An Experiment to Determine the Electrical Parameters of an AEG Firing Cycle.

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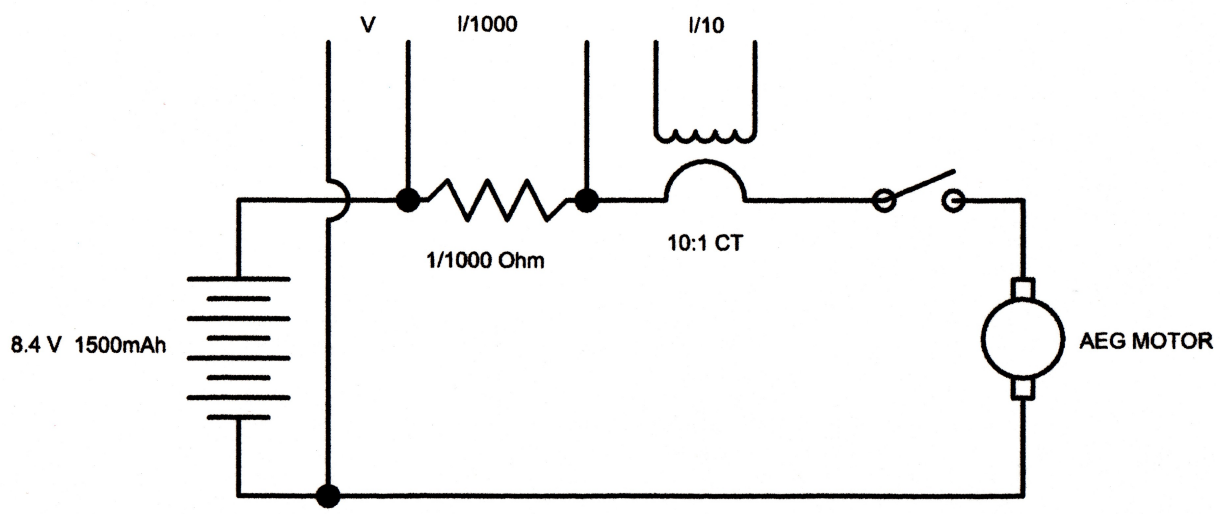
A test was performed to determine the current, voltage, and energy profile over time of an Automatic Electric Gun firing cycle.

EQUIPMENT:
Tektronix TDS 3012 Digital Oscilloscope
HP 34401 Multimeter
HP 34330A Current Shunt
Pearson 411 Current Monitor
Tektronix YT5060 Voltage Probe
Batteryspace.com Mini-Tamiya Connector Sets CN-TMMLFM-MINI
Cheapbatterypacks.com Stick AK-47S Battery using Elite 1500mAh NiMH cells (7)
Jing Gong AK47 Spetsnaz Spetz AEG 347FPS with 0.2g BB
MathCad V6.0e Mathematical Analysis Program

SETUP:
The current shunt and monitor were connected in series with a male to female mini-Tamiya adapter to read the current into the AEG. Two wires in parallel with the battery read the voltage. The AEG simply shoots in the semi-auto mode into a backstop while the oscilloscope records the waveforms.

