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Models for capacitors on a pot plant battery, ppb and impact on lifetime of 3v-batteries with traditional electricity

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Abstract
A LED-lamp, with power supply from Li and Alkaline batteries, together with a fuel cell is studied. The fuel cell consists of a PPB where water and soil is the electrolyte, and a capacitor. Previously, it was found that some of the devices respond such that the lifetimes (mAh) are prolonged, [1]. The results here are similar, in some cases , while others become unstable.

Introduction

Electric components, e.g. resistors and capacitors are used to obtain sufficient voltage and current for e.g. a lamp with a battery. The present paper concerns a LED and batteries attached to a bio-electrical coupling. The latter consists of a pot plant battery, PPB (i.e. a pot with soil, anode & cathode), and a capacitor made of Aluminum [1].

The couplings in prolonged the time from 1 week to 12 weeks, for a LED powered by a Li-battery, button cell [1]. In the present paper, variations of those couplings are gathered. The purpose is to find similar solutions for e.g. other types of batteries and attachment materials.

Also theoretical analysis are performed

The Capacitors are modeled with differential equations in two fashions. A memristor-behaviour for the capacitor, gives results in agreement with experiments. The other model is that for loads in terms of current on the foil [1]. Also this gives qualitative results, however neither provides details on e.g. how to scale.

Experimental Materials and Results

In the present section, the sample devices of bio-battery with additional equipment will be described. With some deviations, the principle is similar to those in []. The variations are

- more dense foils; plate , plate and foil
- two batteries
- Alkaline batteries
- shifted polarity, i.e. PPB and foil at the -pole: Tested at the end of life-time, this worked when the electrodes were attached close to each other on the foil and with sufficiently tight connection. Then, the light got significantly stronger and stable, however a comparison of lifetimes are not yet done.
- elasticity in stiff clamped connection
- Two on same foil: Then, after some days, only the one at strongest battery glows

Al-foil-Capacitor with PPB, Li-B and LED

A pottery battery with a capacitor attached to a LED-lamp and a Li-battery is considered, c.f. Figure 1-3. In Figure 1, the Capacitor is isolated with tape and therefore it becomes denser. The LED with 2 used Li-Button Cells, Li-B, lasted ~2 days. In details: Initially with light some hours. Then :/starts fast with high intensity, twinkles and stay dark:/. The latter may correspond to an exponential increase in current, as will be found in modeling, Section 3.

Figure 1: Device with encapsulated capacitor; lasted 2 days. Right: General circuit scheme. Also NaCl is added together with water.

Two more longlasting devices are seen in Figure 2. Both has two used Li-B which gives enough Voltage to light the LED (~2V).

The rightmost (red), has an Al-plate in the Capacitor-foil. A plate is less sensitive for heat which is an advantage at upscaling. Red light: After ~8 days, there were no light. After ~5 more days (date 10/9), the device was rebuildt and started to shine weakly, on only one of the batteries, which was around <2V at that time. On 25/9 it glows, but almost no intensity. Plausibly, the Capacitor is too dense, thus giving resistance. The left, green light, lasted less time, and it may be due to dynamics between the batteries, such that current is not redirected into the pot and benefits on the V-potential, as in [1].

Figure 2: Two plant-lamps with Al-foil capacitors attached as in the scheme Figure 1. At right, a more rigid plate strip in the capacitor.

In Figure 3, two smaller Li-B; 2*1.5V are used. Data for each battery is ~150mAh and the LED >10mA , i.e. one day. The LED without capacitor, i.e. the battery serial with the PPB, worked around <5 days, after which a capacitor was needed. Then it was lighted in periods additional 19+2 days, after which the batteries were degradated with rust, such that no more light.

Figure 3: Device on 2 new batteries. 30/8, without capacitor, at right and same from 10/9 with Capacitor,at left;. From 25/9, it shined less easily.

Alkaline: Two AAA batteries (each 1.5V and ~1200mAh) in a spring attachment, and 2 LEDs. Despite the tight contacts in the battery, it started to glow less and only one LED after 4 days. In the beginning, the light was less intense than without the capacitor. The PPB-foil were located close to the LEDS, which were in separate chamber and the contacts at the LED were not entirely tight, such that they could have 'promoted' a pause in lightning. Due to this and lice, the experiment was cancelled. Later, the same electric device and a new PPB with shifted polarity put close to the battery (i.e. before and in the spring attachment), were tested. It displayed the same low intensity. It is not known if this increases the battery life time or if energy dissipated in the contacts.

Models for the Al-Foil-Capacitor

Two models will be outlined.

