2} \Rightarrow E_{Pot} = 2 \cdot E_n$$

and this is $E_n = 13.6eV \;\Rightarrow\; E_{Pot} = 2 \cdot 13.6eV$ in the ground state (n=1).

This means that the electron on its orbit around the atomic nucleus has exactly the same frequency as the electromagnetic zero-point-wave, which supports the potential energy of the electron, so that it will not fall down into the nucleus. This is a very clear confirmation for the connection between the electron in the atomic shell and the electromagnetic zero-point-wave supporting this electron.

Obviously the conversion of vacuum-energy is most efficient for such elements of the converter, which have the same frequency as the zero-point-waves, from which the energy shall be converted. And this is not surprising but it is plausible, because after the explanations of section 4 and 5 we know, that the energy-donating zero-point-oscillations have to oscillate in phase with the energy-accepting components of the zero-point-energy converter. And to keep constant phase-relation requires for sure identical frequency. Constant phase-relation has the consequence, that the adjustment of the overlaps and the gaps between the “blue” and the “red” waves in figure 2 can be done once perfectly, and then be kept in perfect condition for all periods of the oscillation. A circulation, as it occurs for the electron of the hydrogen-atom, produces one field-gap and one field-overlap for each turn. This makes the stimulation by this special zero-point-wave most efficient, whose frequency is identical to the frequency of the circulation. This “equality of both frequencies” (of the zero-point-wave and of the converter) is the condition for a resonant stimulation of the circulating electron by the corresponding zero-point-wave.

The calculation of the energy-levels in atomic physics from the fact, that the circulating electrons are supplied with the energy of the zero-point-waves, is the central topic of the theory of Stochastic Electrodynamics. This was published in numerous long publications, not only in Physical Review. In the article here, we see the same principle, demonstrated in less than five lines of formulas (for the example of the ground state of the hydrogen atom) – based on an independent and self-reliant consideration, independent from the formalisms of Stochastic Electrodynamics or Quantum Mechanics.

A further example, how the electron is supplied with vacuum-energy, is the electron as a source of an electric and a magnetic field. Easily understandable is the support of the magnetic field, which is produced because of the rotation of the electron around its own axis of symmetry. This rotation is also a periodic motion, which can be seen as the superposition of oscillations. The magnetic moment of the electron is (except for higher corrections of Quantum Electrodynamics [Köp 97]) known to be $\mu = \frac{e \cdot \hbar}{2 \cdot m_e}$.

Let us now look to this magnetic moment from the point of view of classical Electrodynamics, from where we know it to be $\mu = A \cdot I$, with $A =$ cross section of the conductor-loop producing the magnetic moment and $I =$ electrical current responsible for the magnetic moment. If we bring both expressions for the magnetic moment together, we can calculate the electric current
$I = \frac{\mu}{A} = \frac{e\,\hbar}{2m_e \cdot r_e^2}$.

Taking the classical electron’s radius as value for the radius of the conductor loop, and calculating the electrical current as $I = \frac{e}{T}$ (with T= duration for one turn), we can calculate the frequency of the spin of the electron. If we take additionally the fact into account, that the electric charge is regarded to be distributed homogeneously all over the surface of the electron (and not gyrating completely along the equator), we have to take and additional factor of $3/8$ into account, and thus we come to the frequency $\omega = \frac{3 \cdot \hbar}{8 m_e r_e} = 15405884737 \text{ sec}^{-1} \approx 15.4 \text{ GHz}$.

This leads us to energy of $W = h \cdot f = 6.6260693 \cdot 10^{-34} Js \cdot \frac{15405884737 \text{ s}^{-1}}{2\,\pi} = 1.62466 \cdot 10^{-24} J = 1.014 \cdot 10^{-5} \text{ eV}$, of the stimulating zero-point-wave.

This is less than what we found for the orbital movement of the electron around the nucleus, but it is plausible, because the spin of the very small electron of course needs less energy than the gyration along an orbit, which is by many orders of magnitude larger than the electron itself. Nevertheless, the spin of the electron is supported by electromagnetic zero-point-waves, because there is no other source of energy, which can supply the electron in order to give him the possibility to maintain his magnetic field.

The supply of the electron with zero-point-energy, which allows him to maintain his electrostatic field, is not yet understood, because it is not yet clear, where we find the motion and the oscillations, which are necessary to compress the wave trains of the zero-point-waves according to figure 2. There should be some zero-point oscillation of the electron itself, because the electron is also a particle described by Quantum-mechanics and by Stochastic Electrodynamics – and so it is not free from the zero-point oscillations of these theories. Here, some scientific work is still to be done. Nevertheless, it is sure that this supply is existing. This is clear on the one hand, because there is no other energy supply for the electron but the vacuum. And it is clear on the other hand from the verification experiment of [Tur 09].

In any case we see, that zero-point-energy converters improve their efficiency and power, as soon as the resonance frequency of the oscillating fields is increased. This is clear for magnetic zero-point-energy converters (which even can work as self-running engines) as well as for motionless converters. Central and most important aspect is always the frequency, with which the fields are moving, which are used for the conversion of the zero-point-energy. In order to optimize zero-point-energy converters, we should care about the following:

1. High-frequency of the field
2. Large number of particles, which take up the zero-point-energy
3. Maximization of the overlaps and the gaps between the “red” and the “blue” zero-point wave trains, made by intervals with and without field being applied.

9. Hydrogen-Converters

From literature, we know several Hydrogen-Converters. These are zero-point-energy converters, whose principle is based on the electrolysis of water-molecules, namely by dividing water-molecules into hydrogen and oxygen with a COP of much more than 100% (see for instance [Alm 09], [Bro 10]). This means, that the amount of electrical energy to be spent for the electrolysis is much less than the amount of chemical energy contained in the produced isolated gases of hydrogen and oxygen. This can be interpreted as following: For every Watt of electrical energy, which is necessary to keep the electrolysis running, the process gains many Watts of chemical energy, which can be transferred into thermal energy by burning the hydrogen with the oxygen (into water), or which can be transferred into electrical energy by giving the hydrogen and the oxygen to a fuel cell. By this means it is even possible to build a self running engine, producing permanently classical energy according to figure 3.

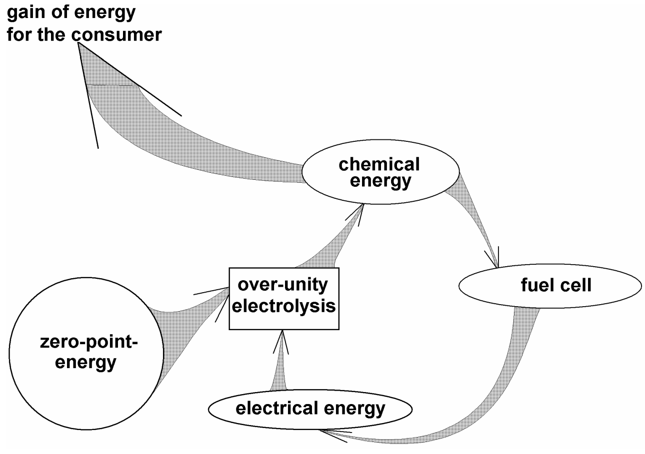

Fig. 3: Flux of energy in a self-running electrolyzer, driven by zero-point-energy.

The mechanism of this type of over-unity water-electrolysis is still under discussion [Nag 10]. Already clear is: The electrons in the atomic shell of the hydrogen- and the oxygen- atoms play the crucial role, because the term of "electrolysis" requires the separation of the covalent (chemical) bond of the atoms. (Please remind here the sections 3 and 8 of the present article.) It is a matter of course, that from there I get my hypothesis about the functioning principle of the over-unity water-electrolysis:
If the electrons (which are supplied with zero-point-energy by nature in order to keep their orbits) can be **oversupplied** with zero-point-energy, it would be imaginable that they might be lifted into an excited state (an energy level above the ground state), from where they lose their covalent bonding, so that they will lose their capability to keep the hydrogen-atoms sticking to the oxygen-atoms. From section 8 we know, that high-frequency excitation gains zero-point-energy very efficiently, because the zero-point-waves of high frequencies carry a large amount of energy according to $W = h \cdot f$. So probably it would be sensible to drive of the over-unity water-electrolysis with a rather high-frequency. But we do not expect, that the frequency will just simply increase the efficiency, because of the frequency of the excitation by zero-point-waves should be in the resonance with the frequency, which the bonding-electrons of the water-molecules needs to be lifted into an excited state. Maybe a good choice for a trial of the excitation-frequency could be the frequency, which is necessary to support the 2s-state of the hydrogen-atom, in order to lift the electron from the 1s-state to the 2s-state. This would be

$$E_{Pot} = 2 \cdot E_n = \frac{-m_e \cdot e^4}{4\varepsilon_0^2 \cdot n^2 \cdot h^2} = \frac{2 \cdot 13.6 eV}{2^2} = 6.8 eV = 1.0895 \cdot 10^{-18} J$$

$$\Rightarrow \quad f = \frac{E_{Pot}}{h} = \frac{1.0895 \cdot 10^{-18} J}{6.62607 \cdot 10^{-34} J\, s} = 1644232788811913\,\mathrm{Hz} \approx 1644.23\,\mathrm{THz}$$

This is not a low frequency, but perhaps it can be produced as a component of the Fourier-spectrum of extremely short pulses to the electrodes. Perhaps an alternative for its production might be an optical method (to produce UV-light of $\lambda = \frac{c}{f} = 182\,nm$), but it is not clear, how an optical frequency can be brought to an electrode. Probably it is also sensible, to try not only this one frequency, but to try the complete frequency-range in the order of magnitude under discussion, because the covalent bonding of the hydrogen-atom to the oxygen-atom influences the energy-levels of the electrons.

10. Resumée

With the present work, the **mechanism** of the conversion of zero-point-energy has been found and explained. Its fundamental basics are presented here. Furthermore a computing-method is explained, according to which the functioning-principle of every zero-point-energy converter can be calculated. The method, let us call it "DFEM", is based on the finite-element-method with a supplement of the propagation-dynamics of the interaction-fields.

This method is developed according to the following idea:

In order to convert zero-point-energy into any classical type of energy, there must be an oscillating (electric, magnetic or gravitational) field inside the converter, where the oscillations are working in such way, that they donate zero-point-energy to converter. This can be achieved by the following method:

Basic fundament is the fact, that the speed of propagation of the zero-point-waves (of the quantum vacuum) can be altered by an applied AC-field. This allows us to develop a clever pattern of fields, which produces **gaps** and **overlaps** between the zero-point-waves, where the gaps reduce the force of interaction and the overlaps enhance the force of interaction. We now can put electrical charges, magnets or ponderable masses into this periodically alternating reduction and enhancement of the force of interaction. And they have to oscillate in such special manner, that the energy-gain will be enhanced, whereas the energy consumption will be reduced (along a closed loop of motion), compared to the static conservative potential. Real engines will have to be constructed in a way, that this tricky motion excites the oscillation more and more, and the energy for this excitation dissipates from the zero-point-wave's energy into the energy of the motion. By this means, the energy of the gained and can be utilized classically.

In order to underline this concept, examples from nature have been a referenced (as for instance the electron with its spin, or the electrons in the atomic shell) which are driven by zero-point-energy, which they get from the zero-point-waves of the quantum vacuum.

The very next step to be done is the realization of the DFEM-algorithm as described, into a very simple principle zero-point-energy converter (for which it is not yet important, whether it can be realized as a practical engine). This should not be very complicate. It has the sense to verify the concept of the DFEM-method.

But the large next step to be done is the realization of this DFEM-algorithm into a good software, for the systematic computation of the design and construction of zero-point-energy converters, which can be really be built up.

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Example of a simple Algorithm for the Construction of Zero-point-energy Converters

Wolfenbüttel, Oktober – 9 – 2010

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Abstract

The fundamental principle of the conversion of zero-point-energy has been explained in [Tur 10]. This enables us to construct zero-point-energy converters systematically. The method of computation for such a construction was presented as dynamic Finite-Element-Method (DFEM), which is a Finite-Element-Algorithm with the supplement of taking the finite speed of propagation of the interacting-fields (responsible for the forces between the partners of interaction) between the components of the zero-point-energy converter into account.

In order to illustrate the development from the fundamental principle to the real DFEM-program, we now present a small example for this computation, including a short source-code as a working performance. This algorithm is explained in detail here, so that everybody can use and further develop it. Finally we analyse a possible zero-point-energy motor with this program, explaining its conditions of operation and its machine power.

1. An uncomplicated setup

This is the very first time that an algorithm for the construction of zero-point-energy converters is presented. Thus, the computer-program was developed as uncomplicated as possible, in order to make it understandable to everybody. For the conversion of zero-point-energy is not something exotic, it is not difficult to find a very simple setup (as a basis for the analysis in our DFEM-algorithm), which can fulfill this task: For the sake of simplicity, we take a one-dimensional example, and it is already sufficient to connect two masses with a helical spring, in order to build up a simple oscillator – nothing more – this is all we need. The only addition we will need is some electrical charge on the bodies No.1 and 2, or some magnets. The arrangement is drawn in figure 1 as it could be seen in every beginner's textbook.

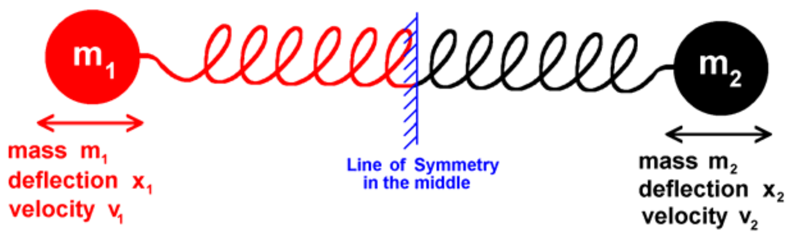

Fig. 1:
Two masses, which are connected by a helical spring, can perform an oscillation.

If we want to trace back the example of figure 1 directly to a simple beginner's example, we can fix one ponderable mass with the use of a helical spring directly to a wall (as drawn in blue) in the middle of the setup and observe harmonic oscillations according to the differential-equation (1) without friction and without excitation. The solution according to equation (2) is generally known as:

Differential-equation $m \cdot \ddot{x}_1 + D \cdot x_1 = 0$ (resp. $m \cdot \ddot{x}_2 + D \cdot x_2 = 0$) (1)

Solution $x(t) = A \cdot \cos(\omega t + \varphi_0)$, (2)

with the symbols as usual in literature.

Of course, the amplitude is constant, and there is no conversion of zero-point-energy in this example.

But if we put some electrical charge on the bodies m_1 and m_2, or if we replace them by two magnets, an additional force will occur (it can be attractive or repulsive), which depends on the distance between the charged spheres or magnets. For the further course of our article, let us chose the direction of this interacting force to be attractive.

In the case of electrically charged spheres, the force follows the (first) coulomb's law according to (3); in the case of permanent magnets the force follows the (second) coulomb's law for dipole-dipole interactions according to (4), see [Ber 71]. Those both laws differ from each other only by the factor of proportionality, and by the fact that in the case of electrical charges, we have to put the charges Q_1, Q_2 into the formula, whereas in the magnetic case, we have to put the magnetic dipole-strengths p_1, p_2 into the formula. In both cases the forces decrease proportional to $1/r^2$. Because of this reason, we can say, that the computation of electrostatic zero-point-energy motors has to be done in complete analogy with the computation of magnetic zero-point-energy motors, because the computations only differ by some constant factors. Nevertheless it has to be emphasized, that a totally different dependency between force and deflection would be absolutely no problem, because it would just require an alteration of two lines in the algorithm of section 3, namely

```
FEL1:=+Q1*Q2/4/pi/epo/r/Abs(r); {electrostatic force between Q1 & Q2}
FEL2:=-Q1*Q2/4/pi/epo/r/Abs(r); {electrostatic force between Q1 & Q2}
```

$$F_{\text{charges}} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{Q_1 \cdot Q_2}{r^2} \quad (3)$$

$$F_{\text{magnets}} = f \cdot \frac{p_1 \cdot p_2}{r^2} \quad (4)$$

If L_0 is the length of our helical spring in the moment without spring-force, the description of the pendulum is now done by adding an expression for the electrostatic resp. for the magnetic force into the differential-equation of (1), so that we come to the differential equation of (5). The left expression is for body No.1, the right expression for body No.2.

$$m \cdot \ddot{x}_1 + D \cdot x_1 + \frac{C_{EM}}{\left(\frac{L_0}{2} + x_1\right)^2} = 0 \qquad \text{(resp. } m \cdot \ddot{x}_2 + D \cdot x_2 + \frac{C_{EM}}{\left(\frac{L_0}{2} + x_2\right)^2} = 0 \text{)}, \quad (5)$$

where C_{EM} are the factors of proportionality mentioned above, which contain the information about Q_1, Q_2 or p_1, p_2. Depending on the algebraic sign of the electrical charge Q_1, Q_2, or of the polarity of the dipoles p_1, p_2, the factor C_{EM} can be positive or negative. Besides the inertial forces and the forces of the helical spring, our differential-equation now takes also magnetic forces resp. electric forces into account.

The solution of the differential equation (5) now is not any further a simple sine-expression as it has been in the harmonic oscillation of equation (2). With a numeric iteration, as shown in part 2 of the algorithm in section 3, we derive the solution as seen in figure 2.

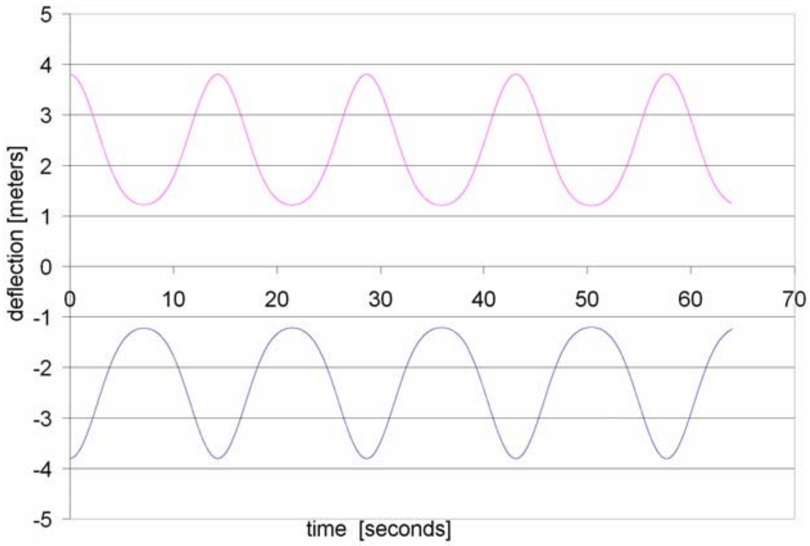

Fig. 2:

Trajectories of the two bodies No.1 and 2, which are electrically charged or permanent magnets. The spring has to be imagined vertically, connecting the bodies No.1 and 2.

Obviously the oscillation is not harmonic.

Obviously classical potential energy (of the electrical or the magnetic field) is converted into the energy of spring energy and kinetic energy. Thus, we have an energy-conversion between these three types of classical energy. Of course zero-point-energy is still not under discussion. The amplitudes are constant, confirming the conservation of classical energy. The computer-simulation of the motion can be found in part 2 in the source-code printed in section 3. Because up to here, we did not yet deal with the zero-point-energy conversion, the algorithm is still a classical static FEM-algorithm (with only two elements).

2. Introducing Dynamics: From FEM to DFEM

We now want to insert the finite speed of propagation of the electric field resp. the magnetic field into the considerations of figure 1 and section 1. In the static theory of electricity, the duration for the propagation of these fields is neglected. This means, that the speed of propagation of the fields is approximated to be infinitely fast. Of course, this is in clear contradiction to the Theory of Relativity, according to which the speed of light is a principle upper limit to all velocity and speed at all. So we regard the static theory of electricity as an approximation, which works rather well in many classical cases for engineering purpose, but which is not sufficient for the explanation of the zero-point-energy motors by principle (see [Tur 10]). Thus we decide to reject this approximation now, in order to make the conversion of zero-point-energy understandable.

By the way, the speed of propagation of the fields is the speed of light only inside the vacuum. In matter, the fields propagate less fast.

Consequently, we have to replace equation (5) and figure 2, which are based on the approximation of infinite speed of propagation of the fields, by a more precise consideration. This is what we do now: For the solution of equation (5), the forces in part 2 of the algorithm (see section 3) had been calculated only with the use of the static version of coulomb's law. For the dynamic computation, we now have to accept the fields of interaction as self-reliant physical entities, and we have to take their finite speed of propagation into account, as illustrated in figure 3. There we see two bodies moving to the left and to the right, and the time-dependant development of the situation is plotted in three steps from the top to the bottom.

At the moment t_a the interacting partner No.1 (magnet or charge) is at the position $x_{1,a}$ and the interacting partner No.2 is at the position $x_{2,a}$. At the moment t_a, No.1 emits a field, which propagates among others also into the direction towards No.2 (red arrow). This part of the field is responsible for force of No.1 acting on No.2. This field(-package) now approaches towards No. 2, but at the same time, No.1 also moves a little bit to the right side, this means, that No.1 follows the direction of the field. But No.2 moves from the right to the left side, this is the direction towards the field(-package). We can see this development, when we follow the course of the time from t_a to t_b. But finally we further follow the course of the time until we reach t_c. This is the moment, at which the field reaches the partner No.2.

For the computation of coulomb's law we now face the question: Which field-strength does partner No.2 feel in this moment ?

The answer is clear: We use Coulomb's law according to equation (3) or (4), and we apply the distance which the field had to pass **really**. This is the distance marked with the blue arrow in figure 3. This means that No.2 feels less field strength in the moment t_c, then it would be derived from the static version of Coulomb's law (for which the distance is marked with a green arrow).

On the other hand, if both partners of interaction would not approach to each other, but run away from each other, the situation would be just the opposite, where No.2 would feel a field, which is a stronger then according to the static version of Coulomb's law. The situation is illustrated in figure 4.

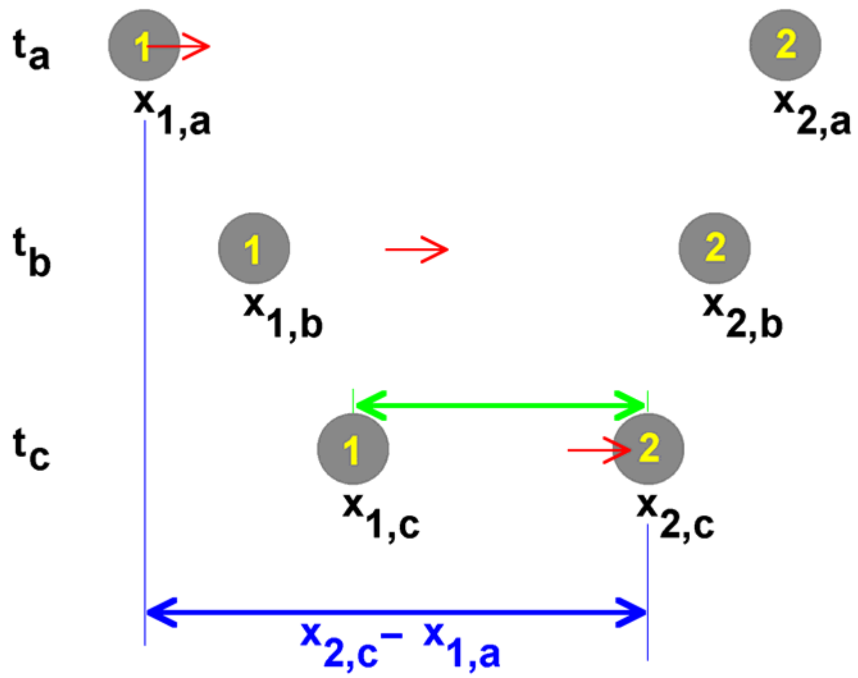

Fig. 3:

Illustration of the influence of the motion of the magnets or the electric charges on the emitted field strength.

Basis of the understanding is the finite speed of propagation of the fields.

The graph displays the situation of two bodies moving away from each other.

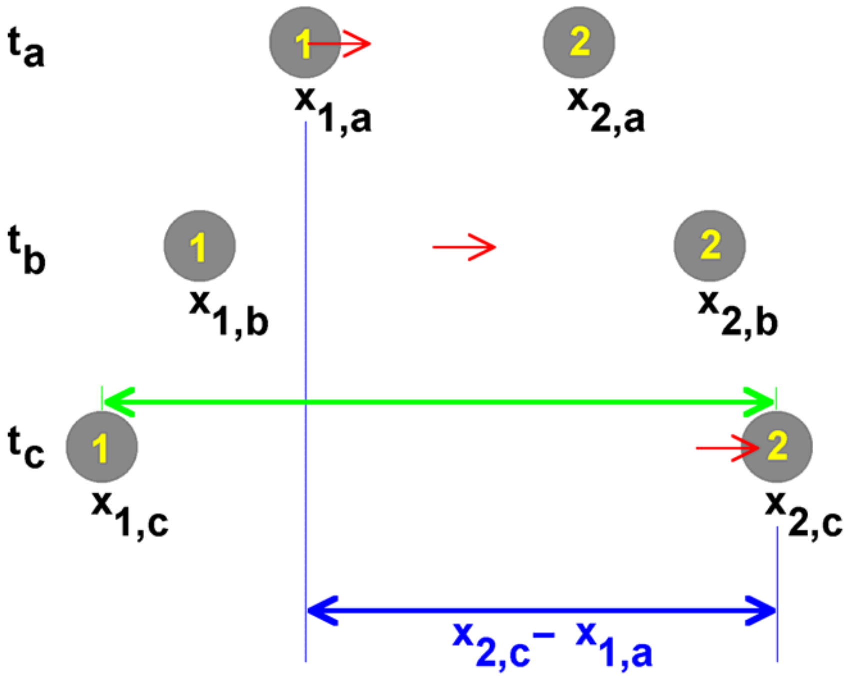

Fig. 4:

Illustration of the influence of the motion of the magnets or the electric charges on the emitted field strength.

Basis of the understanding is the finite speed of propagation of the fields.

The graph displays the situation of two bodies moving towards each other.

If we manage to organize the motion of the bodies (of Fig.1) in a tricky way, we can achieve that they oscillate relatively to each other (due to the helical spring connecting them to each other) in such a way, that they feel a reduced Coulomb-force during the time-intervals when they increase their distance from each other, whereas they feel enhanced Coulomb-force during the time, when they decrease the distance between each other. In the case of attractive Coulomb-forces, these leads to the consequence, that the amplitude of the oscillation increases more and more during time, without any support of classical energy. An illustration can be seen in figure 5, where different colours are used to represent different field strength. In the very first line of figure 5, we see a static field source at rest (charge or magnet), which emits a static field. As long as of the charge is at rest, the field-strength is constant, and thus it is not necessary to perform any dynamic consideration. But if the field source comes into motion, as in the second line of figure 5, the field is reduced on the right side (towards which the field source is moving), as we learned from t_c in Fig.3. The opposite case is a motion of the field source to the left side (third line of figure 5), corresponding to the moment t_c in Fig.4 and causing an enhancement of the field strength on the right side in comparison to the static version of Coulomb's law. Two field sources, which oscillate relatively to each other (this is our setup since figure 1), produce oscillating field strength at the position of each other. This causes, as soon as it is arranged properly, the modulation of the field strength, which leads to the enhancement of the amplitude as described above. Of course this is only possible, because it is supplied with the zero-point-energy of the quantum-vacuum – as explained in [Tur 10].

Of course this is only possible, if the supply with zero-point-energy is kept during many periods of oscillation in good synchronization with the oscillating bodies. In this case, the supply of energy is resonant, and we have an efficient zero-point-energy motor, converting zero-point-energy into classical energy of an oscillation.

In the opposite manner, it is also possible to synchronize the oscillating fields and the oscillating masses with reversed phases to each other, so that the phase of the enhanced field strength always occurs during the time when the attractive partners want to enhance their distance, whereas the phase of reduced field strength always occurs during the time when the attractive partners want to reduce their distance. In this case the dynamics of the fields in

Coulomb's law reduces the oscillation. This means, that classical energy of the oscillation is converted into zero-point-energy of the quantum vacuum.

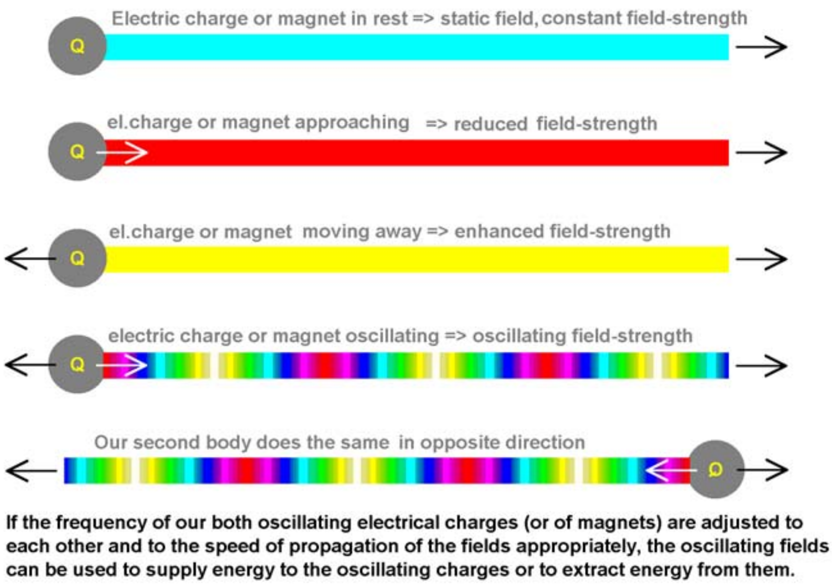

Fig. 5:

Illustration of the oscillating fields, as they are emitted by oscillating electrical charges or by oscillating magnets.

The situation is not surprising, because the Hertz'ian dipole-emitter is known to work according to the same principle.

From there, we understand that the principle of the conversion of zero-point-energy of the quantum-vacuum can be applied in both directions (as soon as we understand it): On the one hand it can be used to convert zero-point-energy into classical energy, and on the other hand it can be used to convert classical energy into zero-point-energy. Which of those both directions is realized in an engine is mainly a question of the adjustment of the system-parameters. Especially the following both system-parameters have to be adjusted appropriately to each other:

- the speed of propagation of the fields and
- the speed of motion of the moving field sources.

In our example-algorithm this means, that we have to adjust the deflections and the amplitude of the oscillating bodies, their ponderable masses, Hooke's spring force constant, and finally of course the electrical charges, which supply the Coulomb-forces necessary to convert zero-point-energy appropriately to each other. Instead of electrical charges, it would also be possible to use permanent magnets and to include the adjustment of their dipole-strengths into the adjustment of the system-parameters.

In order to prove all these statements, within the preceding work, a dynamic Finite-element algorithm (DFEM) was developped, which is a very short and easy to understand. It realizes the oscillation of two electrically charged spheres with a spring as drawn in figure 1, taking the finite speed of propagation of the Coulomb-field into account when analyzing the oscillation. This means that we have the same geometrical setup as we had for our static consideration leading to figure 2. But due to the fact, that we now perform a dynamic analysis, we derive the deflections of figure 6, figures 7 and figure 8. Therefore, the adjustment of the system-parameters (in our algorithm) is given as following:

With Fig.6:

- speed of propagation of the fields $c = 1.4 \, m/s$
- electrical charges Q_1 and Q_2 = $3 \cdot 10^{-5} C$ per each
- Hooke's spring force constant $D = 2.7 \, N/m$
- length of the unloaded helical spring $RLL = 8.0 m$
- starting-position of the bodies' motion at $x_1 = -3.0 m$ and $x_2 = +3.0 m$.

As can be seen, the amplitude increases rather fast at the begin of the oscillation. Obviously the motion of the bodies and the motion of the Coulomb-fields are adjusted in such a way to each other, that the oscillation gains energy from the quantum vacuum rather efficiently. But we further observe, that there is a certain limit for the amplitudes. This comes from the fact, that the speed of the motion of the bodies reaches a value in comparison with the speed of the propagation of the fields, that it will not be possible to gain more energy from the quantum vacuum than seen in this oscillation after time "30 seconds". This means that the gain of energy from the quantum vacuum is saturated at these system-parameters reached here, and the amplitude will become constant. But it must be said: If we would extract mechanical energy from this oscillation (with constant amplitude), the mechanical extraction of energy would act back on the amplitude (as seen in section 5), but in this moment the re-gain of energy from the quantum vacuum would be enhanced, so that the amplitude would still be kept at its constant value (as long as we do not extract too much mechanical energy). The amount of mechanical energy which we can extract, is the engine-power, which we can gain from the zero-point-energy of the quantum vacuum in this mode of the operation of the zero-point-energy motor.

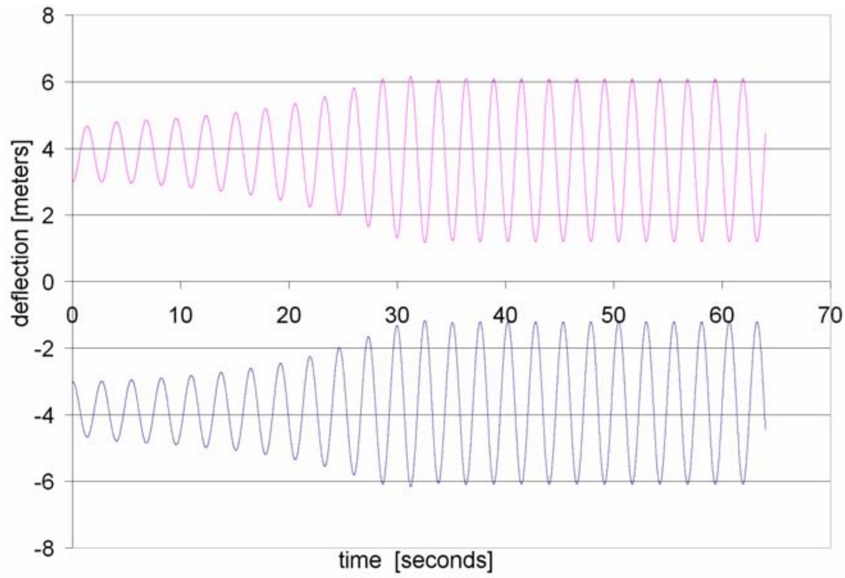

Fig. 6:

Example for the mode of operation of a harmonic oscillator according to figure 1 as a zero-point-energy converter.

We can easily see, that the amplitude is increase-ing due to the gain of zero-point-energy of the quantum vacuum.

With Fig.7:

If the system-parameters are altered only by a small amount, the system behaves completely different. Only a small alteration of the speed of propagation of the fields and of the dimensions of the spring (together with the starting positions of the bodies) in comparison to figure 6 leads to the consequence, that the oscillation can not gain energy from the quantum vacuum, because the speed of the fields and to the speed of the motion of the bodies are not adjusted appropriately to each other:

- speed of propagation of the fields $c = 1.4 \, m/s$
- electrical charges Q_1 and Q_2 = $3 \cdot 10^{-5} C$ per each.
- Hooke's spring force constant $D = 2.7 \, N/m$
- length of the unloaded helical spring $RLL = 12.0 m$
- starting-position of the bodies' motion at $x_1 = -5.0 m$ and $x_2 = +5.0 m$.

Under this mode of operation, the engine is not any further a zero-point-energy converter.

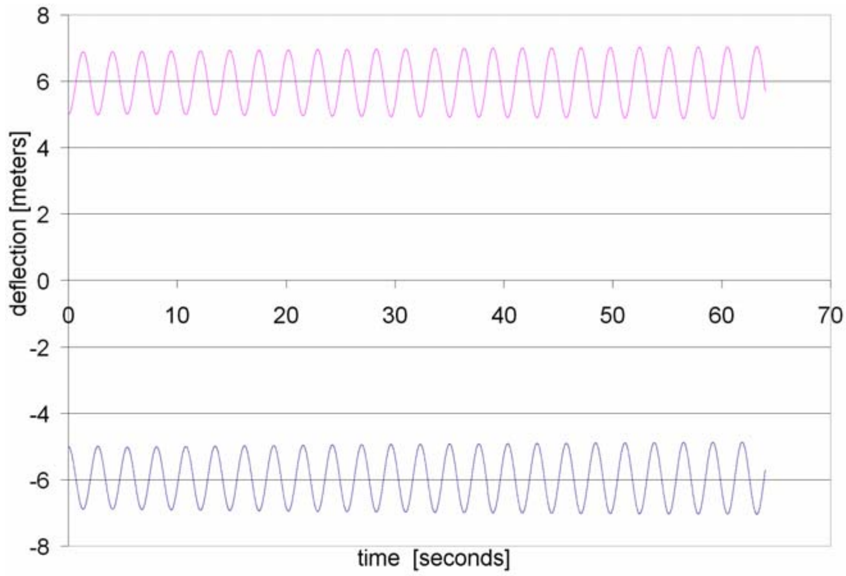

Abb. 7:

Under this mode of operation, the harmonic oscillator according to figure 1 does not gain any energy from the zero-point-oscillations of the quantum vacuum.

With Fig.8:

One tiny further alteration of a system-parameter leads us into the opposite direction, at which the system destroys classical energy by converting it into zero-point-energy. In comparison to figure 6, just only Hooke's spring force constant was altered, nothing else. Nevertheless, the consequence is, that the capability of the system to oscillate was altered in a way, that the duration time for the speed of propagation of the fields work in such way, that they reduce the energy of oscillation of the both bodies. The parameters for this case are:

- speed of propagation of the fields $c = 1.4 \, {}^{m}\!/_{s}$
- electrical charges Q_1 and Q_2 = $3 \cdot 10^{-5} C$ per each
- Hooke's spring force constant $D = 3.5 \, {}^{N}\!/_{m}$
- length of the unloaded helical spring $RLL = 8.0 m$
- starting-position of the bodies' motion at $x_1 = -3.0 m$ and $x_2 = +3.0 m$.

Under this mode of operation, we have an "inverted" zero-point-energy converter, which produces zero-point-energy instead of utilizing it. This provides us with the knowledge, to handle the zero-point-energy of the quantum vacuum just as we need to do, such as to convert it into classical energy back and forth. We may compare this with the situation of a Stirling-engine in Thermodynamics, which can convert mechanical energy into thermal energy as well as thermal energy into mechanical energy, just depending on the direction into which we make him operate. In similar manner we are now able to adjust zero-point-energy converters just as we like them.

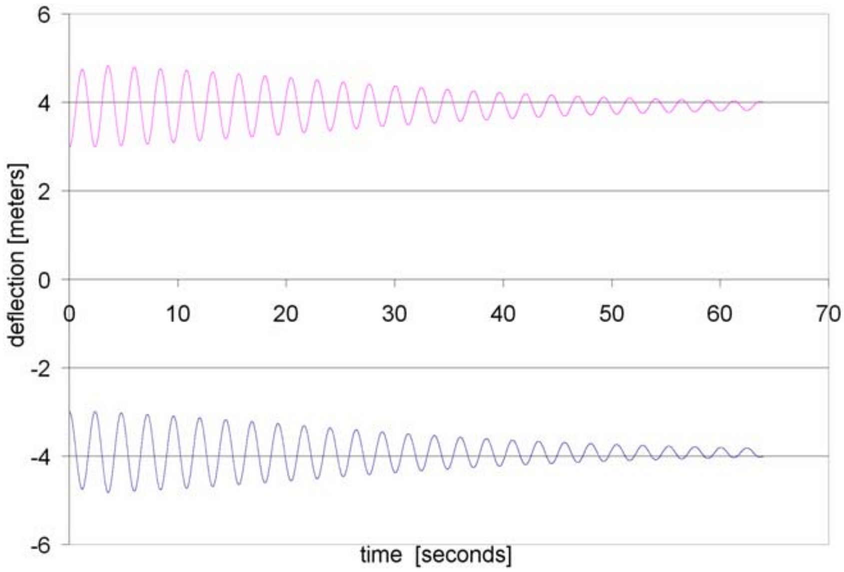

Abb. 8:

Under this mode of operation, the harmonic oscillator according to figure 1 converts mechanical energy into zero-point-energy of the quantum vacuum.

The consequence is an enhancement of the field-strength flowing away from the apparatus.

Remark, regarding the absolute values of the parameters:

These absolute values have been chosen in the way that they are handy, in order to make the article most easy to understand. Of course, in reality the speed of propagation of the fields is much larger than in our little numerical example. We decided to choose such values, because handy figures are easier to fit into the reader's imagination.

The presentation of the DFEM-computer-algorithm in this publication has the sense, to bring everybody who reads this article into the capability to construct his or her zero-point-energy motor. This construction is now possible for every engineer and scientist on the basis of the article presented here. The explanations in [Tur 10] are somehow abstract, so that it became necessary, to support them by a real example-calculation as presented here, giving definite results, which can be used by every technician.

Particularly clear is the answer to the question about the reproducibility of the results presented here: Everybody is invited, to "copy and paste" the DFEM-algorithm as printed in section 3 on his own computer and to run it. All you need is PASCAL-compiler (for instance [Bor 99]). Those who furthermore try the systematic variation of the system-parameters can gain a lot of experience regarding the operation of zero-point-energy converters.

Real zero-point-energy motors, which can be produced and technically applied, are of course more complicated than this simple example presented here. Real zero-point-energy motors rarely consist of only two magnets and one helical spring. But for people with technical training it should not be a principle problem, to expand the algorithm to additional partners of interaction, representing additional components of a machine. The decision to demonstrate a DFEM-program with only two finite elements has the reason, to maximize their understandability. For the same reason, the source-code of the DFEM-algorithm is published below.

3. Source-code of the DFEM-algorithm

```
Program Oszillator_im_DFEM_mit_OVER_UNITY;
{$APPTYPE CONSOLE}
uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs;

Var epo,muo     : Double;  {Constants of nature}
    c           : Double;  {speed of propagation of the waves and fields}
    D           : Double;  {Hooke's spring force constant}
    m1,m2       : Double;  {Masses of both bodides}
    Q1,Q2       : Double;  {electrical charges of both bodides }
    RLL,FL      : Double;  {relaxed length of the unloaded helical spring}
    r           : Double;  {distance with regard to the finite speed of propagation of the
fields}
    diff,ds,ds1 : Double;  {some variables}
    FK1,FK2     : Double;  {spring forces acting on body No.1 and 2}
    FEL1,FEL2   : Double;  {electrical forces acting on body No.1 and 2}
    delt        : Double;  {time-steps for the motion of the bodies and fields}
    x1,x2,v1,v2 : Array [0..200000] of Real48; {time, position, velocity of the bodies}
    t           : Double;  {variable from the propagation-time of the fields}
    a1,a2       : Double;  {acceleration of the bodies}
    i           : Integer; {counter-variable}
    tj,ts,tr    : Extended;{variable for the determination of the field-propagation-duration
in part 3}
    ianf,iend   : Integer; {begin and end of the time under analysis}
    Abstd       : Integer; {distance of the data-points being plotted}
    Ukp,UkpAlt  : Double;  {for part 3}
    unten,neu   : Boolean; {for part 3}
    AmplAnf,AmplEnd : Double; {for the determination of the enhancement of amplitude}
    Reib      : Double; {force of friction}
    P         : Double; {machine power}
    Pn        : Double; {for the determination of the average value of the machine power}

Procedure Wait;
Var Ki : Char;
begin
  Write('<W>'); Read(Ki); Write(Ki);
  If Ki='e' then Halt;
end;

Procedure Excel_Datenausgabe(Name:String);
Var fout  : Text;    {file to write a results for excel}
    Zahl  : String;
    i,j   : Integer; { counter-variables}
  begin  {data-output for excel:}
  Assign(fout,Name); Rewrite(fout); {open the file}
  For i:=ianf to iend do  {from "plotanf" to "plotend"}
  begin
    If (i mod Abstd)=0 then
    begin
{     the first argument is the time:}
      Str(i*delT:10:5,Zahl);
      For j:=1 to Length(Zahl) do
      begin   {replace decimal-points by commata}
        If Zahl[j]<>'.' then write(fout,Zahl[j]);
        If Zahl[j]='.' then write(fout,',');
      end;
      Write(fout,chr(9));  {Tabulator for data-separation}
{     The first function is the Position of particle No. 1:}
      Str(x1[i]:10:5,Zahl);
      For j:=1 to Length(Zahl) do
      begin   { replace decimal-points by commata }
        If Zahl[j]<>'.' then write(fout,Zahl[j]);
        If Zahl[j]='.' then write(fout,',');
      end;
      Write(fout,chr(9));  {Tabulator for data-separation }
{     second column: Position of body 2:}
      Str(x2[i]:10:5,Zahl);
      For j:=1 to Length(Zahl) do
      begin   { replace decimal-points by commata }
        If Zahl[j]<>'.' then write(fout,Zahl[j]);
        If Zahl[j]='.' then write(fout,',');
```

```
      end;
      Write(fout,chr(9));  {Tabulator for data-separation }
{     third column: velocity of body 1:}
      Str(v1[i]:10:5,Zahl);
      For j:=1 to Length(Zahl) do
      begin   { replace decimal-points by commata }
        If Zahl[j]<>'.' then write(fout,Zahl[j]);
        If Zahl[j]='.' then write(fout,',');
      end;
      Write(fout,chr(9));  {Tabulator for data-separation }
{     fourth column: velocity of body 2:}
      Str(v2[i]:10:5,Zahl);
      For j:=1 to Length(Zahl) do
      begin   { replace decimal-points by commata }
        If Zahl[j]<>'.' then write(fout,Zahl[j]);
        If Zahl[j]='.' then write(fout,',');
      end;
      Writeln(fout,'');    {line-feed for data-separation}
    end;
  end;
  Close(fout);
end;

Begin {Main program}
{ Initialisation: }
  D:=0; r:=0;         {Avoid Delphi-Messages}
  epo:=8.854187817E-12;{As/Vm}  {Magnetic field-constant }
  muo:=4*pi*1E-7;{Vs/Am}        {elektric field-constant }
  c:=Sqrt(1/muo/epo);{m/s}      {speed of light }
  m1:=1;{kg}                    {mass of body 1}
  m2:=1;{kg}                    {mass of body 2}
  delt:=1E-3;{sec.}             {Equidistant time-steps for the calculation of the motion}
  ianf:=0; iend:=100000;        {number of the first and the last time.-step }
  Abstd:=2;             {to plot every Abstd-th data-point}

  Writeln('Oscillator in DFEM with OVER-UNITY:');
  Writeln('epo=',epo:20,';  muo=',muo:20,';  c=',c:20);
  Writeln('m1,m2=',m1:15,', ',m2:15,';  D=',D:15);
  Writeln;

{ Begin of the Main Program}
{ Part 1 had been preparations for the program-development, not interesting any further}

{ Teil 2: Test -> anharmonic oscillation, with electrical charge or magnet: STATIC !}
  For i:=ianf to iend do
  begin
    x1[i]:=0;    x2[i]:=0;  {assign the positions to zero}
    v1[i]:=0;    v2[i]:=0;  {assign the velocities to zero}
  end;
  i:=0; {t:=i*delT;} {time in steps of delt.}
  Q1:=2.01E-5{C};  Q2:=2.01E-5{C}; {electrical charge of both bodies}
  D:=0.20;{N/m}                    {Hooke’s spring force constant }
  RLL:=6.0;{m}   {length of the spring without force} {rest-position of the bodies: +/-RLL/2}
  x1[0]:=-3.8;   x2[0]:=+3.8;   {starting-positions of the bodies}
  v1[0]:=00.00;  v2[0]:=00.00;  { starting-velocities of the bodies }
{Now we begin the determination of the motion, step-by-step:}
  Repeat
    i:=i+1;
    FL:=x2[i-1]-x1[i-1]; {length of the spring}
    FK1:=(FL-RLL)*D;  {spring-force, positive pulls to the right side, negative to the left}
    FK2:=(RLL-FL)*D;  {spring-force, positive pulls to the right side, negative to the left}
    FEL1:=0;  FEL2:=0;
    If FL<=1E-20 then
    begin
      Writeln;
      Writeln('Exception: Spring too much compressed in Part 2 at step ',i);
      Excel_Datenausgabe('XLS-Nr-02.DAT');
      Writeln('Data have been stored at "XLS-Nr-02.DAT", then termination of algorithm.');
      Wait; Halt;
    end;
    If FL>1E-20 then
    begin
      FEL1:=+Q1*Q2/4/pi/epo/FL/Abs(FL); {electrostatic force between Q1 & Q2}
      FEL2:=-Q1*Q2/4/pi/epo/FL/Abs(FL); {electrostatic force between Q1 & Q2}
    end;
```

```
{Check:} If i=1 then Writeln('El.-force:  ',FEL1,' and ',FEL2,' Newton');
{Check:} If i=1 then Writeln('Spring-force: ',FK1, ' and ',FK2,' Newton');
    a1:=(FK1+FEL1)/m1;  a2:=(FK2+FEL2)/m2; {acceleration of the bodies}
    v1[i]:=v1[i-1]+a1*delt; {alteration of the speed of body 1}
    v2[i]:=v2[i-1]+a2*delt; {alteration of the speed of body 2}
    x1[i]:=x1[i-1]+v1[i-1]*delt; {alteration of the position of body 1}
    x2[i]:=x2[i-1]+v2[i-1]*delt; {alteration of the position of body 2}
  Until i=iend;
  Excel_Datenausgabe('XLS-Nr-02.DAT'); {position and speed as a function of time}
  Writeln('Part 2 is ready.');

{ Part 3: Test -> Propagation of the fields with finite speed}
  P:=0; Pn:=0; {assign the machine-power to zero}
  For i:=ianf to iend do
  begin
    x1[i]:=0;    x2[i]:=0;  {assign the positions to zero}
    v1[i]:=0;    v2[i]:=0;  {assign the velocities to zero}
  end;
  i:=0;  {counter for the position and velocity}
  c:=1.4; {Sqrt(1/muo/epo);{m/s} {assign the speed of propagation of the fields here}
  Q1:=3E-5{C};  Q2:=3E-5{C};  {electrical charge of the bodies}
  D:=2.7;{N/m}                    { Hooke’s spring force constant }
  RLL:=8.0;{m}   {length of the spring without force} {rest-position of the bodies: +/-RLL/2}
  x1[0]:=-3.0;   x2[0]:=+3.0;   {starting-position of the bodies}
  v1[0]:=00.00;  v2[0]:=00.00;  {starting-velocity of the bodies }
  Ukp:=x2[0]; UkpAlt:=Ukp; unten:=true; neu:=true; {first reversal point}
  Writeln('reversal-point: ',Ukp:12:6,' m ');
  {Now we begin the determination of the motion, step-by-step:}
  Repeat
    i:=i+1;
    FL:=x2[i-1]-x1[i-1]; {length of the spring}
    FK1:=(FL-RLL)*D;  {spring-force, positive pulls to the right side, negative to the left}
    FK2:=(RLL-FL)*D;  {spring-force, positive pulls to the right side, negative to the left}
{   determination of the Field-motion-duration, Field-motion-distance, and Field-strength}
    FEL1:=0; FEL2:=0;
    tj:=i; ts:=i; {i mesures the time}
                  {Start the iteration with natural figures:}
{   Writeln('tj=',tj*delt:9:5,' ts=',ts*delt:9:5,'=>',x2[Round(tj)]-x1[Round(ts)]-c*(tj-
ts)*delt:9:5); }
    Repeat
      ts:=ts-1;
      diff:=x2[Round(tj)]-x1[Round(ts)]-c*(tj-ts)*delt;
{     Writeln('tj=',tj*delt:9:5,' ts=',ts*delt:9:5,'=>',diff:9:5); }
    Until ((diff<0)or(ts<=0));
    If diff>=0 then  {before the motion begin at t=0, the bodies have been in rest.}
    begin
      r:=x2[Round(tj)]-x1[0];
{     Writeln('diff>=0; r=',r); }
    end;
    If diff<0 then   {linear interpolation to determine the fraction after the comma}
    begin
{     Writeln('diff<0 ==> tj=',tj,' ts=',ts);
      Write('x2[',Round(tj),']=',x2[Round(tj)]:13:9);
      Write(' und x1[',Round(ts),']=',x1[Round(ts)]:13:9);
      Write(' und x1[',Round(ts+1),']=',x1[Round(ts+1)]:13:9); Writeln; }
      ds:=x2[Round(tj)]-x1[Round(ts)]-c*(tj-ts)*delt;
      ds1:=x2[Round(tj)]-x1[Round(ts+1)]-c*(tj-(ts+1))*delt;
{     Writeln('ds1=',ds1:13:9,' und ds=',ds:13:9); }
      tr:=ts*delt+delt*(-ds)/(ds1-ds); {for linear interpolation}
      tj:=tj*delt;
{     Write('tj=',tj:13:9,' und tr_vor=',tr:13:9); }
      tr:=(tj-tr);  {interpolated moment of field-emission}
      r:=c*tr;           {interpolated real distance}
{     Writeln(' und tr=',tr:13:9,' und r=',r:13:9); }
    end;
    If r<=1E-10 then
    begin
      Writeln;
      Writeln('Exception: Spring too much compressed in Part 3 at step ',i);
      Excel_Datenausgabe('XV-03.DAT');
      Writeln('Data have been stored at "XV-03.DAT", then termination of algorithm.');
      Wait; Halt;
    end;
    If r>1E-10 then {Now insert data into Coulomb’s law:}
    begin
```

```
      FEL1:=+Q1*Q2/4/pi/epo/r/Abs(r); {electrostatic force between Q1 & Q2}
      FEL2:=-Q1*Q2/4/pi/epo/r/Abs(r); { electrostatic force between Q1 & Q2}
    end;
    Reib:=0.2;    {friction: computation begins here.}
    If i>=10000 then
    begin
      If FEL1>0 then FEL1:=FEL1-Reib;
      If FEL1<0 then FEL1:=FEL1+Reib;
      If FEL2>0 then FEL2:=FEL2-Reib;
      If FEL2<0 then FEL2:=FEL2+Reib;
      P:=P+Reib*Abs(x1[i]-x1[i-1])/delt;
      Pn:=Pn+1;
    end;           {Friction: computation ends here.}
    {Check:} If i=1 then Writeln('El.-force:  ',FEL1,' and ',FEL2,' Newton');
    {Check:} If i=1 then Writeln('spring-force: ',FK1, ' and ',FK2,' Newton');
    a1:=(FK1+FEL1)/m1;  a2:=(FK2+FEL2)/m2; {acceleration of the bodies}
    v1[i]:=v1[i-1]+a1*delt; {alteration of the speed of body 1}
    v2[i]:=v2[i-1]+a2*delt; {alteration of the speed of body 2}
    x1[i]:=x1[i-1]+v1[i-1]*delt; {alteration of the position of body 1}
    x2[i]:=x2[i-1]+v2[i-1]*delt; {alteration of the position of body 2}
{   If (i mod 1000)=0 then Writeln ('Feldstaerke= ',Q1/4/pi/epo/r/Abs(r),' N/C'); }
{   determination of the reversal-points, for determination of the amplitude’s-enhancement:}
    If unten then
    begin
      If x2[i]>Ukp then begin Ukp:=x2[i]; end;
      If x2[i]<Ukp then
      begin
        Writeln('reversal-point: ',Ukp:12:6,' m , amplitude=',Abs(UkpAlt-Ukp));
        If Not(neu) then  AmplEnd:=Abs(UkpAlt-Ukp);
        If neu then begin AmplAnf:=Abs(UkpAlt-Ukp); neu:=false; end;
        unten:=Not(unten); UkpAlt:=Ukp;
      end;
    end;
    If Not(unten) then
    begin
      If x2[i]<Ukp then begin Ukp:=x2[i];  end;
      If x2[i]>Ukp then
      begin
        Writeln('reversal-point: ',Ukp:12:6,' m , amplitude=',Abs(UkpAlt-Ukp));
        If Not(neu) then  AmplEnd:=Abs(UkpAlt-Ukp);
        If neu then begin AmplAnf:=Abs(UkpAlt-Ukp); neu:=false; end;
        unten:=Not(unten); UkpAlt:=Ukp;
      end;
    end;
  Until i=iend;
  Writeln('enhancement of the amplitude: ',AmplEnd-AmplAnf:12:6,' Meter. ');
  Writeln('The machine-power is',P/Pn,' Watt.');
  Excel_Datenausgabe('XV-03.DAT'); {position and speed as a function of time}
  Wait; Wait;
End.
```

4. Background explanation

The conception, showing the way to the DFEM-computation, which is based on the dynamic propagation of the interacting fields, has been discussed in [Tur 10]: According to this conception, the occurrence of electric and magnetic fields can be understood as a reduction of the wavelengths of the zero-point-waves of the quantum vacuum. This reduction of the wavelengths is to be understood as a consequence of the reduction of the speed of propagation of the zero-point-waves due to electric and magnetic fields as one of the consequences of the work of [Hei 36]. If we switch on and off the electric charge suddenly, this would cause gaps between the wave-packets, which are differently emitted during the time when the charge is switched on, or when the charge is switched off. Less sharp than this sudden action of switching on and off, we can understand a continuous motion of the field sources, as explained in figure 3, figure 4 and figure 5. The continuous motion of the field-sources, which we see there, leads to the consequence of a continuous modulation of the field-strength, which goes back to a continuous alteration of the position and velocity of the field-source.

In order to complete the explanations of section 2, we again want to regard the case of a static field-source at rest, as it can be seen in the first line of figure 5. Its field reduces the wave-lengths of the zero-point-waves and it reduces their speed of propagation. Close to the field-source, this effect is much stronger, then more far away from the field source, because the field is the stronger the more close to the field-source. This means, that the zero-point-waves which run away from the field-source and transport the field have to decrease their reduction of the wavelength and the speed of propagation. This has to be done in such a way, that there will not occur any gaps between the waves, because static fields, produced by electric charges in rest do not have any dynamics, but they are continuous. This decrease of the reduction of the wavelength and of the speed of propagation explains the energy dissipating from the field into the quantum vacuum during the propagation of the field. Let us look to the following consideration:

As we know from [Boe 07] for magnetic fields and from [Rik 00], [Rik 03] for electric fields, the reduction of the speed of propagation v of the zero-point-waves is a function of the field strength as following:

$\left(1-\frac{v}{c}\right)=P_e\cdot\left|\vec{E}\right|^2$ for electric fields and (6)

$\left(1-\frac{v}{c}\right)=P_b\cdot\left|\vec{B}\right|^2$ for magnetic fields , (7)

with P_e and P_b being factors of proportionality.

If we dissolve these equations to the speed of propagation v, we can derive the reduction of the length of a given wave-packet and furthermore the reduction of its speed of propagation, while it is running through an alternating field strength, as it is illustrated in figure 9:

(6) $\Rightarrow\ v_1=c\cdot\left(1-P_e\cdot\left|\vec{E}\right|^2\right)$ and $\Rightarrow\ v_2=c\cdot\left(1-P_e\cdot\left|\vec{E}\right|^2\right)$ for electric fields, (8)

(7) $\Rightarrow\ v_1=c\cdot\left(1-P_b\cdot\left|\vec{B}\right|^2\right)$ and $\Rightarrow\ v_2=c\cdot\left(1-P_b\cdot\left|\vec{B}\right|^2\right)$ for magnetic fields. (9)

If we put v for a given duration of propagation into this relation, we derive

$$v=\frac{\Delta s}{\Delta t}\ \Rightarrow\ \Delta t=\frac{\Delta s}{v}=const.\ \Rightarrow\ \frac{\Delta s_1}{v_1}=\frac{\Delta s_2}{v_2}\ \Rightarrow\ \frac{v_1}{v_2}=\frac{\Delta s_1}{\Delta s_2}=\frac{L_1}{L_2}\ \Rightarrow\ L_2=L_1\cdot\frac{1-P_e\cdot\left|\vec{E}_2\right|^2}{1-P_e\cdot\left|\vec{E}_1\right|^2}\ , \qquad (10)$$

resp. for magnetic fields $L_2=L_1\cdot\frac{1-P_b\cdot\left|\vec{B}_2\right|^2}{1-P_b\cdot\left|\vec{B}_1\right|^2}$. (11)

The factor between L_1 and L_2 is the factor, by which the length of the wave-package is altered because of its way through varying field-strength.

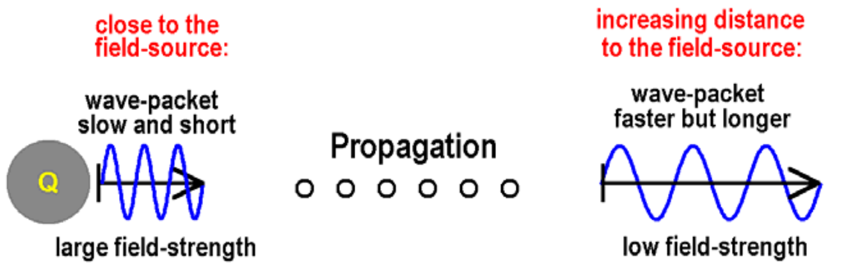

Fig. 9: Illustration of the propagation of the wave-packets of the zero-point-waves through zones of varying field strength.

This consideration corresponds to the fact, that the zero-point wave-packets adjust their compression or prolongation as well as their speed of propagation to the requirements of the field strength which they pass, according to figure 3 and figure 4.

5. Converted machine power

Of course we want to dedicate our attention to the question, how much zero-point energy is converted per time. This means, we want to find out the converted machine-power. Indeed, this question makes sense only if the system-parameters are adjusted as done in figure 6, because under this operation, the machine is a zero-point energy converter.

Power can only be extracted from a motor, if there is some (mechanical) resistor, and not as long as it is running without any force. This makes it necessary to introduce an additional force into our DFEM-algorithm, for instance a force of friction. In order to keep the comprehensibility of our calculation-example as easy as possible, let us decide to introduce dry friction, which is independent from the relative speed of the motion, as it known as Coulomb's friction. This allows us to introduce a force F_R, which is defined in the third part of the algorithm with the name "Reib". This force is switched on at the time of 10 seconds, and from there on it remains constant until to the end of the computation at time of 100 seconds. This is also the time interval over which the machine-power is determined as the average of the absolute value of the machine power (even if the graphic-plot is continued only to the time of few more than 65 seconds).

For the purpose of supervision, we begin with a force of $F_R = 0$, and we identically reproduce the behaviour, which we already know from figure 6 with an enhancement of the amplitude of 3.20 meters. Please compare this result of figure 10.

After this verification of the algorithm, we now decide to enhance the force of friction step-by-step, and to our surprise, we detect that the enhancement of the amplitude does <u>not</u> decrease with increasing friction. We find out that an enhancement of the energy being extracted by friction, enhances the amplitude of the oscillation. Friction does not reduce the speed of the motion, but it additionally empowers it !

