## LiPo deterioration

By Bob Smith

The majority of electric flyers who use LiPo battery packs are well aware of the pros and cons of their use. It is the cons which tend to be of greatest concern, but, in my opinion, the difficulty is simply that we have not been using LiPo packs long enough to have determined exactly what is "best practice" in this area, and the majority of problems stem from this fact. We are improving our procedures continuously, and if we allow for the improvements that manufacturers (of both cells and ancillary equipment such as chargers) are constantly introducing, then our difficulties will reduce significantly over the next couple of years.

I am not referring to the kind of catastrophic failures which do occasionally happen, but to the deterioration which occurs progressively with the use of the pack and which unfortunately seems to be irreversible. This is compounded by the fact that, at the moment, it seems to happen far sooner than we might hope. I recently had an opportunity to look into one particular aspect of this problem, and was surprised by my findings, but at least I now know what to look for in the future.

Let us start by looking at "balancing" as we have come to know it. This is a process intended to make sure that a set of cells in a series pack are kept in ideal condition by keeping the individual cell voltages identical (or as near to that as we can manage) during the re-charging procedure. The need to follow such a procedure stems from the critical nature of the maximum cell voltage during charge. To obtain maximum capacity in a LiPo cell we must charge at a rate of 1C (e.g. 2.4 amps for a 2400 mAh cell) until the voltage reaches, but does not exceed, 4.2 volts. Exceeding this value, even by relatively small amounts, can damage the cell. In a series pack, it is possible to damage one or more cells if we only control the total voltage. As an example, a charger might charge a 4S pack to 16.8 volts (4 x 4.2) but if the individual cell voltages are not measured and controlled this could be the summation of 3 cells at 4.1 volts and 1 cell at 4.5 volts, resulting in irrecoverable damage to that cell.

Balancers are available as add-ons or as a built-in feature of a charger, and they do a good job in preventing over-voltage damage. I recently had a problem with a 4S 3200mAh pack which was well down on capacity, but which I knew had been balance-charged (or maybe charge-balanced) from new. My charger has a computer interface which shows the balancing process as a set of voltage/time traces for each cell in the pack and I knew that although there was some imbalance at the end of the discharge, this was quickly corrected when the charge was started and all four cells in the pack were spot-on 4.2 volts at completion. I originally thought that this meant an optimum condition for the pack but the loss in capacity must mean that there was still a problem of some sort.

If the problem was not in the charging process then could it be in the discharge? My charger was telling me what was happening during charge, but I had no idea what was happening to individual cells during discharge, and there was even a problem at the end of discharge as the voltages began to recover immediately discharge was stopped and the values at the start of the charge would be very different to those at the end of discharge. I did not have a facility for computer-graphing the cell voltages during discharge so had to prepare a cable which connected the balancing lead to a set of DVMs allowing me to read and note the cell voltages at fixed time intervals. I have plotted these individual cell discharge voltages in Graph 1 and compared them to a set from a new pack in Graph 2. In both cases the discharge was at a constant 20 amps (approximately 6C)

