NiMH Recovery

By Bob Smith

The idea behind this article originated in the requirements of electroslot competitions to the BEFA/BMFA rules. These rules require the competitor to fly 5 rounds on a single battery charge using 7 sub-C NiMH cells (NiCd are also allowed but the increased capacity of NiMH means these are invariably used). Each round is an attempt to produce a flight of 15 minutes including a maximum of one minute of motor run although this can be used at any time during the flight. There is then a landing spot with points available for duration and landing accuracy. Long soaring flights can be easy in good lift conditions but not so easy if the lift deserts you. The ability to find lift and to extend the flight is often a function of the height to which the model is climbed and this depends largely upon the power output of the drive train since the power-on duration is limited to one minute per round.

The competitor therefore has a balancing act to attempt. He can set up his model to give 5 minutes of power-on (1 minute per round for 5 rounds) plus any safety margin he wishes to create, and accept that this set up is going to give him a particular rate of climb and a particular height gain potential for each round. If he wishes to obtain a greater rate of climb and height gain potential he can set up to draw more power, i.e. he can increase the prop size and/or use a different motor/gearbox, and hope that he can complete his flights with the lesser power-on time that the new set up will provide. In either case he will sometimes find that as he reaches the final round of the competition his batteries, which are now probably 80% discharged, are delivering much less power, and hence much less height gain potential.

Look at graph 1. This graph displays the discharge voltage curve of a 7-cell sub-C pack of NiMH using constant current discharge at a rate to provide a 5-minute run. This is not a perfect model as in flight both the voltage and current draw of the battery reduce as discharge proceeds, but it is a good approximation and does not affect the point I wish to demonstrate. I have divided the time axis into 5 one-minute periods and you will see that for the last period in particular the voltage reduction means that the power available (in watts) is greatly reduced, and the reduction in the rate of climb is obvious to the pilot. Typical figures might be 40 amps at 8 volts giving 320 watts at the beginning of round 1, and 32 amps, 6.7 volts and 215 watts, half way through round 5, which is a 33% reduction in power. The result of this is that the pilot then tends to run the power-on climb for longer in an attempt to achieve the same height he reached in previous rounds but at a much slower rate of climb. My theory is that this is exactly the wrong approach and I will try to demonstrate this.

Let me firstly define what I mean by “recovery”. On graph 2, you will see an enlarged section of graph 1 with the continuous discharge curve slowly reducing voltage. If, at point X, we stop the discharge the battery voltage begins to build up or recover and follows the upward line. When the discharge is restored at point Y the voltage reduces back towards the original curve but for a while, it is higher than during continuous discharge and therefore there is more power (in watts) available for this brief period.

In fact, the electroslot modeller gains a slight advantage repeatedly through the competition as he uses power in bursts in each round and “recovery” occurs each time he switches off the power throughout the competition. During the early rounds, the effect is too small to be apparent, but “recovery” might be critical in the last round when the voltage is dropping very quickly. Graph 3 shows how the discharge voltage curve might look in a situation where the pilot takes a long (30 seconds) slow power-on climb at the beginning of the slot and then a second even slower climb to use the last of his available power. He does get two “recoveries” but doesn’t gain much. We can calculate the power available by taking the average voltages during the power-on periods so that for the first period 6.6 volts at 40 amps for 30 seconds gives 2.2 watt hours. For the second period, this is 5.4 volts at 40 amps for 30 seconds giving 1.8 watt hours, a total of 4 watt hours. These figures are supported by direct watt-hour values provided by the Hi-Box used in the testing.

If, on the other hand, he deliberately chooses to fly a pattern consisting of several short power bursts with, say, a minute between each, he would benefit from several “recoveries” and the total height gain potential might prove to be significant enough to extend his flight to the end of the slot. This pattern is shown in graph 4 using six short 10-second bursts of power and if we repeat the power calculations, we get 0.85, 0.83, 0.81, 0.80, 0.78, and 0.74 watt hours for the six power-on periods giving a total of 4.8 watt hours, a 20% increase over the original figures. There is a theoretical additional advantage in that the higher voltages involved allow the drive system to operate at higher efficiencies.

