Evaluation of Coil-Induction, Foil-Capacity and growth in Pot Plant Batteries

Abstract The paper concerns experiments and quantitative modelling for sub-power in electricity and the response of plants to such actions. Electric components attached to and integrated in pot plant batteries were constructed and tested. Magnification of power was obtained, for cupper-coils attached to an Al-foil-drum. A model with Hamiltonian dynamics gives a phase space with several energies as the system sub-divides into increased frequencies and amplitudes.

Keywords: *AC-batteries, coil, induction, electro-magnetism, capacitors, oscillator, resonance, modelling, amplification, analysis, Hamiltonian, integrated audio feed-back*

1. Introduction

In a future with different energy sources, an updated knowledge is important, e.g. that of components and their action and impact on the environment, as well as people. More often, humans do not use or profit on the electric energy an sich, but instead heat, light and propulsion.

The present study shows how plants respond to electricity, and the technical results concern amplification of electric power and possible heat-equivalents for plants and soil. The method is to build small Photo-Thermo-Piezo-Electric components operating in AC, combine these and evaluate c.f. [1,2]. The AC is provided by a Pot Plant Battery, PPB, consisting of electrodes in soil and bog moss [1,2]. On this, passive and active components, e.g. inductors, capacitors and diodes, are attached. For batteries, nonlinear results for various organic binders and electrolytes are presented in [3] and a more comprehensive review of related subjects is given in [4].

The analysis with Flower-Power [1,2] have several goals, e.g.

- to create electric power and magnify with e.g. current generators
- to test electrical components at AC, e.g. power amplifiers and inductor coils
- to cultivate

In the present paper, we focus on 3 applications; coils on a membrane-drum, additional capacity for a metallic foil and several electrodes.

In an analysis, audio feed-back is assumed. This is modelled within the framework of oscillations. Energy-levels are given by Hamiltonians with nonlinearities that re-enters as input to forced vibration, giving amplification.

2. Experimental Material and Measurements

2.1. Cupper Coil Magnet and induction on a Drum

Consider the arrangements visualised in Figure 1.

The circuits are activated by drumming i.e. mechanical motion of the membrane with the coil and by motion of the foil in the cup [1]. The impedance-resistance in terms of an inductor and the capacitor is relatively large such that a Voltage between the electrodes is not always easily created. An unloading to zero often occurs, and it might be due to nonlinearities and change of direction, for example it is seen that the resulting battery below ground, is a serial coupling of two pairs of electrodes, however every now and then, the outer part battery may be a short-circuit with that, c.f. Figure 1. With sufficient electric power signal, the drum works as a loudspeaker such that the plastic membrane oscillates. (A magnet would have magnified) and here, at least magnetic induction is present. While put on a plant with electrodes, in serial with a cup, it produced a small power, detected by a multimeter instrument, c.f. Figure 1, with two probes. The instrument gives the levels of voltage and current, but not details of the nonlinear AC. A lower voltage is recorded at lower current, and the latter is what is mostly amplified with the present components above ground.