The finding is the following: When we extract energy from the oscillating system, the amplitude is a little bit larger, compared to the system without energy-output (see blue curve in figure 10). This indicates the following: When we try to slow down the motion, we optimize the adjustment of the phase-difference between the bodies and the fields in such a way, that the extraction of zero-point energy from the quantum vacuum is increasing. This is the reason, why we see a linear growth of the purple curve, representing the machine-power as a function of the force of friction, in figure 10. This indicates, that it should be possible by principle, to maximize the amount of energy being extracted from the quantum vacuum, by doing a search of the maximum of the purple curve in figure 10.

This finding is confirmed by the reports of several vacuum-energy experimentalists. Although they built their engines from intuition (and not on the basis of an existing theory), they observe this phenomenon several times. And sometimes this observation is dangerous for these experimentalists, because their engines suddenly begin to run too fast, so that they lose the control over the engines. Some of them report, that they tried to slow down their engines by using a strong break (enhancing friction very much), and they have been astonished that this extraction of kinetic energy from their apparatus did not reduce its speed. There are even reports, according to which vacuum-energy motors began to run so fast, that the they burst into pieces (one of them is [Har 10]). From our theoretical calculations now we fully understand the reason for this problem: It is just the fact, that the phase-difference between the field's propagation and the motion of the components of the zero-point engine can be optimized by friction.

Every practical experimentalist will express the objection: Very strong and rigid friction can bring every motion to standstill. Certainly this is true. As we see in figure 10, there is a critical value for the friction, at which the power-conversion more or less suddenly collapses and the amplitude of the oscillation goes to zero. Obviously the effect of friction is so strong at this point, that the moving components of the engine can not follow the speed of propagation of the fields any further. This means that the moving components of the engine and the moving fields can not keep the phase-difference necessary for resonant excitation of the engine any further.

If we apply a "zoom" to this part of figure 10 with $F_R = 0.334 \ldots 0.344\ N$, we come to figure 11. There we can see, that there is a certain interval, during which the phase-difference for resonance is being lost. This means, that the zone of maximum power-extraction from the quantum vacuum has some certain width. If a zero-point-energy motor can be operated within this range, friction will be just a little bit too weak to stop the engine.

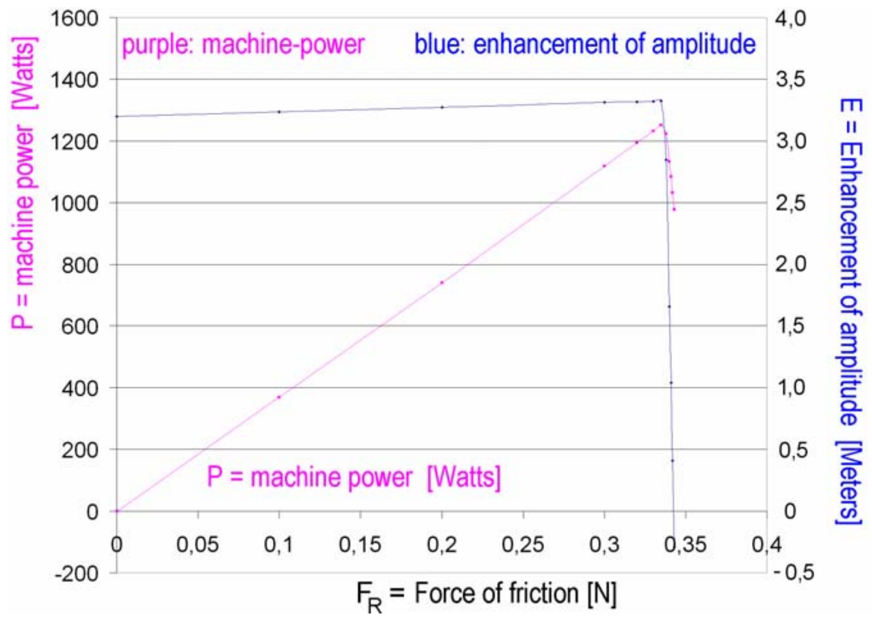

Abb. 10:

Enhancement of the amplitude (blue curve and blue scale at the right ordinate) and the converted power (purple curve and purple scale at the left ordinate) of a zero-point energy motor as a function of the converted energy (here represented as friction).

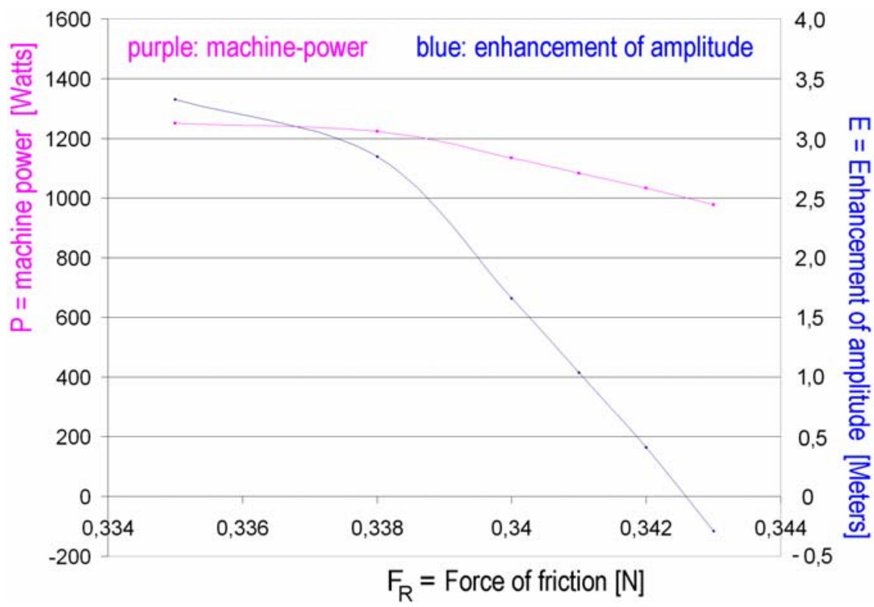

Abb. 11:

„Zoom" to Fig.10 at the range of the power-maximum of a zero-point-energy motor.

By the way, a negative enhancement of the amplitude (blue curve below zero) is understandable very easy. It indicates, that there friction is so strong, that the amplitude is reduced in comparison to its value at the beginning of the oscillation. If we would continue our DFEM-simulation to a longer time interval, the engine would come to standstill under this operation. Under practical operation is necessary, to drive the machine in a way, that the amplitude will be kept constant over long time interval. This should not be difficult, if the extraction of energy (and power) is kept on the left side apart from the maximum of the purple curve.

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DFEM-Computation of a Zero-point-energy Converter with realistic Parameters for a practical Setup

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Abstract

A theoretical method for the computation of zero-point-energy converters has been presented as dynamic finite element method (DFEM) in [Tur 10a], [Tur 10b], but in these articles, only the method of computation has been described, without taking realizable parameters for an experimental setup into account. The way to calculate a realistic system for an experimental setup is developed here.

Therefore, the essential aspect is the question, how to control the speed of propagation of the interacting fields, which are responsible for the force, which drives the zero-point-energy converter. In the work presented here, these are the fields of the electromagnetic interaction, because for our example, a capacitor and a coil have to be adjusted in a way, that the frequency of an electromagnetic oscillation corresponds to the frequency of a mechanical oscillation. It depends on the precision of this adjustment, whether zero-point-energy is converted or not.

1. The method of dynamic finite elements “DFEM”

The DFEM-method was introduced in [Tur 10a] and [Tur 10b]. The first mentioned article explained the theoretical background, and the second one displayed an example, how to use this algorithm.

For the case of electromagnetic interaction, zero-point-energy converters can be calculated according to the classical rules of electrodynamics. The only difference between the classical FEM-engineering-methods and the new DFEM for zero-point-energy converters is the fact, that DFEM takes the finite speed of propagation of the fields of the electromagnetic interaction into account, which is a responsible for the forces between the different parts of the engine. Whereas the classical FEM engineering-calculations are based on the approximation, that the speed of propagation of the electromagnetic field is infinite, the DFEM calculations take the finite speed of propagation of the interaction into account. This is necessary because of the theory of relativity, which does not allow infinite speed by principle.

For classical purpose, the approximation of infinite speed of propagation of the interacting fields looks quite good, but in reality, this approximation is the reason, why classical electrodynamics is unable to compute or to understand zero-point-energy converters by principle. From the point of view of classical engines, the approximation of infinite speed of propagation sounds indeed sensible. If we imagine an electromotor, in which the attractive forces between stator and rotor have to act over a distance of $s = 10\,cm$, the propagation of the fields with the speed of light, as we expect it from the theory of relativity, will cause a time delay of only

$$t = \frac{s}{c} = \frac{0.1\,m}{3 \cdot 10^8\,m} = 0.333\,nano\,Sec. \qquad (1)$$

On this background it looks absolutely normal, that engineers construct electromotors without taking the time delay in the range of fractions of nano-seconds into account.

But if we remember, that the approximation of infinite speed of propagation prevents engineers from understanding zero-point-energy converters, the situation appears totally different. From this point of view, the approximation prevents mankind from making use of a new source of energy, which is absolutely free from environmental pollution and furthermore inexhaustible.

Of course it seems difficult to construct electromotors when taking the finite speed of propagation of the electromagnetic interaction (i.e. fields) into account. If the fields of the electromagnetic force propagates within the empty space, the computation of an electromotor should take fractions of nano-seconds into account as mentioned above - in order to discover a way, how to convert an utilize zero-point-energy. It is not surprising, that many colleagues regard this problem as too difficult or too useless, to work on its solution. Because of this, it is not surprising, that many colleagues do not take the possibility of the conversion of zero-point-energy into account at all. In order to demonstrate, that this problem can be solved by principle, the example in [Tur 10b] has been built up on a handy speed of propagation, in order to make it numerically easy. For the introduction of the computation-method as a basic research, this was sufficient, but it is not sufficient for an experimental verification. A practical setup, which can be experimentally analyzed, requires our ability, to take influence on the speed of propagation of the forces of the interaction, which drives the motor. For a real setup, the speed of propagation has to be much slower than the speed of light, in order to give us the possibility to handle the propagation-delay. From transmission line theory, the speed of propagation of the electrical impulses in wires is well known [Bau 10], [Kow 10], [Stö 10]), and it is slower than the speed of light. In modern computer-industry, this is already taken into account for the construction of modern semiconductor circuits.

If we can find a way, how we can control the speed of propagation of the electromagnetic interaction, we can get away from the dilemma of the fractions of nano-seconds according to (1). If we can decrease the speed of propagation of the interaction by several orders of magnitude relatively to the speed of light, we can get a time-delay for the propagation of the interaction-force, on which we can construct real engines. This is the aim of work, presented here.

2. How to control the speed of propagation of the interacion

From transmission line theory, we know the speed of propagation of the interacting-fields to be (in a two wire transmission

$$v = \frac{1}{\sqrt{L' \cdot C'}} \qquad \text{with } L' = \frac{L}{a} = \text{inductance per wire-length}$$
$$\text{and } C' = \frac{C}{a} = \text{capacitance per wire-length, where } a = \text{wire-length.} \tag{2}$$

In order to get the speed of propagation as low as technically achievable, we need a setup with a large inductance and a large capacitance.

Fortunately, a setup with an inductance and a capacitance is a oscillating circuit, which is known very well, so that we can lead back our calculations to well-known facts [Tuc 10]. In order to arrange our example as clear as possible, we want to build it up on the example of [Tur 10b], which consists of two electrically charged bodies, forming the capacitor. We just have to add a coil (see Fig.1). For the sake of simplicity, we just want to alter the shape of the electrodes of the capacitor, which have been spheres. But not it is easier, to take two parallel plates, which might be connected with a helical spring. In figure 1, the speed of propagation of the electric field was determined by the vacuum, along which the field propagates. This situation is changed completely, as soon as we add the coil, because the coil and the capacitor are an oscillating circuit - and the circuit controls the speed of propagation of the electric signal within the wire – which limits the speed of propagation for our technical setup. This leads us to the setup shown in figure 2.

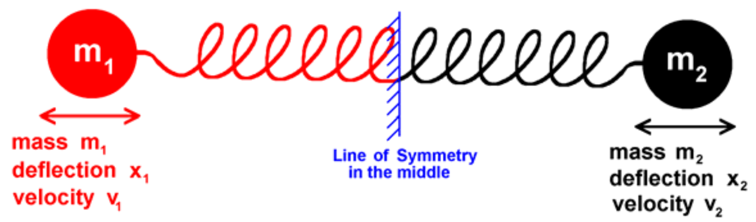

Fig. 1:
Two bodies, which are connected by a spring, can perform a harmonic oscillation. If the bodies are capacitor-plates, the setup can be used to convert zero-point energy.

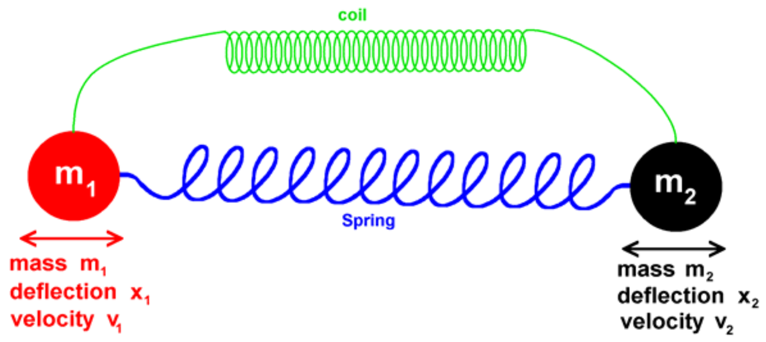

Abb. 2:
A coil together with the capacitor-plates m_1, m_2 forms an electric oscillation circuit, which is responsible for the oscillation of the electrical charge. But the coulomb forces between the capacitor-plates are influenced by their mechanical oscillation.

The crucial limit for the finite time delay of the forces of interaction is now the speed of propagation of the electrical charges within the wire, but not the speed of propagation of the fields within the vacuum. This is important, because it decides about the speed of propagation of the interactions, responsible for the functioning principle of the conversion of zero-point-energy.

The illustration according to figure 2 corresponds to the notation of mechanicians. The notation of electricians follows rather to the illustration according to figure 3.

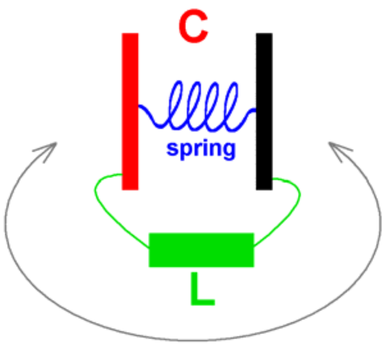

Fig. 3:
From the electrical point of view, the setup is a LC-oscillation circuit, which allows the capacitor-plates to oscillate mechanically, so that the capacity of the capacitor permanently varies as a function of time.
Nevertheless the oscillation of the electrical charge is dominantly determined by the LC-oscillation circuit, as marked with a double arrow in grey colour.

As can be seen in figure 3, the oscillation of the electrical charge is determined by the LC-oscillation circuit. Consequently the electrical field strength between the capacitor-plates follows the LC-oscillation circuit. Thus the electrostatic (Coulomb-) force between the plates is determined by the speed of propagation of the electrical charge in the green wire, from which the coil is made. The electrical field between the capacitor-plates is responsible for the attractive or repulsive forces between the plates. The behavior of these forces can thus be controlled by adjusting the inductance L and the capacitance C to the technical requirements of the setup. This is now our way, how we influence and control the speed of propagation of the interactive forces.

4. The Algorithm for the simulation of the fields and bodies in motion

The source code of the DFEM-algorithm on which the research work presented here is based, is printed completely in the appendix. It is written in Delphi-Pascal [Bor 99]. The Physic's background, on which this algorithm was developed, is explained in sections 4 and 5.

We now follow the development of the simulation-algorithm (of the oscillation) step-by-step. The very first step just analyzes a harmonic oscillation within a simple LC-oscillation circuit. For this very first step, we will not take the motion of the capacitor-plates into account, and we neglect the Ohm's resistance of the wire, from which the coil is made. This very simple setup has the purpose, that we can check the results of the DFEM-algorithm by comparison with the classical oscillation circuit. Please see figure 4.

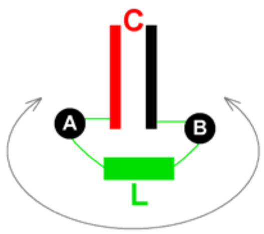

Fig. 4:
Simple classical LC-oscillation circuit as a preparation for our development of the DFEM-algorithm as described in the text. The simple setup can be checked with classical electrodynamics, in order to assure the correctness of the results. There is only one loop according to Kirchhoff's rules, namely "ACBLA".

For the computation of the discharge-procedure of the capacitor with finite speed, we can easily follow the classical considerations, which are based on the differential-equation of the classical LC-oscillation circuit. Therefore we apply Kirchhoff's voltage law, according to which the sum of all voltages within one closed loop is zero:

$$U_C + U_L = 0 \tag{3}$$

There the voltage over the capacitor and the voltage over the coil is:

according to the definition of the capacitance $C = \frac{Q}{U} \Rightarrow U_C = \frac{1}{C} \cdot Q$ (4)

according to the induction-law: $U_L = -L \cdot \frac{d}{dt} I = -L \cdot \ddot{Q}$ (5)

$\Rightarrow U_C + U_L = \frac{1}{C} \cdot Q - L \cdot \ddot{Q} = 0$ as differential equation of the harmonic oscillation. (6)

We want to solve the differential-equations by numerical iteration, because we want to prepare ourselves for the crucial case, in which the capacitance will be variable as a function of time. This case, which is the goal of our considerations, can not be solved analytically. The solution of the harmonic LC-oscillation is "part 1" of the source-code in the appendix. The initial conditions are well known, and we start our calculation at the moment $t = 0$. From there on the time is running continuously and steps of Δt. The initial conditions consist in an electric charge being brought onto the capacitor plates, namely $Q(t=0) = C \cdot U$ and $\dot{Q}(t=0) = 0$ as well as $\ddot{Q}(t=0) = 0$.

The course of time is simulated as an iteration, step-by-step. Every step begins with the second derivative, influencing $\ddot{Q}(t) = \dot{I}(t)$, because the discharge current of the capacitor induces a voltage into the coil.

$$\ddot{Q}(t_i) = \frac{-U}{L} = \frac{-Q(t_{i-1})}{L \cdot C}. \tag{7}$$

Two steps of integration lead us to

$$\dot{Q}(t_i) = \dot{Q}(t_{i-1}) + \ddot{Q}(t_i) \cdot \Delta t \quad \text{and} \tag{8}$$

$$Q(t_i) = Q(t_{i-1}) + \dot{Q}(t_i) \cdot \Delta t \tag{9}$$

By this means, the behaviour of the electrical charge is calculated as a function of time, step-by-step, according to the typical behaviour of an LC-oscillation circuit. Our considerations are determined by the finite speed, with which the electrical charge is propagating along the wire. Here, the differential-equations of the oscillation circuit is a comfortable way to realize the computer simulation of the propagation speed. By the way, the result of our iteration is identical with the classical solution of differential equation (6), so that it is not necessary to display the result graphically, because it is known generally.

The next step of our development is dedicated to Ohm's resistance of the coil, due to its copper wire. If the setup shall be verified experimentally, it would not be enough to calculate an idealized zero-point-energy converter without Ohm's resistance. In reality our setup has to convert enough zero-point-energy, that it will be sufficient to compensate real losses in the wire. For the development of the differential-equation for this situation, which still follows simple classical considerations, we have a look to figure 5.

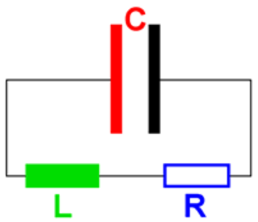

Fig. 5:
Simple classical LC- oscillation circuit, taking losses due to Ohm's resistance of the wire into account, from which the coil is made.

We again apply Kirchhoff's voltage rule and say, that the sum of all voltages within our closed loop is zero:

$$U_L + U_R + U_C = 0 \tag{10}$$

There the voltage over the capacitor and the voltage over the coil is:

according to the definition of the capacitance $C = \frac{Q}{U} \Rightarrow U_C = \frac{1}{C} \cdot Q$ (11)

according to the induction-law: $U_L = -L \cdot \frac{d}{dt} I = -L \cdot \ddot{Q}$ (12)

according to Ohm's law: $U_R = R \cdot I = R \cdot \dot{Q}$ (13)

$\Rightarrow U_L + U_R + U_C = -L \cdot \ddot{Q} + R \cdot \dot{Q} + \frac{1}{C} \cdot Q = 0$ as differential equation of the attenuated oscillation. (14)

Due to these equations, we have two replace the differential equations of (7), (8) and (9) by

$$\ddot{Q}(t_i) = \frac{R}{L} \cdot \dot{Q}(t_{i-1}) + \frac{1}{L \cdot C} \cdot Q(t_{i-1}) \tag{15}$$

two steps of integration lead us to

$$\dot{Q}(t_i) = \dot{Q}(t_{i-1}) + \left(\ddot{Q}(t_i) - \frac{R}{L} \cdot \dot{Q}(t_{i-1}) \right) \cdot \Delta t \quad \text{and} \tag{16}$$

$$Q(t_i) = Q(t_{i-1}) + \dot{Q}(t_i) \cdot \Delta t \tag{17}$$

Again we develop our solution as an iteration step-by-step during time, and again we come to the same result as the well-known classical computation, which is based on an analytical solution of the differential-equation. As generally known, Ohm's resistance has the consequence to decrease the propagation speed of the charge a little bit.

Remark: Please take notice, that in equation (16) the first derivative $\dot{Q}$ occurs on the left side as well as on the right side. For the DFEM-algorithm, equation (16) has been reformed in order to dissolve it to $\dot{Q}$ (as can be seen in the source-code).

For the example of the numerical values $L = 0.126331\,Henry$, $C = 8.85419 \cdot 10^{-11} Farad$ and $R = 2000\,\Omega$ at an initial charge of the capacitor of $Q(t=0) = 3 \cdot 10^{-8} C$ (corresponding with a capacitor voltage of $338.82\,Volt$), as well as the initial conditions $\dot{Q}(t=0) = 0$ and $\ddot{Q}(t=0) = 0$, we come to the result as displayed in figure 6, which is the same for our algorithm and for the classical solution. Up to now, our DFEM-algorithm is developed only for the reproduction of generally known results, which has the purpose to verify its correctness.

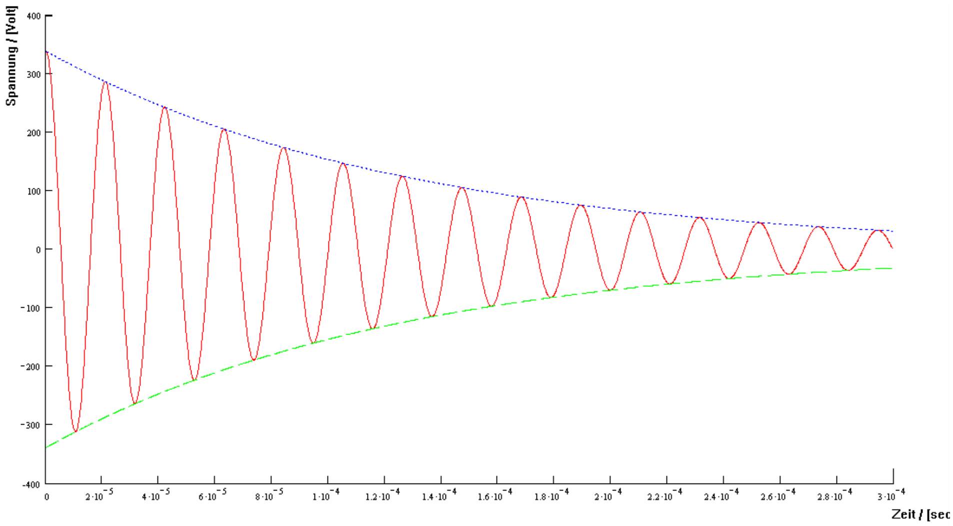

Fig. 6: Reproduction of a LCR-oscillation circuit with additional attenuation. The envelope curves in blue and in green represent the exponential decrease of the amplitude as a function of time.

By the way, the numerical values of the system-parameters are chosen with regard to a clear understanding of the current, and not with regard to the following applications of the algorithm in section 5.

5. DFEM-computation of the zero-point-energy converter from section 3

Within section 4, the preparation of our DFEM-algorithmus was verified successfully. Thus we can now come to the application of this algorithm, which is the LCR-oscillation circuit, with additional mechanical oscillation of the capacitor-plates according to figure 7. It differs from figure 2 and figure 3 because of the Ohm's resistance which is present now.

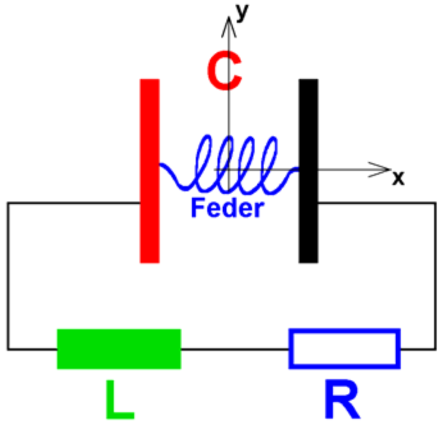

Fig. 7:
LCR- oscillation circuit, which does not follow an attenuated oscillation, because the variable capacitor does something different. Depending on the adjustment of the system parameters, energy can be converted between the zero-point-energy, electrical energy and mechanical energy. The direction, into which this conversion works, depends extremely sensitive on the adjustment of the mechanical oscillation and the electrical oscillation relatively to each other. Due to the time dependent variation of the capacitance C=C(t), the differential equation can not longer be solved analytically, so that the iteration of the DFEM-algorithm is necessary.

The essential change with regard to the classical oscillation of figure 5 and figure 6 is the fact, that we now added a helical spring between the capacitor-plates, which causes a mechanical oscillation of these plates. Thus we now have to introduce this mechanical oscillation into our DFEM-algorithm. This requires some further expressions in our differential equation.

As we know, the differential equation of the mechanical oscillation is very similar to the differential equation of the electrical oscillation circuit. This allows us, to develop the differential equation of the mechanical oscillation in close analogy with equation (7), (8) and (9), with some supplements:

$$\ddot{x}(t_i)=\frac{-D}{m}\cdot\left(x(t_{i-1})-\frac{CD}{2}\right)+\frac{1}{m\cdot 4\pi\varepsilon_0}\cdot\frac{Q^2(t_i)}{\left(2\cdot x(t_i)\right)^2} \quad \text{based on the spring-force and Coulom's force with } m\text{=mass and } D=\text{Hooke's spring-constant.} \tag{18}$$

Two steps of integration now lead us to

$$\dot{x}(t_i)=\dot{x}(t_{i-1})+\ddot{x}\cdot\Delta t \quad \text{and} \tag{19}$$

$$x(t_i)=x(t_{i-1})+\dot{x}(t_i)\cdot\Delta t \tag{20}$$

The capacitor plates are mounted symmetrically with regard to the origin of coordinates, so that their positions are $-x(t_i)$ and $+x(t_i)$. Thus we write Coulomb's force between the capacitor-plate as $F_C=\frac{1}{4\pi\varepsilon_0}\cdot\frac{Q^2}{\left(2\cdot x(t_i)\right)^2}$, because the distance between the capacitor plates is $2\cdot x(t_i)$.

For the calculation of the force of the helical spring, we have to use a totally different length, namely the alteration of the spring length relatively to the spring without load. If $CD=$ length of the unloaded spring, the alteration of its length relatively to CD can be written as $CD-2\cdot x(t_i)$, not forgetting the algebraic sign of $x(t_i)$. If we regard the motion of the capacitor-plates a symmetrically with regard to the origin of coordinates, (where the coordinate-system is fixed in the middle of the capacitor, as shown in figure 7), each half of the spring follows exactly half of $CD-2\cdot x(t_i)$, so that the force of the spring, acting on each of the capacitor plates is $F_F=-D\cdot\left(x(t_i)-\frac{CD}{2}\right)$, as written in equation (18).

The mechanical parameters in the equations (18), (19) und (20) follow the mechanical mass of the capacitor plates and the spring force. The variation of the electrical charge $Q(t)$ follows the electrical oscillation circuit. Thus, $Q(t)$ in equation (18) is to be put into the formulas of the equations (15), (16), (17). By this means, that electric oscillation circuit influences the mechanical oscillation. But in the opposite direction, the mechanical oscillation of the capacitor plates influences the electrical oscillation circuit, because the mechanical distance between the capacitor plates also oscillates.

Indeed, this approach allows us, to convert zero-point-energy into classical energy back and forth. It also can be happen, that mechanical energy is converted into zero-point-energy and at the same time zero-point-energy is converted into electrical energy. Every imaginable configuration of energy conversion back and forth is possible. We will see this very clear, when we read the following explanations with regard to the DFEM-algorithm.

Let us start to put realistic parameters into the DFEM-algorithm:

For the capacitor:
- surface of the capacitor plates: $A_C = 10cm \times 10cm$
- distance between the capacitor plates: $d_C = 2\ mm$

It would be possible to realize the capacitor by stretching a thin plastic foil with metal covering, on a frame of adequate thickness.
- dielectric between the capacitor plates: $\varepsilon_r = 3$

This leads to a capacity of $C = \varepsilon_0 \cdot \varepsilon_r \cdot \frac{A_C}{d_C}$.

For the coil (cylindrical coil):
- length of the coil $l_S = 8cm$
- radius of the coil $R_S = 5cm$, cross-section of the coil $A_S = \pi \cdot R_S^2$
- number of windings $n = 34600$
- magnetic core with permeability $\mu_r = 12534$

This leads to an inductivity of $L = \mu_0 \cdot \mu_r \cdot n^2 \frac{A_S}{l_S}$.

For Ohm's resistance of the copper wire, from which the coil is made:
- specific resistance of copper $\rho_{Cu} = 1.7 \cdot 10^{-8} \Omega \cdot m$ [Koh 96]
- thickness of the wire $D_d = 0.2mm$ $\Rightarrow$ cross-section of the wire $A_D = \pi \cdot \left(\frac{D_d}{2}\right)^2$

$\Rightarrow$ length of the coil's wire $L_D = 2\pi R_S \cdot n$

This leads us to an Ohm's resistance of the copper wire of the coil $R = \rho_{Cu} \cdot \frac{L_D}{A_D}$.

For the mechanical oscillation of the capacitor plates:
- density of the plastic foil $\rho_F = 1.5 \frac{Kg}{cm^3}$
- thickness of the plastic foil $d_F = 10\mu m$
- density of the aluminium film on the plastic foil $\rho_{Al} = 2.7 \frac{Kg}{cm^3}$
- thickness of the aluminium film on the plastic foil $d_{Al} = 2\mu m$
- Hooke's spring constant of the foil $D_H = 1.00 \frac{N}{m}$

$\Rightarrow$ mechanical mass of the capacitor plates $m = A_C \cdot d_{Al} \cdot \rho_{Al} + A_C \cdot d_F \cdot \rho_F$

For the inertial conditions of the electric oscillation circuit:
- charge on the capacitor at the begin of the oscillation $Q(0) = 2 \cdot 10^{-10} C$

$\Rightarrow$ voltage on the capacitor at the begin $U_C = \frac{Q}{C} = \frac{2 \cdot 10^{-10} C}{1.328 \cdot 10^{-10} F} = 1.50588 Volt$

Of course these parameters can and should be varied within realistic limits. The values which are written here, are the basis for the computation of figure 8, where the purple curve describes the oscillation of the electric charge $Q(t)$ in units of $nC = 10^{-9} Coulomb$, and the blue curve describes the mechanical oscillation of the capacitor plates as $x(t_i)$ in units of $mm = 10^{-3} m$.

In order to adjust the system in a way that it converts zero-point-energy, both resonances have to be adjusted to each other, the resonance of the electric circuit and the resonance of the mechanical oscillation. Only if this “Double-resonance” is achieved, the conversion of zero-point-energy is possible.

If we remember, that the adjustment of one simple resonance can be difficult (such as for instance in a radio station), we understand the difficulties to adjust the “Double-resonance” which requires not only the adjustment of two resonances, but also the adjustment of both of them to each other. Thus we must realize, that the operation of a zero-point-energy converter not only requires an appropriate setup, but also a very difficult adjustment-procedure of the “Double-resonance”.

Thus an alteration of the system parameters acts very critical and sensitive on the operation of the zero-point-energy converter. Already very small alterations of some parameters can cause huge effects. Even our DFEM-algorithm requires the adjustment of several of the parameters with a precision of 4-5 significant figures, otherwise it would give weird results. On this background we now understand the technical difficulties and efforts, which many people have with operation of zero-point-energy converters. Not the manufacturing of the zero-point-energy converter is the central difficulty, but the proper adjustment to operate it. For instance Coler’s converter has been built up many times, but the adjustment was not reproduced until today. With out DEFM-algorithm is should be possible to compute, how the Coler-converter has to be adjusted [Hur 40], [Mie 84], [Nie 83].

Figure 8 shows an operation of our system with appropriate adjustment of the system parameters. (Their values are as stated above.) In this example, the amplitude of the mechanical oscillation increases only very slightly, but the amplitude of the electrical oscillation increases remarkably. But there is no classical energy supply with the setup, so that the energy for the increase of the amplitudes can only originate from the zero-point-energy of the quantum-vacuum.

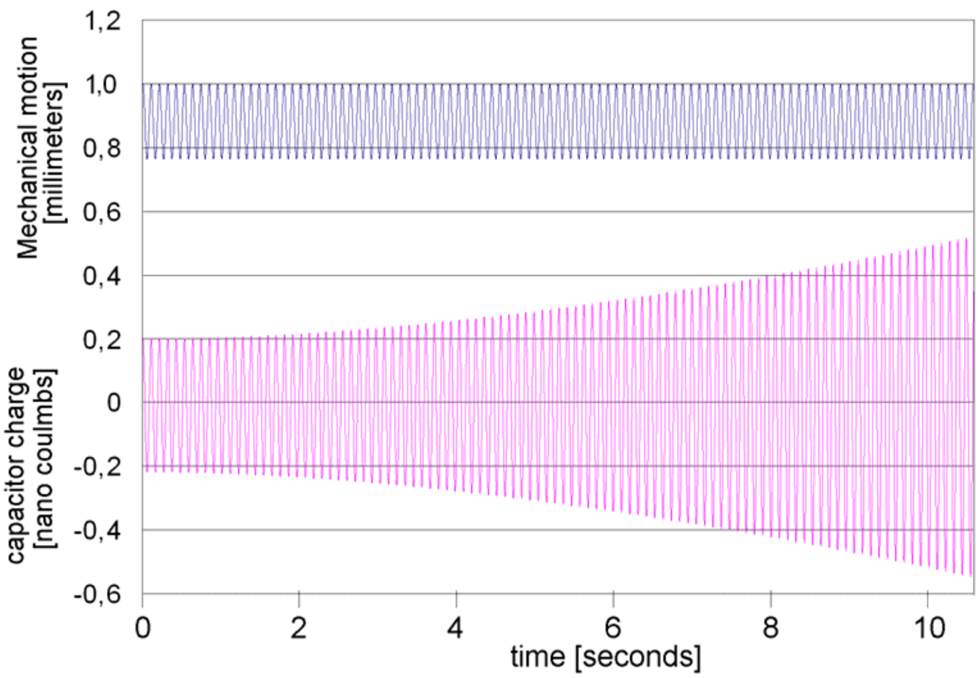

Fig. 8: Oscillations of the both resonances connected with each other: In blue colour, we see the mechanical oscillation of the capacitor plates, and in red colour we see the electrical charge inside the capacitor plates. Both amplitudes increase without being supplied with classical energy.

A numerical evaluation of the DFEM-data, as presented in figure 8, leads us to the result, that the classical energy in the system is increasing. (And the new classical energy is originating from the zero-point energy of the quantum-vacuum, because there is no other energy supply connected with our setup.)

● At the time $t_A = 0$ the system contains the energy, which it has got from the initial conditions. It is:

- mechanical energy at the beginning $W_{mech,A} = 1.981001 \cdot 10^{-8}\,Joule$
- electrical energy at the beginning $W_{elektr,A} = 5.71700 \cdot 10^{-10}\,Joule$

● At the time $t_E = 10.59\sec$, the system contains more classical energy, which now is:

- mechanical energy at the end $W_{mech,E} = 1.981246 \cdot 10^{-8}\,Joule$
- electrical energy at the end $W_{elektr,E} = 3.712196 \cdot 10^{-9}\,Joule$

● This means that both types of classical energy increased during the time $t_E - t_A = 10.59\sec$ without being supplied from some classical energy source: $\Delta W_{mech} = W_{mech,E} - W_{mech,A} = 2.44 \cdot 10^{-12}\,Joule$

$\Delta W_{elektr} = W_{elektr,E} - W_{elektr,A} = 3.1404 \cdot 10^{-9}\,Joule$

● The sum of the energy gain thus is $\Delta W_{elektr} + \Delta W_{mech} = 3.1429 \cdot 10^{-9}\,Joule$.

This is the amount of energy, which has been converted from the-zero-point energy of the quantum vacuum into classical energy, because there is no other energy source within our setup.

6. Crucial: Adjustment of the parameters and the dimensions of the system

It looks like the manufacturing of the zero-point-energy converter is not the most difficult point, but its operation is even more difficult. The problem is the adjustment of the system parameters, as we can understand from section 5. To demonstrate this more clearly, we can now perform small variations of the parameters within the DFEM-algorithm. Let us start with a small variation of Hooke's spring constant, which explains the only difference between figure 8 and figure 9:

▪ Hooke's spring constant $D_H = 1.00 \frac{N}{m} \Rightarrow$ Fig.8

▪ Hooke's spring constant $D_H = 0.99 \frac{N}{m} \Rightarrow$ Fig.9

All other parameters remained unchanged as a given in section 5.

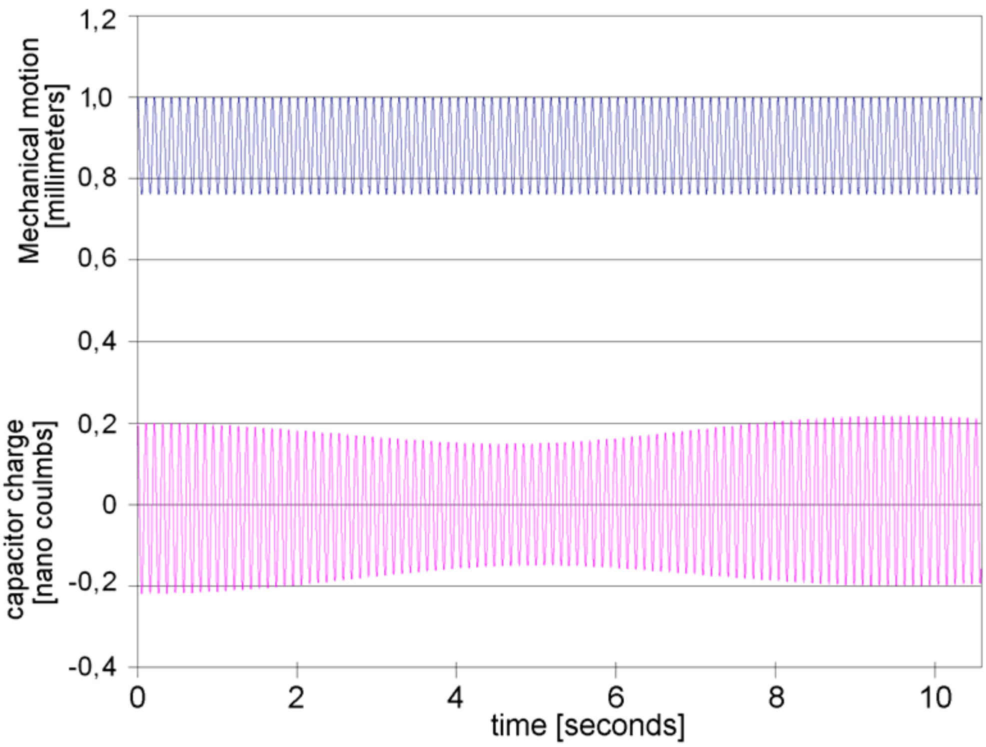

Fig. 9: Other than in figure 8, we now do not observe a continuous conversion of zero-point-energy, but we now observe a conversion back and forth. At the beginning, classical energy is converted into zero-point-energy, but in the second half of the graph, the situation turns around.

Other than in figure 8, we observe in figure 9 the decrease of the mechanical energy. The electrical energy decreases rather visible in figure 9 during the first half on the analysis, but this decrease of the amplitudes causes a variation of the operation of the system by itself, so that the loss of classical energy can not be continued stable. After about 5 seconds, classical electrical energy is gained back from the zero-point-energy.

The fact, that the energy conversion phenomenon is not constant during time goes back to imperfections in the adjustment of the system parameters. The more precise the system parameters are adjusted, the longer we observe a continuous behaviour of the energy conversion, this means, the longer our system can run stable.

A possibility to get rid of this asynchronous behaviour of the resonances, which have to be adjusted to each other, is a periodical reset of the system, which can be given as a small amount of control-energy (for instance as a short electrical pulse), which brings the system back into a well defined initial state from time to time (example: [Kep 10], [Hor 10]).

In order to demonstrate, how the energy-conversion can be brought into different directions, just following the adjustment of the system parameters, table 1 was calculated. Please see the algebraic sign of the conversion from line to line.

	INPUT: System-Parameters			OUTPUT: System-Reaction		
line	spring constant	permeability		ΔW_{mechan}	ΔW_{elektr}	Remark
1	$D_H = 1.00 \frac{N}{m}$	$\mu_r = 12534$	$\Rightarrow$	$+2.44 \cdot 10^{-12} J$	$+3.129 \cdot 10^{-9} J$	see fig.8
2	$D_H = 1.00 \frac{N}{m}$	$\mu_r = 12770$	$\Rightarrow$	$+2.44 \cdot 10^{-12} J$	$+1.103 \cdot 10^{-12} J$	
3	$D_H = 1.00 \frac{N}{m}$	$\mu_r = 12430$	$\Rightarrow$	$+2.44 \cdot 10^{-12} J$	$-4.23 \cdot 10^{-10} J$	
4	$D_H = 0.99 \frac{N}{m}$	$\mu_r = 12534$	$\Rightarrow$	$-3.24 \cdot 10^{-12} J$	$-2.84 \cdot 10^{-11} J$	see fig.9

Table 1: Reaction of the energy-converter-system on variations of the system-parameters

Obviously, even very small variations of the system parameters can have such huge effect, that they even may change the direction of the energy conversion. In table 1 we find:

In line 1 → increase of mechanical energy, and increase of electrical energy
In line 2 → increase of mechanical energy, and increase of electrical energy
In line 3 → increase of mechanical energy, but decrease of electrical energy
In line 4 → decrease of mechanical energy, and decrease of electrical energy

Arbitrary combinations are possible, which even do not have to remain constant during time. Their behaviour depends extremely sensitive on the quality of the adjustment of the system parameters.

7. The speed of propagation of the fields of the interactions

In our example, the important interaction is the electromagnetic one. The electric charge, which is responsible therefore, determines with its motion along the wire, the speed of propagation of the interaction. The distance for this motion is the length of the wire, from which the coil is made. If we follow transmission line theory, the speed of propagation of the voltage-pulses (same as the field-pulses) within the wire will be the crucial speed responsible for the electromagnetic interaction, because it is responsible for the limitation of the speed of interaction, because it is the slowest component in the system. And this speed of interaction is not the vacuum speed of light, but the speed of motion of the (charge induced) voltage-pulses along the wire. We are curious to estimate this speed now.

● The length of the wire, from which the coil is made, can be calculated from the number of windings and the length of each winding (where we use the symbols and the values from section 5):

Length of the wire in the coil $L_D = 2\pi R_S \cdot n = 2\pi \cdot 0.05m \cdot 34600 = 10870m$. (21)

(In reality, the wire is a bit longer, because the outer windings have a radius which is a bit larger.)

● The duration for the propagation of the signal is known from the frequency of the oscillation, respectively from the duration per each period T. During the duration of one period of the oscillation, the electrical charge is moving once forth and once back, this is twice the length of the wire L_D. By evaluating the figures 8 and 9, we find: in fig.8 → 101 periods of electrical oscillation
in fig.0 → 100.5 periods of electrical oscillation

The difference of half a period also causes the difference in energy conversion, and it has its reason from the influence of the electrical circuit and the mechanical circuit onto each other. Thus, for our estimation, we can use the arithmetic average of both:

Duration per period $T = \frac{10.59\,\text{sec.}}{100.75\,Perioden} = 0.105112\frac{\text{sec.}}{Periode}$ (22)

● The speed of propagation of the charge along the wire, which defines the speed of propagation of our system, then is

$$v = \frac{2 \cdot L_D}{T} = \frac{2 \cdot 10870m}{0.105112\,\text{sec.}} = 206.8\frac{km}{\text{sec.}} = 6.89 \cdot 10^{-4} c\,. \quad (23)$$

It is only a small fraction of the speed of light. On the one hand this demonstrates, how strongly the speed of propagation of the interaction fields can be influenced, and how the speed of propagation of these fields can be brought into a range, within which we can operate. But on the other hand, the result also displays very clearly, how sensitive the speed of propagation acts on the conversion of zero-point-energy. Thus it is necessary to determine this speed directly from the system. Therefore the differential equations of the oscillations are not only convenient but really necessary. Not the length of the wire is of main importance, but many other physical values of the system. (Just have the permeability of the magnetic core inside the coil as an example therefore in mind.)

8. The gain of classical electrical power

In order to extract electrical power from the system, which is now operating as a self-running engine, we introduce a ballast resistor into the circuit, as drawn in figure 10.

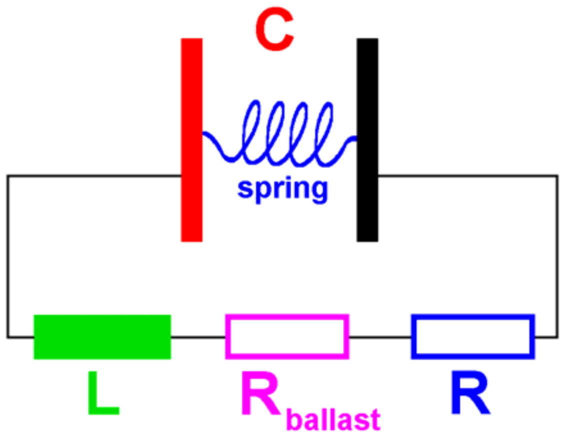

Fig. 10:
A ballast resistor $R_{ballast}$ has been added to our zero-point energy circuit, which is connected in series with the copper wire of the coil and its Ohm's resistance R.
The ballast resistor permanently extracts energy from the zero-point-energy converter.
Within our DFEM-algorithm, it is sufficient to add the resistances R and $R_{ballast}$ linear.

If the ballast resistor is chosen to be $R_{ballast} = 334k\Omega$, the system parameters from section 5 and figure 8 will lead us to an energy gain of $P = 2.32 \cdot 10^{-11} Watt$. The ballast resistor has been chosen in such a way, that the amplitude of the electrical voltage (over the capacitor) is kept constant, in order to maintain constant operation during time. The capacitor voltage has an amplitude of $U_C = 1.50 Volt$.

The electrical power has been calculated as integral average value. Because of Kirchhoff's voltage law, the electrical current is the same in all electrical elements of the circuit. Thus the computation of the converted power goes back to the formulas

$$
\begin{aligned}
& P = U \cdot I = R_{ballast} \cdot I^2 = R_{ballast} \cdot \dot{Q}^2 \\
& \Rightarrow \text{ extracted energy } \bar{E} = \int_0^{10.59\,\mathrm{sec}} R_{ballast} \cdot \dot{Q}(t)^2 \, dt \quad . \\
& \Rightarrow \text{ mean value of converted power } \bar{P} = \frac{\bar{E}}{10.59\,\mathrm{sec}}
\end{aligned}
\tag{24}
$$

The converted power, as we calculated it, is rather small, and thus we want to increase it. This is indeed no problem, because the maximum of the voltage over the capacitor (i.e. the amplitude of the voltage) is only $U_C = 1.50\,Volt$. This can be enhanced very easy. If we enhance the capacitor voltage only up to $U_C = 2.00\,Volt$ (amplitude) and then adjust the system parameters as good as necessary, we get a remarkable enhancement of the power. Please see the following comparison:

► $U_C = 1.50\,Volt$, $D = 1.000\frac{N}{m}$, $Q(0) = 2.000 \cdot 10^{-10} C$ at $R_{Last} = 334\,k\Omega$ (with $\mu_r = 12534$)

$\Rightarrow$ $P_{ballast} = 2.32 \cdot 10^{-11} Watt$ extraction by the ballast resistor and $E_{circuit} = 9.6 \cdot 10^{-12} Joule$ in the capacitor

Thus the power being converted from the zero-point-energy under this operation is

$$P_{ballast} + \frac{E_{circuit}}{\Delta t} = 2.32 \cdot 10^{-11} Watt + \frac{9.6 \cdot 10^{-12} Joule}{10.59\,\mathrm{sec.}} = 2.41 \cdot 10^{-11} Watt \ .$$

► $U_C = 2.00\,Volt$, $D = 1.341\frac{N}{m}$, $Q(0) = 2.665 \cdot 10^{-10} C$ at $R_{ballast} = 230\,k\Omega$ (with $\mu_r = 12539$)

$\Rightarrow$ $P_{ballast} = 1.278 \cdot 10^{-10} Watt$ extraction by the ballast resistor and $E_{circuit} = 1.16 \cdot 10^{-8} Joule$ in the capacitor

plus $E_{mech} = 9.13 \cdot 10^{-12} Joule$ mechanically

Thus the power being converted from the zero-point-energy under this operation is

$$P_{ballast} + \frac{E_{circuit} + E_{mech}}{\Delta t} = 1.278 \cdot 10^{-10} Watt + \frac{1.16 \cdot 10^{-8} Joule}{10.59\,\mathrm{sec.}} = 1.22 \cdot 10^{-9} Watt$$

► Obviously an enhancement of the capacitor voltage-amplitude from 1.5 Volt to 2.0 Volt even leads to an enhancement of the converted power by more than a factor of 50. This shows us, how much optimization is possible.

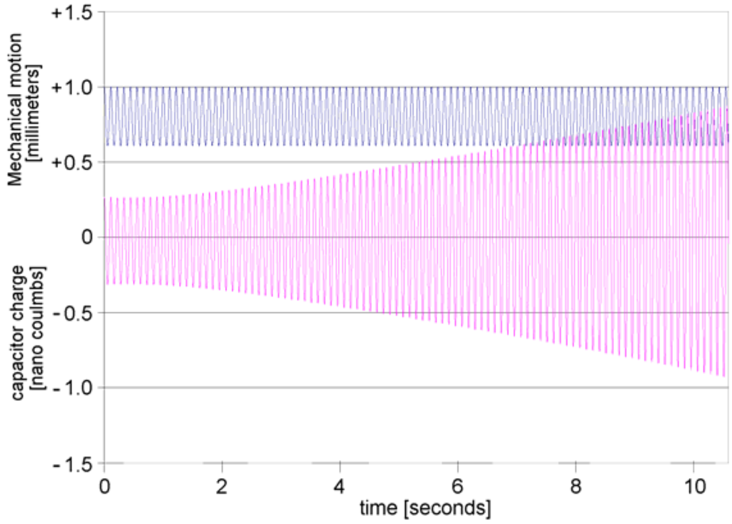

Abb.11: Electrical and mechanical oscillation of our setup at a capacitor voltage-amplitude of U_C=2.00 Volt.

Interestingly, an enhancement of the ballast resistor (same as a decrease of this resistor) does not enhance the power being extracted from the quantum-vacuum (as we would expect from $P = R_{ballast} \cdot I^2$). The opposite is the case, because the ballast resistor also influences (and disturbs) the "Double resonance". In our example the ballast resistor was adjusted with regard to a maximization of the extraction of power from the quantum-vacuum.

For the optimization of the operation-mode of the zero-point-energy converter has to be adjusted for each experiment individually, depending on the available materials and dimensions, the present work contains the source-code of the DFEM-algorithm, so that every dexterous experimentalist can optimize the setup for his or her own purpose. But please keep in mind, that an enhancement of the capacitor-voltage always increases the attractive forces between the capacitor-plates, which makes it necessary to enhance also the stiffness of the spring between the capacitor-plates (which can be the stiffness of the capacitor-plates themselves), in order to avoid a contact between the both capacitor plates. This is a very sensitive aspect with regard to this setup.

The capacitor should not have the too small capacitance. This makes it necessary to mount the capacitor-plates not too far away from each other. This can be done rather easy by the use of two pieces of a thin plastic foil, which can be stretched on both sides of a wooden or plastic frame. The metallic plates can just consist of thin metallic films on the surface of the plastic foils. On this background, you can understand the computation of the mass of the capacitor plates as well as the Hooke's spring constant of these capacitor-plates in the source-code of the algorithm (see also fig.12). The pre-stress of the plastic foil determines their spring constant.

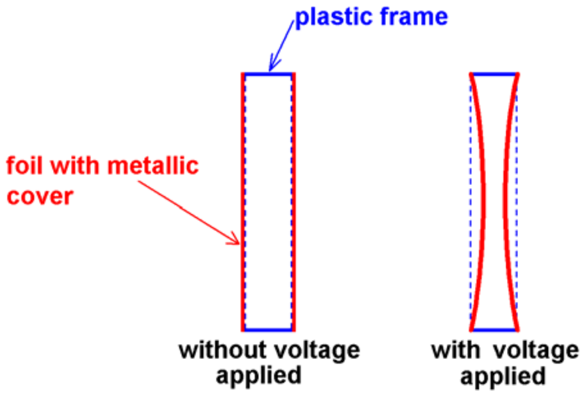

Fig. 12:
Suggestion for an experimental setup of a capacitor with flexible plates, which have a rather small distance between each other in order to get a not too small capacity.

Resumée

Summarizing what we learn from this work, it can be said, that the speed of propagation of the interacting forces in electro-magnetic engines can be controlled in a rather wide range, so that it is possible, to build efficient electro-magnetic zero-point-energy converters. The basic principles have been explained in the work presented here, together with an example for their illustration.

However, the adjustment of the system parameters is a considerable problem. It is necessary to adjust these parameters extremely precise relatively to each other and also within the system, because several resonances have to be adjusted to each other. This teaches us, that the adjustment of the parameters might be even more difficult, than the manufacturing of the zero-point-energy converter itself. Trigger-pulses, which do not consume much energy, might be a good help for a zero-point-energy converter to run stable.

