Anomalous Behaviour of a Transformer plus Delay Line

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1. Introduction

It is over 30 years since Steven Mark demonstrated his invention in the USA showing anomalous generation of electrical power. He did several demonstrations each with slightly different versions of his invention. They all contained some form of toroidal transformer hence his device has been named TPU (toroidal power unit). At the end of one demonstration, he cut open the toroid so people could view its internals. During the working demonstrations two aspects were noted: (a) it exhibited some inertial property as some vibration could be felt and (b) it stopped working if the unit was turned upside down. Mark claimed the unit derived its power from the Earth's magnetic field. There is claimed correspondence from Mark that a unit was run in another country on the opposite side of the equator (where the vertical component of the Earth's field would be reversed) where it only then worked in the upside-down configuration. Many people (including me) have offered explanations for how the device worked, but until recently there have been no observable replications.

Recently a claimed replication named STEAP (Space Time Energy Absorption Pump) has been offered where the toroidal part is a complicated assembly of delay lines. How this device works is the subject of debate. In this paper I show that a classical transformer with secondary connected to a delay line that is shorted at the far end theoretically has anomalous behaviour when driven from a current source delivering specific shaped short pulses of width equal to double the delay time, Figure 1.

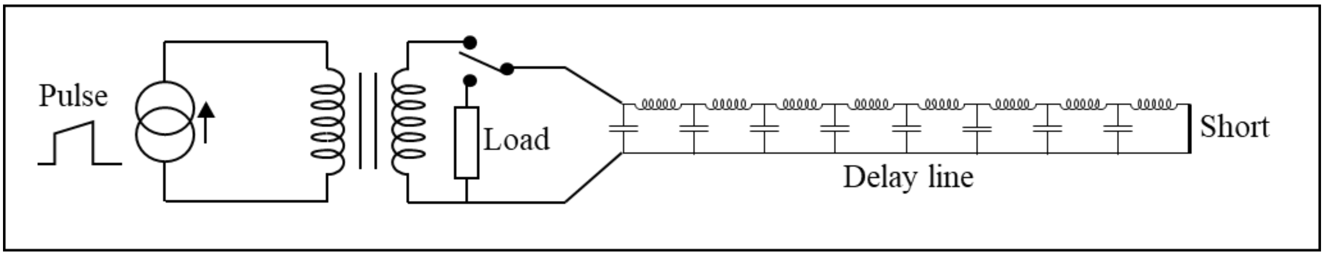

Figure 1. Basic circuit

In brief, the reflection of the short circuit across the secondary at that delayed time forces the situation where the energy taken from the primary source is all returned, but leaving the delay line with stored inductive energy that can be retrieved, thus showing deviation from the conservation of energy (CoE). (It is noted that deviation from CoE occurs in other situations involving purely reactive components, like discharging a charged capacitor into an uncharged one, but there the energy is lost. Here we have a collection of inductors and capacitors theoretically showing energy gain.)

2. Transformer with resistive load

We start by considering the secondary connected to a resistive load, since initially the classical delay line appears as a resistor. It is customary in transformer analyses to consider the primary current to have two components, magnetizing current and load current. Only the magnetizing component creates flux in the core and that statement hides the fact that the primary load current and the secondary current feeding the load negate each other with regard to creating flux. For power transformers that are generally driven with sinusoidal AC the two primary current components are separated by phase, being 90° apart. For transformers driven by pulses it is difficult to characterise that separation, but nevertheless at any instant some of the primary current is going to flux generation and some is going to load power, the mmf of that load part being equal to the mmf of the secondary current but of opposite polarity. We suddenly apply a fixed voltage to the primary and very quickly the current rises to a value to meet the load demand on the secondary, the magnetizing current value being small due to the high permeability of the transformer core. Then the input current and flux keep rising at the rate determined by the input voltage, keeping the voltage across the load resistor constant. This is shown in Figure 2 with a chart of core flux Φ against input ampere-turns U.

