

Introduction

In battery powered applications, such as laptop computers, power control has a major impact on battery life. For example, laptop or notebook computers often have a "sleep" mode, where the hard drive spins down and the display backlighting turns off while the RAM—containing valuable user data—is maintained. A microprocessor can easily make such power management decisions, but implementing the

hardware for the actual switching can be complicated. "High-side" switching is required; i.e., the positive supply voltage must be controlled. Common grounds for busses and shielding limits the possibility of "low side" switching in a standard negative ground system. This note discusses a logic controlled power switch that simplifies microprocessor driven high-side supply switching.

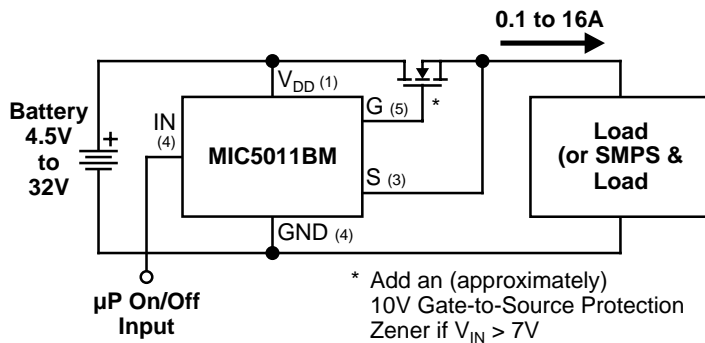


Figure 1. MIC5011 DB-1 Schematic Diagram.

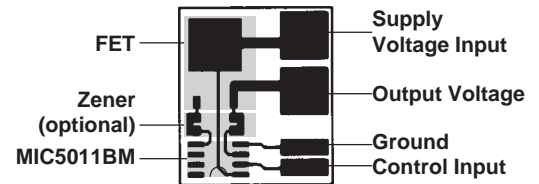


Figure 2. MIC5011 DB-1 Low Voltage Logic Controlled Power Switch

Power Switches

These high-side implementations have historically taken one of two forms: relays or PNP transistors. Both have drawbacks in that relatively large drive current is required: neither can be switched directly from a microprocessor port or standard logic. Mechanical relays are bulky, expensive, and have limited lifetimes. Bipolar transistors exhibit a fixed voltage drop that reduce margins, especially in 5V logic systems. This voltage drop has a devastating effect on defining battery end-of-life (per charge cycle).

Another method of power switching is the N-Channel DMOS FET. This FET has no inherent voltage drop, except for the $I \times r_{DS}$ loss, and requires almost no drive power; unfortunately, it does need a gate driving voltage of from 4V to 10V above the supply voltage in high-side applications. In other words, it is an *almost* ideal switch.

DMOS FET Advantages vs. Relays

- Non-mechanical (much longer life)
- No contact bounce
- Extremely low drive current requirement
- Smaller Size
- Lighter weight
- Lower cost

DMOS FET Advantages vs. PNP

- No fixed voltage drop
- Extremely low drive current requirement
- Larger Safe Operating Region

The Micrel MIC5010 Family

The MIC5011 and its relatives control the N-Channel DMOS FET by generating a gate drive control voltage 4V to 10V above the supply. Its CMOS compatible control input directly interfaces with microprocessors, and its BCD (Bipolar-CMOS-DMOS) construction allows nearly zero power drain in the OFF state. Pairing the MIC5011 with a low cost DMOS FET gives you a simple, reliable, easy-to-interface method of power management.

The MIC5011 is designed for this application and features:

- 4.5V to 32V Operation
- Very low OFF power consumption—0.1 μ A typical
- No external components required
- Built-in zener clamp for protecting standard DMOS gates
- Available in small 8-pin surface mount packages

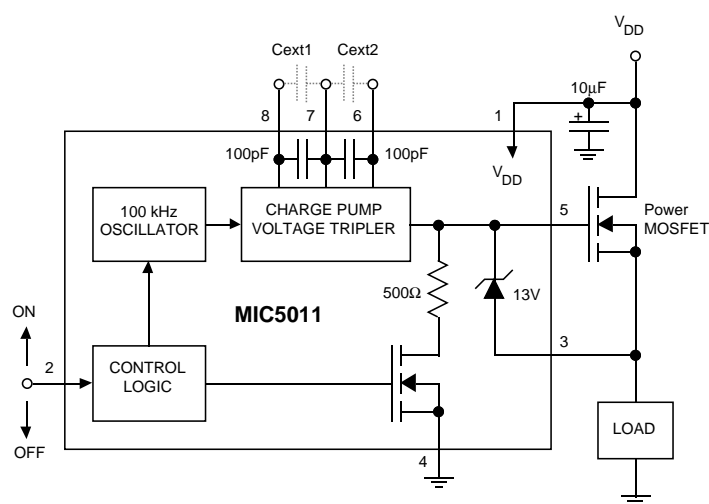


Figure 3. MIC5011 Block Diagram and Typical Application

The IRLR024 N-Channel DMOS FET

The 100m Ω surface mount IRLR024 is employed as the pass device in this demonstration circuit. This N-Channel DMOS FET features “Logic Level” gate drive voltages and can pass over 50A of peak current (limited by power dissipation considerations). Key features include:

- Low ON resistance—100m Ω maximum
- “Logic Level” gate threshold—ON at $V_{GS}=4V$; $V_{GS}=5V$ for full enhancement.
- High pass current
- Surface mount package

One drawback of this “logic level” device is that its sensitive gate cannot withstand more than 10V of V_{GS} drive. Although the MIC5011 includes a protective zener clamp, the zener’s 12.5V threshold is inadequate. With supply voltages from 4.5V to 7V, this is not a problem; however, above 7V, either an external zener clamp must be added to the MIC5011 gate drive output or else a standard threshold FET should be used.