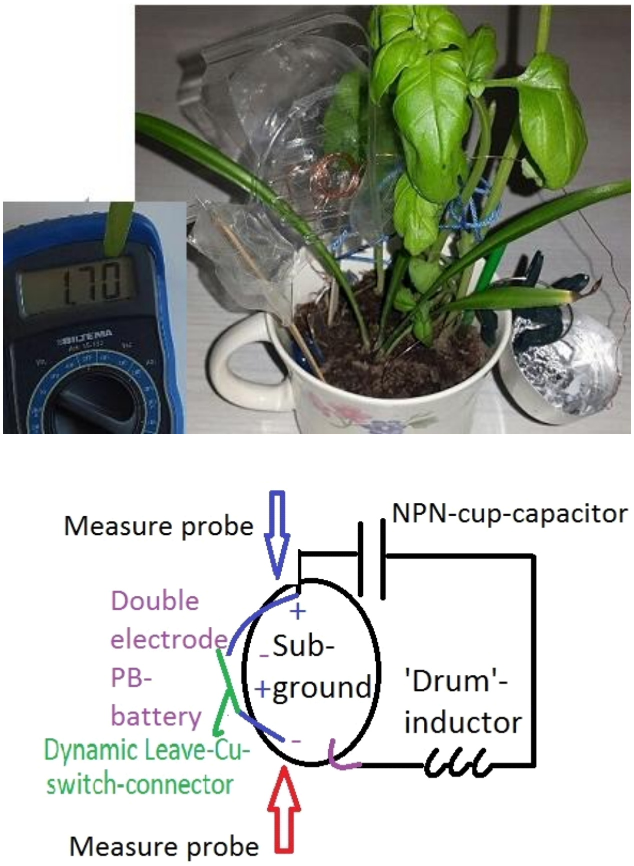


Figure 1. Upper .Leftmost. Multimeter with two measure probes (not on photo). A coil attached to a plastic membrane (left) and a deformable Al-Cup-capacitor and circuit scheme. The device displays >0.2V and 0.001 to 0.005 mA. It 'pumps up' by tapping on the membrane, as a microphone. (significant, but not much more with a magnet).

A similar membrane with three coils each leading to an electrode in the soil but of different materials (Cu, Fe, Al), was attached on a larger plant, Figure 2a. The electrodes were put in the soil, with equal distance. Next to the Cu-anode, another cathode was sunk and between these, a cup and a dynamic Flower Beam-capacitor. Apparently, it was interaction, since the current became larger; with maximum 0.04 mA and 0.65V between the Cu-electrode and the Fe-cathode.

Figure 2a. Improved device with 3 inductor coils on a membrane. .

A much larger current was obtained with coils on an Aluminium-membrane, Figure 2b. With two coils down to electrodes of Al and Fe, the multi-meter shows 0.17mA and 0.6V. In another study, it was found that the device consumes power itself, such that probably rectifiers and serial couplings of several equal, would be necessary if to deliver as a power source.

Figure 2b. Two inductor coils on an Al-membrane. The latter responds as both inductor and Capacitor.

2.2. Electrodes in serial

A method to obtain a stable electric flow is a serial coupling. In Figure 3, electrodes are coupled in serial, in this case 2 pairs were used, but since there is space; a larger amount is possible. This plant grew, remained small and durable but died after 5 months, probably due to over-dose of water or electricity. In general, plants in PPB become miniaturised, so it's not the method to obtain bulk. Benefits are that they need less water, less light and withstand cold, to some extent. Similar arrangements outdoor were evaluated in [2].

Figure 3. PPB with double pair of electrodes in the soil (not visible) and a small coil at the end of the line behind the stem.

2.3. Experimental results

With an Al-drum, the magnification capacity added significantly, and it was self-induced, compared with a plastic drum, that needed tapping. Probably the Farad-capacity of Al multiplied with induction, as in some electric oscillators.

Although not exactly scaled with coils and foil-material, the above results may be compared. The instrument gave (0.005, 0.04, 0.17)mA, for (1,3,2)-coils on a (plastic, plastic, Al)-drum-membrane.

3. Theoretical Models

In modelling, we will seek solutions to forced vibrations. This branch is chosen, since an amplification was found with the components, increasingly with more magnetic coils.

3.1 Model for the Al-Cup-Capacitor in Fig. 1

As found in the literature and seen in previous experiments, the Al-cup-capacitor responds to Sun and heat, with an NPN-amplification. As a model, the framework for Solar Cells in [5], is a candidate. [5] presents spatial differential equations for electrons and holes, represented by their densities on a doped semi-conductor. Linearisation gives solutions in terms of an elliptic equation for the electrons and a hyperbolic for the holes. The period for the harmonic solutions depends on electric properties as well as geometry and material of the semi-conductor. For an oscillator, amplification is possible, and large when input is close to resonance.