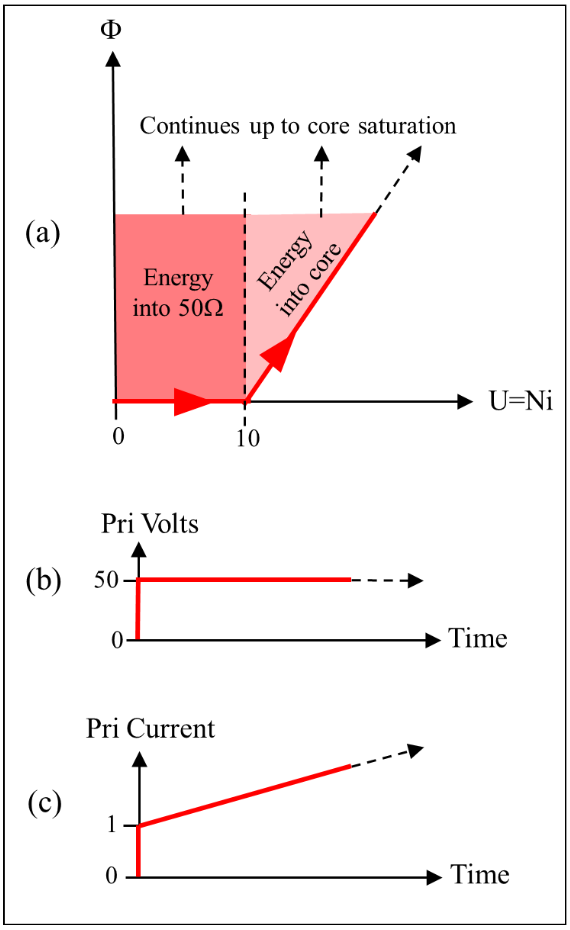

Figure 2. (a) Flux v. Pri Current, (b) Pri Volts and (c) Pri current

Also shown are the primary voltage and current waveforms. The values there relate to a ring core modelled in FEMM where the closed core length averaged 127mm having area 50mm^2 and a relative permeability of 14,872 (pure Fe), yielding a reluctance value of 1.35x10^{5}H. Primary and secondary turns were both 10 giving inductance 742μH, and the secondary is connected to a 50Ω load.

The chart 2(a) is unusual, normally charts showing flux v. current are used to depict the core characteristics where only magnetizing current is considered; then the area to the left of the curve is the input energy into the core that is stored magnetically and generally recoverable later. Here we plot flux v. total primary current where the area to the left of the curve now identifies both that quantity of energy being transferred to the secondary and dissipated in the resistive load and that quantity going towards the rising magnetic energy stored in the core.

The primary current and core flux would continue to rise until core saturation is reached when input inductance would drop demanding more current from the source, but we do not do that.

In place of the voltage source, we use a pulsed current source matched to the primary current waveform shown in Figure 2 (c), having a fast rise-time up to 1 amp followed by a linear rise to maintain the 50 volts. The reason we do this is because later in the pulse we have a deliberate increase in secondary current where we must consider the transformer action working in reverse, where that primary source is now acting as a load to the secondary current change. A current source having infinite internal impedance then demands zero energy from the secondary current step to transfer a voltage onto it. Be assured that this change from a voltage to a current source does not alter the waveforms shown in Figure 2, instead of a 50V source seeing a load current of 1A we have a 1A source seeing a load voltage of 50V.

3. Transformer with shorted delay-line

The pulse width is set to match twice the delay time of a 50Ω delay line that replaces the load resistor, this delay line having its far end as a short circuit. At that point in time the reflection of that short circuit causes the input voltage of the delay line to fall to zero and the current to rise from 1 amp to 2 amps (see Annex 1 for the travelling waves within the delay line). We also choose the delay line length (hence time) such that the primary current has risen to 2 amps at the time the reflection drives the secondary current to 2 amps. Those matching values of equal but opposite direction currents drive the core flux to zero, as shown in Figure 3.