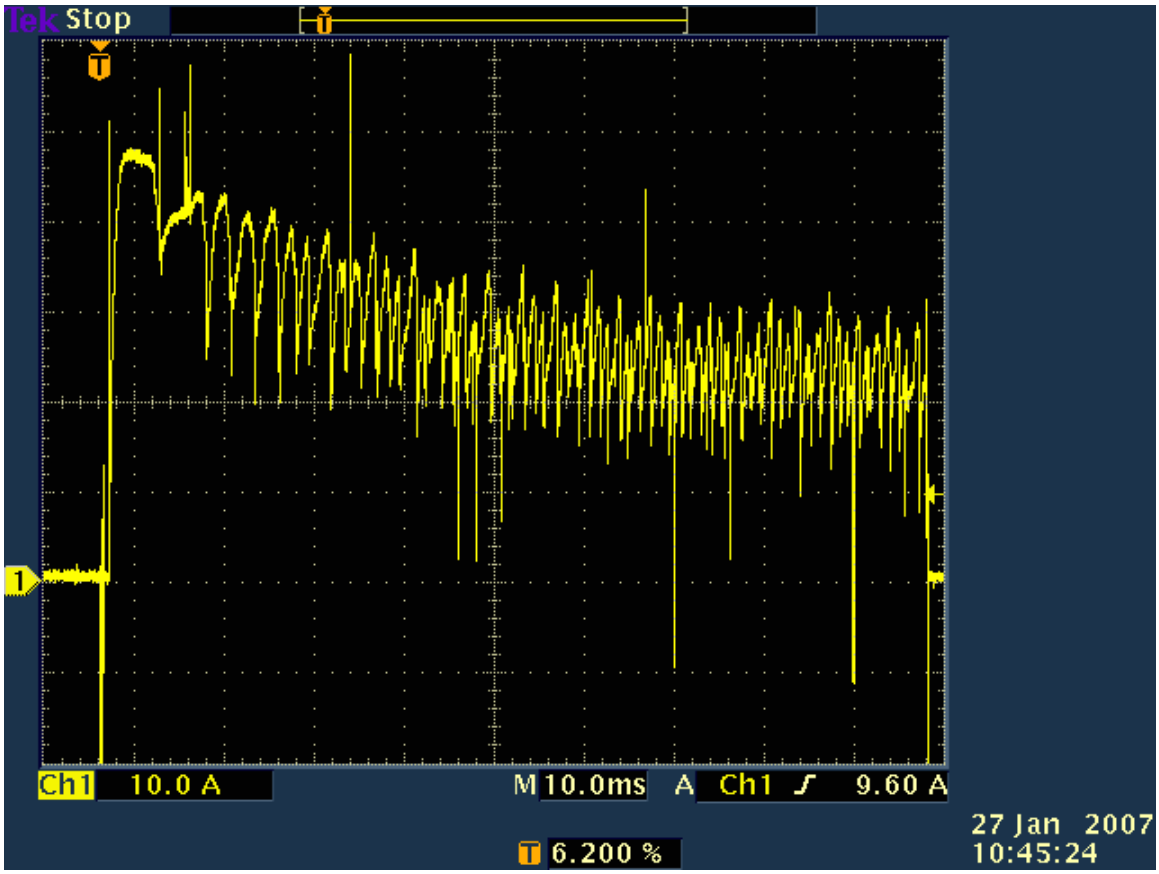


Wiring Diagram

Test Setup

RESULTS:

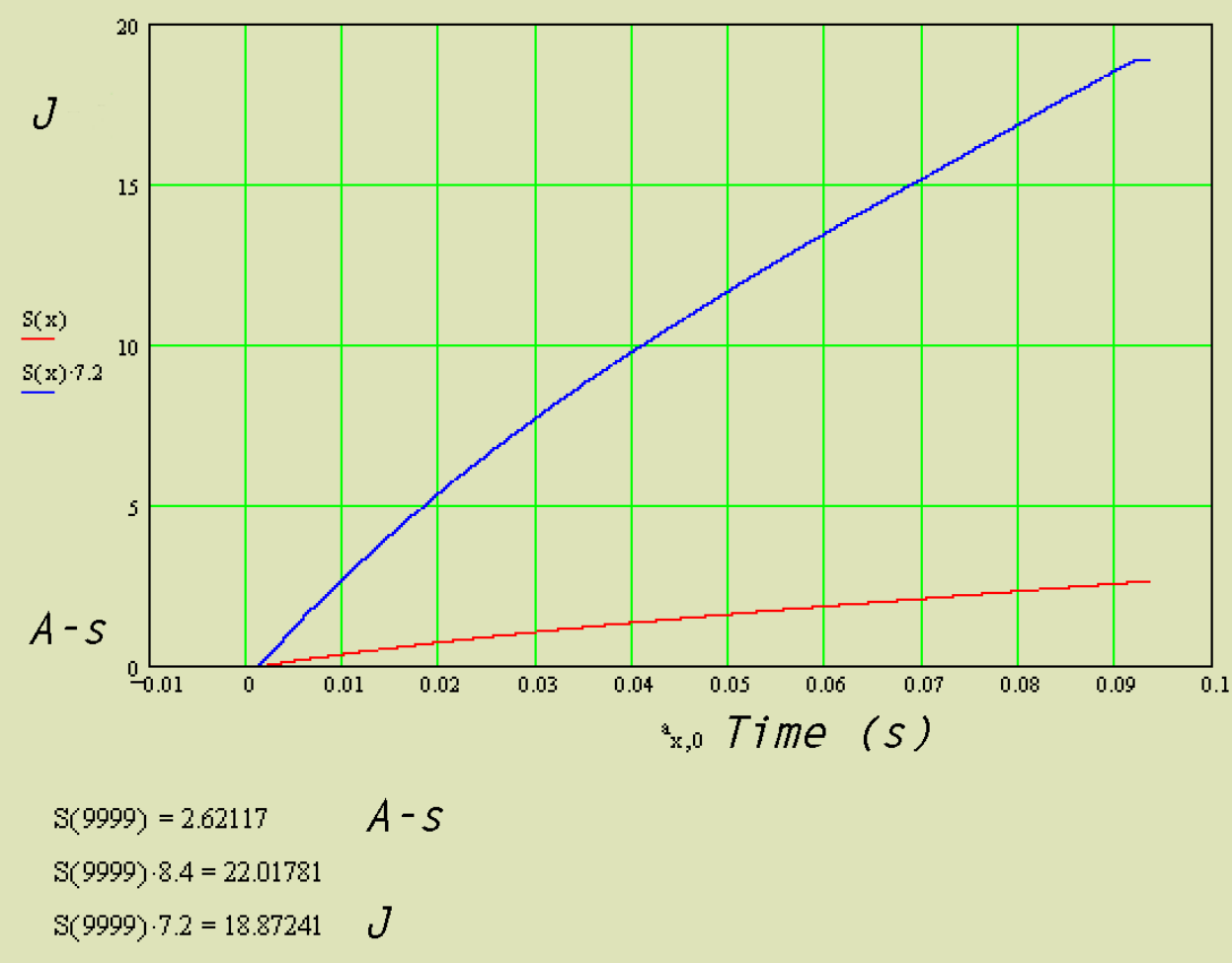
The current waveform of a single firing is show below:



Current waveform 10A/div. 10mS/div.

The current quickly rises to 47.5 amps and levels out to about 24 amps once the motor reaches full speed in about 40mS. The cycle lasts 91.85mS total. The current "humps" from the motor poles are clearly shown as the armature speeds up. The noise is minimal and the the turn off and turn on is sharp and clean.