3.2. Magnetic models for induction

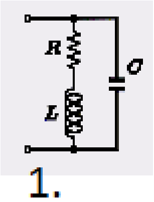
In vicinity of the coils, there is a magnetic field which interact to provide current and load transportation in the lines, which are measured. Therefore, as a model, parts of [6] can be assumed, when the bath is considered as a surrounding of magnetics. With some interpretations, solutions, in terms of a harmonic oscillator may be derived, together with eigenfrequency, input periodic load and input in terms of a short pulse i.e. a delta-distribution.

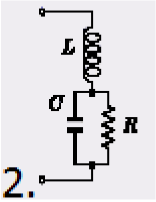
3.3. Circuit models

Linear modeling in EM is in terms of RC-circuits and LC-oscillators. The latter may apply to this device; however the foil also act as an NPN-capacitor. Elaborations for models are the Josephson junction [7], with L depending on current. Applied in this case, it can reduce the LC-oscillator to an exponential capacitor-solution added by a term proportional to L. Other experimental modeling shows how the velocity c given by the electric constants, can be measured with an LC-circuit, [8].

The characterisation of a shift in a LC-circuit sensor is addressed in [9] and measurement of strain and torque with inverse magnetostriction are derived.

In [10], the harmonic oscillation with damping for a circuit with L, C and R in series are analysed. The eigen frequency w fulfils $w^2=1/(LC)$. Also the Circuits 1 and 2 below, are found in [10].





Circuit 1. The eigenfrequencies when R is in series with L reads $1/(LC)^{1/2}(1-CR^2/L)^{1/2}$

Circuit 2. The eigenfrequencies when R is parallel with C reads $1/(LC)^{1/2}(1-L/R^2C)^{1/2}$

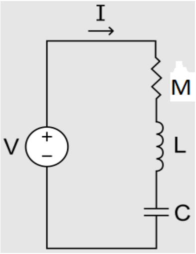
Here we will consider these cases, motivated by the spatial distribution of the Al-foil such that it may cause resistance; R, beside its main performance as a capacitor; C. Assuming that the current from one of these models is an input to a circuit with only L and C in series gives a forced vibration with *amplification*. Neglecting damping, the amplification reads $1/\mathrm{abs}(1-(q/w)^2)$ where q is the input frequency, which gives the magnification factors $L/(R^2C)$ and CR^2/L with the input from Circuit 1 and 2, respectively.

3.3.1 Theoretical results

The modeling agrees with the results for the devices in Figure 2, summarised above in Section 2.3. The amplification factor is around 4 between the one on plastic and the one with Al in the drum and this is obtained when the ratio w^2L^2/R^2 is 1/4 if choosing the latter of the models. (The first is seen to amplify exponentially with decreasing R.)

3.4 Nonlinear Circuit models and Hamiltonian Dynamics

Yet another modeling is the so-called memristor, such that a variable resistance is assumed for the Al. This agrees with the capacitor performance in other applications and the shape distributed around the lines. With the notation M(t, I(t)) , the eigen frequency w for the memristor M in series with L and C fulfils $w^2 =1/(LC)+M_{,t}(T)/L$ where ,t denoted time differentiation and $M_{,t}(T)$ denotes the constant value for a linearisation at time T.



The differential equation for the current I(t) in the LC-circuit referred to above, including a memristor in series is given by

$$I/C+ L\, I_{,tt}+ (MI)_{,t} =0 \quad ..... \quad (1)$$

For (1), there is a Hamiltonian, that reads

$$H= I^2/(LC) + I_{,t}^2 + f \ldots (2)$$

where f is a nonlinear function with memory given by

$$f= (2/L)\int (I_{,t}\ (MI)_{,t})\, dt$$

Theory and other normalisations are found in e.g. [11]. Since a large current is more difficult to achieve than a voltage, we will assume that this Hamiltonian is a measure of power and energy for the system. (As it appears, an increased voltage is obtained with serial couplings of PPB, stable, however linear, thus requiring several PPB).

In Figure 4, phase portraits for H=const are given for certain values of parameters L,C and some nonlinear functions f given in the code.

