Interim Report
Control Experiments

Introduction:

This report presents the details of some control experiments undertaken as part of ongoing investigations into energy harvesting using a Pulsed Flyback Generator, the basis and testing of which has been presented in other documents.

Previous experimentation has been focused on confirming or refuting prior claims of an energy gain when pulsed high voltage transients are delivered to a receiving battery and in order to observe the effect on the charging process and enable any additional energy influx to be measured. From the measurements of the energy supplied to the generator to create the pulses, and the total energy received by the battery being pulsed charged, the Coefficient of Performance (CoP) can be calculated.

Further work is soon to take place with power tests to determine what external load can be supplied by the system which still maintains the battery voltages when normal battery swapping operation in enabled. Additionally, experimental clarification will be sought as to the likely source of the observed energy gain, whether it arises from within the internal electrochemistry of the battery itself or, as is normally suggested, from the local 'environment' by some as yet unspecified route and mechanism.

The control experiments described here serve to remove from the process the one factor that, under the original hypothesis, is proposed to result in an energy gain, namely the HV pulses.

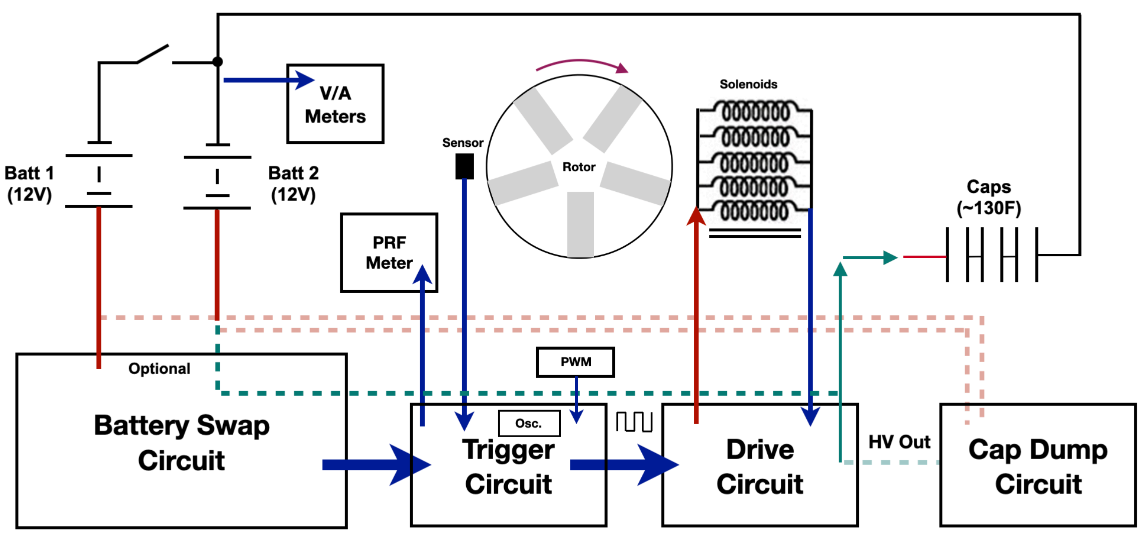

Fig 1: Functional circuit diagram for control experiments

To achieve this, the HV pulses, while being generated in the normal way by the coils and circuit, were diverted away from the receiving battery to a suitable destination that did not interfere with the circuit's operation. Rather than let the pulses discharge to air, or some other grounded path, it was decided to direct them to a set of super-capacitors which would satisfactorily absorb the pulses and avoid any high voltage arcing on the PCB.

This was achieved by connecting a bank of super-capacitors to the terminals dedicated to measuring the pulses on a scope. To observe the pulses they are normally directed to a pair of terminals via a 'load switch', and this arrangement is shown in Fig 1. With the 'load switch' off, the pulses are directed away from the path to the battery to a set of terminals on the PCB where they can be measured using a dedicated 10:1 potential divider. Instead of the divider the pulses were directed to the bank of super-capacitors wired in series so as to give a total approximate capacitance of 130F at a combined voltage of 16.2V.

