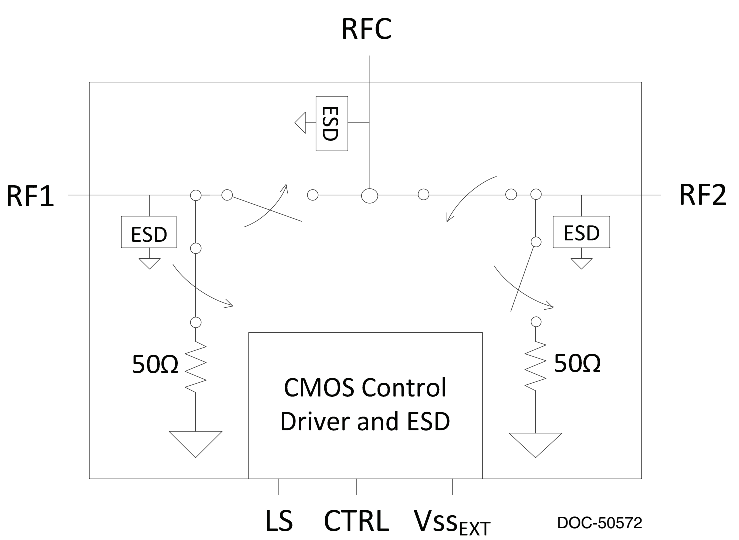
UltraCMOS® SPDT RF Switch 9 kHz – 13 GHz

Product Description

The PE42521 SPDT absorptive RF switch is designed for use in Test/ATE and other high performance wireless applications. This broadband general purpose switch maintains excellent RF performance and linearity from 9 kHz through 13 GHz. This switch is a pin-compatible upgraded version of PE42552 with fast switching time and higher power handling of 36 dBm continuous wave (CW) and 38.5 dBm instantaneous power in 50Ω @ 4 GHz. The PE42521 exhibits high isolation, fast settling time, and is offered in a 3x3 mm QFN package.

The PE42521 is manufactured on Peregrine's UltraCMOS® process, a patented variation of silicon-on-insulator (SOI) technology on a sapphire substrate, offering the performance of GaAs with the economy and integration of conventional CMOS.

Figure 1. Functional Diagram



Features

- HaRP™ technology enhanced
  - Fast settling time of 2 µs
  - No gate and phase lag
  - No drift in insertion loss and phase
- Fast switching time of 500 ns
- High power handling @ 4 GHz in 50Ω
  - 36 dBm CW
  - 38.5 dBm instantaneous power
  - 26 dBm terminated port
- High linearity
  - 65 dBm IIP3
- Low insertion loss
  - 0.75 dB @ 3 GHz
  - 1.15 dB @ 10 GHz
  - 1.85 dB @ 13 GHz
- High isolation
  - 44 dB @ 3 GHz
  - 30 dB @ 10 GHz
  - 17 dB @ 13 GHz
- ESD performance
  - 3kV HBM on RF pins to GND
  - 1.5kV HBM on all pins
  - 1kV CDM on all pins

Figure 2. Package Type
16-lead 3x3 mm QFN

Table 1. Electrical Specifications @ 25°C, V_{DD} = 3.3V, Vss_{EXT} = 0V or V_{DD} = 3.4V, Vss_{EXT} = -3.4V, (Z_S = Z_L = 50Ω) unless otherwise noted