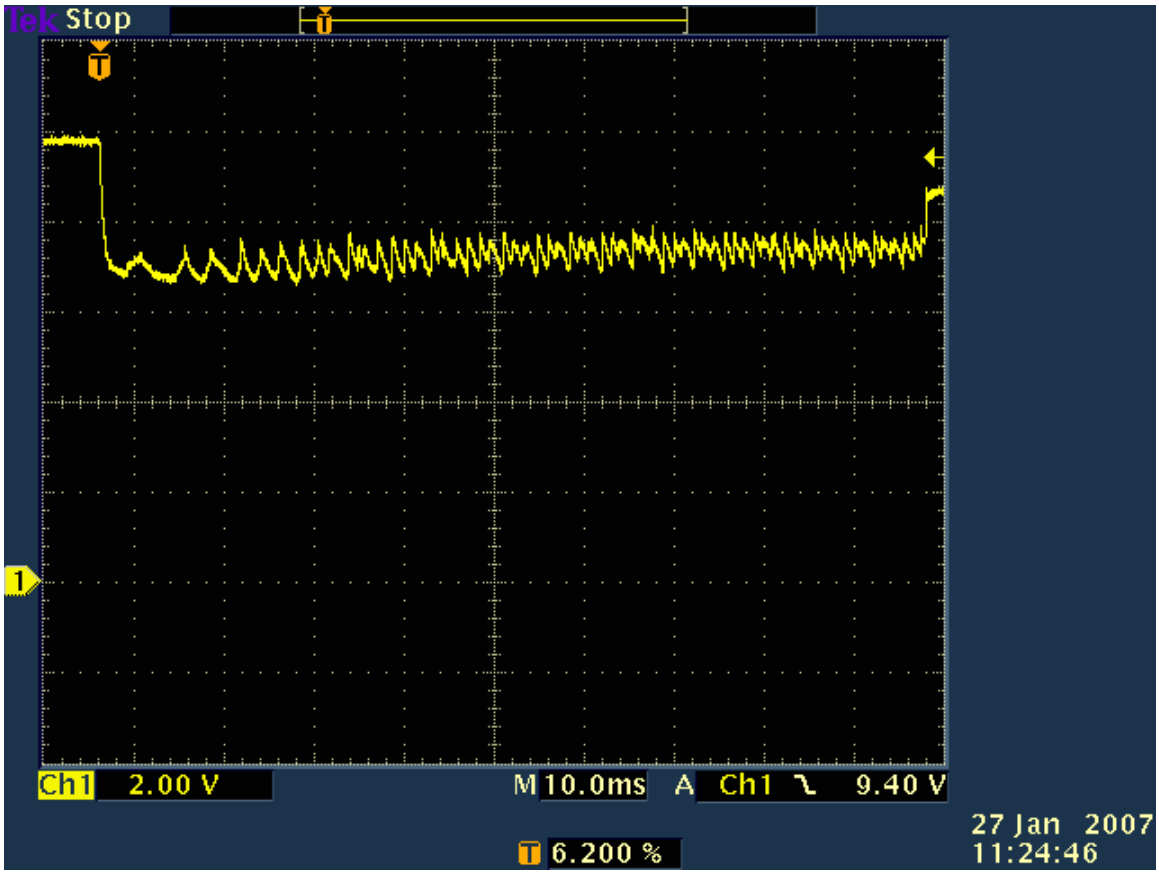
The waveforms were downloaded to a computer mathematics program (MathCad) for further analysis. Buy integrating the current over time, we can fine the total Amp-Seconds used in the firing cycle.



Computer Integration of Current over Time.

There were 2.621 Amp-Seconds of battery capacity used in the firing cycle which is equal to 0.728 mAh. For a 1500mAh battery, that is 2060 shots. If we multiply the drain rate by the loaded voltage (7.2 volts) we get 18.872 Joules/shot. At 347 FPS for a 0.2g BB, the BB energy is 1.119 Joules so the efficiency is 1.119 / 18.872 = 5.93%.

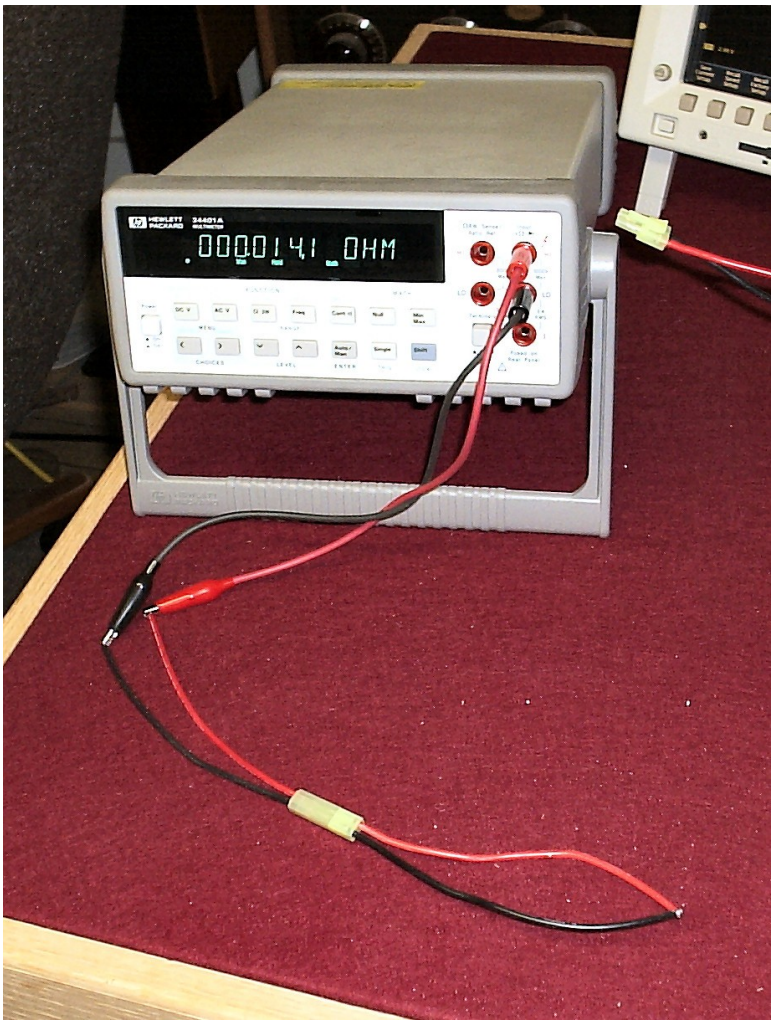
The voltage during the firing cycle is as shown below:



Voltage During Firing Cycle 2V/div. 10mS/div.

The voltage of the fully charged 1500mAh 8.4V Ni-MH pack is 9.76 volts open load. When the gun is firing, that voltage drops to 7.208 volts average after an initial drop to 6.64 volts. Directly after the cycle the voltage returns to 8.64 volts. Since the voltage is fairly constant even with an almost 2X current load difference from the beginning to end of the firing cycle, the voltage drop is not very resistive but rather the actual loaded voltage on the battery.

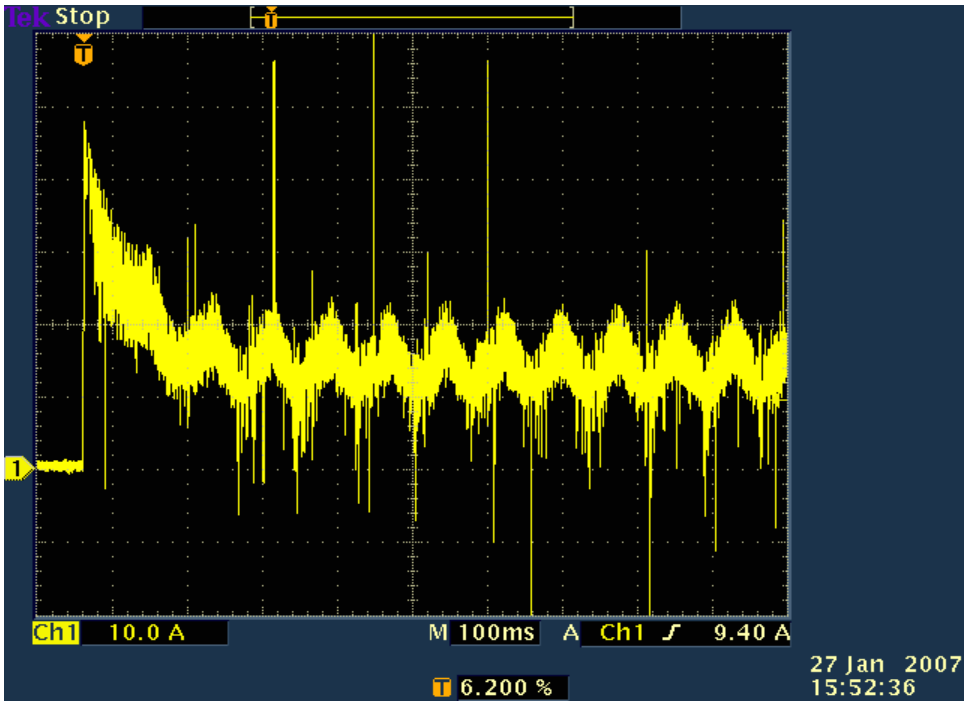
We can also measure the resistance of a fairly typical mini-Tamiya wiring harness which uses 16AWG silicon wire with a quality multimeter.