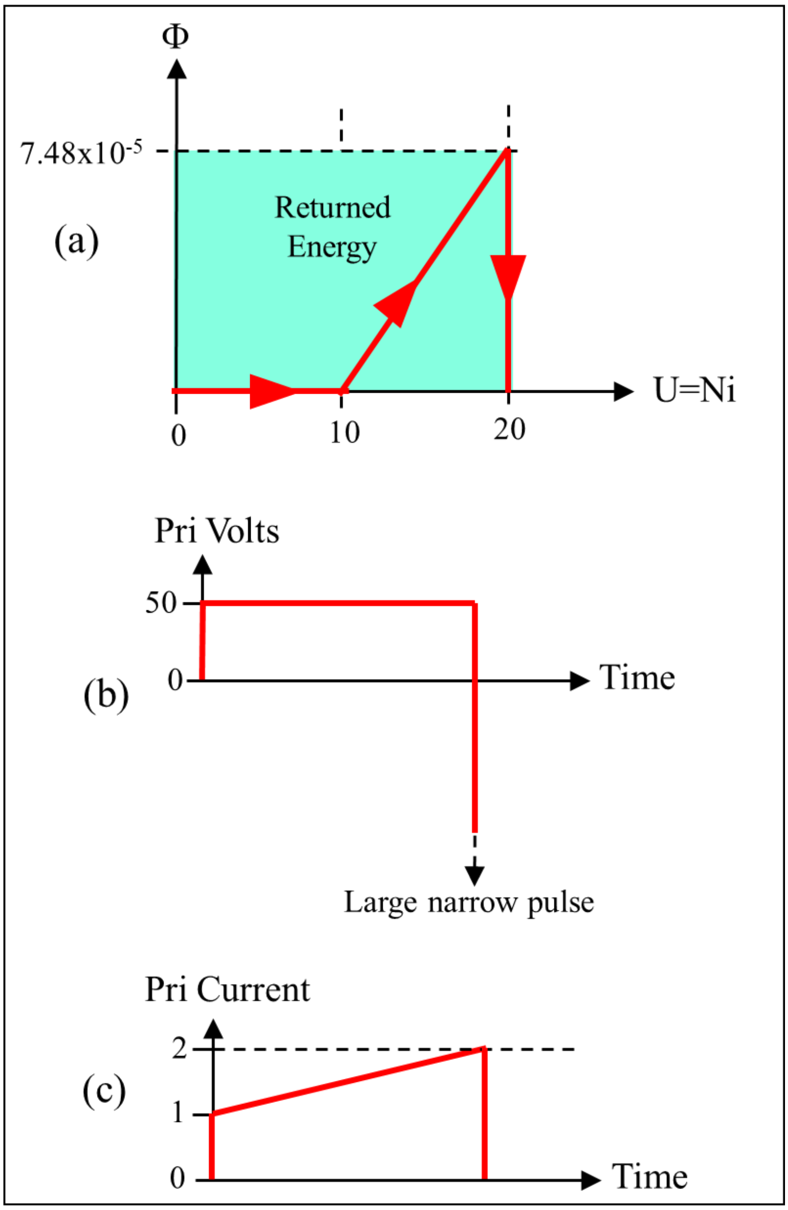

Figure 3.

The sudden drop in flux to zero causes the energy shown in green to be returned to the input current source, and by comparison with Figure 2 showing the energy taken in red, it is seen that more energy is returned than taken. The rapid fall in flux creates a negative high-voltage spike applied to the input current source creating that energy feedback. Immediately after this spike has occurred we end the current pulse and at the same time disconnect the delay line from the secondary and switch its current into a load resistor. Energy stored by that 2-amp current in the total series inductance of the delay line is also then recovered. With repetitive pulses the system offers a free running source of energy into the load that as a series of unidirectional voltage pulses that can be smoothed to a DC level. For the system modelled here the return time delay is 15μS allowing a repetition frequency of 60KHz. The recovered energy from the delay line is a 750μJ pulse that yields 45W at the 60KHz rate.

4. Comparison with known STEAP characteristics.

The system described above has two characteristics in common with those of STEAP. The STEAP system has two toroidal transformers in the guise of CMCs (Common Mode Chokes) each with a charged capacitor as a power source.

- Once the system is running these sources do not lose their charges, there is pulsed feedback to maintain them.
- Output from STEAP is from the complex delay line network smoothed to a DC level.

Thus, it seems STEAP is not a replication of Marks' TPU that genuinely gained energy from the Earth's magnetic field but instead is a new discovery working on a different principle. For the single transformer system described here the input current pulse shape must be specifically tailored according to the transformer core reluctance, number of turns, delay line impedance and delay line length. For the STEAP with its two transformers and complicated arrangement of interacting delay networks it appears the specifically tailored pulse requirements are not obvious and have been found by trial and error over many years. It is therefore not surprising that replication attempts are proving to be difficult.

5. Discussion

The waveforms up to the point just before the reflection from the short circuit appears at the secondary are correct for zero losses in the coils and the core, and for linear B v. H core characteristic. They correctly show the stored energy in the delay-line and in the core equates to the energy taken from the primary input source. The next step, where the sudden rise in secondary current pulls the core flux down to zero, is questionable if that secondary current is now treated as a source (the delay-line charged with current being that source) that is capable driving that flux change. The primary input device would now appear as a load to that, which is why a current generator is specified that has infinite impedance, but that still leaves the question of driving the core-flux change. Perhaps some experiments will supply the answer.

6. Conclusion

In parallel with the replication attempts of the complicated STEAP system, it would seem sensible to experiment with the simpler system described here.

Annex A

Figure A1 shows the 50V 1A waveform travelling along the delay line towards the short circuit.

