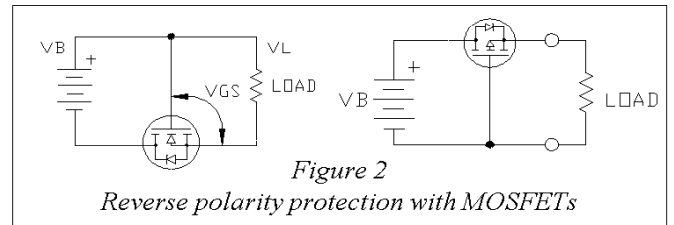
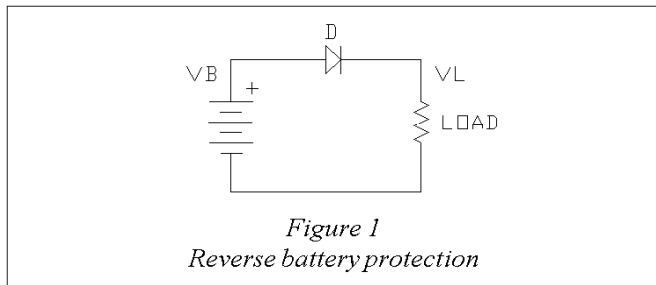


REVERSE BATTERY PROTECTION WITH HEXFETs DOUBLES BATTERY LIFE

Introduction

In low voltage applications, the widely used reverse battery protection diode shown in Figure 1 has a significant negative impact on battery life: the voltage drop across the diode reduces the voltage available to the load and the amount of charge that can be taken from the battery. Since the vast majority of electronic loads are constant power, a decrease in available voltage implies an increase in load current and an even more rapid discharge of the battery. Furthermore, the power dissipation in the diode reduces the efficiency of the circuit.

Using a P-channel MOSFET, the protection can be mounted on the positive side of the battery without disturbing the ground return.



Test results with a constant power load

The constant power test circuit is shown in Figure 3. The load voltage V_O is held constant by tight loop regulation and component selection. The use of synchronous re-circulation insures that the efficiency of the circuit is close to 1 over a wide range of input voltages. Considering that the power drawn by the constant power electronic load at points A-B is

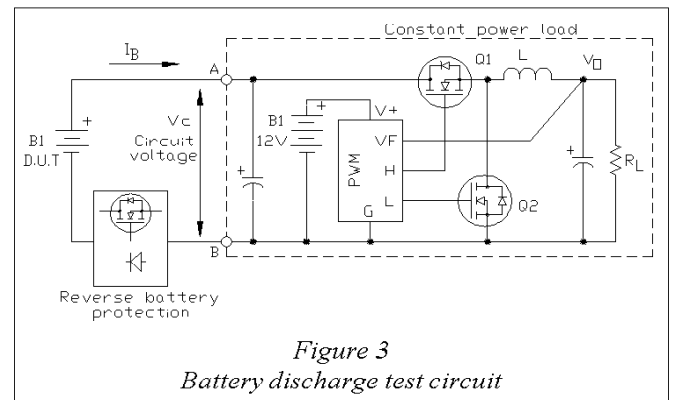
$$PL = V_O^2 / (R_L * \eta)$$

where η is the efficiency, if V_O is constant and $\eta = 1$, the power delivered to the load is constant.

Reverse battery protection with the new low-threshold HEXFETs

The circuit in Figure 2 uses a MOSFET for reverse battery protection. When the battery is connected to the circuit, the body diode of the MOSFET starts conducting current. The load voltage, as well as the gate-to-source voltage of the MOSFET, is $V_B - V_D$, where V_D is the voltage drop across the body diode of the MOSFET at the given load current.

As the voltage appears at the load, the MOSFET turns on and the channel shorts out the body diode. The voltage drop across the MOSFET is $R_{DS(on)} \times I_{LOAD}$ when this value is less than the forward voltage of the body diode.



With the help of this constant power load we have measured battery life with three types of devices acting as reverse battery protection:

- 1) a standard Schottky diode,
- 2) a very low voltage drop Schottky diode,
- 3) a low-threshold HEXFET.

