Power Multiplexer Prevents Cross-Current Conduction

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Many systems require a power multiplexer to select between two different power sources. For example, a PCI-based board needs to be able to select between the main power-supply rail and the auxiliary supply rail. Another example is a battery-operated portable device that must select between the battery or wall adapter.

This power-switching feature could be easily implemented with a pair of diodes wired together to perform a logic OR function. However, this approach has a severe impact on the system's efficiency and heat generation. Additionally, the voltage available to the system would be one diode drop lower than the input voltage. Also, some systems require the use of the main supply if it is available, regardless of the voltage of the auxiliary supply. The diode OR function can only select the highest input voltage to supply the load, which may not be the preferred main supply.

An approach to increase the efficiency of the diode OR is to use the body diodes of two p-channel MOSFETs as the diode OR function (**Fig. 1**). Once the body diode is conducting, its associated MOSFET can be turned on to provide a low impedance path to effectively short the diode and remove the associated diode voltage drop. This method reduces lost power due to the diode and improves the overall efficiency.

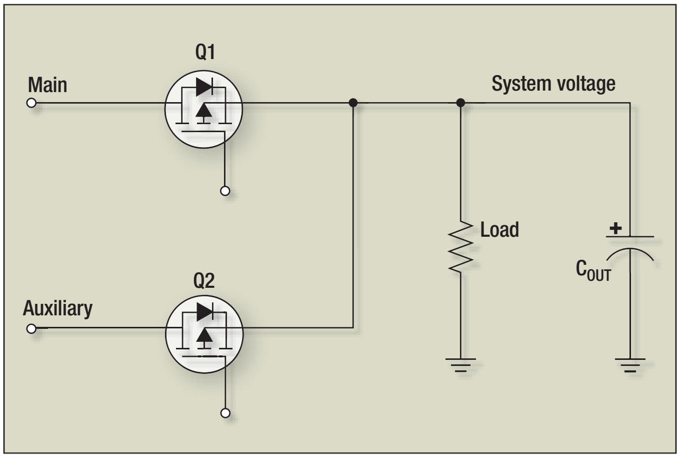

Fig. 1. *Two p-channel MOSFETs can be used to perform a diode OR function for power-rail switching, but this approach permits cross conduction.*

Adding some extra transistors and passives to the basic two-MOSFET ORing circuit eliminates cross- and reverse-current conduction.

Unfortunately, the two-MOSFET circuit can suffer from cross-conduction currents. For example, in **Fig. 1**, assume Q1 is on, providing a low-impedance path from the main supply to the load, and Q2 is off and looks like a diode. If the voltage on the auxiliary supply increases above the main voltage, then the body diode of Q2 will be forward biased. This effectively shorts the auxiliary supply to the main supply, creating large cross-conduction currents and possibly damaging the MOSFETs or the input power sources.

This configuration also can produce large reverse currents when switching from a higher-voltage to a lower-voltage supply. For example, just before switching to a lower-voltage auxiliary supply, the output capacitor (C_{OUT}) is charged to the level of the main supply. When Q1 turns off and Q2 turns on, there will be a large current flow from the output capacitor to the auxiliary supply. This is necessary to discharge the output capacitance down to the auxiliary supply's voltage level. Not all power supplies can handle this large reverse-current flow.

The circuit in **Fig. 2** uses two more p-channel MOSFETs to eliminate cross conduction by forming back-to-back diodes with the body diodes of the MOSFETs. The circuit uses the TPS3803 voltage detector to monitor the voltage of the main supply.

The detector keeps the main supply connected to the load until the main-supply voltage drops below a preset threshold, set to 4.25 V by R1, R2 and R3. Once the main voltage falls below 4.25 V, the comparator will disconnect the main supply from the load and connect the auxiliary supply. The auxiliary supply will stay connected until the main voltage returns above the preset threshold. In the **Fig. 2** circuit, R3 provides 0.5 V of hysteresis, so the main voltage must increase above 4.75 V before it is reconnected to the load.

When turned off, each transistor pair forms a back-to-back diode to keep current from flowing. Transistors Q1A and Q2A prevent current flowing from the supply to the load during off times, while Q1B and Q2B keep current