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Appendix: The source code of the DFEM-algorithm

```
Program Harmonischer_Oszillator_im_DFEM;
{$APPTYPE CONSOLE}
uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs;

Var epo,muo     : Double;  {Constants of nature}
    v           : Double;  {Propagation-speed of the charges}
    CA,CD,C     : Double;  {Capacitor: surface and distance of the plates, capacity}
    GG3         : Double;  {equilibrium position of the flexible plates, part 3}
    SP3         : Double;  {distance of the plates with initial voltage}
    UC,UL{,UR}  : Double;  { voltage of the capacitor, coil, resistor}
    SN,SL,SA,SR : Double;  {coil: windings, length, cross-section, Radius}
    L           : Double;  {inductivity of the coil}
    DL          : Double;  {length of the copper wire}
    epr,mur     : Double;  {Epsilon_r und Mü_r for capacitor and coil}
    rho,R       : Double;  {specific resistance of the copper wire}
    AD          : Double;  {cross-section of the copper wire}
    Q,Qp,Qpp    : Array[0..200000] of Double;  {charge and derivatives as a function of time}
    x,xp,xpp    : Array[0..200000] of Double;  {deflection of the capacitor-plates}
    dt          : Double;  {time step-by-step}
    N           : LongInt; {number of time-steps}
    i           : LongInt; {counter}
    Abstd       : Integer; {plot-counter}
    rhoAL,rhoFol: Double;  {density of aluminium and plastic foil}
    dAL,dFol    : Double;  {thickness of aluminium and plastic foil }
    D           : Double;  {spring constant}
    m           : Double;  {(mechanical) mass of the capacitor plates}
    omfol,fFol  : Double;  {oscillation frequency}
    F           : Double;  {force between the capacitor plates}
    Stern1      : Double;  {variable}
    Fc,Fd       : Double;  {coulomb force and spring force}
    MacheFiles  : Boolean; {data-storage yes/no ?}
    om          : Double;  { Omega}
    Rlast       : Double;  {ballast resistor}

Procedure Wait;
Var Ki : Char;
begin
  Write('<W>'); Read(Ki); Write(Ki);
  If Ki='e' then Halt;
end;

Procedure Excel_Datenausgabe(Name:String);
Var fout  : Text;    {prepare data for Excel}
    Zahl  : String;
    lv,j  : Integer; {variable}
    A0    : Double;  {Amplitude}
begin  { prepare data for Excel:}
  Assign(fout,Name); Rewrite(fout); {File open}
  For lv:=0 to N do  {from "plotanf" to "plotend"}
  begin
    If (lv mod Abstd)=0 then
    begin
{     the first argument is the time:}
      Str(lv*dt*1e6{nafo_sec.}:14:10,Zahl);
      For j:=1 to Length(Zahl) do
      begin   {uns commata}
        If Zahl[j]<>'.' then write(fout,Zahl[j]);
        If Zahl[j]='.' then write(fout,',');
      end;
      Write(fout,chr(9));  {Data-separation }
{     the first function is the voltage:}
      Str(Q[lv]/C{Volt}:14:7,Zahl);
      For j:=1 to Length(Zahl) do
      begin   {use commata}
        If Zahl[j]<>'.' then write(fout,Zahl[j]);
        If Zahl[j]='.' then write(fout,',');
      end;
      Write(fout,chr(9));  { Data-separation }
{     second function: envelope}
      A0:=Q[0]/C/sin(arctan(sqrt(1/L/C-R*R/4/L/L)/(R/2/L)));      {klassische}
      Str(A0*exp(-R/2/L*lv*dt){Volt}:20:10,Zahl);                 {Formeln}
      For j:=1 to Length(Zahl) do
      begin   {use commata}
        If Zahl[j]<>'.' then write(fout,Zahl[j]);
```

```
        If Zahl[j]='.' then write(fout,',');
      end;
      Writeln(fout,'');    {line-separation }
    end;
  end;
  Close(fout);
end;

Procedure Excel_andere_Ausgabe(Name:String);
Var fout  : Text;    {prepare data for Excel}
    Zahl  : String;
    lv,j  : Integer; {variable}
begin  {prepare data for Excel:}
  Assign(fout,Name); Rewrite(fout); {File open}
  For lv:=0 to N do  {from "plotanf" to "plotend"}
  begin
    If (lv mod Abstd)=0 then
    begin
{     the first argument is the time:}
      Str(lv*dt*1e6{nano_sec.}:14:10,Zahl);
      For j:=1 to Length(Zahl) do
      begin   {use commata}
        If Zahl[j]<>'.' then write(fout,Zahl[j]);
        If Zahl[j]='.' then write(fout,',');
      end;
      Write(fout,chr(9));  {Data- separation }
{     first Funktion:   }
      Str(x[lv]{Volt}:20:14,Zahl);
      For j:=1 to Length(Zahl) do
      begin   {use commata}
        If Zahl[j]<>'.' then write(fout,Zahl[j]);
        If Zahl[j]='.' then write(fout,',');
      end;
      Write(fout,chr(9));  {Data-separation }
{     second Funktion:   }
      Str(Q[lv]*1E6{Volt}:20:14,Zahl);
      For j:=1 to Length(Zahl) do
      begin   {use commata}
        If Zahl[j]<>'.' then write(fout,Zahl[j]);
        If Zahl[j]='.' then write(fout,',');
      end;
      Writeln(fout,'');    {line-separation }
    end;
  end;
  Close(fout);
end;

Procedure Excel_Raumenergieausgabe(Name:String);
Var fout  : Text;    {prepare data for Excel}
    Zahl  : String;
    lv,j  : Integer; {variable}
begin  {prepare data for Excel:}
  Assign(fout,Name); Rewrite(fout); {File open}
  For lv:=0 to N do  {from "plotanf" to "plotend"}
  begin
    If (lv mod Abstd)=0 then
    begin
{     the first argument is the time:}
      Str(lv*dt*1e6{nano_sec.}:14:10,Zahl);
      For j:=1 to Length(Zahl) do
      begin   {use commata}
        If Zahl[j]<>'.' then write(fout,Zahl[j]);
        If Zahl[j]='.' then write(fout,',');
      end;
         Write(fout,chr(9));  {Data-separation}
   {     the first function is the voltage:}
         Str(x[lv]{Volt}:14:7,Zahl);
         For j:=1 to Length(Zahl) do
         begin   {use commata}
           If Zahl[j]<>'.' then write(fout,Zahl[j]);
           If Zahl[j]='.' then write(fout,',');
         end;
         Writeln(fout,'');    {line-separation }
       end;
     end;
     Close(fout);
   end;

   Procedure Excel_eine_Kolumne(Name:String);
```

```
   Var fout  : Text;    {prepare data for Excel}
       Zahl  : String;
       lv,j  : Integer; {variable}
   begin  { prepare data for Excel:}
     Assign(fout,Name); Rewrite(fout);  {File open}
     For lv:=0 to N do  {from "plotanf" to "plotend"}
     begin
       If (lv mod Abstd)=0 then
       begin
         Str(x[lv]{Volt}:20:14,Zahl); {write the array to be plotted here.}
         For j:=1 to Length(Zahl) do
         begin   {use commata}
           If Zahl[j]<>'.' then write(fout,Zahl[j]);
        If Zahl[j]='.' then write(fout,',');
      end;
      Writeln(fout,'');    {line-separation}
    end;
  end;
  Close(fout);
end;

Function Plapos(z:LongInt):Double;  {Iterative determination of the plate’s position.}
Var xs    : Double; {initial value}
    sw    : Double; {Stepp-width}
    an,ab : Boolean;
begin
  xs:=0;
  If z=0 then xs:=CD/2;   {the position of the plates is at +/-xs.}
  If z>0 then xs:=x[z-1]; {this can eventually be taken from the last step.}
  sw:=xs/20;
  Repeat
    sw:=sw/10;
    an:=false; ab:=false;
    Repeat
      Fc:=1/4/pi/epo*q[z]*q[z]/(2*xs)/(2*xs);
      Fd:=D*(xs-CD/2);  {deflection of the spring with regard to CD.}
      If Fc+Fd>0 then begin xs:=xs-sw; an:=true; end;
      If Fc+Fd<0 then begin xs:=xs+sw; ab:=true; end;
      If xs<=1e-10 then
      begin
        Writeln ('Capacitor plates touch each other. Coulomb-force too strong. STOP.');
        Wait; Wait; Halt;
      end;
    Until (an and ab);
  Until (sw<xs/1e14);
  Plapos:=xs;
end;

Procedure Amplituden_anzeigen;
Var i             : Integer;
    schreibe      : Boolean;
    SteigX,SteigQ : Boolean;
    BildX,BildQ   : Array[0..200] of Double;
    zvx,zvQ       : Integer;
    eq,lq,ex,lx   : Double;
    Wmech1,Wmech2,Wel1,Wel2:Double;
begin
{ first that x-Amplitudes:}
  SteigX:=false; If x[1]>x[0] then SteigX:=true;
  schreibe:=false;  zvx:=0;
  Writeln('     I:   t/[sec.]  |           x/[m]         |        Q[i]');
  For i:=1 to N do
  begin
    If SteigX then
    begin
      If x[i]<x[i-1] then begin schreibe:=true; SteigX:=Not(SteigX); Write('X-Max:'); end;
    end;
    If Not(SteigX) then
    begin
      If x[i]>x[i-1] then begin schreibe:=true; SteigX:=Not(SteigX); Write('X-Min:'); end;
    end;
    If schreibe then
    begin
      Writeln(i:6,': ',i*dt:7:5,' | ',x[i],' |',Q[i]); {Wait;}
      BildX[zvx]:=x[i]; zvx:=zvx+1;
    end;
    schreibe:=false;
  end;
  zvx:=zvx-1;
```

```
{ then the Q-Amplitudes:}
  SteigQ:=false; If Q[1]>Q[0] then SteigQ:=true;
  schreibe:=false;  zvQ:=0;
  Writeln('     I:   t/[sec.]  |           x/[m]         |        Q[i]');
  For i:=1 to N do
  begin
    If SteigQ then
    begin
      If Q[i]<Q[i-1] then begin schreibe:=true; SteigQ:=Not(SteigQ); Write('Q-Max:'); end;
    end;
    If Not(SteigQ) then
    begin
      If Q[i]>Q[i-1] then begin schreibe:=true; SteigQ:=Not(SteigQ); Write('Q-Min:'); end;
    end;
    If schreibe then
    begin
      Writeln(i:6,': ',i*dt:7:5,' | ',x[i],' |',Q[i]); {Wait;}
      BildQ[zvQ]:=Q[i]; zvQ:=zvQ+1;
    end;
    schreibe:=false;
  end;
  zvQ:=zvQ-1;
{ overview over "amplitudes":}
  Writeln('pos., amplitudes :  ');
  i:=2;  ex:=BildX[i]-BildX[i-1];
  Repeat
    Writeln(i,': ',BildX[i]-BildX[i-1]);
    lx:=BildX[i]-BildX[i-1];
    i:=i+2;
  Until (i>=zvx);
  Writeln('charges , amplitudes   :');
  i:=2;  eq:=BildQ[i]-BildQ[i-1];
  Repeat
    Writeln(i,': ',BildQ[i]-BildQ[i-1]);
    lq:=BildQ[i]-BildQ[i-1];
    i:=i+2;
  Until (i>=zvQ);
  Write('total alteration, X  -Amplitude: ');
  If Abs(lx)>Abs(ex) then Write('+');
  If Abs(lx)<Abs(ex) then Write('-');
  om:=pi*zvx/N/dt; Writeln('ang.frequency omega= ',om);
  Writeln(Abs(lx-ex));
  Wmech1:=m/2*(ex*ex)*om*om; Wmech2:=m/2*(lx*lx)*om*om;
  Writeln('Mechanical  energy  at Begin : ',Wmech1,' Joule');
  Writeln('Mechanical  Energy  at End :   ',Wmech2,' Joule');
  Writeln('Mechan. Energy-alteration  : ',Wmech2-Wmech1,' Joule');
  Write('total change, charge -Amplitude: ');
  If Abs(lq)>Abs(eq) then Write('+');
  If Abs(lq)<Abs(eq) then Write('-');
  Writeln(Abs(lq-eq));
  Wel1:=L/2*(eq*eq)*om*om; Wel2:=L/2*(lq*lq)*om*om;
  Writeln('Elektrical  Energy  at Begin : ',Wel1,' Joule');
  Writeln('Elektrical  Energy  at End :   ',Wel2,' Joule');
  Writeln('Elektr. Energy-alteration  : ',Wel2-Wel1,' Joule'); Writeln;
  Writeln('Sum: total energy-gain     : ',Wmech2-Wmech1+Wel2-Wel1,' Joule'); Writeln;
end;

Procedure Leistung_berechnen;  {over the ballast resistor "Rlast", Integral average}
Var i   : Integer;
    P   : Double;              {power in the time interval dt}
    Eges: Double;              {total power over the total time}
begin
  Eges:=0;
  For i:=0 to N do
  begin
    P:=+Rlast*Qp[i]*Qp[i];
    Eges:=Eges+P*dt;
  end;
  Writeln('Eges= ',Eges, ' Joule in ',N*dt,' sec.');
  Writeln('=> power    Pmean  = ',Eges/(N*dt),' Watt');
end;



Begin {main program}
{ Initialization of the values: }
{ General: }
  epo:=8.854187817E-12{As/Vm}; {Magnetic Field constant}
```

```
  muo:=4*pi*1E-7{Vs/Am};       {Elektric Field constant }
  v:=Sqrt(1/muo/epo){m/s};     {speed of light}
  Abstd:=1;                    {how many points shall be plotted ?}
{ Kondensator: }
  CA:=0.1*0.1{m²}; CD:=0.002{m};  {capacitor-Geometrie, plate’s surface & distance}
  epr:=3;                                                 {Dielectric isinde capacitor}
  C:=epo*epr*CA/CD;                                           {capacity without voltage}
{ Spule: }
  SN:=34600; SL:=0.08{m}; SR:=0.05{m}; SA:=pi*SR*SR{m²};               {coil’s-Geometry}
{}mur:=12534;                                 {core material to adjust the frequency}
  L:=muo*mur*SN*SN*SA/SL;                                                   {inductance}
  rho:=1.7E-8{Ohm*m};                    {Spez. resistance of copper, Kohlrausch,T193}
  AD:=pi*0.0002*0.0002{m²};                          {cross-section of the copper wire}
  R:=rho*2*pi*SR*SN/AD{Ohm};                        {Ohm`s resistance of the copper wire}
  DL:=SN*2*pi*SR;                                          {length of the copper wire}
{mechanical oscillations of the capacitor plates:}
  rhoAL:=2700{kg/m³};    {density of Aluminium}
  rhoFol:=1500{kg/m³};   {density of plastic foil}
{}dAL:=2e-6{m};          {thickness of Aluminium-capacitor plates}
  dFol:=10e-6{m};        {thickness of the plastic foil}
{}D:=1.0{N/m};           {Hooke’s spring constant of the capacitor plates}
  m:=CA*dAL*rhoAL+CA*dFol*rhoFol; {(mechanical) mass of the Aluminium-capacitor plates}
  omFol:=Sqrt(D/m);        {mechanical frequency of the capacitor plates}
  fFol:=omFol/2/pi;        {mechanical frequency of the capacitor plates}
{ extraction of electrical power:}
  Rlast:=0;    {Ohm}                                       {electrical ballast resistor}
  {start of the electrical oscillation: }
{}Q[0]:=2E-10{C}; Qp[0]:=0; Qpp[0]:=0;                   {initial charge on the capacitor}
  UC:=Q[0]/C{V};                                       {initial voltage of the capacitor}
  dt:=3.53E-4{sec.};                                                        {Time-steps}
  N:=30000;                                                  {total number of Time-steps}
{ start of the mechanical oscillation: }
  x[0]:=Plapos(0);       {Iterative determination of the position of the capacitor plates.}
  GG3:=x[0]; {equilibrium position of the flexible plates, part 3, Federkraft=Coulombkraft}
  SP3:=CD/2;                   {distance of the plates with regard to mechanical prestress}
  F:=1/4/pi/epo*Q[0]*Q[0]/(2*x[0])/(2*x[0]);            {Anziehung nach dem Coulomb-Gesetz}
                                                    {the position of the plates is at CD/2+x[i]}
  xp[0]:=0; xpp[0]:=0;                           {initial conditions of the plates motion t=0}
  MacheFiles:=true;                                 {should we write the results for Excel ?}
  {screen outputs of initial data:}
  Writeln('DFEM-computation of LC - oscillation:'); Writeln;
  Writeln('epo=',epo:20,';  muo=',muo:20,';  v=',v:20);
  Writeln('C=',C:20,' Farad;     L=',L:20,' Henry');
  Writeln('Klass. Elek. Osc. frequ. fo=2*pi/Sqrt(L*C)=',2*pi/Sqrt(L*C),' Hz');
  Writeln(' ==> duration per period T=1/fo=',2*pi*Sqrt(L*C),' sec.');
  Writeln('Ohm`s resistance of the copper-wire:',R,' Ohm');
  Writeln('length of the copper wire:',DL,' Meter');
  Writeln('cross-section of the copper wire:',AD*1e6:10:5,' mm^2');
  Writeln('Volume of the coil: ',DL*AD*1E6:10:5,' cm^3');
  Writeln(weight of the coil: ',DL*AD*1E6*8.92:10:5,' Gramm');  {Dichte Cu: 8.92 g/cm^3}
  Writeln('initial voltage of the capacitor:',UC:12:5,' Volt');
  Writeln('total amount of time: ',N*dt,' sec. in ',N,' Schritten');
  Writeln; Writeln(’mechanical oscillation of the capacitor plates:');
  Writeln('mass of the capacitor plates m= ',m*1000:10:5,' Gramm');
  Writeln('frequency of the capacitor plates: fFol= ',fFol:10:7,' Hz.');
  Writeln('attractive formce of capacitor plates: Kraft F= ',F,' N');
  Writeln('initial deflection of capacitor plates: F/D= ',F/D,' m');
  Writeln('position of the unloaded capacitor plates: ',CD/2);
  Writeln('position of the loaded capacitor plates: X[0]: ',X[0]);
  Writeln('precision of the plates position, Differenzkraft: ',Fc+Fd,' N');
  Writeln('initial plates position, part 3: ',SP3:10:7,' m');
  Writeln('capacity of the of the unloaded capacitor:  C= ',epo*epr*CA/CD,' Farad');
  Writeln('capacity of the of the loaded capacitor: C[0]= ',epo*epr*CA/(2*x[0]),' Farad');
  Writeln('enhancement of the capacity: ',epo*epr*CA*(1/2/x[0]-1/CD),' Farad');
  Writeln('duration of computation: ',N*dt,' sec.');
  Writeln;    {Wait;}

{ Begin of the algorithm.}
  Writeln('1.part -> classical harmonic oscillation, without attenuation:');
  Writeln('  t/[sec.]  |  Uc/[V] | ');
  For i:=1 to N do
  begin
    UC:=Q[i-1]/C; UL:=-UC;
    Qpp[i]:=UL/L;
    Qp[i]:=Qp[i-1]+Qpp[i]*dt;
    Q[i]:=Q[i-1]+Qp[i]*dt;
{   Writeln(i*dt:11:9,' | ',Q[i]/C:7:2,' |'); }
  end;
  If MacheFiles then Excel_Datenausgabe('Teil_01.dat'); Writeln;
```

```
{----------------------------------------------------------------}
  Writeln('2.part -> classical harmonic oscillation, with Ohm’s attenuation:');
  Writeln('  t/[sec.]  |  Uc/[V] | ');    { R:=2000; {enhanced resistance for testing}
  For i:=1 to N do
  begin
    Qpp[i]:=-1/L/C*Q[i-1]-R/2/L*Qp[i-1];
{   Qp[i]:=(Qp[i-1]+Qpp[i]*dt)/(1+R/L*dt); }  {alternative simple approximation}
    Qp[i]:=Qp[i-1]+(Qpp[i]-R/2/L*Qp[i-1])*dt;    {vgl. s=1/2*a*t^2}
    Q[i]:=Q[i-1]+Qp[i]*dt;
{   Writeln(i*dt:11:9,' | ',Q[i]/C:7:2,' |'); }
  end;
  If MacheFiles then Excel_Datenausgabe('Teil_02.dat'); Writeln;

{----------------------------------------------------------------}

  Writeln('3.part -> oscillation with zero-point-energy conversion');
{ Writeln('  t/[sec.]  |           x/[m]         |        Q[i]'); }
  x[0]:=SP3;       {mechanical starting position of the capacitor plates}
  For i:=1 to N do
  begin
    Fd:=-D*(x[i-1]-CD/2);                              {spring force}
    Fc:=-Q[0]*Q[0]/4/pi/epo/(2*x[i-1])/(2*x[i-1]);     {Coulomb- force}
    xpp[i]:=(Fc+Fd)/m;                                 {acceleration}
    xp[i]:=xp[i-1]+xpp[i]*dt;
    x[i]:=x[i-1]+xp[i]*dt;
    If x[i]<=1e-10 then
    begin
      Writeln (,'Capacitor plates touch each other. Coulomb-force too strong. STOP.');
      Wait; Wait; Halt;
    end;
    C:=epo*epr*CA/(2*x[i]);
    Qpp[i]:=-1/L/C*Q[i-1]-(R+Rlast)/2/L*Qp[i-1];
    Qp[i]:=Qp[i-1]+(Qpp[i]-(R+Rlast)/2/L*Qp[i-1])*dt;
    Q[i]:=Q[i-1]+Qp[i]*dt;
{   Writeln(i*dt:11:9,' | ',x[i],' |',Q[i]);}
  end;
  If MacheFiles then Excel_andere_Ausgabe('Teil_03.dat'); Writeln;
  Amplituden_anzeigen;
  Leistung_berechnen;

{----------------------------------------------------------------}

  Wait;   Wait;
End.
```

DFEM-Simulation of a Zero-point-energy Converter with realisable Dimensions and a Power-output in the Kilowatt-range.

by Claus W. Turtur Wolfenbüttel, 7. Feb. 2011

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Abstract

In precedent work, the author presented a method for the theoretical computation of zero-point-energy converters, called Dynamic Finite-Element-Method (DFEM). In several articles some examples for the conversion of zero-point-energy have been demonstrated, which deliver an output power in the Nanowatt- or in the Microwatt- range, which is a fundamental proof of the principle, but not sufficient for any technical application.

The way towards a powerful zero-point-energy converter in the Kilowatt-range needed some additional investigation, of which the results are now presented. Different from former fundamental basic research, the new converter has to be operated magnetically, because the energy-density of magnetic fields is much larger the energy-density of electrostatic fields, namely by several orders of magnitude.

In the article here, the author presents step by step the solution of the theoretical problems, which now allows the theoretical construction of a zero-point-energy converter in the Kilowatt-range. The result is a model of a zero-point-energy motor with a diameter of 9 cm and a height of 6.8 cm producing 1.07 Kilowatts.

1. Definition of the project

A principle proof of the utilization of zero-point-energy was given in [Tur 09]. A basic understanding of the physical fundament how to convert zero-point-energy was shown in [Tur 10a], but there it was not yet possible to present a model for a machine with realizable parameters. The first theoretical model with realizable parameters has been published in [Tur 10b], but the output power was so small, that only acoustic noise could be produced, which requires very low power. The article presented here is the last logical step in this theoretical train of thoughts, which shows the theory of a powerful zero-point-energy converter and gives hope for technical utilization. The Kilowatt zero-point-energy engine presented here, needs less space then a washing-machine. From the point of zero-point-energy conversion, the power-density could even be much larger, but the material gives restrictions to the power-density in order not to be damaged during operation. Restrictions come for instance from the electrical current in copper wires, or from the speed of the revolution of a rotation magnet, which should not damage the bearing.

With the model presented here, the theory is developed far enough, that an experimental verification is desirable now, so that the next step is not a theoretical one, but an experimental one.

2. A first approach to the solution

Our solution is a continuation of the DFEM-model known from [Tur 10b], working with two coupled oscillations, one is a mechanical oscillation and the other one an electrical oscillation-circuit. The setup is drawn in fig.1.

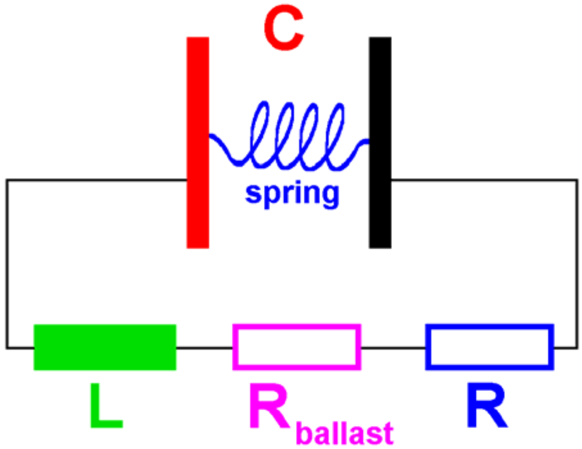

Figure 1:
LCR (electrical) oscillation-circuit, where a capacitor is charged (AC-) electrically, but the distance of the capacitor-plates is variable (by the use of a spring), so that the capacity is not constant. If a mechanical oscillation is coupled with the electrical oscillation in appropriate manner, it is possible to convert zero-point-energy into electrical energy within the electrical circuit and/or mechanical energy within the mechanical oscillation.
By the way: The inductivity of the coil is enhanced by the use of a coil bobbin.

Power can for instance be extracted from the mechanical oscillation of the capacitor plates (as shown in fig.2) as well as from the electrical oscillation by the use of a load resistor R_{Last}, which is operating in series with the Ohm's resistance R of the wire from which the coil is made.

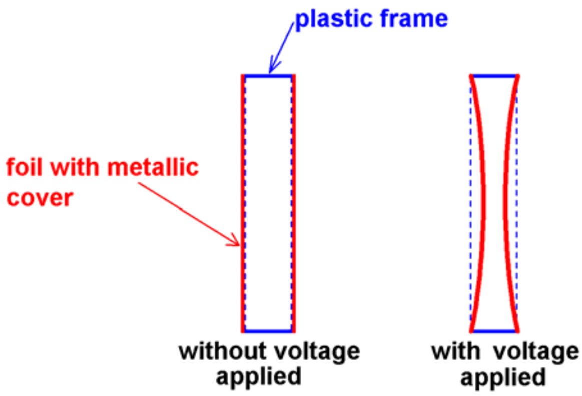

Figure 2:
Variable capacitor with flexible plates, made from thin stretchable plastic-foil, which is covered with a thin metallic film. It can be stretched on a frame. This is an imaginable realization of the capacitor in figure 1, which would be supplied permanently with zero-point-energy so that it can oscillate permanently without consuming classical energy.
The vibration of the plastic-foil might be noticed if it can be arranged in a way that it produces acoustic noise, because the sensitivity of the human ears allows to hear a power of only $10^{-12}\ \mathrm{Watt/m^2}$. The setup should produce noise without any classical power supply.

Unfortunately it can not be extracted more power than only for acoustic noise, which requires typically some Nanowatts or Microwatts. The example shown here was computed to produce a power of only $P = 1.22 \cdot 10^{-9}\,Watt$, although all system-parameters have be optimized till the very end, and the capacitor plates have a cross section area of several square meters. For a principle proof of the utilization of zero-point-energy this might be nice, because everybody might feel the effect of zero-point-energy very directly by hearing it. But a technical application needs a different setup, which can produce several orders of magnitude more power. This leads us to the following questions:

- By which means would it be possible to enhance the power-density within the setup remarkable ?
- By which means would it be possible to extract remarkable power from the system ?

Furthermore we face an additional question:

- The converter according to fig. 1 and fig. 2 requires a very complicated and sensitive adjustment of the system-parameters. Would it be possible to find a more stable way to operate the systems ?

By the way it should be noticed, that we first want to begin with some thoughts, which can not be regarded as the solution to the power-extraction problem. A possible solution is presented not earlier than in section 6. Nevertheless, we want to regard all the steps which leads us to section 6, because otherwise nobody would understand section 6 on its own. Besides, the steps towards the solution help colleagues to avoid tiresome trying and solving the same problems as me. But for the sake of overview, we will not look into all preliminary blind alleys with all details. The very details are written only for the final solution in section 6.

Among the three above questions we want to start out with the last one first.

3. Stabilizing the operation of the zero-point-energy converter by pulsed signals

The problem with the adjustment of all system-parameters of the zero-point-energy converter results from the time-drift of the both resonances (the mechanical and the electrical one), which have to be adjusted exactly to each other. If both resonance-frequencies are not identical, which is normally the case due to practical reasons (for instance such as tolerances), the phase-difference between the both oscillations increases as a function of time. The consequence is that the oscillations run away from each other, and the adjustment of the propagation-speed of the forces of the interaction will become worse within a certain time of operation. This causes a limit of the conversion of zero-point-energy only due to the apparatus in use, as can be understood as following:

Decreasing adjustment of the propagation-time of the forces of interaction also decreases the amount of energy converted per time, which is the converted power. Finally the system comes into a state, where it can no longer be accelerated (or even supported) by zero-point-energy. This means, the system might run into a stable state of operation, which is kept by zero-point-energy, but in this state of operation the system can not give away any energy-output. If some energy should be extracted, the adjustment of all system-parameters should be renewed. Perhaps the system might even come to standstill, because the support with zero-point-energy is even missing completely. From there we come to the idea, which engineers call “phase lock”:

If we want to extract power continuously, we have to solve the problem of adjustment of both resonances to each other. Periodic input pulsed signals could be the way for renewing this adjustment periodically. These signals shall act similar like a trigger, which resets the adjustment of all system-parameters from time to time, bringing back the system into a well defined initial state with optimal adjustment of the resonances to each other. From this moment of “triggering”, the resonances begin to drift again, but the next trigger-pulse will be given much earlier than the adjustment becomes seriously bad. Thus we investigated the DFEM-Simulation of a triggered operation.

For electrical triggering is much easier than mechanical triggering, it was decided to try the following: The mechanical position shall be the orientation for the moment, at which the electrical trigger-pulse shall be given into the system. The electrical trigger-pulses shall be given into the circuit as a voltage as shown in fig.3, which can be understood as an upgrading of fig.1.

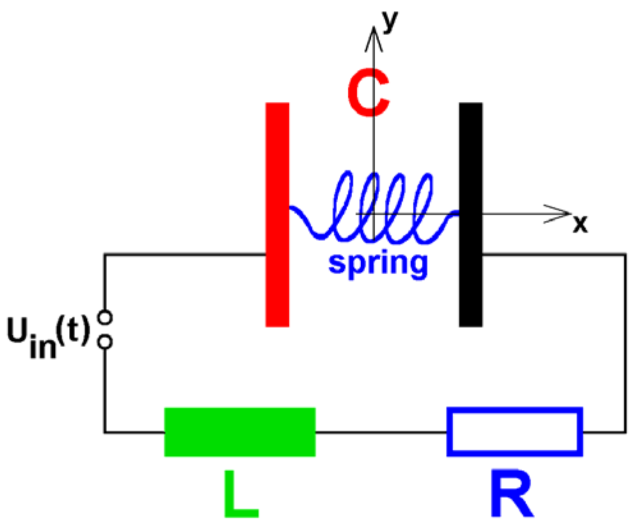

Figure 3:
Insertion of trigger-pulses to our zero-point-energy converter, with the purpose to make the adjustment between the mechanical resonance and the electrical resonance stable in time (phase lock).

The trigger-pulses can be given as shown in fig.4. They are actuated at a well defined geometrical position of the mechanical part of the sytem. Of course the trigger-pulses themselves shall consume as low power as possible, otherwise they would feed the engine instead of the zero-point-energy.

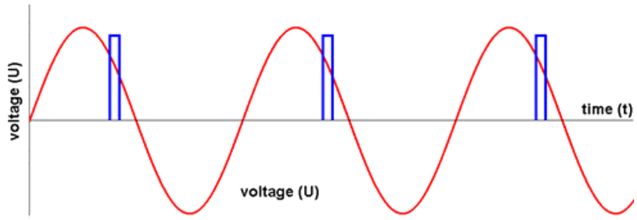

Figure 4:

Red: Mechanical oscillation, at which the trigger-pulses are orientated.

Blue: Trigger-pulses with very low power.

The differential equation on which the electrical oscillation is based, can be derived from the use of Kirchhoff's voltage rule [Ger 95]:

$$U_L + U_R + U_C = U_{in}(t)$$

$$\Rightarrow \; U_L + U_R + U_C = -L \cdot \ddot{Q} + R \cdot \dot{Q} + \frac{1}{C} \cdot Q = U_{in}(t). \qquad (1)$$

with the voltage of the capacitor, the coil and the resistor as following:

according to the definition of the capacity $C = \frac{Q}{U} \;\Rightarrow\; U_C = \frac{1}{C} \cdot Q$ (2)

according to the law of induction: $U_L = -L \cdot \frac{d}{dt} I = -L \cdot \ddot{Q}$ (3)

according to Ohm's law: $U_R = R \cdot I$ (4)

This is an inhomogeneous differential equation of 2nd order, with a disturbance function according to fig.4.

The mechanical oscillation follows the differential equation:

$$m \cdot \ddot{x}(t_i) = -D \cdot \left(x(t_{i-1}) - \frac{CD}{2} \right) + \frac{1}{4\pi\varepsilon_0} \cdot \frac{Q^2(t_i)}{\left(2 \cdot x(t_i)\right)^2}$$

based on the spring-force and the Coulomb-force with m=mass and D = Hooke's spring constant (5)

The capacitor plates are mounted symmetrically with regard to the origin of coordinates, so that their positions are $-x(t_i)$ and $+x(t_i)$. Thus we write Coulomb's force between the capacitor-plate as $F_C = \frac{1}{4\pi\varepsilon_0} \cdot \frac{Q^2}{\left(2 \cdot x(t_i)\right)^2}$, because the distance between the capacitor plates is $2 \cdot x(t_i)$.

For the computation of the force of the helical spring, we have to use a totally different length, namely the alteration of the spring length relatively to the spring without load. If CD = length of the unloaded spring, the alteration of its length relatively to CD can be written as $CD - 2 \cdot x(t_i)$, not forgetting the algebraic sign of $x(t_i)$. If we regard the motion of the capacitor-plates a symmetrically with regard to the origin of coordinates, (where the coordinate-system is fixed in the middle of the capacitor, each half of the spring follows exactly half of $CD - 2 \cdot x(t_i)$, so that the force of the spring, acting on each of the capacitor plates is $F_F = -D \cdot \left(x(t_i) - \frac{CD}{2} \right)$, as written in equation (5).

The coupling between the mechanical oscillation and the electrical oscillation can be recognized when regarding the last summand of equation (5), where the electrical part of the apparatus carries out its influence onto the mechanical part of the apparatus. But we also recognize it in equation (1), where the capacity C is influenced by the mechanical oscillation.

Actually this concept allows a stable operation of the zero-point-energy converter, as can be seen in fig.5 and fig.6.

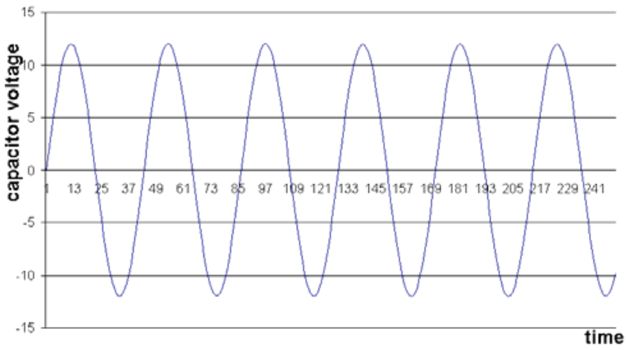

Figure 5:

The electrical charge in the capacitor oscillates with a sine.

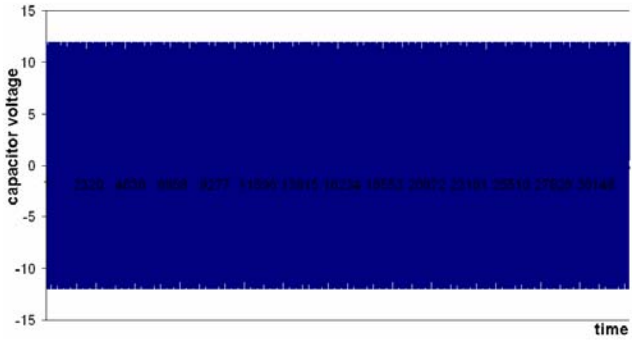

Figure 6:

If we observe the oscillation over long time, the graphics display does not dissolve all pixels of the sine, but it becomes very clear, that the operation runs stable.

If we want to extract energy from the system, we can try to insert a load resistor as a consumer of energy. This load resistor has to be inserted into equation (1) in series with the resistance of the wire from which the coil is made, following equations (6) and (7).

$$R = R_{coil} + R_{load} \tag{6}$$

with an extraction of power: $$P_{extract} = U_{load} \cdot I_{load} = R_{load} \cdot I_{load}^2 \tag{7}$$

For the extraction of power, we optimize the load resistor in such way, that it extracts just the amount of energy coming from the zero-point-energy. A larger load resistor would decrease the oscillation and a smaller load resistor would have the consequence that the oscillation would increase during time.

But the result of these DFEM-simulations was, that the triggered zero-point-energy converter allowed only few microwatts to be extracted. This is more than the acoustic power to be extracted from the setup without triggering and phase lock, but it is not really satisfactory. Besides, the capacitor had plates of 6 m^2 up to 20 m^2 (for different trials) with power-output between Nanowatts and few ten microwatts.

Although the gained power is very low, the result is encouraging, because the gained power is by several orders of magnitude larger than the input-power of the trigger-pulses. Obviously the trigger-pulses are only needed for the adjustment of the system and not as an energy-supply. There have been examples of simulation with a mechanical power-gain which is more than a factor of 10^6 larger than the energy-supply of the input trigger-pulses.

Furthermore it was observed, that the mechanical oscillation of the capacitor plates acquires much more energy than the electrical oscillation in the LCR-circuit. This leads us to the question, whether a mechanical extraction of energy is more efficient than the electrical extraction of energy. In order to try this, a constant mechanical friction was included into the DFEM-algorithm, not thinking about the question how this constant mechanical friction could be realized in praxis (especially with regard to the capacitor plates of several m^2).

For this purpose we expand differential equation (5) by a constant load force F_{load} and thus come to the differential equation (8) of a damped oscillation.

$$m \cdot \ddot{x}(t_i) = -D \cdot \left(x(t_{i-1}) - \frac{CD}{2} \right) + \frac{1}{4\pi\varepsilon_0} \cdot \frac{Q^2(t_i)}{\left(2 \cdot x(t_i)\right)^2} - F_{load} \tag{8}$$

The constant load force acts in counter-direction with regard to the acceleration (thus the negative algebraic sign), and it can be switched on at an arbitrary moment of time. By this means a converter has been simulated with

an input-power (trigger) of $P_{input,electr} = 1.354 \cdot 10^{-7}\,Watt$

and an electrical output-power of $P_{output,electr} = 1.350 \cdot 10^{-7}\,Watt$

plus mechanical-output $P_{output,mechan} = 2.611 \cdot 10^{-5}\,Watt$

Even if the extracted power exceeds the input-power of the electrical trigger-pulses by a factor of 194, the total power gain is only few more than 260 microwatts (see fig. 7), although the capacitor had plates of $6\,m^2$ (difficult to realize, and thus not satisfactory).

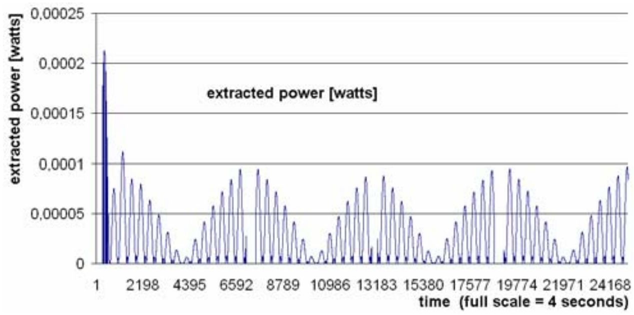

Figure 7a: Extracted mechanical power

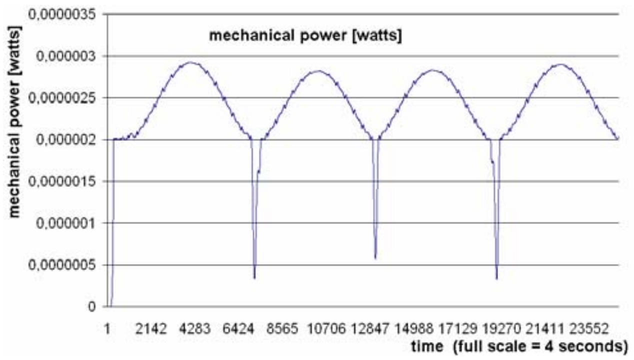

Figure 7b: Mechanical power staying in the oscillator.

The electrical power is negligible.

This example is for sure not the solution of the power-extraction problem, even if the trigger-pulses help us to come into the upper microwatt-range.

Comparative tests with a load-force of friction proportional to the velocity of the capacitor plates $F_{load} = \beta \cdot \dot{x}$ allow us to enter the milliwatt-range, but I even regard this not as the solution of the power-extraction problem. Fig.8 is based on a load-force of friction proportional to the velocity and comes to a power-gain of a bit more than 4.5 milliwatts. The trigger-pulses are orientated with their phase relatively to the mechanical oscillation. At the beginning of the operation, there is not yet any mechanical power in the system, and the trigger-pulses initiate the oscillation at all. At this time, the amplitude of the oscillation is growing permanently. At the moment t = 100 sec., the mechanical load-force is switched on with a friction keeping the amplitude constant from there on. From t = 100 sec. up to t = 200 sec., a mechanical power-extraction of a bit more than 4.5 milliwatts is observed as stated above. Obviously the mechanical damping reduces the frequency of the oscillation, which is rather typical for damped oscillations. But this does not disturb our system, because the trigger-pulses are orientated relatively to the mechanical deflection.

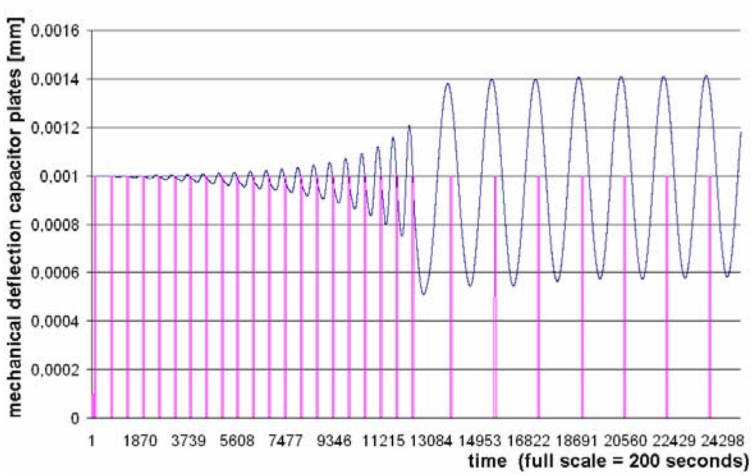

Figure 8:

blue: Mechanical deflection of the capacitor-plates in meters. The position of rest is located at 1.0 Millimeters = 0.001 Meter. The deflection is to be understood relatively to the rest position.

purple: Electrical power-supply of the trigger-pulses. They have an amplitude of 0.1 Volt and are rather short.

For the capacitor-plates in the simulation example have a mass of 440 kg per each, the stiffness of the springs is rather high, with a Hooke's spring constant of 86487 N/m. This means that the converter has no practical sense at all, even if it appears realizable by principle. But – how to extract few milliwatts from such large capacitor-plates ? The question will remain unsolved, because we will soon see a better design.

4. Power extraction from the coil

After we found out, that the capacitor is almost incapable to release its energy, we want to try, whether the coil is capable to release its energy. This requires some impedance-transforming, so that we come to a design as seen in fig.9.

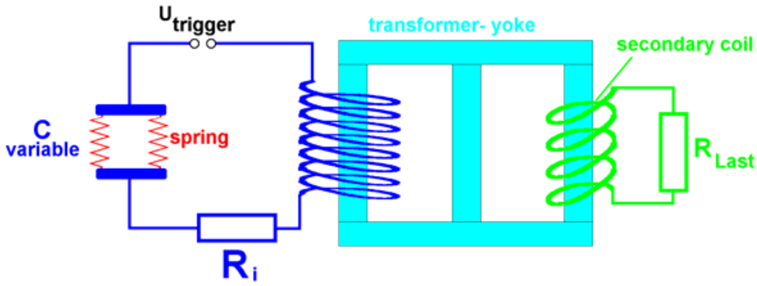

Figure 9: Suggestion for making the extraction of energy from the zero-point energy converter better.

There the coil bobbin from fig.1 is extended to be yoke of a transformer now, so that coil in the LRC-oscillation circuit will be the primary-coil of a transformer, from whose secondary-coil we can extract energy. This arises the hope, that the impedance of the coil can now be transformed in such way, that we can gain more energy and/or power than before.

The primary-coil produces a magnetic field due to its current [Stöcker S.441], which is

$$H = \frac{n \cdot I}{\sqrt{l^2 + 4R^2}} \qquad (9)$$

with n = number of windings in the primary coil
l = length of the coil-body
R = radius of the coil-body

From there we calculate the magnetic flux and the voltage induced in the secondary-coil:

$$B = \mu_0 \mu_r \cdot H \quad \Rightarrow \quad \phi = \int_A \vec{B}\, d\vec{A} \quad \Rightarrow \quad U_{ind} = -m \cdot \frac{d\phi}{dt} \qquad (10)$$

with m = number of secondary -windings

If we put the equations into each other, assuming a homogeneous magnetic field, we come to a magnetic flux in the yoke, which has the same value in the secondary-coil as in the primary-coil:

$$\phi = \int_A \vec{B}\, d\vec{A} = B \cdot A = \mu_0 \mu_r \cdot \frac{n \cdot I}{\sqrt{l^2 + 4R^2}} \cdot \pi R^2 = \mu_0 \mu_r \cdot \frac{\pi R^2}{\sqrt{l^2 + 4R^2}} \cdot n \cdot \frac{dQ}{dt} \quad , \qquad (11)$$

The notation has been adapted to the use in the differential equations of the coupled oscillations. From there we come to the relation of the electrical currents in the secondary-coil relatively to the primary-coil:

$$\underbrace{U_{ind,2} = -n_1 \cdot \frac{d\phi}{dt}}_{because\ of\ \phi_1=\phi_2} = -\mu_0\,\mu_r \cdot n_1^2 \frac{\pi R_1^2}{\sqrt{l_1^2+4R_1^2}} \cdot \frac{d^2Q_1}{dt^2} = -L_2 \cdot Q_2 = -\mu_0\,\mu_r \cdot n_2^2 \frac{\pi R_2^2}{\sqrt{l_2^2+4R_2^2}} \cdot \frac{d^2Q_2}{dt^2} \quad , \tag{12}$$

where we give the values of the inductivities of the both coils as

$$L_1 = \mu_0\,\mu_r \cdot \frac{\pi R_1^2}{\sqrt{l_1^2+4R_1^2}} \cdot n_1^2 \quad \text{and} \quad L_2 = \mu_0\,\mu_r \cdot \frac{\pi R_2^2}{\sqrt{l_2^2+4R_2^2}} \cdot n_2^2 \ . \tag{13}$$

This allows us to convert the values of the primary sizes $Q_1, \dot{Q}_1, \ddot{Q}_1$ into the values of the secondary sizes $Q_2, \dot{Q}_2, \ddot{Q}_2$ (see index), so that we can calculate the power-extraction of the system. This is the way, how we include the secondary-coil into the differential equations of the oscillation. The load resistor can be translated into a resistor in parallel to the primary-coil, which can then be inserted into the differential equations of the oscillation.

The translating computation requires a longsome derivation, finally resulting in the differential equations (14), which shall not be derived here explicitly, because we will soon observe, that this way is also not the very solution of out power-extraction problem.

$$\ddot{Q}_L = \underbrace{\frac{-1}{C\cdot(R+R_V)}\dot{Q}_L}_{\text{term for the extraction of power}} + \underbrace{\frac{-1}{C\cdot L}\cdot\frac{R_V}{R+R_V}Q_L}_{\text{term for the capacitor}} + \underbrace{\frac{R}{L}\cdot\frac{R_V}{R+R_V}\dot{Q}_L}_{\text{term for the Ohm's resistance of the coil's wire}} \underbrace{-\frac{1}{L}\cdot\frac{R_V}{R+R_V}\cdot U_0(t)}_{\text{term for the voltage of the trigger-pulses}} \quad , \tag{14}$$

where we have: R = Ohm's resistance of the coil's wire
R_V = load - resistor
C = capacity
L = inductivity
$U_0(t)$ = trigger-pulses (if applicable)

With this construction it was possible to enhance the extracted power to 63 milliwatts, but still using the unrealistic large capacitor-plates as have been used for the simulation-examples of fig.8. The extracted power is low enough not the justify the enumeration of the more than 20 parameters of the system, which have been necessary for the DFEM-simulation of the differential equations containing equation (14). The situation is not advanced by the suggestion of fig. 9 very much. We will have to try something else.

5. Variability of the coil

After all we found, we come back to our questions at the end of section 2, which should guide us towards the solution of out power-extraction problem. We now see, that the pulse-operation is not the only way.

First of all, we remark, that an enhancement of the power-density within the system is absolutely necessary. If there is low energy and power within the system, there is not much to be extracted. The weak point in the design is the capacitor with only two massive (thick) parallel plates. This type of capacitor is known for its low capacity. The capacitor on which fig.8 is based had a capacity of only 79.7 nF with a surface of the plates of $6\,m^2$. It should be mounted like a window.

If we want to enhance the power-density of the system, we should respect equations (15) and (16) and come to the point to make the energy within the capacitor about the same large as the energy within the coil. This means that we have to use a capacitor much larger than what we did up to now. This should help us to have the same amount of energy in the electric circuit as in the mechanical oscillation.

energy of the capacitor $E_C = \frac{1}{2} C \cdot U^2$ (15)

energy of the coil $E_L = \frac{1}{2} L \cdot I^2$ (16)

An enhancement of the capacity can be realized rather easily with a standard commercial capacitor. But this means that we lose the possibility to have an oscillation of the capacitor-plates. So we have to go back to the very beginning and look again to fig.1. The variability of the electric LC- oscillation circuit can be achieved not only by the capacitor but also by the coil. We need this variability in order to control the speed of propagation of the field of the interacting forces, but this control can be realized either by the capacitor or by the coil. So we come to an alternative design as shown in fig.10. There we have a coil with the coil bobbin moving inside the windings, which gives rise to an alteration of the inductivity of the coil, as soon as the coil bobbin has a permeability different from 1, this is $\mu_r \neq 1$.

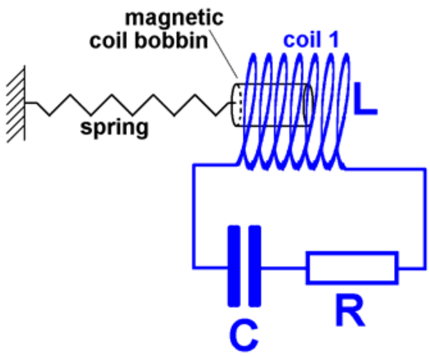

Figure 10:
Suggestion for an improvement of the zero-point energy motor namely by improving the energy inside the system, which allows to improve the energy-coupling between the mechanical part of the system and the electrical part of the system.
The variation of the inductivity of the coil is due to an oscillation of the coil bobbin, which has a permeability different from 1.

The permeability of the coil bobbin can be very large (depending on appropriate material), so that the variation of the inductivity of the coil is very large. The coil bobbin is fixed to a spring which makes the bobbin oscillate mechanically, so that we now do not alter the capacity but we alter the inductivity in the LC-circuit. Thereby the electrical energy-density of the system can be enhance so much, that the electrical circuit contains about the same amount of energy as the mechanical oscillation. This helps us to get rid of the weak link in the system, which has been the electrical part.

The disadvantage of the procedure is the rather large mathematical effort for the DFEM-calculations, because we now have to calculate the inductivity of the coil as a function of the position of the coil bobbin. This causes that we can not use any standard-formulas from any formulary tables. This brings us into the necessity to derive the behaviour of each winding individually, and to derive the behaviour of the whole coil as a summation of the behaviour of each winding. Therefore we chose a setup as shown in fig 11.

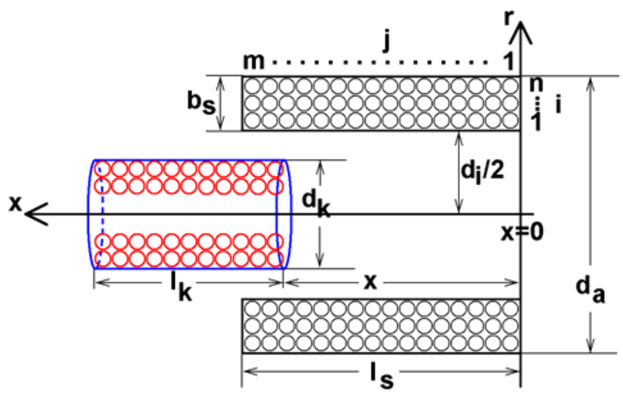

Figure 11:
Characterization of the parameters of a coil bobbin (blue), which is emulated as a cylindrical coil (red), and which is oscillating inside a real cylindrical coil (black). On the one hand, the coil bobbin takes up Coulomb-forces from the magnetic field of the outside cylindrical coil, but on the other hand, the coil bobbin induces a voltage into the outside cylindrical coil due to its movement relatively to the outside cylindrical coil. The crucial point is, that the coil bobbin influences the inductivity of the coil.

Abbreviations:
l_s = length of the coil body
b_s = latitude of the coil body
d_i = inner diameter of the coil body
d_a = outer diameter of the coil body
D_d = diameter of the coil's wire
n = number of windings in radial direction
m = number of windings in axial direction
d_k = diameter of the coil bobbin
l_k = length of the coil bobbin
x = deflection of the coil bobbin relatively to the rest position
l_s-x = retrection depth of the coil bobbin into the outside cylindrical coil

The theoretical simulation now goes as following:
The magnetic field of a cylindrical permanent magnet has the same structure as the magnetic field of a cylindrical coil, thus we can calculate both fields in the same way. Therefore we use the law of Biot-Savart and calculate the magnetic field of each single conductor loop (as shown in fig.12). The magnetic field of one conductor loop of the coil causes a Lorentz-force onto each single conductor loop of the coil simulating the coil bobbin. If we calculate in such way the interaction between each pairs of all single conductor loops (in combination), we can sum up all forces of interaction until we get the total force between the coil bobbin and the cylindrical outside coil. This calculation was done for each arbitrary position of the coil bobbin relatively to the cylindrical outside coil, so that a force-deflection curve was computed.

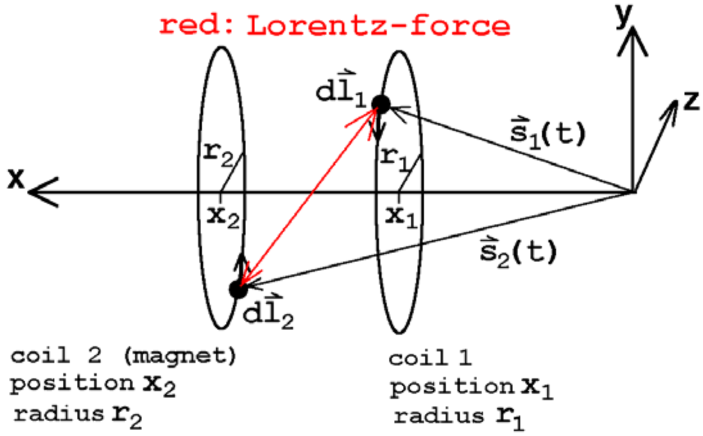

Figure 12:
Illustration of the parameters of two single conductor loops interacting with each other. The parameters are used for the application of Biot-Savart's law and for the calculation of the Lorentz-forces between the conductor loops.

The field produced by a finite conductor element of loop 1 at the position of a finite conductor element of loop 2 is (see [Jac 81])

$$dH = \frac{q_1 \cdot \vec{v}_1 \times (\vec{s}_1 - \vec{s}_2)}{4\pi \cdot |\vec{s}_1 - \vec{s}_2|^3} \cdot \frac{d\varphi}{2\pi} \tag{17}$$

Summation over all finite conductor loop elements of loop 1 brings us to the total field produced by this loop:

$$\vec{H} = \oint_{(A)} d\vec{H} \quad \Rightarrow \quad \vec{B} = \mu_0 \cdot \mu_r \cdot \vec{H} \tag{18a}$$

For the magnetic field of a cylindrical permanent magnet has the same structure as the magnetic field of a cylindrical coil, we can use this consideration for the calculation of the magnetic field of both components in the same way. The Lorentz-force acting onto the conductor loop elements of loop 2 are then calculated in the usual way:

$$d\vec{F} = I_2 \cdot (d\vec{l}_2 \times \vec{B}) \tag{18b}$$

If we conduct the outer vector product within the integrals, then perform the integration, and finally sum up all the forces between all finite conductor loop elements (using the cylindrical symmetry of the setup), we come to the following result:

The field of the permanent magnet (loop 2) can be separated into two components, a radial and an axial component. A motion of the magnet will cause Lorentz-forces. The Lorentz-forces due to the radial component of the field want to move the electrons in the coil (loop 1) perpendicular to the direction of the wires, which is a direction, in which electrical current is not possible. This means that the whole wires take mechanical forces, which we know in every day's life to be the magnetic forces between a magnet and a coil. Their calculation has been demonstrated above. On the other hand, the Lorentz-forces due to the axial component of the magnetic field of the permanent magnet (with its motion) want to move the electrons in the coil (loop 1) into the direction of the wires, where they can flow easily. This gives rise to induction, as we know it in every day's life from the induced voltage in the coil.

The magnetic flux, which the coil bobbin causes in the coil can be derived after some calculation to be

$$\phi = \int \vec{B}\, d\vec{A} = \mu_0 \cdot H_x \cdot A = \frac{\mu_0 \cdot \pi \cdot r_1^2 \cdot r_2^2 \cdot I_2}{2 \cdot \left(r_2^2 + \left(x_1 - x_2 \right)^2 \right)^{3/2}} \tag{19}$$

The current I_2 in coil no.2 (which represents the permanent magnet, loop 2) is to be understood as the current which is necessary to emulate the permanent magnet by a coil.

The derivative of the magnetic flux is the induced voltage in the coil, by which the mechanical motion of the permanent magnet acts into the coil and thus into the electric circuit. Its formula can be developed as following:

$$U_{ind} = -\frac{\Delta \phi}{\Delta t} = \frac{-\mu_0 \cdot \pi \cdot r_1^2 \cdot r_2^2 \cdot I_2}{2 \cdot \Delta t} \cdot \left(\frac{1}{\left(r_2^2 + \left(x_1 - x_2(t) \right)^2 \right)^{3/2}} - \frac{1}{\left(r_2^2 + \left(x_1 - x_2(t - \Delta t) \right)^2 \right)^{3/2}} \right) \tag{20}$$

With these formula we are now able to calculate
- the magnetic forces, which the coil with electrical current causes onto a permanent magnet, and
- the induced voltage, which a permanent magnet in motion brings into a coil.

On this basis we can now perform the DFEM-simulation of the system shown in fig.10.

From this simulation we learn a technical problem, which still prevents us from extracting noteworthy power from the zero-point-energy converter system. The difficulty consists of two aspects, which conflict each other. They are explained as following:

The first aspect results from the mass of the permanent magnet. If we activate the converter system by a mechanical motion of the permanent magnet, the geometrical oscillation of the permanent magnet causes the induction of some voltage-pulses into the coil, but this electrical energy is not enough to excite the electrical oscillation of the LCR-circuit (at least due to the damping of the Ohm's resistance of the wire of the coil). Because of the mass inertia of the permanent magnet, which has to be accelerated and decelerated all the time due to its oscillation, it is impossible to enhance the velocity of motion of the permanent magnet enough, that it will bring a voltage into the coil, which is sufficient to arise a permanent oscillation of the electrical charge in the LCR-circuit. The energetical coupling between the two oscillations (the mechanical and the electrical oscillation) is constrained seriously by the mass inertia of the permanent magnet. We can also regard this aspect from the point of view of the spring (which moves the permanent magnet): If the spring is not very strong (low Hooke's constant), the permanent magnet oscillates rather slow, and the low velocity of the magnet is responsible for the problem, that the induced voltage in the coil is very low. But on the other hand, if the spring is strong (large Hooke's constant), the mechanical amplitude of the magnet is rather low, which also results in the problem, that the induced voltage in the coil is very low. In any case, the electrical oscillation can not be properly coupled with the mechanical oscillation.

The other aspect of the difficulty can be seen, if we try to activate the converter system from the electrical side, putting electrical input-pulses into the LCR-circuit. Due to the Ohm's resistance of the wire of the coil, the electrical oscillation is damped. And the energy of the electrical oscillation is absorbed by the resistance of the wire of the coil so fast, that it is impossible to activate the mechanical oscillation of the permanent magnet via Lorentz-forces. Very low amplitudes are possible, which do not allow satisfactory power-conversion from the zero-point energy.

If we would like to adjust the mechanical oscillation of the permanent magnet to the electrical oscillation of the LCR-circuit, we have to adjust the resonance-frequencies of both oscillations to each other. Therefore we should decrease the mass (inertia) of the permanent magnet (together with Hooke's spring constant) so far, that the mass density of the permanent magnet is lower then the mass density of air. Obviously this is not realistic, but our aim was the theoretical development of a realizable zero-point-energy converter. This means that the setup according to fig.10 is not even capable for a sensible operation of a zero-point-energy converter at all. To say it in clear words: The setup according to fig.10 is not a zero-point-energy motor. It can not convert zero-point-energy by principle.

Nevertheless, this setup helps us mentally to find a way towards a good design for an appropriate zero-point-energy motor. With other words: From the setup in fig.10, we now come to the solution of our energy-extracting problem, namely as following:

We found that the only problem in our design was the mass inertia of the permanent magnet in combination with the fact, that the permanent magnet has to change its direction of motion all the time (twice per period). If we would find a possibility to avoid, that the permanent magnet has to go back and forth all the time, its mass inertia would no longer be a problem. A continuous periodic motion – this would be the solution of our problem. And it is not very complicated. It is a circular motion, a rotation. That's all we need to add into our concept. A circular motion does not need oscillating acceleration and deceleration, but it repeats its position periodically nevertheless. Thus we can enhance the speed of the motion without needing the strong spring-force at all. Mass inertia does not disturb our possibility to enhance the speed of the circular motion. The periodicity of the rotation can be easily understood, if we regard the Cartesian components of this motion. This approach will indeed be our solution of the energy conversion problem as well as of the energy extraction problem.

6. The solution: A zero-point-energy motor with a rotating magnet

For the mechanical rotation, we want to use a magnet with cylindrical shape, but for the electrical induction of voltage into the coil, a magnet with a homogeneous field is preferable. (And besides, that calculation is easier with a homogeneous magnetic field, which is indeed important for the elapsed time to run the DFEM-algorithm), so that we decide to use a magnet according to fig.13.

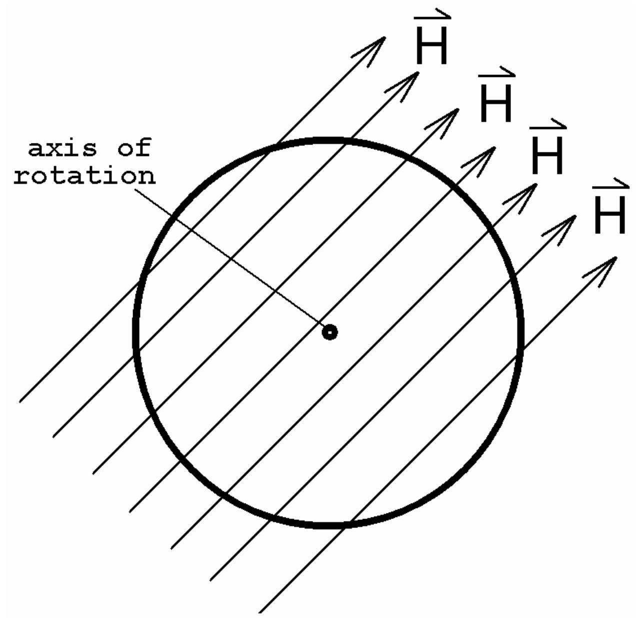

Figure 13: A cylindrical magnet, which produces a homogeneous magnetic field. Such magnets are available in commercial magnet shops.

This magnet has to rotate inside a coil with "n" windings. All windings can be located at the same position in good approximation. Other then in section 5, this is a good approximation here, because the magnet interacts with the coil not by translation but by rotation.

Also due to the rotation we now have to deal with a torque acting onto the magnet (and not with linear forces as it was the case in section 5). This means that we want to take the motion as a pure rotation in the DFEM-simulation. Consequently we have to calculate the torque between a magnetic dipole and the magnetic field of the coil. Because of Newton's axiom "actio = reactio", the magnet gets the same torque as the coil, so that we can calculate the torque of the magnet in the field of the coil or on the other hand the torque of the coil in the field of the magnet as well. Due to the fact that the magnetic field of the permanent magnet is homogeneous, the calculation of the torque onto the coil inside the field of the permanent magnet is the more efficient variant, so that we will follow this way.

The magnetic dipole moment $\vec{m}$ of a coil is given in equation (21), the torque of the coil in the magnetic field is given in equation (22) [Tip 03].

$$\vec{m} = n \cdot I \cdot \vec{A} \,, \qquad \text{mit} \quad I = \text{electrical current} \tag{21}$$

$$n = \text{number of windings}$$

$$\vec{M} = \vec{m} \times \vec{B} = n \cdot I \cdot \vec{A} \times \vec{B} \qquad \vec{A} = \text{cross section area and normal vector} \tag{22}$$

$$\vec{m} = \text{dipole moment}$$

$$\vec{B} = \mu_0 \vec{H} \qquad \vec{M} = \text{torque} \tag{23}$$

This calculation of the torque represents the mechanical influence of the coil onto the magnet. This allows us to calculate, how the electrical circuit acts onto the mechanical motion.

The opposite direction of the coupling of the two motion, namely the influence which the rotation of the magnet brings into to the electrical circuit has to be calculated via the induced voltage, which the rotating permanent magnet brings into the coil. This can be performed via the magnetic flux ϕ, which the permanent magnet brings into the coil. It is

$$\phi = \int_A \vec{B} \cdot d\vec{A} = \vec{B} \cdot \vec{A} = |\vec{B}| \cdot |\vec{A}| \cdot \cos(\varphi) \qquad \text{with } \varphi = \varphi(t) = \text{angle between the direction of the magnetic field flux lines and the direction of the area and normal vector of the coil.} \tag{24}$$

An illustration can be seen in fig.14.

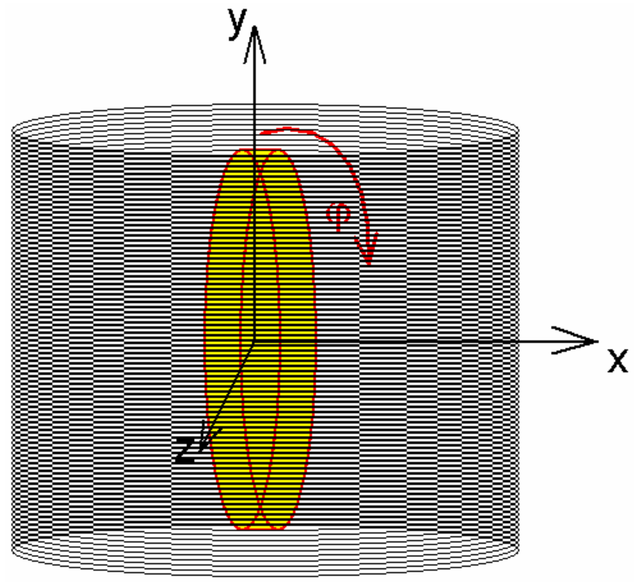

Figure 14:
Placement of the permanent magnet in the coil. The permanent magnet rotates around the x-axis, so that the angle $\varphi(t)$ between the magnetic field flux lines of the permanent magnet and the normal vector of the area of the coil's conductor loops is to be measured relatively to the y-axis.

The induced voltage is now

$$U_{ind} = -n \cdot \frac{d\phi}{dt} = -n \cdot |\vec{B}| \cdot |\vec{A}| \cdot \frac{d}{dt}\left[\cos(\varphi(t))\right] = \underbrace{+n \cdot |\vec{B}| \cdot |\vec{A}| \cdot \sin(\varphi(t)) \cdot \dot{\varphi}(t)}_{\text{use chain rule for derivative}} \tag{25}$$

The one component of the torque, which is responsible for the acceleration and the deceleration of the rotation of the magnet is the x-component, namely M_x . For the vector calculus in equation (22) can be done most easy in Cartesian coordinates, we write (leaving away the arrow over a vector-size means a calculation of its absolute value):

$$\vec{m} = n \cdot I \cdot \vec{A} = n \cdot I \cdot A \cdot \vec{e}_y = n \cdot I \cdot A \cdot \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix} \tag{26}$$

$$\vec{B} = \mu_0 \vec{H} = \mu_0 H \cdot \begin{pmatrix} 0 \\ \cos(\varphi(t)) \\ \sin(\varphi(t)) \end{pmatrix} \tag{27}$$

$$\Rightarrow \vec{M} = \vec{m} \times \vec{B} = n \cdot I \cdot A \cdot \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix} \times \mu_0 H \cdot \begin{pmatrix} 0 \\ \cos(\varphi(t)) \\ \sin(\varphi(t)) \end{pmatrix} = \mu_0 \cdot n \cdot I \cdot A \cdot H \cdot \begin{pmatrix} \sin(\varphi(t)) \\ 0 \\ 0 \end{pmatrix} \tag{28}$$

We come to the crucial x-component of the torque: (29)

$\mathrm{M_x} = \mathrm{B_0} \cdot n \cdot I \cdot A \cdot \sin(\varphi(t))$ because of $\vec{B}_0 = \mu_0 H$

The inductivity of a cylindrical coil can be found in every good standard formulary-table [Stö 07]

$$L = \frac{\mu_0 \cdot A \cdot n^2}{l}, \quad \text{with } l = \text{length of the coil} \tag{30}$$

Because the rotation always goes back into its starting-point without any restoring spring-force, we do not have a spring at all, and thus no oscillation in our calculation. Therefore a spring-term in the mechanical differential equation is not to be applied any more here.

