Veljko Milkovic's
Two-Stage Mechanical Oscillator

- Efficiency Measurement -

Mk 5 INPUT/OUTPUT DETERMINATION

THROUGH LOAD CELL MEASUREMENT

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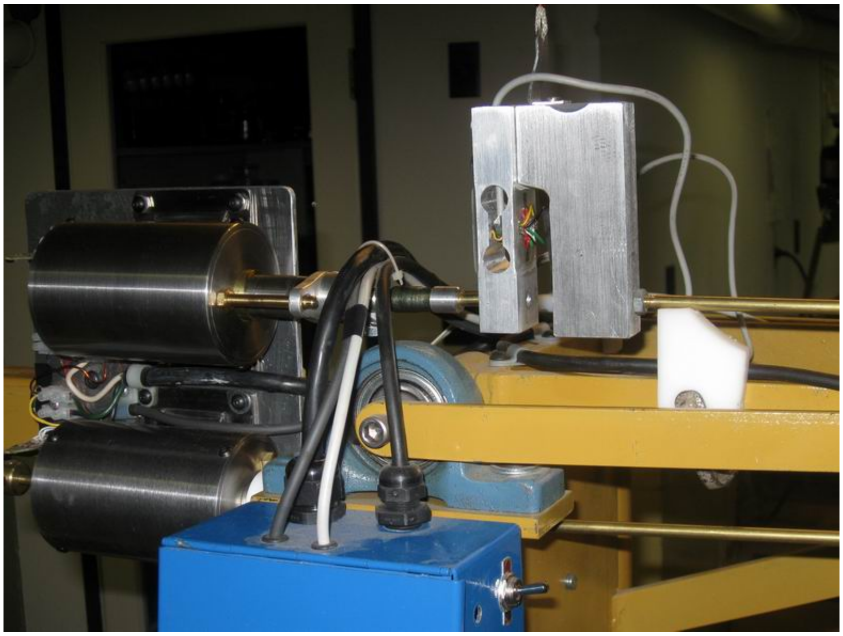
Victoria BC, Canada, May 12th, 2009

Addendum added, May 21, 2009

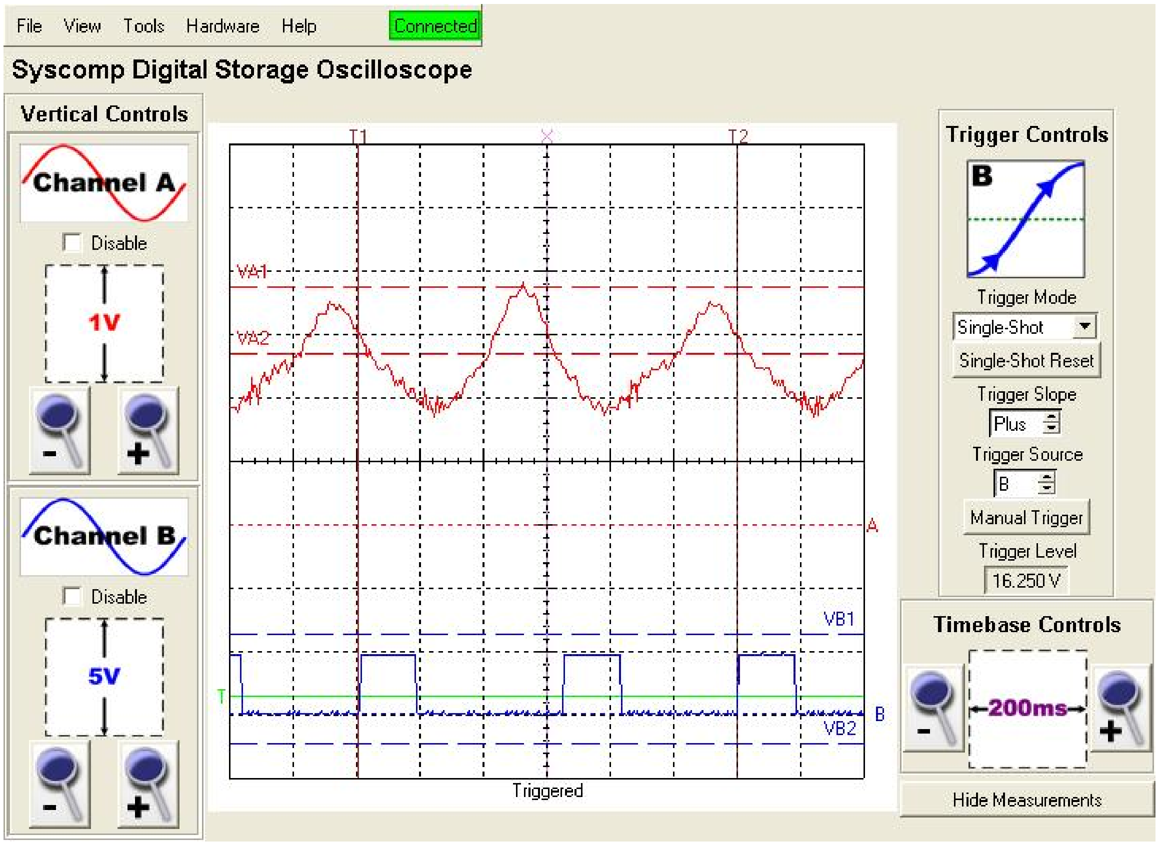
It was my intention to strain gauge Mk 5.3 [4] to see the input and output relationship; the output to be measured between the secondary arm and the counter weight, as in a Veljko Milkovic pendulum in hammer mode (www.veljkomilkovic.com).



