Explaining the behavior of the Joule Thief Circuit from the Oscilloscope Analysis

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Nov 14, 2012

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Background

- The Joule Thief circuit has been around for many years. Refer to thread in overunity.com
- Many people have used it to light many LEDs
- Some questioned whether it is an overunity device (Output Power > Input Power)
- Some added a secondary circuit and achieved more amazing things (G-LED Lighted 1KW of LEDs with less than 80 watts of Input Power)
- BSI Energy Holdings Limited is ready to send its oscilloscope-test-ready boards to Universities.

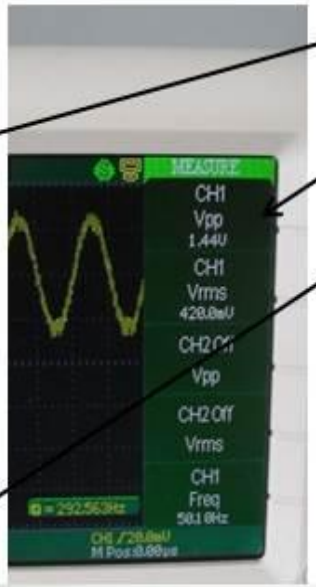
The oscilloscope file to focus on

- Lawrence Tseung always believes in the results of oscilloscope analysis.
- The key concept is
  - Instantaneous Power =
    Instantaneous Voltage x Instantaneous Current
- A 2 channel oscilloscope such as Atten can capture voltage and current simultaneously and store them as CSV file for analysis
- We shall focus on **Nov 12.xls** here

The Input Voltage Explained (1)

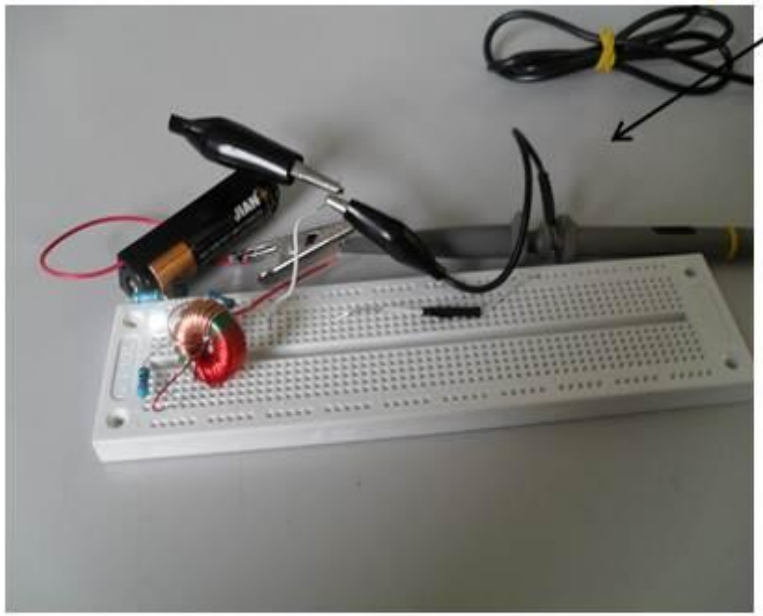
- The Input comes from an AA battery.
  - Voltage of this AA battery is 1.44V from voltmeter
- The oscilloscope is set to measure AC
  - Voltage peak-to-peak (Vpp) = 1.44V (directly)
  - The use of AC setting on oscilloscope is acceptable
- When the AA battery is used to power the Joule Thief board, Vpp drops to 220mV
- Please refer to next slide.