Wiring Harness Resistance

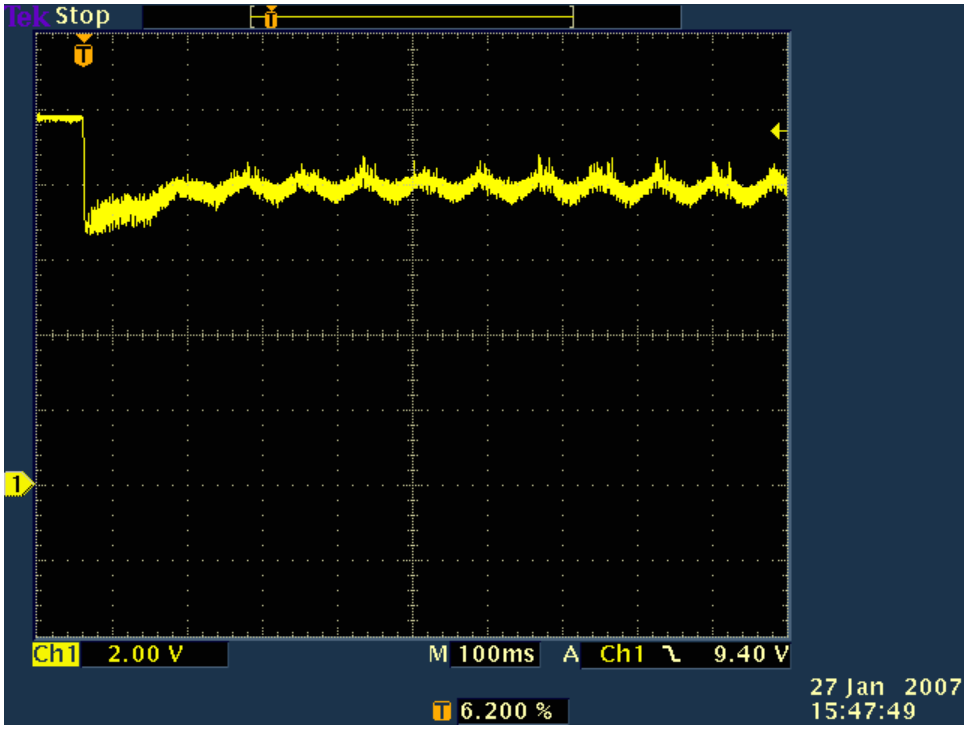
The resistance of this setup was 0.0141 ohms. At 47.5 and 24 amps the voltage drop would be 0.670 and 0.338 volts. As shown later, the continuous current draw is 13.61 amps resulting in a 0.192 volt drop.

The gun was also tested for continuous firing:



Continuous Firing Current 10A/div. 100mS/div.

The initial current peaks at 47.8 amps and drops down to an average of 13.61 amps in about 250mS.



Continuous Firing Voltage 2V/div. 100mS/div.

The voltage initially drops from 9.75 to 6.64 volts and then averages out to 7.94 volts.

Note that the firing rate is 13.06 RPS.

Under continuous firing, the gun is consuming 108.1 watts of power at an efficiency of 13.52%. The battery drain is 13.61 Amp-Seconds per second, or 3.78mAh every second. The 1500 mAh battery should last 396.8 seconds or 5182 shots if fired continuously.

CONCLUSIONS:

In single shot mode, the motor has to rev up to speed which draws a peak current of 47.5 amps. That levels out to 24 amps at about 40mS into the firing cycle. The battery voltage drops from an initial 9.76 volts to a low of 6.64 volt and averages out at 7.21 volts and returns to 8.64 volts after the cycle. The gun consumes 0.728mAh of battery capacity per shot at an efficiency of 5.93%.

In continuous firing (13.06 RPS), the current averages 13.61 amps after 250mS. The battery voltage averages 7.94 volts. At 13.06 RPS the gun is consuming 108.1 watts of power at and efficiency of 13.52%. The battery drain rate is 3.78mAh every second or 0.289mAh per shot.