Using Low Resistance MOSFETs as Load Switches

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To conserve battery power and increase operation time in portable equipment, MOSFET switches are commonly used as 'load switches' or 'power saving switches' to disable sections of a system when they are not required (Figure 1). MOSFETs are normally used due to their low resistance and ease of operation. This function is often overlooked by the designer and its implementation is frequently left until very late in the design stage, when PCB space is at a premium.

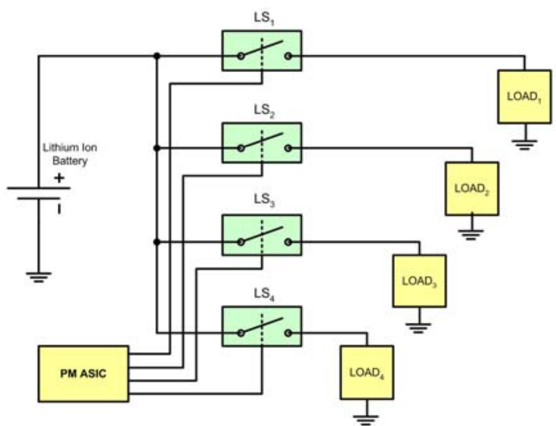

Figure 1.

The MOSFET provides a low resistance path between the battery and the load. When fully turned on, the MOSFET appears and acts like a resistor and therefore Ohms law applies; when turned off, the MOSFET appears as a diode and as such blocks current in one direction with a very high resistance (if reverse protection is required, an additional MOSFET or blocking diode is required). P-channel MOSFETs are normally used as they are very simple to turn on or off (Figure 2).

Turning the MOSFET ON and OFF requires the gate terminal to be switched between the battery voltage and ground. The control can be from a power management ASIC or a GPIO port from a microcontroller; if the battery voltage is higher than the control voltage, then an open drain output can be used with an external pull-up resistor (see Figure 2). To avoid high current spikes due to capacitive or inductive loads, the MOSFET switching speed needs to be controlled by adding some additional components for slew-rate control. Alternatively, MOSFETs with integrated slew-rate control can also be used (see Figure 3).

When selecting a MOSFET for a load switch application, the following parameters should be considered:

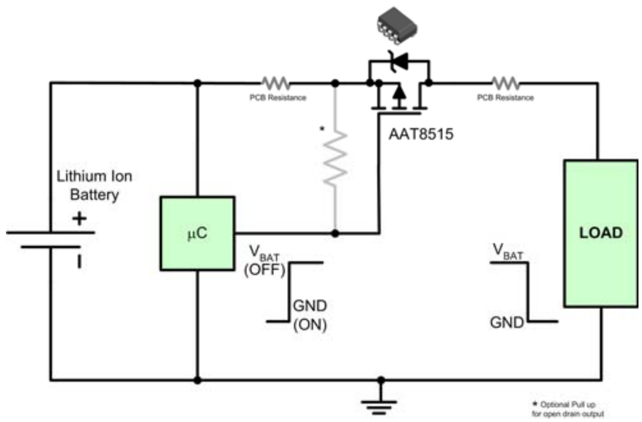

Figure 2.

- BV_{DSS}: This is the maximum breakdown voltage of the device and should be chosen so that the battery voltage (or charging voltage when the battery is disconnected) is lower. Some safety margin should be considered for voltage transients, but too much margin could result in a decrease in performance (higher resistance MOSFET) or a more expensive switch.

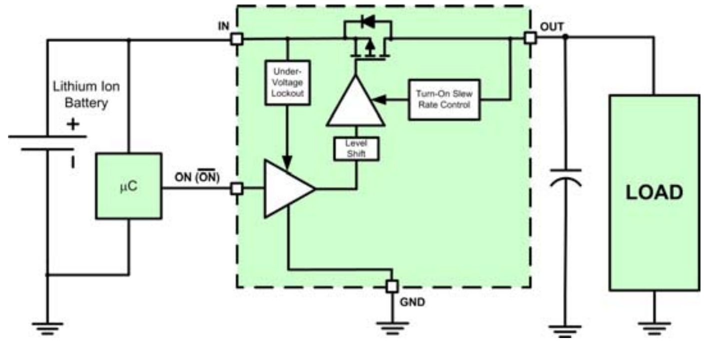

Figure 3.

- $R_{DS(ON)}$: This is the resistance of the MOSFET, which is inserted between the battery and the load. The resistance will vary according to maximum applied gate voltage and also the device junction temperature (approx +40-50% from 25 degrees C to 150 degrees C). The choice of MOSFET is always going to be a compromise based on performance and cost. Ideally, the resistance should be as low as possible to ensure that the maximum battery voltage is applied to the load and that it should occupy the least amount of PCB area. When specifying the MOSFET, it is important to remember to include the resistance contribution of the PCB copper tracks.

- Package: This is really defined by the maximum resistance of the MOSFET, the forward current, and the number of load switches required. Both single and dual configurations are available in Pb-free, space-saving SC70JW-8 and TSOPJW-8 packages, providing a range of products suitable for loads up to 10A, with resistances down to typically 11mΩ. Power dissipation is rarely a problem, as the device is chosen more for the voltage drop across the switch than its current handling capability.

Design Example (ignoring PCB resistance)

Assumptions:

Battery Voltage:	Typically 3.6V
Max Load Current:	1.0A
MOSFET Max Junction Temp:	$T_J = 135°C$
MOSFET:	AAT8515, SC70JW-8 package (2.00mm x 2.10mm), -20V P-Channel, 35mΩ @ VGS = 4.5V (from product datasheet ~40mΩ @ V_{GS} = 3.6V)

Calculations:

Voltage Applied to Load	$= V_{BAT} - V_{MOSFET}$
V_{MOSFET}	$= R_{DS(ON)}$ @ 70ºC x I_{LOAD}
	= 0.040 x 1.4 x 1.0
	= 56mV

Therefore, the voltage applied to the load is 3.54V, resulting in just under a 2% reduction -- well within acceptable limits. If the system has a supply voltage tolerance of ±5%, then a higher on resistance MOSFET may be used to reduce cost. A further calculation to ensure the MOSFET would not over-dissipate would show only 56mW or less than 2% of the power when the load is turned on.