Parameter	Path	Condition	Min	Typ	Max	Unit
Operation frequency			9 kHz		13 GHz	As shown
Insertion loss	RFC–RFX	9 kHz – 10 MHz 10 MHz – 3 GHz 3 GHz – 7.5 GHz 7.5 GHz – 10 GHz 10 GHz – 12 GHz 12 GHz – 13 GHz		0.60 0.75 0.95 1.15 1.75 1.85	0.80 1.00 1.20 1.40 2.20 2.60	dB dB dB dB dB dB
Isolation	RFX–RFX	9 kHz – 10 MHz 10 MHz – 3 GHz 3 GHz – 7.5 GHz 7.5 GHz – 10 GHz 10 GHz – 12 GHz 12 GHz – 13 GHz	70 46 35 23 16 14	90 49 37 26 19 17		dB dB dB dB dB dB
Isolation	RFC–RFX	9 kHz – 10 MHz 10 MHz – 3 GHz 3 GHz – 7.5 GHz 7.5 GHz – 10 GHz 10 GHz – 12 GHz 12 GHz – 13 GHz	80 42 39 26 18 14	90 44 41 30 21 17		dB dB dB dB dB dB
Return loss (active port)	RFC-RFX	9 kHz – 10 MHz 10 MHz – 3 GHz 3 GHz – 7.5 GHz 7.5 GHz – 10 GHz 10 GHz – 12 GHz 12 GHz – 13 GHz		23 19 16 21 10 15		dB dB dB dB dB dB
Return loss (common port)	RFC-RFX	9 kHz – 10 MHz 10 MHz – 3 GHz 3 GHz – 7.5 GHz 7.5 GHz – 10 GHz 10 GHz – 12 GHz 12 GHz – 13 GHz		23 19 16 21 10 16		dB dB dB dB dB dB
Return loss (terminated port)	RFX	9 kHz – 10 MHz 10 MHz – 3 GHz 3 GHz – 7.5 GHz 7.5 GHz – 10 GHz 10 GHz – 12 GHz 12 GHz – 13 GHz		32 23 18 11 6 5		dB dB dB dB dB dB
Input 0.1 dB compression point[1]	RFC–RFX	600 MHz – 13 GHz		*Fig. 5*		dBm
Input IP2	RFC–RFX	834 MHz, 1950 MHz		120		dBm
Input IP3	RFC–RFX	834 MHz, 1950 MHz, and 2700 MHz		65		dBm
Settling time		50% CTRL to 0.05 dB final value		2	4	µs
Switching time		50% CTRL to 90% or 10% of final value		500	700	ns

Note 1: The input 0.1 dB compression point is a linearity figure of merit. Refer to *Table 3* for the RF input power P_{IN} (50Ω)

Figure 3. Pin Configuration (Top View)

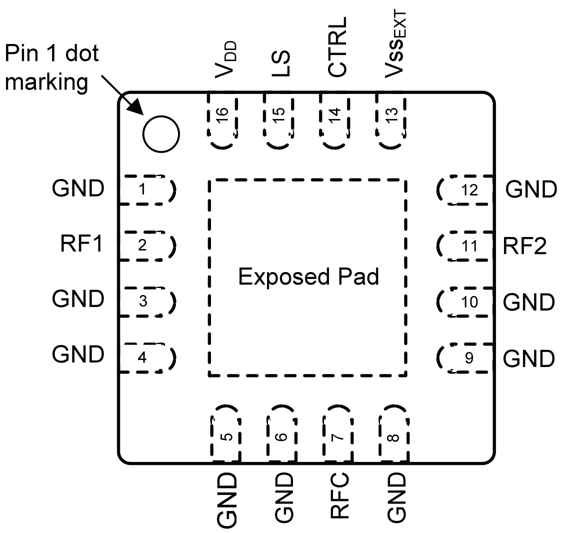


Table 2. Pin Descriptions

Pin #	Pin Name	Description
2	RF1[1]	RF port 1
1, 3, 4, 5, 6, 8, 9, 10, 12	GND	Ground
7	RFC[1]	RF common
11	RF2[1]	RF port 2
13	Vss_{EXT}[2]	External Vss negative voltage control
14	CTRL	Digital control logic input
15	LS	Logic Select - used to determine the definition for the CTRL pin (see *Table 5*)
16	V_{DD}	Supply voltage
Pad	GND	Exposed pad: ground for proper operation

Notes: 1. RF pins 2, 7, and 11 must be at 0V DC. The RF pins do not require DC blocking capacitors for proper operation if the 0V DC requirement is met
2. Use Vss_{EXT} (pin 13) to bypass and disable internal negative voltage generator. Connect Vss_{EXT} (pin 13) to GND (Vss_{EXT} = 0V) to enable internal negative voltage generator