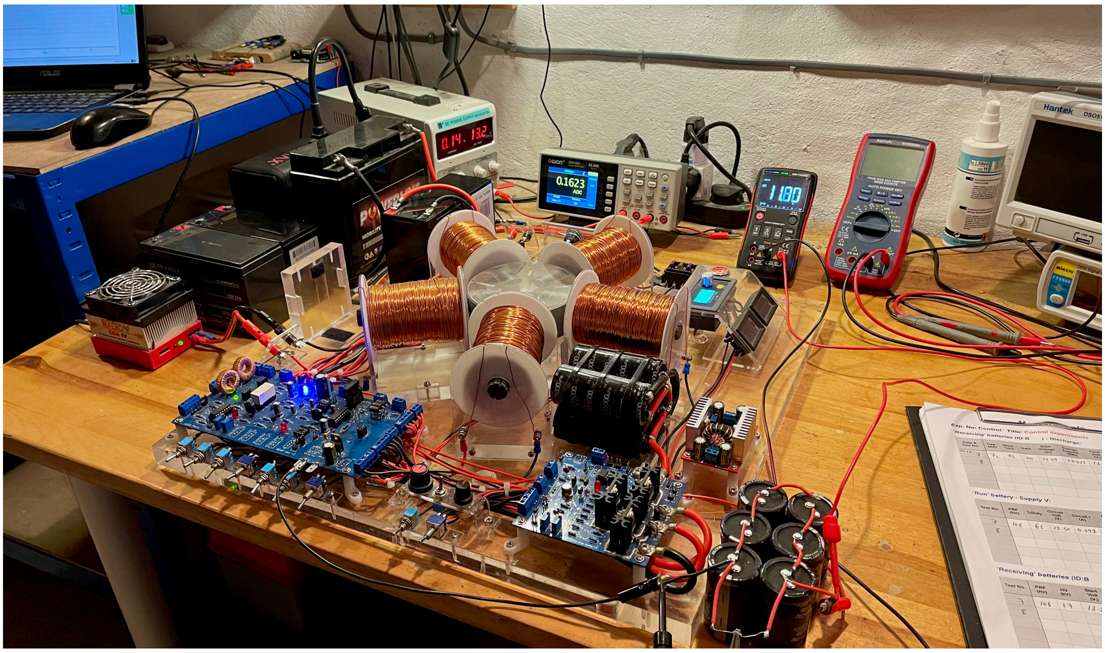

Fig 2: Setup for control experiments

To avoid the inevitable voltage rise of the capacitors, that might approach their maximum voltage limit, a 500Ω shorting resistor was placed across them to allow for a continuous dissipation of the energy being deposited. Heat loss from this resistor was also aided using a pair of heat sink clips and the testing setup is shown in Fig 2.

Methodology:

The experimental procedure for the control experiments was the same as for regular test runs, albeit updated in one small but significant aspect as explained below. The method involves the same equipment and four stages as used to determine the Coefficient of Performance (CoP) of the battery charging process. This measurement process is represented in Fig 3 with the only difference being the destination of the HV pulses. The four stages are:

1. A measurement of the energy dissipated, in a controlled discharge of the 'receiving' battery, from a state of full, or near full charge.

   [*Undertaken using the discharge feature of the computerised battery analyser (CBA) followed by the charge monitor feature to plot the voltage recovery stage*]

2. A measurement of the energy delivered by the 'run' battery to the generator in operation.

   [*By recording average current, supply voltage and run time*]

3. The return of the 'receiving' battery to its original energy state and voltage by the generator in a measured time.

   [*With pulse charging while recording the response with the charge monitor feature*]

4. The calculation of CoP as the ratio of '*energy returned to the receiving battery*' divided by the '*energy supplied to the generator by the run battery*'.

This process is normally repeated for different operational variables of the generator and so far has involved the following variables of PRF, duty cycle, coil voltage, swap interval, number of batteries in series, battery capacity (Ah), peak transient voltage and chemical format.

A value of CoP>1 means that the device is drawing in (harvesting) additional energy from the local environment, or another source, over and above the losses that the generator, with an estimated efficiency of 30% - 50%, is encountering.

For the control tests the variables were fixed at the optimum values for the specific batteries used.

