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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. This can create conditions that compromise reliability, especially for parts that do not have HaRP™ technology enhancements. This application note describes the effect and recommends a solution to ensure reliable operation.

Blocking Cap Charges Up

Peregrine's switches and DSAs use an assorted combination of series and shunt FETs. In general, 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 $+/-V_{DD}$. However, if the RF path is biased to a non-zero DC voltage, V_{GS} will not be $+/-V_{DD}$ causing the transistors to be in an undetermined state. In addition, V_{GS} can exceed maximum ratings, stressing the gate-oxide and reducing reliability of the part.

For such applications, blocking caps can be added to ensure proper biasing. However, leakage from a transient startup condition can charge up the capacitors, causing the same issues of improper FET biasing and gate-oxide breakdown. With even modest voltages (as little as +0.3V) held on the RF pins, V_{GS} gradually responds at a rate proportional to the internal gate charging time constant. This non-zero DC voltage may last for some time, compromising the performance and reliability of the part.

See Table 1 for the list of affected products. Unlike HaRP™ enhanced parts, these parts are more sensitive to transient leakage conditions.

Summary:

- UltraCMOS™ switches and DSAs that require blocking caps but do not have HaRP™-technology enhancements can have non-zero 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 products

Table 1. Switches and DSAs without HaRP™ technology enhancements

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

Solution

A discharge path to ground can be added between each RF port and blocking capacitor. A resistor value of 1 kΩ to 8 kΩ is recommended as seen in Figure 1. The actual value is a tradeoff between RF performance and improved reliability. The smaller the resistor, the higher the Insertion Loss and shorter the time the voltage is non-zero. The larger the resistor, the lower the Insertion Loss and longer the time the voltage is non-zero.

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

Conversely, for a given pulse width, 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 with no resistor (black) and with a 3.9kΩ resistor (aqua) for Cblock = 100pF.

Conclusion

Non-zero DC voltages can build up on the RF ports of certain UltraCMOS™ products in applications that require blocking capacitors. Transient leakage can charge the capacitors and cause the voltages to exceed maximum ratings, stressing the part and compromising reliability. Discharge resistors should be added to the RF ports to improve the reliability without compromising RF performance.

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

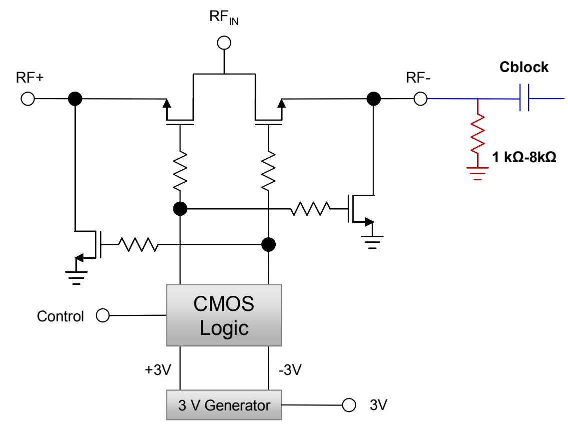

Figure 2. PE4259 EVK with several R values

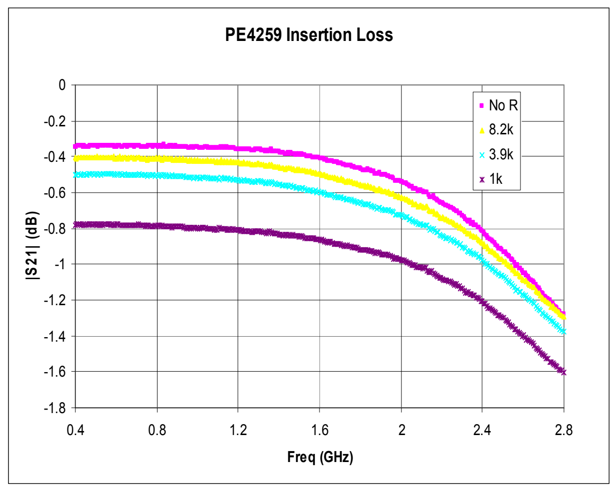

Figure 3. PE4259 EVK 2µs Pulse Response