Above: load cell on the solenoid pull rod

Below: load cell in between secondary arm and counter weight (hammer)

Then, with the pendulum working on 15 volts,
and travel on the counter weight of around 45 mm …



Load cell output is 1 volt per 20 pounds.

In static mode, the 55 pound counter weight is suspended on the load cell. The DSO 101 [2] would read, on channel A, in red, at the 2.55 volt mark or “VA2”.

Channel A’s zero mark is at the red A on the right, (level with the “Manual Trigger” box). When in operation the counter weight (hammer) gains and loses about 20 pounds.

The original intent was to see what the forces were when I let the counter weight sit right down and let the gauge go to zero but in letting it touch down caused the reading to become unstable.

Note that channel B (blue) is just a relay switching five volts in conjunction with the solenoid, so this is for reference only, to show the timing.

One complete cycle, from T1 to T2, is 1.195 seconds or 50 strokes per minute for the pendulum, or 50 pulses for each solenoid. That is 100 power strokes per minute counting both solenoids.

Power: [1]

It lifts 40 pounds 1.75 inches 100 times a minute

that is 40 pounds 175 inches in one minute

divide that by 60 to get distance in one second = 2.9166 inches or .24 feet per second

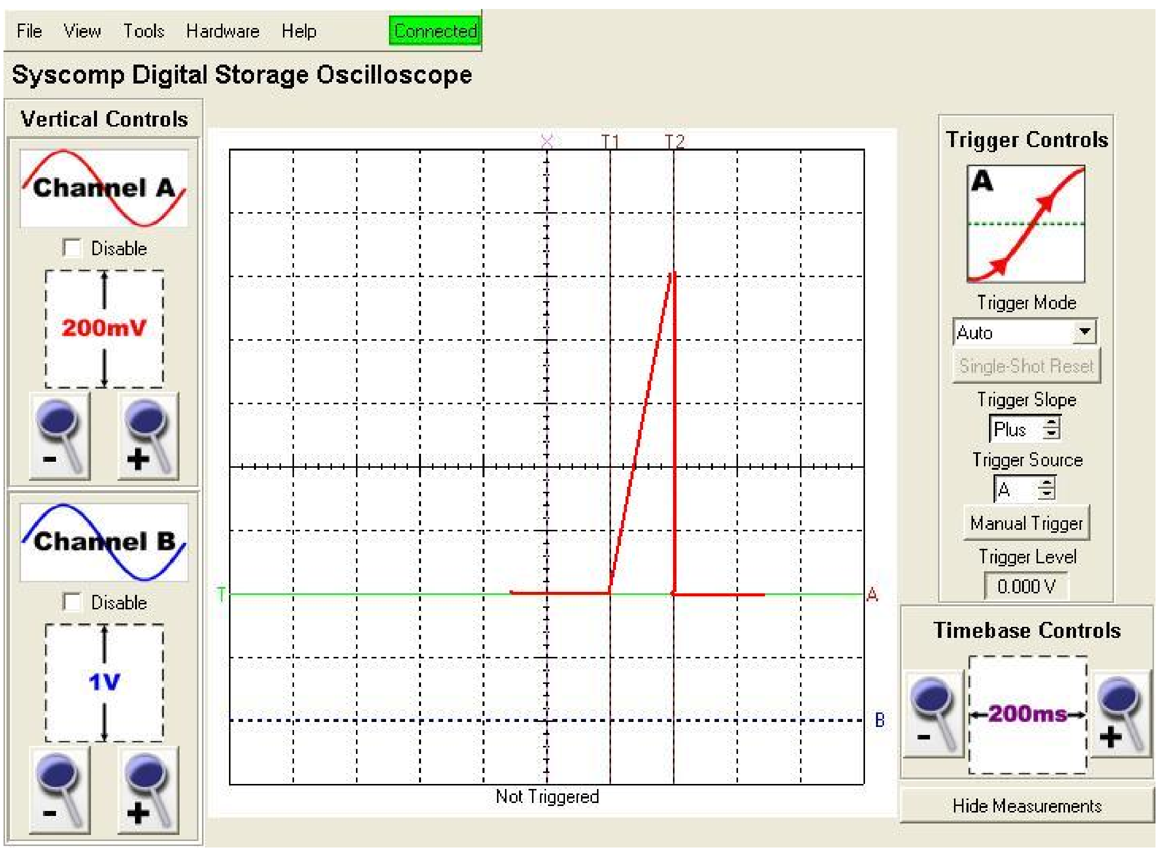
40 times .24 = 9.722 foot pounds per second divided by 550 = .01767 HP