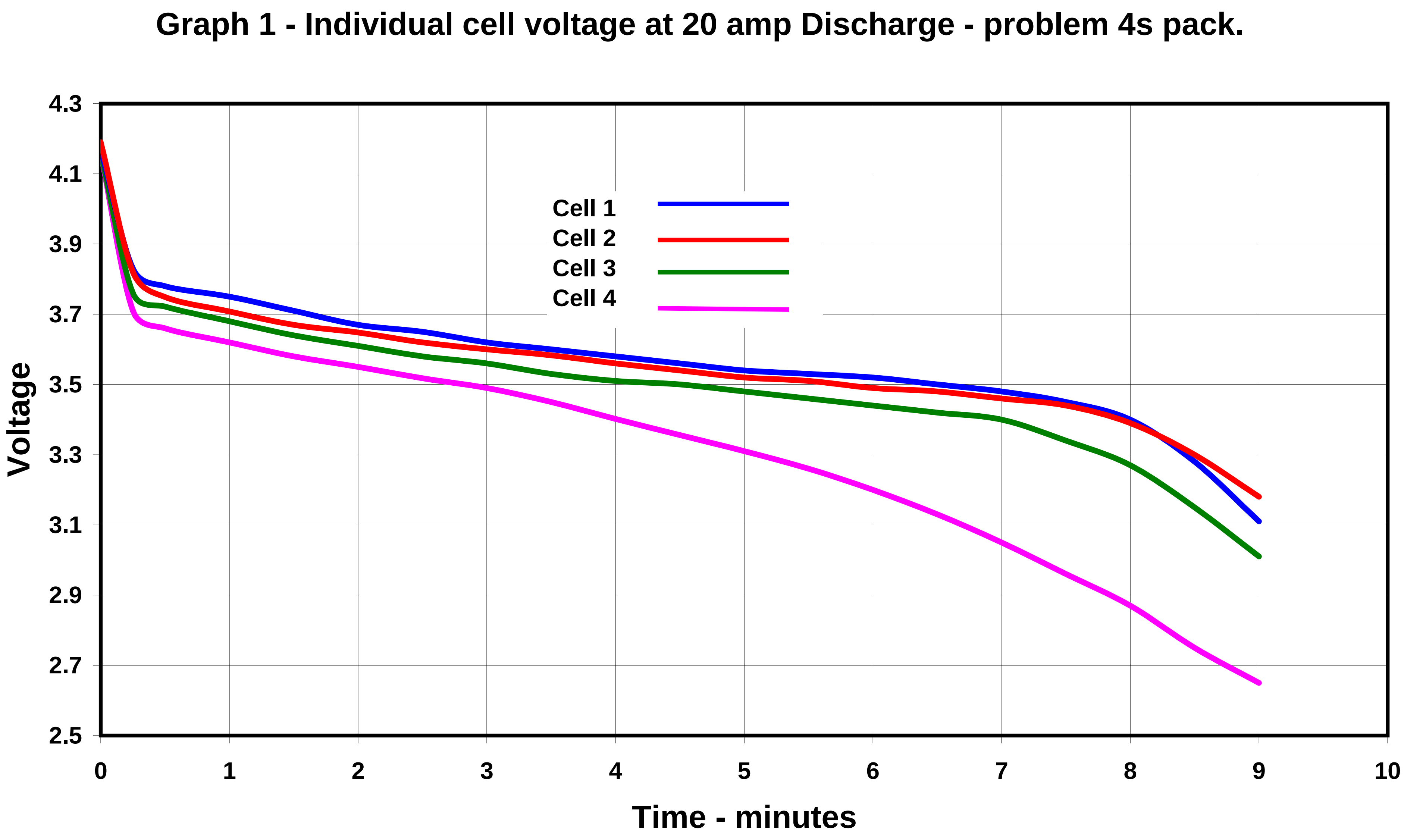
It is now easy to see why the first pack was producing reduced capacity. Of the 4 cells, cells 1 and 2 were OK, but 3 was well down and 4 was critically low. Even though the cells were balanced during charging, this procedure was not able to correct the problem with cells 3 and 4, and the discharge cut-off was exacerbating the situation. In this test, I used a manual cut-off when cell 4 became critical and the total voltage at this point was 12.0. If an auto cut-off had been used set at 2.9 volts per cell (11.6 v total), the readings at the end of discharge would have been lower still with cell 4 being subjected to even further damage by each cycle. The point about recovery masking the extent of the imbalance is given by the cell voltages at the start of the charge, which were 3.62, 3.62, 3.55, and 3.48 volts. These give a clue that there may be a problem but do not indicate its magnitude, especially when the balanced charge brings all the cells back to 4.2 volts.

My conclusions from this brief investigation are that we need to check the balance of our series LiPo packs in terms of discharge as well as charge. It would be nice if we could apply the same active logic that we use in charging to the pack whenever it is discharging but that may not be feasible in the model during flight. What may well be helpful is an occasional bench discharge using a system which displays the traces of individual cell voltages throughout discharge but again I do not know of such a system at the moment. I imagine that the hardware/software used for the balanced charger could be adapted to this task, i.e. a balancing charger/discharger, but until such a unit is available I will use my set of DVMs to give me occasional checks.

That, of course, is only diagnosis. The real problem is how to correct such problems when they arise, and to quote “aye, there’s the rub!”