The question of Input Voltage



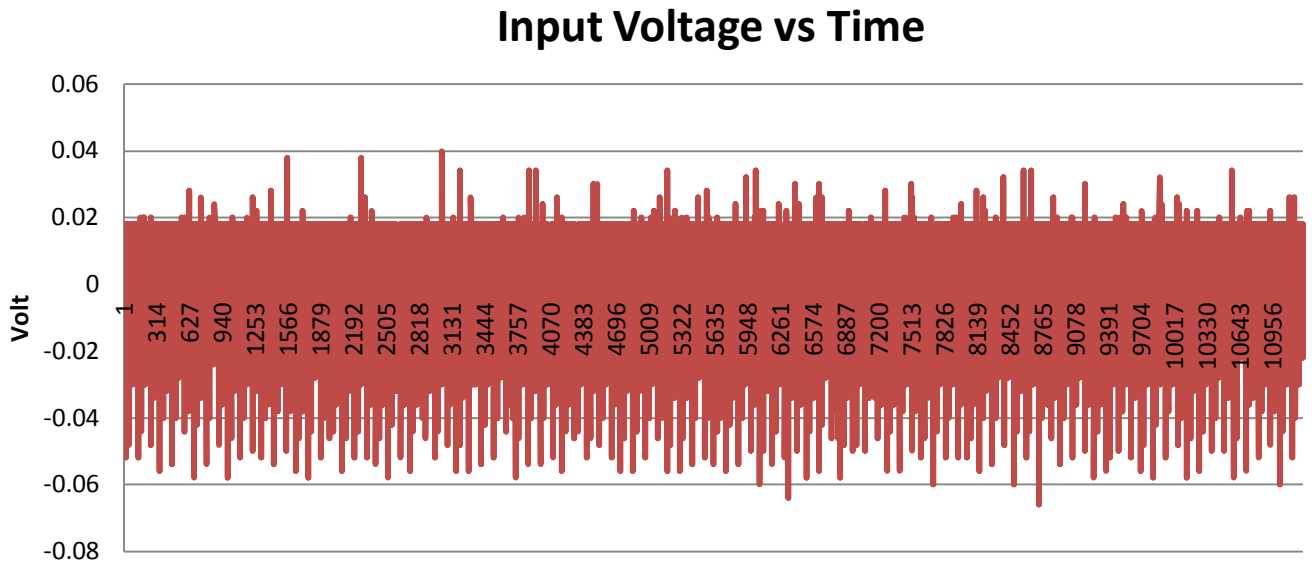
Probe across battery
(no FLEET board)
Vpp = 1.44V

Probe across battery
With FLEET board
Vpp = 220mV



Back EMF from FLEET
Reduced Input Voltage!

The Input Voltage Explained (3)

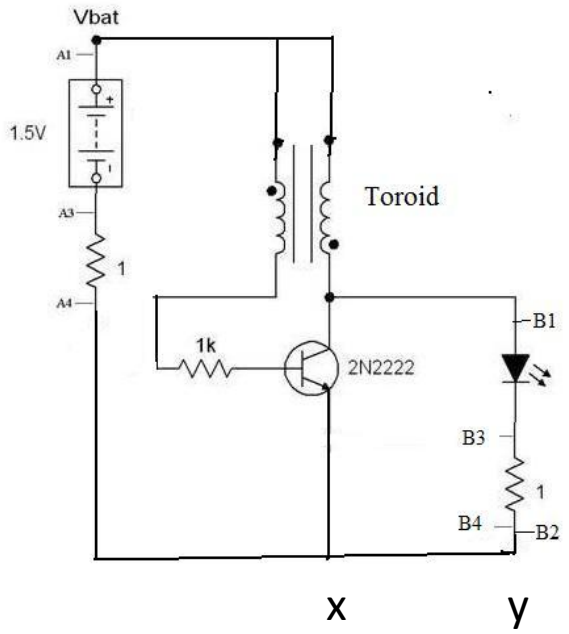


The most common question is – What happened to the 1.44V value?
The probe is across the two ends of the AA battery.
The answer is that the Circuit sends **Back EMF** opposing the DC voltage.
The Joule Thief is a switching circuit because of the 2n2222.
Thus a resulting fluctuating voltage around zero V is NOT a surprise.