The electrical part of system of two coupled differential equations can be used identically as in our former consideration (see for instance section 5) and also follows the equations (1), (2), (3), (4). But we now want to set the input voltage identically to zero, i.e. $U_{in}(t) = 0$, because we do not need any input voltage at all. We will soon see, that the machine is self-running, i.e. it works without any classical energy input. And we will also see, that the machine operates stable, so that it does not need any triggering.

The mechanical part of the differential equations is based on the rotation:

$$J \cdot \ddot{\varphi} = \mathrm{M_x} = \mathrm{B_0} \cdot n \cdot I \cdot A \cdot \sin(\varphi(t)) \tag{31}$$

$$\Rightarrow \ddot{\varphi} - \frac{\mathrm{B_0} \cdot n \cdot I \cdot A}{J} \cdot \sin(\varphi(t)) = 0 \tag{32}$$

[Dub 90]

with $J = \frac{1}{2} m_T r_M^2 =$ inertia of rotation of the cylindrical magnet

$m_T =$ inertial mass of the magnet

$r_M =$ radius mass of the magnet (half of its diameter)

This is indeed the differential equation to describe a rotation.

The coupling between the differential equations (1), (2), (3), (4) and the differential equation (32) is given via the magnetic (Lorentz-) forces and via the induced voltage.

Our coupled system of inhomogeneous differential equations of 2nd order contains nonlinear disturbance functions. Thus it is sensible to solve it numerically with our DFEM-algorithm. The Sorce-code of the algorithm is printed in the appendix of the article. The central part of the solver can be seen in the body of the main program [Bor 99]. The coupling of the differential equations is explained in the following equations (33) and (34). The Sorce-code of the algorithm has to take additionally constants of integration into account, which are taken from the initial conditions of the system [Bro 08].

$$\ddot{\varphi}(t) = -\frac{\mathrm{B_0} \cdot n \cdot A}{J} \cdot \dot{Q}(t) \cdot \sin(\varphi(t)) \tag{33}$$

$$\ddot{Q}(t) = \frac{\mathrm{B_0} \cdot n \cdot A}{L} \cdot \dot{\varphi}(t) \cdot \sin(\varphi(t)) \tag{34}$$

At first the algorithm has to be verified. Therefore a torque-computation was checked with a constant electrical current in the coil. The rotation of the permanent magnet has been started with constant angular velocity, and the rotation was observed as a function of time (see fig.15). Obviously the angular velocity is modulated by the magnetic forces as expected.

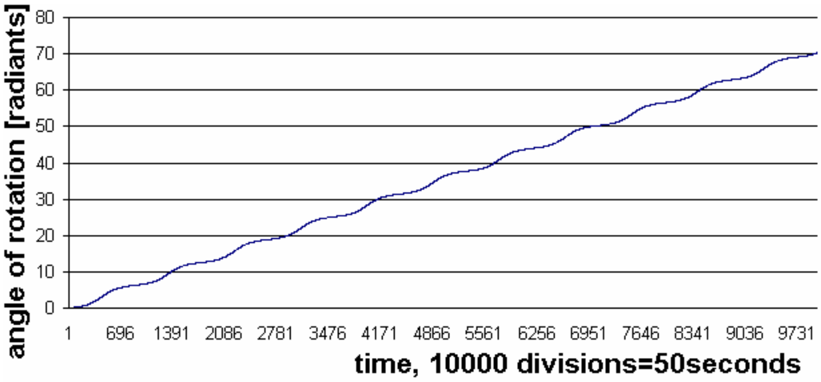

Figure 15: Display of the angle of the rotation, which shows the modulation of the angular velocity, due to the magnetic forces between the magnet and the coil.

By the way, the angular acceleration does not follow a sine shape, as can be seen in fig.16.

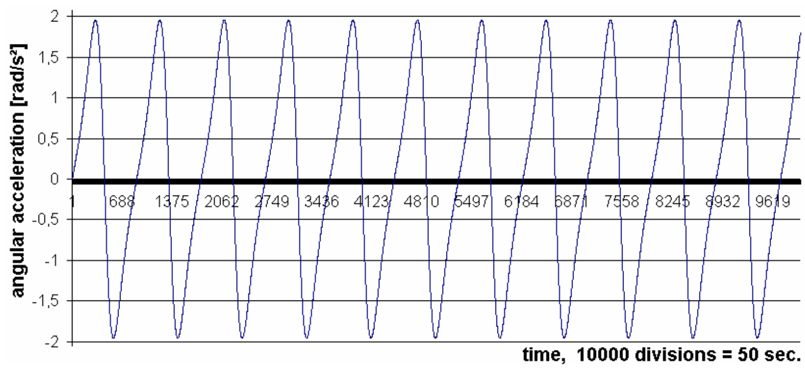

Figure 16: This is the angular acceleration, which leads the motion shown in fig.15.

If we start the rotation with a constant angular velocity, and allow the coil to take induced voltage, but also produce a magnetic field due to the induced current, we can find very different behaviour of the magnetic forces (as well as very different behaviour of the angle of rotation), depending on the choice of the system-parameters. An example therefore is shown in fig.17 (angle of rotation) and in fig.18 (electrical current in the coil). If we analyse the total energy of the system (with normal classical adjustment of the parameters), we find perfectly the conservation of classical energy, this is the energy-sum of the kinetic energy (of the rotation of the magnet), the electric energy in the coil and the electric energy in the capacitor, because the potential energy of the magnet in the coil is converted immediately into electrical energy going into the coil (and later also into the capacitor).

For the purpose of illustration: During the rotation of the magnet, a voltage is induced into the coil, which converts mechanical energy (in the rotation) into electrical energy in the LCR-circuit. But the Lorentz-forces convert electrical energy in the opposite way back from the LCR-circuit into energy of the mechanical rotation. This causes a rather complicated type of motion of the magnet, as can be seen in fig.17.

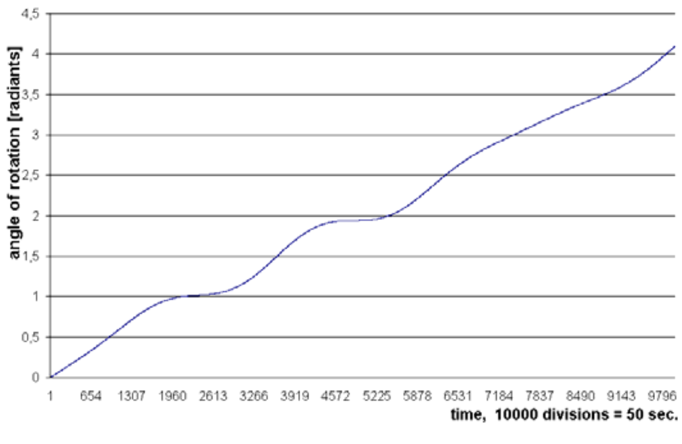

Figure 17: Angle of rotation of the magnet inside the coil.

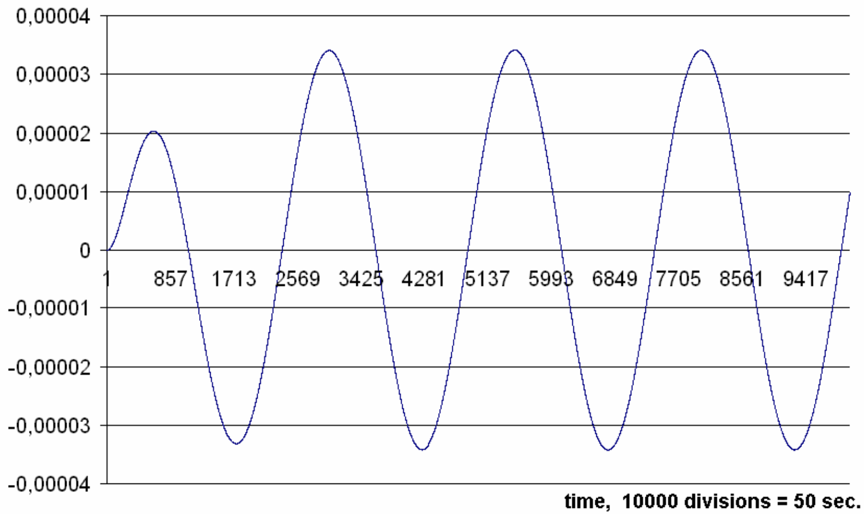

Figure 18: Electrical current (Amperes) in the coil, which is caused by induction due to the rotation of the magnet.

We now introduce the Ohm's resistance of the wire, from which the coil is made (and later additionally also some additional load resistance for the purpose of the extraction of energy from the system). By this means we come to the following test of verification:

We start the rotation with a constant angular velocity (as initial condition), but without any electrical charge or energy in the LCR-circuit. The rotation of the magnet induces a voltage into the coil, which then causes some energy-loss at the resistor. This absorbs some energy from the system as can be see in fig.19 (the kinetic energy of the rotation is decreasing as a function of time) and in fig.20 (the electric current in the coil is decreasing also as a function of time).

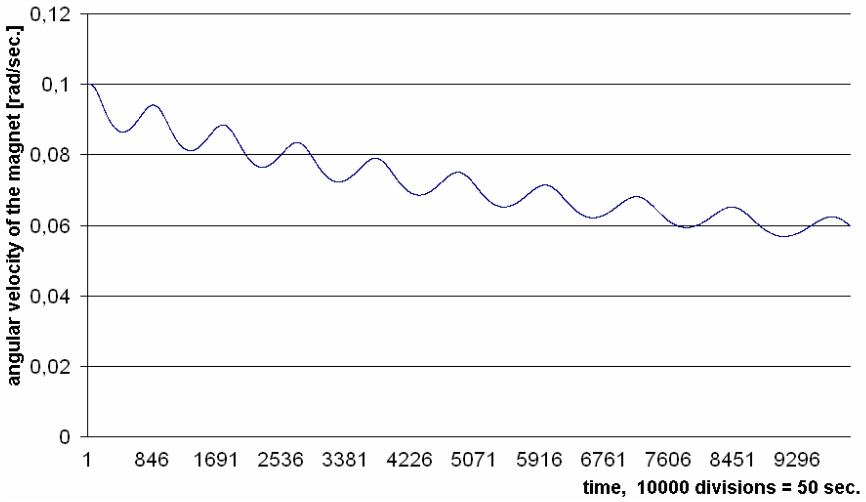

Figure 19: Angular velocity as a function of time.

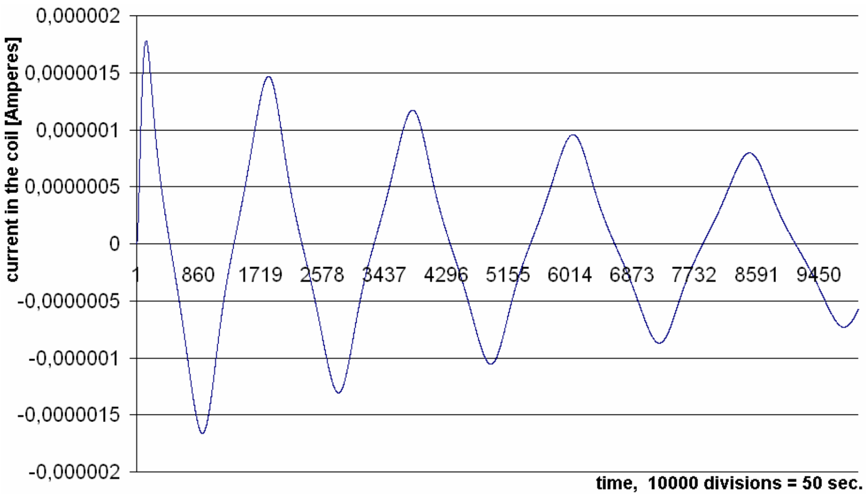

Figure 20: Electrical current in the coil as a function of time.

If we reduce the Ohm's resistance to zero (the wire of the coil as well as the load resistor), for the purpose of verification, we can verify the conservation of classical energy accurately: Fig.24 shows the total energy of the system as the sum of the coil's energy (fig.21), the capacitor's energy (fig.22) and the rotation-energy of the magnet (fig.23) [Bec 73] – as long as the system's parameters are not adjusted for the conversion of zero-point energy.

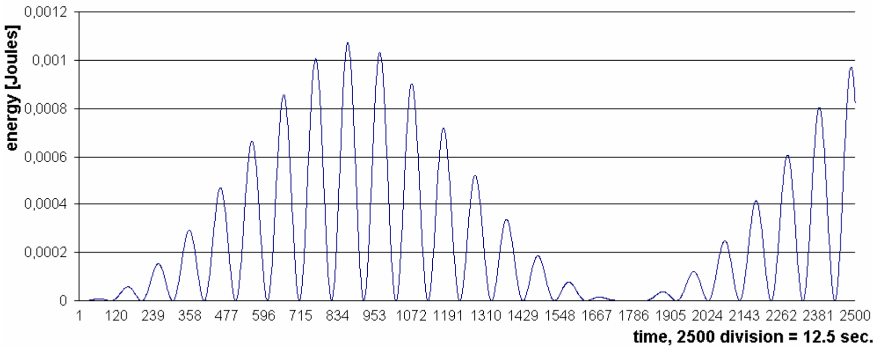

Figure 21:
Energy in the coil
$E_S = \frac{1}{2} L \cdot I^2$

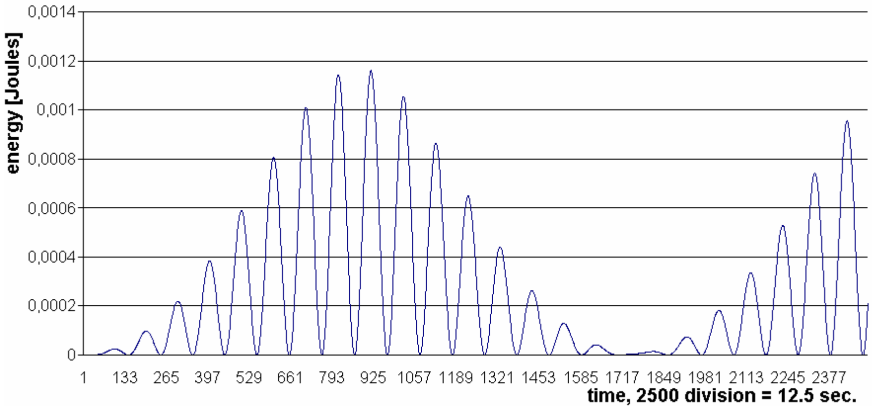

Figure 22:
Energy in the capacitor
$E_C = \frac{1}{2} C \cdot U^2$

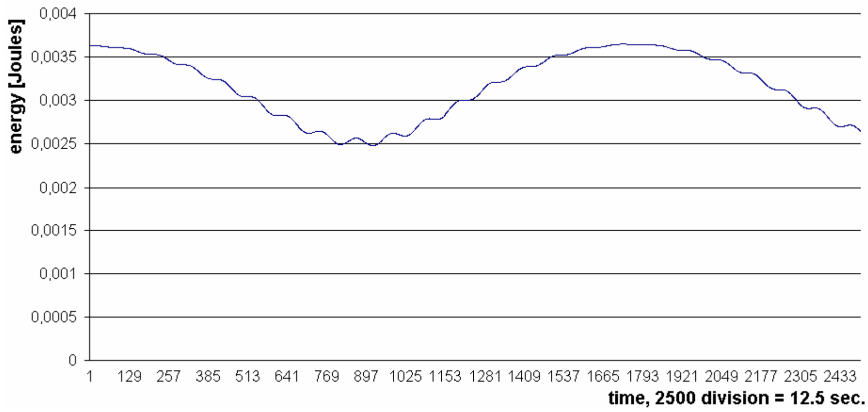

Figure 23:
Energy of rotation in the magnet
$E_R = \frac{1}{2} J \cdot \omega^2$

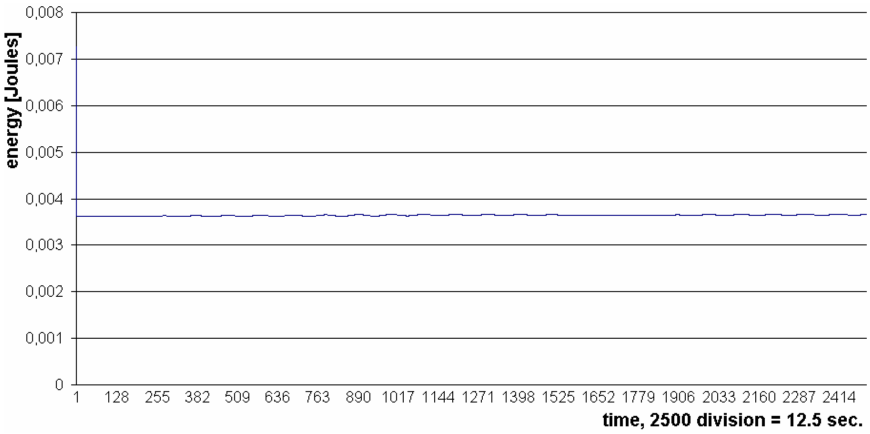

Figure 24:
Total energy-sum
$E_{Ges} = E_S + E_C + E_R$

Except for numerical noise, the total energy-sum is constant (when solving the differential equation without adjustment to zero-point-energy conversion).

We now begin the adjustment of the system parameters for the conversion of zero-point-energy. Therefore we have to align the resonance frequency of the electric LCR-oscillation-circuit with the frequency of rotation of the permanent magnet. But they can not be identical, because the power-extraction from the electric circuit acts like a damping of the oscillation-circuit, which de-tunes its characteristic resonance frequency.

We approach to the adjustment of the system parameters with all resistors being switched of (Ohm's resistor and load resistor both being zero). Then we start the rotation of the magnet with a well defined number of revolutions per minute. Under these conditions, we start to adjust the electric LCR-oscillation-circuit to the same frequency as the rotation of the magnet has. At the beginning, the electrical circuit did not contain any energy. When the adjustment of the electrical oscillation-circuit is close enough to the frequency of the initial rotation, we have a state of the system, which can be understood as the double-resonance of the electrical and the mechanical parts. In this state, the system begins to build up classical energy by alone, and the new classical energy is coming from the zero-point reservoir.

As soon as we have found this point of operation, we can slowly introduce the Ohm's resistance of the coil's wire, in tiny steps, step by step, into the differential equations. But we have to perform very small steps for the enhancement of this Ohm's resistance, and always to renew the adjustment the parameters of the electrical circuit (capacity, inductivity, number of coil's windings) step by step, in order not to lose the state of operation, in which zero-point energy is gained. This procedure has to be done very carefully; otherwise we would lose the information about the good operation of the system. Step by step we learn how to operate the system in a way, that the power-gain from the zero-point-energy is large enough to support the complete coil (with its whole Ohm's resistance) with power. Very carefully we give attention to the double-resonance in order not to lose it.

When this mode of operation is found, the rotor runs safe and reproducible with the system parameters we have found, to be a self-running engine. With these parameters, the motor can be started with a given initial number of revolutions per minute. Therefore it is started once by hand, and then the rotation continues by alone, being supplied from the zero-point energy of the quantum-vacuum. We now can measure the angular velocity of the rotor (see fig.25) und the electrical current in the coil (see fig.26). Now it is clear, that the total sum of the classical energy within the system is not constant, because the system is connected to the zero-point energy of the quantum-vacuum (fig.27).

By the way, it should be mentioned, that an improper adjustment of the system parameters can have the consequence, that classical energy is converted into zero-point energy of the quantum-vacuum. In this case, the engine has to be feeded with more classical mechanical energy, than the Ohm's resistances consume. This means, that under such operation, the total energy sum, including the Ohm's losses and the load is not constant, but decreasing during time. The lack of classical energy, which can not be explained from classical energy conservation, has its reason in the conversion of classical energy into some zero-point energy of the quantum-vacuum. This means that the machine can be used in both directions: As a converter of classical energy into zero-point energy as well as a converter of zero-point energy into classical energy.

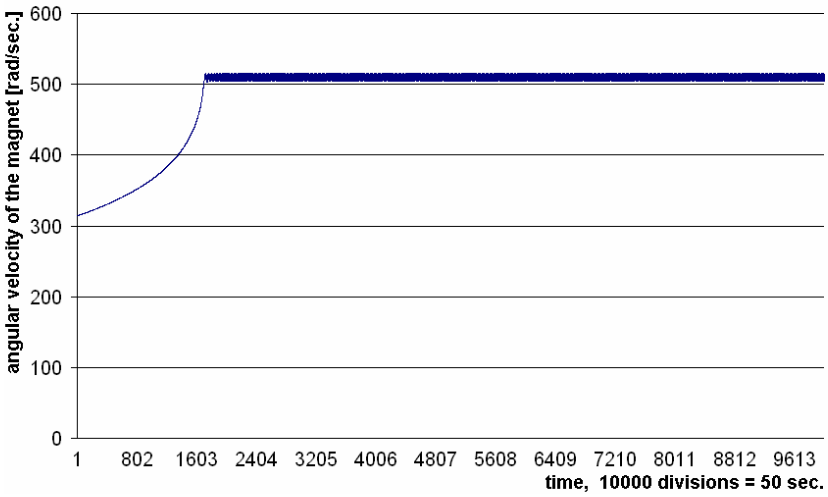

Figure 25:
Angular velocity of the rotation.

Due to the high revolution speed, the resolution of the graphics does not allow to see the single oscillations.

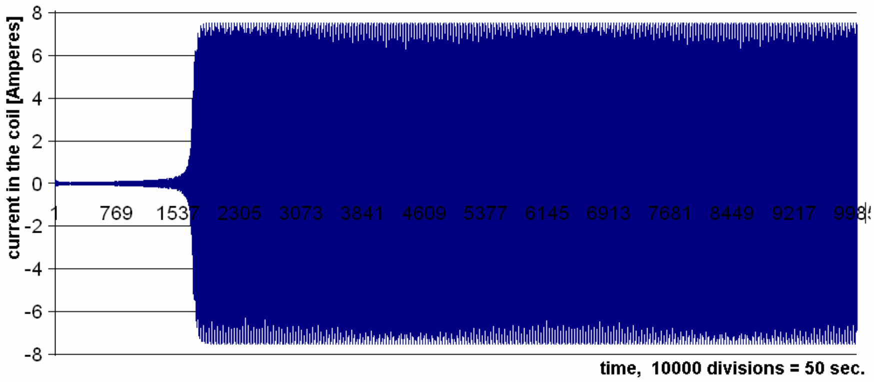

Figure 26:
Electrical current in the coil.

Due to the high revolution speed, the resolution of the graphics does not allow to see the single oscillations.

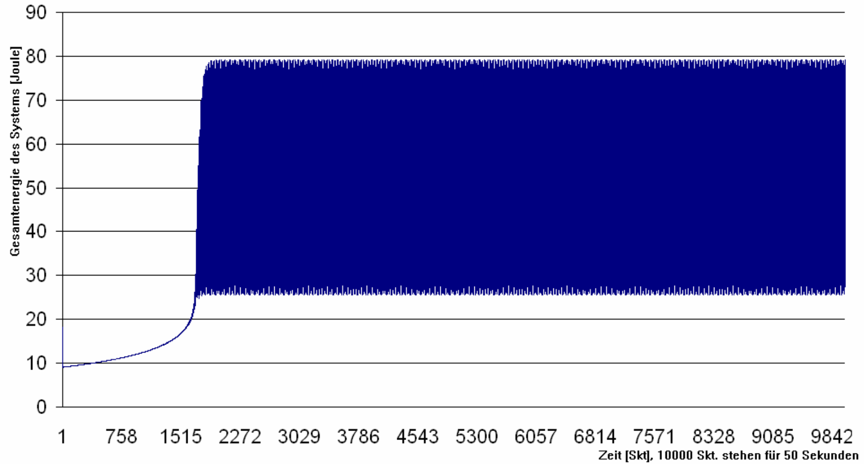

Figure 27:
Total energy-sum of the system.

Due to the high revolution speed, the resolution of the graphics does not allow to see the single oscillations.

Obviously, the system is started with a given angular velocity at the very beginning. From there on, it gains classical energy from the zero-point energy, which it converts completely into the energy of rotation. This is done until the angular velocity of the rotation reaches a certain value. The restriction to this value has its reason in the fact, that a further additional enhancement of the angular velocity would decrease the adjustment of the system parameters, with the consequence that from there on less zero-point energy could be converted. This point is reached at a time of about 1700 Skt. (see fig.25).

From this point on, where the mechanical energy due to the angular velocity must be constant, the energy gain from the zero-point energy is pumped into the electrical circuit, so that from time of about 1700 Skt. up to about 1900 Skt., the electrical oscillation gains energy (see fig.26).

Now both parts of the system are filled up with enough energy, so that the system itself can not take more energy inside than it already has. In this state, every enhancement of the amount of energy inside would decrease the adjustment of the parameters, so that energy will be given away, until the system comes back into its good state of operation. From there we see, that the system runs into a stable operation by alone, so that is not necessary to support trigger-pulses to control the operation. The system can now run (as long as nobody will stop or damage it) being supported by zero-point energy. This state of stable operation can be called as "**energetically saturated**".

We now want to introduce an additional load resistor (additional to the Ohm's resistance of the coil's wire) in order to extract energy from the system (see fig.28). This load resistor will extract permanently energy, which is the energy-output and power- output of the zero-point energy machine. In the differential equations, we have to introduce an additional load resistor in series with the Ohm's resistance of the coil's wire, see equation 35. The calculation of the extracted power is shown in equation 36.

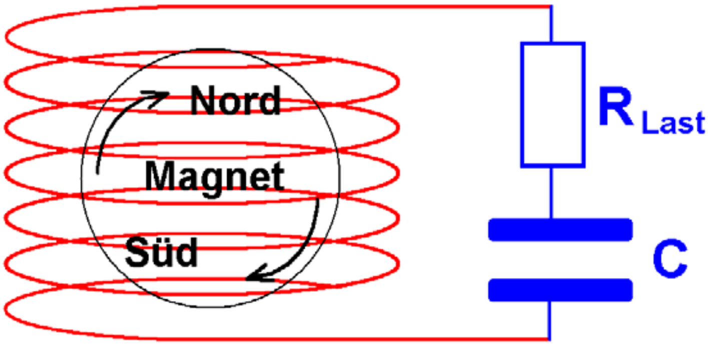

Figure 28:
This setup now shows the results of the present publication:
It is a powerful zero-point energy motor with realizable dimensions.

$$-L \cdot \ddot{Q}(t) + (R + RLast)\dot{Q}(t) + \frac{1}{C} \cdot Q(t) = 0 \qquad (35)$$

$$P_{Last} = U_{Last}\dot{Q} = R_{Last}\dot{Q}^2 \qquad (36)$$

The crucial point is, that the converter has to be driven in a state short below the „energetical saturation", so that the energy-gain from the zero-point energy is maximal. This state of operation can be found in theory quite well, because in theoretical calculations it is easily possible to control the behaviour of the system with very different values of the system parameters very efficiently and very exactly. Under this control it is possible to adjust the system parameters, such as the capacity, the inductivity, the number of windings, and so on… The parameters which have been found for good operation can be seen in the Source-code of the DFEM-algorithm in the appendix.

A practical experiment to build up such a zero-point-energy converter is only sensible on the basis of a well understood theory, from which we can learn how to adjust the system parameters. The adjustment of the system parameters appears difficult enough, that it is not very likely, that anybody might manage to find this adjustment without theoretical understanding: From theory we must learn how adjust the zero-point-energy converter, and in experiment we will have to build up, what we learned from theory.

As soon as the system is adjusted, the motor will run stable, as long as we do not try to extract more energy then the motor can deliver. (For more energy we should use a larger motor.) Our Motor has a diameter of 9 cm and a height of 6.8 cm – so this is not very much – and we will soon see that it produces a power of 1.07 Kilowatt. On the other hand, if the load is decreased, the power production will be decreased. This is a feature of the system, because the system never can overtake the state of "energetic saturation". This feature is a great advantage of the zero-point energy converter presented here, because it never can run away (as it is known from other systems reported in literature, see for instance [Har 10]). This makes our system safe in operation and avoids accidents.

Question: Can the power-density of 1.07 Kilowatts in a cylinder of 9 cm x 6.8 cm be enhanced even more ?

Answer: YES !

In reality the optimization of the system parameters can be developed much further, so that even such a small zero-point-energy converter as in our example could be brought into the Megawatt-range, because the energy- density of the zero-point-energy is tremendously large. But in the example shown here, the further optimization of the system parameters has been withdrawn in order to restrict the converted power to 1kW, because there we reach the limit of the strength of the material. The magnet rotates with 6000 rpm, which should not be a problem for a good commercial bearing, and the copper wire from which the coil is made has a cross section area of 1.0 mm^2 , which is not too much for an electric alternating current of I_{max} = 18 Ampere in the peak (the effective values are smaller of course). This is the reason, why I decided not to demonstrate even more power-density, because this would be not realizable due to the stability of the material.

Let us now have a look into few details of the DFEM-model of the zero-point energy motor:

The electrical current in the coil (see fig.29) is AC, same as in fig.26. But please have in mind, that the time scale in fig.29 is different from the time scale in fig.26, so that the oscillations can be seen now. Please notice, that the energy in the coil (see fig.32) must go back to zero within every revolution, because there has to be a moment in every turn of the magnet, during which the coil does not produce any magnetic field. This is necessary, because the magnetic field has to be switched on and off periodically, otherwise it would not be possible to convert zero-point energy. During each turn of the magnet, there are two moments in time, at which the coil produces a magnetic field, which accelerates the magnet. But there must be intermediate time-intervals between these field-moments, where the magnet has an orientation, that the field would decelerate its rotation. During this intermediate time-intervals, the electrical charge is stored in the capacitor, so that the coil has no current, so that the magnetic field is absent, so that the magnet is not decelerated. The fact that this procedure accelerates the magnet can be seen in fig.30, where the magnet become faster and faster (up to a certain point as stated above). This can be seen in fig.31 very clearly, when we look to the angular velocity. There we see, that the angular velocity is increasing until the motor finally comes into its "energetical saturation".

The fact that the angular velocity contains a small part of an oscillation is also clear, because the rotating magnet is accelerated twice per each turn, and in between there is a time-interval without acceleration. In the intermediate time-intervals between the acceleration, there is even some deceleration, because the flux of the electrical charges, which causes the acceleration needs some time to leave the coil and go into the capacitor. Nevertheless it is clear, that the system is optimized for energy-conversion from the zero-point energy, so that the acceleration and deceleration and the electrical AC-current are adjusted to each other. The result can be seen in fig.32, where we see the total energy-sum of the classical energy in the system. (The saturation is due to the extraction of energy by the load resistor.)

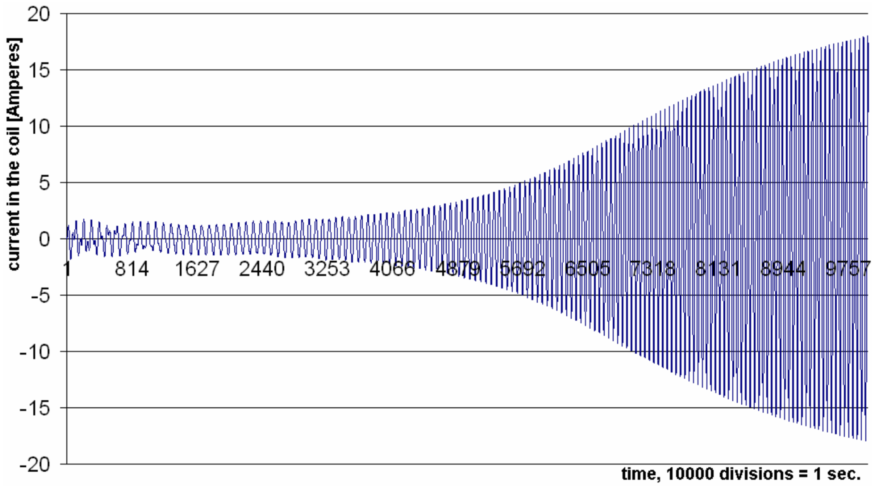

Figure 29: Electrical current in the coil

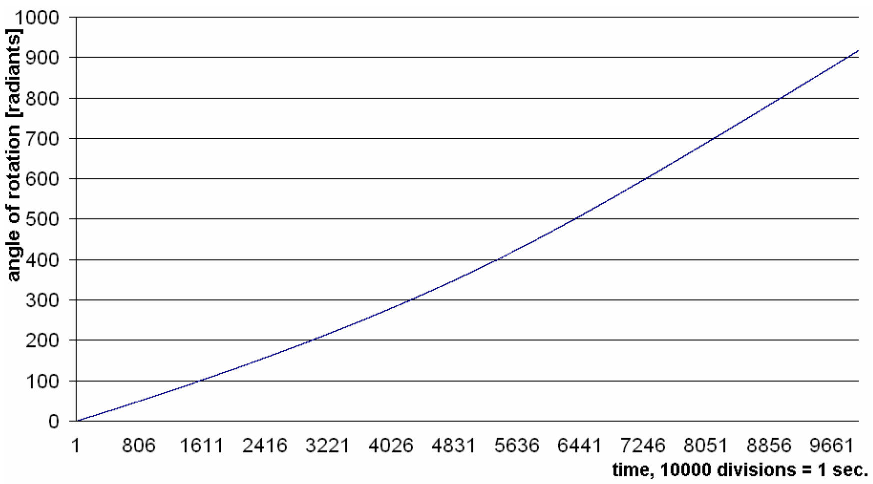

Figure 30: Angle of rotation

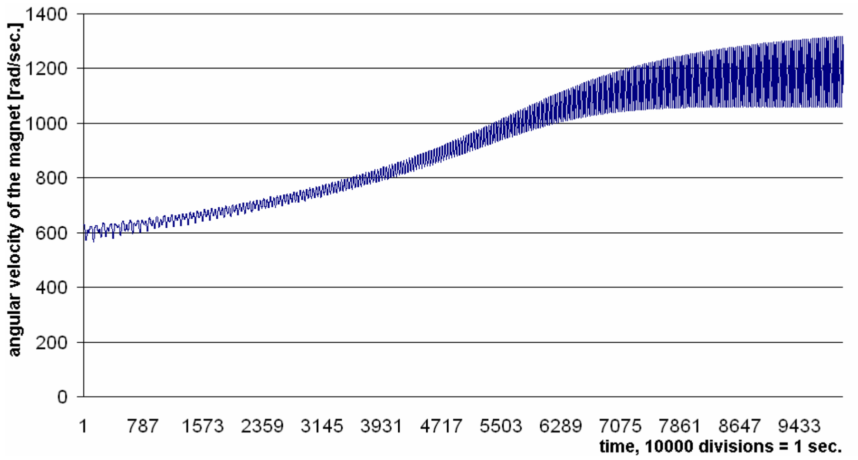

Figure 31:
Angular velocity

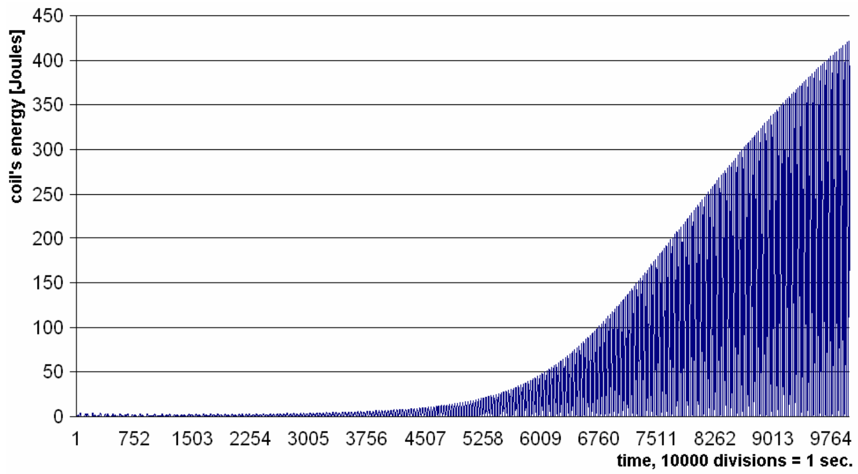

Figure 32:
Energy in the coil

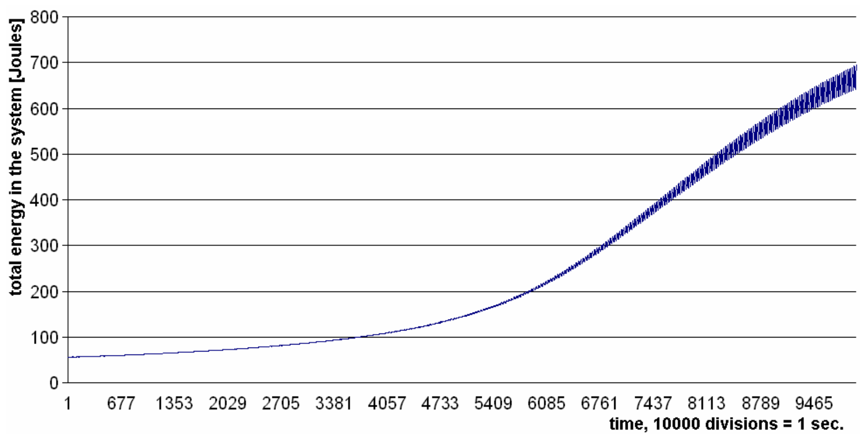

Figure 33:
Total energy-sum in the system.

For we have a listing of the 11 system parameters in the algorithm in the appendix, everybody can understand the presented example and optimize his or her own system and adjust it to the available materials. This means that the theoretical conception is developed far enough, that experimentalists are invited to verify the zero-point-energy converter system in the laboratory. Everybody is welcome to build up his or her own zero-point-energy motor.

7. Resumée

The result of the present work is, that the available theory not only explains the theoretical fundament of the conversion of zero-point-energy, but it also allows to construct a machine with practicable dimensions and powerful operation. It is a self-running zero-point-energy motor in the Kilowatt-range, which is now theoretically understood. On this basis it should be possible to develop a practical setup.

Different from practical experiments reported in literature, this is the first complete theory and a basic understanding of zero-point-energy motors. This arises hope for a reproducible practical machine.

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Claus W. Turtur, PHILICA.COM, ISSN 1751-3030, Article number 213, (7. Dez. 2010)

9. Appendix: Sorce-Code of the DFEM-algorithm

```
Program Magnetic_converter_with_power_extraction;
{$APPTYPE CONSOLE}
uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs;

Const AnzPmax=10000;   {number of time-steps to solve the differential equation}

Type Feld = Array[0..AnzPmax] of Double;

Var epo,muo    : Double;   {constants of nature}
    lichtgesch : Double;   {speed of light}
    n          : LongInt;  {number of windings in the coil}
    A          : Double;   {cross section area of the coil}
    Bo         : Double;   {magnetic field (Amplitude) of the permanent magnet}
    ls         : Double;   {length of the cylindrical coil}
    di         : Double;   {diameter of the coil body}
    Dd         : Double;   {diameter of the wire}
    rm         : Double;   {Radius of the permanent magnet }
    L          : Double;   {Inductivity of the coil}
    C          : Double;   {capacity of the capacitor}
    R          : Double;   {Ohm`s resistance of coil’s wire }
    rho        : Double;   {Specific resistance of copper}
```

```
    phi,phip,phipp : Feld; {angle and its derivatives}
    Q,Qp,Qpp       : Feld; {electrical charge and its derivatives}
    i          : LongInt;  {counter}
    AnzP       : LongInt;  {number of the time-steps in computation}
    dt         : Double;   {duration of the time-steps in computation}
    Abstd      : Integer;  {plot-interval}
    omo        : Double;   {characteristic frequency of the electric oscillation-circuit}
    T          : Double;   {duration per oscillation of the electric oscillation-circuit}
    UC,UL      : Double;   {voltage at capacitor and coil}
    rhom       : Double;   {density of the magnet-material}
    dm         : Double;   {thickness of the cylindrical magnet}
    mt         : Double;   {mass of the cylindrical magnet}
    J          : Double;   {moment of inertia of the cylindrical magnet}
    K0,K1,K2,K3,K4,K5 : Feld;  {control-arrays for display }
    EmA,EmE,siA,siE : Double;  {Energy: average and Sigma "beginning" and "End"}
    delE,sigdelE    : Double;  {alteration of  the averages}
    UmAn            : Double;  {Start value: rounds per time at the beginning}
    Eent            : Double;  {extracted energy, elektrically}
    Rlast           : Double;  {Ohm's resistance for load}

Procedure Wait;
Var Ki : Char;
begin
  Write('<W>'); Read(Ki); Write(Ki);
  If Ki='e' then Halt;
end;

Procedure ExcelAusgabe(Name:String;Spalten:Integer;KA,KB,KC,KD,KE,KF,KG,KH,KI,KJ,KK,KL:Feld);
Var fout   : Text;    {Up to 12 columns can be written}
    lv,j,k : Integer; {counter}
    Zahl   : String;  {to be printed to Excel}
begin
  Assign(fout,Name); Rewrite(fout);       {open File}
  For lv:=0 to AnzP do       {from "plotanf" to "plotend"}
  begin
    If (lv mod Abstd)=0 then
    begin
      For j:=1 to Spalten do
      begin   {Kolumnen drucken}
        If j=1  then Str(KA[lv]:19:14,Zahl);
        If j=2  then Str(KB[lv]:19:14,Zahl);
        If j=3  then Str(KC[lv]:19:14,Zahl);
        If j=4  then Str(KD[lv]:19:14,Zahl);
        If j=5  then Str(KE[lv]:19:14,Zahl);
        If j=6  then Str(KF[lv]:19:14,Zahl);
        If j=7  then Str(KG[lv]:19:14,Zahl);
        If j=8  then Str(KH[lv]:19:14,Zahl);
        If j=9  then Str(KI[lv]:19:14,Zahl);
        If j=10 then Str(KJ[lv]:19:14,Zahl);
        If j=11 then Str(KK[lv]:19:14,Zahl);
        If j=12 then Str(KL[lv]:19:14,Zahl);
        For k:=1 to Length(Zahl) do
        begin   {use commata, not decimal points }
          If Zahl[k]<>'.' then write(fout,Zahl[k]);
          If Zahl[k]='.' then write(fout,',');
        end;
        Write(fout,chr(9));  {Data separation, Tabulator}
      end;
      Writeln(fout,'');    {line-feed}
    end;
  end;
  Close(fout);
end;


Begin {main program}
{ Initialisierung - Vorgabe der Werte: }        {we use SI-units}
  Writeln(vacuum-energy-converter with rotation.');
{ Input-Parameters:}
  epo:=8.854187817E-12{As/Vm}; {Magnetic constant}
  muo:=4*pi*1E-7{Vs/Am};       {Elektric constant}
  lichtgesch:=Sqrt(1/muo/epo){m/s};   Writeln(speed of light c = ',lichtgesch, ' m/s');
{ coil, magnet, capacitor:}
  n:=1600;     {number of windings in the coil}
  di:=0.09;    {diameter of the coil body}
  Dd:=0.0010;  {diameter of the wire}
  Bo:=0.700;   {Tesla} {Magnetic field (Amplitude) of the permanent magnet}
  ls:=0.01;    {Meter} {length of the cylindrical coil}
```

```
  C:=0.23E-6;  {Farad} {capacity of the capacitor}
  rm:=0.039;   {Meter} {Radius of the cylindrical permanent magnet}
  dm:=0.01;    {Meter} {thickness of the cylindrical permanent magnet}
  rhom:=7.8E3;         {density of the magnet-material, iron}
{ composed Parameters, calculated from the above Parameters:}
  A:=di*di; {Meter * Meter} {cross section area of the coil}
  L:=muo*a*n*n/ls;  {Inductivity of the coil}
  omo:=1/Sqrt(L*C); {characteristic frequency of the electric oscillation-circuit}
  T:=2*pi/omo;      {duration per oscillation of the electric oscillation-circuit}
  rho:=1.7E-8; {Ohm*m}  {Specific resistance of the copper wire}
  R:=rho*(2*pi*di*n)/(pi*(Dd/2)*(Dd/2)); {Ohm} {Ohm`s resistance of the coil's wire}
{ Sonstige:}
  UmAn:=100;              {Start value: revolutions per second at the beginning}
  Rlast:=28;              {Ohm`s resistance for load}
  AnzP:=AnzPmax;          {number of the time-steps in computation}
  dt:=0.0001; {sec.}      {duration of the time-steps in computation}
  Abstd:=1;               {how many points to be plotted}
  mt:=pi*rm*rm*dm*rhom;   {mass of the cylindrical magnet}
  J:=1/2*mt*rm*rm;        {moment of inertia of the cylindrical magnet}
{ Anzeige der Werte:}
  Writeln('Inductivity of the coil: L = ',L,' Henry');
  Writeln('Freqency of the harmon.el.Osc.: omo = ',omo:8:4,' Hz => T = ',T:15,'sec.');
  Writeln('length of the coil-wire: ',(2*pi*di*n),' m');
  Writeln('Ohm`s resistance of the coil-wire: R = ',R:8:2,' Ohm');
  Writeln('Mass of the cylindrical permanent magnet: mt = ',mt,' kg');
  Writeln('moment of inertia of the cylindrical magnet: J = ',J,' kg*m^2');
  Writeln('total duration of operation: ',AnzP*dt,' sec.');

{ Begin of the computation.}
  Writeln('Mechaniacl and electrical linked oscillation.');
  UC:=0;{Volt}  Q[0]:=C*UC;         Qpp[0]:=0;  Qp[0]:=0; {Electrical initial values}
  phi[0]:=0;    phip[0]:=UmAn*2*pi;  phipp[0]:=0;         {Mechanical initial values }
  Eent:=0;                             {Reset for: extracted Energy, electrically}
  K0[0]:=0;
  K1[0]:=1/2*L*Sqrt(Qp[0]);  {coil-Energy}
  K2[0]:=1/2*C*Sqr(Q[0]/C);  {capacitor- Energy}
  K3[0]:=1/2*J*Sqr(phip[0]); {Rotation-Energy}
  K4[0]:=K1[0]+K2[0]+K3[0];  {total-Energy}
  K5[0]:=0;
  For i:=1 to AnzP do
  begin
    Qpp[i]:=-1/L/C*Q[i-1]-(R+Rlast)/2/L*Qp[i-1];
    Qpp[i]:=Qpp[i]+n*Bo*A*sin(phi[i-1])*phip[i-1]/L; {Induced voltage into the coil.}
    Qp[i]:=Qp[i-1]+(Qpp[i]-R/2/L*Qp[i-1])*dt;
    Q[i]:=Q[i-1]+Qp[i]*dt;
    phipp[i]:=-Bo*n*Qp[i]*A/J*sin(phi[i-1]); {Mechanical torque, x-component}
    phip[i]:=phip[i-1]+phipp[i]*dt;
    phi[i]:=phi[i-1]+phip[i]*dt;
    K0[i]:=0;
    K1[i]:=1/2*L*Sqr(Qp[i]);   {coil-Energy}
    K2[i]:=1/2*C*Sqr(Q[i]/C);  {Kondensator-Energie}
    K3[i]:=1/2*J*Sqr(phip[i]); {capacitor-Energy}
    K4[i]:=K1[i]+K2[i]+K3[i];  {total-Energy}
    K5[i]:=Rlast*Sqr(Qp[i]);   {extracted power at the load resistor}
    Eent:=Eent+K5[i]*dt;       {extracted energy at the load resistor}
  end;
{ total-Energy-balance and display of the results:}
  EmA:=0; EmE:=0; siA:=0; siE:=0;
  For i:=1 to 10 do  EmA:=EmA+K4[i]/10;              {average at the beginning}
  For i:=AnzP-9 to AnzP do EmE:=EmE+K4[i]/10;        {average at the End}
  For i:=1 to 10 do siA:=siA+Sqr(EmA-K4[i]);         {Variance at the beginning}
  For i:=AnzP-9 to AnzP do siE:=siE+Sqr(EmE-K4[i]);  {Variance at the End}
  siA:=Sqrt(siA)/10;  siE:=Sqrt(siE)/10;             {root mean square deviation}
  Writeln('Energy-values:  E_begin = (',EmA:11:7,' +/- ',siA:11:7,') Joules');
  Writeln('                E_End   = (',EmE:11:7,' +/- ',siE:11:7,') Joules');
  delE:=EmE-EmA;  sigdelE:=Sqrt(Sqr(siE)+Sqr(siA));
  Writeln('=> alteration:  delta_E = (',delE:11:7,' +/- ',sigdelE:11:7,') Joule');
  Writeln('=> converted power = (',delE/(AnzP*dt):11:7,' +/- ',sigdelE/(AnzP*dt):11:7,')
Watts');
  Writeln('extracted power at the load resistor =  ',Eent/(AnzP*dt):11:7,' Watts');
  ExcelAusgabe('test_04.dat',12,Q,Qp,Qpp,phi,phip,phipp,K0,K1,K2,K3,K4,K5);
  Wait;   Wait;
End.
```

Construction guidelines for a ZPE-Converter on the basis of realistic DFEM-Computations

von Claus W. Turtur Wolfenbüttel, April - 3 - 2011

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Abstract

In [Tur 11] the theory of a powerful vacuum-energy converter was developed, and such converters have been simulated with a dynamic finite element method (DFEM). The result was a theoretical description of the machine which should be appropriate for technical applications.

Due to many questions from colleagues who read the mentioned article, the author decided to continue his development on the DFEM-algorithm in order to simulate a zero-point-energy (ZPE) motor on the computer, as close to reality as possible.

The theoretical background of the simulation is explained in detail here, so that every colleague should be able, to use the algorithm in the appendix of the publication and to adapted it to the setup of a vacuum-energy motor according to his own conception.

Table of contents

1. Physical fundament and preliminary work

The algorithm is designed to simulate electric and magnetic ZPE-motors by principle, and it is not restricted to one special design or setup. Thus it allows simulating ZPE-motors with arbitrary position and numbers of coils as well as arbitrary positions and numbers of magnets. Even electrostatic ZPE-motors can be simulated. Also interaction with external entities can be included into the simulation, such as connections of coils with electrical circuits.

The functioning principle of the DFEM-algorithm is the following: Any motion (of mechanical components as well as of electrical charge or even of electrical and magnetical fields) is being brought back to differential equations, which also contain the information of external electrical circuits. Permanent magnets have to be simulated by conductor loops containing electrical current without power supply (which is not an unusual point of view). This allows the algorithm to determine Lorentz-forces, with which external magnetic fields interact with permanent magnets.

In order to present a concrete result (for the suggestion of a prototype), the algorithm which is shown in the appendix, is designed to simulate two coils and one permanent magnet as being drawn in figure 1.

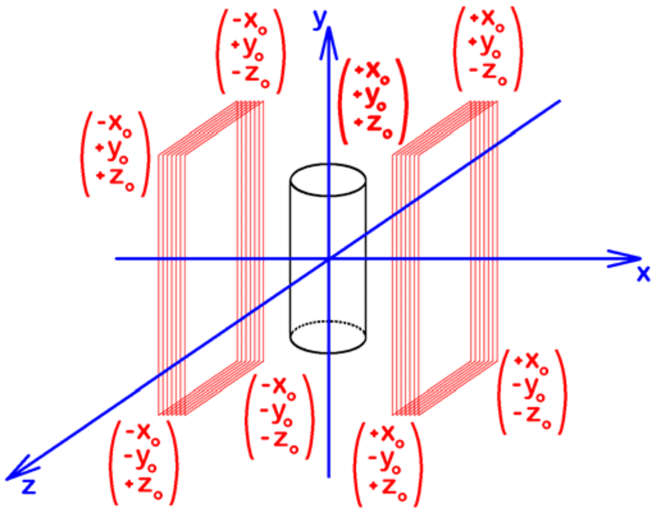

Fig.1:
In a three-dimensional Cartesian coordinate system (blue colour), we see two coils oriented parallel to the yz-plain (red colour). The corners of the coils are located at the Cartesian coordinates as written in red colour. A cylindrical permanent magnet is being simulated by two conductor loops, one at its top end and the other one at its bottom end. The magnet can rotate around the z-axis. The number and the arrangement of the coils can be chosen arbitrarily in the DFEM-algorithm. The example as being shown here, corresponds to the source-code in the appendix of the publication.

In order to prepare the solution of the differential-equations within the DFEM-algorithm, we need the following:

(a.) The computation of the induced voltage, which the rotating permanent magnet induces in the coils,

and

(b.) The computation of the magnetic force Lorentz-force with which the coils act onto the permanent magnet.

These both computations have the purpose to realise the coupling of the mechanical and the electrical parts of the system to each other (see [Tur 11]). On the one hand, the mechanical rotation of the magnet is influenced by the electrical current in the coils due to the Lorentz-force (between these currents and the permanent magnet), and on the other hand the electrical current in the LC-oscillation-circuit is influenced by the induced voltage which the rotation of the permanent magnet brings into the coils.

We now want to turn our attention to those both calculations as given under (a.) and (b.):

<u>Details of a:</u>

The determination of the voltage induced in the coils (due to the motion of the magnet) is based on the time dependent alteration of the magnetic flux ψ, which has its reason in the rotation of the permanent magnet (in our example around the z-axis), which is normally calculated as being seen in equation (1). [Jac 81]

$$\psi = \int \vec{B} \cdot d\vec{A} \;\Rightarrow\; U_{ind} = -\mathrm{N} \cdot \frac{\mathrm{d}\psi}{\mathrm{dt}} \qquad (N = \text{number of windings of the coil}) \qquad (1)$$

This computation begins with a determination of the magnetic field of the permanent magnet as a vector field which has to be stored in a data-array. This can be done experimentally or theoretically, as for instance with one of the subroutines „Magnetfeld_zuweisen", which are marked with different numbers in the source-code in order to allow all the emulation of different permanent magnets. The vector field is now fixed rigidly to the permanent magnets so that each of permanent magnets has its own vector field. As soon as we rotate a magnet, the field is rotating together with its magnet. The rotation around the z-axis is realised with a coordinate-transformation as usual (see equation 2). The angle φ describes the orientation of the length-symmetry-axis of the magnet relatively to the y-axis. (x,y) are the coordinates in the system without rotation (as shown in figure 1), and (x',y') are the coordinates in the system being rotated relatively to (x,y) by an angle of φ. The responsible subroutine in the algorithm has the name „Magnet_drehen".

$$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} \cos(-\varphi) & \sin(-\varphi) \\ -\sin(-\varphi) & \cos(-\varphi) \end{pmatrix} \cdot \begin{pmatrix} x \\ y \end{pmatrix} \qquad \text{Matrix multiplication} \tag{2}$$

By this means, we calculate the magnetic field strength, which the magnet produces at any arbitrary position in the space, namely as a function of the angle φ. Responsible for the computation of the field strength is the subroutine with the name „Feldstaerke_am_Ort_suchen". Furthermore, at the end of this subroutine, the magnetic flux through the coil is being determined, in which the induced voltage has to be calculated. Therefore we use a subdivision of the coils into finite area-element, so that the magnetic flux can be taken into account as a function of the position, where it passes the coils.
In our very example, this computation is being simplified by the fact, that all orthogonal-vectors on all area elements of each coil are orientated exactly into the direction of the x-axis, so that the scalar-product of the field with orthogonal-vectors of the coil-area-elements can be derived as simple as shown in equation (3), namely as the x-component of the flux.

$$\psi_{SFE} = \vec{B} \cdot d\vec{A} = B_x \cdot \left| d\vec{A} \right| \tag{3}$$

The magnetic flux through the whole coil is then being calculated as the sum of all magnetic flux-elements through all finite area-elements forming the coil, so that the total flux follows equation (4).

$$\psi_{GES} = \sum \psi_{SFE} \tag{4}$$

Remark regarding the area-elements of the coil (index „SFE):
In order to formulate the possibilities for the variation of the geometry of the coils as flexible as possible, each coil has to be described as a polygonal line, connecting arbitrarily defined support points. Each coil is modulated connecting its support points with each other. This allows the definition of arbitrarily shaped areas to be surrounded by coils. Finite conductor-loop elements are defined by the geometrical connections between support point and support point. Finite area-elements of the coils fill up the area surrounded by the conductor-loops, so that the magnetic flux through each coil can be calculated as the sum of the finite magnetic flux elements through all area-elements of the individual coil.

From this result as described in equation (4), the calculation of the induced voltage is simply a derivation to time as shown in equation (1). Therefore we need the time-dependency of the orientation of the magnet (given by the angle φ), this is the angular velocity of the permanent magnet at each moment of time. If we check our calculation with a constant angular velocity of the magnet, we come to a result as shown in figure (2).

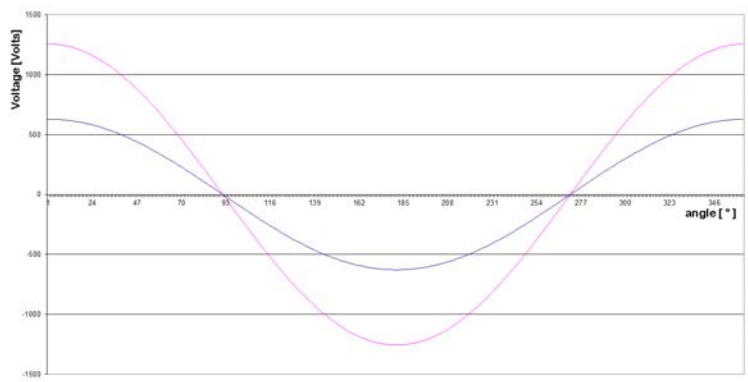

Fig.2:
For the verification of the computation-method, a permanent magnet producing a homogeneous magnetic field was rotated with constant angular velocity, and the induced voltage in both red coils of figure 1 was plotted.
The fact, that both voltages differ by a factor of 2 (from coil to coil) has its reason in the fact, that one coil has twice as many windings as the other one.

For additional computations (see b.), we need to determine the torque which the magnet experiences due to the electric current in the coils. This requirement makes it necessary to emulate the permanent magnet by a configuration of conductor loops. If the magnetic field is not just a simple homogeneous field (on which fig.2 is based), the computation of the magnetic flux depends on the spatial resolution of the computation of the magnetic field. Due to this reason, the magnetic flux of more complicated magnets always display some numerical noise (due to the fact, that the finite elements are not continuous but disctere in spatial resolution). And the problem is, that the numerical noise is enhanced remarkably, when we calculate the derivative to time. An example for such numerical noise is shown in figure 3, as it was calculated by the subroutine „Magnetfeld_zuweisen_02“. When we will emulate a real cylindrical bar-magnet later (with the subroutine "Magnetfeld_zuweisen_03"), the numerical noise will be even much worse.

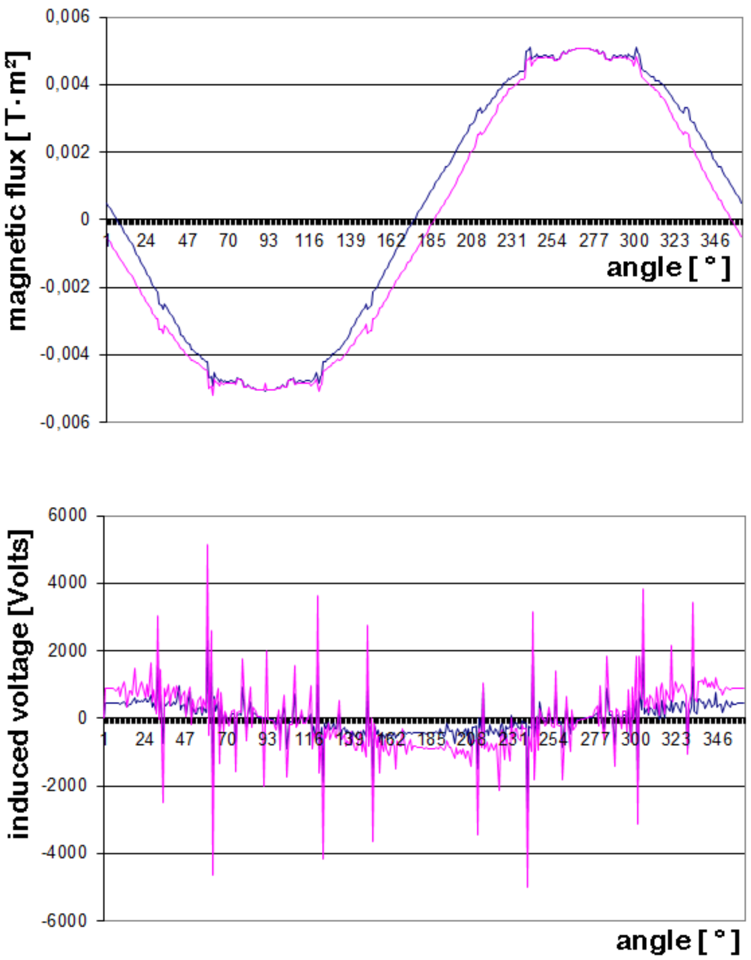

Fig.3a:
Although the magnetic flux from a magnet rotating with constant angular-velocity has only moderate numerical noise, the computation of the induced voltage needs numerical smoothing urgently. Otherwise it would not be sufficient for any use in the DFEM-algorithm.

In order to smooth the numerical noise of the voltage-signal, a Fourier-series was developed (in the subroutine "Fourier_Entwicklung"). It is important to take only low order components (maximum up to fifth order), in order to assure, that high frequency components are excluded. The less high-order components we take, the smoother the signal we get.

An additional effect of the Fourier-series is, that it helps to save CPU-time remarkably, when we will have to calculate the magnetic flux very often for the solution of the differential equation later. The computation of the magnetic flux itself contains a sum (see equation 4), which contains time-consuming operations (see equations 2 and 3), which take much more CPU-time, then the calculation of the Fourier-series with only five rather simple expressions to be summed up. This is important, because the solution of the differential-equation will have to be done with very many time-steps of few nanoseconds, so that the computation of the magnetic flux has to be done several 10^8 or 10^9

during each run of the DFEM-algorithm. This forces us to speed up the very innerst loops in the program, as the computation of the magnetic flux is one of them.

$$\psi_{GES} = \sum_{\nu=1}^{N_0} A_\nu \sin(\nu\,\omega t) \qquad \begin{array}{c}\text{approximation by Fourier-series in 5.order}\\ A_\nu = \text{Fourier-coefficients}\end{array} \qquad \text{(see [Bro 08])} \qquad (5)$$

The fact that the Fourier-series approximation is done in rather low order ($N_0 \le 5$) allows us to determine the Fourier-coefficients very easy by the use of the Gauß'ian method of the least square fit, to compare the Fourier approximation with the original data. This method is used to determine the Fourier-coefficients A_ν .

