

Eliminate Power Sequencing With Powered-Off Protection Signal Switches



Introduction

System isolation is critical for power sequencing, managing bus contentions, and turning off sub-circuits to save power. Signal switches are one way to provide isolation in both analog and digital signaling applications such as I2C, LAN, MIPI, SPI, UART, JTAG, etc. Signal switches can ensure that a high impedance (Hi-Z) path is maintained between the input and output (I/O) signal paths and system power rails. However, there are cases where power sequencing, hot plug / hot insertion, and fault / over-voltage events can cause the switch isolation to fail.

During these events, voltages on the switch I/O path can exceed the supply voltage rail (VDD) which forward-biases the internal electrostatic discharge (ESD) protection diode that exists between the I/O pins and VDD. When the internal ESD diode is forward-biased, the voltage on the I/O path can back-power the switch supply pin and damage components on the power rail. Additionally, the forward biased diode can provide a path to back-power the signal switch itself, unintentionally turning on the I/O path. Designers must know the voltage limits of the signal switch I/O pins relative to the switch power supply (VDD) especially when the switch is powered off (VDD = 0 V). Devices with **powered-off protection** features protect their systems in cases where the signal switch is powered-off and a voltage is present on the I/O path and eliminate the need for power sequencing.

Definition of Powered-Off Protection Features: Back-Power Protection and powered-Off Isolation

Back-power protection: prevents a device from providing power to a circuit other than through the designated power supply circuitry.

Powered-off isolation: ensures a device maintains a high impedance (Hi-Z) state when an IC is powered down (VDD = 0 V).

Figure 1 shows a signal switch used to isolate a Wi-Fi® module that is always transmitting and waiting to wake up the rest of the powered-off circuitry. In this case, the switch is powered-off (VDD = 0 V), but continuously receives 3.3-V signal from the Wi-Fi module to its input. Since the input voltage is greater than the switch power supply voltage VDD, the voltage on the input forward-biases the internal ESD protection diode. For devices without **powered-off protection**, the supply rail can be back-powered and compromise the Hi-Z isolation from the Wi-Fi module to the processor.

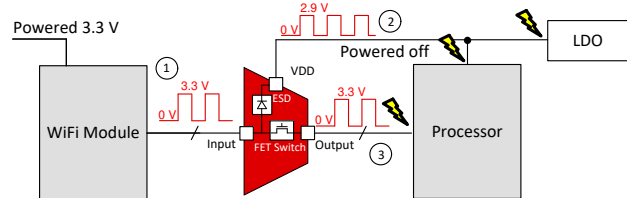


Figure 1. Subsystem A Back-Powering the Switch

1. Wi-Fi module transmits 3.3-V data or clock signals to the switch input
2. The 3.3-V data/clock signals from the Wi-Fi module forward-biases the internal ESD diode, creating a low impedance path that unintentionally back-powers the switch power rail.
3. The signal switch is back-powered through the ESD diode and turns on the FET that isolates the I/O path, causing the data/clock signals to unintentionally transmit to the powered-off processor.

Ensuring System Isolation With Powered-Off Protected Switches

Powered-off protected switches ensure the device maintains its high impedance (Hi-Z) performance even without power to the IC. Switches with **powered-off protection** include proprietary IP which prevents back-power conditions when the voltage on the I/O signal paths are greater than the supply rail (VDD). This feature eliminates the need for power sequencing because the I/O paths remain Hi-Z even when VDD = 0 V.

To determine if a signal switch has **powered-off protection**, check the device-specific data sheet for the powered-off leakage specifications with the test conditions including $V_{DD} = 0\text{ V}$.

6.5 Electrical Characteristics

$T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$. Typical values are at $V_{CC} = 3.3\text{ V}$, $T_A = 25^\circ\text{C}$. (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_{OFF} Power-off leakage current	$V_{CC} = 0\text{ V}$ Switch ON or OFF, $V_B = 1.65\text{ V}$ to 3.45 V , $V_{COM} = \text{NC}$	-10		10	μA

Figure 2. TMUX136 Power-Off Leakage Current Specification

Figure 2 shows the leakage current specification of the **TMUX136** device. It states no more than $10\ \mu\text{A}$ leaks through the I/O signal path with $V_{CC} = 0\text{ V}$ and $V_{I/O} = 3.45\text{ V}$.

Example Using Signal Switches With and Without Powered-Off Protection Features

Figure 3 is an example using two different signal switches to isolate a DC 1.8-V input signal (top) or 3.3-V AC clock input signal (bottom). The **TS3A44159** device (left) does not have **powered-off protection** and the **SN74CBTLV3125** device (right) has **powered-off protection**. In both examples, the VDD supply rail is powered-off and the voltage on VDD drops to 0 V. In both cases, the device without **powered-off protection** back-powers the signal switch and a voltage that is one diode drop ($\sim 0.4\text{ V}$) below the input voltage can be seen on VDD. When the switch is back-powered, the switch unintentionally turns and passes the signals through the switch. The device with **powered-off protection**; however, maintains the signal path isolation when the $V_{DD} = 0\text{ V}$.

Summary

During power sequencing, hot plug / hot insertion, and fault / over-voltage events, voltages on the switch I/O signal path exceeding the supply voltage rail make the switch isolation ineffective. Using signal switches with **powered-off protection** can assure Hi-Z isolation performance when $V_{DD} = 0\text{ V}$, eliminating the need for power sequencing and protecting system components.

Table 1. Alternative Device Recommendations

Device	Configuration	Key Features
TMUX1574	4-channel 2:1	Powered-off protection , Low Con (7.5 pF), Low Ron ($2\ \Omega$), Wide bandwidth (2 GHz), 1.8 V Logic Compatible
TMUX1575	4-channel 2:1	1.3 mm x 1.3 mm package, 1.2-V compatible control inputs, Powered-off protection , Low Con (10 pF), Low Ron ($1.7\ \Omega$), 1.8 GHz Bandwidth
TMUX1511	4-channel 1:1	Powered-off protection , Low Con (3.3 pF), Low Ron ($2\ \Omega$), Wide bandwidth (3 GHz), 1.8 V Logic Compatible
TMUX1072	2-channel 2:1	Powered-off protection , Overvoltage Protection (up to 20 V) Wide bandwidth (1.2 GHz), 1.8 V Logic Compatible

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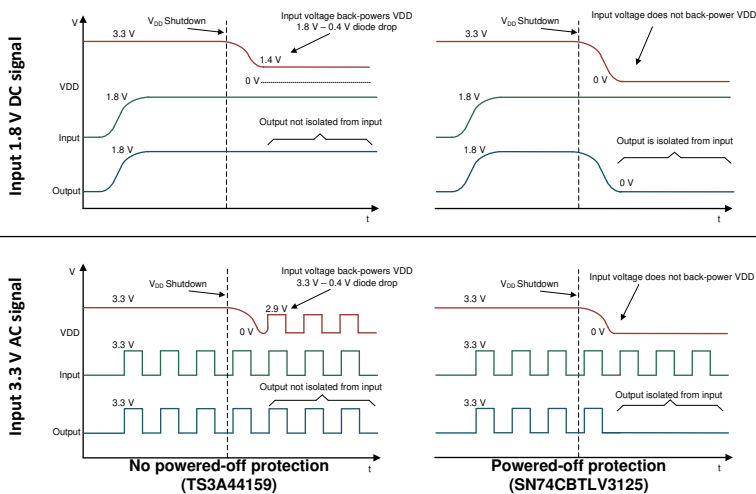


Figure 3. Signal Switch With and Without Powered-Off Protection

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