Table 3. Operating Ranges

Parameter	Symbol	Min	Typ	Max	Unit
Supply voltage (normal mode, Vss_{EXT} = 0V)[1]	V_{DD}	2.3		5.5	V
Supply voltage (bypass mode, Vss_{EXT} = -3.4V, V_{DD} ≥ 3.4V for full spec. compliance)[2]	V_{DD}	2.7	3.4	5.5	V
Negative supply voltage (bypass mode)[2]	Vss_{EXT}	-3.6		-3.2	V
Supply current (normal mode, Vss_{EXT} = 0V)[1]	I_{DD}		120	200	µA
Supply current (bypass mode, Vss_{EXT} = -3.4V)[2]	I_{DD}		50	80	µA
Negative supply current (bypass mode, Vss_{EXT} = -3.4V)[2]	I_{SS}	-40	-16		µA
Digital input high (CTRL)	V_{IH}	1.17		3.6	V
Digital input low (CTRL)	V_{IL}	-0.3		0.6	V
Digital input current	I_{CTRL}			10	µA
RF input power, CW (RFC-RFX)[3] 9 kHz ≤ 600 MHz 600 MHz ≤ 4 GHz 4 GHz ≤ 13 GHz	P_{IN-CW}			 *Fig. 4* 36 *Fig. 5*	 dBm dBm dBm
RF input power, pulsed (RFC-RFX)[4] 9 kHz ≤ 600 MHz 600 MHz ≤ 13 GHz	$P_{IN-PULSED}$			 *Fig. 4* *Fig. 5*	 dBm dBm
RF input power, hot switch, CW[3] 9 kHz ≤ 10 MHz 10 MHz ≤ 13 GHz	P_{IN-HOT}			 *Fig. 4* 20	 dBm dBm
RF input power into terminated ports, CW (RFX)[3] 9 kHz ≤ 30 MHz 30 MHz ≤ 13 GHz	$P_{IN,TERM}$			 *Fig. 4* 26	 dBm dBm
Operating temperature range	T_{OP}	-40	+25	+85	°C

Notes: 1. Normal mode: connect Vss_{EXT} (pin 13) to GND (Vss_{EXT} = 0V) to enable internal negative voltage generator
2. Bypass mode: use Vss_{EXT} (pin 13) to bypass and disable internal negative voltage generator
3. 100% duty cycle, all bands, 50Ω
4. Pulsed, 5% duty cycle of 4620 µs period, 50Ω

Table 4. Absolute Maximum Ratings

Parameter/Condition	Symbol	Min	Max	Unit
Supply voltage	V_{DD}	-0.3	5.5	V
Digital input voltage (CTRL)	V_{CTRL}	-0.3	3.6	V
LS input voltage	V_{LS}	-0.3	3.6	V
RF input power, CW (RFC-RFX)[1] 9 kHz ≤ 600 MHz 600 MHz ≤ 4 GHz 4 GHz ≤ 13 GHz	P_{IN-CW}		*Fig. 4* 36 *Fig. 5*	dBm dBm dBm
RF input power, pulsed (RFC-RFX)[2] 9 kHz ≤ 600 MHz 600 MHz ≤ 13 GHz	$P_{IN-PULSED}$		*Fig. 4* *Fig. 5*	dBm dBm
RF input power into terminated ports, CW (RFX)[1] 9 kHz ≤ 30 MHz 30 MHz ≤ 13 GHz	$P_{IN,TERM}$		*Fig. 4* 26	dBm dBm
Storage temperature range	T_{ST}	-65	+150	°C
ESD voltage HBM[3] RF pins to GND All pins	$V_{ESD,HBM}$		3000 1500	V V
ESD voltage MM[4], all pins	$V_{ESD,MM}$		200	V
ESD voltage CDM[5], all pins	$V_{ESD,CDM}$		1000	V

Notes: 1. 100% duty cycle, all bands, 50Ω
2. Pulsed, 5% duty cycle of 4620 µs period, 50Ω
3. Human Body Model (MIL-STD 883 Method 3015)
4. Machine Model (JEDEC JESD22-A115)
5. Charged Device Model (JEDEC JESD22-C101)

Exceeding absolute maximum ratings may cause permanent damage. Operation should be restricted to the limits in the Operating Ranges table. Operation between operating range maximum and absolute maximum for extended periods may reduce reliability.