Memristor model

The first is to consider the capacitor as a memristor, i.e. a varying resistor, denoted M.
With U being voltage and I current, this fulfils U=MI and U,t= M,tI +MI,t where ,t denotes time differentiation. It is noticed that the devices react somewhat on a mechanical punch. The response after a Dirac pulse-input on the memristor is U,t= MI,t

Hereby, it may be considered as a switch, when the loads move into the capacitor such that the current increases.

The same reaction for U (obtained either by a mechanical push or by itself) yields U,t proportional to a Dirac-pulse and M,tI+MI,t=0 (0)

This has constant solutions for M and I. Other solutions are transient and exponential, such that M= M0exp(-mt) and I= I0exp(mt)

Remarks. The device in Figure 1 exhibits strong pulsed shine after dark, which agrees with m>0.
For m<0, the memristor value M increases exponentially, as the current in the circuit decreases.

Harmonic oscillator, nonlinearities and hyperbolic solutions

The other model is based on that in, given in Appendix. With a linear variable transformation y=y(x, parameters), a Hamiltonian for (2) reads,

$$H= y_{,t}^2+y^2+f_{nl}$$

where fnl denotes a nonlinear function emanating from the nonlinear terms deviating from a harmonic oscillator in equation (2). In Figure 4, Hamiltonians for some nonlinearities are given [1].

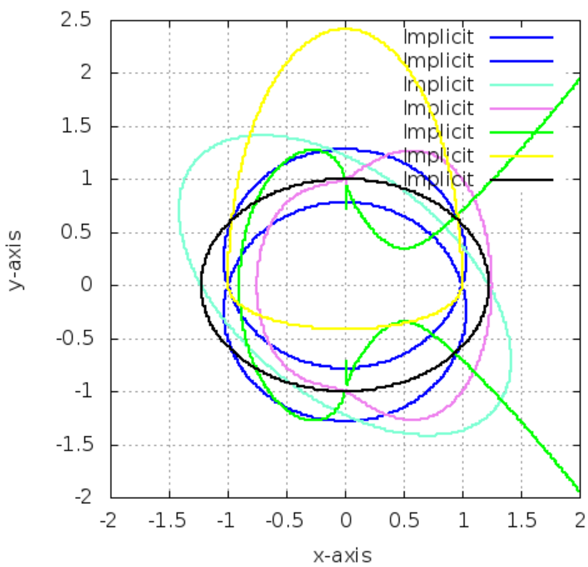

Figure 4: Phase portraits at H=const, for certain values of parameters and some nonlinear functions fnl given in the code below, as script to Maxima Online [2].

Draw2d(/*global options*/title = " ", xlabel = "x-axis", ylabel = "y-axis", grid = true,dimensions = [500,500],/* implicit function */key = "Implicit", line_width = 2, color = blue,implicit(y^2=-x^2 +1 -0.5*y , x, -2,2, y, -2,2.2),implicit(y^2=-x^2 +1 +0.5*y , x, -2,2, y, -2,2.2),color = aquamarine,implicit(y^2=-x^2+1.5 -x*y , x, -2,2, y, - 2,2.2),color = violet,implicit(y^2=-x^2 +1 +x -2*x^2*log(x) , x, -2,2, y, -2,2.2),color = green,implicit(y^2=-x^2 +1 +2*x*log(x) +0.5*x^3 , x, -2,2, y, -2,2),color = yellow, implicit(y^2=-x^2+ 2*y*(1-x^2)$^{1/2}$+1 , x, -2,2, y, -2,2.5), color = black,implicit(y^2=-x^2 +1.5 -0.5*y*y, x, - 2,2, y, -2,2.2)) $

Parameter linearisation. In order to linearise, an additional assumption into a=a(t) may be applied. This is motivated by a wave motion on the capacitor such that a=a(x(t)), and an interpretation is that the effective length adapts.

Theorem. a(t)=tan(t) linearises equation (2).

Remark. The tangens solution gives a possibility of a large effective length. This may be applicable at upscaling, however heat is found to cause fire in a non-dense Al-foil subjected to high power.

Hyperbolics. For T>0, a linearisation of equation (2) has hyperbolic solutions. This apply to the behaviour for shifted polarity and close electrodes on the foil: Then, remaining distances to the anode and cathode of the PPB become relatively large. Tacitly assuming a load wave, c.f. Figure 5, such that location is related to time t, this can be modeled with sinh(dt), d being a parameter. Other techniques for spatially distributed fields in material modeling are given in [3]-[5] and in [6], suggestions for methods for non-linear and step-wise modeling in elasto-dynamics are found.