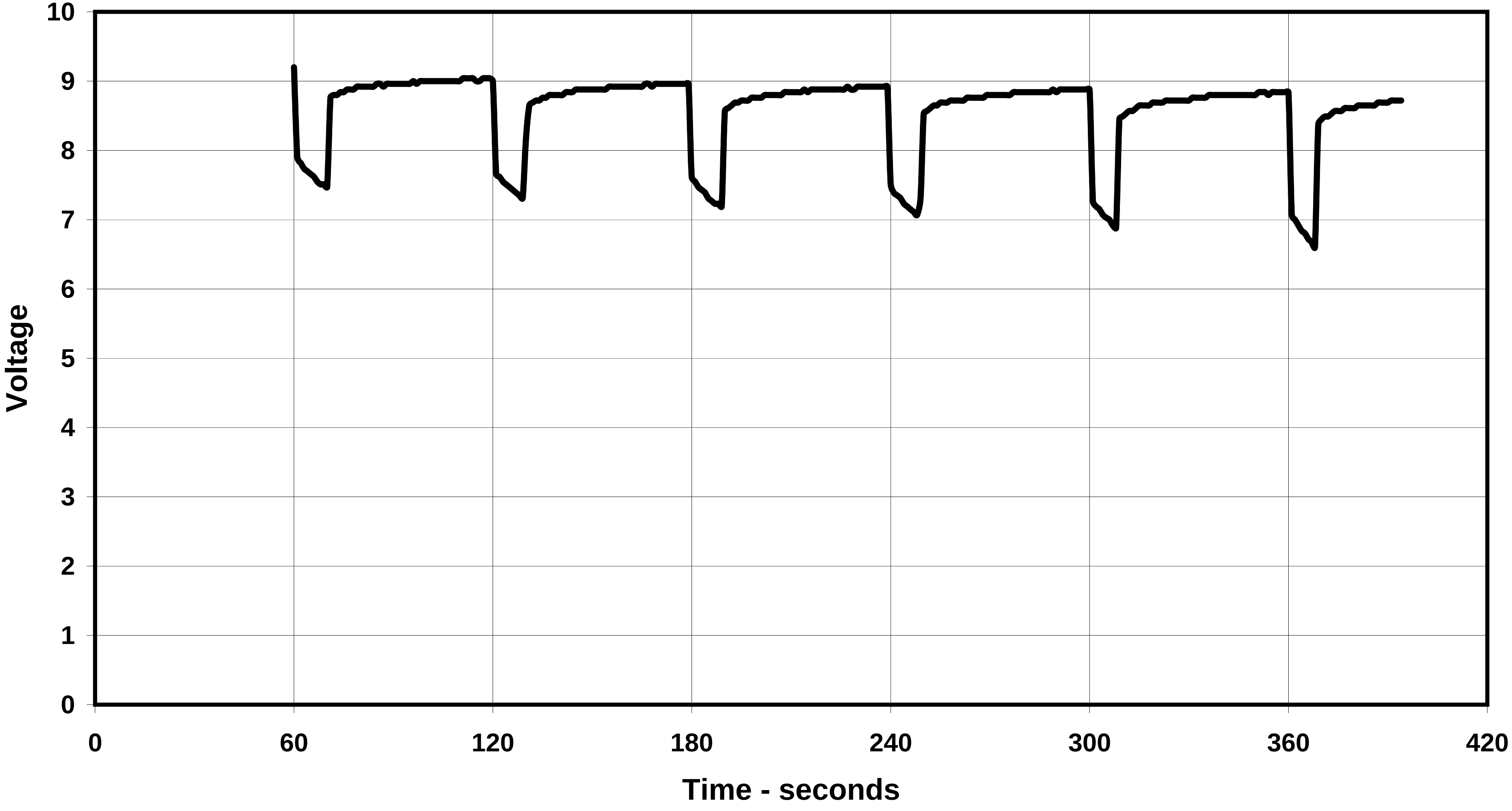
I have to admit that tales of quarts and pint pots come to mind, and if this edition of EFUK had been published on April 1st you might well have taken it all with a pinch of snuff, but I promise you that although the testing was fairly basic the figures are realistic and there is an advantage available if you can use it. It must originate with the electrochemistry of the cells and that is way beyond my ability to explain. If you really want to complicate it, you could try to include the effects of acceleration and momentum in the model, but if you can do that whilst still searching for lift, you are a better man than I Gunga Din.