The Input Current Explained (1)

FLEET Circuit Diagram and required Oscilloscope Connections

(No Secondary)



The exact location for the Oscilloscope Probes are:

Oscilloscope 1 (Input)
Channel 1 +ve A1
Channel 1 –ve A3
Channel 2 –ve A3
Channel 2 +ve A4

Oscilloscope 2 (Output)
Channel 1 +ve B1
Channel 1 –ve B2
Channel 2 +ve B3
Channel 2 –ve B4

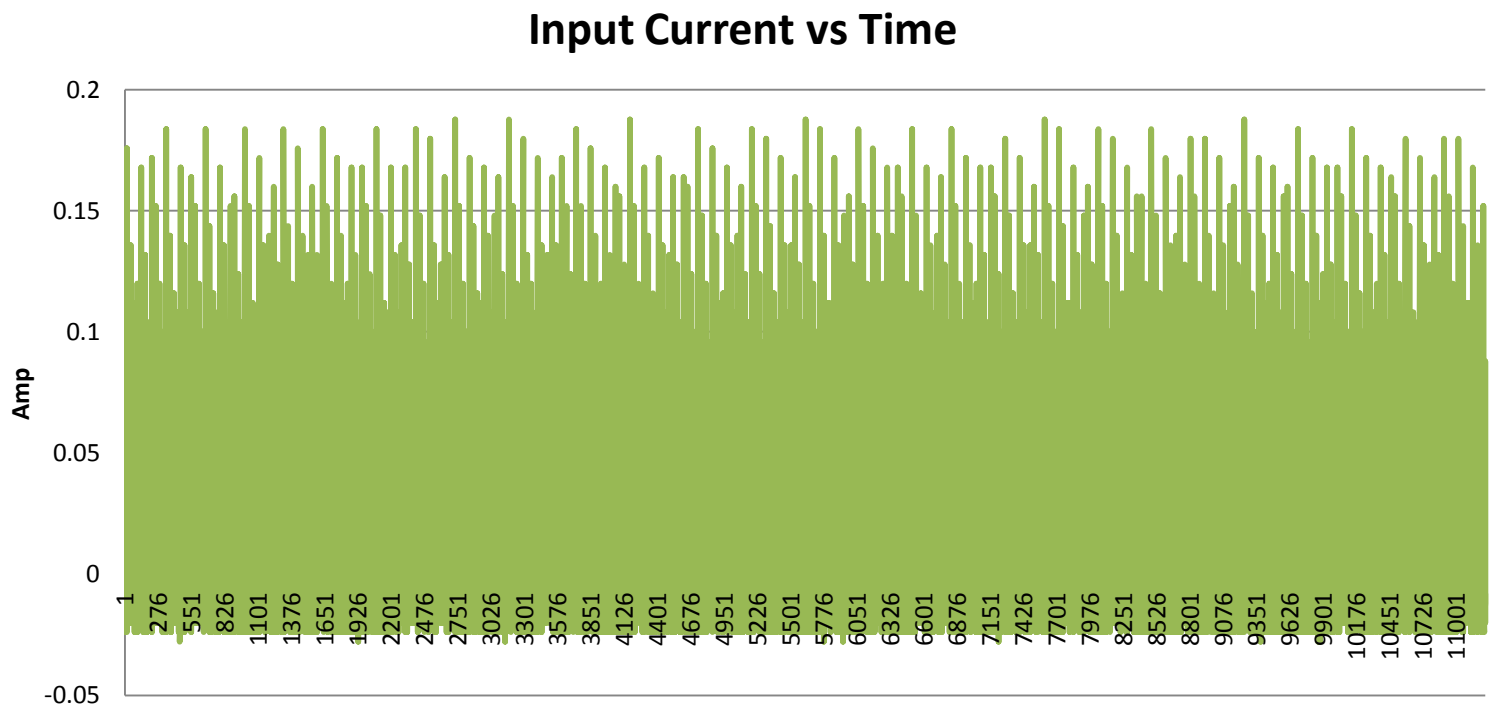
May God bless you in your replication efforts. Amen.