The discharge curves for double and single alkaline AA cells are shown in Figures 4 and 5. The results are summarized in Table I. Assuming that the battery is depleted at two-thirds of its original voltage, a low-threshold HEXFET with an on-resistance of 0.3Ω in a Micro3 package extends the life of the battery 2.5 times, compared with a standard Schottky diode.

The threshold drop of the Schottky subtracts directly from the battery voltage and is the main reason for its poor performance, particularly when operated from a single cell. However, the

on-resistance of the MOSFET also has an impact on battery life, as shown in Table I. For this reason, an N-Channel MOSFET is the device of choice, as its on-resistance is intrinsically lower than that of a P-Channel device. A P-Channel should be considered if the ground return cannot be interrupted.

Conclusion

Low-threshold, low-on-resistance HEXFETs can be used to protect the load from reverse polarity. Compared to a standard Schottky, or even a very low voltage drop Schottky, these new devices extend battery life as much as 3 to 4 times. Since N-Channel MOSFETs have lower on-resistance than P-Channel MOSFETs, they will give the best performance. In those applications that do not allow the MOSFET drop in the ground return, a P-Channel MOSFET is a more convenient solution.

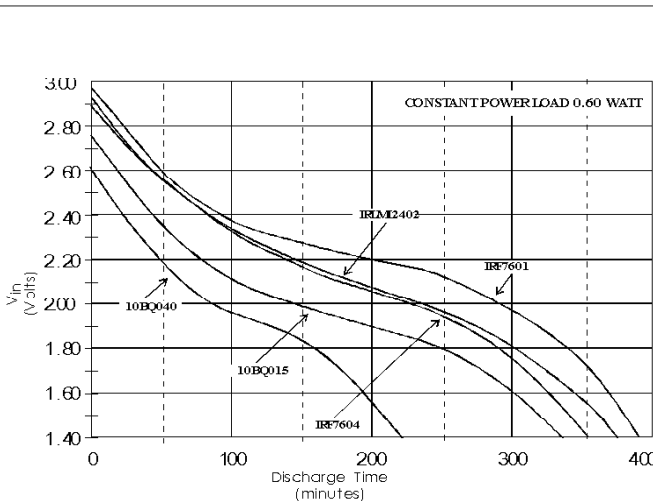


Figure 4

Discharge time vs. circuit voltage with two alkaline AA cells

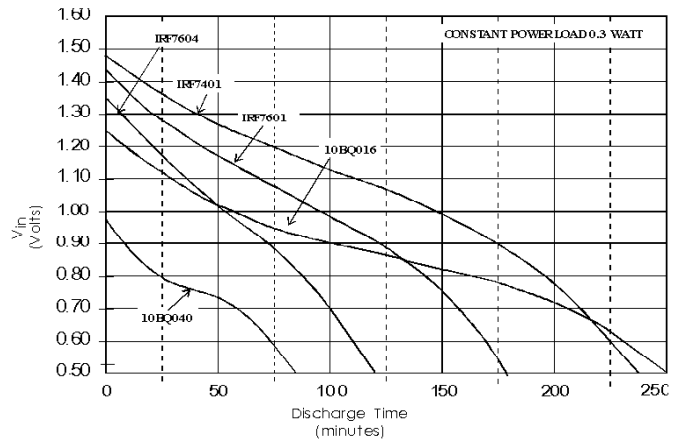


Figure 5

Discharge time vs. circuit voltage, with one alkaline AA cell

TABLE I. BATTERY LIFE TO 66% OF INITIAL VOLTAGE

Part	Type of Device	ONE CELL, 0.3W		TWO CELLS, 0.6W	
		Battery Life	Improvement	Battery Life	Improvement
10BQ040	standard Schottky in SMB	N/A	N/A	100 min.	N/A
10BQ015	very low drop Schottky in SMB	30 min.	N/A	150 min.	50%
IRLML2402	0.3 ohm N-channel MOSFET in Micro3	N/A	N/A	240 min.	140%
IRF7604	0.09 ohm P-channel MOSFET in Micro8	50 min.	67%	280 min.	180%
IRF7601	0.045 ohm N-channel MOSFET in Micro8	80 min.	167%	285 min.	185%
IRF7401	0.022 ohm N-channel MOSFET in SO-8	150min.	400%	N/A	N/A