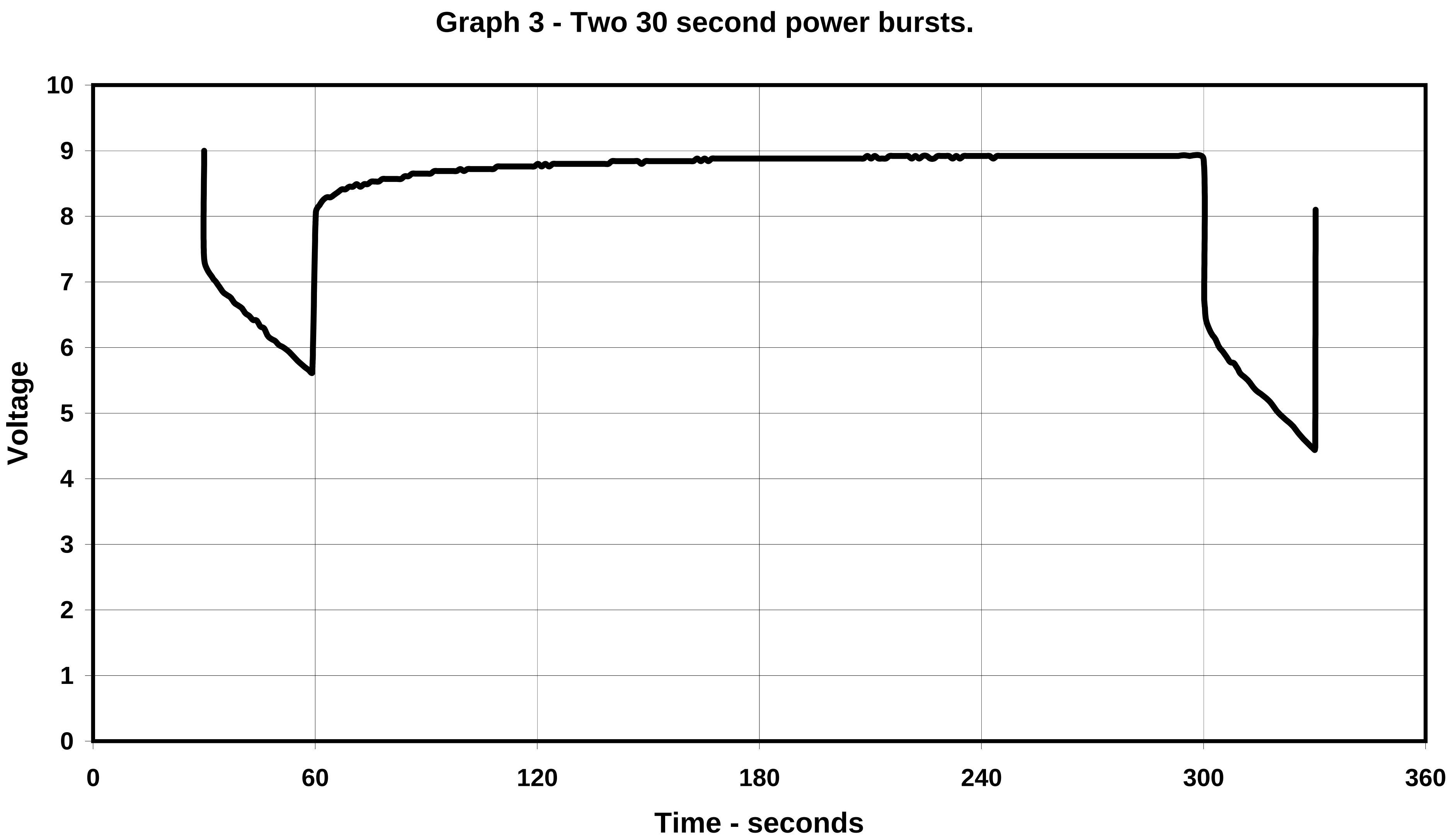
Tongue in cheek, well maybe a little, but it all helps to keep the grey cells active, and that must be good for us, mustn't it?

End.