Note that the current Is the voltage across the One Ohm resistor between A3 and A4.

The current should be Equal to the sum of the currents from Brach X and Branch Y.

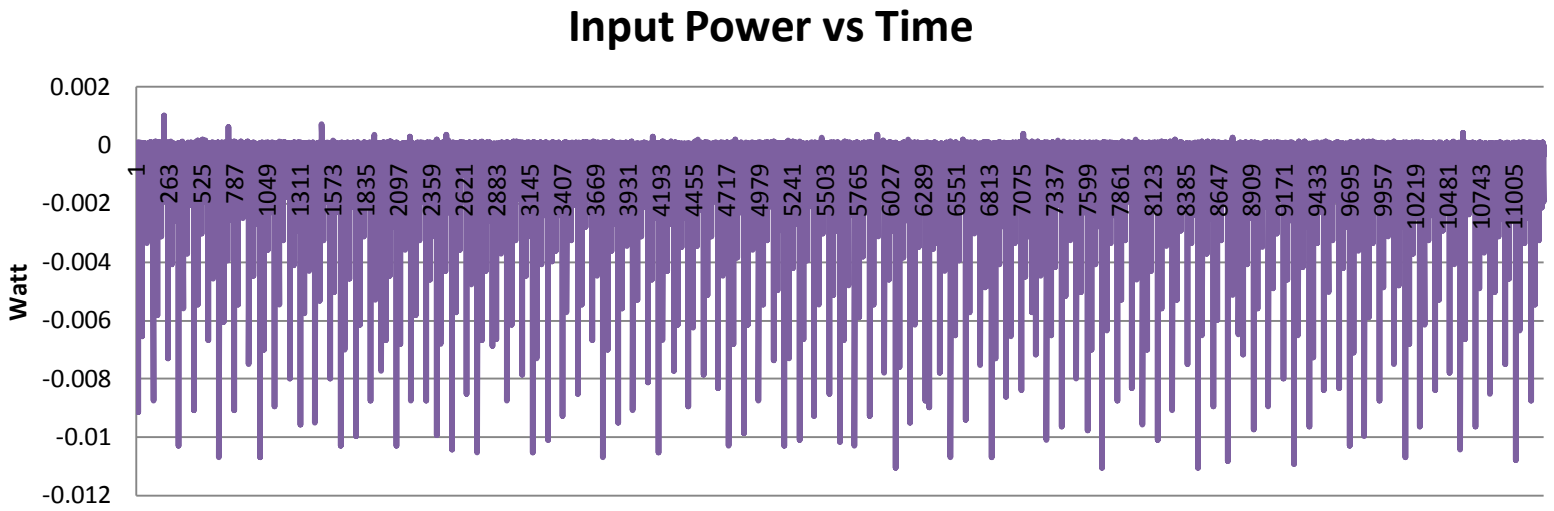
This is confirmed in the Input Voltage Waveform on the next page.

The Input Current Explained (2)



Channel 1 is used to measure Instantaneous Voltage.
Channel 2 is used to measure Instantaneous Current.
Their Product will give the Instantaneous Power.

The Instantaneous Input Power



Note that the Instantaneous Power has a large negative component. There are both positive and negative power. This is not a surprise in AC or Pulse circuits.

The average Input Power can easily be calculated using EXCEL.