746 watts per HP divided by .01767 = 13.18 watts

Therefore, 9 watts input, for 13.18 watts output

= COP, 1.46

Now this is not a true figure of the machines capability as I did not let the “hammer” strike the anvil. If this were the case the full weight of the counter weight would have registered on the load cell plus the strike impact should have been recorded and added to the above.



This is a hand drawn representation as the original suffered from hum interference and thus was difficult to interpret.

It is showing one volt, which is 20 pounds pull at the peak. I have averaged the pull to 12 pounds for the calculations.

Averaged pull 12 pounds

100 input pulses per minute = 1.666 per second

Distance in one second, 1.25 inches X 1.66 = 2.0825 in/sec

Divided by 12 = .1735 feet/sec

Weight of 12 pounds X .1735 = 2.082 Ft/ Lbs

2.082 divided by 550 = .0037854 HP

.0037854 X 746 = 2.8 watts

The 9 watts was taken from the electrical input. The voltage and current were measured on the DSO 101 [3] and the power in watts derived therefrom.

I have arbitrarily taken the 9 watts for the COP calculations above. This is done to err on the plus side as I have not included the draw of the ratchet solenoids nor the draw of the electronics in these calculations.

Ronald Pugh

Victoria BC, Canada, May 12th, 2009

References:

(1) How to Calculate One's Power and Horsepower
http://www.ehow.com/how_2240422_calculate-ones-power-horsepower.html

(2) Syscomp Electronic Design http://www.syscompdesign.com/index.html

(3) Ron Pugh, *Current and Power Waveform Measurement Technique*, 2009
http://www.syscompdesign.com/current-measurement.pdf

(4) Mk 5.3 Video: Double Solenoid Pendulum
http://www.youtube.com/watch?v=iI_ooL8hcrE

Addendum 1, Terminology:

When a force acts upon an object to cause a displacement of the object, it is said that work was done upon the object.

Work is a force acting upon an object to cause a displacement.

An object which possesses mechanical energy is able to do work. In fact, mechanical energy is often defined as the ability to do work. Any object which possesses mechanical energy - whether it be in the form of potential energy or kinetic energy - is able to do work. That is, its mechanical energy enables that object to apply a force to another object in order to cause it to be displaced.

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1 Joule = 1 Newton * 1 meter

1 J = 1 N * m

Non-standard units of work

$$ft*pound \qquad kg*\frac{m}{s^2}*m \qquad kg*\frac{m^2}{s^2}$$

Power *is the rate at which work is done. It is the work/time ratio.*

The standard metric unit of power is the Watt. As is implied by the equation for power, a unit of power is equivalent to a unit of work divided by a unit of time. Thus, a Watt is equivalent to a Joule/second. For historical reasons, the horsepower is occasionally used to describe the power delivered by a machine. One horsepower is equivalent to approximately 746 Watts.