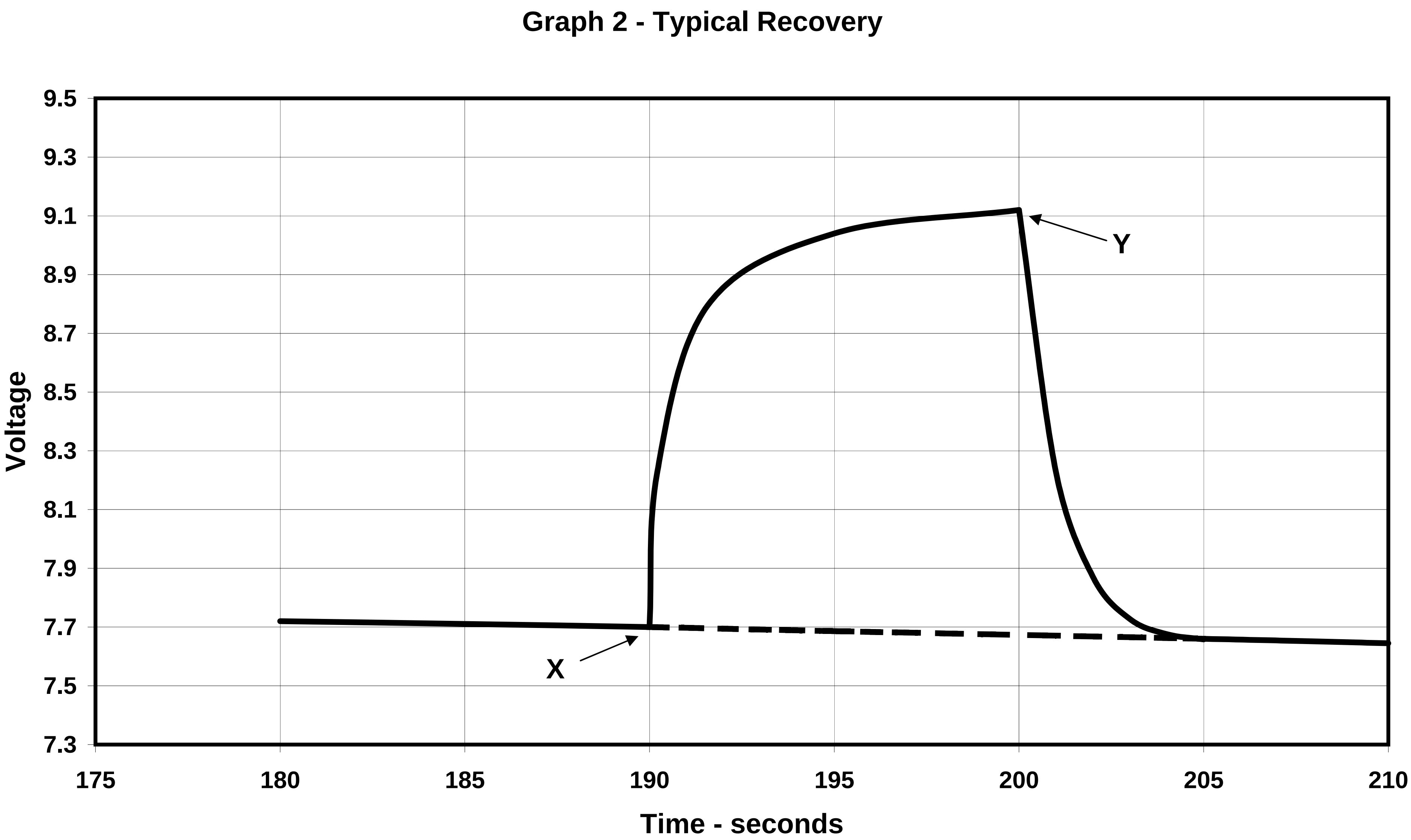
Included
4 graphs
1 picture – Title – " Set-up of the battery test equipment".

Graph 4 - Six 10 second power bursts.