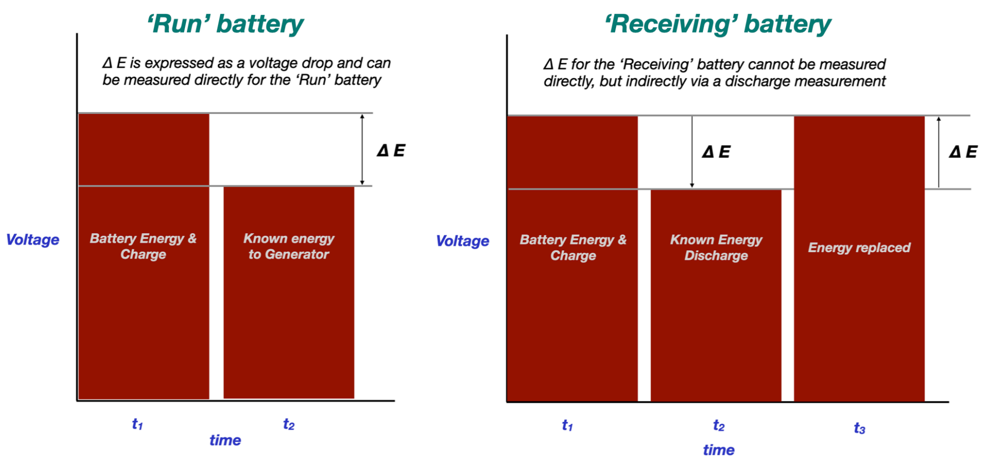

Fig 3: Measurement Process

One of the values of undertaking these control tests was that they could reveal factors that were otherwise masked by the pulses and their effects on the whole system. One such factor that was identified was the extent of the voltage recovery after the discharge stage.

In previous tests, the battery was left for only 10 minutes after discharge (stage 1) to allow the electrochemistry to settle down and for the battery voltage to return to a stable value. This is compared to the 60 minute stabilisation used after the pulse charging (stage 3) to allow the 'surface charge effect' to dissipate.

With no pulses interacting with the battery, it was observed that the voltage recovery after discharge was in fact considerably longer and more protracted than previously recognised and that, in previous tests, a small component (3-5%) of the recorded pulse-induced voltage rise was due to the continuation of the battery recovery after its presumed finishbut which was hidden within the graphical data.

This observation resulted in a modification to the experimental procedure and sequence such that the battery was allowed to undergo voltage recovery after discharge for 60 mins instead of the previously used 10 mins. Conversely, the stabilisation period after pulse charging was reduced from 60 mins to just 10 mins as this was found to be sufficient. With this revised procedure in place, more accurate readings, devoid of the influence of the battery's discharge recovery, were obtained.

Using this revised method, the following stages of a control run were completed using, as an example, a 7Ah $LiFePO_4$ battery pulsed at 108Hz with 1.7kV pulses.

