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Using Blocking Capacitors with UltraCMOS® Devices

Introduction

Peregrine's UltraCMOS® switches and DSAs have many advantages over other technologies. One advantage is that no blocking capacitors are required when $0V_{DC}$ exists on the RF ports. However, for applications placing non-zero DC voltages on the RF ports, blocking capacitors are required. In addition, blocking capacitors used with certain part numbers can still have performance limitations. This application note describes the use of blocking capacitors with UltraCMOS® devices and recommends a solution to ensure optimal performance for all use cases.

Blocking Cap Charges Up

Peregrine's switches and DSAs use an assorted combination of series and shunt UltraCMOS® FETs. In general, the FETs are turned on with supply voltage $+V_{DD}$ applied to the gate and turned off with $–V_{DD}$ applied to the gate. The active RF path is simply a drain-source channel with $V_{DS} \approx 0V$. Thus, when the RF path is properly biased at 0V, V_{GS} is $\pm V_{DD}$. However, if the RF path is biased to a non-zero DC voltage, V_{GS} will not be $\pm V_{DD}$ causing the transistors to be in an undetermined state.

For such applications, blocking caps can be added to ensure proper biasing. However, a large peak voltage from a transient startup condition can charge up the capacitors, causing the same issue of improper FET biasing and potential gate-oxide breakdown. Even a few hundred mV held on the RF pins can stress the gate oxide and compromise the RF performance of the part, if not adequately discharged.

See *Table 1* for a list of affected parts. These parts do not have internal discharge paths, and are more likely to have degraded performance if used with external blocking capacitors.

Summary:

- UltraCMOS® switches and DSAs that require blocking caps but do not have internal discharge paths can develop non-zero DC voltages on the RF ports
- A 1 kΩ to 8 kΩ discharge resistor is recommended on all RF ports that have a blocking cap so that voltages do not exceed maximum ratings
- Please see *Table 1* for a list of affected parts

Table 1. Switches and DSAs Without Discharge Paths

Part Type	Part Number	Description
RF Switches (50 Ω)	PE4210	SPDT, Reflective
	PE4230	SPDT, Reflective
	PE4237	SPDT, Reflective
	PE4239	SPDT, Reflective
	PE4242	SPDT, Reflective
	PE4244	SPDT, Reflective
	PE4245	SPDT, Reflective
	PE4246	SPST, Absorptive
	PE4257	SPDT, Absorptive
	PE4259	SPDT, Reflective
	PE4283	SPDT, Reflective
	PE42359	SPDT, Reflective
Broadband Switches (75 Ω)	PE4231	SPDT, Reflective
	PE4256	SPDT, Absorptive
	PE4270	SPST, Absorptive
	PE4271	SPST, Absorptive
	PE4272	SPDT, Reflective
	PE4273	SPDT, Reflective
	PE4280	SPDT, Absorptive
	PE42742	SPDT, Absorptive
Cellular/ Communications Switches (50 Ω)	PE42612	SP4T - 2Tx/2Rx
	PE4268	SP6T - 2Tx/4Rx
RF DSAs (50 Ω)	PE4302	6-bit, 31.5 range / 0.5 steps
	PE4305	5-bit, 15.5 range / 0.5 steps
	PE4306	5-bit, 31 range / 1.0 steps
	PE4309	6-bit, 31.5 range / 0.5 steps
Broadband DSAs (75Ω)	PE4304	6-bit, 31.5 range / 0.5 steps
	PE4307	5-bit, 15.5 range / 0.5 steps
	PE4308	5-bit, 31 range / 1.0 steps
	PE43404	4-bit, 15 range / 1.0 steps

Solution

A discharge path to ground can be added to the common/antenna port on the switches and either RF port on the DSAs. Since the RFC/ANT port is always tied to an RFx port, the active path will always be covered. As seen in *Figure 1*, a resistor value in the range of 1 kΩ to 8 kΩ is recommended.

Based on application, the actual value can be chosen after experimentation. The smaller the resistor, the higher the IL and shorter the time the voltage is non-zero. The larger the resistor, the lower the IL and longer the time the voltage is non-zero. Longer exposure times to non-zero DC voltages can adversely stress the gate-oxide.

As an example, the **PE4259** Hi-Power SPDT Switch was measured with several shunt resistors added to the RFC port. As seen in *Figure 2*, as the shunt resistor value was decreased, the Insertion Loss degraded as the loading effect was magnified.

Conversely, as the resistor value was decreased, the RC time constant Rext*Cblock decreased and the voltage decayed faster to 0V. *Figure 3* shows the pulse response of the active path with No R (black) and with a 3.9 kΩ(aqua) for Cblock = 100 pF.

Conclusion

Blocking capacitors are required when non-zero DC voltages are placed on the RF ports. In such applications, transient peak voltages can still charge up the capacitors connected to the RF ports, degrading the RF performance and potentially exceeding device maximum ratings. Shunt resistors should be added to the RF ports to prevent any degradation in the RF performance.

Figure 1. Recommended Solution: Rext = 1kΩ to 8kΩ

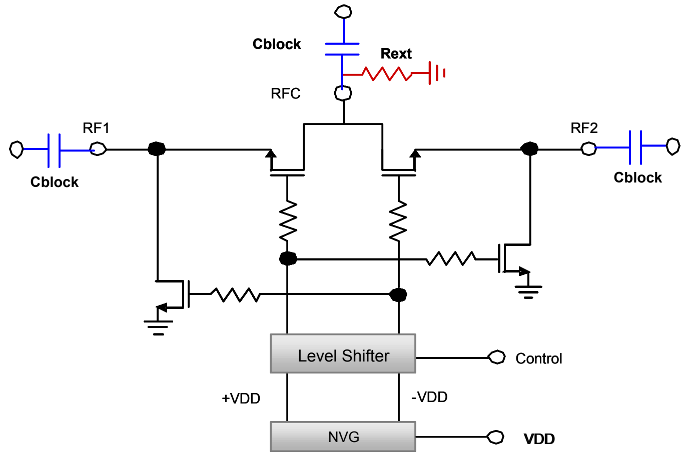

Figure 2. PE4259 EVK With Several R Values

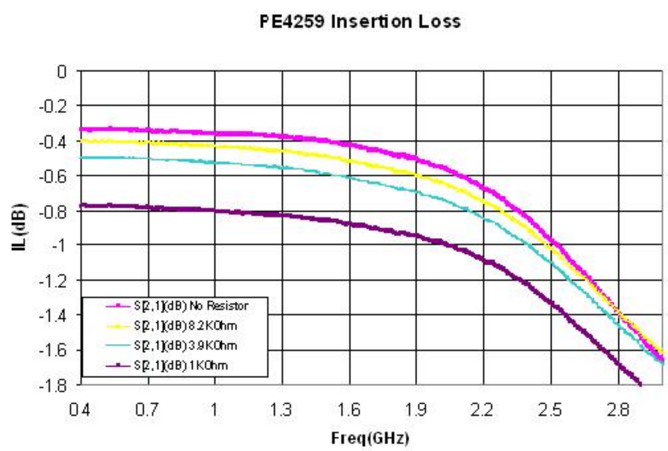

Figure 3. PE4259 EVK 2µs Pulse Response @ RFC