Electrostatic Discharge (ESD) Precautions

When handling this UltraCMOS® device, observe the same precautions that you would use with other ESD-sensitive devices. Although this device contains circuitry to protect it from damage due to ESD, precautions should be taken to avoid exceeding the rating specified.

Latch-Up Avoidance

Unlike conventional CMOS devices, UltraCMOS® devices are immune to latch-up.

Switching Frequency

The PE42521 has a maximum 25 kHz switching rate when the internal negative voltage generator is used (pin 13 = GND). The rate at which the PE42521 can be switched is only limited to the switching time (*Table 1*) if an external negative supply is provided (pin 13 = Vss_{EXT}).

Switching frequency describes the time duration between switching events. Switching time is the time duration between the point the control signal reaches 50% of the final value and the point the output signal reaches within 10% or 90% of its target value.

Optional External Vss Control (Vss_{EXT})

For proper operation, the Vss_{EXT} control pin must be grounded or tied to the Vss voltage specified in *Table 3*. When the Vss_{EXT} control pin is grounded, FETs in the switch are biased with an internal negative voltage generator. For applications that require the lowest possible spur performance, Vss_{EXT} can be applied externally to bypass the internal negative voltage generator.

Spurious Performance

The typical spurious performance of the PE42521 is -135 dBm when Vss_{EXT} = 0V (pin 13 = GND). If further improvement is desired, the internal negative voltage generator can be disabled by setting Vss_{EXT} = -3.4V.

Table 5. Control Logic Truth Table

LS	CTRL	RFC-RF1	RFC-RF2
0	0	off	on
0	1	on	off
1	0	on	off
1	1	off	on

Moisture Sensitivity Level

The Moisture Sensitivity Level rating for the PE42521 in the 16-lead 3x3 mm QFN package is MSL3.

Logic Select (LS)

The Logic Select feature is used to determine the definition for the CTRL pin.

Figure 4. Power De-rating Curve for 9 kHz – 600 MHz (50Ω)