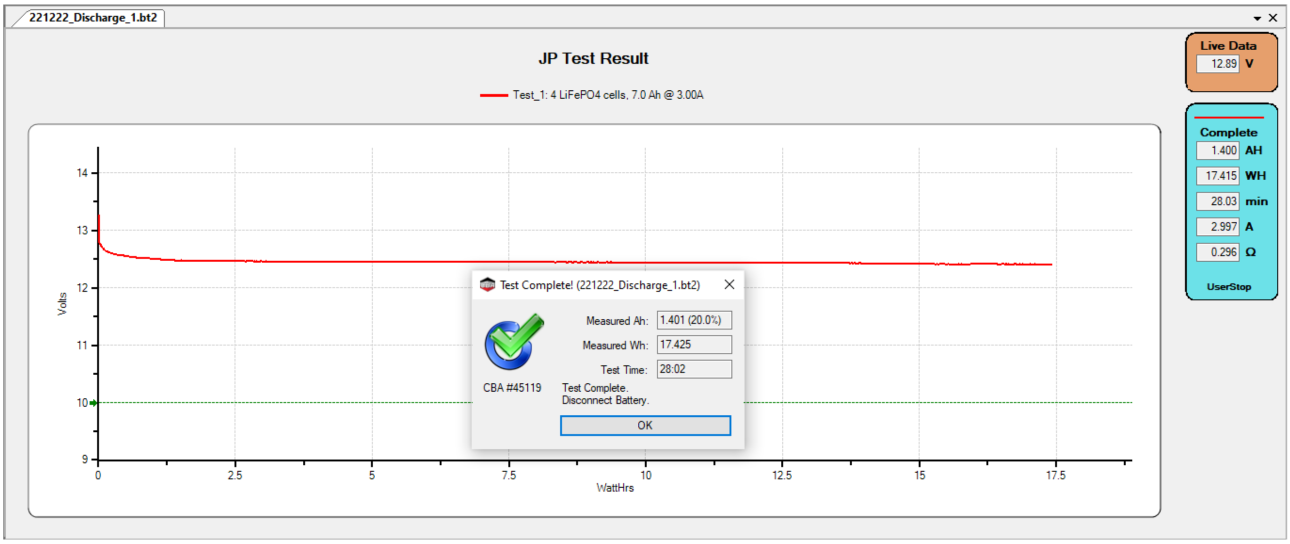

Fig 4: Discharge stage

Figure 4 shows the first discharge stage using a discharge current of 3A and where 17.425Wh (62.73kJ) of energy and 20% of the battery's capacity were expended through the CBA's electronic load. As soon as the discharge ended, the live battery voltage increases at the start of voltage recovery and with the live data reading showing as 12.89V compared to the value at actual switch off of 12.40V as shown in Fig 4.

Within about 10 seconds of this stage being completed, the charge monitor function was started to plot the battery voltage recovery over a period of 60 minutes, using an enlarged