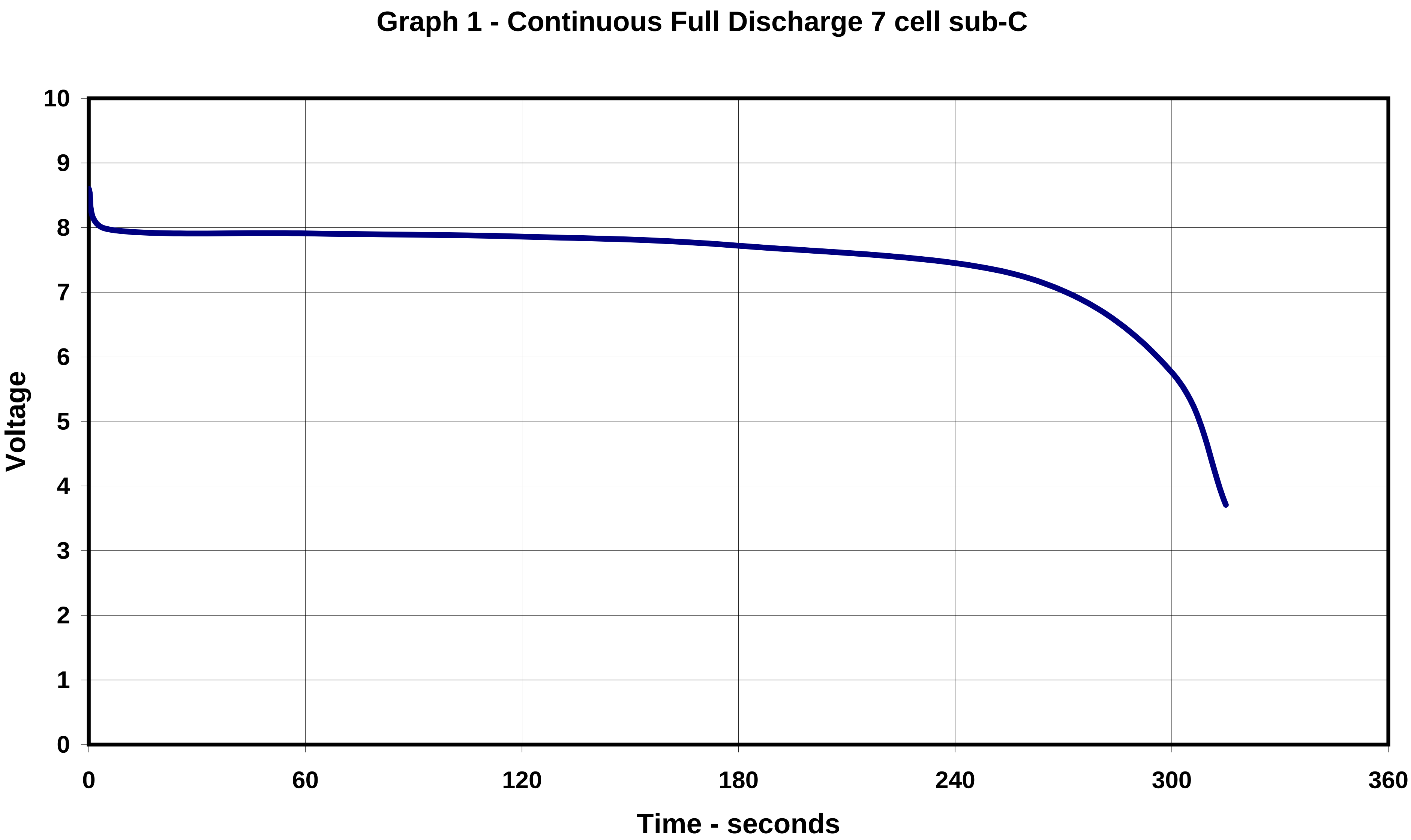


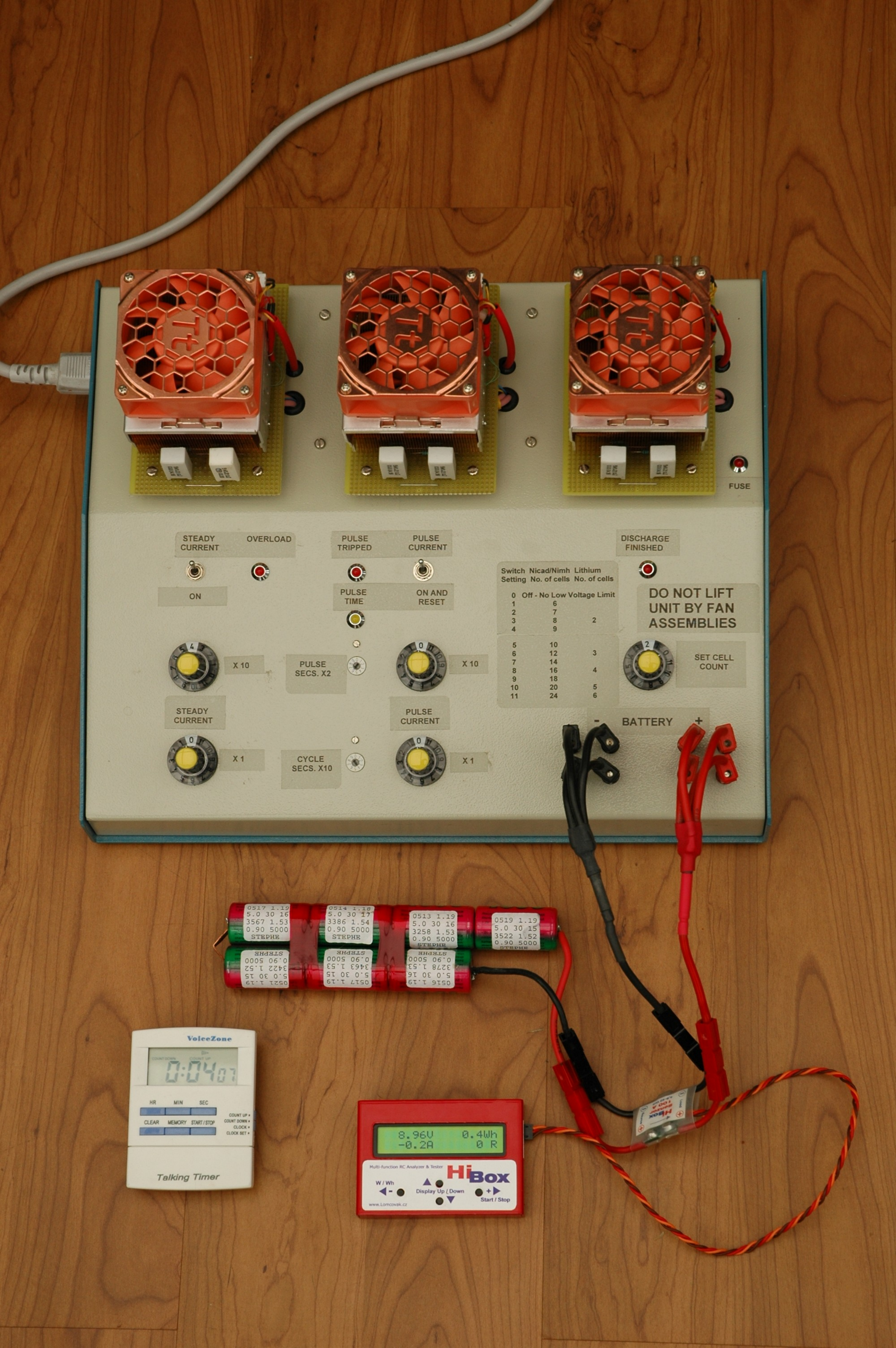


Graph 3 - Two 30 second power bursts.
Voltage
10
9
8
7
6
5
4
3
2
1
0
0
60
120
180
240
300
360
Time - seconds



Graph 2 - Typical Recovery
Voltage
9.5
9.3
9.1
8.9
8.7
8.5
8.3
8.1
7.9
7.7
7.5
7.3
175
180
185
190
195
200
205
210
Time - seconds
X
Y


Graph 1 - Continuous Full Discharge 7 cell sub-C
Voltage
10
9
8
7
6
5
4
3
2
1
0
0
60
120
180
240
300
360
Time - seconds


FUSE
STEADY CURRENT
OVERLOAD
PULSE TRIPPED
PULSE CURRENT
DISCHARGE FINISHED
ON
PULSE TIME
ON AND RESET
Switch Setting
Nicad/Nimh No. of cells
Lithium No. of cells
0 Off - No Low Voltage Limit
1 6
2 7
3 8 2
4 9
5 10
6 12 3
7 14
8 16 4
9 18
10 20 5
11 24 6
DO NOT LIFT UNIT BY FAN ASSEMBLIES
X 10
PULSE SECS. X2
X 10
SET CELL COUNT
STEADY CURRENT
PULSE CURRENT
X 1
CYCLE SECS. X10
X 1
- BATTERY +
VoiceZone
HR MIN SEC
CLEAR MEMORY START / STOP
Talking Timer
8.96V 0.4Wh
-0.2A 0 R
Multi-function RC Analyzer & Tester
HiBox
W / Wh
Display Up / Down
Start / Stop