Details of b:

For the determination of the Lorentz-forces, by which the electrical currents in the coils accelerate the permanent magnets, the emulation of the permanent magnets have being realised (as mentioned above) by conductor loops containing electrical current. In our example for the demonstration, we want to emulate cylindrical bar-magnets, because they are easy to buy and not very expensive, with regard to experiments. For the sake of simplicity, the cylindrical bar-magnets are emulated by two circular conductor loops, located at each end of the cylindrical bar. This means, the magnetic field of the bar-magnets is emulated by the magnetic field of one pair of circular coils.

The parameters we need are only the length of the bar, the diameter of the bar and the magnetic field at each end of the bar. Especially the magnetic field-strength can be adjusted by the choice of the electric current in the conductor loops emulating the bar-magnet.

The calculation of the magnetic field of the emulation-conductor-loops is done with the use of Biot-Savart's law. The approach is illustrated in figure 4.

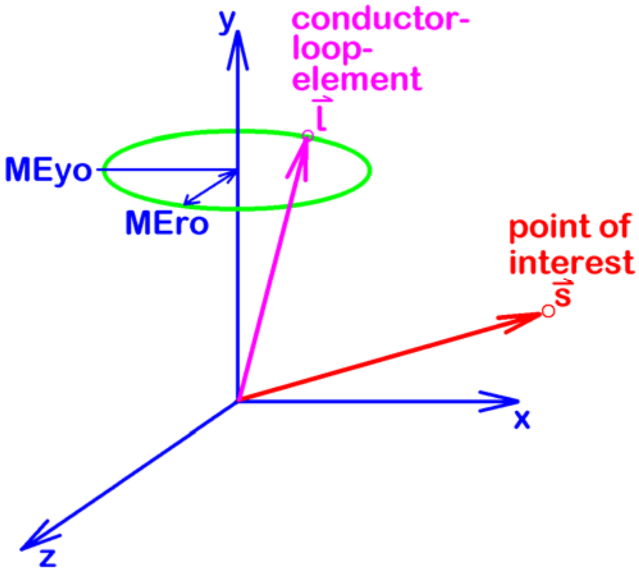

Fig.4:
Illustration of the geometry of a conductor loop (green) whose elements are parametrized by a position vector $\vec{l}$. According to Biot-Savart, we calculate the magnetic field, which the conductor loop produces at any arbitrary point of interest $\vec{s}$.
The conductor loop shown here describes the top end of the cylindrical bar-magnet, which is orientated along the y-axis. Thus the loop is orientated parallel to the xz-plane, has the radius „MEro", and is located at the y-position „MEyo".

The parameterisation of the conductor loop can be realised rather simple according to equation 6.

$$\vec{l}(t) = \begin{pmatrix} MEro \cdot \cos(\omega t + \varphi) \\ MEyo \\ MEro \cdot \sin(\omega t + \varphi) \end{pmatrix} \quad \Rightarrow \quad \vec{v}(t) = \frac{d}{dt}\vec{l}(t) = \begin{pmatrix} -\omega \cdot MEro \cdot \sin(\omega t + \varphi) \\ 0 \\ +\omega \cdot MEro \cdot \cos(\omega t + \varphi) \end{pmatrix} \qquad (6)$$

Giving the point of interest $\vec{s} = \begin{pmatrix} s_x \\ s_y \\ s_z \end{pmatrix}$ in cartesian coordinates, we can introduce equation (6) into the law of Biot-Savart:

$$d\vec{H} = \frac{q_1 \cdot \vec{v} \times \left(\vec{l} - \vec{s}\right)}{4\pi \cdot \left|\vec{l} - \vec{s}\right|^3} \cdot \frac{d\varphi}{2\pi} \tag{7}$$

The outer-product in the counter of equation (7) is

$$\vec{v} \times \left(\vec{l} - \vec{s}\right) = \begin{pmatrix} -\omega \cdot MEro \cdot \cos(\omega t + \varphi) \cdot \left[MEyo - s_y\right] \\ \omega \cdot MEro \cdot \cos(\omega t + \varphi) \cdot \left[MEro \cdot \cos(\omega t + \varphi) - s_x\right] + \omega \cdot MEro \cdot \sin(\omega t + \varphi) \cdot \left[MEro \cdot \sin(\omega t + \varphi) - s_z\right] \\ -\omega \cdot MEro \cdot \sin(\omega t + \varphi) \cdot \left[MEyo - s_y\right] \end{pmatrix} \tag{8}$$

The absolute value of the denominator in equation (7) is

$$\left|\vec{l} - \vec{s}\right|^3 = \left(\left[MEro \cdot \cos(\omega t + \varphi) - s_x\right]^2 + \left[MEyo - s_y\right]^2 + \left[MEro \cdot \sin(\omega t + \varphi) - s_z\right]^2\right)^{3/2} \tag{9}$$

In principle, we now can introduce the expressions of (8) and (9) into the outer product of (7), but in order to make (6) complete, we additionally need the electrical charge q_1 in (8). This has to be determined from the current I in the coil and the propagation-velocity of the electrical charge, as being described by the angular velocity ω. Therefore I and ω have to be combined in such a way, that the motion of the electrical charge is being described appropriately. As we know, the electrical current is defined as the amount of electrical charge flowing per time. Thus we can write:

$$\left.\begin{aligned} I &= \frac{q_1}{T} \\ \mathrm{T} &= \frac{2\pi}{\omega} \end{aligned}\right\} \quad \Rightarrow \quad I = \frac{\omega}{2\pi} \cdot q_1 \tag{10}$$

Therefore either q_1 or ω can be chosen arbitrarily, and the other one has to be adjusted adequately, so that the electrical current I is correct to produce of the magnetic field which has to be emulated. We decide to chose arbitrarily $q_1 = 1\,Ampere$, and to adjust ω. This can be done by a calculating ω from equation 10 as being shown in equation (11):

$$\omega = \frac{2\pi \cdot I}{q_1} \tag{11}$$

For the summation of the infinitesimal field-elements of equation (7), we could in principle solve the integral of equation (12). But the algorithm is designed for arbitrarily shaped conductor loops, and we already have N discrete finite elements, so that we can solve equation (12) by an approximation of a discrete sum as also shown in the same equation (12). But we shall keep in mind that a discrete sum always makes numerical noise (similar as shown in figure 3).

$$\vec{H}_{GES} = \oint\limits_{\substack{Leiter- \\ schleife}} d\vec{H} \approx \sum_{i=0}^{N} d\vec{H} = \sum_{i=0}^{N} \frac{q_1 \cdot \vec{v} \times \left(\vec{l} - \vec{s}\right)}{4\pi \cdot \left|\vec{l} - \vec{s}\right|^3} \cdot \frac{\Delta\varphi_i}{2\pi} \tag{12}$$

The summation has been realised within the subroutine „Magnetfeld_zuweisen_03“, with the variable of summation being $\mathrm{I} = 0 \ldots N$, with the aim to make the argument of the parametrization run from $\mathrm{t} = 0 \ldots T = \frac{2\pi}{\omega}$ (for detailed understanding, please see subroutine in the appendix).

The results have been checked by the classical formula for the calculation of the field-strength (see equation 13) along the axis of the coil (which here is the y-axis), and the check confirms our results.

$$\vec{H}_{Klass} \approx \frac{I \cdot a^2}{2 \cdot \left(a^2 + r^2\right)^{3/2}} \tag{13}$$

Now our simulation of the magnetic field of a cylindrical bar-magnet by the use of two conductor loops at each end of the cylinder is complete.

The determination of the magnetic field of a permanent magnet is not our goal, but it is one important step on our way towards the goal. Our goal finally is the determination of the torque, with which the coil accelerates or decelerates the rotating permanent magnet. Therefore we have to determine the Lorentz-force with which the currents in the coils (red colour in figure 1) does act onto the conductor loops emulating the permanent magnet. With other words: We have to calculate the Lorentz-force, which is the fundament for the calculation of the torque, which the permanent magnet experiences.

Therefore we again use Biot-Savart's law. Now we apply it in a way that we calculate the magnetic field produced by the red coils at the position of the permanent magnet emulation conductor loops, which have been used to emulate the permanent magnet. This is necessary that we can calculate the Lorentz-force, which the permanent magnet emulation conductor loops experience within this field of the red coils

This means, that the conductor loops producing the field to be calculated now, are described by the polynomial line of the red coil, and the points of interest at which the field has to be calculated is the position of each conductor loop-element, which experiences a Lorentz-force. The situation is illustrated in figure 5.

Due to the rectangular shape of the red loops, we could in principle use a polynomial line with only for support points. But in reality this is not sensible, because we need to have several (many) finite area-elements within the red coils, so that the magnetic flux through the coils will be calculated properly (see equation 4).

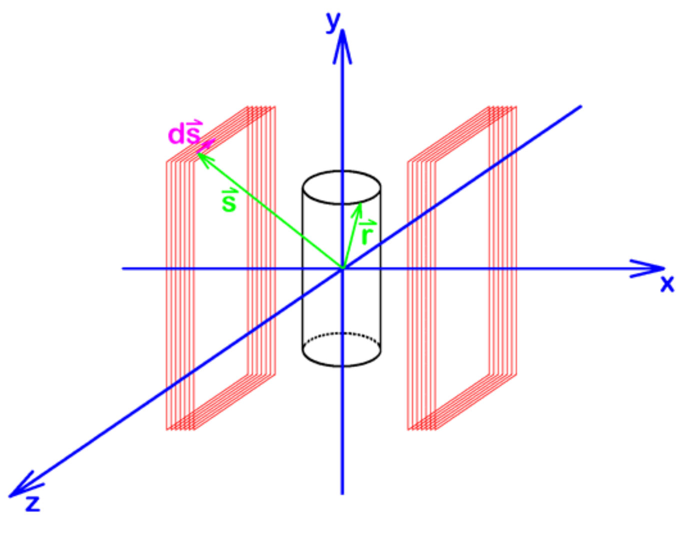

Fig.5:
Illustration of the vectors as being used for the calculation of the magnetic fields of the red coils at the position of the conductor loops emulating the permanent magnet as being used for the application of Biot-Savart's law.

$\vec{s} = \begin{pmatrix} s_x \\ s_y \\ s_z \end{pmatrix}$ conductor-loop element

$\vec{r} = \begin{pmatrix} r_x \\ r_y \\ r_z \end{pmatrix}$ point of interest

$d\vec{s} = \begin{pmatrix} d\vec{s}_x \\ d\vec{s}_y \\ d\vec{s}_z \end{pmatrix}$ motion of the electrical charges in the conductor loop-element

With regard to the parameters according to figure 5, we can write Biot-Savart's law according to equation (14):

$$d\vec{H} = \frac{I \cdot d\vec{s} \times \left(\vec{s} - \vec{r}\right)}{4\pi \cdot \left|\vec{s} - \vec{r}\right|^3} \tag{14}$$

The outer product in the counter is

$$d\vec{s} \times (\vec{s} - \vec{r}) = \begin{pmatrix} d\vec{s}_x \\ d\vec{s}_y \\ d\vec{s}_z \end{pmatrix} \times \begin{pmatrix} s_x - \mathrm{r}_x \\ s_y - \mathrm{r}_y \\ s_z - \mathrm{r}_z \end{pmatrix} = \begin{pmatrix} d\vec{s}_y \cdot (s_z - \mathrm{r}_z) - d\vec{s}_z \cdot (s_y - \mathrm{r}_y) \\ d\vec{s}_z \cdot (s_x - \mathrm{r}_x) - d\vec{s}_x \cdot (s_z - \mathrm{r}_z) \\ d\vec{s}_x \cdot (s_y - \mathrm{r}_y) - d\vec{s}_y \cdot (s_x - \mathrm{r}_x) \end{pmatrix} \tag{15}$$

As usual, we put the expression of (15) into equation (14) to calculate the finite field-elements $d\vec{H}$, which are produced by all finite conductor elements of the red coils. This is the way how we come to the field which the red coils produce at the position of the magnet-emulation-coils. This calculation has to be done individually for each loop-elements of the magnet-emulation-coils. From there we come to Lorentz-force acting onto each magnet-emulation-coil (see equation 16).

$$\begin{aligned} & d\vec{F} = q \cdot \left(\vec{v} \times d\vec{B}\right) = I \cdot \left(\vec{l} \times d\vec{B}\right) \\ & \text{with the field elements } d\vec{B} = \mu \cdot d\vec{H} \end{aligned} \tag{16}$$

From all finite Lorentz-force-elements $d\vec{F}$ we now calculate the finite torque-elements with which they act onto the rotation of the permanent magnet. The summation of these torque elements (as a discrete sum, see equation (17)) delivers the torque on the rotating magnet as being used in the DFEM-algorithm.

$$\begin{aligned} & d\vec{M} = \vec{r} \times d\vec{F} && (\text{finite torque-element}) \\ & \vec{M}_{ges} = \sum d\vec{M} && (\text{Summation for the total torque, approximation by discrete sum}) \end{aligned} \tag{17}$$

The calculations are realised in the subroutine „Drehmoment“.

Due to the spatial discretization, we also have numerical noise which has to be smoothed by a Fourier-series. Therefore we develop the torque as a function of the angle φ of the orientation of the magnet. We again restrict ourselves to fifth order or less in order to exclude high-frequency components for sure (compare (5)).

Again, the elapsed CPU-time to calculate the torque is rather large, so that the explicit torque-calculation is not recommendable within the solution of the differential-equation. Here we have again the advantage to save computer time due to the Fourier-series.

Now we reach the point, that the preparations are complete, as they are the following two steps:

- the calculation of the induced voltage, which the rotation of the permanent magnet induces into the coils, and
- the computation of the torque, with which the electrical current in the coils act onto the permanent magnet.

The subroutines which do this calculations in fast manner (due to the quick Fourier-series) have the names „Schnell_Drehmoment“, „Fluss_T“ and „Fluss_I“. They can be seen in the source code in the appendix.

We summarise the results of section 1 in figure 6 and figure 7, which corresponds to the geometry of figure 5.

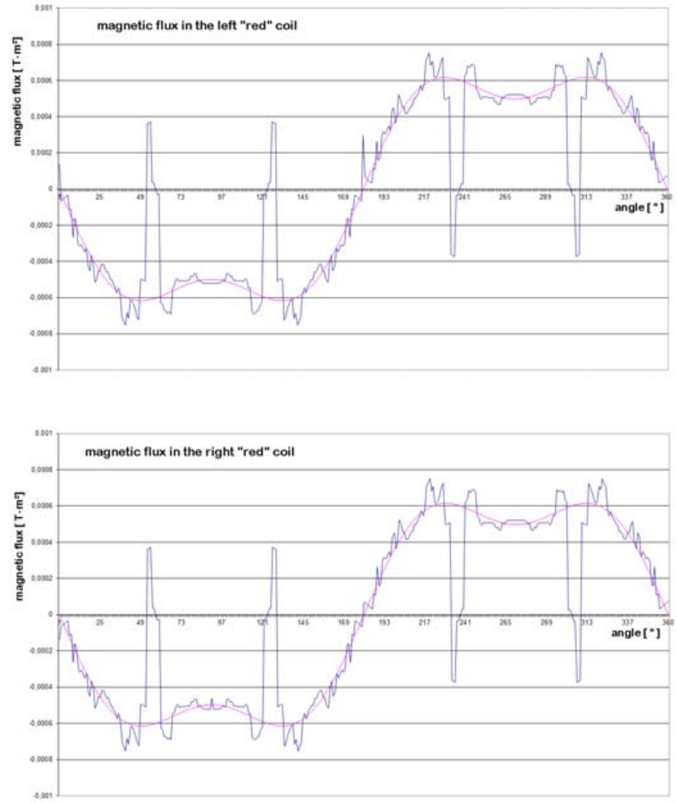

Fig.6:
The magnetic flux, which the permanent magnet according to figure 5 produces in the red coils depends on the orientation of the permanent magnet (angle).
Due to the symmetry of the setup, the magnetic flux has the same value for both coils.
The blue signal allows us to estimate the numerical noise, which has its reason in the spatial discretization of the geometry. The maximum of the numerical noise occurs in the moment, when the windings of the magnet emulation coils, come most close to the wires of the red coils.
The purple signal is a smoothing of the blue signal as being calculated by the approximation of a 5th order Fourier series.

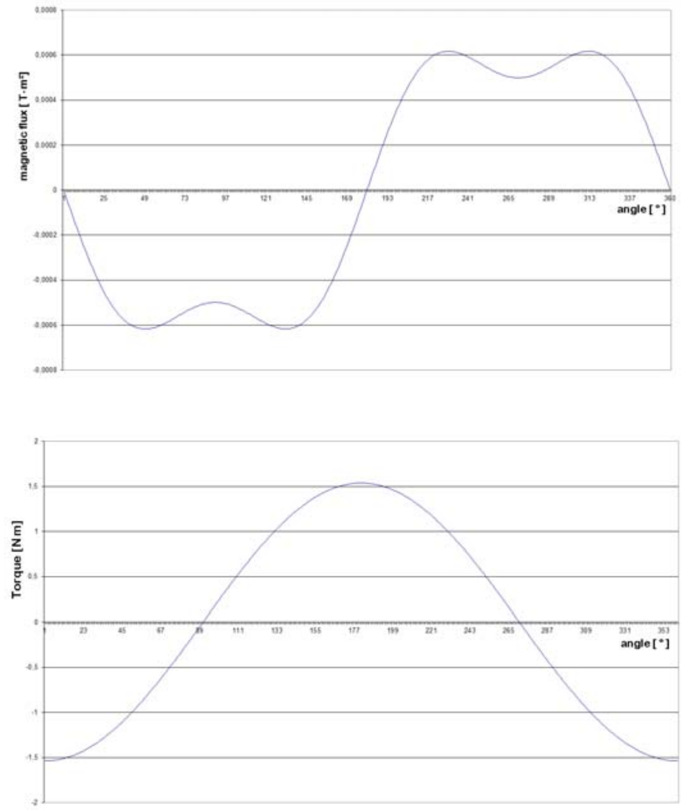

Fig.7:

If we later derive the magnetic flux to time, we calculate the induced voltage in the red coils (later, not printed here). Therefore we need to know the angular velocity of the rotating magnet.

The curve of the torque is made to check the computation. Therefore the red coils are driven with a constant current, so that the torque depends mainly on the orientation of the magnet.

The values for the parameters are:
- permanent magnet, cylindrically, 4 cm thick, 8 cm long, field strength 1 Tesla at ist end.
- „Red“ coils, rectengular, 6 cm wide, 12 cm height, located at x=–2 cm and at x=+2cm.

We explicitely emphasize, that the number of coils can be chosen arbitrarily same as the number of permanent magnets within the DFEM-algorithm presented here. This means that the algorithm can be used for the computation of every ZPE-converter working electrically or magnetically:

- If the DFEM-algorithm is used to emulate several permanent magnets, their interaction can be analysed. This is an interesting application of the algorithm for the simulation of self-running ZPE-magnetmotors, as they can for instance be found at [Hoh 11], [Jeb 06].
- If the DFEM-algorithm is used to emulate several coils, which might be connected with each other by a yoke if requested (in order to conduct the magnetic flux in an appropriate way), motionless ZPE-converters can be simulated, for instance as can be seen at [Mar 88-98], [Bea 02].
- If the DFEM-algorithm is used to emulate one coil and one permanent magnet, the “Electro-Mechanic Double Resonance” converter (EMDR-converter) as proposed by the author of this article can be simulated [Tur 11].
- If the DFEM-algorithm is used to emulate two coils and several permanent magnets fixed to each other in appropriate manner, the Keppe-motor can be simulated [Kep 10].
- If 6 cylindrical bar-magnets are mounted within 6 coils and are arranged with each other in a hexagon, the Coler-apparatus can be simulated. The behaviour of these elements will lead us to a rather complicated differential-equation, and some electrical elements forming an electric circuit are introduced as boundary conditions into the system of differential-equations. (For differential-equations, please see also section 2.) Perhaps, a simulation of the Coler-apparatus might help to decide whether this motionless-converter can work or not. [Hur 40], [Mie 84], [Nie 83]
- Also dynamic input and output of energy is no problem, because the differential-equations describing the motion can be expanded with some input- voltages, load-resistors, an so on… Such elements have to be taken into the differential-equations additionally. Also mechanical force of torque can be applied as boundary conditions in the differential-equations. In order to illustrate this, the source-code in the appendix contains two coils (see fig.5). In the source code, the left coil has of the name input-coil on the right coil has the name turbo-coil (see subroutine “U7”). Additionally there is a load-resistor („R_{Last}“) being connected with the turbo-coil. The rotating axis of the permanent magnet is being supported initially with a given angular velocity, being applied as initial-condition for the solution of the differential-equation. This initial rotation brings energy into the system once at the very beginning of the motion and can then be disconnected. This means that the EMDR-converter is a self running motor, which needs energy support only at the very beginning of the motion to initialise the rotation. Furthermore the input-coil is not active in the source code as printed in the appendix, because of EMDR-converter does not need permanent input-energy, for it is a self running engine. Nevertheless the input-coil can be used if somebody wants to do this, as for instance for the purpose to control the “rounds per minute” of the motor.
- Furthermore the algorithm allows mechanical extraction of power. In our differential-equation this is simulated by a decelerating torque proportional to the angular velocity of the rotation (of the magnet). Such type of energy-extraction can be used to simulate friction as well as to simulate energy-extraction for technical application.
- In order to develop an exemplary ZPE-converter and bring it into a stable permanent mode of operation, it is a convenient method, to control some input-power or to control the extraction of power. With regard to a self running engine, there is no input power, so that we decided to control the output-power in the DFEM-algorithm shown in the appendix. Therefore we define a special value for the speed of revolution (rounds per minute). If the rotation is faster, the energy extraction is enhanced, and of the rotation is less fast, the energy extraction has to be reduced (respecting a given hysteresis, necessary for proper switching). Later we will find out, that our exemplary ZPE-motor can also work without a regulation, but with constand extraction of energy.

The variability of the DFEM-method is large, so that it is not restricted only to magnetic ZPE-converters, but it is also applicable to electrostatic ZPE-converters. The only necessary change is, to replace the Lorentz-force from equation (16) by the Coulomb-force as seen in equation (18).

$$d\vec{F}_{12} = \frac{Q_1 \cdot dQ_2}{4\pi\,\varepsilon_0} \cdot \frac{\vec{r}_1 - \vec{r}_2}{\left|\vec{r}_1 - \vec{r}_2\right|^3} \qquad \begin{array}{c}\text{with finite force-elements,}\\ \text{by which the charge } Q_1 \text{ acts}\\ \text{on finite charge elements } dQ_2.\end{array} \tag{18}$$

The precision of the calculation mainly depends on the precision of the input-data, namely the data of the mechanical and electrical components as well as of the data of the interacting fields with which the components act onto each other.

2. Motion of the components of the ZPE-Converter

In section 1 we did the preparation of the necessary fundamental equations of physics. This is now done, and we can turn our attention towards the solution of the differential-equations describing the motion in the ZPE-converter. Hereby we speak about motions of the mechanical components as well as about motions of the electrical components (such as electrical charges and fields or magnetic fields).

The functioning principle of every ZPE-converter can be described by the motion of its components. The adequate means for this description are the differential-equations based on the interactions of the components with each other.

For ZPE-converters of course do not consist only of one single component, but of several components, which have to interact with each other, we always have two put up and solve coupled systems of differential-equations of higher order. If converters need input-energy (such types which do not work as self running engines, but only as over-unity systems), the energy-input has to be introduced as perturbation-function in the differential-equations. For all types of interaction with some external elements components, the appropriate means is the introduction of perturbation-functions into the differential-equations. This makes the higher order differential-equation systems inhomogeneous.

Mathematically, this has the consequence, that we cannot simply derive an analytical solution, valid for each type of differential-equation system. Consequently, the central core of computation of the DFEM-algorithm is a numerical iterative solver of the differential equations. This topic is, to what we want to focus our attention in section 2.

On this background it is clear, that the DFEM-algorithm needs some certain amount of CPU-time, if you want to have the solution with sufficient precision. You cannot expect the DFEM-algorithm to come to good convergence within few seconds.

The understanding, how the differential-equations of the motions have to be formulated, is the central point of understanding, which every user of the DFEM-algorithm has to work on. Only on the basis of this understanding, the user can apply the DFEM-algorithm onto his own system.

Let us now begin to develop the differential-equations for the example of the EMDR-converter, which define the core of computation of the algorithm. We will do this in analogy to [Tur 11].

The differential-equations by principle operate completely dynamically, so that the DFEM-algorithm has to do the same (taking the finite speed of propagation of the interacting fields into account). This has the consequence, that all physical sizes, entities and values under consideration have to be drawn back to the oscillating electrical charges or to the rotating magnet, using the fundamental entities of $q,\ \frac{d}{dt}q=\dot{q},\ \frac{d^2}{dt^2}q=\ddot{q}$ and of $\varphi,\ \frac{d}{dt}\varphi=\dot{\varphi},\ \frac{d^2}{dt^2}\varphi=\ddot{\varphi}$, where q if the electrical charge and φ is the angle of rotation of the permanent magnet.

From [Tur 11] we learned, that it is necessary to have very fine time-steps in order to get reliable results. Consequently it will not be possible to save all data of all time-steps within special data-arrays. So the program now allows the calculation of as many time steps as required, but the data-storage will be done only for maximum 35,000 points which is a sensible upper limit for the data-export to Excel.

Values as for instance the inductivity of the cylindrical coil (see equation 19) or the momentum of inertia of the rotating magnet as a massive cylinder (see equation 20) are taken from standard textbooks of physics or engineering disciplines.

Inductivity $L=\mu\cdot\frac{N^2\ A}{s}$, with $N=$ number of windings
$A=$ cross-section area of the coil [Ger 95] (19 a)
$s=$ length of the coil-body

Or more precise for short coils:

Inductivity $L=\mu\cdot\frac{N^2\ A}{\sqrt{s^2+\frac{A}{\pi/4}}}$, *mit* $N=$ number of windings (19 b)
$A=$ cross-section area of the coil to be derived from [Stö 07]
$s=$ length of the coil-body

$J_y=\frac{m}{4}\cdot\left(r_a^2+r_i^2+\frac{h^2}{3}\right)$ moment of inertia of rotation of a massive cylinder rotating around a axis perpendicular to its length [Dub 90] (20)

On this basis we can simulate a setup according to figure 8.

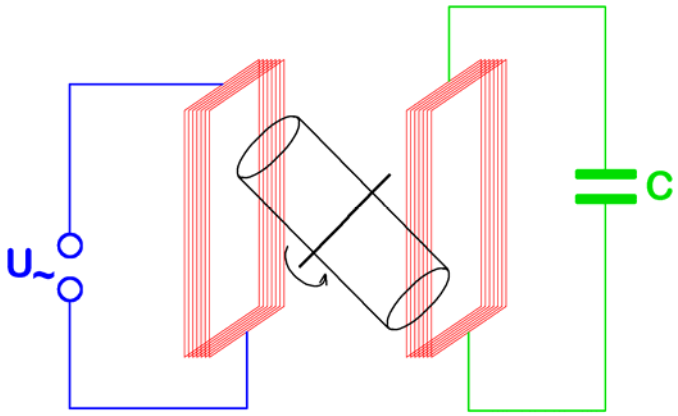

Fig.8:
This is the setup of a ZPE-converter for whose simulation we want to develop the DFEM differential-equations.
It consists of two coils (red colour) and one rotating permanent magnet (black colour) and additionally an input-voltage (blue colour) and one capacitor (green colour).

For our EMDR-converter as our very example of a ZPE-converter can be operated as a self running motor, the input-voltage is not applied at all, so that the left coil together with voltage-supply is taken away completely. Within the source-code, those lines for the simulation of the input-voltage-components are left away; they are marked as comment so that they do not take part at the calculation at all. In order to make the setup symmetrically, the right coil was moved symmetrically around the axis of rotation of the permanent magnet. In order to make clear to everybody how the setup is now looking, figure 9 was drawn. Those elements which are not necessary for the simulation of our exemplary EMDR-converter are only printed as comments in the source-code of the algorithm for those who want to use the algorithm for other ZPE-motors. These comments have only the purpose to help colleagues to simulate their ZPE-machines.

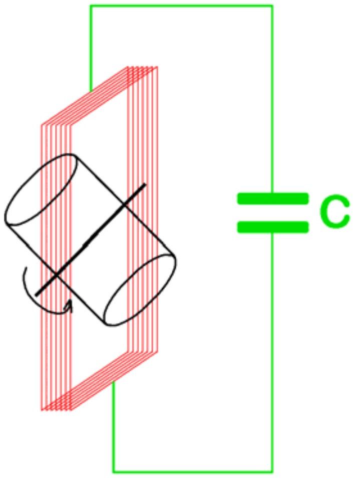

Fig.9:
This very simple setup of an EMDR-converter already allows the powerful conversion of ZPE-energy into classical electrical and classical mechanical energy. Its differential equation system was formulated and solved as explained on the following pages, together with the results describing the behaviour of this ZPE-motor.

The development and formulation of the differential equation system is done rather similar as in [Tur 11].

(a.)

The differential equation of a harmonic oscillation of an electric LC-oscillation circuit is described by equation (21).

$$-L \cdot \ddot{Q} + \frac{1}{C} \cdot Q = 0 \quad \Rightarrow \quad \ddot{Q} = \frac{1}{LC} \cdot Q \tag{21}$$

(b.)

The differential equation of an attenuated oscillation of an electric LCR-circuit is described by equation (22).

$$\ddot{Q} = -\frac{1}{LC} \cdot Q + \frac{R}{L} \cdot \dot{Q} \tag{22}$$

Its numerical iterative solution, as being achieved with the solver of the differential equations in our DFEM-algorithm, is described in equation (23) in analogy with [Tur 11], which is in good agreement with the classical solution (see figure 10).

$$Q_i = \dot{Q}_{i\text{-}1} + \ddot{Q}_i \cdot \Delta t - \frac{R}{L} \cdot \dot{Q}_{i\text{-}1} \cdot \Delta t \tag{23}$$

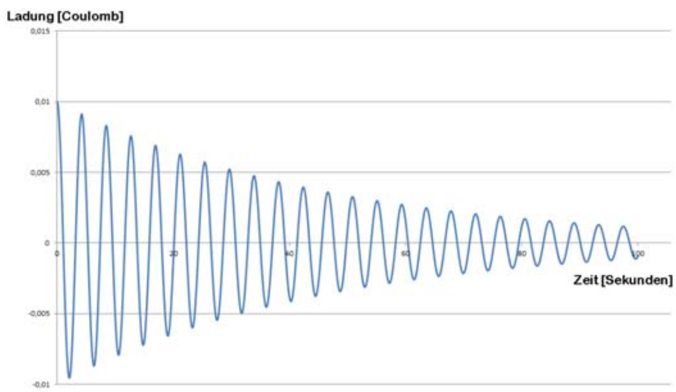

Fig.10:
Verification of an attenuated oscillation in the electric LCR-oscillation circuit for the check of the differential equation (22) and the solution (23).

(c.)

Different from the electrical oscillation, the mechanical motion (of the permanent magnet) is not an oscillation but a rotation and thus it has no restituive force. So we have to take two contributions into account to describe the torque $\vec{M}$. The first contribution goes back to the magnetic field from the coil, which acts onto the permanent magnet. The second contribution goes back to the mechanical extraction of power, which will be the dominant part of the output-power of our ZPE-motor. This second contribution is made by the torque proportional to the angular velocity of the rotation. (Its mechanism could be friction or some other mechanism as well.) The first mentioned contribution is well-known from section 1. The last mentioned contribution will be discussed in detail in section 6.

Consequently the differential equation of the mechanical part of the system can be integrated rather simply as shown in equation (24). This also indicates that equation (24a) contains the coupling of the electrical part of the system into the mechanical part of the system.

$$\ddot{\varphi}(t) = \frac{M(t)}{J} \qquad with \;\; M(t) = torque \;\; and \;\; J = moment\ of\ inertia \tag{24a}$$

$$\Rightarrow \quad \dot{\varphi}(t) = \int_0^t \ddot{\varphi}(\tau)\, d\tau \;\Rightarrow\; numerical\;\; Iteration \;\; \dot{\varphi}(t) = \underbrace{\ddot{\varphi}(t)\cdot dt}_{\text{Integration}} + \underbrace{\dot{\varphi}(t-dt)}_{\text{Integration-constant}} \tag{24b}$$

$$\Rightarrow \quad \varphi(t) = \int_0^t \dot{\varphi}(\tau)\, d\tau \;\Rightarrow\; numerical\;\; Iteration \;\; \varphi(t) = \underbrace{\dot{\varphi}(t)\cdot dt}_{\text{Integration}} + \underbrace{\varphi(t-dt)}_{\text{Integration-constant}} \tag{24c}$$

(d.)

Still missing in our system of differential equations, and thus to be introduced now, is the coupling of the mechanical part of the system into the electrical part of the system. The appropriate means therefore is the induced voltage (and this is the reason, why we did its calculation), which the rotation of the permanent magnet brings into the coil. Therefore the differential equation of the electrical system is expanded, from equation (22), so that we come to equation (25).

$$\ddot{Q} = -\frac{1}{LC}\cdot Q + \frac{R}{L}\cdot\dot{Q} - \frac{U_{ind}}{L} \tag{25}$$

(e.)

On this basis, the numerical-iterative solution of the electrical part of the differential equation system can be integrated according to equation (26) - and by the way in analogy to [Tur 11].

$$\underbrace{\ddot{Q}(t) = -\frac{1}{LC}\cdot Q}_{\text{coil and capacitor}} + \underbrace{\frac{R}{L}\cdot\dot{Q}}_{\substack{\text{Ohm´ian}\\ \text{resistor}}} - \underbrace{\frac{U_{ind}}{L}}_{\substack{\text{Induced}\\ \text{voltage}}} \tag{26a}$$

$$\Rightarrow \quad \dot{Q}(t) = \int_{t-\Delta t}^{t} \ddot{Q}(\tau)\, d\tau \;\Rightarrow\; numerical\;\; Iteration \;\; \dot{Q}(t) = \underbrace{\ddot{Q}(t)\cdot dt}_{\text{Integration}} - \underbrace{\dot{Q}(t-dt)}_{\text{Integration-constant}} \tag{26b}$$

$$\Rightarrow \quad Q(t) = \int_{t-\Delta t}^{t} \dot{Q}(\tau)\, d\tau \;\Rightarrow\; numerical\;\; Iteration \;\; Q(t) = \underbrace{\dot{Q}(t)\cdot dt}_{\text{Integration}} + \underbrace{Q(t-dt)}_{\text{Integration-constant}} \tag{26c}$$

This was the explanation, how the main program of the DFEM-algorithm performs the calculation of the motions of the components of the ZPE-converter, analysing on the one hand the motion of the electrical charges and on the other hand the motion of the rotating magnet. This is a dynamical computation. Therefore the algorithm has the dynamical FEM (=DFEM).

General remark:

Within our calculations it is only allowed to use formulas which follow the dynamics of the system. Also the physical sizes used in these formulas have to respect that this criterion. This means that physical sizes as for instance the mean value of an electrical current, some effective values, and so on… are strictly forbidden. Even physical sizes, entities and values, which somehow refer to a special signal-shape are not allowed, because they do not follow the full dynamics of the differential equations. Those who want to adopt the DFEM-algorithm to their own machines and/or experiments have to be very careful, to respect this criterion without any exception. This is important.

Fundamental philosophical remark regarding the propagation of the fields (and first of all the speed of propagation of these fields) within the electrical circuit:

An electrical LC-oscillation-circuit (which for instance can be seen in figure 9) has an electrical oscillation within the coil and the capacitor.

The question is now: Which type of physical entities do oscillate in this circuit ?

Is it electrical charges which oscillate back and forth ?

No - this is for sure not the case ! This can be understood rather easy, when we follow the electrical charges within the LC-circuit, beginning at the moment of time, at which the coil is free from any electrical current. This is the moment, in which the capacitor is charged up to its maximum voltage and charge, so that the total energy of the oscillation circuit is now stored as electrostatic field energy of the electrostatic field between the capacitor plates. From now on, the capacitor begins to discharge, so that electrical fields (and voltages) propagate along the wire of the coil. From the positive capacitor plate one field propagates towards the negative capacitor plate, and in the opposite way another field propagates from the negative capacitor plate into the direction towards the positive capacitor plate. But the propagating entities are only fields, not charge-carriers (such as for instance electrons or electron holes). There are two reasons explaining this argument: The first reason is, that the charge-carriers can not propagate with the speed of $v = 1/\sqrt{LC}$, which we know to be the speed of the propagating electrical signal. The second reason is, that positive and negative charge-carrier would compensate each other as soon as they meet each other in the middle of the coil. If this would happen (as for instance electrons and electron holes would compensate each other), the complete oscillation would stop as soon as the charge carriers from the different capacitor plates meet each other. This would be the case after one quarter of a period of oscillation. Everybody knows that this is in contradiction with the real observation (at LC-oscillation circuits), so obviously the oscillating physical entities are not charge carriers.

But which are the oscillating physical entities - is it electrical fields ?

Yes - this is indeed the case ! Among the typical properties of electrical fields (as well as electrical waves) is the ability to superpose without disturbing each other, and even to cross the path of each other without taking notice of each other. So we can imagine one field as a wave crest and the other one as a way through, both of them moving from one capacitor plate to the opposite plate, not interfering with each other when they pass the coil at the same moment. Both of them follow their speed of propagation $v = 1/\sqrt{LC}$, and thus the oscillation circuit behaves as we know it from wave theory.

Because of their ability to pass each other without disturbing each other, the positive wave crest and the negative way through reaches the opposite capacitor-plate after half an oscillation, and they take the other half of the oscillation to find their way back "home", and so on… (cyclically…).

Of course the propagating fields cause small displacements of the charge-carriers within the wire of the coil, but these displacements are rather small - by several orders of magnitude too small to transport charge-from one capacitor plate the opposite one.

We can understand this rather easy, when we have a look to the acoustic analogon. If an acoustic signal propagates within a tube (the one-dimensional consideration makes it easier, and it is in good agreement with the one-dimensional propagation of the electrical signals in the wire), we can also send the wave crest and the wave trough from the opposite ends of the tube, and we will also see, that they pass each other without disturbing each other. What we regard here is the field of air-pressure, in which waves always superpose without disturbing each other. The conception is the following: The tube can be subdivided in small finite volumes, containing gas atoms of the air. And these volumes change their positions by a very small amount, as soon as the pressure field is coming. We face the same situation of the electrons in the wire of the coil. We can imagine small finite volumes, containing electrons. And these volumes alter their positions by a small amount as soon as they are exposed to an electrical field.

The gas atoms of the air are moving very fast, same as the electrons in the wire. But the small finite elements of volume filled by electrons resp. gas molecules only move with a very moderate speed, which we know as the "drift-speed" in the case of the electrons and as the "acoustical velocity" in the case of the gas molecules. Nevertheless signals and waves are propagating with typical signals speed, which we know to be the "speed of sound" in acoustics and $v = 1/\sqrt{LC}$ in electrodynamics.

The signal speed defines the speed of propagation of the field and waves in the wire of the LC-oscillation-circuit. This means that we really control the speed of propagation of the interacting fields (of the electromagnetic interaction), when we adjust the inductivity "L" and the capacity "C" of the oscillation circuit.
This explanation demonstrates, how the DFEM-computation is traced back to the conversion of ZPE-energy, as explained in detail in [Tur 10a] and [Tur 10b]. It shall help the readers of this publication to understand, how the LC-oscillation-circuit is indeed used, to control the speed of propagation of the interacting fields, as being necessary for ZPE-conversion.

Now the principle our calculation is explained. The execution of the calculation can be seen in details in the algorithm in the source-code. And it is clear, that the calculation will give results. So, this is the time to begin to analyse the results. This is, to what we will turn our attention beginning with the next section.

3. Evaluation of the results of a converter example

A very first evaluation of the behaviour of the converter-system can be done with some first results, which the program displays on the screen, directly when the program is running. Table 1 is a list of the very first and important physical values for the evaluation of a ZPE-converter. The table is of course made for the example of our EMDR-converter, for which we later will have concrete hints how to build it up.

Physical entity	Explanation
$U_{cap,I,\max} = \dfrac{q_{I,\max}}{C_I}$	Maximum voltage the input-capacitor
$U_{cap,T,\max} = \dfrac{q_{T,\max}}{C_T}$	Maximum voltage at the turbo-capacitor
$\dot{q}_{I,\max}$	Maximum current in the input-coil
$\dot{q}_{T,\max}$	Maximum current in the turbo-coil
$L_I \cdot \ddot{q}_{I,\max}$	Maximum voltage of the input-coil
$L_T \cdot \ddot{q}_{T,\max}$	Maximum voltage of the turbo-coil
$\dot{\varphi}_{\max}$	Maximum angular velocity of the rotating magnet (rad/sec)
$\dfrac{\dot{\varphi}_{\max}}{2\pi}$	Maximum angular velocity of the rotating magnet (U/sec)
$E_{Anf} = E_{ges}(t=0)$	Initial start energy inside the system
$E_{End} = E_{ges}(t = Ende)$	Final energy inside the system at the end of the computation time
$E_{End} - E_{Anf}$	Increase of system-energy during the computation time
$\dfrac{E_{End} - E_{Anf}}{T_{ges}}$	Power due to the increase of system-energy during the computation time
$P_{ent} = \int_{o}^{T_{ges}} R_{Last} \cdot \dot{q}_T^2 \cdot dt$	Extracted energy at the load resistor
$\dfrac{P_{ent}}{T_{ges}}$	Average power being extracted at the load resistor
$E_{in} = \int_{o}^{T_{ges}} \dot{q}_I \cdot U_{in}\, dt$	Total energy being introduced by the input voltage
$\dfrac{E_{in}}{T_{ges}}$	Average power being introduced by the input power supply
$P_{mech} = M_{mech} \cdot \dot{\varphi}$	Mechanical power extraction by the torque $M_{mech} = c_r \cdot \dot{\varphi}$, with $c_r =$ coefficient of friction for power extraction proportional to the angular velocity.
T_{ges}	The relation of the analysis

Tab. 1: Overview of some results presented on the screen.

Several further physical values should be analysed due to their dynamic behaviour as a function of time. They are listed in table 2. The program exports these data into a file which can be read by Excel. There they are available for being displayed graphically. Thus table 2 also contains information about the column in which the data are to be found in Excel.

Excel-column	Physical size	How to calculate it
A	t	Time-scale
B,C,D	q_T , $\dot{q}_T$, $\ddot{q}_T$	Electrical charge and its derivations in the turbo oscillation circuit
E,F,G	q_I , $\dot{q}_I$, $\ddot{q}_I$	Electrical charge and its derivations in the input oscillation circuit
H,I,J	φ, $\dot{\varphi}$, $\ddot{\varphi}$	Angle of the rotating magnet and its time dependent derivations
K,L	ψ_I , ψ_T	Magnetical flux through the coils
M,N	$U_{ind,I}$, $U_{ind,T}$	Voltage induced into the coils
O,P	$E_{mag,I}$, $E_{mag,T}$	Energy within the coils: $E_{mag} = \frac{1}{2} \cdot L \cdot \dot{Q}^2$
Q,R	$E_{cap,I}$, $E_{cap,T}$	Energy within the capacitors: $E_{cap} = \frac{1}{2} \cdot C \cdot U^2 = \frac{1}{2} \cdot \frac{Q^2}{C}$
S	E_{rot}	Energy of the mechanical rotation: $E_{rot} = \frac{1}{2} \cdot J \cdot \omega^2 = \frac{1}{2} \cdot J \cdot \dot{\varphi}^2$
T	E_{ges}	Total energy in the system: $E_{ges} = E_{mag,I} + E_{mag,T} + E_{cap,I} + E_{cap,T} + E_{rot}$
U	E_{Last}	Power extracted by the load resistor: $E_{Last} = R_{Last} \cdot \dot{q}_T^2$
V	U7	Input voltage
W	P_{zuf}	Power being introduced by input power supply
X	c_r	Coefficient of friction, can be varied as a function of time
Y	P_{mech}	Mechanical power extracted by friction $P_{mech} = P_{reib} = M_{reib} \cdot \dot{\varphi} = c_r \cdot \dot{\varphi}^2$
Z	NULL	Auxiliary column

Tab. 2: Overview over the data being exported into Excel.

Now our DFEM-algorithm is developed so far, that we can perform realistic computations of arbitrary electric and/or magnetic ZPE-converters. An example therefore shall be calculated in the following sections - namely with the EMDR-converter suggested by the author of this publication.

4. Computation example for a concrete ZPE-motor

The namely reason for the development of the DFEM-algorithm presented here is the fact, that the author wants to show realistic computations on his EMDR-Converter („Electro-Mechanical Double-Resonance“ Converter), and to get reliable results with sensible precision on this machine. This has the purpose to prepare building up an experimental prototype. Even if the author of this article can not built up such a prototype by himself due to his very restricted possibilities, he hopes, that many colleagues will read this article and try to build up prototypes by themselves.

In order to make it most efficient for those colleagues, who already began to think about building up such prototypes, the author decided to develop the new calculations for a setup which is a rather similar to this one in his former calculation performed in [Tur 11]. The setup is, what we saw in figure 9.

The definition of the geometry in the computer program needs a set of the 32 input parameters. Additionally the program works with some constants of nature and some other parameters derived from the input parameters (additionally 18 such parameters), which are displayed on the screen during the runtime of the program. Sensible definition of the input parameters needs exact fine tuning of their values, and thus take several hours/days even when the author does it by himself.

Caution: The parameter-set displayed on the following pages corresponds directly to the geometry and setup of figure 9. Different design needs different parameters. Furthermore the program contains several subroutines, which are developed to perform automatic meshing for the finite element method. But this automatic meshing only works, if the setup is not altered by principle. If somebody wants to change the design of the converter, it will be necessary to change the subroutines as well.

(a.) Definition of the geometry of the setup

We start now with the explanation of the input parameters, which the realistic DFEM-algorithm requires. For didactical reasons we now do not want to take mechanical power extraction into consideration, because if we leave this aspect for later, it will be easier to understand the converter. Mechanical power extraction will be introduced later within this publication.

{Constants of nature, not Input-parameters:}
- epo:=8.854187817E-12{As/Vm}; {electric field constant}
- muo:=4*pi*1E-7{Vs/Am}; {magnetic field constant}
- LiGe:=Sqrt(1/muo/epo){m/s}; {speed of light}

{For the solution of the differential-equations and for the display of the results:}
- AnzP:=5000000; {number of time steps of the numerical iteration}
- dt:=1E-6; {Sec. } {Duration of each single time step}
- Abstd:=1; {only for preparation, do not alter the value}
- PlotAnfang:=0000; {For Data-export to Excel: First Plot-Punkt}
- PlotEnde:=5000000; {For Data-export to Excel: Last Plot-Punkt}
- PlotStep:=200; {For Data-export to Excel: step width of the data being exported}

{Remark: Excel is restricted to maximal 32.767 Data-groups. If the number of time steps is larger than this value, not all computed data can be plotted graphically by Excel. In our example, only every 200th point is being exported to Excel.}

{For the definition of the geometry of the coils (DFEM-meshing is done automatically):}
- Spsw:=0.01; {Meters of step width of the meshing}
- xo:=0; yo:=6; zo:=5; {Geometrical parameters according Fig.1, steps of Spsw}
- Ninput:=80; {number of windings of the Input-coil, left coil in figure .1}
- Nturbo:=12; {number of windings of the Turbo-coil, right coil in figure .1}
- nebeninput:=8; {windings side-by-side in Input-coil}
- ueberinput:=10; {windings on top of each other Input-coil}
- nebenturbo:=3; {windings side-by-side in der Turbo-coil}
- ueberturbo:=3; {windings on top of each other Turbo-coil}

{Remark: Here the parameters are used to define rectangular coils according to Fig. 1. The cross-section of the Input-coil consists of 8 windings side-by-side and 10 such layers on top of each other. The cross-section of the Turbo-coil consists of 3 windings side-by-side and 3 such layers on top of each other. “On top of each other”means, that the layers are built up radially.}

{For the emulation of the permanent magnet:}
- Bsw:=1E-2; {Meters} {The magnetic field shall be stored in steps of centimetres.}
- MEyo:=0.05; {Half length of the cylindrical bar magnet}
- MEro:=0.01; {Radius of the cylindrical bar magnet}

- MEI:=15899.87553475; {Amperes, current in the coil is to emulate the permanent magnet}

  {Remark: We here use a cylindrical bar-magnet according to Fig. 8 and Fig.9. The shape can be altered if required, but the meshing-subroutines have to be altered also.}

  {Remark regarding the data-storage of the magnetic field: The magnetic field is fixed rigidly to the magnet within a sufficiently extended volume of space. The values of the field strength are stored in a data-array at finite geometrical steps. When the magnet is moving, the field is moving together with the magnet. The step length for the data-storage of the field is „Bsw".}

  {Remark: The weird value for the electrical current in the magnet-emulation-coils has its reason in the fact, that a given value of the magnetic field has to be emulated. The field strength of this field to be emulated is displayed on the screen during the runtime of the program. It can be read in order to adjust the current MEI in such way that the required field strength is achieved. In our example we have a magnet with 1 Tesla at its ends.}

{Further technical dimensions:}

- DD:=0.10; {Meter} {Thickness of the wire from which the coil is made}
- rho:=1.35E-8; {Ohm*m} {Specific electrical resistance of copper, [Koh 96]}
- rhoMag:=7.8E3; {kg/m^3} {Density of the magnet-material, Iron, [Koh 96]}
- CT:=36.61E-6; {Farad} {Capacity within the oscillation circuit of the Turbo-coil}
- CI:=100E-6; {Farad} {Capacity within the oscillation circuit of the Input-coil}

  {Remark: In our example, the input-coil has been modelled in order to prepare it for everybody who wants to have an additional coil in the DFEM-algorithm. But the input-coil is not used for the computation of the converter, and the complete oscillation circuit containing the input-coil is left away for the computation of the self running EMDR-converter.}

- Rlast:=0.0111; {Ohm} {Ohm'ian load resistor in the Turbo-circuit for the extraction of energy}
- UmAn:=50000; {U/min} {Initial angular velocity: mechanical boundary condition - rotating magnet}
- Uc:=0;{Volt} Il:=0; {Ampere} {electrical boundary conditions – capacitor-voltage, current in the coil}

  {Remark: Even a self running ZPE-motor needs an initial energy to be started. It will not start just by alone. The initial energy can be supplied mechanically (as it is done in the example here), but it can be supplied electrically as well, for instance by charging the capacitor the coil in order to initialize the operational the motor.}

- U7(t)=0;

  {Remark: If the ZPE-converter is not a self running engine, but only an over-unity engine, it permanently needs some classical input-energy for operation. This can be supplied mechanically (at the axis of rotation) or electrically with some input-voltage. The last version is displayed in the source-code printed in the appendix, by the use of a subroutine with the name "U7". Nevertheless this input-voltage is not used for the solution of the differential-equations, because the EMDR-converter is a self running engine and does not need any classical input power.}

{Composed Parameters, for the purpose to control the input data. Do not use them for input.}

- DLI:=4*(yo+zo)*Spsw*Ninput; {Meter} {length of the wire of the Input-coil}
- DLT:=4*(yo+zo)*Spsw*Nturbo; {Meter} { length of the wire of the Turbo-coil }
- RI:=rho*(DLI)/(pi/4*DD*DD); {Ohm} {Ohm`ian resistance of the wire of the Input-coil}
- RT:=rho*(DLT)/(pi/4*DD*DD); {Ohm} { Ohm`ian resistance of the wire of the Turbo-coil}
- BreiteI:=nebeninput*DD; HoeheI:=ueberinput*DD; {Width and height of the Input-coil}
- BreiteT:=nebenturbo*DD; HoeheT:=ueberturbo*DD; {Width and height of the Turbo-coil}
- fkI:=Sqrt(HoeheI*HoeheI+4/pi*2*yo*2*zo)/HoeheI; {Induktivity-correction for short coil}
- fkT:=Sqrt(HoeheT*HoeheT+4/pi*2*yo*2*zo)/HoeheT; {Induktivity-correction for short coil}
- LI:=muo*(2*yo+BreiteI)*(2*zo+BreiteI)*Ninput*Ninput/(HoeheI*fkI);

  {Geometrical average => Induktivity of the Input-coil}
- LT:=muo*(2*yo+BreiteT)*(2*zo+BreiteT)*Nturbo*Nturbo/(HoeheT*fkT);

  {Geometrical average => Induktivity of the Turbo-coil}

- omT:=1/Sqrt(LT*CT); {Resonance-angular-frequency of Turbo-cicuit of LT & CT}
- TT:=2*pi/omT; {classical duration of oscillation of Turbo-circuit of LT & CT}
- Mmag:=rhoMag*(pi*MEro*MEro)*(2*MEyo); {Mass of the Magnet}
- J:=Mmag/4*(MEro*MEro+4*MEyo*MEyo/3); {moment of inertia of the magnet of rotation}
- omAn:=UmAn/60*2*pi; {Start angular velocity (rad/sec.) of the rotating magnet}
- UmSec:=UmAn/60; {Start angular velocity, rotating Magnet (rounds per second)}

  {Remark: Some of these values are not only necessary to control the input data but they are also necessary for the further computation in the DFEM-Algorithm.}

With these parameters, the ZPE-motor is modelled as being displayed in figure 11. As explained above, there is only the Turbo-coil and no Input-coil.

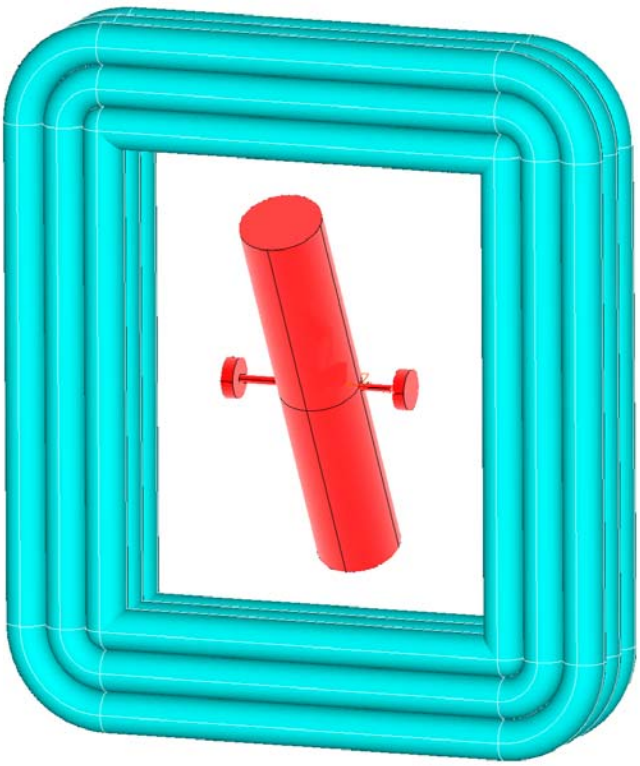

Fig.11:
(Drawn by the use of ANSYS [Ans 08].)

EMDR-converter with a rotating magnet (red colour: length 10 cm, thickness 2 cm).

Also in red colour we see a thin axis of rotation, around which the magnet can rotate. At each end of the axis, there is a bearing (also red) to keep the axis of the rotating magnet at its position.

The windings of the Turbo-coil are drawn in light blue colour. As we see, the field flux lines of the rotating magnet cut the windings of the coil exactly perpendicular.

Because of practical aspects (as can be seen later), the windings of the coil have to be made from rather thick material, and the coil should be made of not very many windings. In our example, the cross-section of the coil has an inside area of 5 × 6 cm^2, and the thickness of the wire 10 mm.

The time steps for the numerical iterative the solution of the differential-equations have to be choosen fine enough, that every period of motion consists of sufficiently many steps of calculation. Thefore the parameters as displayed above have time steps of $dt = 1 \mu\text{sec}.$ at an angular velocity of 50,000 rpm. This is for sure not sufficient. The time steps must be much smaller.

But during the practical application of the DFEM-algorithm, we start with rather rough time steps in order to get a first rough feeling for the behaviour of the machine. Rough time steps save computer (CPU)- time. We can use such rough times steps, to see what is happening, during the phase of definition of the geometry of the machine. We can also use such rough time steps for the maximisation of the converted power, when we want to alter the system-parameters by hand. As soon as this task is done, we have to reduce the time steps remarkably in order to check the convergence of the algorithm. Good convergence is achieved, when we see that any further reduction of the length of the time steps does not have a remarkable influence on the results. As soon as we reach the condition of good convergence, we have to begin the fine tuning of the system parameters, together with a renewal of the maximisation of the converted power.

In order to make the optimisation of the system parameters as efficient as possible, there is a data-output routine included into the program. This allows a fast evaluation of the behaviour of the system, when we alter the system parameters by hand (by trial and error). During this phase, we see the following data on the screen:

- The start energy within the system, which is brought into the differential-equations by initial conditions. This energy is computed among others from the parameters UmAn, Uc, Il.
- The energy within the system at the end of the time of analysis. Therefore all amount of energy within the system summed up, this is the energy of motion of the magnets, the energy within the coils and the energy within the capacitors.
- The amount of energy being gained within the system during the analyzed time of operation. This is the difference between the start energy and the energy at the end of the analysis-time. If the energy-gain plus the energy being extracted from the system is positive, the system converts ZPE-energy into classical energy. If this energy-gain plus the energy being extracted is negative, the system converts in the opposite manner classical energy into ZPE-energy. An ideal classical electromotor will contain the same start energy plus input energy, as it contains energy at the end of operation plus energy being extracted during operation. (Friction to be taken into account as energy-extraction.)
- The power corresponding to the energy gain, which is calculated by dividing the energy gain trough the time of observation.
- The energy being extracted from the Ohm'ian resistor during the time of operation, and the power corresponding with this energy gain. Not very interesting is the knowledge about the Ohm'ian losses in the wires of the coil. These losses are included into the calculation, but they are not printed on the computer screen, because we do not have any influence on them.
- The average of the mechanically extracted power and the sum of the mechanically extracted energy during the time of observation. Mechanical energy and power can be extracted from the rotating shaft (which is located in the middle of the permanent magnet). Mechanical energy is not yet regarded now in the sections 4 and 5, but soon in section 6 it will be regarded detailed.
- Additional to the mechanically extracted power and energy, there is some mechanical gain of energy, which remains inside the system.
- The input-voltage and the input-power in connection with the input-supply is printed on the computer screen, but it is ZERO, because there is no classical energy brought into the system during operation. The EMDR-converter is a self running system. The values are only displayed for those, who want to modify the DFEM-algorithm to simulate an over-unity machine.
- The total duration of the observation, which is the sum of all time-steps "dt". We do not speak about the elapsed CPU-time, but we speak about the simulated time of operation during which the converter is running.

The simple online data-evaluation as described above helps the user to get a quick impression about the mode of operation of the converter, which allows to perform a variation and optimization of the system-parameters by hand. This means, that we can alter the values of the system parameters, check the behaviour of the system, alter the values again, check again, and so on… By this means we should be capable to develop a design which should work properly (at least theoretically).

As soon as this design is found, it is recommended to evaluate the system more precise. This can be done by observing those variables as a function of time, which follow the dynamics of the motion. Therefore the time dependent variables of the system are exported into a data-file for Excel, where they can be displayed graphically. The listing of the contents of the different Excel-columns have been printed above in Table 2. From the evaluation of these data, we have to answer questions such as the following:

- Does the system run into a stable mode of operation ?

  This can be seen for instance, when we regard the angular velocity $\dot{\varphi}$ as a function of time, because a stable mode of operation can only be achieved if the angular velocity is constant, or at least if it oscillates around a constant value (within a well controlled hysteresis). If this is not the case, the converter is still in the phase of initialisation, or it does not run stable at all. In order to decide between these both possibilities, the length of the time steps “dt” should be reduced, and the total oberservation time has to be enhanced. Then the calculation shall be repeated with longer observation time.

  The same observation can be done with regard to the electrical current in the coil or with the voltage in the capacitor.

- Does the machine convert enough ZPE-energy, so that it will not be brought to standstill by friction ?

  Therefore we check the energy of the mechanical rotation remaining in the rotation of the permanent magnet, as a function of time. The gain should be large enough, that we can expect, that it is sufficient to surmount the energy loss due to friction. If the calculation is done taking mechanical power extraction into account (see section 6), we can define the coefficient of friction and check the extracted power (as a function of time).

- Also the time dependent behaviour of the electrical currents and the voltages in the LC-oscillation circuit should be observed graphic only, because this contains more reliable and detailed information than the simple estimation of the maximum, which is printed during the runtime on the screen. If the machine is running properly as a ZPE-converter, the values of the voltage and the current are nomaly rather large, so that we have to be careful not to overload the wire of the coil or the capacitor.

By the way it should be mentioned, that the elapsed CPU-time can take several minutes or several hours, especially when the time steps are very short (for instance in the range of few nanoseconds).

5. A concrete EMDR vacuum energy converter

The DFEM-program in the appendix can only run, if there is a data-file in the same directory with the name *'schonda'*, which can be downloaded together with source-code of the DFEM-program for free from the Internet-page of the author of the publication presented here. The data-file *'schonda'* only has the purpose to save CPU-time, as following: During the phase of initialisation of the main program, all preliminary work takes some CPU-time, which is only necessary, if the parameters describing the geometry of the setup have been altered since the last run of the program. (In this case, the automatic meshing has to be renewed.) If the geometry-parameters remain unchanged since the last run of the program, the results of the initialisation can be taken directly from the last run of the program (together with the existing mesh, stored in ‘*schonda*’). This is exactly what the program does, when it reads the data-file *'schonda'*, in order to save the time for the same initialisation which already has been calculated before. This makes it more efficient to repeat the program several times during the phase of the optimisation of the system parameters.

We now (in section 5) want to discuss the system parameters, with the values as printed in the source-code in the appendix.

The typical construction of a EMDR-converter begins with a search for an appropriate permanent magnet. As soon as the magnet is found and its field strength is measured (for instance with a Hall-probe), its dimensions are put into the input-pata lines of the source-code. Then we have to construct the conductor loops for the emulation of the permanent magnet and to apply an appropriate electrical current within the conductor loops, in order to reproduce the measured values of the magnetic field.