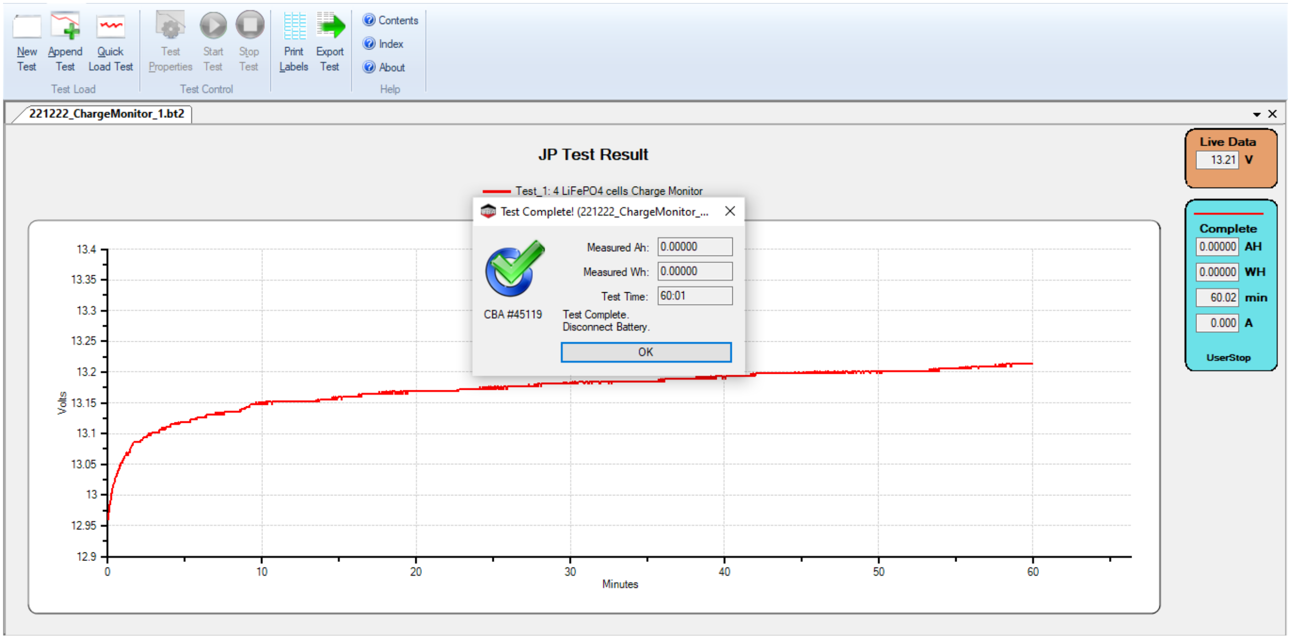

Fig 5: Voltage recovery after discharge stage

Y-axis scale to clearly show the voltage 'bounce back', as in Fig 5. Over this time the voltage recovered from 12.96 to 13.21V. After 60 minutes the battery voltage is considered to have stabilised enough to begin the actual 'control' pulse charging stage. With this method sequence there was no contribution to the voltage change, during the 'control' pulse charging, arising from the voltage recovery and which would have given a less accurate reading of what the pulse charging was actually producing.

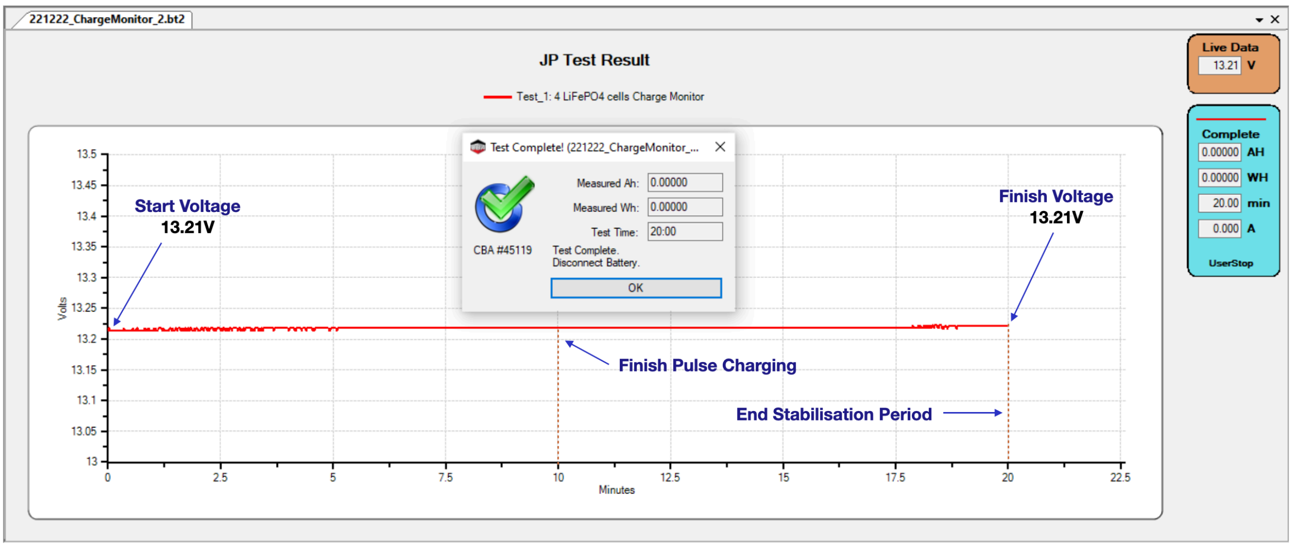

Fig 6: 'Pulse charging' in a Control measurement ($LiFePO_4$)

Figure 6 displays the Vt plot with all the pulse charging parameters the same but with the pulses directed to the capacitor bank instead of the receiving battery. The voltage remains the same over the duration of the pulses and the additional 10 minutes stabilisation. The same result of a steady voltage was obtained using a 7Ah sealed Lead Acid battery (SLA) as shown in Fig 7. This is compared to a typical charging plot, as shown in Fig 8, with the pulses being directed to a 17Ah Lead Acid gel battery over 15 mins and with 10 mins stabilisation.

