Submission No 26

ELECTRIC AND HYBRID VEHICLE BATTERIES

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Im a retired Electrical Engineer with no current or previous connections to Li-Ion battery manufacturers or suppliers. I am concerned that many (if not all) current types of these batteries that use series connected "stacks" of Li-Ion cells and have capacities greater than about 10W seem to be inherently unstable, which was not the case with previous types of rechargeable battery. I enclose a paper (that is slightly technical but hopefully not too much) in which I outline my concerns. I encourage your Committee to seek technical input from experts who have no particular connection to Li-Ion battery suppliers or manufacturers.

Lithium Ion Rechargeable Batteries

Unlike most other rechargeable batteries, most if not all of current types of Li-ion rechargeable) batteries (during charge and discharge) cant be simply placed in series to increase the voltage to useful amounts

fig 1 shows a typical 12V “lead acid” car battery which has 6 off “cells” connected directly in series. The overall battery only has 2 external terminals and contains no electronics and requires only a simple circuit to charge it.

During charging a total voltage of about 14.5V (from a current limited circuit) is applied across the complete “battery of cells” and (because of the basic charterships of this type of cell) each cell automatically adjusts to divide the total voltage to be fairly equally distributed between each cell. During discharge each cell produces close to 2V each to give a total voltage of around 12V.

Fig 2 shows a typical 12V Nickel Cadmium battery from a 1990 era electric drill. This battery has 10 off cells which each produce 1.2V during discharge. Like the lead acid type battery it also only requires 2 external terminals and simple “constant current” type charger and has no internal electronic components.

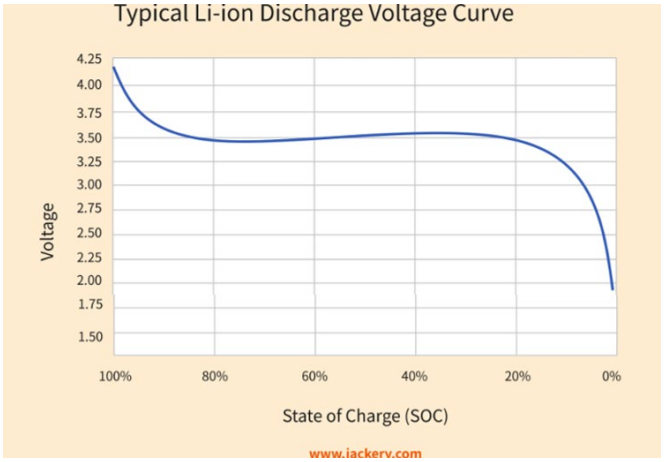

Fig 3 shows the Voltage v State of Charge of a typical Li-Ion cell. Notice that between about 30% and 70% SOF the curve has a negative slope. Both Lead Acid and Nickel Cadmium cells have a positive slope throughout their charge cycle.

I believe it is this negative slope that makes Li-Ion batteries inherently unstable when connected in series unless they have a electronic system that allows them to be.

Fig 4 shows 2 off typical current Li Ion batteries used in a (Dyson) “Stick” type vacuum cleaner. In the lower one its outer case has been removed to reveal the electronic circuit board that is usually enclosed with these type of batteries. The label on this battery indicates “22.42, 1300mAH, 30WH”. This type of battery typically produces around 3.7V per cell during discharge and in this battery 6 cells are again connected in series. However (as explained in other literature including the extract on the next page) an electronic circuit board in contained within the “battery” with connecting leads to the internal “busbar” connections between the cells. This type of circuit is often called a Li-Ion Battery Management System (BMS).

This is a extract from a article freely available via a Internet Search explaining the basic functions of Battery Management Systems:-

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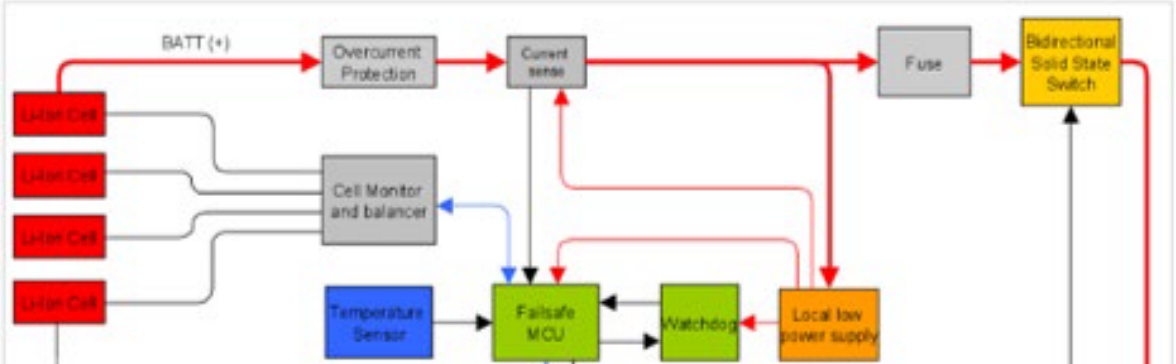
Learn the high-level basics of what role battery management systems (BMSs) play in power design and what components are necessary for their basic functions.

Nowadays, Li-ion batteries reign supreme, with energy densities up to 265 Wh/kg. They do, however, have a reputation of occasionally bursting and burning all that energy should they experience excessive stress. This is why they often require battery management systems (BMSs) to keep them under control.