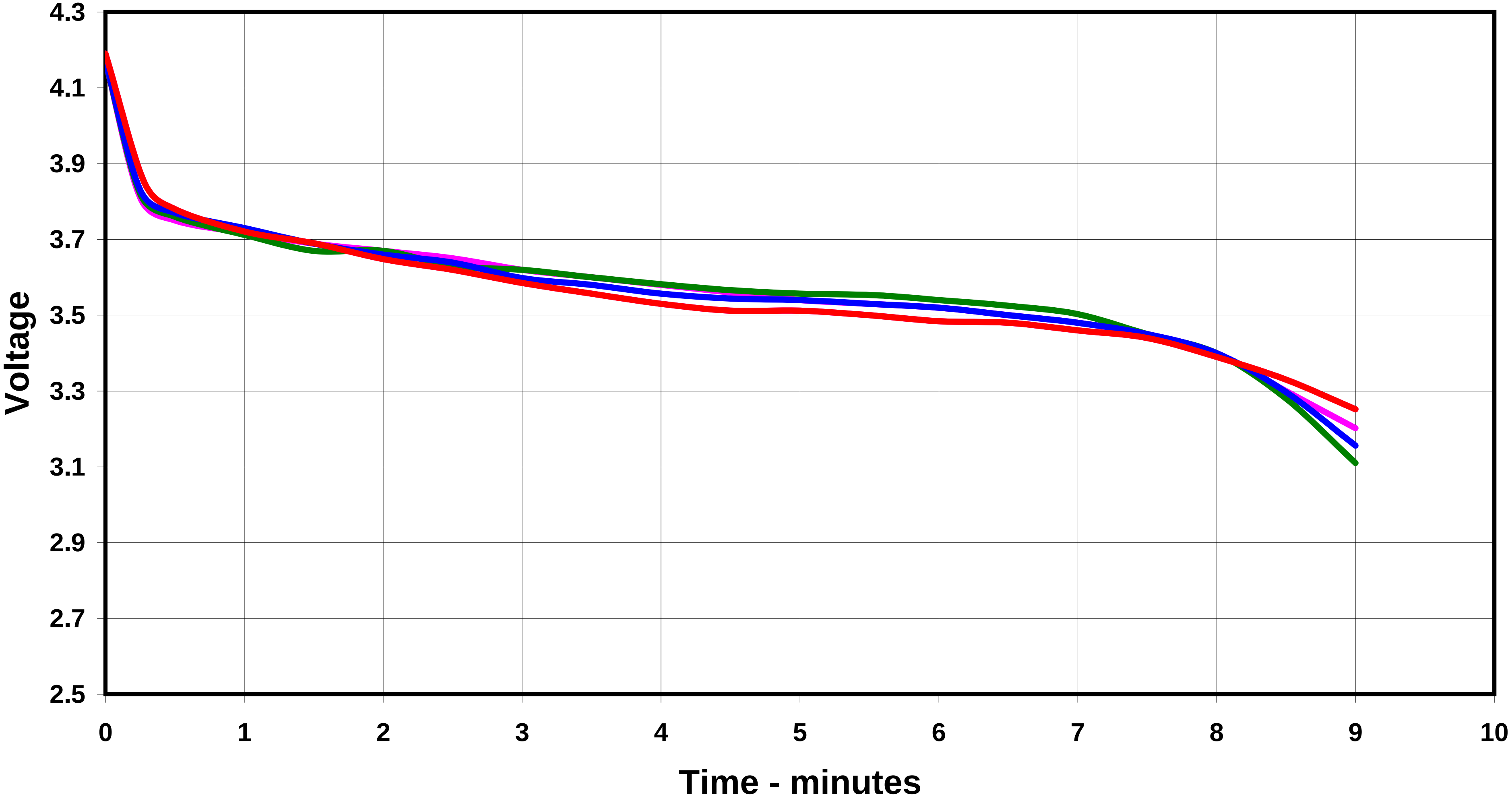
End.

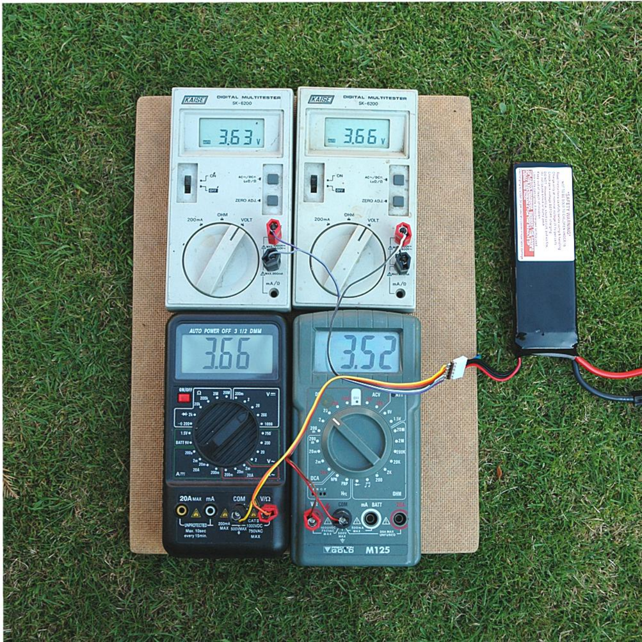
Included
2 graphs
1 picture – Title – “ Use of four DVMs to measure individual cell voltages”.



Graph 1 - Individual cell voltage at 20 amp Discharge - problem 4s pack.
Cell 1
Cell 2
Cell 3
Cell 4
Voltage
4.3
4.1
3.9
3.7
3.5
3.3
3.1
2.9
2.7
2.5
0
1
2
3
4
5
6
7
8
9
10
Time - minutes

## Graph 2 - Individual cell voltage at 20 amp Discharge - new 4s pack.




KAISE
DIGITAL MULTITESTER
SK-6200
3.63 V
KAISE
DIGITAL MULTITESTER
SK-6200
3.66 V
AUTO POWER OFF 3 1/2 DMM
3.66
3.52
M125