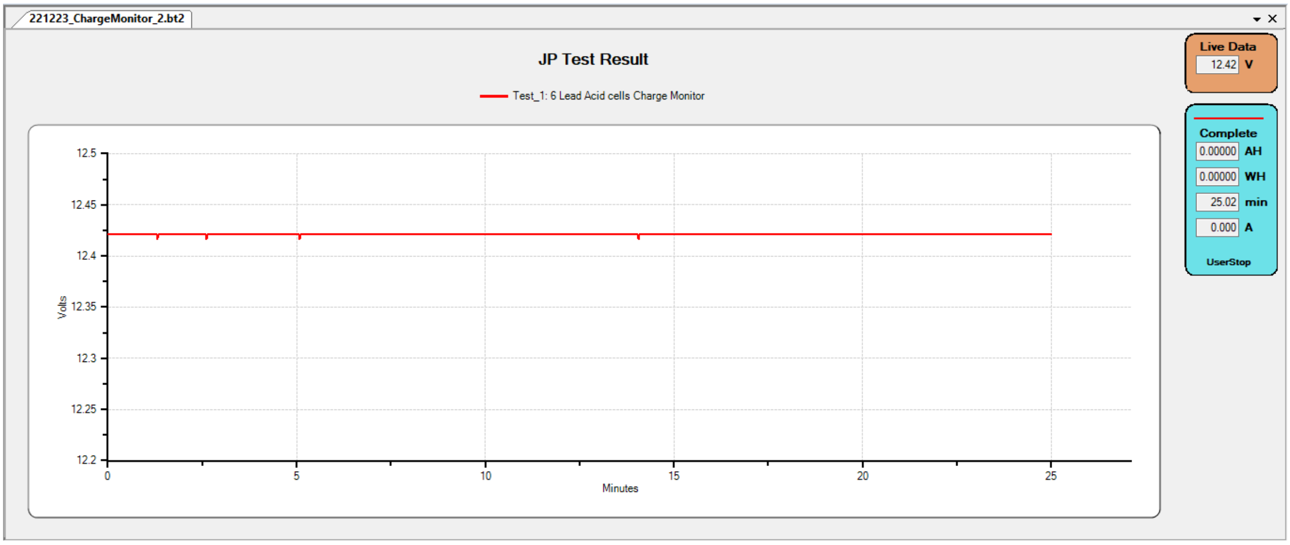

Fig 7: 'Pulse charging' in Control Measurement (SLA)

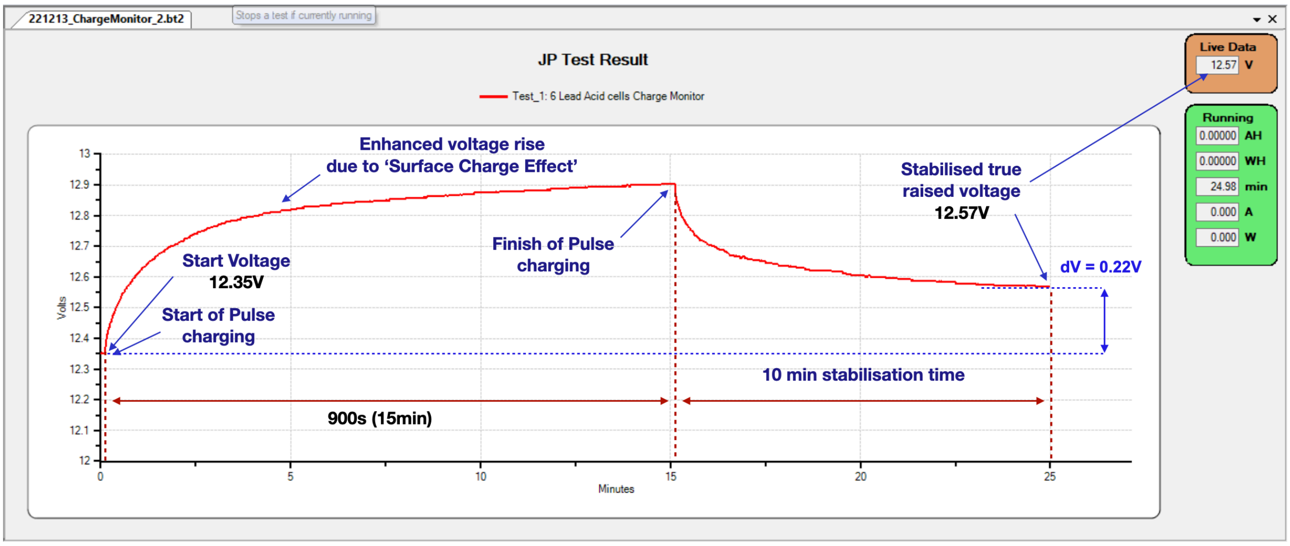

Fig 8: Pulse charging with 'Non-Control' process

The calculation of a CoP value was irrelevant with the control tests since the energy that would have to be supplied, to return the battery to its starting voltage, would be infinite since no voltage rise was recorded. This would equate to a CoP of zero.