Then we have to modulate the Turbo-coil and to put all the other requested data into the DFEM-algorithm. Finally the initial angular velocity of the rotating magnet has to be adopted, and the very last step is the adjustment of the capacitor in the Turbo-oscillation-circuit. The criterion of the initial angular velocity of the rotating magnet shall be decided from the stability of the bearing keeping the rotating axis. The bearing must withstand the angular velocity of the stable mode of operation, which can be remarkable larger than the initial angular velocity. Thus the value of the maximum possible angular velocity of the magnet plays an important role for the adjustment of the capacitor. High-speed rotation has the consequence to enhance the amount of power being converted from the ZPE of the quantum vacuum. If the system operators as a ZPE-converter, the angular velocity is increasing during the initial phase of the operation. And we can use the amount of the increase of the angular velocity as an indicator for the quality of adjustment of the system parameters. The more ZPE-power we convert, the more increase of the angular velocity we observe. At the very beginning of the adjustment procedure, we apply a very small load resistor and adjust the capacity to a maximum of increase of the angular velocity of the magnet.

Rather often (depending on the geometry of the system) we observe, that the mechanical power-gain is much larger than the electrical power-gain. This is also the reason, that we will soon (in section 6) have to take the real benefit of the converter mechanically from the rotating shaft.

The next step of the optimisation now consists in enhancing the load resistor in many small steps, and always readjusting the capacitor, while checking the mechanical and electrical power gain. Depending on the configuration of the system parameters, the mechanical and the electrical power can increase both or decrease both at the same time, but it is also possible that one is increasing and the other one is decreasing. The load resistor should not be enhanced to much, otherwise it will attenuate the LC-circuit rather strong, and thus prevent the engine to start properly.

If the mechanical power gain of the machine is rather large, this is absolutely no problem, because it simply indicates that we have enough mechanical power, to overcome friction without any problems. The way how to extract mechanical power will be the topic of section 6.

Even the theoretical adjustment procedure makes clear, that the load resistor as well as the capacitor have to be adjusted with very high precision. The consequence is, that we need a capacitor and a load resistor for the practical setup, which can be adjusted very precisely. The precision of the adjustment-quality should be at least somewhere between 1% and 0.1%. When we will soon see, how large the voltage and the electrical current in the LC-oscillation-circuit really are, we will understand that this defines a really serious requirement to the *capacitor* and to the *resistor*.

The example under discussion here is not optimized with regard to the converted power, because of this optimisation will be much better soon in section 6. Nevertheless it should be mentioned, that the converted power can be enhanced remarkably, when we enhance the number of windings in the Turbo-coil a little bit (accepting the disadvantage, that the voltage in the capacitor will be enhanced strongly if we do so).

The most effective way to enhance the converted power is the angular velocity in the stable operation. Enhancing the angular velocity has the consequence to enhance the converted power tremendously. 30,000 rounds per minute as used in the example here is not a really high angular velocity. Such a rather moderate value has the purpose to make it easier to find an adequate bearing for the rotating permanent magnet. But if we have the typically angular velocity of Turbo-rotor in the automotive industry in mind (which spins with about 100,000 rounds per minute or even more), we see that an enhancement of the angular velocity should not be very difficult - and with it a remarkable enhancement of the converted power. Even much higher angular velocity is known from dentistry and from turbomolecular vacuumpumps in ultra high vacuum technology. If we could use such speedy rotation, the restriction to the power density of the ZPE-converter should probably be the electrical current in the copper wire, which should not be too strong, so that the copper wire will not get too hot.

If the results of the algorithm shall be documented, there is a simple option to press the "D"-button before you leave the program with the last <wait>, and the program will write the input-data as well as the most important results into a file named „Auswertung". This file can be read with a text program. An example for such a file is printed here.

DFEM-Simulation of an EMDR-Motor (here still without mechanical power extraction)

```
Parameters for the solution of the differential equation and the output of the results:
AnzP =     10000000           {number of time steps for the observed operation}
dt   =  2.000E-0007 {seconds,   duration of each time steps for the solution of the differential equations}
Abstd=     1                   {only for preparation, do not alter the value}
PlotAnfang =         0         {first point for the Data-export to Excel }
PlotEnde   =   10000000        {first point for the Data-export to Excel }
PlotStep   =       400         {step width for the Data-export to Excel }

{Definition of the both coils (turbo and input):}
Spsw   =     0.010000          {Meters: step width for the automatic mesh-generation of the coils}
xo = 0,                        {number of steps of Spsw}
yo = 6,                        {number of steps of Spsw}
zo = 5,                        {number of steps of Spsw}
Ninput =       100             {number of windings of the input-coil}
Nturbo =         9             {number of windings of the turbo-coil}
nebeninput =       10          {windings side-by-side of the input-coil}
ueberinput =       10          {layers of windings of input-coil}
nebenturbo =        3          {windings side-by-side of the turbo-coil}
ueberturbo =        3          {layers of windings of the turbo-coil}

Bsw =  1.0E-0002               {spatial resolution of the computation of the magnetic field}
MEyo =  5.00000E-0002          {y-coordinates of the conductor-loops for the emulation of the permanent magnet}
MEro =  1.00000E-0002          {Radius of the conductor-loops for the emulation of the permanent magnet}
MEI  =  1.58998E+0004          {Electrical current in the conductor-loops for the emulation of the permanent magnet}

further technical dimensions:
DD =    0.0100000  {Meters}    {diameter of the wire for the coils}
rho =  1.35000000000000E-0008  {Ohm*m}     {Specific electr. resistance of copper, depending on temperature}
rhoMag =  7.80000000000000E+0003  {kg/m^3}     {density of the permanent magnet, Iron}
CT =  9.83000E-0005  {Farad}    {capacitor in the turbo-circuit}
CI =  1.00000E-0004  {Farad}     {capacitor in the input-circuit}

additional necessary values:
Rlast =  6.400000E-0002  {Ohm}     {Ohm´s load resistor in the LC-Turbo-circuit
UmAn =   30000.00  {U/min}     {mechanical initial conditions - rpm of the rotating magnet}
Uc =       0.00  {Volt}        {electrical initial conditions - voltage at the turbo-capacitor}
Il =       0.00  {Ampere}    {electrical initial conditions - electrical current in the turbo coil}

composed parameters. These values are calculated, no input possible:
DLI:=4*(yo+zo)*Spsw*Ninput =   44.00000 {Meter,   length of the wire oft he Input-coil}
DLT:=4*(yo+zo)*Spsw*Nturbo =    3.96000 {Meter,  length of the wire oft he turbo-coil}
RI:=rho*(DLI)/(pi/4*DD*DD) =    0.00756 {Ohm}   {Ohm`resistance of the wire of the Input-coil}
RT:=rho*(DLT)/(pi/4*DD*DD) =    0.00068 {Ohm} {Ohm`resistance of the wire of the turbo-coil}
BreiteI:=nebeninput*DD =    0.10000                  {Width of the input-coil}
```

HoeheI:=ueberinput*DD = 0.10000 {height of the input-coil}
BreiteT:=nebenturbo*DD = 0.03000 {Width of the Turbo-coil}
HoeheT:=ueberturbo*DD = 0.03000 {height of the Turbo-coil}
fkI:=Sqrt(HoeheI*HoeheI+4/pi*2*yo*2*zo)/HoeheI = 123.61179 {factor of correction for inductivity}
fkT:=Sqrt(HoeheT*HoeheT+4/pi*2*yo*2*zo)/HoeheT = 412.02703 {factor of correction for inductivity}
LI:=muo*(2*yo+BreiteI)*(2*zo+BreiteI)*Ninput*Ninput/(HoeheI*fkI) = 1.24238647244960E-0001 {Induktivity, Input-coil}
LT:=muo*(2*yo+BreiteT)*(2*zo+Breitet)*Nturbo*Nturbo/(HoeheT*fkT) = 9.93606632469255E-0004 {Induktivity, Turbo-coil}
omT:=1/Sqrt(LT*CT) = 3.19974964955735E+0003 {classical angular frequency of the Turbo-circuit}
TT:=2*pi/omT = 1.96364903362012E-0003 {classical period of the Turbo-circuit }
Mmag:=rhoMag*(pi*MEro*MEro)*(2*MEyo) = 0.245 kg {Mass of the Magnet}
J:=Mmag/4*(MEro*MEro+4*MEyo*MEyo/3) = 2.10329628157837E-0004 {moment of inertia of the rotating magnet}

Several parameters, to be calculated from the above values:
Magnet: start angular velocity.: omAn = 3141.592654 rad/sec
Magnet: start angular velocity, Umdr./sec.: UmSec = 500.0000000000 Hz
Mass of the Magnet = 0.245044 kg
moment of inertia of the rotating magnet: 2.10329628157837E-0004 kg*m^2
total duration of observation: 2.00000000000000E+0000 sec.
Excel-Export: 0.00000E+0000... 2.00000E+0000 sec., Step 8.00000E-0005 sec.
These are 25000 data-point tob e exported to Excel.

****

Some of the results of the computation:
initial energy within the system: 1037.93511187 Joule
final energy within the system: 1171.18167853 Joule
power gain in the system: 66.62328333 Watt
energy extracted at the load resistor = 13.29139772 Joule
power extracted at the load resistor= 6.64569885828765E+0000 Watt
inserted energy by voltage supply: 0.00000000000000E+0000 Joule
inserted power by voltage supply: 0.00000000000000E+0000 Watt
total duration of the observation 2.00000000000000E+0000 sec.

This is the documentation of a set of important data written automatically by the program. We now want to discuss these data and further more other data:

The duration of observation is 2.0 seconds (the elapsed CPU-time is much larger on a normal computer). During this time-interval, the system gains a mechanical power of 66.62 Watts, and additionally an electrical power of 6.645 Watts. For both of them, there is no classical source of energy, so the energy can only come from some non-classical source which we regard as invisible for classical eyes. According to former explanations, it should be the energy of the electromagnetic zero-point waves of the quantum vacuum.

If we enhance the duration of the observation, we see that the converted power is reduced. The reason is not an incomplete convergence of the algorithm (for instance due to the duration of the finite time steps “dt”), but the reason is the fact, that the engine has totally different behaviour within the initial phase then after reaching a stable equilibrium mode of operation. We see this when we regard figure 12, which displays the angular velocity of the rotating magnet as a function of time (this is column ”I” in the Excel-data, of the automatically written file with the name „test“.) Further explanation will follow later.

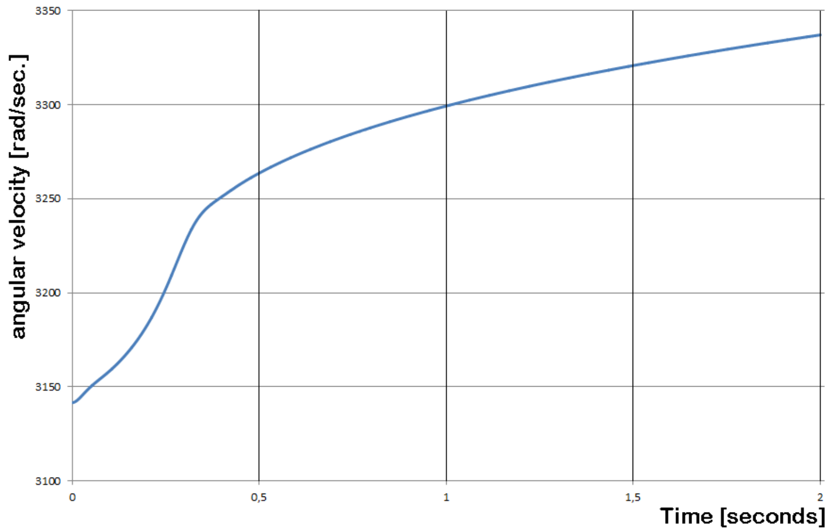

Fig.12:

Angular velocity of the rotating magnet, which increases as function of time.

At the begin of the initial phase, the energy gain is rather large. After some time the operation converges to saturation, but within the two seconds under analysis, it does not yet reach the saturated stable condition.

The voltage of the capacitor can be calculated from the electrical charge inside the capacitor as being plotted in figure 13. Please notice, that the calculation was done with 10.000.000 time steps, which is far too much to be resolved by any computer graphics. Consequently we only can see the envelope of the oscillation.

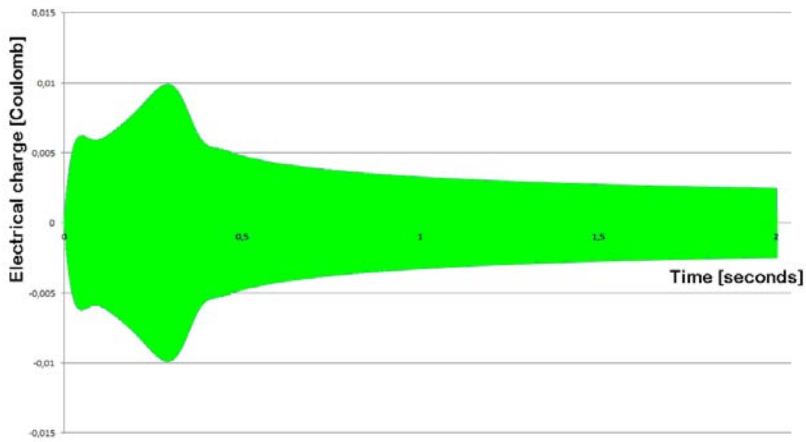

Fig.13:

In green colour we see the envelope of the oscillation of the electrical charge, which is flowing into and out of the capacitor.

The maximum of the voltage-amplitude is to be found at $U_{C,\max} = \frac{Q_{\max}}{C_{Turbo}} = \frac{0.01C}{98.3\mu F} \approx 102 Volt$.

It should not be a problem to get such capacitors. If the number of windings is enhanced, it is possible to work with higher voltage, which allows to enhance the electrical power in the circuit as well as the power ready for extraction (at load-resistor as well as mechanically).

The current in the coil, shown in figure 14, has a maximum of a bit more than 30 Amperes. If the number of windings (of the Turbo-coil) is enhanced and the load resistor is adjusted together with other systems parameters (such as the capacitor) at the same time, a strong enhancement of the current is possible. With our wire according to figure 11, with a diameter of 10 mm (cross-section of 78.5 mm²), a current of 30 Amperes should not be a problem at all.

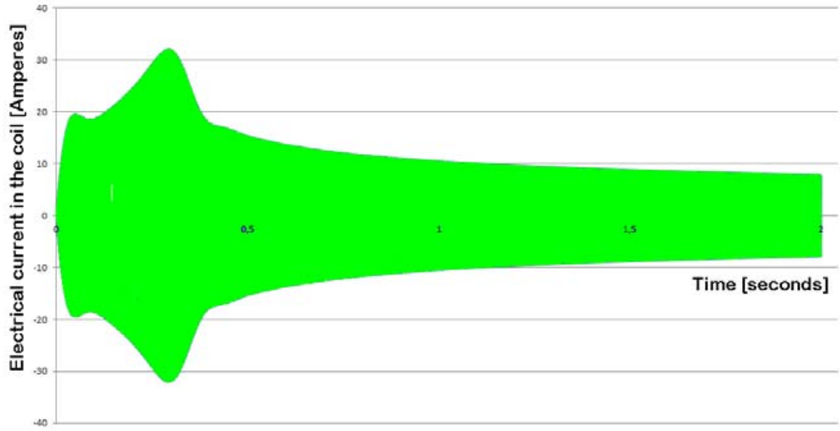

Fig.14:

Envelope of the oscillating current in the coil as a function of time.

The voltage over the coil, which graphically has a shape very similar to figure 13 and 14, should have an amplitude of the same order of magnitude as the voltage of the capacitor, as soon as the system is adjusted sensible. In our example we find a value of 99 Volts, which fulfils this criterion surprisingly well.

The angular acceleration of the rotating magnet, of which we see the envelope in figure of 15, displays a remarkable oscillation within each period of rotation. This makes it clear, that there are remarkable Lorentz-forces between the magnet and the coil of the LC-circuit. This indicates, that those colleagues who want to build up the design in a practical experiment, should take care of mechanical forces, which should be done by a stable fixation of the coil and the axis of the magnet.

A stable mode of operation is achieved, as soon as the oscillation of the torque (and the angular acceleration) is symmetrically around the abscissa - which is not the case here in our example, as can be expected from the discussion of figure 12. As we see, even at the end of the observation-time, the average of the angular acceleration is clearly positive, so that the rotor did not yet come to its maximum (final) angular velocity.

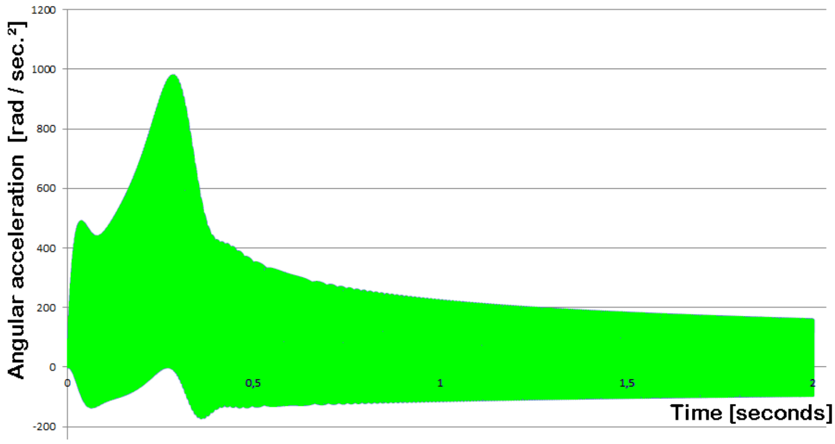

Fig.15:

Envelope of the angular velocity of the rotating magnet as a function of time.

The question about the quality of the numerical iteration can be answered, when we focus the plot to a high-resolution interval of time, so that we do not only see the envelopes of the curves, but the curves themselves. This is shown in figure 16, showing that time-zoom of the total duration of about 5 milliseconds, within which we can resolve about five periods of oscillation. The plot displays the angular acceleration. If the curves are irregular or not smooth, we have the typical case of too low scanning frequency (too long time steps “dt”), so that we face the necessity to reduce the length of time steps. Of course such an enhancement of the precision of the calculation does enhance the elapsed computer-time for the computation. In our example of figure 16, we see satisfactory numerical scanning, because the curve is a regular and smooth.

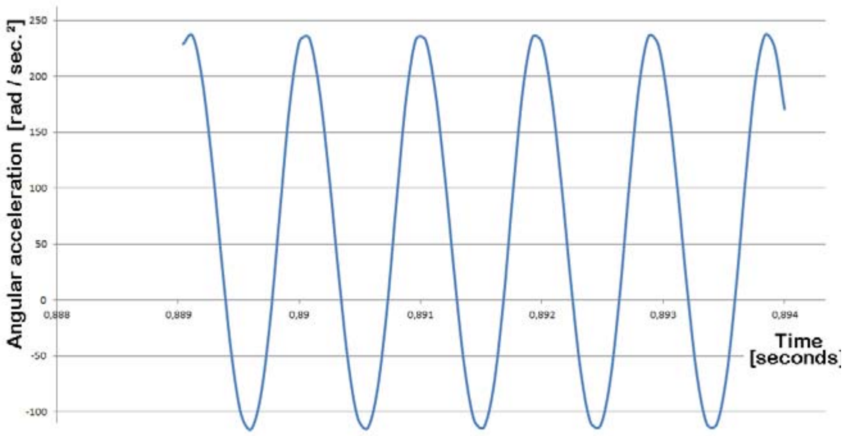

Fig.16:

The observation with high time-resolution allows us to evaluate the quality of the numerical iteration.

Although we permanently extract power from the system (see figure 17), the total energy within the system is increasing strictly monotonously during the whole time of our observation (see figure 18). This will be the case as long as the rotor does not achieve the stable equilibrium-condition of constant angular-velocity. Remark: The situation is totally different, as soon as we extract mechanical power from the system, but we will see this later in section 6.

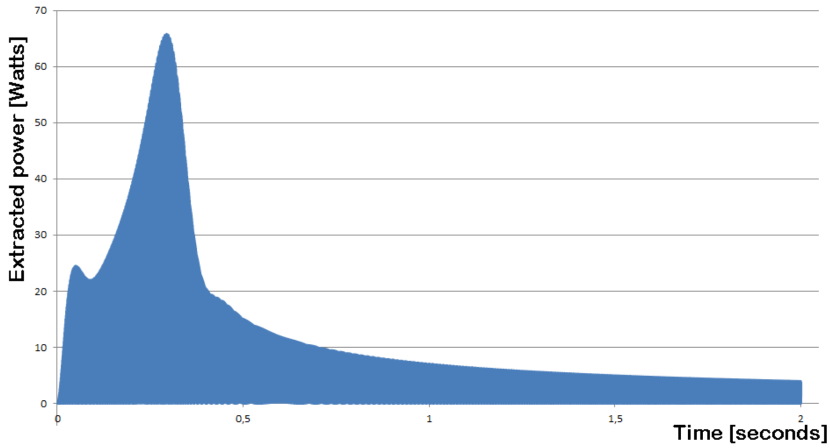

Fig.17:

Electrical power extraction at the load resistor.

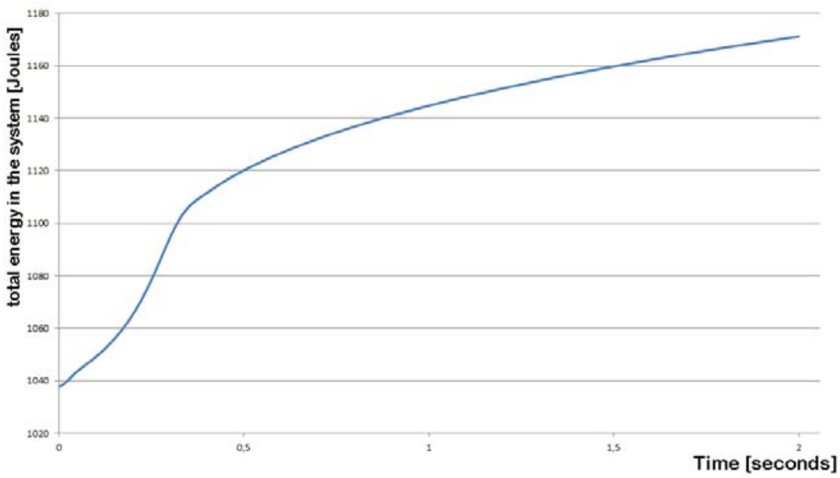

Fig.18:

Total energy within the system.

This is the energy of the coils, the capacitors and the rotation of the magnets.

In our example we do not have to analyse any power being supplied to the system, because the input-circuit is not existing at all, for there is no input of energy. The machine is a self-running engine (not an over-unity system).

A long-term analysis of the electrical power being extracted from the load resistor is shown in figure 19. The only aspect which was changed with regard to the short-term analysis reported before, is the total duration of the observation, which is now 40 seconds for the computation to figure 19. Obviously the extractable power at the load resistor converges to ZERO. This observation is confirmed very clearly, if we perform a further enhancement of the duration time of the observation. This arises of the question, whether the EMDR-system is capable as a ZPE-motor at all !

The answer will be **YES** (!), as we will soon see in section 6. The EMDR-motor needs some mechanical resistance (such as for instance friction or power extraction) that it can work as a ZPE-motor.

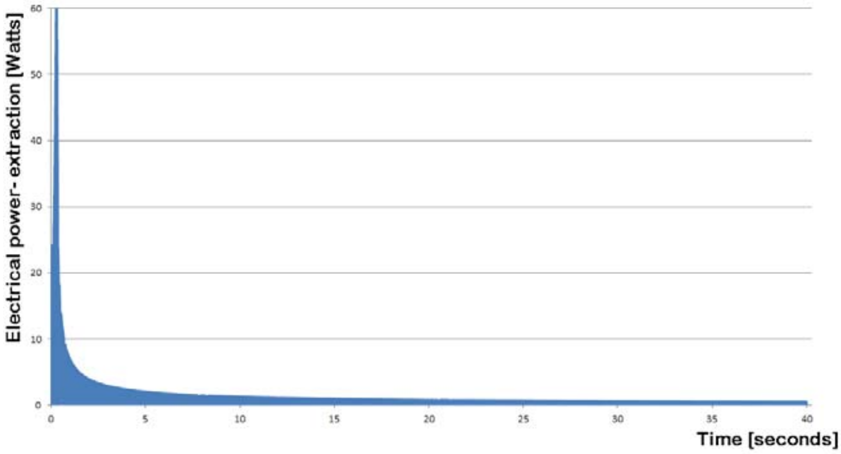

Fig.19:

Electrical power being extracted from the load-resistor in the Turbo circuit in a long-time analysis.

Let us discuss this now:

If we want to have the EMDR-converter in powerful operation, the machine needs a constant phase-difference between the electric oscillation in the LC-circuit and the mechanical rotation of the permanent magnet. There is an optimum value for this phaseshift, which has to be maintained during long-term operation, in order to maintain the conversion of ZPE-energy constantly. This phase shift is absolutely necessary, that the oscillating magnetic field made by the turbo-coil can accelerate the rotating magnet exactly in this moment, in which the turbo-coil-field is the most strong. But on the other hand the turbo-coil-field should decelerate the magnet at this moment at which it is the most weak.

Let us remind, that a constant field would accelerate and decelerate the magnet to the same amount, so that the angular velocity will alter during each period of rotation, but it will become the same after a full period of rotation. Differently from this, an oscillating field has the possibility to make the acceleration different from deceleration.

We can illustrate this explanation by a rather simple model, as following: The oscillation within the LC-circuit causes the energy within this circuit move periodically back and forth between the (energy of the) electrostatic field in the capacitor and (energy of the) the magnetic field in the coil. This is exactly happening twice per period, because the capacitor plates will be charged alternating “positive” and “negative”, as well as the coil is alternating between “north” and “south” (at each side). At these moments, in which the field energy is inside the coil (i.e. the field energy is the energy of a magnetic field), the magnet has to be accelerated remarkably. But in the moment when the field is inside the capacitor (i.e. the field energy is the energy of an electrostatic field), the magnet is decelerated by the coil only very weak, because the coil has almost no magnetic field.

A graphical illustration can be seen in figure 20 and 21, which is an animation of eight pictures cyclically following one after each other as a function of time. Let us start our considerations with figure 20, where we see the case of a “beneficial phase-shift”, driving a strong rotation. The capacitor is drawn with purple colour, and the electrical charge within the capacitor is illustrated by “positive” and “negative” algebraic signs noted at the capacitor-plates. The more charge we find inside the capacitor plates, the more algebraic signs are noted. When the field (and some electrical charge) moves into the oscillation-circuit, an arrow in black colour symbolises the direction of propagation of the field. Obviously the field has to pass the long wire, which is formed as a coil drawn in blue-colour.

This has the consequence, that there is an electric current within the coil, producing a magnetic field. This magnetic field is noted next to the wire of the coil by the use of the symbols („N“ and „S“). Again the number of symbols represents the strength of the field.

Let us now begin our considerations with part “1” of figure 20. This is the moment t_1, where the capacitor still contains some electrical charge, but it is far away from being charged to its maximum. This means that some of the field’s energy is in the coil, causing some magnetic fields (also away from its maximum). But we see the polarity of the magnetic field and the polarity of the permanent magnet, which are orientated relatively to each other in such a way, that the magnet will begin to rotate clockwise. In part “2”, the capacitor is discharged completely, so that the electrical current within the coil reaches its maximum. Now the total field’s energy is the energy of a magnetic field, so that the attractive force accelerating the permanent magnet is rather strong. This means that the angular velocity of the rotation is enhanced remarkably (because the phase-difference between the fields in the LC-circuit and the position of the rotating magnet is “beneficial”). In part “3”, the magnetic fields of the coil is reduced partially, but due to the orientation of the permanent magnet, there is no more torque and thus no angular acceleration on the magnet. In this situation, the magnet is simply continuing his rotation constantly. In part “4”, there is no more magnetic field in the coil, because there is no electrical current and the coil. This means that there is no deceleration which might like to move the magnet back with its “south-pole” to the position where we formally had the “north-pole” of the coil. In this situation, the magnet is also continuing his rotation constantly. But where is the energy of the oscillating field in the LC-circuit ? It is inside the capacitor, so that it does not have the chance to have any influence on the motion of the magnet. This means, up to now we can say, that the magnet was accelerated but not decelerated. In part “4”, the capacitor is charged up to its maximum. From now on the capacitor begins to discharge, which can be ovserved clearly in part “5”. Of course the discharge-current has the opposite direction as in part “1”, so that the magnetic field of the coil in part “5” has the opposite polarity as in part “1”. And this is fine, because the magnet also has the opposite direction as in part “1”. This means that the field of the coil begins to accelerate the rotation of the magnet also clockwise in part “5”. In part “5” we have a magnetic field growing slowly, but in part “6”, this magnetic field already reaches its maximum value, so that we have a good angular acceleration of the magnet which is again orientated clockwise. (The situation of “6” corresponds to the situation of “2”.) Part “7” now corresponds to the situation of “3”, and after the above explanation it is clear, that neither in “7” nor in “8” there is any deceleration disturbing the rotation of the magnet. The rotation is going clockwise, so that part “8” is followed by part “1”, and so on…

The acceleration of the magnet is active as long as the phase shift between the orientation of the magnet and the magnetic field in the LC-circuit is present.

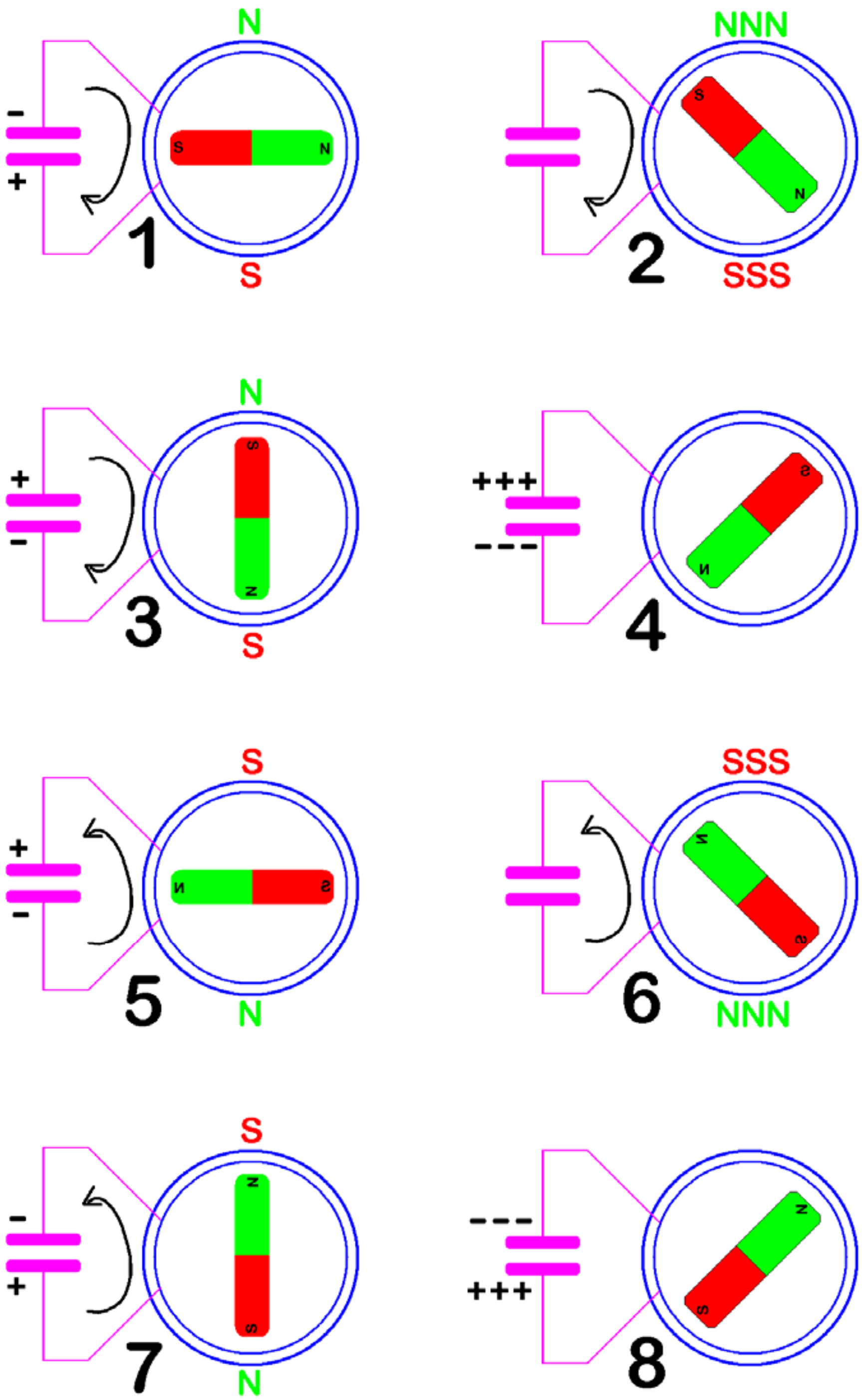

Fig.20:

Rotation of a magnet in the coil of a LC-circuit with constant “beneficial phase-shift” between the orientation of the magnet and the orientation of the oscillating magnetic field in the circuit.

If the magnet would be accelerated permanently, due to the beneficial phase shift, the angular velocity of the rotation would increase until the rotation of the magnet catches the rotation of the LC-circuit. But this would have the consequence, that the phase-shift between the electric LC-oscillation and rotation would disappear. And then the phase-shift would no longer be “beneficial”, but it would come into a condition which we can see in figure 21. Under this condition there is no more acceleration of the magnet (i.e. no further conversion of vacuum-energy).

Let us begin our explanations with part “1” of figure 21. Here we still see a slight clockwise acceleration acting on the permanent magnet. The magnetic field of the coil is not extremely strong, but it is existing. Part “2” does not need very much explanation, because the orientation of the permanent magnet does not allow any acceleration at all. But interesting is now part “3” with counterclockwise acceleration of the permanent magnet. And as we see, the absolute value of the deceleration in “3” is of the same size as the absolute value of the acceleration in “1”. This means that the acceleration in “1” is completely compensated by the deceleration in “3”, indicating that the time from “1…3” does not cause any acceleration or deceleration in sum at all. Part “4” does not change our general situation, because here we again have no acceleration or deceleration. There is simply no magnetic field of the coil in part “4”. The train of thoughts, which we applied from “1…4” can be repeated for “5…8” analogously, so that we come to the conclusion, that during one turn, the angular velocity of the rotating magnetic is increasing and decreasing periodically, but there is no sum acceleration or deceleration at all. There is no “beneficial” phase-shift between the rotation of the magnet and the oscillation of the LC-circuit.

From here we understand, that the EMDR-converter permanently needs a “beneficial phase-shift” between the electrical and magnetic motion. If this phase shift decreases to “zero”, it is not further possible to convert any ZPE-energy. This means that we need the “beneficial phase-shift” for proper operation of the ZPE-motor. But the phase shift cannot be generated electrically (as for instance by a load-resistor). Thus we have to generate the “beneficial phase-shift” mechanically by applying some mechanical load to the rotating shaft at the axis of the magnet.

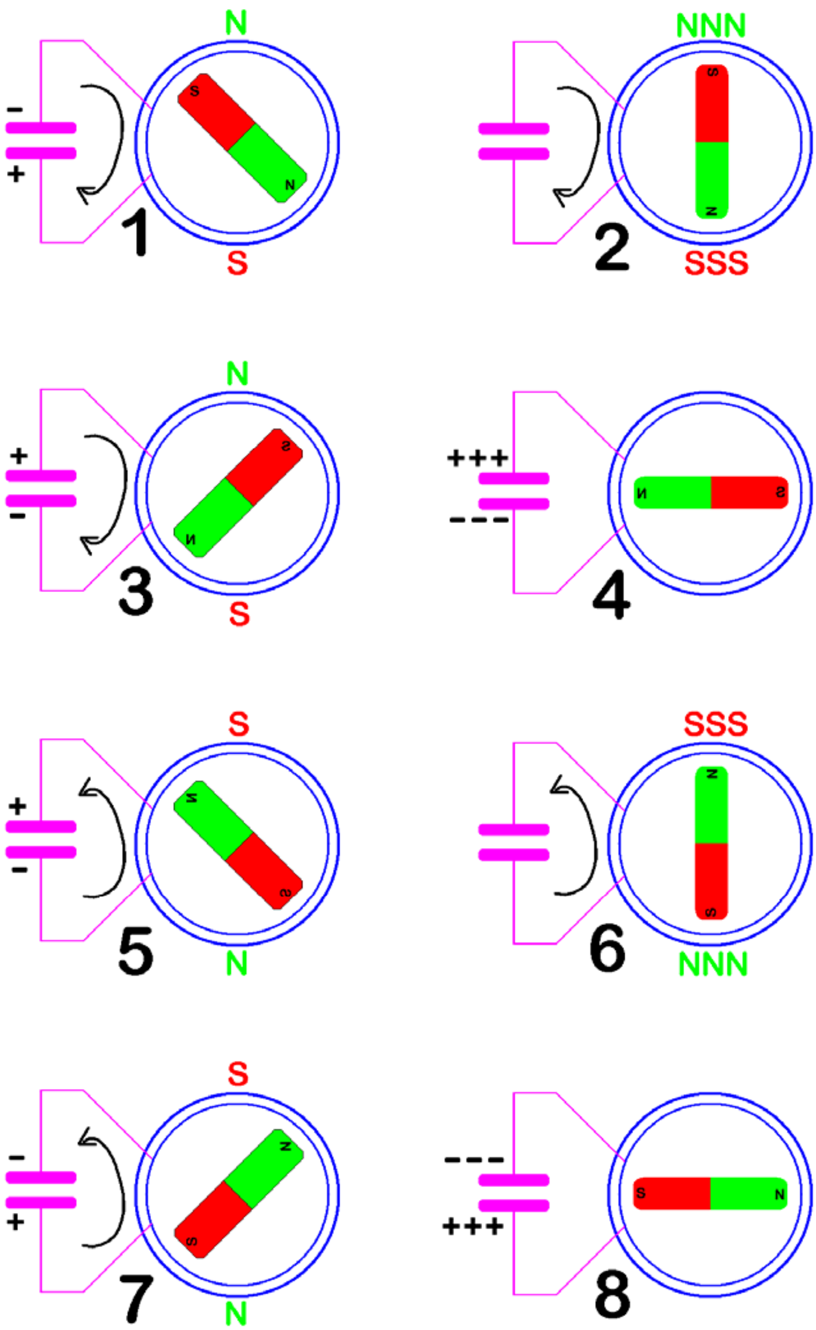

Fig.21:

Rotation of a magnet in the coil of a LC-circuit without “beneficial phase-shift” between the orientation of the magnet and the orientation of the oscillating field in the circuit.

Due to the absence of mechanical load, the rotating magnet can catch the position of the oscillating field, so that no further ZPE- energy will be converted.

This way of operation brings us to the knowledge, that the EMDR-converter can be operated as a ZPE-converter only, if permanently some mechanical power is extracted.

The fact that the rotating magnet can never overtake the oscillation of the LC-circuit (even not if it is free from any load), assures that there is an upper limit to the angular velocity of the mechanical rotation. This prevents us from the danger of too speedy rotation, which might cause a damage of the machine or an accident. Of course we have to make sure, that the rotating magnet can withstand the frequency of the LC-circuit.

In order to convert ZPE-energy, the EMDR-motor must have a positive “beneficial phase-shift”, of which the ideal case is shown in figure 20, representing a phase-shift of 45°. For it is not possible to maintain this phase-shift only by electrical means, mechanical power extraction from the shaft is absolutely necessary. This means that the rotating axis of the permanent magnet has to be loaded permanently with some mechanical torque, in order to maintain the requested “beneficial phase-shift”.

With regard to this aspect, our ZPE-motor shows completely different behaviour than a classical electrical motor. If we for instance decide to use good bearings in order to minimise friction and to avoid mechanical load to the shaft, we will even not be able to get any electrical power of the engine. But already if we begin to enhance mechanical friction in the bearings, this would help to enhance the amount of electrical power which can be extracted.

Of course, the application of bad bearings with much friction is not, what we recommend. Preferable is the well-controlled extraction of beneficial mechanical power from the rotating shaft. In the ideal case, we could have some active control, to influence the mechanical power extraction in such a way, that the “beneficial phase-shift” will always be regulated most close to its optimum value of 45°. This would allow long-term stable operation of the EMDR-motor with a maximum of extracted energy. This regulation can be constructed with regard to the angular velocity, or with regard to the phase shift. If we decide to choose the first alternative, we can define an “upper-level” and the “lower-level” for the angular velocity, and as soon as the rotating magnet becomes faster than the “upper-level”, the amount of the power being extracted can be enhanced. Analogously, the amount of power being extracted can be reduced, as soon as the angular velocity becomes slower than the “lower-level”. This is the basic idea on which the following chapter 6 is constructed.

6. The EMDR-Converter with mechanical power-extraction

As we saw in the figures 13, 14, 15 and especially in figure 19, the conversion of zero-point-energy in our EMDR-system can work efficiently during the initialisation of the operation. But the converted power goes asymptotically down to zero, in the same way as the phase shift between the rotation of the magnet and the LC-oscillation-circuit goes asymptotically down to zero, if we do not have some special technique maintain some “beneficial phase-shift” remarkably different from zero. We know the reason from section 5.

Therefore we have two apply mechanical torque $M_{mech}(t)$ to the shaft, in order to get a beneficial operation-mode of the EMDR-system. This torque $M_{mech}(t)$ has to be brought into equation (24a), as additional contribution, additionally to the torque of the magnetic forces (between permanent magnet and coil). The power which is extracted from the shaft by this torque is written in equation (27), and we find it in the second last line of table 1.

$$P_{mech} = M_{mech} \cdot \dot{\varphi} \tag{27}$$

Mechanical power-extraction, due to the torque
$M_{mech} = c_r \cdot \dot{\varphi}$ with $c_r =$ coefficient of friction
with a torque proportional to the angular-velocity of the rotation.

We will see, that this will enable us to run the EMDR-motor long-term stable and extract remarkable power. The DFEM-simulation is very encouraging, and therefore it's source-code is printed completely in the appendix of the publication here.

What we apply is a torque proportional to the angular velocity of the rotation (this is an arbitrary decision, it could also be made different), which we find in the source-code in those lines which begin with the comment "{GG}". The coefficient of friction has the name "cr" in the program, and it can be controlled with the subroutine "Reibung_nachregeln". This subroutine works with an angular velocity called "phipZiel", around which we have a small hysteresis, within which the angular velocity of the EMDR-motor shall be kept. In order to make the results convincing (with regard to the conversion of ZPE-energy), we allow the magnet to spin a little bit faster than with the initial frequency, so that everybody can see that also the angular velocity is enhanced during operation, fed by ZPE-energy.

As can be seen in the input-data of the source-code, the solution of the differential equation is made by numerical iteration with 10^8 steps, of which everyone has 43 nanoseconds. It was verified, that this is indeed a sufficient time-resolution, so that the algorithm has converged to the serious result.

When you run the algorithm, you get the following data onto the screen:

```
power gained within the system:    5.04845399 Watt
total extraction of energy on the load resistor = 223.50737922 Joule
corresponding to a power of:       5.19784602848813E+0001 Watt
energy being supplied from input:  0.00000000000000E+0000 Joule
corresponding to a power of:       0.00000000000000E+0000 Watt
totally extraction of mechanical energy =   2271.25431928806 Joule
corresponding to a power of =               528.19867890420 Watt
at a duration of observation of    4.30000000000000E+0000 sec.
```

We interpret this as following:

The start of the EMDR-converter is initialised with an angular velocity of 30,000 rounds per minute, while there is no initial electrical energy within the LC-oscillation-circuit. The rotation of the magnet induces a voltage into the coil and thus brings electrical energy into the LC-oscillation-circuit. Of this reason, the initialisation of the operation extracts some energy from the rotation of the magnet and brings it into the LC-oscillation-circuit. We see this in figure 22. But even during the first oscillation we see the energy gain from the ZPE-energy, so that the angular velocity of the magnet will be soon faster than at the very beginning. There we see the transient behaviour of the system, during which the energy is distributed between the electrical and mechanical part of the system as the laws of physics require. The transient behavior finally leads us to the frequency "phipZiel" with precision of a small hysteresis due to the control mechanism of the "beneficial phase-shift".

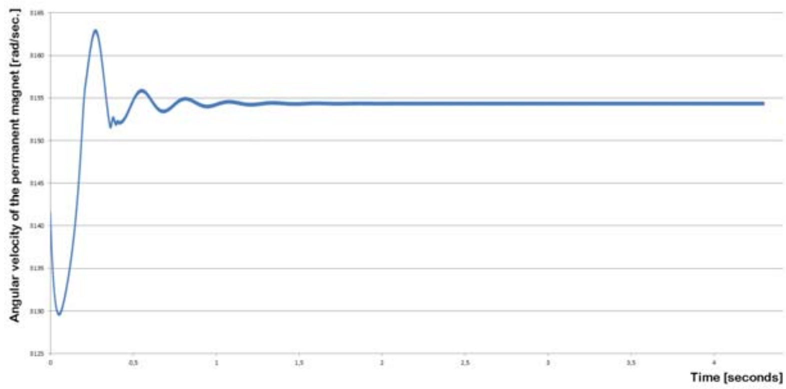

Fig.22:

Angular velocity of the rotating permanent magnet in a powerful EMDR-converter.

The graphic is plotted from column „I“ of the Excel data-export.

The control of the power extraction is being done via a time-dependent regulation of the coefficient of friction c_r. The time-dependent dynamic behaviour of this coefficient is printed in figure 23. Obviously the transient motion at the very beginning of the operation requires some control of the coefficient. But is seems as if this control is not further necessary, when the stable mode of operation is achieved. (We will discuss this later in detail.)

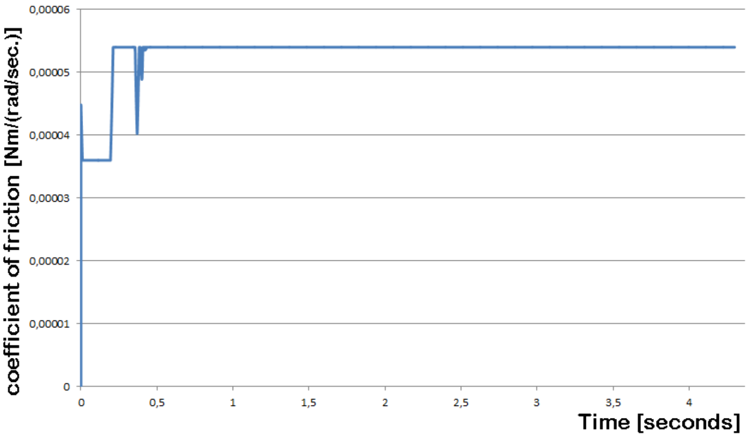

Fig.23:

Dynamic behaviour of the coefficient of friction, as it is used for the control of mechanical power extraction from the EMDR-motor.

The graphic is plotted from column „X" of the Excel data-export.

The amount of power actually being extracted is plotted in figure 24. With regard to the size of the setup, a mechanical power-output of a bit more than 530 whites is okay - as the permanent magnet has a length of only 10 cm. And it shall be mentioned that there is additional electrical power-output and the machine (at the load resistor), which is not yet fully optimised with regard to power-output.

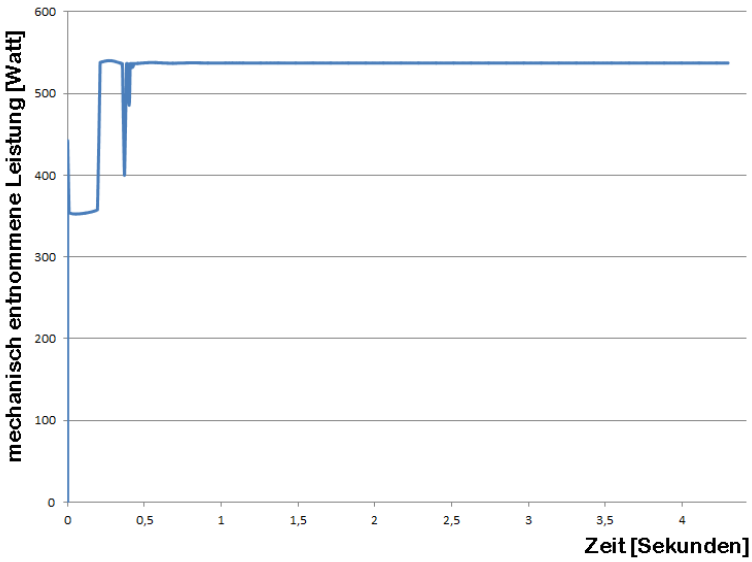

Fig.24:

Mechanical power output from the EMDR-converter.

The graphic is plotted from column „Y" of the Excel data-export.

In order to get an imagination about the mechanical and electrical dimensions, necessary for the design of the prototype, we now want to inspect the electrical current and the voltage in the LC-oscillation-circuit (see figure 25).

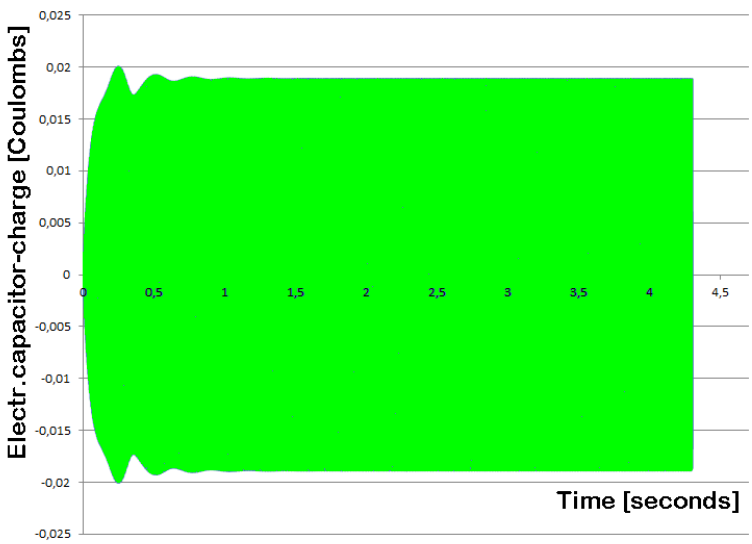

Fig.25:

Electrical charge Q in the capacitor of the EMDR-converter of our example.

The graphic is plotted from column „A" of the Excel data-export.

The capacitor-voltage goes rather quick from the transient behaviour to the stable operation. Figure 25 displays the envelope of the oscillating charge in the capacitor, from which we calculate the capacitor-voltage according to equation (28), as being nearly 200 Volts. This value is not a problem for a practical experiment.

But it is important to know, that the capacitor must be tuned extremely fine, because this is the device, with which the EMDR-converter is fine-tuned. The adjustment of its value with a precision of about 1% … 0.1% is necessary, so that it is a good advice to use a capacitor bank for instance as shown in figure 26. All single capacitors must be connected parallel and not in series. The capacitor should have almost the same internal resistance. And it is recommendable that they have the same time constants for being charged and discharged. Nevertheless they shall have different capacity in order to make the fine-tuning possible over a wide range of capacity.

Finally it should be emphasized, that the adjustment of the capacitor is the means, by which the uncertainties and the approximations of the theoretical calculations have to be compensated !

This means, that the computation can deliver a theoretical value of the capacity deviating from the real experimental value even by a factor of 1 … 2 … 3 (or more ?).

$$U_C = \frac{Q}{C} = \frac{0.02C}{101.7\,\mu F} = 197V \tag{28}$$

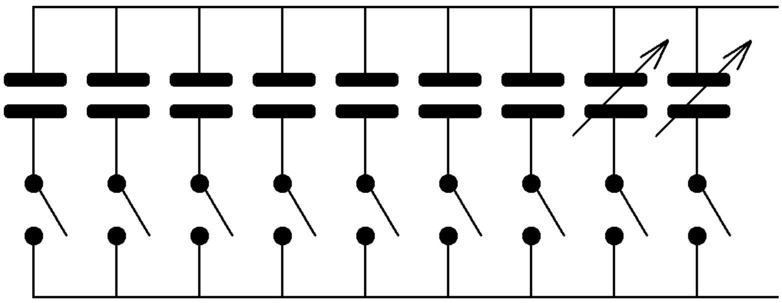

Fig.26:

Capacitor bank for fine-tuning of the capacity.

All single capacitors may have different capacity, so that a wide range of capacity can be tuned to this very fine adjustment.

An electrical current of about 60 Amperes (see figure 27) is not very much for the coil we have used, which has a diameter of the wire of 10 mm (i.e. a cross section 78.5 mm²). The problem is the handling of such a thick wire, but a trained mechanician should be able to do this. The capacitor bank must withstand a current of 60 Amperes.

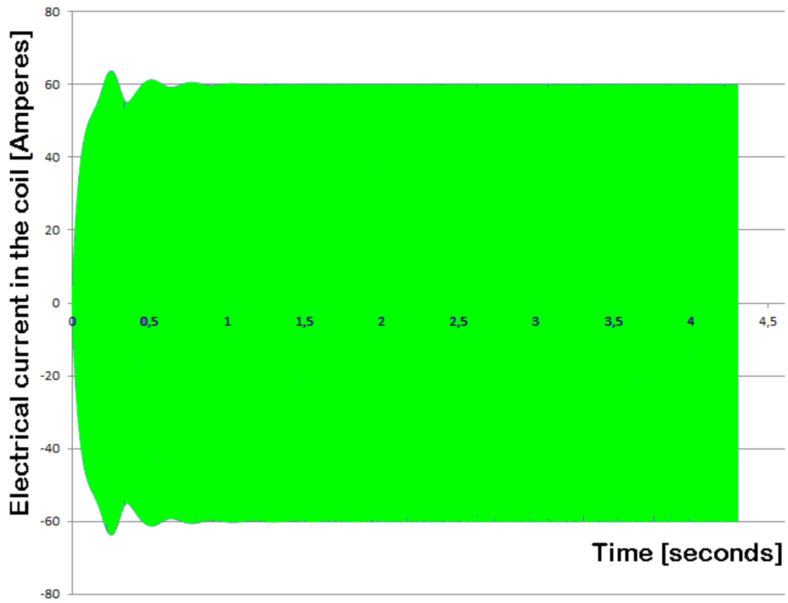

Fig.27:

Electrical current $\dot{Q}$ in the LC-oscillation-circuit of our EMDR-converter.

The graphic is plotted from column „B" of the Excel data-export.

The voltage over the coil can be found by equation (29) from the law of induction. It's amplitude is also close to 200 Volts, and thus far away from causing difficulties.

$$U_L = -L \cdot \dot{I} = 9.936 \cdot 10^{-4}\, Henry \cdot 200000 \frac{A}{\sec} = -199\, Volt \qquad (29)$$

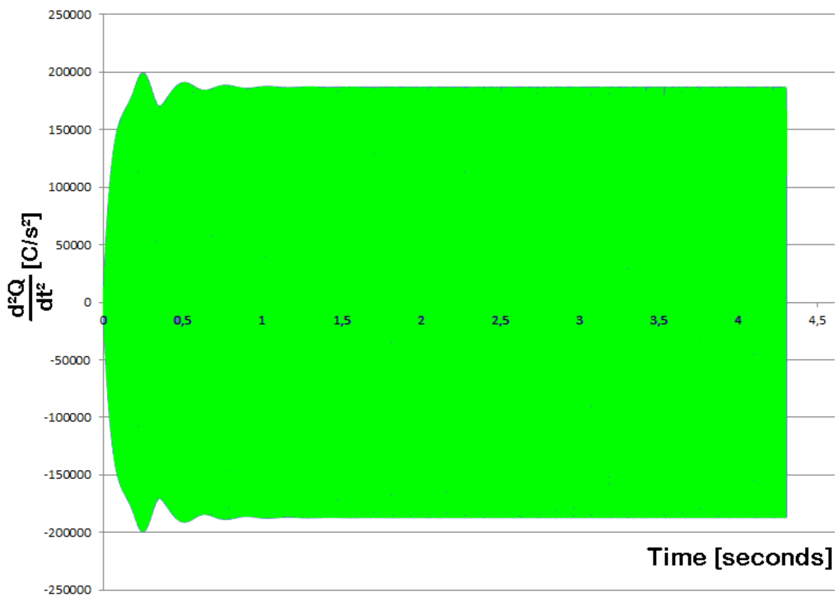

Fig.28:

Time derive of the current in the coil, i.e. $\ddot{Q}$ in our EMDR-converter.

The graphic is plotted from column „C" of the Excel data-export.

The angular acceleration of the rotating magnet (column "J" in Excel) with an amplitude of nearly 1000 rad/s^2 makes us understand, that the components of the EMDR-converter have to be mounted with appropriate mechanical stability. This angular acceleration acts on the magnet with a ponderable mass of 245 Gramms and a moment of inertia of rotation of $2.1 \cdot 10^{-4}$ kg·m^2. If the coil and the axis of rotation is not mounted with appropriate stability, the experiment might be dangerous.

The total energy of the system remains rather close to the value to which it is regulated (keep hysreresis in mind), as we see in figure 29. Similar behaviour can be seen in all channels of the energy analysis of the EMDR-system, because in the stable and durable long-term mode of operation, the energy is just oscillating between the different components of the system. And the amount of power per time, which is gained from the ZPE-energy is immediately converted into mechanical energy per time, being extracted at the shaft.

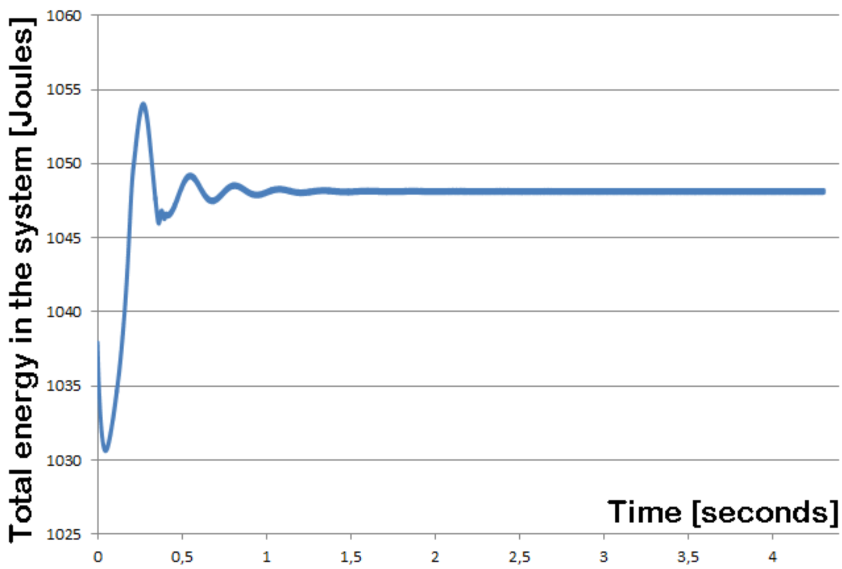

Fig.29:

Total energy in the EMDR-system.

The graphic is plotted from column „T" of the Excel data-export.

Additional question:

Is it allowed to drive the EMDR-motor without elaborated regulation of mechanical power extraction?

This would make it much easier to build up a prototype.

Answer:

Yes, it is allowed. It is even not the problem at all.

Also when the coefficient of friction is simply constant (in algorithm, const: „cr = crAnfang"), the EMDR-motor will run into a stable mode of operation by alone, as long as the coefficient of friction is within certain limits, which are not extremely narrow. If for instance we run the algorithm as shown in the appendix, but let us apply one single change, namely to use a constant coefficient of friction without any regulation, applying the value "crAnfang:=37E-6", the motor will come rather quick to a stable mode of operation, as we can see it in figure 30. Also the mechanically extracted power will come to a constant value rather soon, as we see in figure 31.

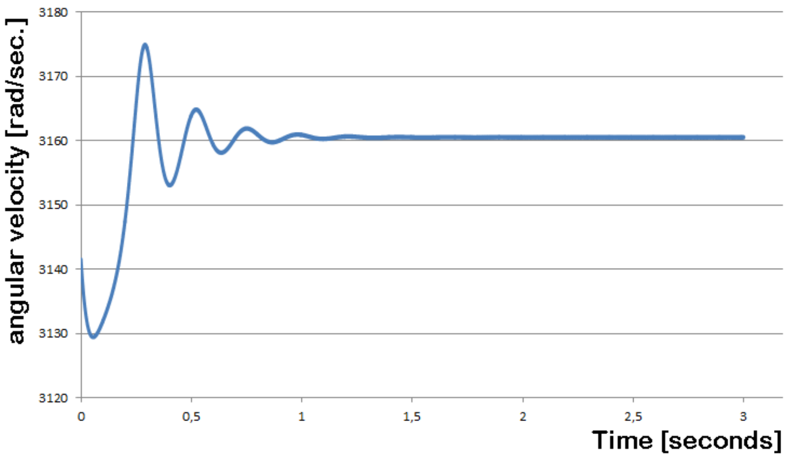

Fig.30:

Angular velocity of the rotating permanent magnet.

The graphic is plotted from column „I" of the Excel data-export.

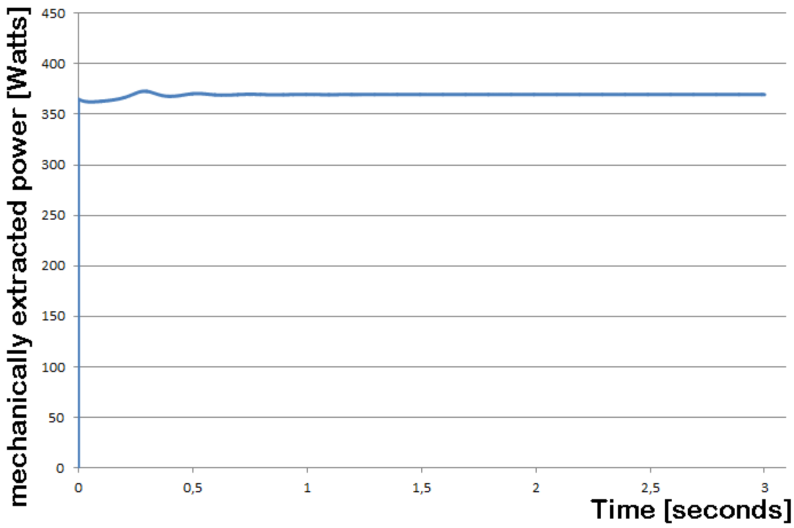

Fig.31:

Mechanical power extraction from the rotating shaft. The load-torque is proportional to the angular velocity of the axis.