Conclusion

Previously, it was found that similar devices respond, such that the lifetimes (mAh) are prolonged, [1]. This is due to that the electric loads transfer beneficially to maintain the power, when a PPB is used together with classical electricity. Plausibly, the plant act as a reservoir for loads, and the capacitor coupling is creating dynamics such that current (power) is added also from another direction than the Li-battery. Therefore, the battery may not supply all time, and hereby, the lifetime for the device (mAh), compared with that of only a battery, is increased.

In Conclusion

None of the variations here, gave better performance than the pair in [1]. In some cases, the behaviour were similar, i.e. a prolonged time compared with electricity data. For the single applications, the blue LED on 2 batteries lasted longest time with intense light.

Concluding remarks

- In general, a blue LED gave the most intense light.
- A valuable energy indoor is heat, and which LED that gives most heat, is not yet evaluated. Probably, the blue LED, is the most energetic, also for this, and a heat wave might be generated beneficially, with several. The lines twisted is found to produce heat, and that may be due to generation of local electromagnetism in interaction with the line material and cover isolation.
- The contacts to the foil are crucial at the end of life-time, (when more power from the PPB is needed,) and it works if an oscillating motion is added, until it begins to shine. That could be accomplished in a network application, when put on the same foundation as machines.
- Presumably, there is a wave in the room, because two devices shines more easily, and longer time.
- After an initial time (~5 weeks), they appear somewhat organic*, i.e sometimes obtains a cycle (around 12h) where part time un-lighted. A motion and rearrangement of the lines on the capacitor and at the other attachments makes it re-light strong, for another ~12 h or several days, or they glow weakly. (*apparantly choosing between several states, and prefers to shine at night when dark)
- Elasticity in the connections implies a stiffness and promote an oscillation beneficially.
- Hypothesis: elasticity in the connection and a stiff contact is favourable to redirect the current into the capacitor where it can recombine with the PPB.
- A future issue is to find if/how the ideas can be upscaled and amplify current and power in a network.

Appendix

The loads connected to Voltage on the capacitors will be modeled as population dynamics , namely the function f(x)=Ax(1-x) with additional parameters. Instead of assuming a state dependency xn+1=f(x), we will consider the rate of x denoted x,t , in a similar distribution as f such that

x,t(a-bx,t)T= x(c-x) .... (1)

where a,b,c and T are constant parameters. Comparing with the graphs of each side, the parameters get somewhat interpreted; e.g. a small b gives a wide curve for x,t since the zero is at a/b

It is seen that (1) has a constant solution c.

Proposition 1. A time differentiation of (1), dividing with 2bTx,t and assuming T<0 gives a harmonic oscillator and a nonlinear term, such that

-a/(2b)(x,tt/x,t)- x,tt +x/(bT)=c/(2bT) ....(2)

Proof. Insertion in (1) and evaluation.

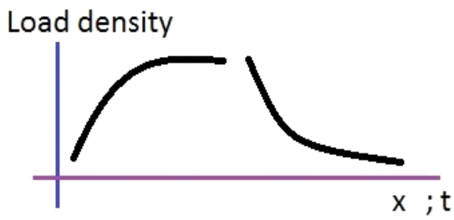

Figure 5: Wave-shape, spatially and time-distributed over the Capacitor.

References

1. Strömberg, L. (2021). Pot plant batteries, PPB: Results for a LED-lamp on a Li-battery and a fuel cell made by a PPB

and a capacitor. Article, in print.
2. Maxima Online. (n.d.). Retrieved from http://maxima.cesga.es/
3. Andrade, F. X. C., César de Sá, J. M. A., & Andrade Pires, F. M. (2011). A ductile damage nonlocal model of integral-type at finite strains: Formulation and numerical issues. International Journal of Damage Mechanics, 20(5), 515–557.
4. Smith, E. J., Bouazza, A., & King, L. E. (2022). Numerical simulation of the progressive development of soil arching in column-supported embankments. Canadian Geotechnical Journal, 59(2), 159–176. https://doi.org/10.1139/cgj-2020-0672
5. Yin, B., Zhao, D., & Kaliske, M. (2022). A gradient micromorphic modeling for plasticity softening. Mechanics Research Communications, 124, Article 103988. https://doi.org/10.1016/j.mechrescom.2022.103988
6. Zhang, M. H., Cao, Z. C., Xia, F. C., & Yao, Z. (2022). Structural stiffness matching modeling and active design approach for multiple stepped cantilever beam. International Journal of Engineering, 35, 1227–1236.