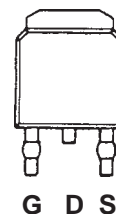


Figure 4. IRLR024 DMOS FET

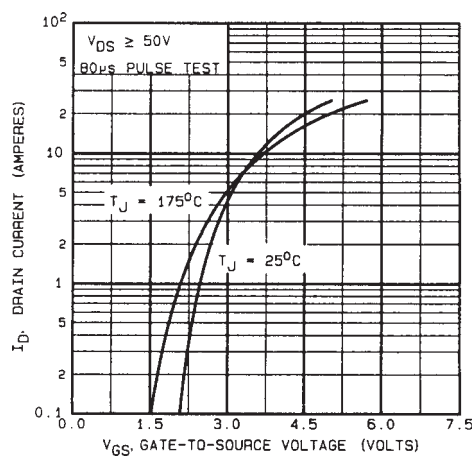


Figure 5. IRLR024 Characteristics

The Micrel MIC5011 DB-1 Demonstration Unit

This demonstration unit is built on a single sided board using surface mount techniques. It has been designed to control 4.5V to 7V supplies, but can easily be modified to use 4.5V to 32V supply voltages. The first thing you will notice from the schematic, Figure 1, is its simplicity; only two components are needed. The MIC5011 contains all of the necessary intelligence and the drive circuitry required by the N-Channel DMOS FET.

Four lines provide +VCC, Switched-VCC, Control, and Ground. VCC and Switched-VCC are current carrying lines, so thick, low resistances traces are necessary. Both Control and Ground are low current lines, so thin traces are sufficient.

Simply connect VCC to 4.5V to 7V, Switched-VCC to your load, Control to a logic output, and Ground. When the logic

level is high (greater than approximately 3.5V), the load will be energized. The IRLR024 will exhibit less than 100mΩ of resistance, so voltage drop, hence power loss, with typical peripherals will be low. Current drain of up to 16A continuous, 64A peak, can be drawn with suitable heatsinking (limit current to 3A without additional heatsinking). With a low logic level, the load will be switched off. Total power drain from the VCC line will be negligible; only approximately 0.1μA (leakage current) flows.

Application Notes

Operating Voltages

This circuit, as designed, controls 4.5V to 7V digital supply voltages. If higher voltages must be switched, one of two modifications must be made. To switch widely varying supplies in the 4.5V to 32V range, use an approximately 7.5V zener clamp, such as the MLL4693 or equivalent, across the gate and source of the FET. If your application switches 7V to 32V, replace the “logic level” FET with a standard gate N-Channel DMOS FET, such as the IRF540, BUZ1LS2, or the SMP60N05. Regardless of the FET employed, the MIC5011 allows power control from a standard CMOS-level logic signal.

TO-220 Package FETs

The MIC5011-DB1 demonstration board also allows using a standard TO-220 package FET. Connect the gate and source to the zener diode pads, and solder the tab (drain) to the drain heatsink pad. Remove the center lead drain connection. The TO-220 tab will extend from the top of the board a short distance.

Faster Switching

If switching time is critical, adding a 1000pF capacitor from pins 6-7 on the MIC5011 will help. Another 1000pF capacitor from pins 7-8 will further accelerate switching time, but by a smaller margin.

Dual Independent Switches

When two separate circuits require switching, the MIC5012 Dual High Side FET Driver provides two independent drivers in a single 14-pin DIP or 16-pin surface mount package.

Over Current Protection

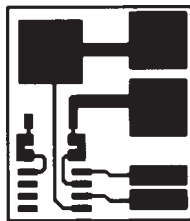
Replace the MIC5011 with the MIC5013 to enable over current protection with fault detection and signalling. See the MIC5013 datasheet for further information and suggested component values.

Parts List

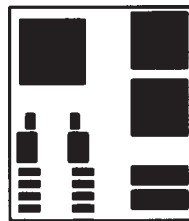
- MIC5011BM Surface mount MOSFET driver
- IRLR024 Surface mount DMOS FET
- MLL4693 Surface mount 7.5V zener diode (optional)

Additional Notes

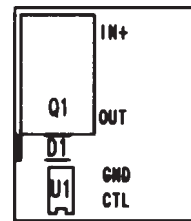
Although the MIC5011 datasheet specifically states that a minimum of 7V of supply voltage is required for high-side driving, the introduction of “logic level” N-Channel DMOS FETs requiring only 4V to 5V V_{GS} for full ON operation enables this minimum operating voltage to be lowered. The MIC5011 provides gate enhancement with supply voltages down to below 3.5V. Variations in the control voltage threshold, however, restrict low voltage operations to somewhat less than 4.5V (for lower voltage devices, please contact the factory).



Component Side



Solder Mask



Silk Screen

Figure 6. MIC5011 DB-1 Board Layout