Of interest was the fact that the recorded current during the control pulse charging stage was much lower than when delivering pulses to a regular battery. With the pulses being received by the capacitors, as a high reactive impedance load, the supply current was typically about 25% of that with a low impedance receiving battery.

This indicates an interactive feedback loop within the generator as a whole and, while changes in supply current demand have always been noted with different batteries, and with different states of charge of a single battery, here the effect is more pronounced. The exact nature of the feedback is unclear and it goes against the idea that the energy required to produce the pulses is independent of their destination. Clearly this observation is more pertinent to the behaviour of the coils than the trigger circuit but it indicates an interaction between the time-varying fields, the flyback pulses with their particular qualities and the receiving medium.

Conclusions and Discussion:

Running control experiments allowed for the observation of any underlying factors that would otherwise be hidden within the normal operational data. They presents themselves in the graphical plots and results alongside demonstrating the effect on the receiving battery when no pulses are directed to it, but when all other conditions and factors are the same as for regular pulse charging. This was the case with the voltage recovery after the discharge stage and which contributed a small component to the voltage rise during pulse charging. Modifying the experimental method, by extending the recovery time after discharge, removed it from subsequent test runs to give more accurate measurements of the actual pulse-induced voltage rise.

The results from the control runs clearly showed that, in the absence of the HV pulses at the positive battery electrode, no voltage rise or collection of charge was observed. This is compared to normal operation where the pulses arriving at the positive terminal and electrochemistry result in the release of energy and charge that is then stored within the electrochemistry in the normal way via the reversible redox chemical reactions. This energy and charge is then released when required and, in normal operation, would occur when the receiving battery becomes the run (supply) battery when using the normal battery swapping system.

With the pulse charging clearly the cause of the battery voltage rise, and earlier tests with capacitors, used in place of the receiving battery, also confirming that the electrochemistry is central to the observed phenomenon, the question inevitably turns to what mechanisms might be involved. In this there seem to be only two viable options. Either the energy gain is purely an internal process, perhaps the result of the pulses acting directly on the battery's electrochemistry and using it as a form of 'fuel' or, as is usually suggested, the battery chemistry is acting like a diode or one way valve to ‘capture’ and harness an energy influx from the local environment by an as yet undetermined processes.

The answer to this question is as important as that of whether there is a confirmed and repeatable energy gain since the implications of an energy flux from the environment are considerable in the context of our understanding of the space-time metric and the availability of energy from some of Reality’s underpinning mechanisms. This would indeed be a basis for “riding the wheel-work of Nature” as Nikola Tesla put it.

Further Work:

Work is already underway to devise a rationale and the practical means to answer this all important question. Such experiments will address the issue of the effect of the pulses on the electrochemistry by considering the battery’s ‘state of health’ (SOH) as an indicator of any pulse-induced damage and its overall internal condition. The SOH, using relevant indicators, will give a useful measure of changes to the internal chemistry and, as a consequence, its capacity to store and deliver energy compared to a new control battery that has never been pulse charged.

Also, since data on the accumulated pulse and cycle history of each battery has been recorded throughout all the testing to date, it will be possible to collate it and identify any correlations between the pulse charging time and battery capacity, as well as determine any links between the quantitive chemistry and the sustainable power delivered to an external load.

While pulse-induced damage should be differentiated from the loss of any electrolyte consumed as a ‘fuel’ in the process, if the battery is itself the source of the observed energy gain, then its quantitive chemistry must be able to account for the energy and power measured on an ongoing basis.

These proposals will be presented first in a discussion document for comment before devising a specific methodology and measurements are undertaken.

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29th December, 2022