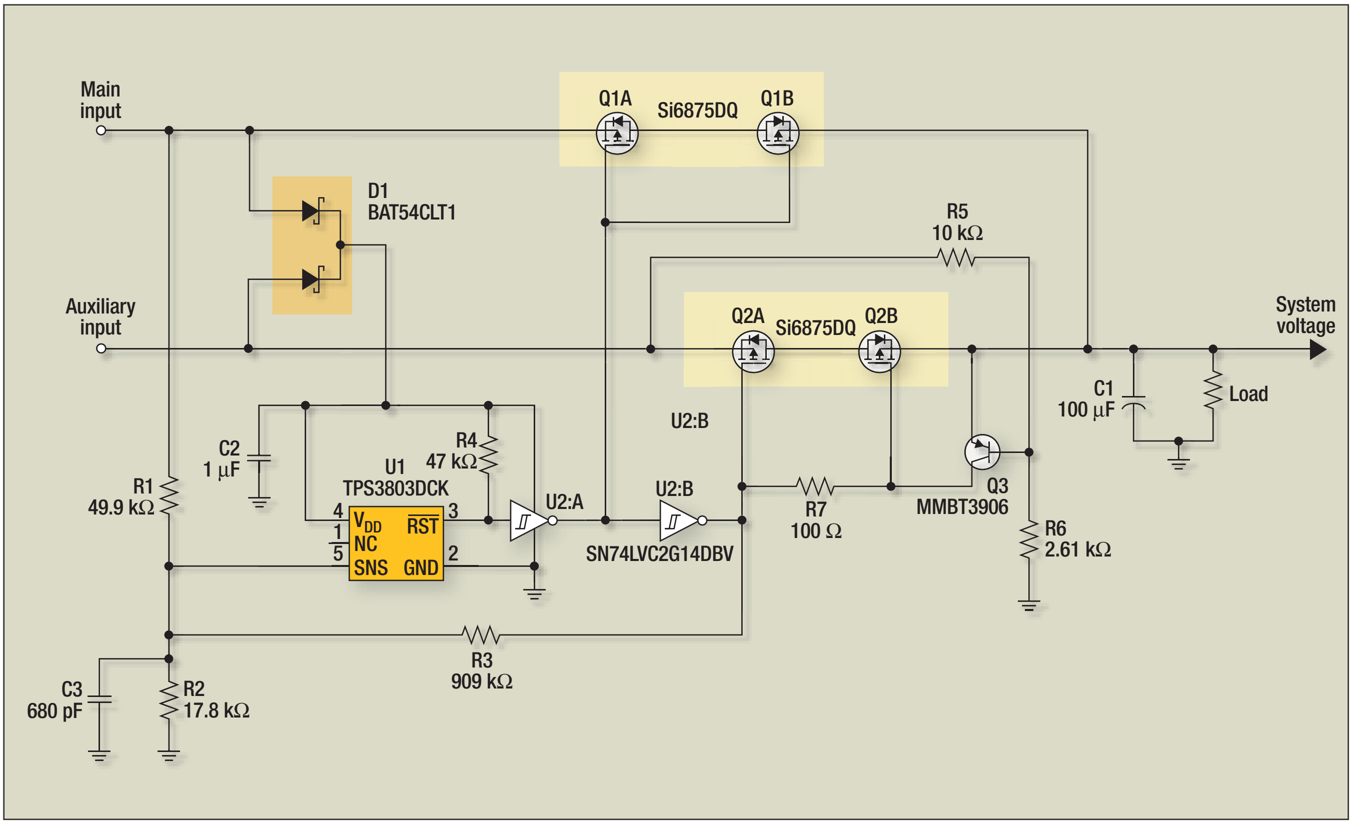

Fig. 2. *A voltage-detector-controlled power multiplexer switches between two supply rails, while protecting against cross conduction and reverse-current flow.*

from flowing from the load to the input power source during off times.

The voltage detector and the inverter are powered through D1, which selects the higher of the main or auxiliary supply. This allows the circuit to continue operating even if one of the input supplies is shorted to ground. Additionally, the inverter will always have enough voltage to turn off the MOSFETs because the output voltage of the inverters will always be close to the highest voltage available in the system. Either or both of the main and auxiliary supplies can be between 1.8 V and 5.5 V for proper operation.

Fig. 3 shows the output voltage and the supply currents during the switchover from one supply to the other with a 3-A load current. **Fig. 3** depicts the case where the circuit switches from the 5-V main to the 3.3-V auxiliary supply. However, the results are similar when switching from the auxiliary supply to the main supply. In both cases, there are no cross-conduction currents. The circuit was designed to handle loads up to 3 A, but can be scaled to any load current by selecting transistors with a higher current capability.

As the current flow in the circuit decreases, the possibility of reverse-current flow increases. If the load currents are small, the output capacitor may not discharge down to the auxiliary voltage level before transistor Q2 is turned on. This would produce a large reverse current into the auxiliary supply, which may be undesirable.

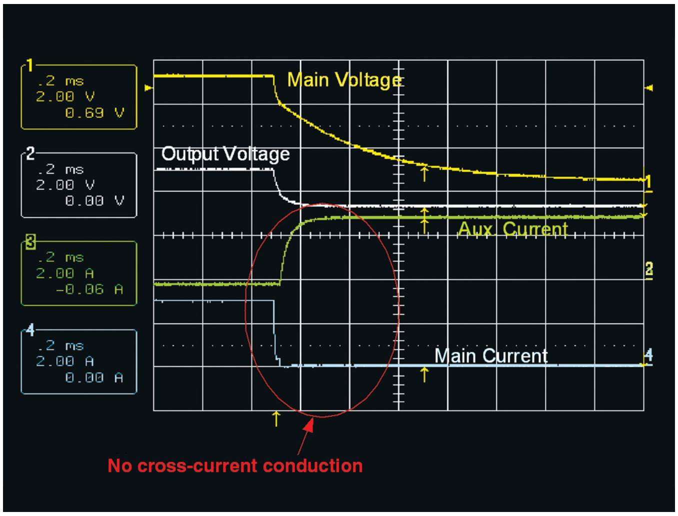

Fig. 3. *When the circuit in Fig 2. switches from the 5-V main to the 3.3-V auxiliary supply with a 3-A load, there are no cross-current conduction.*

The inclusion of three resistors (R5, R6 and R7) and a transistor (Q3) in **Fig. 2** eliminates the possibility of reverse-current flow into the auxiliary supply. The Q3 transistor forces Q2B off until the system voltage is equal to the auxiliary voltage level. With the input and output voltages equal, no reverse current will flow. **PETech**