The graphic is plotted from column „I" of the Excel data-export.

Experimentalists, who build up an EMDR-converter with simple constant friction c_r, should be careful not to use to strong friction, because strong mechanical load during the transient (initialization-) phase of operation does extract too much energy, so that the system cannot come into the long-term stable mode of operation. The allowed mechanical load without regulation is smaller than the allowed mechanical load with regulation. This means, if we take the average value of the load-coefficient of figure 23 (this is cr:=crAnfang:=54E-6), the EMDR-converter would never come to a stable mode of operation, because it would be slowed down too much during the initial phase. If we apply "crAnfang:=54E-6" with good regulation of "cr", we can extract 537 Watts mechanically, but if we apply “cr:=54E-6=const” without any regulation, EMDR-converter does work as a self-running ZPE-engine.

Here are some examples for load-coefficients recommendable or not recommendable:

cr:=crAnfang:=$2.0\cdot 10^{-5}$ => Pmech = 201 Watt (goes to stable operation)

cr:=crAnfang:=$2.5\cdot 10^{-5}$ => Pmech = 251 Watt (goes to stable operation)

cr:=crAnfang:=$3.0\cdot 10^{-5}$ => Pmech = 300 Watt (goes to stable operation)

cr:=crAnfang:=$3.5\cdot 10^{-5}$ => Pmech = 349 Watt (goes to stable operation)

cr:=crAnfang:=$3.7\cdot 10^{-5}$ => Pmech = 369 Watt (goes to stable operation)

cr:=crAnfang:=$4.0\cdot 10^{-5}$ => Pmech = 247 Watt (no stable operation, angular velocity goes asymptotically down to zero)

cr:=crAnfang:=$5.3\cdot 10^{-5}$ => Pmech = 117 Watt (average of Fig.23, no stable operation)

Obviously the extractable mechanical power increases linearly with increasing load-coefficient, as long as the mechanical load is not to strong (see the range of cr:=$2.0\cdot 10^{-5}$ ... $3.7\cdot 10^{-5}$). But if the load is too strong, the EMDR-engine will not have a chance to adjust the “beneficial phase-shift” between its electrical and its mechanical motion in such a way, that it can find its stable operation. This is, what we observe at cr:=$4.0\cdot 10^{-5}$, and of course much more at cr:=$5.3\cdot 10^{-5}$.

So we can say, that the control of the load coefficient is not absolutely necessary, especially not for the first prototypes, but it is nice to have for EMDR-motors build later, in order to maximise the extractable power in technical application. This is, what we got from regulation of the load-coefficient:

initial phase: crAnfang:=$4.5\cdot 10^{-5}$,

after regulation : cr:=$5.4\cdot 10^{-5}$, => Pmech = 537 Watt (long-term operation, figure.23)

The reason is, that the load is regulated down in those moments in which the torque is weak (during initialization), and the load is regulated up during those moments in which strong torque and power is available.

7. Practical advice for experimenalists, who want to build an EMDR-Converter

With the end of section 6, the theory of the EMDR-system is discussed. But we now want to speak about practical aspects, which are interesting for those, who want to try to verify the theory experimentally [PC 11].

Central part of the EMDR-converter is the magnet. But the algorithm allows to simulate almost every available magnet or configuration of magnets. For the sake of simplicity, our calculation-example was done with the simple cylindrical bar-magnet, which should be available very easily. In [Tur 11], the calculation-example was restricted to a homogeneous magnetic field of a disc magnet, with an orientation of the magnetisation “in plain” (in order to make the computations easy). This restriction is now not necessary any further, with the new algorithm presented here. Thus the calculation-example in [Tur 11] has been a rather rough approximation, but the accuracy now is better.

Experimentalists who use a cylindrical bar-magnet should not forget about the aerodynamic drag of the rotating magnet due to its rather high angular velocity. We can accept this aerodynamic drag as a mechanical load which helps to maintain the “beneficial phase-shift” according to figure 20, when we will try to build the first prototypes.

But this is not the version which shall be used for future technical applications. For technical applications, engineers will have to try to maximise the output-power, and thus the aerodynamic drag should be minimized. This can be for instance done by inserting the cylindrical bar-magnet into a round disk, as shown in figure 32. But the disc must not be made of ferromagnetic material, because such a disc would guide the magnetic field flux lines into the totally wrong direction, or even keep the magnetic field flux lines inside the disc. And probably it is recommendable, to manufacture the round carrier-disc from nonconductive material in order to avoid eddy-currents carefully. Thus it is a good idea, to manufacture the round carrier-disc from plastic, and to use a type of plastic which is mechanically stable, so that it can withstand the centrifugal forces.

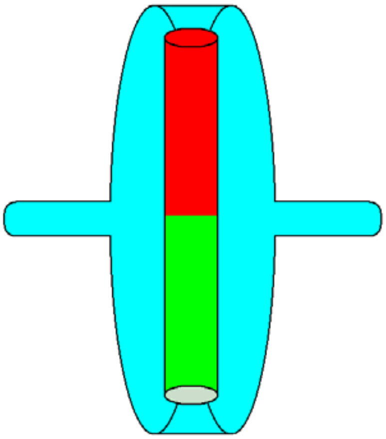

Fig.32:

Possible suggestion to encapsulate a cylindrical bar-magnet in order to minimise the aerodynamic drag due to the rotation of the magnet.

Regarding eddy-currents: Up to now, there are no investigations about the question, whether they disturb the EMDR-motor or not. There is even no theoretical analysis of the role of eddy-currents up to now. There have been hints in discussions with colleagues, that eddy-currents would prevent the EMDR-motor to run at all, but perhaps eddy-currents might perhaps define a mechanical load and thus help to maintain the “beneficial phase-shift”. It should be part of the experimental investigations to find out, whether eddy-currents disturb the EMDR-system or not. But for the first experimental trials and approaches, I recommend to avoid eddy-currents, because the theory works fine without eddy-currents.

Several colleagues discussed about the question, whether rare-earth magnets (such as neodymium) are mechanically stable enough to withstand the centrifugal-forces at 30,000 rounds per minute. It is well-known that neodymium magnets are less mechanically stable than steel. Nevertheless an encapsulation with steel in order to enhance the mechanical stability is absolutely forbidden, due to its influence on the field flux lines. For those, who want to maximise the mechanical stability, it is recommended to use an Iron-Cobalt-Nickel alloy for the magnet (without any encapsulation). It is possible to make a cylindrical bar-magnets of such alloy with a magnetic field-strength of 1 Tesla at each end of the bar. Such field-strength is absolutely sufficient for the operation in the EMDR-system. And furthermore the application of magnets of such alloy allows the mechanical stability of steel without encapsulating the magnet at all.

For sure the problem of eddy-currents is not neglectable for any encapsulation. We can see this, when we regard the energy-transfer from the rotating magnet into the coil as some special type of eddy-current-loss, which we need for the operation of the EMDR-converter.

Nevertheless, eddy-current-losses in the axis of rotation (we speak about the axis necessary to keep the magnet in its rotating-position), should not be regarded as a very large problem. It was discussed to use special glassfibre-plastic (for instance “GFK”) in order to get an axis without any eddy-current-losses. There is no argument against such an axis, as long as it is stable enough. But due to the stability of such a material, it might be recommendable, to mount the bearings rather close to the magnet (as drawn in figure 11), which makes it difficult, to apply the initial angular velocity as well as to extract mechanical power during operation. Furthermore, if eddy-current-losses are the reason to use an axis made of glassfibre-plastic, the bearings, which are rather close to the magnet and inside the coil, should also be of some isolating material, as for instance ceramic-ball-bearings. But such bearings are not stable for the same angular frequency as steel bearings. This is the reason, why I do not want to exclude the use of non-ferromagnetic metallic axis, which is long enough, to mount the steel-bearings far away from the magnet and the coil (i.e. outside the coil). Finally the experiment will have to decide between these different suggestions for the setup - some of them might work and some others not.

Also a second coil has been under discussion, which could be brought to the position in which we have the input-coil, but which has the purpose is to extract energy, namely electrically induced energy due to the rotation of the magnet. This application would change the name of the “input-coil” into “output-coil”. But the algorithm in the appendix makes it rather easy to add such an output-coil into our EMDR-model. Such an output-coil would have the advantage, that we can adjust the number of windings to the requirements of the voltage-current-characteristics, which will be preferable for future applications. (The output-coil can also be mounted perpendicular to the turbo-coil in order to allow both of them to come most close to the rotating magnet.)

A further suggestion regards the reduction of the angular velocity of the rotation of the magnet, namely the use of a multipole-magnet (of higher order), as it can be seen for instance in figure 33. There we have 16 bar-magnets (dipoles) mounted around a wheel, so that the whole magnetic setup has a multi-polarity of 16, instead of 2, as we have it with simple cylindrical bar-magnet. The consequence is, that such a multipole-wheel will have 16 changes of the magnetic polarity within every turn instead of 2. An enhancement of the number of polarity-changes per turn by a factor of 8 means, that we can reduce the angular velocity (of the magnet) by a factor of 8 (in comparison with the simple cylindrical bar-magnet). A simple numerical example shows the advantage: If we for instance have an electrical LC-oscillation-circuit with a resonance frequency of the 32,000 rounds per minute, the mechanical rotation of the multipole-wheel only requests 4000 rounds per minute. The numerical example can be changed arbitrarily, as long as the number of the multipoles is even (not odd).

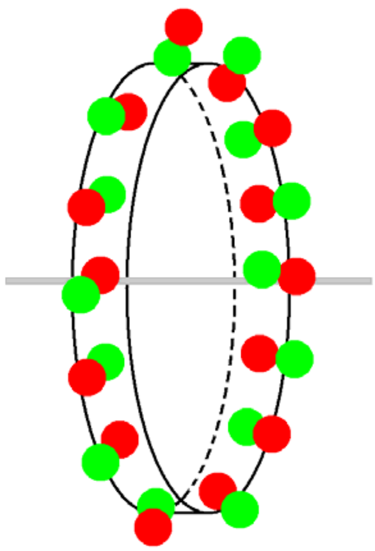

Abb.33:

Multipole-Magnet, which is manufactured by mounting several magnetic dipoles around a wheel.

Nevertheless it should be pointed out again, that a dipole-magnet has to be mounted mechanically very stable, same as a multipole-magnet of higher-order in order to avoid accidents. But the situation is less critical for multipole-magnet of higher order, because it runs more smoothly than dipole magnet (similar as every electrical engine).

8. Resumée

The result of the work presented here, is a computation method for ZPE-motors, which is much more close to reality than the very first development in [Tur 11], which explained the very principle more than the engineering aspects. The algorithm in the appendix is written in a way, that every trained researcher should be able to use it for the simulation of his own ZPE-converter, which can be the EMDR-design (invented by the author of this article) or which can also be some other design.

Important part of the work presented here, is the design of concrete example for a self-running ZPE-motor (this is the EMDR-engine). The design is calculated and suggested practicable enough, that every trained experimentalist should be able to build it up, as soon as he or she has the possibility to work in an appropriately equipped laboratory. Of course there are still several open experimental questions to be solved, but I am convinced, that this should not be an existential problem. (It might be a problem of time, and thus I do not dare any predictions.)

The author of this article would like to build up such a prototype by himself very much (especially on the background that he is educated/trained as an experimental physicist), but unfortunately he does not have any possibility to work in a laboratory in the moment now.

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[Tur 10b] DFEM-Computation of a Zero-point-energy Converter with realistic Parameters for a practical setup
Claus W. Turtur, PHILICA.COM, ISSN 1751-3030, Article number 213, (7. Dez. 2010)

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Claus W. Turtur, PHILICA.COM, ISSN 1751-3030, Article number 219, (7. Feb. 2011)