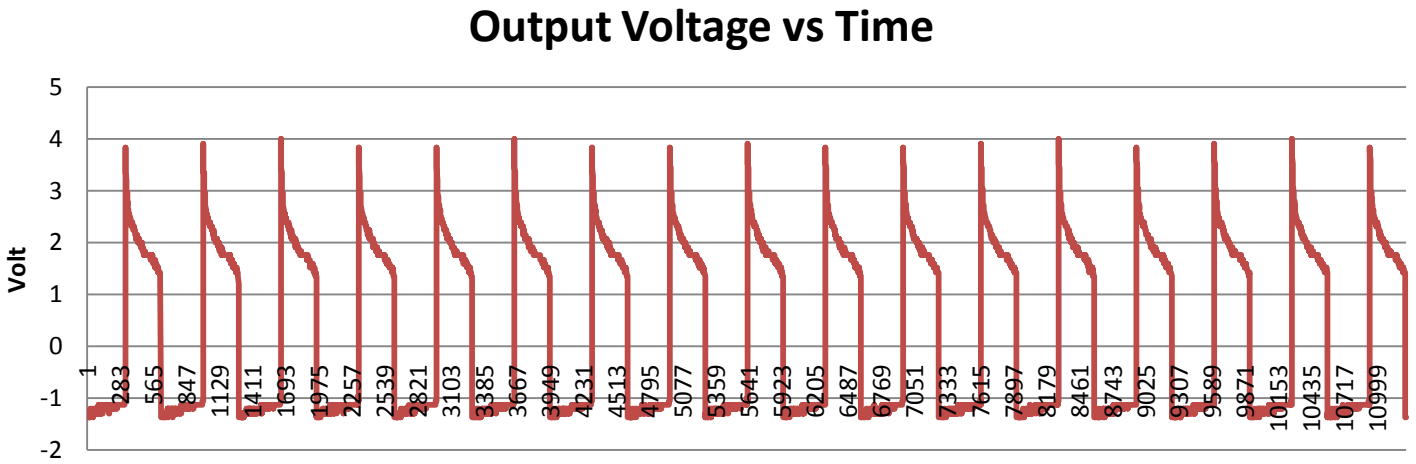
In this case, the value is -0.000336 watts.

In classic electricity theory, negative power means power coming Back to source (or an energy feedback circuit).

The Output Voltage Explained (1)

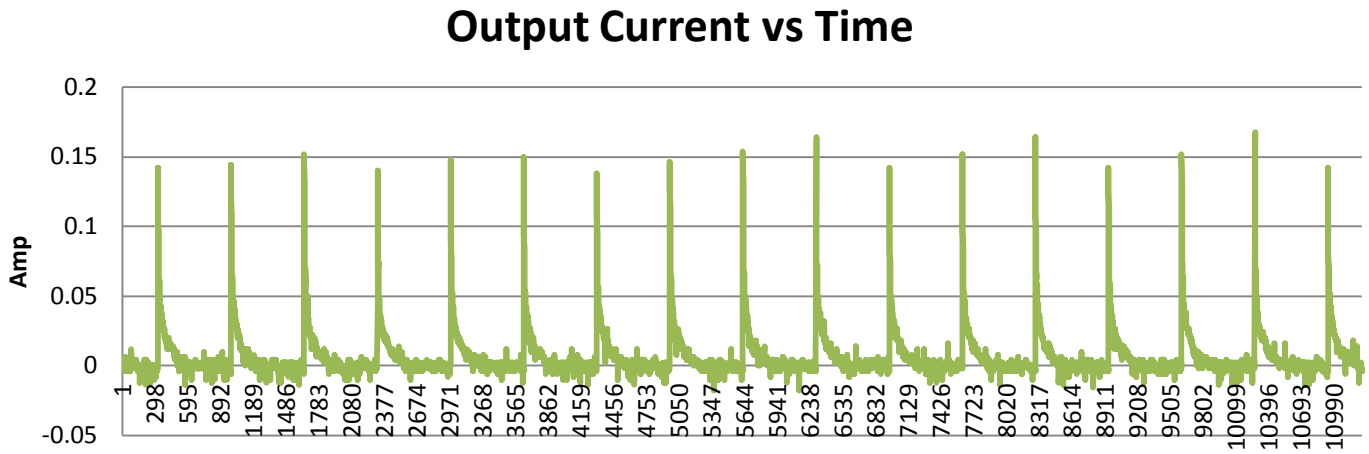
- The windings on the toroid in this case is based on Shirley Yung's finding.
  - Two equal-turn windings on two sides of toroid
  - Joined in Joule Thief fashion with positive point feeding the joint wires.
- The Switch (sudden ON and OFF) induces high pulsing voltage.
  - Vpp exceeded 5 V
  - Enough to drive the 3V LED easily