In this article, we'll discuss the basics of the BMS concept and go over a few foundational parts that make up the typical BMS.

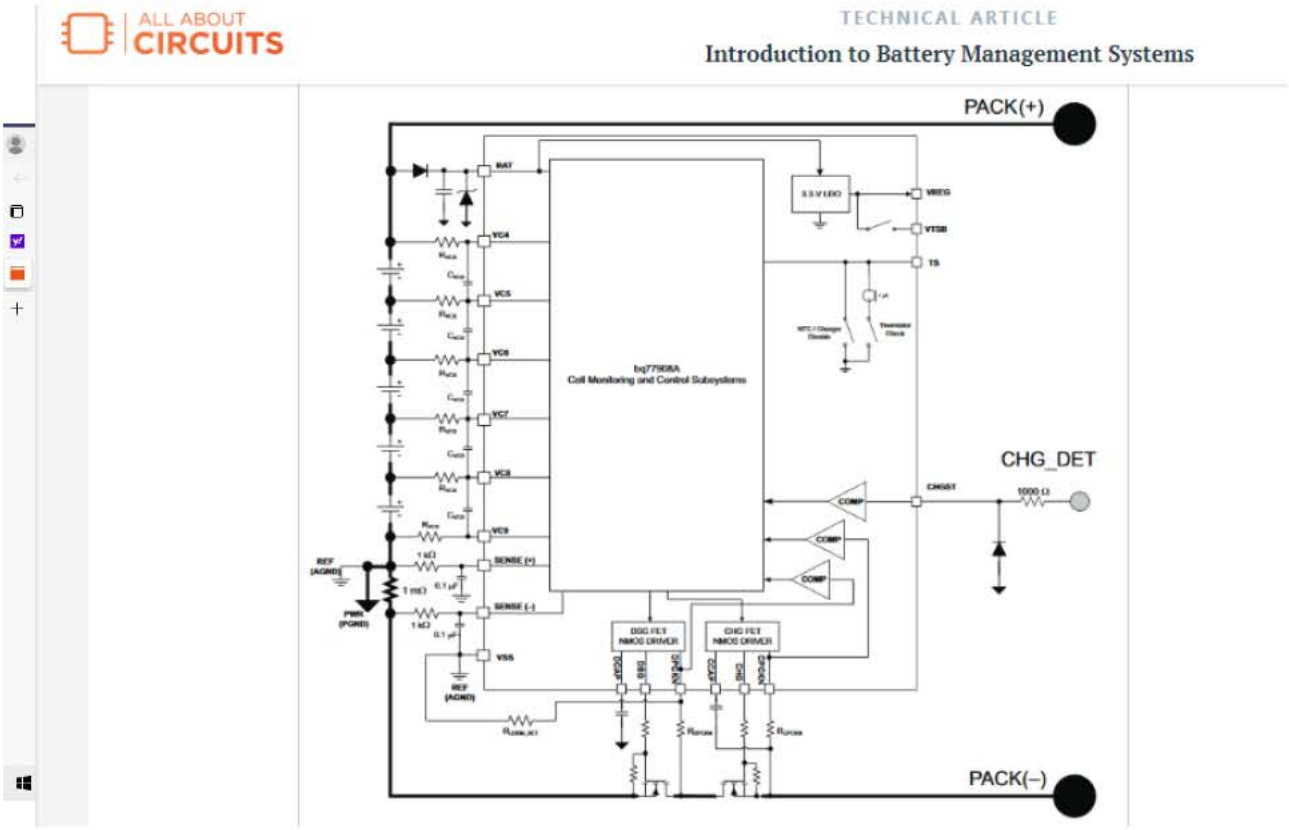
Basic BMS Configurations

In Figure 1, we see the basic blocks of how a BMS can look while serving the function of preventing major battery malfunctions.



Im trying not to get too technical but you will notice that the circuit functions include 'Overcurrent Protection', 'Cell monitoring and Balancing' and cell 'Temperature Sensing'.

The following Fig is from the same paper on BMS's and shows the circuit of a typical BMS unit for a Li-Ion battery having 5 cells.



This circuit has connections from between every series connected cell to a electronic circuit having power resistors as well as both low power and high power semiconductors.

SUMMARY

I have included the above information about what is typically included in Li-Ion battery management systems to emphasise the basic point that many existing types of Li-Ion batteries and their charging systems are only fairly stable and safe to use when they are properly designed, manufactured and in good working condition. However all batteries tend to "wear out" (and not all cells in a 'stack' not necessarily at the same rate) after repeated charge/discharge cycles and unfortunately electronic power circuits are prone to failure. And if such failure happens the battery stack may become unstable with the result that one or more cells of a series connected stack may "suck in" more of the energy being delivered by the charger than it should with the result it overheats and causes a fire and/or explosion.

MY CONCLUSION IS.

Until manufacturers of high power Li-Ion batteries can prove that their products remain safe during storage, charging and use for their complete life (and afterwards) even if there are failures of any associated BMS equipment there should be adequate fire safety requirements to ensure that any battery initiated fires are contained. Also as many types of Li-Ion batteries fires are apparently made worse by water sprinklers that type of automatic fire reduction method should probably not be relied upon.

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