AN231

Cell Balancing Design Guidelines

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CELL BALANCE APPLICATIONS

When battery packs are built with multiple cells in series, cell balancing becomes an issue. Cell balance occurs when all the individual cells in series have the same capacity, and as a result, the same voltage. This is not a concern for cells in parallel since parallel cells will balance each other with mutually applied voltage.

For cells in series, this is a concern because it is the weakest cell that determines the empty point for the battery. The lowest capacity cell will have the lowest voltage and cause end of discharge conditions in battery gauges and under voltage conditions in safety circuits to trip. Thus an undercharged series cell will cause the entire pack to have less lifetime. During charge, the highest voltage cell will trip the battery gauge or safety circuit, and not allow the lower charged cells to fully charge. For this reason, cell balancing circuitry should be considered for optimum runtime for any cell chemistry that has difficulty maintaining a balance.

Cell imbalance occurs when cells do not hold the same amount of charge. It is important in the manufacturing process to match the capacitance of the cells to achieve cell balance. Since the capacitance of the cell is the coulombs per volt, then cells of the same voltage will contain the same charge. This is done well today for Lithium Ion cells, but for Lithium Polymer cells, it is difficult to match the capacitance. Thus same voltage cells could vary somewhat in charge. It is important then for Lithium Polymer cells to utilize cell balancing to ensure the longest possible run time.

CELL BALANCING IMPLEMENTATIONS

In order to keep cells balanced, the individual voltages must be monitored. When a voltage difference between cells becomes too large, a circuit can be enabled to draw more current from the higher cells. Power transistors connected to each cell can be turned on to bleed high cells when necessary. During a discharge, the transistor path will draw more current from high cells. During charge, the transistor path will take some charge current away from high cells. More balance current will occur near end of discharge and end of charge than in the middle of the cycles due to the flatness of the voltage curve in the middle. Also it may not be desirable to drain balance current near end of discharge, thus a controlling circuit can be used to only drain balance current near end of charge on a charging cycle. The PS401 can provide this monitoring and control.

A power transistor is necessary due to the amount of current that needs to be drained. For example, if there is an imbalance of 100 mV between cells, this may correspond to 200 mAH of charge (this will vary between cell manufacturers and operating conditions). It would take 2 hours to balance these cells with a balancing current of 100 mA. This is too much current to drain internally in an integrated circuit, thus it requires power transistors controlled by the IC. There are cell balancing safety IC’s available that can sink up to 10 mA of balancing current, but this would take the above example 20 hours to balance. A trade off must be made between time to balance and power dissipation in the battery module. This trade off will be determined by the severity of expected imbalance.

CELL BALANCING WITH PS401

The PS401 monitors all individual cell voltages, and with its programmable I/O pins, it can be programmed to control the external power transistors to bleed balancing current whenever voltage imbalance exists. It can also enable balancing only when charging if desired. A reference circuit is shown in Figure 1.