Audio feed-back with EM-signals in a loud-speaker more-often involve several frequencies, and when added, it applies with the nonlinear modeling incorporated in the Hamiltonian (2). The amplification formula refers to a linearisation and involves two frequencies. Magnification gets large when they are close, e.g. when shifted due to small relative motions, strain or torque, c.f. also [9].

Next, we will assume a Hamiltonian which is a sum of generalised kinetic and potential energy after amplification, i.e. the input part of Euler-Lagrange equations is included. With the above amplification; 4, and a linear model, the new energy H would be 16 times the first, i.e. much larger than graph no 2 in Figure 4.

Inspection of the format (2) gives that increased energy can distribute to both higher frequency and amplitude for I. This agrees with audio feed-back, which is intense and shifted to higher frequencies. Here, the signals are not transported in the air, but primarily in Al since the parts ('microphone and loudspeaker') are integrated. In a phase diagram, the Hamiltonians for several frequencies and amplitude will form a dense space, corresponding to many energies, requiring adequate measures, and validation of performance in desired applications.

A cumulative sum would give high power; convenient if the goal is to amplify in a network.

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implicit(y^2=-x^2 +1  -0.5*x*y -0.5*x , x, -2,2, y, -
3.2,3.2),
implicit(y^2=-x^2 +4  -0.5*x*y -0.5*x  , x, -2.5,2, y, -
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3.2,3.2),color = green,
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2,2, y, -3.2,3.2),color = yellow,
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3.2,3.2), color = aquamarine,
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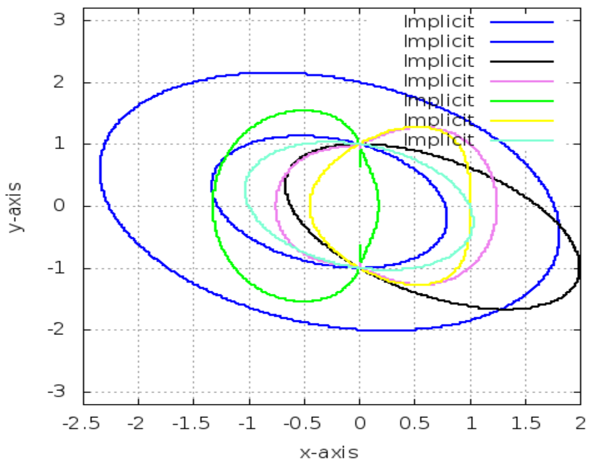

Figure 4. Phase portraits, i.e. $I_{,t}$ versus I at H=const according to the code above, for an LC-circuit with nonlinearities from a memristor.

4. Conclusion

Experiments on interactions for electricity and mechanical motion is essential in safety assessments and to obtain reliable products.
Parallel with experiments, mathematical models were discussed, in order to quantify, predict and verify (specific and general) results: For loads and vacancies on an NPN-capacitor, the equations in [5] provide possibilities to describe amplification. In [5] moving electrons and holes are considered with a density field, and the rest mass. Equations for magnetism and e.g. rotations are given in [6,9], and may be modified to describe larger scale induction on a drum membrane. A model could be that of piezo-electric response to acoustic displacement. Other recent applications with battery nano-systems and magnetism are given in [12].

A harmonic oscillator implies a stiffness modulus if assuming that the current is moving, traveling loaded particles with a mass-equivalent. For a distributed flow, a mass could be identified in a representative volume element, of a defined size.

In solid mechanics, stiffnesses can be combined, and rheological models for interaction in space can be visualised, which may be useful in piezo-electricity and other material oscillators. Here, it was found that the lines in the inductor-coil-capacitor-oscillator in Figure 2b, had much current and that is probably due to resonance both for the electro-magnetic sound and in the material.

Finally, circuits models with generalised LC-oscillators were cast into a format of Hamilton dynamics. A scenario similar to audio feed-back was assumed for the coil on Aluminium. This was exemplified with Hamiltonian functions, frequencies and amplitude for current.

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