10. Appendix: Source-Code of the DFEM-Algorithm (EMDR_009i.dpr) [Bor 99]

Hint: Those lines of the Pascal-Program, which are longer than the text lines of the publication are continued right-aligned. (If you want to run the program, you should remove this alignment, or easier use the source-code to be downloaded for free from my internet-page.)

```
Program KM_009i;
{$APPTYPE CONSOLE}
uses
  Windows,
  Messages,
  SysUtils,
  Classes,
  Graphics,
  Controls,
  Forms,
  Dialogs;

Const Bn=7;           {number of steps for the data-storage of the magnetic field-strength}
Const SpNmax=200;     {maximal number of possible support points for the meshing of the coils}
Const FlNmax=2000;    {maximal number of possible finite area-elements of the coils}
Const MESEanz=200;    {actual number of elements for the permanent-magnet emulation-coils}
Const AnzPmax=35000; {Dimension of the Arrays for data-export to Excel)}

Var epo,muo  : Double;  {constants of nature}
    Bsw      : Double;  {step width for the storage of the magnetic field}
    Spsw     : Double;  {step width for the mesh-generation of the coils}
    SpN      : Integer; {number of support points of the coils}
    FlN      : Integer; {number of area elements for mesh generation of the coils}
    LiGe     : Double;  {speed of light}
    xo,yo,zo : Integer; {Geometrical parameters Fig.1}
    Ninput   : Integer; {number of windings of the Input-coil}
    Nturbo   : Integer; {number of windings of the Turbo-coil}
    PsiSFE   : Double;  {magnetic flux through every area element of the coils}
    PsiGES   : Double;  {magnetic flux through the total coil}
    B1,B2,B3,B4,B5      : Double;  {Fourier-coefficients, general}
    B1T,B2T,B3T,B4T,B5T : Double;  {Fourier-coefficients, Turbo-coil}
    B1I,B2I,B3I,B4I,B5I : Double;  {Fourier-coefficients, Input-coil}
    B1dreh,phase : Double;  {coefficients for fast torque computation}
    MEyo, MEro, MEI : Double;{dimensions of the coils for the emulation of the permanent magnet}
    Bx,By,Bz : Array [-Bn..Bn,-Bn..Bn,-Bn..Bn] of Double; {Cartesian components from magnetic induction}
    MESEx,MESEy,MESEz    : Array [1..MESEanz] of Double;{position of the magnet emulation coils}
    MESEdx,MESEdy,MESEdz : Array [1..MESEanz] of Double;{current direction within magnet emulation coils}
    OrtBx,OrtBy,OrtBz : Array [-Bn..Bn,-Bn..Bn,-Bn..Bn] of Double; {Cartesian components for determination
                                                                              of the magnetic field}
    SpIx,SpIy,SpIz    : Array [1..SpNmax] of Double; {support points for polygonial line, Input-coil}
    SpTx,SpTy,SpTz    : Array [1..SpNmax] of Double; {support points for polygonial line, Turbo-coil}
    SIx,SIy,SIz       : Array [1..SpNmax] of Double; {centre of conductor loop elements, Input-coil}
    STx,STy,STz       : Array [1..SpNmax] of Double; {centre of conductor loop elements, Turbo-coil}
    dSIx,dSIy,dSIz    : Array [1..SpNmax] of Double; {direction vector,conductor loop elements,Input-coil}
    dSTx,dSTy,dSTz    : Array [1..SpNmax] of Double; {direction vector,conductor loop elements,Turbo-coil}
    FlIx,FlIy,FlIz    : Array [1..FlNmax] of Double; {area elements, Input-coil, Cartesian coordinates}
    FlTx,FlTy,FlTz    : Array [1..FlNmax] of Double; {area elements, Turbo-coil, Cartesian coordinates}
    BxDR,ByDR,BzDR          : Array [-Bn..Bn,-Bn..Bn,-Bn..Bn] of Double; {rotated magnetic field}
    OrtBxDR,OrtByDr,OrtBzDR : Array [-Bn..Bn,-Bn..Bn,-Bn..Bn] of Double; {rotated position vectors}

    {Zum Lösen der Bewegungs-Differentialgleichung:}
    phi,phip,phipp      : Array[0..AnzPmax] of Double; {orientation angle of the magnet, derivatives}
    Q,Qp,Qpp            : Array[0..AnzPmax] of Double; {electrical charge in Turbo-coil}
    QI,QpI,QppI         : Array[0..AnzPmax] of Double; {electrical charge in Input-coil}
    phio,phipo,phippo,phim,phipm,phippm : Double; {angle and derivatives}
    qoT,qpoT,qppoT,qmT,qpmT,qppmT       : Double; {electrical charge in Turbo-coil and derivatives}
    qoI,qpoI,qppoI,qmI,qpmI,qppmI       : Double; {electrical charge in Input-coil and derivatives}
    PSIinput,PSIturbo   : Array[0..AnzPmax] of Double; {magnetic flux in the coils: Input & Turbo}
    UindInput,UindTurbo : Array[0..AnzPmax] of Double; {induced voltage, Input- and Turbo- coil}
    UinduzT,UinduzI     : Double;                      {induced voltage in the moment "NOW"}
    i                   : LongInt;  {control-variable to count time-steps}
    AnzP,AnzPmerk       : LongInt;  {total number of times steps for the solution of DGL.}
    dt                  : Double;   {duration of times steps}
    PlotAnfang,PlotEnde,PlotStep : LongInt; {control variables for data-export to Excel}
    Abstd               : Integer;  {plot control during initialisation}
    znr                 : Integer;  {plot control for data-export to Excel}
    LPP                 : Integer;  {last plot-point, to be used for data-export}
    Zeit : Array[0..AnzPmax] of Double; {time-scale}
    KG,KH,KI,KJ,KK,KL,KM,KN,KO,KP : Array[0..AnzPmax] of Double; {arrays for data-export to Excel}
    KQ,KR,KS,KT,KU,KV,KW,KX,KY,KZ : Array[0..AnzPmax] of Double; {arrays for data-export to Excel}
```

```
    BTx,BTy,BTz : Double;  {magnetic field of the Turbo coil at any position}
    BIx,BIy,BIz : Double;  { magnetic field of the input coil at any position }
    merk        : Double;  {for the purpose of testing}
    schonda     : Boolean; {have these data already be initialized ?}
    DD,DLI,DLT  : Double;  {diameter and length of the wires of the coils}
    rho         : Double;  {Ohm*m}  {specific resistance of copper, Kohlrausch,T193}
    RI,RT       : Double;  {Ohm's resistance of the coils}
    CT          : Double;  {Farad}  {capacitor in the Turbo-circuit}
    CI          : Double;  {Farad}  {capacitor in the Input-circuit}
    LT,LI       : Double;  {intductivity of the coils, Turbo and Input}
    nebeninput  : Double;  {windings side-by-side, Input-coil}
    ueberinput  : Double;  {windings on top of each other, Input-coil}
    nebenturbo  : Double;  {windings side-by-side, Turbo-coil}
    ueberturbo  : Double;  {windings on top of each other, Turbo-coil}
    BreiteI,HoeheI,BreiteT,HoeheT : Double; {wide and height of the coil bodies}
    omT,TT      : Double;  {angular frequency of Turbo oscillation circuit LT & CT.}
    UmAn,omAn   : Double;  {initial angular velocity of the magnet}
    UmSec       : Double;  {initial angular velocity of the magnet}
    J           : Double;  {moment of inertia of rotation of the magnet}
    rhoMag      : Double;  {density of the magnet-material}
    Mmag        : Double;  {Mass of the magnet}
    Rlast       : Double;  {Ohm's load resistor in the Turbo circuit}
    Uc,Il       : Double;  {initial conditions electrically: capacitor-voltage, coil-current}
    Tjetzt      : Double;  {moment now for the solution of the differential equation}
    QTmax,QImax,QpTmax,QpImax,QppTmax,QppImax,phipomax : Double; {maximum values for screen display}
    Wentnommen : Double; {total extracted energy}
    AnfEnergie,EndEnergie : Double; {energy comparison within the system}
    steigtM,steigtO : Boolean;  {check the slope of the reference signal}
    Iumk            : LongInt;  {reverse point of the reference Input-Signal}
    fkI,fkT         : Double; {correction of interactivity}
    Pzuf,Ezuf       : Double; {supported power by Input-voltage}
    crAnfang,cr     : Double; {coefficient of friction proportional to angular velocity}
    phipZiel        : Double; {angular velocity for friction-control}
    Preib           : Double; {extracted mechanical power}
    Ereib           : Double; {extracted mechanical energy}

Procedure Dokumentation_des_Ergebnisses;
Var fout   : Text;
begin
  Assign(fout,'Auswertung'); Rewrite(fout); {open file}
  Writeln(fout,'DFEM-Simulation of a EMDR-Motor.');
  Writeln(fout,' ');
  Writeln(fout,'Parameters for the solution of the differential equation:');
  Writeln(fout,'AnzP = ',AnzP:12,' number of times steps in calculation');
  Writeln(fout,'dt   = ',dt:12,' {Seconds} duration of times steps for iteration.');
  Writeln(fout,'Abstd= ',Abstd:5,'  {only for preparation-work, do not alter the value}');
  Writeln(fout,'PlotAnfang = ',Round(PlotAnfang):10,' {first plot point, data-Export to Excel}');
  Writeln(fout,'PlotEnde   = ',Round(PlotEnde):10,' {last plot point, data-Export to Excel}');
  Writeln(fout,'PlotStep   = ',Round(PlotStep):10,' {step-width for data-Export to Excel}');
  Writeln(fout,' ');
  Writeln(fout,'input data for the coils:');
  Writeln(fout,'Automatic mesh generation.');
  Writeln(fout,'Spsw   = ',Spsw:12:6,' Meters: Coil-meshing in steps of Spsw');
  Writeln(fout,'xo = ',xo,',  number of steps of "Spsw" ');
  Writeln(fout,'yo = ',yo,',  number of steps of "Spsw" ');
  Writeln(fout,'zo = ',zo,',  number of steps of "Spsw" ');
  Writeln(fout,'Ninput = ',Ninput:9,'  number of windings Input- Coil');
  Writeln(fout,'Nturbo = ',Nturbo:9,'  number of windings Turbo- Coil ');
  Writeln(fout,'nebeninput = ',Round(nebeninput):9,' windings side-by-side Input- Coil');
  Writeln(fout,'ueberinput = ',Round(ueberinput):9,' windings on top of each other Input- Coil');
  Writeln(fout,'nebenturbo = ',Round(nebenturbo):9,' windings side-by-side Turbo- Coil');
  Writeln(fout,'ueberturbo = ',Round(ueberturbo):9,' windings on top of each other Turbo-coil');
  Writeln(fout,' ');
  Writeln(fout,'Bsw = ',Bsw:9,' store magnetic field in centimeter-steps');
  Writeln(fout,'emulation of the one Tesla magnet:');
  Writeln(fout,'MEyo = ',MEyo:14,'  y-coordinates of the magnet emulation coils');
  Writeln(fout,'MEro = ',MEro:14,'  Radius of the magnet emulation coils');
  Writeln(fout,'MEI  = ',MEI:14,'  Current in the magnet emulation coils');
  Writeln(fout,' ');
  Writeln(fout,'several technical values:');
  Writeln(fout,'DD = ',DD:12:7,'  {Meter} {diameter of the coil wire');
  Writeln(fout,'rho = ',rho,'  {Ohm*m}    {Spezific resistance of copper');
  Writeln(fout,'rhoMag = ',rhoMag,'  {kg/m^3} {Density of the magnet material');
  Writeln(fout,'CT = ',CT:14,'  {Farad}    {Turbo-Capacitor');
  Writeln(fout,'CI = ',CI:14,'  {Farad}    {Input- Capacitor');
  Writeln(fout,' ');
  Writeln(fout,'other values:');
  Writeln(fout,'Rlast = ',Rlast:15,'  {Ohm} load resistor in Turbo-circuit');
```

```
  Writeln(fout,'UmAn = ',UmAn:10:2,'  {U/min} mechanical initial conditions- Rotating Magnet');
  Writeln(fout,'Uc = ',Uc:10:2,'  {Volt} electrical initial conditions - voltage TURBO-capacitor');
  Writeln(fout,'Il = ',Il:10:2,'  {Ampere} electrical initial conditions - TURBO-current');
  Writeln(fout,' ');
  Writeln(fout,'Mechanical power-extraction : ');
  Writeln(fout,'Coeffizient of power-extraction: ',crAnfang:17:12,' Nm/(rad/s)');
  Writeln(fout,'angular velocity for control: ',phipZiel:17:12,' U/min');
  Writeln(fout,' ');
  Writeln(fout,'Other Parameters, no input');
  Writeln(fout,'DLI:=4*(yo+zo)*Spsw*Ninput = ',DLI:10:5,' {Meter} Length of coil-wire, Input-coil');
  Writeln(fout,'DLT:=4*(yo+zo)*Spsw*Nturbo = ',DLT:10:5,' {Meter} Length of coil wire, Turbo-coil');
  Writeln(fout,'RI:=rho*(DLI)/(pi/4*DD*DD) = ',RI:10:5,' {Ohm} Ohm`s resistance of Input-Coil');
  Writeln(fout,'RT:=rho*(DLT)/(pi/4*DD*DD) = ',RT:10:5,' {Ohm} Ohm`s resistance of Turbo-Coil');
  Writeln(fout,'BreiteI:=nebeninput*DD = ',BreiteI:10:5,' Width and Height of Input-Coil');
  Writeln(fout,'HoeheI:=ueberinput*DD  = ',HoeheI:10:5,' Width and Height of Input-Coil');
  Writeln(fout,'BreiteT:=nebenturbo*DD = ',BreiteT:10:5,' Width and Height of Turbo-Coil');
  Writeln(fout,'HoeheT:=ueberturbo*DD  = ',HoeheT:10:5,' Width and Height of Turbo-Coil');
  Writeln(fout,'fkI:=Sqrt(HoeheI*HoeheI+4/pi*2*yo*2*zo)/HoeheI = ',fkI:10:5,' correction of Induktivity
                                                                                   short Input-Coil');
  Writeln(fout,'fkT:=Sqrt(HoeheT*HoeheT+4/pi*2*yo*2*zo)/HoeheT = ',fkT:10:5,' correction of Induktivity
                                                                                   short Turbo-Coil');
  Writeln(fout,'LI:=muo*(2*yo+BreiteI)*(2*zo+BreiteI)*Ninput*Ninput/(HoeheI*fkI) = ',LI,' Induktivität
                                                                                         Input-Coil');
  Writeln(fout,'LT:=muo*(2*yo+BreiteT)*(2*zo+Breitet)*Nturbo*Nturbo/(HoeheT*fkT) = ',LT,' Induktivität
                                                                                         Turbo-Coil');
  Writeln(fout,'omT:=1/Sqrt(LT*CT) = ',omT,' oscillation frequency of Turbo circuit');
  Writeln(fout,'TT:=2*pi/omT = ',TT,' Period of Turbo-circuit LT & CT.');
  Writeln(fout,'Mmag:=rhoMag*(pi*MEro*MEro)*(2*MEyo) = ',Mmag:8:3,' kg Mass of the magnet');
  Writeln(fout,'J:=Mmag/4*(MEro*MEro+4*MEyo*MEyo/3) = ',J,' moment of inertia, Rotation of magnet');
  Writeln(fout,' ');
  Writeln(fout,'display of several Parameters:');
  Writeln(fout,'Magnet: Start-angular velocity.: omAn = ',omAn:15:6,' rad/sec');
  Writeln(fout,'Magnet: Start-angular velocity, Umdr./sec.: UmSec = ',UmSec:15:10,' Hz');
  Writeln(fout,'Mass of the Magnet = ',Mmag:10:6,' kg');
  Writeln(fout,'Tmoment of inertia, Rotation of magnet',J,' kg*m^2');
  Writeln(fout,'duration of observation: ',AnzP*dt,' sec.');
  Writeln(fout,'Excel-Export: ',PlotAnfang*dt:14,'...',PlotEnde*dt:14,' sec., Step ',PlotStep*dt:14,'
                                                                                              sec.');
  Writeln(fout,'These are ',(PlotEnde-PlotAnfang)/PlotStep:8:0,' Data-points (lines).');
  Writeln(fout,' ');
  Writeln(fout,' ********************************************************************************');
  Writeln(fout,' ');
  Writeln(fout,'some results of the computation:');
  Writeln(fout,'initial energy in the system:    ',AnfEnergie:14:8,' Joule');
  Writeln(fout,'final energy in the system:        ',EndEnergie:14:8,' Joule');
  Writeln(fout,'corresponding to a power of:',(EndEnergie-AnfEnergie)/(AnzP*dt):14:8,' Watt');
  Writeln(fout,'extracted to energy at load resistor = ',Wentnommen:14:8,' Joule');
  Writeln(fout,'ecorresponding to a power of:',Wentnommen/(AnzP*dt),' Watt');
  Writeln(fout,'input-energy: ',Ezuf,' Joule');
  Writeln(fout,'corresponding to a power of:',Ezuf/(AnzP*dt),' Watt');
  Writeln(fout,'totally extracted mechanical energy = ',Ereib:18:11,' Joule');
  Writeln(fout,'corresponding to a power of = ',Ereib/(AnzP*dt):18:11,' Watt');
  Writeln(fout,'duration of observation',(AnzP*dt),' sec.');
  Close(fout);
end;

Procedure Wait;
Var Ki : Char;
begin
  Write('<W>'); Read(Ki); Write(Ki);
  If Ki='e' then Halt;
  If Ki='E' then Halt;
  If Ki='d' then Dokumentation_des_Ergebnisses;
  If Ki='D' then Dokumentation_des_Ergebnisses;
end;

Procedure ExcelAusgabe(Name:String;Spalten:Integer);
Var fout   : Text;
    lv,j,k : Integer; {control variables}
    Zahl   : String;  {print values to excel}
begin
  Assign(fout,Name); Rewrite(fout); {File open}
  For lv:=0 to AnzP do  {from "plotanf" to "plotend"}
  begin
    If (lv mod Abstd)=0 then
    begin
      For j:=1 to Spalten do
      begin   {print columns, 3*charge, 3*angle, then 8 auxiliary}
```

```
        If j=1  then Str(Q[lv]:19:14,Zahl);
        If j=2  then Str(Qp[lv]:19:14,Zahl);
        If j=3  then Str(Qpp[lv]:19:14,Zahl);
        If j=4  then Str(phi[lv]:19:14,Zahl);
        If j=5  then Str(phip[lv]:19:14,Zahl);
        If j=6  then Str(phipp[lv]:19:14,Zahl);
        If j=7  then Str(KG[lv]:19:14,Zahl);
        If j=8  then Str(KH[lv]:19:14,Zahl);
        If j=9  then Str(KI[lv]:19:14,Zahl);
        If j=10 then Str(KJ[lv]:19:14,Zahl);
        If j=11 then Str(KK[lv]:19:14,Zahl);
        If j=12 then Str(KL[lv]:19:14,Zahl);
        If j=13 then Str(KM[lv]:19:14,Zahl);
        If j=14 then Str(KN[lv]:19:14,Zahl);
        For k:=1 to Length(Zahl) do
        begin   {use "commata" instead of decimal points}
          If Zahl[k]<>'.' then write(fout,Zahl[k]);
          If Zahl[k]='.' then write(fout,',');
        end;
        Write(fout,chr(9));  {Data-separation Tabulator}
      end;
      Writeln(fout,'');    {line-separation}
    end;
  end;
  Close(fout);
end;

Procedure ExcelLangAusgabe(Name:String;Spalten:Integer);
Var fout   : Text;    {timescale and up to 25 columns}
    lv,j,k : Integer; {control variables}
    Zahl   : String;  {print data to excel}
begin
  If (Spalten>25) then
  begin
    Writeln('FEHLER: Zu viele Spalten. Soviele Daten-Arrays sind nicht vorhanden.');
    Writeln(' => PROGRAMM WURDE ANGEHALTEN : STOP !');
    Wait; Wait; Halt;
  end;
  Assign(fout,Name); Rewrite(fout); {File open}
  For lv:=0 to LPP do  {from "plotanf" to "plotend"}
  begin
    If (lv mod Abstd)=0 then
    begin
      For j:=0 to Spalten do
      begin   {print columns, 3*charge, 3*angle, then auxiliary}
        If j=0  then Str(Zeit[lv]:19:14,Zahl);  {Markieren der Zeit-Skala}
        If j=1  then Str(Q[lv]:19:14,Zahl);     {Turbo-coil}
        If j=2  then Str(Qp[lv]:19:14,Zahl);    {Turbo-}
        If j=3  then Str(Qpp[lv]:19:14,Zahl);   {Turbo-coil}
        If j=4  then Str(QI[lv]:19:14,Zahl);    {Input-coil}
        If j=5  then Str(QpI[lv]:19:14,Zahl);   {Input-coil}
        If j=6  then Str(QppI[lv]:19:14,Zahl);  {Input-coil}
        If j=7  then Str(phi[lv]:19:14,Zahl);   {Magnet}
        If j=8  then Str(phip[lv]:19:14,Zahl);  {Magnet}
        If j=9  then Str(phipp[lv]:19:14,Zahl); {Magnet}
        If j=10 then Str(KK[lv]:19:14,Zahl);    {Auxiliary}
        If j=11 then Str(KL[lv]:19:14,Zahl);    {Auxiliary}
        If j=12 then Str(KM[lv]:19:14,Zahl);    {Auxiliary}
        If j=13 then Str(KN[lv]:19:14,Zahl);    {Auxiliary}
        If j=14 then Str(KO[lv]:19:14,Zahl);    {Auxiliary}
        If j=15 then Str(KP[lv]:19:14,Zahl);    {Auxiliary}
        If j=16 then Str(KQ[lv]:19:14,Zahl);    {Auxiliary}
        If j=17 then Str(KR[lv]:19:14,Zahl);    {Auxiliary}
        If j=18 then Str(KS[lv]:19:14,Zahl);    {Auxiliary}
        If j=19 then Str(KT[lv]:19:14,Zahl);    {Auxiliary}
        If j=20 then Str(KU[lv]:19:14,Zahl);    {Auxiliary}
        If j=21 then Str(KV[lv]:19:14,Zahl);    {Auxiliary}
        If j=22 then Str(KW[lv]:19:14,Zahl);    {Auxiliary}
        If j=23 then Str(KX[lv]:19:14,Zahl);    {Auxiliary}
        If j=24 then Str(KY[lv]:19:14,Zahl);    {Auxiliary}
        If j=25 then Str(KZ[lv]:19:14,Zahl);    {Auxiliary}
        For k:=1 to Length(Zahl) do
        begin   {use "commata" instead of decimal points}
          If Zahl[k]<>'.' then write(fout,Zahl[k]);
          If Zahl[k]='.' then write(fout,',');
        end;
        Write(fout,chr(9));  {Data-separation Tabulator}
      end;
```

```
      Writeln(fout,'');    {line-separation}
    end;
  end;
  Close(fout);
end;

Function Sgn(Zahl:Integer):Double;
Var merk : Double;
begin
  merk:=0;
  If Zahl>0 then merk:=+1;
  If Zahl<0 then merk:=-1;
  Sgn:=merk;
end;

Procedure Magnetfeld_zuweisen_01; {homogeneous Magnetic field}
Var i,j,k : Integer;
begin
  For i:=-Bn to Bn do  {in x-direction}
  begin
    For j:=-Bn to Bn do  {in y-direction}
    begin
      For k:=-Bn to Bn do  {in z-direction}
      begin
        Bx[i,j,k]:=0.0; {Telsa}
        By[i,j,k]:=1.0; {Telsa}
        Bz[i,j,k]:=0.0; {Telsa}
        OrtBx[i,j,k]:=i*Bsw;
        OrtBy[i,j,k]:=j*Bsw;
        OrtBz[i,j,k]:=k*Bsw;
      end;
    end;
  end;
end;

Procedure Magnetfeld_zuweisen_02; {arbitrary trial of inhomogeneous magnetic field}
Var i,j,k : Integer;
begin
  For i:=-Bn to Bn do  {in x-direction}
  begin
    For j:=-Bn to Bn do  {in y-direction}
    begin
      For k:=-Bn to Bn do  {in z-direction}
      begin
        Bx[i,j,k]:=-Sgn(i)/(i*i+j*j+k*k+1); If i=0 then Bx[i,j,k]:=0; {Telsa}
        By[i,j,k]:=     10/(i*i+j*j+k*k+1);                           {Telsa}
        Bz[i,j,k]:=-Sgn(k)/(i*i+j*j+k*k+1); If k=0 then Bz[i,j,k]:=0; {Telsa}
        OrtBx[i,j,k]:=i*Bsw;
        OrtBy[i,j,k]:=j*Bsw;
        OrtBz[i,j,k]:=k*Bsw;
{       Writeln('Ort:',OrtBx[i,j,k]:12:8,', ',OrtBy[i,j,k]:12:8,', ',OrtBz[i,j,k]:12:8); Wait; }
      end;
    end;
  end;
end;

Procedure Magnetfeld_zuweisen_03;
Var KRPx,KRPy,KRPz : Double; {Cartesian components of the outer product in the counter}
    lmsbetrag      : Double; {absolute value in the denominator}
    lmsbetraghoch3 : Double; {control variable}
    qwill          : Double; {electrical charge, arbitrarily nach S.7}
    om             : Double; {frequency for adjustment qwill to I}
    t              : Double; {time as control variable  0 ... 2*pi/om}
    sx,sy,sz       : Double; {position, where the field has to be determined}
    dHx,dHy,dHz    : Double; {Infinitesimal field element of Biot-Savert}
    Hx,Hy,Hz       : Double; {total field at the point of interest}
    dphi           : Double; {mesh generation of the coil}
    Hxkl,Hykl,Hzkl : Double; {classical result compared}
    Nenner         : Double; {helping variable for classical computation}
    i2,j2,k2       : Integer;{controlled variable for space}
    BXmax,BYmax,BZmax : Double; {field maximum on Y-axis}
Procedure Berechne_dH;
begin
  KRPx:=-om*MEro*cos(om*t)*(MEyo-sy);
  KRPy:=+om*MEro*cos(om*t)*(MEro*cos(om*t)-sx)+om*MEro*sin(om*t)*(MEro*sin(om*t)-sz);
  KRPz:=-om*MEro*sin(om*t)*(MEyo-sy);
  lmsbetrag:=Sqr(MEro*cos(om*t)-sx)+Sqr(MEyo-sy)+Sqr(MEro*sin(om*t)-sz);
  lmsbetrag:=Sqrt(lmsbetrag);
```

```
  lmsbetraghoch3:=lmsbetrag*lmsbetrag*lmsbetrag;
  If lmsbetraghoch3<=1E-50 then begin dHx:=0; dHy:=0; dHz:=0; end;
  If lmsbetraghoch3>=1E-50 then
  begin
    dHx:=qwill*KRPx/4/pi/lmsbetraghoch3*dphi/2/pi;
    dHy:=qwill*KRPy/4/pi/lmsbetraghoch3*dphi/2/pi;
    dHz:=qwill*KRPz/4/pi/lmsbetraghoch3*dphi/2/pi;
  end;
{ Writeln('Infinitesimal Field-element: ',dHx:12:7,', ',dHy:12:7,', ',dHz:12:7,' A/m'); }
end;
Procedure Berechne_Hges;
Var ilok : Integer;{control- variable for coil- meshing}
begin
  Hx:=0;  Hy:=0;  Hz:=0;  {initialisation of the total field}
  qwill:=1;  om:=2*pi*MEI/qwill; {charge and frequency of the magnet emulation coil, *1 von S.7}
  dphi:=2*pi/1000;    {Radiants}
  For ilok:=0 to 999 do  {1000 steps of counting}
  begin
    t:=ilok*dphi/om;  {control  variable (Time), once around the coil}
{   Writeln('ilok = ',ilok:4,' => ',om*t:12:6);  Wait; }
    Berechne_dH;   {Infinitesimal  Field-element of Biot-Savart berechnen}
    Hx:=Hx+dHx;
    Hy:=Hy+dHy;
    Hz:=Hz+dHz;
  end;
{ Writeln('total field at the point of interest. : ',Hx:12:7,', ',Hy:12:7,', ',Hz:12:7,' A/m'); }
  Hxkl:=0; Hzkl:=0; {classic competition for comparison.}
  Nenner:=Sqrt(MEro*MEro+(MEyo-sy)*(MEyo-sy)); Nenner:=2*Nenner*Nenner*Nenner;
  Hykl:=MEI*MEro*MEro/Nenner; {classical comparison is only at y-axis.}
{ Writeln('classical comparison at y-axis: ',Hxkl:12:7,', ',Hykl:12:7,', ',Hzkl:12:7,' A/m'); }
end;
begin
  Writeln; Writeln('Magnetfeld Emulations-Spulenpaar nach *1 von S.5');
  Writeln('y-Koordinaten der Magnetfeld-Emulationsspulen nach *1 von S.5: ',MEyo:8:5,' m');
  Writeln('Radius der Magnetfeld-Emulationsspulen nach *1 von S.5: ',MEro:8:5,' m');
  Writeln('Strom der Magnetfeld-Emulationsspulen nach *1 von S.5: ',MEI:8:5,' Ampere');
  Writeln('Anzahl der Schritte: ',Bn,' hoch 3 => ', 2*Bn+1,' Bildschirm-Aktionspunkte je Spule.');
{ first calculate the top coil: }
  For i2:=-Bn to Bn do  {in x-direction}
  begin
    For j2:=-Bn to Bn do  {in y-direction}
    begin
      For k2:=-Bn to Bn do  {in z-direction}
      begin
        OrtBx[i2,j2,k2]:=i2*Bsw;  sx:=OrtBx[i2,j2,k2];
        OrtBy[i2,j2,k2]:=j2*Bsw;  sy:=OrtBy[i2,j2,k2];
        OrtBz[i2,j2,k2]:=k2*Bsw;  sz:=OrtBz[i2,j2,k2];
        Berechne_Hges;
        Bx[i2,j2,k2]:=muo*Hx; {Telsa}
        By[i2,j2,k2]:=muo*Hy; {Telsa}
        Bz[i2,j2,k2]:=muo*Hz; {Telsa}
{       Write(OrtBx[i2,j2,k2]:10:6,', ',OrtBy[i2,j2,k2]:10:6,', ',OrtBz[i2,j2,k2]:10:6);
        Writeln(' =>',Bx[i2,j2,k2]*1E8:7:4,'E-8, ',By[i2,j2,k2]*1E8:7:4,'E-8, ',Bz[i2,j2,k2]*1E8:7:4,'E-8
                                                                                            Tesla');
        Wait; }
      end;
    end;
    Write('.');
  end;  Writeln(' top coil is calculated.');
{ Writeln('top coil, field at origin of coordinates: ');
  Writeln(Bx[0,0,0],', ',By[0,0,0],', ',Bz[0,0,0]*1E8:7:4,' T'); }
{ Then to add the bottom coil: }
  MEyo:=-MEyo;   {Position of the bottom coil}
  For i2:=-Bn to Bn do  {in x-direction}
  begin
    For j2:=-Bn to Bn do  {in y-direction}
    begin
      For k2:=-Bn to Bn do  {in z-direction}
      begin
        OrtBx[i2,j2,k2]:=i2*Bsw;  sx:=OrtBx[i2,j2,k2];
        OrtBy[i2,j2,k2]:=j2*Bsw;  sy:=OrtBy[i2,j2,k2];
        OrtBz[i2,j2,k2]:=k2*Bsw;  sz:=OrtBz[i2,j2,k2];
        Berechne_Hges;
        Bx[i2,j2,k2]:=Bx[i2,j2,k2]+muo*Hx; {Telsa}
        By[i2,j2,k2]:=By[i2,j2,k2]+muo*Hy; {Telsa}
        Bz[i2,j2,k2]:=Bz[i2,j2,k2]+muo*Hz; {Telsa}
{       Write(OrtBx[i2,j2,k2]:10:6,', ',OrtBy[i2,j2,k2]:10:6,', ',OrtBz[i2,j2,k2]:10:6);
        Writeln(' =>',Bx[i2,j2,k2]*1E8:7:4,'E-8, ',By[i2,j2,k2]*1E8:7:4,'E-8, ',Bz[i2,j2,k2]*1E8:7:4,'E-8
```

```
                                                                                                   Tesla');
        Wait; }
      end;
    end;
    Write('.');
  end;  Writeln(' Untere Spule ist durchgerechnet.'); Writeln;
  MEyo:=-MEyo;   {MEyo reset.}
  Writeln('Gesamtes Feld am Koordinaten-Ursprung: ');
  Writeln(Bx[0,0,0],', ',By[0,0,0],', ',Bz[0,0,0],' T');
  Writeln; Writeln('Gesamtes Feld im Zentrum der oberen Spule:');
  {centre of top coil:} sx:=0; sy:=MEyo; sz:=0;
  Berechne_Hges; BXmax:=muo*Hx; BYmax:=muo*Hy; BZmax:=muo*Hz;
  {centre of bottom coil:} sx:=0; sy:=-MEyo; sz:=0;
  Berechne_Hges; BXmax:=BXmax+muo*Hx; BYmax:=BYmax+muo*Hy; BZmax:=BZmax+muo*Hz;
  Writeln(BXmax,', ',BYmax,', ',BZmax,' T');
  Writeln('Ist dieses Feld gewünscht ? ? ! ? ? ! ? ?');
  Wait; Wait;
end;

Procedure Magnetfeld_anzeigen;
Var i,j,k : Integer;
begin
  Writeln('Feld "Magnetische Induktion" des Dauermagneten:');
  For i:=-Bn to Bn do  {in x-direction}
  begin
    For j:=-Bn to Bn do  {in y-direction}
    begin
      For k:=-Bn to Bn do  {in z-direction}
      begin
        Write('x,y,z=',OrtBx[i,j,k]*100:5:2,', ',OrtBy[i,j,k]*100:5:2,', ',OrtBz[i,j,k]*100:5:2,'cm =>
                                                                                                      B=');
        Write(Bx[i,j,k]:8:4,', ');
        Write(By[i,j,k]:8:4,', ');
        Write(Bz[i,j,k]:8:4,' T ');
        Wait;
      end;
    end;
  end;
end;

Procedure Stromverteilung_zuweisen_03;
Var i : Integer;
begin
  Writeln('Kontrolle der Magnetfeld-Emulations-Spulen:');
  For i:=1 to Round(MESEanz/2) do
  begin
    MESEx[i]:=MEro*cos((i-1)/Round(MESEanz/2)*2*pi); {position of the top field emulation coils}
    MESEy[i]:=MEyo;                                  {position of the top field emulation coils}
    MESEz[i]:=MEro*sin((i-1)/Round(MESEanz/2)*2*pi); {position of the top field emulation coils}
    MESEdx[i]:=-sin((i-1)/Round(MESEanz/2)*2*pi);    {direction of the top field emulation coils}
    MESEdy[i]:=0;                                    {direction of the top field emulation coils}
    MESEdz[i]:=cos((i-1)/Round(MESEanz/2)*2*pi);     {direction of the top field emulation coils}
{   Writeln(i:4,': x,y,z = ',MESEx[i]:12:6 ,', ',MESEy[i]:12:6 ,', ',MESEz[i]:12:6 ,' m');
    Writeln(i:4,': dx,y,z= ',MESEdx[i]:12:6,', ',MESEdy[i]:12:6,', ',MESEdz[i]:12:6,' ');
    Writeln('Laengenkontrolle: ',Sqr(MESEdx[i])+Sqr(MESEdz[i]));  Wait; }
  end;
  For i:=Round(MESEanz/2)+1 to MESEanz do
  begin
    MESEx[i]:=MEro*cos((i-1)/Round(MESEanz/2)*2*pi); {position of the bottom field emulation coils}
    MESEy[i]:=-MEyo;                                 {position of the bottom field emulation coils}
    MESEz[i]:=MEro*sin((i-1)/Round(MESEanz/2)*2*pi); {position of the bottom field emulation coils}
    MESEdx[i]:=-sin((i-1)/Round(MESEanz/2)*2*pi);    {direction of the bottom field emulation coils}
    MESEdy[i]:=0;                                    {direction of the bottom field emulation coils}
    MESEdz[i]:=cos((i-1)/Round(MESEanz/2)*2*pi);     {direction of the bottom field emulation coils}
{   Writeln(i:4,': x,y,z = ',MESEx[i]:12:6 ,', ',MESEy[i]:12:6 ,', ',MESEz[i]:12:6 ,' m');
    Writeln(i:4,': dx,y,z= ',MESEdx[i]:12:6,', ',MESEdy[i]:12:6,', ',MESEdz[i]:12:6,' ');
    Writeln('control of length: ',Sqr(MESEdx[i])+Sqr(MESEdz[i]));  Wait; }
  end;
end;

Procedure Spulen_zuweisen; {coil for the optional input of energy}
Var i,j : Integer;
begin
  {support points of the Polygone:}
  For i:=0 to 2*zo do
  begin   {begin at the left bottom, go first to z- direction}
    SpIx[i+1]:=-xo*Spsw;  SpIy[i+1]:=-yo*Spsw;  SpIz[i+1]:=(i-zo)*Spsw;     {support point}
    SpTx[i+1]:=+xo*Spsw;  SpTy[i+1]:=-yo*Spsw;  SpTz[i+1]:=(i-zo)*Spsw;     {support point}
```

```
    SIx[i+1] :=-xo*Spsw;  SIy[i+1] :=-yo*Spsw;  SIz[i+1] :=(0.5+i-zo)*Spsw; {centre}
    STx[i+1] :=-xo*Spsw;  STy[i+1] :=-yo*Spsw;  STz[i+1] :=(0.5+i-zo)*Spsw; {centre}
    dSIx[i+1]:=0;         dSIy[i+1]:=0;         dSIz[i+1]:=+Spsw;           {direction vector}
    dSTx[i+1]:=0;         dSTy[i+1]:=0;         dSTz[i+1]:=+Spsw;           {direction vector}
  end;
  For i:=0 to 2*yo do
  begin   {then go to y- direction}
    SpIx[2*zo+i+1]:=-xo*Spsw;  SpIy[2*zo+i+1]:=(i-yo)*Spsw;     SpIz[2*zo+i+1]:=+zo*Spsw;  {support point}
    SpTx[2*zo+i+1]:=+xo*Spsw;  SpTy[2*zo+i+1]:=(i-yo)*Spsw;     SpTz[2*zo+i+1]:=+zo*Spsw;  {support point}
    SIx[2*zo+i+1] :=-xo*Spsw;  SIy[2*zo+i+1] :=(0.5+i-yo)*Spsw; SIz[2*zo+i+1] :=+zo*Spsw;  {centre}
    STx[2*zo+i+1] :=+xo*Spsw;  STy[2*zo+i+1] :=(0.5+i-yo)*Spsw; STz[2*zo+i+1] :=+zo*Spsw;  {centre}
    dSIx[2*zo+i+1]:=0;         dSIy[2*zo+i+1]:=Spsw;            dSIz[2*zo+i+1]:=0;    {direction vector}
    dSTx[2*zo+i+1]:=0;         dSTy[2*zo+i+1]:=Spsw;            dSTz[2*zo+i+1]:=0;    {direction vector}
  end;
  For i:=0 to 2*zo do
  begin   {go back and z- direction}
    SpIx[2*zo+2*yo+i+1]:=-xo*Spsw;  SpIy[2*zo+2*yo+i+1]:=yo*Spsw;  SpIz[2*zo+2*yo+i+1]:=(zo-i)*Spsw;
                                                                                     {support point}
    SpTx[2*zo+2*yo+i+1]:=+xo*Spsw;  SpTy[2*zo+2*yo+i+1]:=yo*Spsw;  SpTz[2*zo+2*yo+i+1]:=(zo-i)*Spsw;
                                                                                     {support point}
    SIx[2*zo+2*yo+i+1] :=-xo*Spsw;  SIy[2*zo+2*yo+i+1] :=yo*Spsw;  SIz[2*zo+2*yo+i+1] :=(zo-i-0.5)*Spsw;
                                                                                              {centre}
    STx[2*zo+2*yo+i+1] :=+xo*Spsw;  STy[2*zo+2*yo+i+1] :=yo*Spsw;  STz[2*zo+2*yo+i+1] :=(zo-i-0.5)*Spsw;
                                                                                              {centre}
    dSIx[2*zo+2*yo+i+1]:=0;         dSIy[2*zo+2*yo+i+1]:=0;        dSIz[2*zo+2*yo+i+1]:=-Spsw;
                                                                                  {direction vector}
    dSTx[2*zo+2*yo+i+1]:=0;         dSTy[2*zo+2*yo+i+1]:=0;        dSTz[2*zo+2*yo+i+1]:=-Spsw;
                                                                                  {direction vector}
  end;
  For i:=0 to 2*yo do
  begin   {finally go back in y- direction}
    SpIx[4*zo+2*yo+i+1]:=-xo*Spsw;  SpIy[4*zo+2*yo+i+1]:=(yo-i)*Spsw;      SpIz[4*zo+2*yo+i+1]:=-zo*Spsw;
                                                                                     {support point}
    SpTx[4*zo+2*yo+i+1]:=+xo*Spsw;  SpTy[4*zo+2*yo+i+1]:=(yo-i)*Spsw;      SpTz[4*zo+2*yo+i+1]:=-zo*Spsw;
                                                                                     {support point}
    SIx[4*zo+2*yo+i+1] :=-xo*Spsw;  SIy[4*zo+2*yo+i+1] :=(yo-i-0.5)*Spsw;  SIz[4*zo+2*yo+i+1] :=-zo*Spsw;
                                                                                              {centre}
    STx[4*zo+2*yo+i+1] :=+xo*Spsw;  STy[4*zo+2*yo+i+1] :=(yo-i-0.5)*Spsw;  STz[4*zo+2*yo+i+1] :=-zo*Spsw;
                                                                                              {centre}
    dSIx[4*zo+2*yo+i+1]:=0;         dSIy[4*zo+2*yo+i+1]:=-Spsw;            dSIz[4*zo+2*yo+i+1]:=0;
                                                                                  {direction vector}
    dSTx[4*zo+2*yo+i+1]:=0;         dSTy[4*zo+2*yo+i+1]:=-Spsw;            dSTz[4*zo+2*yo+i+1]:=0;
                                                                                  {direction vector}
  end;   {the very last point is indentically to the first point}
  SpN:=4*zo+4*yo+1;
  Writeln('Anzahl der Punkte der Spulen-Linienaufteilung: von 1 - ',SpN);
  If SpN>SpNmax then
  begin
    Writeln('--- ERROR --- zu viele Spulen-Linienelemente');
    Writeln('--- ABHILFE -> Array groesser dimensionieren');
    Wait; Wait; Halt;
  end;
  {now the area elements:}
  For j:=1 to 2*yo do
  begin
    For i:=1 to 2*zo do
    begin
      FlIx[i+(j-1)*2*zo]:=-xo*Spsw;
      FlIy[i+(j-1)*2*zo]:=(j-0.5-yo)*Spsw;
      FlIz[i+(j-1)*2*zo]:=(i-0.5-zo)*Spsw;
      FlTx[i+(j-1)*2*zo]:=+xo*Spsw;
      FlTy[i+(j-1)*2*zo]:=(j-0.5-yo)*Spsw;
      FlTz[i+(j-1)*2*zo]:=(i-0.5-zo)*Spsw;
    end;
  end;
  FlN:=4*zo*yo;
  Writeln('number of area elements of each coil: von 1 - ',FlN);
  If FlN>FlNmax then
  begin
    Writeln('--- ERROR --- too many area elements');
    Writeln('--- HELP  -> Array should be larger');
    Wait; Wait; Halt;
  end;
end;

Procedure Spulen_anzeigen;  {coil for optional input of energy}
Var i : Integer;
begin
```

```
  Writeln('Input-Sp.-> support point of the Polygon, position, direction vectors:');
  For i:=1 to SpN do
  begin
    Writeln('SP [',i:5,']= ',SpIx[i]*100:10:6,', ',SpIy[i]*100:10:6,', ',SpIz[i]*100:10:6,' cm ');
    Writeln('ORT[',i:5,']= ', SIx[i]*100:10:6,', ', SIy[i]*100:10:6,', ', SIz[i]*100:10:6,' cm ');
    Writeln('RV [',i:5,']= ',dSIx[i]*100:10:6,', ',dSIy[i]*100:10:6,', ',dSIz[i]*100:10:6,' cm ');
    Wait;
  end;
  Writeln('Turbo-Sp.-> support point of the Polygon, position, direction vectors:');
  For i:=1 to SpN do
  begin
    Writeln('SP [',i:5,']= ',SpTx[i]*100:10:6,', ',SpTy[i]*100:10:6,', ',SpTz[i]*100:10:6,' cm ');
    Writeln('ORT[',i:5,']= ', STx[i]*100:10:6,', ', STy[i]*100:10:6,', ', STz[i]*100:10:6,' cm ');
    Writeln('RV [',i:5,']= ',dSTx[i]*100:10:6,', ',dSTy[i]*100:10:6,', ',dSTz[i]*100:10:6,' cm ');
    Wait;
  end;
  Writeln('Input-Spule -> area elements, their centre:');
  For i:=1 to FlN do
  begin
    Write('x,y,z[',i:5,']= ',FlIx[i]*100:10:6,', ',FlIy[i]*100:10:6,', ',FlIz[i]*100:10:6,' cm ');
    Wait;
  end;
  Writeln('Turbo-Spule -> area elements, their centre:');
  For i:=1 to FlN do
  begin
    Write('x,y,z[',i:5,']= ',FlTx[i]*100:10:6,', ',FlTy[i]*100:10:6,', ',FlTz[i]*100:10:6,' cm ');
    Wait;
  end;
  Writeln('--------------------------------------------------------------------------------');
end;

Procedure Magnet_drehen(fi:Double); {rotate by an angle of "fi":}
Var i,j,k : LongInt; {control variables}
begin
  fi:=fi/180*pi;  {go to Radiants}
  For i:=-Bn to Bn do  {x-part}
  begin
    For j:=-Bn to Bn do  {y-part}
    begin
      For k:=-Bn to Bn do  {z-part}
      begin
        {rotation of the position vectors:}
        OrtBxDR[i,j,k]:=+OrtBx[i,j,k]*cos(-fi)+OrtBy[i,j,k]*sin(-fi);
        OrtByDR[i,j,k]:=-OrtBx[i,j,k]*sin(-fi)+OrtBy[i,j,k]*cos(-fi);
        OrtBzDR[i,j,k]:=+OrtBz[i,j,k];
        {rotation of the vectors of field strength:}
        BxDR[i,j,k]:=+Bx[i,j,k]*cos(-fi)+By[i,j,k]*sin(-fi);
        ByDR[i,j,k]:=-Bx[i,j,k]*sin(-fi)+By[i,j,k]*cos(-fi);
        BzDR[i,j,k]:=+Bz[i,j,k];
        {print magnetic field first without rotation and then with rotation:}
{       Write('x,y,z=',OrtBx[i,j,k]:5:2,', ',OrtBy[i,j,k]:5:2,', ',OrtBz[i,j,k]:5:2,'mm => B=');
        Write(Bx[i,j,k]:8:4,', ');
        Write(By[i,j,k]:8:4,', ');
        Write(Bz[i,j,k]:8:4,' T ');  Writeln;
        Write('x,y,z=',OrtBxDR[i,j,k]:5:2,', ',OrtByDR[i,j,k]:5:2,', ',OrtBzDR[i,j,k]:5:2,'mm => B=');
        Write(BxDR[i,j,k]:8:4,', ');
        Write(ByDR[i,j,k]:8:4,', ');
        Write(BzDR[i,j,k]:8:4,' T ');
        Wait; Writeln; }
      end;
    end;
  end;
end;

Procedure Feldstaerke_am_Ort_suchen(xpos,ypos,zpos:Double);
                                                       {this is the position to search the field strength}
Var ixo,iyo,izo : Integer;
    ix,iy,iz    : Integer;
    dist,disto  : Double;
begin
  {first find out which field positions most close to xpos,ypos,zpos .}
  ixo:=0; iyo:=0; izo:=0;
  disto:=Sqrt(Sqr(xpos-OrtBxDR[ixo,iyo,izo])+Sqr(ypos-OrtByDR[ixo,iyo,izo])+Sqr(zpos-
OrtBzDR[ixo,iyo,izo]));
{ Writeln('initial distance to origin of coordinates: ',disto*100:1:15,' cm'); }
  For ix:=-Bn to Bn do  {x-search}
  begin
    For iy:=-Bn to Bn do  {y-search}
```

```
    begin
      For iz:=-Bn to Bn do  {z-search}
      begin
        dist:=Sqrt(Sqr(xpos-OrtBxDR[ix,iy,iz])+Sqr(ypos-OrtByDR[ix,iy,iz])+Sqr(zpos-OrtBzDR[ix,iy,iz]));
        If dist<=disto then
        begin
          ixo:=ix; iyo:=iy; izo:=iz;
          disto:=dist;
{                      Write('Position:  ',OrtBxDR[ix,iy,iz]*100:8:5,',     ',OrtByDR[ix,iy,iz]*100:8:5,',
',OrtBzDR[ix,iy,iz]*100:8:5,' cm'); }
{         Writeln(disto);}                       {Wait;}
        end;
      end;
    end;
  end;
{ Writeln('point number (ixo,iyo,izo): ',ixo,',  ',iyo,',  ',izo); }
  {now I will give the magnetic field at this point:}
{       Writeln('Magnetfeld       dort:       ',BxDR[ixo,iyo,izo]:8:4,',        ',ByDR[ixo,iyo,izo]:8:4,',
',BzDR[ixo,iyo,izo]:8:4,' T '); }
  {now I will calculate the magnetic flux through this coil area element:}
  PsiSFE:=BxDR[ixo,iyo,izo]*Spsw*Spsw;      {nach *1 von S.3}
{ Writeln('magnetic flux through this coil area element: ',PsiSFE,' T*m^2'); }
end;

Procedure Gesamtfluss_durch_Input_Spule;  {according to *2 von S.3}
Var i : Integer;
begin
  PsiGES:=0;
  For i:=1 to FlN do
  begin
    Feldstaerke_am_Ort_suchen(FlIx[i],FlIy[i],FlIz[i]);
    PsiGES:=PsiGES+PsiSFE;
  end;
end;

Procedure Gesamtfluss_durch_Turbo_Spule;  {according to *2 von S.3}
Var i : Integer;
begin
  PsiGES:=0;
  For i:=1 to FlN do
  begin
    Feldstaerke_am_Ort_suchen(FlTx[i],FlTy[i],FlTz[i]);
    PsiGES:=PsiGES+PsiSFE;
  end;
end;

Procedure FourierDatenspeicherung(PSIF : Array of Double); {magnetic flux for Fourier-series}
Var i    : Integer;
    fout : Text;
begin
  Assign(fout,'PSIF.DAT'); Rewrite(fout); {File open}
  Writeln('FOURIER - HIER:');
  For i:=0 to 360 do Writeln(fout,PSIF[i]);
  Close(fout);
end;

Procedure FourierEntwicklung;
Var i    : Integer;
    PSIF : Array [0..360] of Double;
    fin  : Text;
    QSplus,QSmitte,QSminus : Double;
    Qanf,Q1p,Q1m,Q2p,Q2m,Q3p,Q3m : Double; {for B1,2,3 - Iteration}
    Q4p,Q4m,Q5p,Q5m : Double; {for B4,5 - Iteration}
    QSminimum : Double; {for minimum search}
    weiter : Boolean;
Function QuadSum1:Double;
Var merk : Double;
    i    : Integer;
begin
  merk:=0;    {'i' is control variable for the angle,  in Grad}
  For i:=0 to 360 do merk:=merk+Sqr(PSIF[i]-B1*sin(i/360*2*pi));
  QuadSum1:=merk;
end;
Function Fourier(t,Ko1,Ko2,Ko3,Ko4,Ko5:Double):Double;
Var merk : Double;
begin         {'t' is control variable for the angle,  in Grad}
  merk:=Ko1*sin(t/360*2*pi);
  merk:=merk+Ko2*sin(2*t/360*2*pi);
```

```
  merk:=merk+Ko3*sin(3*t/360*2*pi);
  merk:=merk+Ko4*sin(4*t/360*2*pi);
  merk:=merk+Ko5*sin(5*t/360*2*pi);
  Fourier:=merk;
end;
Function QuadSum3(Koeff1,Koeff2,Koeff3:Double):Double;
Var merk : Double;
    i    : Integer;
begin
  merk:=0;        {'i' is control variable for the angle,  in Grad}
  For   i:=0   to   360   do   merk:=merk+Sqr(PSIF[i]-Koeff1*sin(i/360*2*pi)-Koeff2*sin(2*i/360*2*pi)-
Koeff3*sin(3*i/360*2*pi));
  QuadSum3:=merk;
end;
Function QuadSum5(Koeff1,Koeff2,Koeff3,Koeff4,Koeff5:Double):Double;
Var merk : Double;
    i    : Integer;
begin
  merk:=0;
  For i:=0 to 360 do    {'i' is control variable for the angle,  in Grad}
  begin
    If PSIF[i]<>0 then merk:=merk+Sqr(PSIF[i]-Fourier(i,Koeff1,Koeff2,Koeff3,Koeff4,Koeff5));
  end;
  QuadSum5:=merk;
end;
begin
  Assign(fin,'PSIF.DAT'); Reset(fin); {File open}
  Writeln('FOURIER - ENTWICKLUNG:');
  For i:=0 to 360 do Readln(fin,PSIF[i]);
  Close(fin);
  B1:=0;   {average value for the first period as starting condition}
  For i:=0 to 180 do B1:=B1+PSIF[i];
  {estimate the order of magnitude of B1:}
  B1:=B1/90;      {writeln('B1 : ',B1);  Wait;}
  {Put B1 into least square fit:}
  Repeat
    B1:=0.99*B1; QSminus:=QuadSum1;
    B1:=B1/0.99; QSmitte:=QuadSum1;
    B1:=1.01*B1; QSplus:=QuadSum1;  B1:=B1/1.01;
    weiter:=false;
    If QSminus<QSmitte then begin B1:=0.99*B1; weiter:=true; end;
    If QSplus<QSmitte  then begin B1:=1.01*B1; weiter:=true; end;
{   Writeln('QS: ',QSminus,', ',QSmitte,', ',QSplus); }
  Until Not(weiter);
  writeln('B1-vorab : ',B1,',  QS = ',QSmitte);
  {printer values for the purpose of control:}
  AnzP:=360; Abstd:=1;
  For i:=0 to 360 do      {'i' is control variable for the angle,  in Grad}
  begin
    Q[i]:=PSIF[i]; Qp[i]:=B1*sin(i/360*2*pi);
  end;
  {Then put B1 & B2 & B3 into the least square feet:}
  {search initial values for B2 :}
  B2:=0;
  B2:=+B1/10;  QSplus:=QuadSum3(B1,B2,0);
  B2:=-B1/10;  QSminus:=QuadSum3(B1,B2,0);
  If QSplus<QSminus then B2:=+B1/10;
  If QSminus<QSplus then B2:=-B1/10;
  {search initial values for B3 :}
  B3:=0;
  B3:=+B1/10;  QSplus:=QuadSum3(B1,B2,B3);
  B3:=-B1/10;  QSminus:=QuadSum3(B1,B2,B3);
  If QSplus<QSminus then B3:=+B1/10;
  If QSminus<QSplus then B3:=-B1/10;
  Writeln('AnfB1,2,3: ',B1:20,' ,  ',B2:20,' ,  ',B3:20);
  {Put B1, B2, B3 into least square feet:}
  Repeat
    {QuadSums:}
    Qanf:=QuadSum3(B1,B2,B3);
    Q1p:=QuadSum3(B1*1.01,B2,B3);          Q1m:=QuadSum3(B1*0.99,B2,B3);
    Q2p:=QuadSum3(B1,B2*1.01,B3);          Q2m:=QuadSum3(B1,B2*0.99,B3);
    Q3p:=QuadSum3(B1,B2,B3*1.01);          Q3m:=QuadSum3(B1,B2,B3*0.99);
    {find smallest QuadSum:}
    QSminimum:=Qanf;
    If Q1p<QSminimum then QSminimum:=Q1p;  If Q1m<QSminimum then QSminimum:=Q1m;
    If Q2p<QSminimum then QSminimum:=Q2p;  If Q2m<QSminimum then QSminimum:=Q2m;
    If Q3p<QSminimum then QSminimum:=Q3p;  If Q3m<QSminimum then QSminimum:=Q3m;
    {adjust coefficients to smallest QuadSumme :}
```

```
    weiter:=false;
    If Q1p=QSminimum then begin B1:=B1*1.01; weiter:=true; end;
    If Q1m=QSminimum then begin B1:=B1*0.99; weiter:=true; end;
    If Q2p=QSminimum then begin B2:=B2*1.01; weiter:=true; end;
    If Q2m=QSminimum then begin B2:=B2*0.99; weiter:=true; end;
    If Q3p=QSminimum then begin B3:=B3*1.01; weiter:=true; end;
    If Q3m=QSminimum then begin B3:=B3*0.99; weiter:=true; end;
{   Writeln('QS: ',QSminimum); }
  Until Not(weiter);
  Writeln('Nun B1 = ',B1:17,',  B2 = ',B2:17,'  B3 = ',B3:17);
  Writeln('Zugehoerige Quadsum: ',Quadsum3(B1,B2,B3));
  {printer values for the purpose of control:}
  For i:=0 to 360 do
  begin
    Qpp[i]:=B1*sin(i/360*2*pi)+B2*sin(2*i/360*2*pi)+B3*sin(3*i/360*2*pi);
  end;
  {delete very noisy points, with more than 75% distance:}
  For i:=0 to 360 do
  begin
    If    Abs(PSIF[i]-(B1*sin(i/360*2*pi)-B2*sin(2*i/360*2*pi)-B3*sin(3*i/360*2*pi)))>Abs(0.75*B1)    then
PSIF[i]:=0;
  end;
  {Dmake Fourier-series with five coefficients:}
  {search start value for B4 :}
  B4:=0;
  B4:=+B1/40;  QSplus:=QuadSum5(B1,B2,B3,B4,0);
  B4:=-B1/40;  QSminus:=QuadSum5(B1,B2,B3,B4,0);
  If QSplus<QSminus then B4:=+B1/40;
  If QSminus<QSplus then B4:=-B1/40;
  {Ssearch start value for B5 :}
  B5:=0;
  B5:=+B1/40;  QSplus:=QuadSum5(B1,B2,B3,B4,B5);
  B5:=-B1/40;  QSminus:=QuadSum5(B1,B2,B3,B4,B5);
  If QSplus<QSminus then B5:=+B1/10;
  If QSminus<QSplus then B5:=-B1/10;
  Writeln('Und B4,5: ',B4:20,' ,  ',B5:20);
  Writeln('Anf Quadsum: ',QuadSum5(B1,B2,B3,B4,B5));
  {Iteration for B1, B2, B3, B4, B5 least square fit:}
  Repeat
    {QuadSums to be calculated:}
    Qanf:=QuadSum5(B1,B2,B3,B4,B5);
    Q1p:=QuadSum5(B1*1.01,B2,B3,B4,B5);        Q1m:=QuadSum5(B1*0.99,B2,B3,B4,B5);
    Q2p:=QuadSum5(B1,B2*1.01,B3,B4,B5);        Q2m:=QuadSum5(B1,B2*0.99,B3,B4,B5);
    Q3p:=QuadSum5(B1,B2,B3*1.01,B4,B5);        Q3m:=QuadSum5(B1,B2,B3*0.99,B4,B5);
    Q4p:=QuadSum5(B1,B2,B3,B4*1.01,B5);        Q4m:=QuadSum5(B1,B2,B3,B4*0.99,B5);
    Q5p:=QuadSum5(B1,B2,B3,B4,B5*1.01);        Q5m:=QuadSum5(B1,B2,B3,B4,B5*0.99);
    {smallest QuadSumme to be searched:}
    QSminimum:=Qanf;
    If Q1p<QSminimum then QSminimum:=Q1p;  If Q1m<QSminimum then QSminimum:=Q1m;
    If Q2p<QSminimum then QSminimum:=Q2p;  If Q2m<QSminimum then QSminimum:=Q2m;
    If Q3p<QSminimum then QSminimum:=Q3p;  If Q3m<QSminimum then QSminimum:=Q3m;
    If Q4p<QSminimum then QSminimum:=Q4p;  If Q4m<QSminimum then QSminimum:=Q4m;
    If Q5p<QSminimum then QSminimum:=Q5p;  If Q5m<QSminimum then QSminimum:=Q5m;
    {adjust coefficients to smallest QuadSumme :}
    weiter:=false;
    If Q1p=QSminimum then begin B1:=B1*1.01; weiter:=true; end;
    If Q1m=QSminimum then begin B1:=B1*0.99; weiter:=true; end;
    If Q2p=QSminimum then begin B2:=B2*1.01; weiter:=true; end;
    If Q2m=QSminimum then begin B2:=B2*0.99; weiter:=true; end;
    If Q3p=QSminimum then begin B3:=B3*1.01; weiter:=true; end;
    If Q3m=QSminimum then begin B3:=B3*0.99; weiter:=true; end;
    If Q4p=QSminimum then begin B4:=B4*1.01; weiter:=true; end;
    If Q4m=QSminimum then begin B4:=B4*0.99; weiter:=true; end;
    If Q5p=QSminimum then begin B5:=B5*1.01; weiter:=true; end;
    If Q5m=QSminimum then begin B5:=B5*0.99; weiter:=true; end;
{   Writeln('QS: ',QSminimum); }
  Until Not(weiter);
  Writeln('Ergebnis: B1 = ',B1:17,',  B2 = ',B2:17,'  B3 = ',B3:17);
  Writeln('          B4 = ',B4:17,',  B5 = ',B5:17);
  Writeln('Endliche Quadsum: ',Quadsum5(B1,B2,B3,B4,B5));
  {print the values for the purpose of control:}
  For i:=0 to 360 do
  begin
    phipp[i]:=Fourier(i,B1,B2,B3,B4,B5)
  end;
  ExcelAusgabe('fourier.dat',6);
end;
```

```
Function FlussI(alpha:Double):Double;
Var merk : Double;  {alpha in 'radiants'.}
begin
  merk:=B1I*sin(alpha);
  merk:=merk+B2I*sin(2*alpha);
  merk:=merk+B3I*sin(3*alpha);
  merk:=merk+B4I*sin(4*alpha);
  merk:=merk+B5I*sin(5*alpha);
  FlussI:=merk;
end;

Function FlussT(alpha:Double):Double;
Var merk : Double;  {alpha in 'radiants'.}
begin
  merk:=B1T*sin(alpha);
  merk:=merk+B2T*sin(2*alpha);
  merk:=merk+B3T*sin(3*alpha);
  merk:=merk+B4T*sin(4*alpha);
  merk:=merk+B5T*sin(5*alpha);
  FlussT:=merk;
end;

Procedure SinusEntwicklung_fuer_Drehmoment;
Var i,j,jmerk : Integer;
    PSIF : Array [0..360] of Double;
    fin  : Text;
    QSalt,QSneu : Double;
    weiter : Boolean;
    Qanf,QB1plus,QB1minus,Qphaseplus,Qphaseminus : Double; {for numerical Iteration}
    QSminimum : Double; {for the search of the least square fit.}
Function QuadSum2(B1lok,phaselok:Double):Double;
Var merk : Double;
    i    : Integer;
begin
  merk:=0;    {'i' control variable for the angle, in Grad}
  For i:=0 to 360 do merk:=merk+Sqr(PSIF[i]-B1lok*sin((i+phaselok)/360*2*pi));
  QuadSum2:=merk;
end;
begin
  Assign(fin,'PSIF.DAT'); Reset(fin); {File open}
  Writeln('FOURIER-series for quick torque computation:');
  For i:=0 to 360 do Readln(fin,PSIF[i]);
  Close(fin);
  B1:=0;   {search initial value for "B1"}
  For i:=0 to 360 do
  begin
    If PSIF[i]>B1 then B1:=PSIF[i];
  end;
  Writeln('Startwert von B1: ',B1); Wait;
  phase:=0; QSalt:=QuadSum2(B1,phase); jmerk:=Round(phase); {search initial value for "phase"}
  For j:=1 to 360 do
  begin
    phase:=j; QSneu:=QuadSum2(B1,phase);
    If QSneu<QSalt then
    begin
      QSalt:=QSneu;
      jmerk:=j;
{     Writeln(phase,' => ',QSalt); Wait; }
    end;
    phase:=jmerk;
  end;
  Writeln('Startwert von phase: ',phase); Wait;
{Nor the exact Iteration of the Parameters:}
  Repeat
    {QuadSums computation:}
    Qanf:=QuadSum2(B1,phase);
    QB1plus:=QuadSum2(B1*1.0001,phase);
    QB1minus:=QuadSum2(B1*0.9999,phase);
    Qphaseplus:=QuadSum2(B1,phase*1.0001);
    Qphaseminus:=QuadSum2(B1,phase*0.9999);
    {find the smallest QuadSumme:}
    QSminimum:=Qanf;
    If QB1plus<QSminimum     then QSminimum:=QB1plus;
    If QB1minus<QSminimum    then QSminimum:=QB1minus;
    If Qphaseplus<QSminimum  then QSminimum:=Qphaseplus;
    If Qphaseminus<QSminimum then QSminimum:=Qphaseminus;
    {adjust coefficients to the smallest QuadSumme:}
    weiter:=false;
```

```
    If QB1plus=QSminimum     then begin B1:=B1*1.0001; weiter:=true; end;
    If QB1minus=QSminimum    then begin B1:=B1*0.9999; weiter:=true; end;
    If Qphaseplus=QSminimum  then begin phase:=phase*1.0001; weiter:=true; end;
    If Qphaseminus=QSminimum then begin phase:=phase*0.9999; weiter:=true; end;
    Writeln('QS: ',QSminimum);
  Until Not(weiter);
  phase:=phase/360*2*pi; {Phase in Radiants}
  B1dreh:=B1;        {amplitude of torque.}
end;

Function Schnell_Drehmoment(winkel:Double):Double;
begin
  Schnell_Drehmoment:=B1dreh*sin(winkel+phase);
end;

Procedure Magfeld_Turbo_Berechnen(rx,ry,rz,Strom:Double);
Var i : Integer;
    sx,sy,sz    : Double;    {position of the conductor loop elements}
    dsx,dsy,dsz : Double;    {direction vectors of the conductor loop elements}
    AnzLSE      : Integer;   {number of the conductor loop elements}
    smrx,smry,smrz : Double; {Differences for the outer product}
    krpx,krpy,krpz : Double; {outer product in Biot-Savart}
    smrbetrhoch3   : Double; {absolute value for the denominator}
    dHx,dHy,dHz    : Double; {Infinitesimal magnetic field}
    Hgesx,Hgesy,Hgesz:Double;{total magnetic field of the input coil}
begin
{ Spulen_anzeigen; }   {Optional subroutine.}
  AnzLSE:=SpN-1;
  If AnzLSE<>4*yo+4*zo then
  begin
    Writeln('something is wrong:');
    Writeln('problem im mesh-generation of turbo coil');
    Writeln('number of support points of the coil, AnzLSE = ',AnzLSE);
    Writeln('But: 4*yo+4*zo = ',4*yo+4*zo);
    Wait; Wait; Halt;
  end;
  {position and direction vectors of the conductor loop elements, Field according to Biot-Savart:}
  Hgesx:=0;  Hgesy:=0;  Hgesz:=0;
  For i:=1 to AnzLSE do
  begin
    sx:=SpTx[i];  sy:=SpTy[i];  sz:=SpTz[i];     {position of the conductor loop elements}
    dsx:=dSTx[i]; dsy:=dSTy[i]; dsz:=dSTz[i];    {direction vectors of the conductor loop elements}
    smrx:=sx-rx;   smry:=sy-ry;   smrz:=sz-rz;   {Differences for the outer product}
    krpx:=dsy*smrz-dsz*smry;   krpy:=dsz*smrx-dsx*smrz;   krpz:=dsx*smry-dsy*smrx; {outer product}
    smrbetrhoch3:=Sqrt(Sqr(smrx)+Sqr(smry)+Sqr(smrz));
    If smrbetrhoch3<Spsw/1000 then
    begin
      Writeln('Mechanical Kollision -> Magnet touches Turbo-coil. STOP.');
      Writeln('area element at   : ',sx:18,', ',sy:18,', ',sz:18,'m.');
      Writeln('Magnet position at: ',rx:18,', ',ry:18,', ',rz:18,'m.');
      Wait; Wait; Halt;
    end;
    smrbetrhoch3:=smrbetrhoch3*smrbetrhoch3*smrbetrhoch3;
                                                {absolute value for the denominator in Biot-Savart}
    dHx:=Strom*krpx/4/pi/smrbetrhoch3;          {Finite magnetic field of the conductor loop elements}
    dHy:=Strom*krpy/4/pi/smrbetrhoch3;
    dHz:=Strom*krpz/4/pi/smrbetrhoch3;
    Hgesx:=Hgesx+dHx;  Hgesy:=Hgesy+dHy;  Hgesz:=Hgesz+dHz; {Summation of all field elements}
  end;       {next line: algebraic sign according to technical current direction.}
  BTx:=-muo*Hgesx*Nturbo;   BTy:=-muo*Hgesy*Nturbo;   BTz:=-muo*Hgesz*Nturbo;
end;

Procedure Magfeld_Input_Berechnen(rx,ry,rz,Strom:Double);
Var i : Integer;
    sx,sy,sz    : Double;    {position of the conductor loop elements}
    dsx,dsy,dsz : Double;    {direction vectors of the conductor loop elements}
    AnzLSE      : Integer;   {number of the conductor loop elements}
    smrx,smry,smrz : Double; {Differences for the outer product}
    krpx,krpy,krpz : Double; {outer productin Biot-Savart}
    smrbetrhoch3   : Double; {absolute value for the denominator}
    dHx,dHy,dHz    : Double; {Infinitesimal magnetic field}
    Hgesx,Hgesy,Hgesz:Double;{total magnetic field of the input coil}
begin
{ Spulen_anzeigen; } {Optional subroutine.}
  AnzLSE:=SpN-1;
  If AnzLSE<>4*yo+4*zo then
  begin
    Writeln('something is wrong:');
```

```
    Writeln('problem im mesh-generation of input coil');
    Writeln('number of support points of the coil, AnzLSE = ',AnzLSE);
    Writeln('but: 4*yo+4*zo = ',4*yo+4*zo);
    Wait; Wait; Halt;
  end;
  {position and direction vectors of the conductor loop elements, Field according to Biot-Savart:}
  Hgesx:=0;  Hgesy:=0;  Hgesz:=0;
  For i:=1 to AnzLSE do
  begin
    sx:=SpIx[i];  sy:=SpIy[i];  sz:=SpIz[i];     {position of the conductor loop elements}
    dsx:=dSIx[i]; dsy:=dSIy[i]; dsz:=dSIz[i];    {direction vectors of the conductor loop elements}
    smrx:=sx-rx;   smry:=sy-ry;   smrz:=sz-rz;   {Differences for the outer product}
    krpx:=dsy*smrz-dsz*smry;   krpy:=dsz*smrx-dsx*smrz;   krpz:=dsx*smry-dsy*smrx; {outer product}
    smrbetrhoch3:=Sqrt(Sqr(smrx)+Sqr(smry)+Sqr(smrz));
    If smrbetrhoch3<Spsw/1000 then
    begin
      Writeln('Mechanical Kollision -> Magnet touches Turbo-coil. STOP.');
      Writeln('area element at   : ',sx:18,', ',sy:18,', ',sz:18,'m.');
      Writeln('Magnet position at: ',rx:18,', ',ry:18,', ',rz:18,'m.');
      Wait; Wait; Halt;
    end;
    smrbetrhoch3:=smrbetrhoch3*smrbetrhoch3*smrbetrhoch3;
                                                  {absolute value for the denominator in Biot-Savart}
    dHx:=Strom*krpx/4/pi/smrbetrhoch3;           {Finite magnetic field of the conduct loop element}
    dHy:=Strom*krpy/4/pi/smrbetrhoch3;
    dHz:=Strom*krpz/4/pi/smrbetrhoch3;
    Hgesx:=Hgesx+dHx;  Hgesy:=Hgesy+dHy;  Hgesz:=Hgesz+dHz; {Summation of the field elements}
  end;       {next line: algebraic sign according to technical current direction.}
  BIx:=-muo*Hgesx*Ninput;   BIy:=-muo*Hgesy*Ninput;   BIz:=-muo*Hgesz;
end;

Function Drehmoment(alpha:Double):Double;  {Argument : angle of the magnet "alpha"}
Var i : Integer; {control variable}
    Idlx,Idly,Idlz : Double; {Cartesian Components of dl-Vektor according (*1 von S.11)}
    Bxlok,Bylok,Bzlok : Double; {lokal magnetic field}
    FLx,FLy,FLz : Double; {Lorentz-force as outer product}
    dMx,dMy,dMz : Double; {torque of every conductor loop element acting on the magnet.}
    MgesX,MgesY,MgesZ : Double; {SUM: total torque acting on the magnetaus (Emulation-coils).}
    rx,ry,rz : Double; {position of the magnet loop elements after rotation}
begin
  MgesX:=0;  MgesY:=0;  MgesZ:=0;
  For i:=1 to MESEanz do
  begin
    {we now begin with the computation of the Lorentz-force of each element of the magnet-Emulation-coils}
    Idlx:=MEI*MESEdx[i]*4*pi*MEro/MESEanz; {element of the magnet-Emulation-coils}
    Idly:=MEI*MESEdy[i]*4*pi*MEro/MESEanz; {element of the magnet-Emulation-coils}
    Idlz:=MEI*MESEdz[i]*4*pi*MEro/MESEanz; {element of the magnet-Emulation-coils}
    {the next is the magnetic field strength at the position of each conductor loop element}
    Magfeld_Input_Berechnen(MESEx[i],MESEy[i],MESEz[i],qpoI); {adjust current}
    Magfeld_Turbo_Berechnen(MESEx[i],MESEy[i],MESEz[i],qpoT); {adjust current}
    Bxlok:=BIx+BTx;  Bylok:=BIy+BTy;  Bzlok:=BIz+BTz;
                                   {local magnetic field at the position of the conductor loop elements}
    {outer product for computation of Lorentz-force:}
    FLx:=Idly*Bzlok-Idlz*Bylok;
    FLy:=Idlz*Bxlok-Idlx*Bzlok;
    FLz:=Idlx*Bylok-Idly*Bxlok;
    {Check the Lorentz-force:}
{   Writeln('Ort: ',MESEx[i],', ',MESEy[i],', ',MESEz[i]);
    Writeln(' dl: ',MESEdx[i],', ',MESEdy[i],', ',MESEdz[i]);
    Writeln('FLo: ',FLx,', ',FLy,', ',FLz);               }
    {transformation of rotation}
    rx:=+MESEx[i]*cos(-alpha)+MESEy[i]*sin(-alpha);
    ry:=-MESEx[i]*sin(-alpha)+MESEy[i]*cos(-alpha);
    rz:=MESEz[i];
    {from their calculate the torque-element, caused by each Lorenzt-force-Element:}
    dMx:=ry*FLz-rz*FLy;           {torque as outer product M = r x F }
    dMy:=rz*FLx-rx*FLz;
    dMz:=rx*FLy-ry*FLx;
    {check the torque:}
{   Writeln('Dreh:',dMx,', ',dMy,', ',dMz); Wait;         }
    MgesX:=MgesX+dMx; {summation of all torque elements gives the total torque.}
    MgesY:=MgesY+dMy; {in cartesian Components}
    MgesZ:=MgesZ+dMz; {due to the orientation of the magnet, only the z-Component is important.}
  end;              {the magnet rotates around the z-Axis.}
{ Writeln('torque:',MgesX:20,', ',Mgesy:20,', ',Mgesz:20); }
  Drehmoment:=MgesZ;
end;
```

```
Procedure Daten_Speichern;
Var fout  : Text;
    i,j,k : Integer;
begin
  Assign(fout,'schonda'); Rewrite(fout);  {File open}
  {first the Parameters:}
  Writeln(fout,Spsw);
  Writeln(fout,xo);
  Writeln(fout,yo);
  Writeln(fout,zo);
  Writeln(fout,Ninput);
  Writeln(fout,Nturbo);
  Writeln(fout,Bsw);
  Writeln(fout,MEyo);
  Writeln(fout,MEro);
  Writeln(fout,MEI);
  {then the Magnetic field:}   {the number of steps is Bn = "Const."}
  For i:=-Bn to Bn do  {in x-direction}
  begin
    For j:=-Bn to Bn do  {in y-direction}
    begin
      For k:=-Bn to Bn do  {in z-direction}
      begin
        Writeln(fout,OrtBx[i,j,k]);
        Writeln(fout,OrtBy[i,j,k]);
        Writeln(fout,OrtBz[i,j,k]);
        Writeln(fout,Bx[i,j,k]);
        Writeln(fout,By[i,j,k]);
        Writeln(fout,Bz[i,j,k]);
      end;
    end;
  end;
  {the coils and the current distribution can be calculated and does not have to be stored.}
  {the torque-Parameters have to be stored:}
  Writeln(fout,B1T);
  Writeln(fout,B2T);
  Writeln(fout,B3T);
  Writeln(fout,B4T);
  Writeln(fout,B5T);
  Writeln(fout,B1I);
  Writeln(fout,B2I);
  Writeln(fout,B3I);
  Writeln(fout,B4I);
  Writeln(fout,B5I);
  Writeln(fout,B1dreh);
  Writeln(fout,phase);
  Writeln(fout,'All data are atored.');
  Close(fout);
end;

Procedure Alte_Parameter_vergleichen;
Var fin  : Text;
    x : Double;  {Parameters for input}
    n : Integer; {Parameters for input}
    i,j,k : Integer;
begin
  Assign(fin,'schonda'); Reset(fin);  {File open}
  {first the Parameters:}
  Readln(fin,x); If x<>Spsw   then begin schonda:=false; Writeln(' Spsw  geaendert'); end;
  Readln(fin,n); If n<>xo     then begin schonda:=false; Writeln('  xo   geaendert'); end;
  Readln(fin,n); If n<>yo     then begin schonda:=false; Writeln('  yo   geaendert'); end;
  Readln(fin,n); If n<>zo     then begin schonda:=false; Writeln('  zo   geaendert'); end;
  Readln(fin,n); If n<>Ninput then begin schonda:=false; Writeln('Ninput geaendert'); end;
  Readln(fin,n); If n<>Nturbo then begin schonda:=false; Writeln('Nturbo geaendert'); end;
  Readln(fin,x); If x<>Bsw    then begin schonda:=false; Writeln('  Bsw  geaendert'); end;
  Readln(fin,x); If x<>MEyo   then begin schonda:=false; Writeln(' MEyo  geaendert'); end;
  Readln(fin,x); If x<>MEro   then begin schonda:=false; Writeln(' MEro  geaendert'); end;
  Readln(fin,x); If x<>MEI    then begin schonda:=false; Writeln('  MEI  geaendert'); end;
  If schonda then Writeln('Die Parameter sind bereits bekannt.');
  If Not(schonda) then
  begin
    Writeln('Die Parameter sind neu. Es beginnt eine neue Vernetzung.');
    Wait; Wait;
  end;
  {then the magnetic field:}   {the number of steps is Bn = "Const."}
  For i:=-Bn to Bn do  {in x-direction}
  begin
    For j:=-Bn to Bn do  {in y-direction}
```

```
    begin
      For k:=-Bn to Bn do  {in z-direction}
      begin
        Readln(fin,OrtBx[i,j,k]);
        Readln(fin,OrtBy[i,j,k]);
        Readln(fin,OrtBz[i,j,k]);
        Readln(fin,Bx[i,j,k]);
        Readln(fin,By[i,j,k]);
        Readln(fin,Bz[i,j,k]);
      end;
    end;
  end;
  Writeln('Das Magnetfeld ist gelesen.');
  {the coils and the current distribution can be calculated and does not have to be stored.}
  {the torque-Parameters have to be stored:}
  Readln(fin,B1T);
  Readln(fin,B2T);
  Readln(fin,B3T);
  Readln(fin,B4T);
  Readln(fin,B5T);
  Readln(fin,B1I);
  Readln(fin,B2I);
  Readln(fin,B3I);
  Readln(fin,B4I);
  Readln(fin,B5I);
  Writeln('the parameters for the computation of the magnetic flux are read.');
  Readln(fin,B1dreh);
  Readln(fin,phase);
  Writeln('the parameters for the computation of the quick computation of the torque are read.');
  Writeln('Data our prepared for the DFEM-Algorithm.');
  Close(fin);
end;

Function U7:Double;       {Input-voltage for the Input-circuit}
Var UAmpl : Double;       {voltage-Amplitude}
    Pulsdauer : LongInt;  {duration of the pulse in units of time steps "dt"}
    Phasenshift : Double; {Phasenshift between reversal point and voltage-pulse}
    Umerk : Double;       {help variable}
begin
  Umerk:=0;          {Initialisation of help variable}
  UAmpl:=6E-6;       {Volts, voltage-Amplitude}
  Pulsdauer:=20;     {duration of the pulse in units of time steps "dt"}
  Phasenshift:=000;  {Phasenshift between reversal point and voltage-pulse}
{ If i<=Pulsdauer then Umerk:=UAmpl;          {if required: Start-pulse}
  If i>=Pulsdauer then        {triggered Pulses during operation}
  begin
    If (i>=iumk+Phasenshift)and(i<=iumk+Pulsdauer+Phasenshift) then
                                          {the Trigger-Signal is orientated on the top reversal point}
    begin Umerk:=UAmpl; end; {apply voltage}
                                              {alternatively it could be orientated on the zero-point}
  end;
  U7:=Umerk*0; {Now we do not want to apply a energy-suppl, for the engine is a self-running engine.}
end;

Function Reibung_nachregeln:Double;
Var merk:Double;
begin  {Small Hysterese is necessary:}
  merk:=cr; {if I am not out of hysteresis}
  If (phipo/2/pi*60)>1.000001*phipZiel then merk:=cr*1.000001;
                                                  {if engine is too fast, enhance energy extraction}
  If (phipo/2/pi*60)<0.999999*phipZiel then merk:=cr*0.999999;
                                                   {if engine is too slow, reduce energy extraction}
  If (merk<0.8*crAnfang) then merk:=0.8*crAnfang; {avoid too much oscillation in the control}
  If (merk>1.2*crAnfang) then merk:=1.2*crAnfang; {avoid too much oscillation in the control}
  Reibung_nachregeln:=merk;
end;

Begin {main program}
{ Initialisation - data input: }        {use SI-units}
  Writeln('DFEM-Simulation des EMDR-Motors.');
{ constants of nature:}
  epo:=8.854187817E-12{As/Vm}; {Magnetic field constant}
  muo:=4*pi*1E-7{Vs/Am};       {Elektric field constant}
  LiGe:=Sqrt(1/muo/epo){m/s};  Writeln('speed of light c = ',LiGe, ' m/s');
{ For the solution of the differential equations and plot of the results:}
  AnzP:=100000000; {number of time steps in computation}
  dt:=43E-9;   {seconds} {duration of each single time step}
  Abstd:=1;              {plot control during initialisation}
```

```
  PlotAnfang:=0000;      {first point for the Data-Export to Excel}
  PlotEnde:=100000000;   {last point for the Data-Export to Excel}
  PlotStep:=4000;        {step width for the Data-Export to Excel}
{ Both coils, see. drawing fig.1 :} {automatic mesh generation for the coils}
  Spsw:=0.01; {Meters: step width for the automatic mesh generation}
  xo:=0; yo:=6; zo:=5; {in units of Spsw} {Geometry parameters according to figure 1}
  Spulen_zuweisen;      {coil for input energy,optional}
  Ninput:=100;          {number of windings of the input coil}
  Nturbo:=9;            {number of windings of the turbo coil}
  nebeninput:=10;       {windings side-by-side in Input-coil}
  ueberinput:=10;       {layers of windings on top of each other in Input-coil}
  nebenturbo:=3;        {windings side-by-side in Turbo-coil}
  ueberturbo:=3;        {layers of windings on top of each other in Turbo-coil}
  If nebeninput*ueberinput<>Ninput then
  begin Writeln; Writeln('wrong number of windings: Input-Spule impossible !'); Wait; Wait; Halt; end;
  If nebenturbo*ueberturbo<>Nturbo then
  begin Writeln; Writeln('rong number of windings: Turbo-Spule impossible !'); Wait; Wait; Halt; end;
{ Spulen_anzeigen;      {Optional subroutine to check the positions.}
{ Permanent magnet-Emulation:}   Writeln;  {magnetic field can be measured with Hall probe}
  Bsw:=1E-2; {store magnetic fields in steps of centimetres}
  {not emulate the magnetic field of a one tesla magnet.}
  MEyo:=0.05; {y-coordinates of the emulation coils of the magnet}
  MEro:=0.01; {Radius of the emulation coils of the magnet}
  MEI:=15899.87553474; {Amperes, current in the emulation coils of the magnet}
  schonda:=true; Alte_Parameter_vergleichen;
  If Not(schonda) then Magnetfeld_zuweisen_03;  {calculate and display magnetic field}
  Stromverteilung_zuweisen_03; {calculate current distribution in the emulation coils of the magnet}
{ Other technical values:}
  DD:=0.010;     {Meter}    {diameter of the wire of the coil (input & turbo)}
  rho:=1.35E-8;  {Ohm*m}    {specific electrical resistance of copper}
  rhoMag:=7.8E3; {kg/m^3}   {density of the magnet material, iron, Kohlrausch Bd.3}
  CT:=101.7E-6;  {150E-6;}  {Farad}    {capacitor in the Turbo circuit}
  CI:=100E-6;    {Farad}    {capacitor in the input circuit}
{ Other variables for input:}
  Rlast:=0.030;  {Ohm}   {Ohm's load resistor in the Turbo circuit}
  UmAn:=30000;   {U/min} {mechanical initial conditions of angular velocity, rotating magnet}
  Uc:=0;{Volt}  Il:=0; {Ampere} {electrical initial conditions - no voltage, no current}

{ Mechanical power extraction (the torque is proportional to the angular velocity of the rotating magnet)}
  crAnfang:=45E-6;  {coefficient for mechanical power extraction}
  phipZiel:=30100;  {angular velocity for control of power extraction}

{ Calculated parameters, no input possible:}
  DLI:=4*(yo+zo)*Spsw*Ninput; {Meter} {length of the wire, Input-coil}
  DLT:=4*(yo+zo)*Spsw*Nturbo; {Meter} {length of the wire, Turbo-coil}
  RI:=rho*(DLI)/(pi/4*DD*DD); {Ohm} {Ohm`s resistance of the Input-coil}
  RT:=rho*(DLT)/(pi/4*DD*DD); {Ohm} {Ohm`s resistance of the Turbo-coil}
  BreiteI:=nebeninput*DD; HoeheI:=ueberinput*DD; {width and height of Input-coil}
  BreiteT:=nebenturbo*DD; HoeheT:=ueberturbo*DD; {width and height of Turbo-coil}
  fkI:=Sqrt(HoeheI*HoeheI+4/pi*2*yo*2*zo)/HoeheI; {correction of Induktivity short Input-coil}
  fkT:=Sqrt(HoeheT*HoeheT+4/pi*2*yo*2*zo)/HoeheT; {correction of Induktivity short Turbo-coil}
  Writeln('Induktivitaets-Korrektur: fkI = ',fkI:12:5,',  fkT = ',fkT:12:5);
  LI:=muo*(2*yo+BreiteI)*(2*zo+BreiteI)*Ninput*Ninput/(HoeheI*fkI);
                                                 {Geometrical average => Induktivity Input-coil}
  LT:=muo*(2*yo+BreiteT)*(2*zo+Breitet)*Nturbo*Nturbo/(HoeheT*fkT);
                                                 {Geometrical average => Induktivity Turbo-coil}
  omT:=1/Sqrt(LT*CT);  {circular resonance frequency of the turbo-circuit}
  TT:=2*pi/omT;        {period of the turbo-circuit}
  Mmag:=rhoMag*(pi*MEro*MEro)*(2*MEyo);{Mass of the Magnet}
  J:=Mmag/4*(MEro*MEro+4*MEyo*MEyo/3); {moment of inertia of rotation of the magnet, Dubbel S.B-32}
{ Also to be calculated from the above parameters:}
  omAn:=UmAn/60*2*pi;  {rotating Magnet: angular velocity (rad/sec.), initial value}
  UmSec:=UmAn/60;      {rotating Magnet: rounds per second, initial value}

{ Print the values on the screen:}
  Writeln('****************************************************************************');
  Writeln('Display few Parametes:');
  Writeln('length of the wire, Input-coil: ',DLI,' m');
  Writeln('length of the wire, Turbo-coil: ',DLT,' m');
  Writeln('Ohm`s resistance of the Input-coil: RI = ',RI:8:2,' Ohm');
  Writeln('Ohm`s resistance of the Turbo-coil: RT = ',RT:8:2,' Ohm');
  Writeln('Induktivity of the Input-coil, ca.: LI = ',LI,' Henry');
  Writeln('Induktivity of the Turbo-coil, ca.: LT = ',LT,' Henry');
  Writeln('circular resonance frequency of the turbo-circuit: omT = ',omT:8:4,' Hz (omega)');
  Writeln('=> period of the turbo-circuit TT = 2*pi/omT = ',TT:15,'sec.');
  Writeln('Magnet: initial angular velocity.: omAn = ',omAn,' rad/sec');
  Writeln('Magnet: initial angular velocity, Umdr./sec.: UmSec = ',UmSec:15:10,' Hz');
  Writeln('Mass of the Magnet = ',Mmag:10:6,' kg');
```

```
  Writeln('moment of inertia of rotation of the magnet',J,' kg*m^2');
  Writeln('total duration of observation: ',AnzP*dt,' sec.');
  Writeln('Excel-Export: ',PlotAnfang*dt:14,'...',PlotEnde*dt:14,' sec., Step ',PlotStep*dt:14,' sec.');
  Writeln('these are ',(PlotEnde-PlotAnfang)/PlotStep:8:0,' Data-lines.');
  If ((PlotEnde-PlotAnfang)/PlotStep)>AnzPmax then
  begin
    Writeln; Writeln('ERROR: too many data-lines.');
    Writeln('so many data-lines cannot be printed in Excel.');
    Writeln('=> stop computation.');  Wait; Wait; Halt;
  end;
{ Wait; }
{ For the preparation, I need AnzP=360, later I will restore the original value.}
  AnzPmerk:=AnzP; {don't forget the value for later}
  AnzP:=360;      {one around in steps of angle-Grad}

{ Test the Data-Export-Routine to Excel:}
  For i:= 1 to AnzP do
  begin
    Q[i]:=i*dt; Qp[i]:=2*i*dt; Qpp[i]:=3*i*dt;      phi[i]:=4*i*dt; phip[i]:=5*i*dt; phipp[i]:=6*i*dt;
    KG[i]:=7*i; KH[i]:=8*i; KI[i]:=9*i; KJ[i]:=10*i; KK[i]:=11*i; KL[i]:=12*i; KM[i]:=13*i; KN[i]:=14*i;
  end;
  {ExcelAusgabe('test.dat',14);}   {Optional subroutine for data export to Excel.}
  {Reset all arrays}
  For i:= 1 to AnzP do
  begin
    Q[i]:=0; Qp[i]:=0; Qpp[i]:=0;      phi[i]:=0; phip[i]:=0; phipp[i]:=0;
    KG[i]:=0; KH[i]:=0; KI[i]:=0; KJ[i]:=0; KK[i]:=0; KL[i]:=0; KM[i]:=0; KN[i]:=0;
  end;

{ Begin on the computation.}
  {Part 1: test of the torque acting on the magnet:}
  Writeln;  {first calculate the magnetic field of the coils (input and turbo)}
  Writeln('first calculate the magnetic field of the coils (input and turbo)');
  Magfeld_Input_Berechnen(-0.00,0.01,0.01,1.0);
                                     {three cartesian components for the position, current = 1.0 Ampere}
  Writeln('B_Input_x,y,z:',BIx:19,', ',BIy:19,', ',BIz:19,' T');
  Magfeld_Turbo_Berechnen(+0.00,0.01,0.01,1.0);
                                     {three cartesian components for the position, current = 1.0 Ampere}
  Writeln('B_Turbo_x,y,z:',BTx:19,', ',BTy:19,', ',BTz:19,' T');
  merk:=Sqrt((2*yo*Spsw*2*zo*Spsw)+Sqr(xo*Spsw)); merk:=merk*merk*merk;
  Writeln('Vgl->Input:    Round    conductor    loop,    Field    in    the    origin    of    coordinates:
',muo*Ninput*1.0*2*yo*Spsw*2*zo*Spsw/2/merk,' T');
  Writeln('Vgl->Turbo:    Round    conductor    loop,    Field    in    the    origin    of    coordinates:
',muo*Nturbo*1.0*2*yo*Spsw*2*zo*Spsw/2/merk,' T');
  {the computation of the both coils (Input & Turbo) is now verified.}
  If Not(schonda) then
  begin         {only for the purpose of control}
    For i:=0 to 360 do
    begin
      KN[i]:=Drehmoment(i/180*pi);
      Writeln(i:4,'Grad => Drehmoment-Komponente: Mz = ',KN[i]);
                                          {The Argument is the angle of the magnet's orientation "alpha"}
    end;
    ExcelAusgabe('drehmom.dat',14);   {Optionales subroutine for data-export to Excel.}
    Writeln('the calculation of the torque is done.');
  end;

  {part 2: test the magnetic flux, which the magnet brings into the coils (to be used later for the
                                                                                     induced voltage)}
  If Not(schonda) then
  begin
    Writeln('we will now calaulate the magnetic flux of geometry "03"');
    Magnet_drehen(00); {angle in Grad , 0...360}
    Gesamtfluss_durch_Input_Spule;     Writeln('total flux in Input-coil: ',PsiGES,' T*m^2');
    Magnet_drehen(01); {angle in Grad , 0...360}
    Gesamtfluss_durch_Input_Spule;     Writeln('total flux in Input-coil: ',PsiGES,' T*m^2');
    Writeln('-----------------------');
    Magnet_drehen(00); {angle in Grad , 0...360}
    Gesamtfluss_durch_Turbo_Spule;     Writeln('total flux in Turbo-coil: ',PsiGES,' T*m^2');
    Magnet_drehen(01); {angle in Grad , 0...360}
    Gesamtfluss_durch_Turbo_Spule;     Writeln('total flux in Turbo-coil: ',PsiGES,' T*m^2');
    Writeln('-----------------------');
  end;
  {result up to now: the flux difference allows the computation of the induced voltage}

{ Test: rotate the magnet once and measure the magnetic flux and the induced voltage:}
  {use 360 time steps = 360*dt = 36 milliseconds per one turn, corresponding to 1666.666 U/min}
  If Not(schonda) then
```

```
  begin
    Writeln('first the Input-coil:');
    For i:= 0 to 360 do  {first try of the Input-coil}
    begin
      phi[i]:=i; {values in Grad}
      Magnet_drehen(phi[i]);  Gesamtfluss_durch_Input_Spule;  {the result is in "PsiGES"}
      PSIinput[i]:=PsiGES; {this is the magnetic flux in the Input-coil}
      Writeln('phi = ',phi[i]:5:1,' grad  =>  magn. total Fluss = ',PSIinput[i],' T*m^2');
      If i=0 then UindInput[i]:=0;
      If i>0 then UindInput[i]:=-Ninput*(PSIinput[i]-PSIinput[i-1])/dt;
      KG[i]:=0; KH[i]:=PSIinput[i]; KI[i]:=UindInput[i];  {Excel-data output}
    end; Writeln('---------------------------------');
    Writeln('Danach die Turbo-Spule:');
    For i:= 0 to 360 do  {now I will try the Turbo-coil}
    begin
      phi[i]:=i; {values in Grad}
      Magnet_drehen(phi[i]);  Gesamtfluss_durch_Turbo_Spule;  {the result is in "PsiGES"}
      PSIturbo[i]:=PsiGES; {this is the magnetic flux in the Turbo-Spule}
      Writeln('phi = ',phi[i]:5:1,' grad  =>  magn. ges. Fluss = ',PSIturbo[i],' T*m^2');
      If i=0 then Uindturbo[i]:=0;
      If i>0 then Uindturbo[i]:=-Nturbo*(PSIturbo[i]-PSIturbo[i-1])/dt;
      KJ[i]:=0; KK[i]:=PSIturbo[i]; KL[i]:=Uindturbo[i];  {Excel-data output}
      KM[i]:=0; KN[i]:=KN[i]; {two empty columns at the end}
    end;
    {now I smooth the numerical noise:}
    FourierDatenspeicherung(PSIturbo);  FourierEntwicklung;
    B1T:=B1; B2T:=B2; B3T:=B3; B4T:=B4; B5T:=B5;
{**}Writeln('Aktuelle Kontrolle der Fourier-Koeffizienten für den Turbo-Fluß:');
{**}writeln(B1T:13,', ',B2T:13,', ',B3T:13,', ',B4T:13,', ',B5T:13);   Wait;
    FourierDatenspeicherung(PSIinput);  FourierEntwicklung;
    B1I:=B1; B2I:=B2; B3I:=B3; B4I:=B4; B5I:=B5;
    {Controll-Output of the flux curve after smoothing to Excel:}
    For i:=0 to 360 do
    begin       {FlussI and FlussT is the smoothed magnetic flux.}
      KJ[i]:=FlussI(i/360*2*pi);     {the angle of the magnet in "Radiants" to Excel.}
      KM[i]:=FlussT(i/360*2*pi);     {the angle of the magnet in "Radiants" to Excel.}
    end;
  end;
  {The computation of the torque absorbs so much of CPU-time, that it should not be done with smaller
                                                                                         step-width.}
  {Thus I develop a Fourier-serious to accelerate the elapsed computer time:}
  If Not(schonda) then
  begin
    qpoT:=1; qpoI:=0; {quick calibration for turbo-coil, 1A, without Input-coil}
    Writeln('Bring the torque into a sinus-expression in order to save computer time later:');
    For i:=0 to 360 do
    begin       {the total torque, which the magnet gets in the field of both coils(Input&Turbo).}
      KN[i]:=Drehmoment(i*2*pi/360); {The angle of the magnet is given in Radiants.}
      Write('.');  {Writeln(KN[i]);}
    end;
    FourierDatenspeicherung(KN);  SinusEntwicklung_fuer_Drehmoment;
    Writeln('Drehmom-Ampl: ',B1dreh,' und Phase: ',phase);
    {Check whether the quick torque determination gives correct results:}
    For i:=0 to 360 do
    begin
      KG[i]:=Schnell_Drehmoment(i*2*pi/360); {The angle of the magnet is given in Radiants.}
    end;
  end;
  {Store Data, if Parameter-Konfiguration is existing:}
  {If Not(schonda) then} Daten_Speichern;
  {Now the preparation work is done.}

  {I wwill now check whether all necessary data arrived in the file "schonda":}
  For i:=0 to 360 do
  begin       {FlussI and FlussT contains the smoothed magnetic flux through the coils.}
    KJ[i]:=FlussI(i*2*pi/360); {magnetic flux through Input-coil, angle of the magnet in Radiants}
    KM[i]:=FlussT(i*2*pi/360); {magnetic flux through Turbo-coil, angle of the magnet in Radiants}
  end;
  For i:=0 to 360 do
  begin
    KG[i]:=Schnell_Drehmoment(i*2*pi/360); {torque acting on the magnet Magnet, angle in Radiants}
  end;
  ExcelAusgabe('kontroll.dat',14);  {Optionales subroutine for Data-export to Excel.}
  {Now restore the original value for the number timesteps for the solution of the differential
                                                                                          equations:}
  AnzP:=AnzPmerk;
  {Now all data are ready to begin the DFEM-algorithm.}
  Writeln('****************************************************************************');
```

```
  {again one initialisation:  reset all arrays for the subroutine "ExcelLangAusgabe":}
  For i:=0 to AnzPmax do
  begin
   Zeit[i]:=0;  Q[i]:=0;     Qp[i]:=0;     Qpp[i]:=0;  QI[i]:=0;  QpI[i]:=0;  QppI[i]:=0;
   phi[i]:=0;   phip[i]:=0;  phipp[i]:=0;  KJ[i]:=0;   KK[i]:=0;  KL[i]:=0;   KM[i]:=0;
   KN[i]:=0;    KO[i]:=0;    KP[i]:=0;     KQ[i]:=0;   KR[i]:=0;  KS[i]:=0;   KT[i]:=0;
   KU[i]:=0;    KV[i]:=0;    KW[i]:=0;     KX[i]:=0;   KY[i]:=0;
  end;

 {initialisation for the search of the maximum values of current-, angular velocity- and voltage, to be
                                                                              displayed on the screen:}
  QTmax:=0; QImax:=0; QpTmax:=0; QpImax:=0; QppTmax:=0; QppImax:=0; phipomax:=0;
  Wentnommen:=0; {initialisation of the extracted energy at the load resistor}
  Ereib:=0;      {initialisation of the mechanical extracted energy}

  {initialisation of the Reference for the Input-voltage-Signal:}
  steigtM:=false;   steigtO:=false;
  Ezuf:=0;  {initialisation supplied energy by input voltage}
  LPP:=0;   {initialisation number of data points for Excel-Plot}

{ This is now the moment to start the solution of the system of differential equations:}
{ The main core of the computation begins:}
{ We start out with the initial conditions:}
  phio:=0;      phipo:=omAn;  {phippo:=0;} {initial condition of the mechanical rotation of the magnet}
                                           {we start with a given angular velocity}
  qoT:=CT*Uc;   qpoT:=Il;     {qppoT:=0;}  {electrical initial conditions of the Turbo-circuit, here ZERO}
                                           {the  capacitor  in  the  Turbo  circuit  can  be  pre-charged  if
required}
  qoI:=0;       qpoI:=0;       qppoI:=0;   {electrical initial conditions of the Input-circuit, here ZERO}
{ For the step number zero, there is no "step before":}
  {phim:=phio;}{phipm:=phipm;} {phippm:=phippm;}
  qmT:=qoT;    {qpmT:=qpmT;}   {qppmT:=qppmT;}
  {qmI:=qoI;}  {qpmI:=qpmI;}   {qppmI:=qppmI;}

{ Initial conditions are ready, solver begins:}
  For i:=0 to AnzP do
  begin
    {initialisation of the Reference of the Input-voltage-Signal:}
    If i=0 then iumk:=0;
    If i>=1 then {Input-voltage-Reference to be orientated on the turbo circuit.}
    begin
      steigtM:=steigtO;  {remind the signal slope}
      If qoT>qmT then steigtO:=true;
      If qoT<qmT then steigtO:=false;
      If (steigtM)and(Not(steigtO)) then iumk:=i;
    end;
    {Aktual Moment of Analysis, running time in seconds, the moment "now", "Jetzt-Schritt":}
    Tjetzt:=i*dt;
    {the last step will be the step before the moment now:}
    phim:=phio; phipm:=phipo; {phippm:=phippo;}   {rotation}
    qmT:=qoT; qpmT:=qpoT;     {qppmT:=qppoT;}     {Turbo-coil}
    qmI:=qoI; qpmI:=qpoI; qppmI:=qppoI;           {Input-coil}
    {the new step will be calculated as following:}
    {first the rotation of the magnets, talk is generated by the current in the coils:}
{KK}phippo:=Schnell_Drehmoment(phim)*qpoT/J;
        {subroutine "Schnell_Drehmoment" is scaled with ITurbo=1A & IInput=0A, linear with Turbo-current.}
{!! all line with "!!" are commented out because the input coil is not used.}
{!! phippo:=Drehmoment(phim)/J;
                              {Complete torque-computation with Turbo-coil and Input-coil, not very fast.}
{For phippo -> I have two alternatives depending on whether the input-coil is active or not.}
{if the input coil is active, I shall allways set "schonda:=false", so that the complete preparation is
                                                                              computed for every run.}
{All "GG"-line are for extraction of mechanical power:}
{GG}If i=1 then cr:=crAnfang;           {coefficient of friction proportional to angular velocity}
{GG}If i>1 then cr:=Reibung_nachregeln;
           {the coefficient of friction can be controlled in order to keep the angular velocity stable.}
{GG}If phipo>0 then phippo:=phippo-cr*phipm/J; {negative acceleration acts against the angular velocity}
{GG}If phipo=0 then phippo:=phippo;
{GG}If phipo<0 then phippo:=phippo+cr*phipm/J; {negative acceleration acts against the angular velocity}
{GG}{now friction respectively energy extraction is calculated.}
    If (i mod 100000)=0 then write('.');
    phipo:=phipm+phippo*dt;            {1. step of integration without extracting mechanical power}
    phio:=phim+phipo*dt;               {2. step of integration}
{GG}Preib:=cr*phipm*phipo;       {extracting mechanical power now}
{GG}Ereib:=Ereib+Preib*dt;       {computation of the power and energy being extracted}
    {Dann die Turbo-Spule. Gedämpfte elektrische Schwingung, dazu induzierte Spannung aufgrund Magnet-
                                                                                          Drehung:}
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{FF}qppoT:=-1/(LT*CT)*qmT-(RT+Rlast)/LT*qpmT; {differential equation of the attenuated oscillation.}
    UinduzT:=-Nturbo*(FlussT(phio)-FlussT(phim))/dt;
                                               {bring the induced voltage into the differential equations}
    qppoT:=qppoT-UinduzT/LT;                  {the induced voltage acts on the second time derivative}
{??}qpoT:=qpmT+qppoT*dt; {-Rlast/(2*LT)*qpmT*dt;} {1. step of integration}
    qoT:=qmT+qpoT*dt;                             {2. step of integration}
    {Dann die Input-Spule:}     UinduzI:=0;
    qoI:=qmI; qpoI:=qpmI; qppoI:=qppmI;          {The input coil doesn't do anything now.}
{!! If I want to activate the input coil, I shall activate the following five lines:}
{!! qppoI:=-1/(LI*CI)*qmI-RI/LI*qpmI+U7/LI;
                {differential equation of attenuated oscillation, perturbation function for Input-voltage}
{!! UinduzI:=-Ninput*(FlussI(phio)-FlussI(phim))/dt;
                                                  {the induced voltage acts of the rotation of the magnet}
{!! qppoI:=qppoI-UinduzI/LI;
                            {action of the induced voltage on the second derivative of q, namely "qppoT")}
{!! qpoI:=qpmI+qppoI*dt;                             {1. step of integration}
{!! qoI:=qmI+qpoI*dt;                                {2. step of integration}
    Pzuf:=U7;{*qpoI}                                 {supplied power by input voltage}
    Ezuf:=Ezuf+Pzuf*dt;                              {supplied energy babe would voltage}
{caution: the quick torque-computation "phippo" does not work for Turbo- & Input-coil. The current is not
                                                                          known in the subroutines.}

    {I now one to find the maximum values for current, voltage and angular velocity:}
    If Abs(qoT)>QTmax then QTmax:=Abs(qoT);  {Maximum of electrical charge in the Turbo capacitor}
    If Abs(qoI)>QImax then QImax:=Abs(qoI);  {Maximum of electrical charge in the Input capacitor}
    If Abs(qpoT)>QpTmax then QpTmax:=Abs(qpoT);       {Maximum of electrical current in the Turbo coil}
    If Abs(qpoI)>QpImax then QpImax:=Abs(qpoI);       {Maximum of electrical current in the Input coil}
    If Abs(qppoT)>QppTmax then QppTmax:=Abs(qppoT);   {Maximum of Ipunkt in Turbo-coil}
    If Abs(qppoI)>QppImax then QppImax:=Abs(qppoI);   {Maximum of Ipunkt in  Input-coil}
    If Abs(phipo)>phipomax then phipomax:=Abs(phipo); {Maximum of angular velocity of the magnet}
    Wentnommen:=Wentnommen+Rlast*qpoT*qpoT*dt;  {summation of the extracted energy at the load resistor}

    {now export the data into Excel:}
    If (i>=PlotAnfang)and(i<=PlotEnde) then {These lines shall be plotted to Excel.}
    begin
      If ((i-PlotAnfang)mod(PlotStep))=0 then
      begin
        znr:=Round((i-PlotAnfang)/PlotStep);
        Zeit[znr]:=Tjetzt;                                   {time-scale.}
        Q[znr]:=qoT;    Qp[znr]:=qpoT;    Qpp[znr]:=qppoT;
                                               {Turbo-coil, it Array without index "T" (and only there!).}
        QI[znr]:=qoI;   QpI[znr]:=qpoI;   QppI[znr]:=qppoI;   {Input-coil}
        phi[znr]:=phio; phip[znr]:=phipo; phipp[znr]:=phippo; {rotation of the magnet}
        KK[znr]:=FlussT(phio);    KL[znr]:=FlussI(phio);      {magnetic flux through the coils}
        KM[znr]:=UinduzT;         KN[znr]:=UinduzI;           {voltage induced into the coils}
        KO[znr]:=1/2*LT*qpoT*qpoT;                            {Energy in Input-coil}
        KP[znr]:=1/2*LI*qpoI*qpoI;                            {Energy in Turbo-coil}
        KQ[znr]:=1/2*qoT*qoT/CT;                              {Energy im Input-capacitor}
        KR[znr]:=1/2*qoI*qoI/CI;                              {Energy im Turbo-capacitor}
        KS[znr]:=1/2*J*phipo*phipo;                           {Energy of Magnet-Rotation}
        KT[znr]:=KO[znr]+KP[znr]+KQ[znr]+KR[znr]+KS[znr];     {total energy in the system}
        KU[znr]:=Rlast*qpoT*qpoT;      {power being extracted at the load resistor in the Turbo circuit}
        KV[znr]:=U7;                   {control of the input voltage in the input circuit}
        KW[znr]:=Pzuf;                 {power supply by the input voltage}
        KX[znr]:=cr;         {control of the coefficient of friction for mechanical extraction of power}
        KY[znr]:=Preib;
                 {mechanical power being extracted, emulated by friction proportional to angular velocity}
        KZ[znr]:=0;       {one column for optional data, not used now.}
        LPP:=znr;         {number of the last plot point, length of the excel-file -> ExcelLangAusgabe}
      end;
    end;
    AnfEnergie:=KU[0];          {initial total energy within the system}
    EndEnergie:=KU[LPP];        {total energy at the end of observation within the system}
  end;
  Writeln; Writeln('number of data points for Excel-Plot: LPP = ',LPP);
  Writeln; Writeln('display of some amplitudes Amplitudes: (not effective-values)');
  Writeln('Input-capacitor, voltage, UmaxI =',QImax/CI,' Volt');
                                                          {Maximum of electrical charge in Input-capacitor}
  Writeln('Turbo-capacitor, voltage, UmaxT =',QTmax/CT,' Volt');
                                                          {Maximum of electrical charge in Turbo-capacitor}
  Writeln('Input-circuit,   current, ImaxI =',QpImax,' Ampere');
                                                              {Maximum of electrical current in Input-coil}
  Writeln('Turbo-circuit,   current, ImaxT =',QpTmax,' Ampere');
                                                              {Maximum of electrical current in Turbo-coil}
  Writeln('Input-coil,      voltage, UmaxSI=',LI*QppImax,' Volt');
                                                                      {Maximum of Ipunkt in der Input-coil}
  Writeln('Turbo-coil,      voltage, UmaxST=',LT*QppTmax,' Volt');
                                                                      {Maximum of Ipunkt in der Turbo-coil}
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  Writeln('Maximum of angular velocity  =   ',phipomax,' rad/sec');
                                                          {Maximum of the angular velocity of the magnet}
  Writeln('Maximum of angular velocity  =   ',phipomax/2/pi*60:15:6,' U/min.');
                                                          {Maximum of the angular velocity of the magnet}
  Writeln('angular velocity at the end  =   ',phip[LPP]/2/pi*60:15:6,' U/min.');
  Writeln;
  Writeln('initial energy in the System:    ',AnfEnergie:18:11,' Joule');
  Writeln('system`s energy at the end:      ',EndEnergie:18:11,' Joule');
  Writeln('Energy-gain during observation:  ',(EndEnergie-AnfEnergie):18:11,' Joule');
  Writeln('Power-gain during observation :  ',(EndEnergie-AnfEnergie)/(AnzP*dt):18:11,' Watt');
  Writeln('total energy extracted at load resistor = ',Wentnommen:18:11,' Joule');
  Writeln('corresponding to a power of :    ',Wentnommen/(AnzP*dt):18:11,' Watt');
  Writeln('supplied energy by input supply: ',Ezuf,' Joule');
  Writeln('corresponding to a power of:     ',Ezuf/(AnzP*dt),' Watt');
  Writeln('total extracted mechanic. energy:',Ereib:18:11,' Joule');
  Writeln('corresponding to a power of  =   ',Ereib/(AnzP*dt):18:11,' Watt');
  Writeln('total duration of observation :  ',(AnzP*dt):18:11,' sec.');
  ExcelLangAusgabe('test.dat',25);
  Writeln; Writeln('computation done -> bye bye.');
  Wait;   Wait;
End.
```