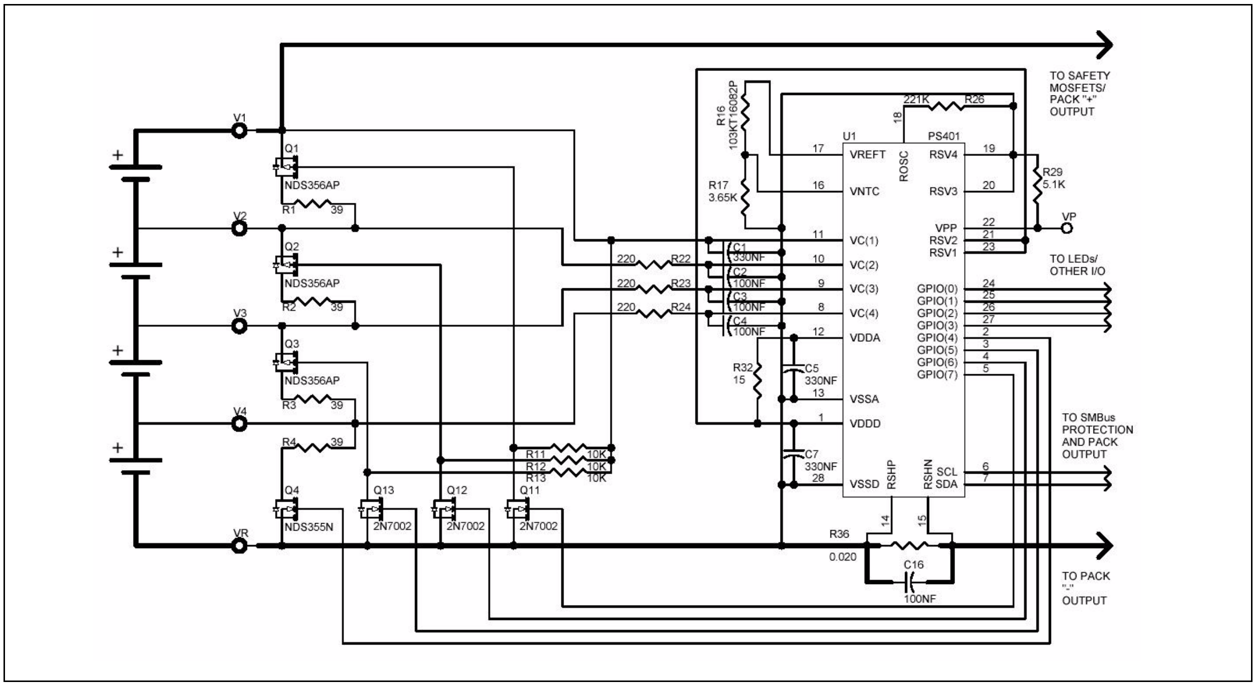
The resistor values in the above schematic can be chosen to limit the balance current to any required amount based on balancing speed vs. power consumption. PS401 firmware will control I/O1-4 to turn on the pass transistors when cell imbalance is measured on the Vcell pins, and only during charge phase if desired.

The cell balancing control could also be turned on only when the cells are near full, based on the PS401 fuel gauge. Because voltage curves are flat in the middle of the voltage vs. capacity curve, the voltage differential due to capacity imbalance is only prominent near full and near empty. To save power, cell balancing can be enabled only during charge phase, and only when the cells are almost full, entering the steep voltage curve phase. For example the transistors could be turned on only when:

- Cells are charging
- Voltage differs more than 100 mV
- Fuel gauge is more than 75% full

The PS401 can be programmed to handle all of this control with no intervention by the host system.

FIGURE 1: CELL BALANCING CIRCUIT WITH PS401



CELL BALANCING WITH EXTERNAL INTEGRATED CIRCUIT BALANCER/ PROTECTOR

Some protector circuits have built in cell balancing circuitry that will monitor voltage and drain cells without the need for external transistors. As stated before, these IC's do not have the current drain capability of external transistors, but have more capability than an ordinary IC. One such protector circuit with built in balancing is the AIC1804 from Analog Integrated Circuits. This IC has overcharge protection and cell balancing for up to four series cells. The cell balancing circuit can drain 9 mA of current. Since this function is integrated into the protector circuit, there are no other extra components needed and power consumption of the module will be less than with external transistors.

SUMMARY

- To correct small imbalances with current less than 10 mA, use a protector IC with integrated cell balancing function such as AIC1804.
- To correct larger imbalances with current on the order of 100 mA, use a battery gauge IC with built in cell balance control functions, such as Microchip PS401, with external pass transistors.
- The choice will depend on expected imbalance, and tolerable battery module power consumption.
- The capacity balance correction is equal to the balance current x time, the voltage imbalance as a function of capacity correction will vary over the battery cycle – it will be greater near full and empty.

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