Application Note 189
Advanced Rechargeable Lithium Battery Pack Solution

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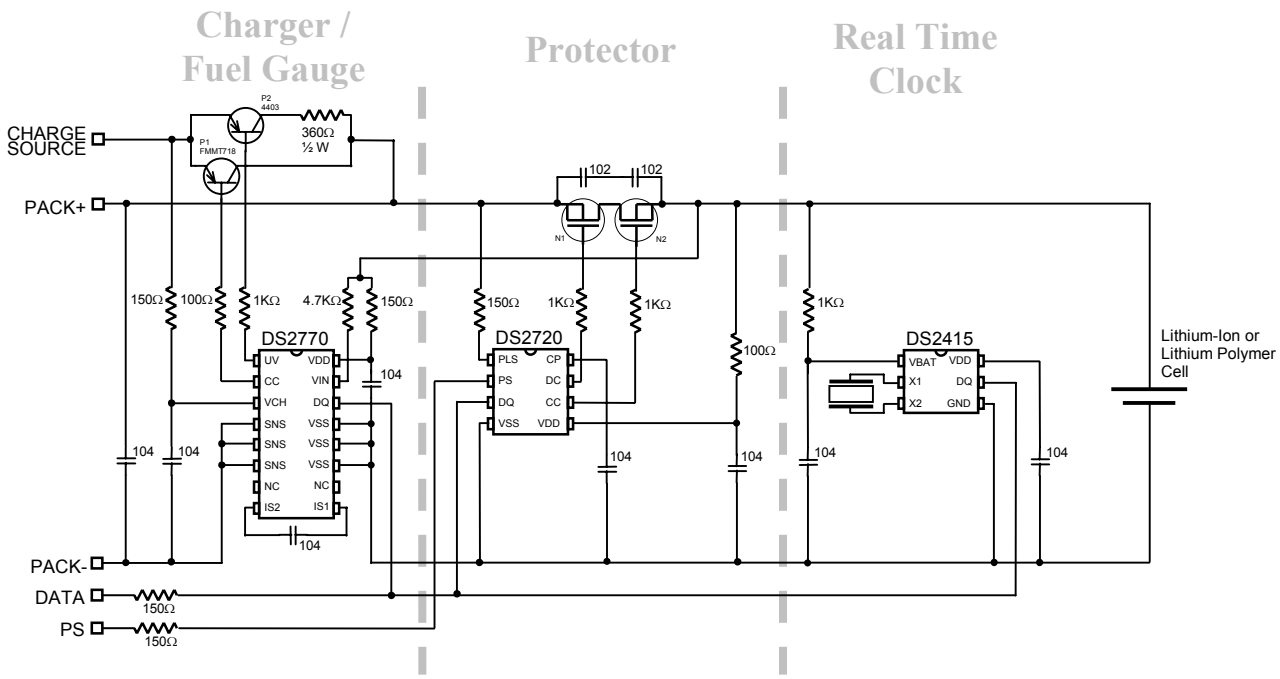
With the addition of the DS2770 and DS2720 to the Dallas Semiconductor product line, it is now possible to design an affordable cell pack that supports charge control, power control, fuel gauging, cell protection, time keeping, and pack identification. The circuit shown in Figure 1 is designed to accomplish all this by replacing an existing protection or protection/charge control circuit in a cell pack.

Cell Pack Circuit Diagram Figure 1



The Circuit

In Figure 1, the DS2720 is a protector for the cell, the DS2415 is a real-time clock (RTC), and the DS2770 is a charge controller/fuel gauge. All three devices share a common ground, supply, and communication line. All external capacitors and resistors shown are for signal filtering and ESD protection. The host device is powered from the PACK+ and PACK- pins on the left-hand side of the circuit. Communication to the pack takes place over the standard Dallas 1-Wire® interface labeled as DATA. The optional PS connection is an active low pack enable input designed to be connected to the system's ON/OFF switch. The CHARGE SOURCE pin can handle an input of up to 15V that is current limited to the charge rating of the cell. The entire circuit draws less than 100µA typical when in active mode and less than 3µA typical when the pack is disconnected.

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Protection Features

The DS2720 IC, located in the middle of Figure 1, provides all the safety features required for a single Li-Ion or Lithium Polymer cell circuit through the use of external N-FETs. The cell is protected from over charging, excessive depletion, high discharge currents, and high temperatures. The DS2720 has a trickle charge feature allowing a severely depleted cell to be recovered by using the standard system charger. The host software is able to determine what condition caused the fault and report it.

Note that the protection FETs are mounted on the high side of the circuit between the host/charge source and the positive terminal of the battery as shown in Figure 1. It is preferable to power the DS2770 and DS2415 directly from the battery. This insures that their data will be maintained during a protection fault or when the pack is in sleep mode when the FETs are disabled and data would otherwise be lost. It is possible to do this without violating protection rules because high-side FETs block any possible secondary charge path through the communication lines that would be a concern with low-side FETs.

Charger

One function of the DS2770 is to control cell charging using a simple current limited power source. It performs this feature independent of cell characteristics such as manufacturer or capacity. By controlling external PNP transistors (P1 and P2 in Figure 1) the DS2770 charges Li-Ion or Lithium polymer based packs with constant current up to a factory set limit of either 4.1V or 4.2V and then pulse charges to top off the cell. The DS2770 provides a secondary charge termination if the cell temperature exceeds +50°C or a user defined maximum charge time elapses. All that is needed to initiate charging is to attach a current limited supply (up to 15V) to the Charge Source Pad (Figure 1).

Fuel Gauge

The DS2770 also operates as a highly accurate fuel gauge. Current is measured through an internal 25mΩ sense resistor down to a resolution of 62.5µA with a dynamic range of ±2A average current (the input filter allows current spikes much higher than 2A to be registered in the current accumulator). The DS2770 can easily track discharge current in GSM/CDMA applications, and its internal auto compensation maintains measurement accuracy over the entire operating range of the device. Real-time measurements of accumulated current, voltage, and temperature, combined with cell characterization data stored in the DS2770's EEPROM, allow a system processor to run a very accurate fuel gauge algorithm while consuming very few system resources. Also, because the DS2770 is powered directly from the battery, coulomb count information is not lost when the battery pack is removed or if power is lost due to a protection fault.

Real-Time Clock

The DS2415 provides an RTC accurate to 2 minutes per month for the host system. This requires a 32kHz, 6pF external crystal attached to the X1 and X2 pins. This architecture has a huge advantage over other systems because the DS2415 is powered directly from the battery. By locating the clock on the inside of the protection FETs, the system is guaranteed a clock that will maintain proper time even when system power is lost eliminating the need for super cap or button cell backup in the host.

Pack Information

The DS2770 contains 40 bytes of user accessible EEPROM and the DS2720 has an additional 8 bytes. The pack manufacturer should use this space to store relevant pack information such as cell chemistry, assembly date, cell characterization information for fuel gauging, etc. Once written to, the EEPROM can be permanently locked insuring data integrity even through power loss and ESD events. In addition, each chip has a unique 64 bit serial number that can be used for pack identification.

Summary

A more detailed description of any of the Dallas Semiconductor battery management ICs, the Dallas fuel gauging approach, and 1-Wire communication can be found at www.maxim-ic.com under the following titles:

- DS2415 Real Time Clock
- DS2720 Single Cell Li-Ion Protection IC
- DS2770 Battery Monitor and Charge Controller
- DS1WM 1-Wire Master
- AN131 Fuel Gauging with Dallas Semiconductor Devices
- AN126 1-Wire Communication through Software

Layout — Sample 8.1mm x 35.5mm 4 Layer Board