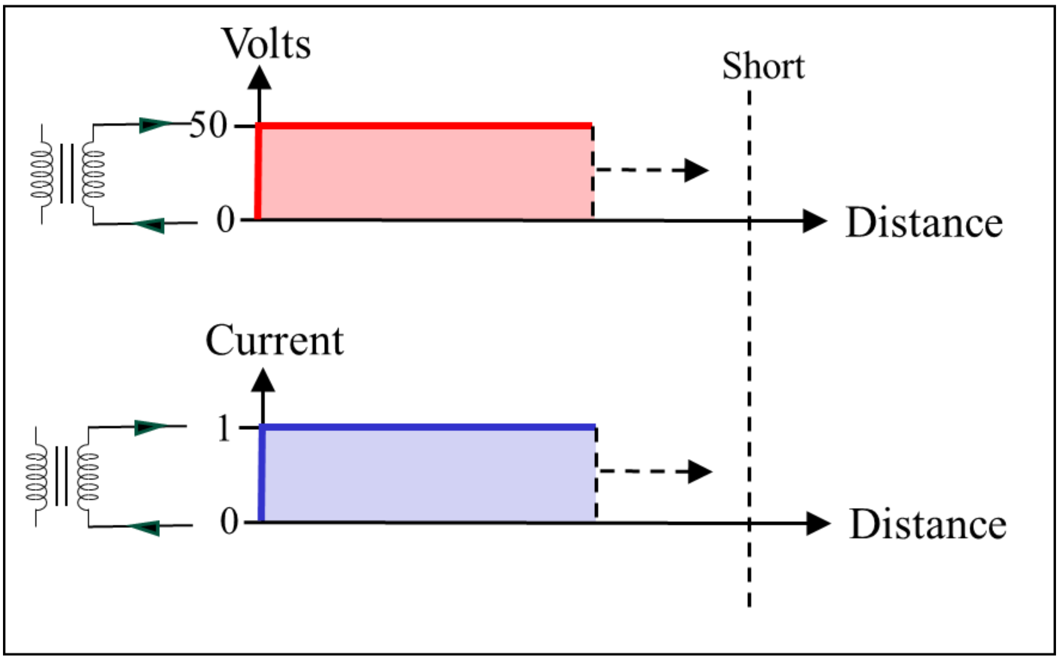

Figure A1

Figure A2 shows the reflection travelling back towards the start.

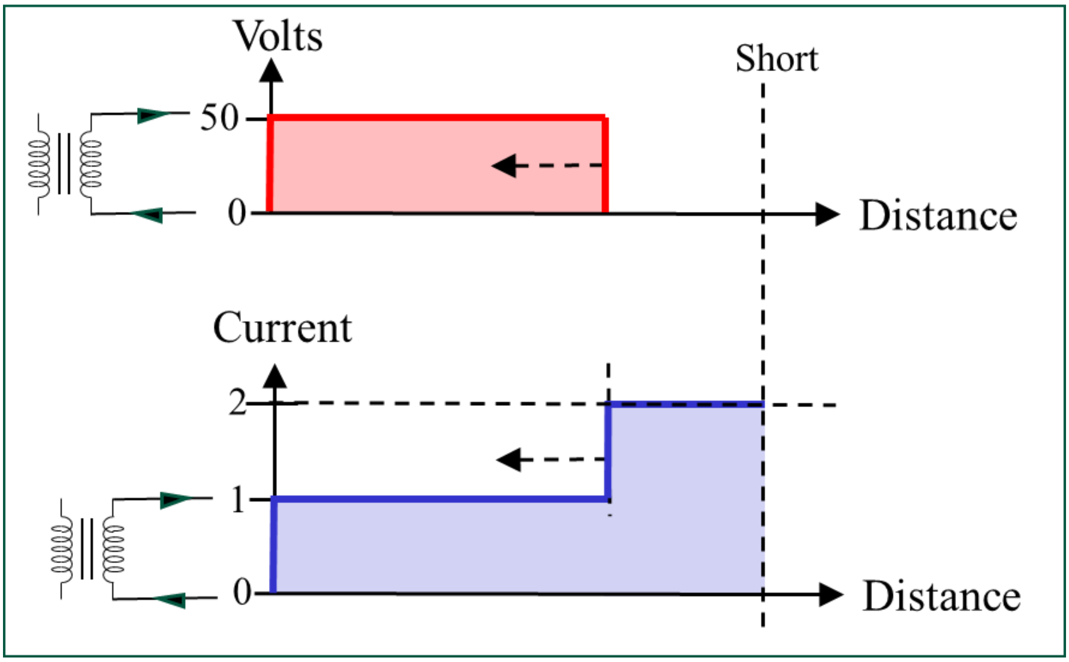

Figure A2

When that reflection geta back to the start the voltage at the transformer secondary drops to zero and the current rises from 1A to 2A