The Output Voltage Explained (2)



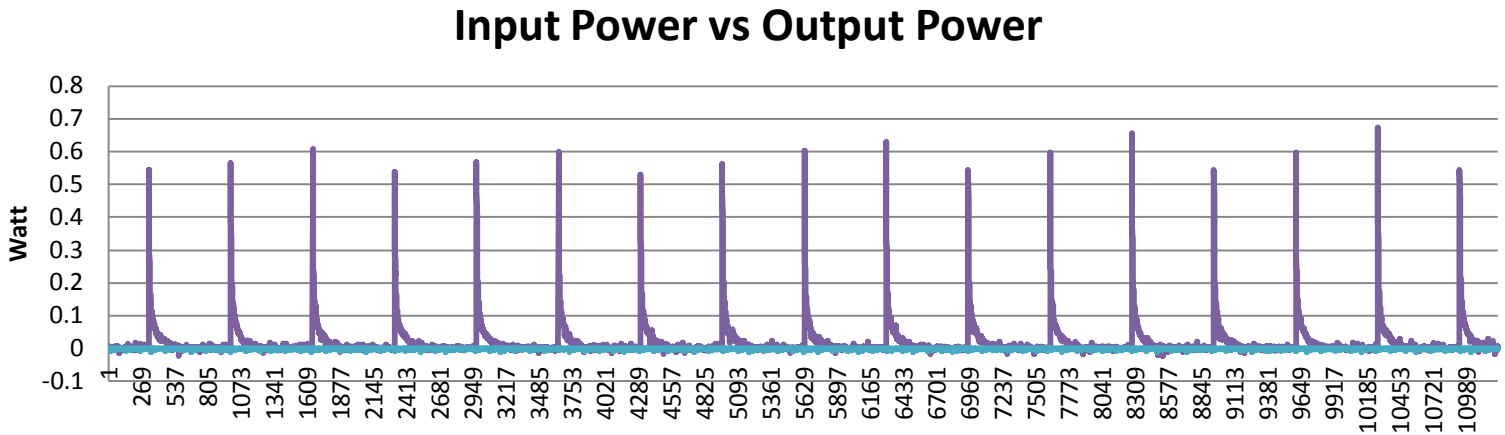
Note that the Output Voltage has a much larger value than Input.
5 Volts scale compared with 0.06V scale.
The waveform has both positive and negative portions and repeats Itself. However, it is NOT a sine wave or AC.
The explanation of such a waveform is because of the Back EMF induced by the Pulse Switching.

The Output Current Explained



The Output Current is expected to be less than the Input Current because The Output Current measures the current in Branch y only.
However, the Output Voltage is so much higher. The result is a much Higher Output Power!
Thus the magic of how energy is lead-out or brought-in is via the high EMF induced by the pulse switching.

The Output Power vs Input Power



The Input Power is a line along the horizontal axis. It is very small compared with the Output Power.

In this case the Coefficient of Performance (average output/Input power) is Equal to – 52.

The actual average power and the COP will vary with the load.

In this case, the load is a single LED.

One tuning parameter is the load – **more LEDs can have higher COP**.

The concept of Negative Power

- Some people initially thought that our getting negative power was because we placed our probes incorrectly.
- After double checking and comparing with the circuit diagrams, such an error was ruled out.
- This means if the average Input Power is negative, more energy is **flowing back** to the battery theoretically.
- Can we use this energy to recharge the battery?

Conclusion

- The experiments can be replicated.
- Different oscilloscopes can be used.
- BSI Energy Holdings Limited has oscilloscope-test-ready boards to send to Universities.
- Lead-out or Brought-in energy **is confirmed**
  - Can we make the process more efficient?
  - What is the maximum amount of energy we can lead-out?