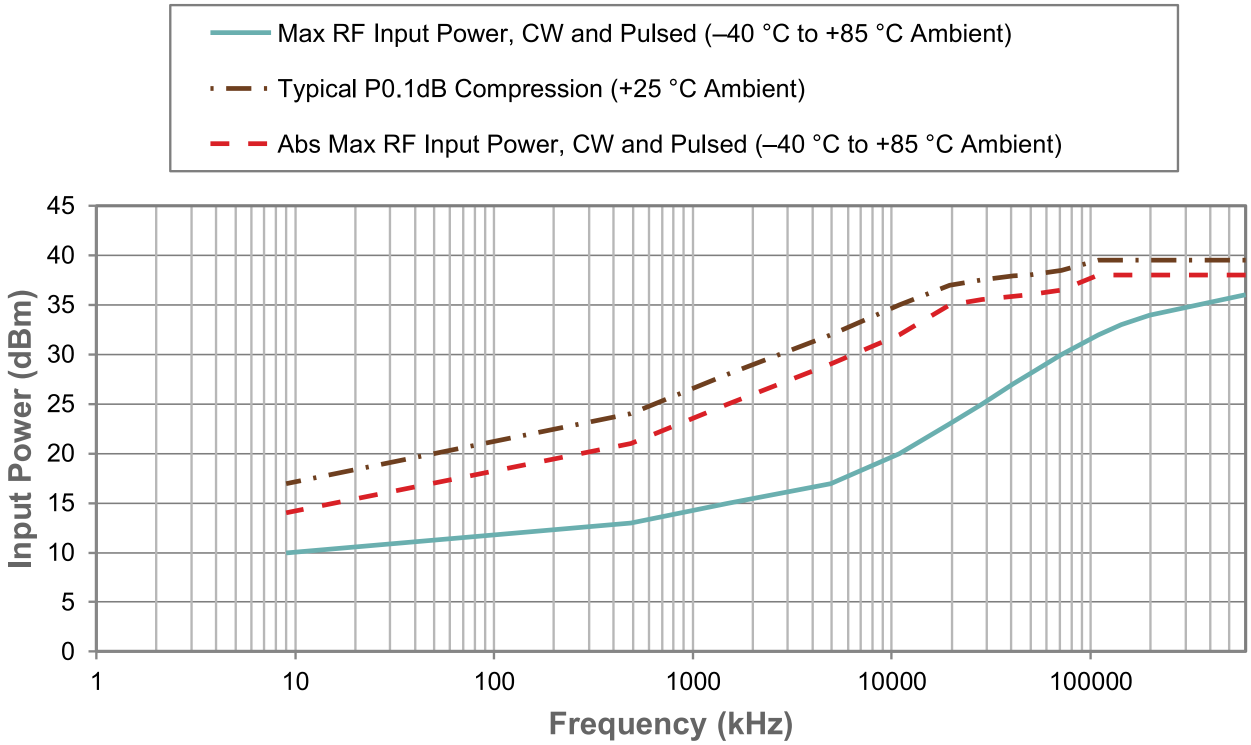


Figure 5a. Power De-rating Curve for 600 MHz – 13 GHz @ 25°C Ambient (50Ω)

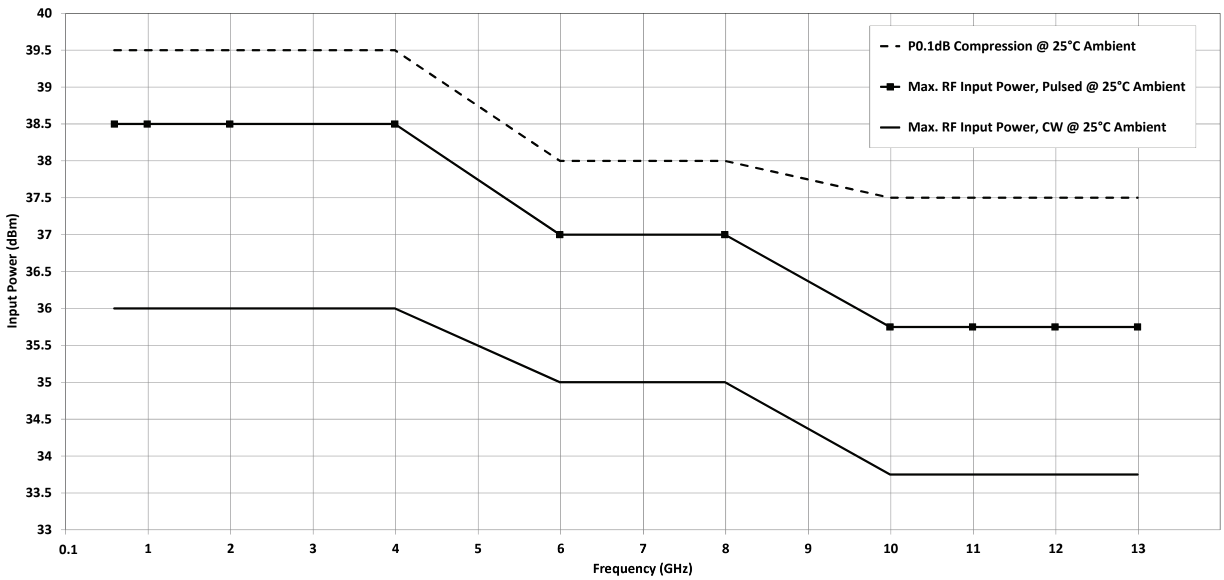
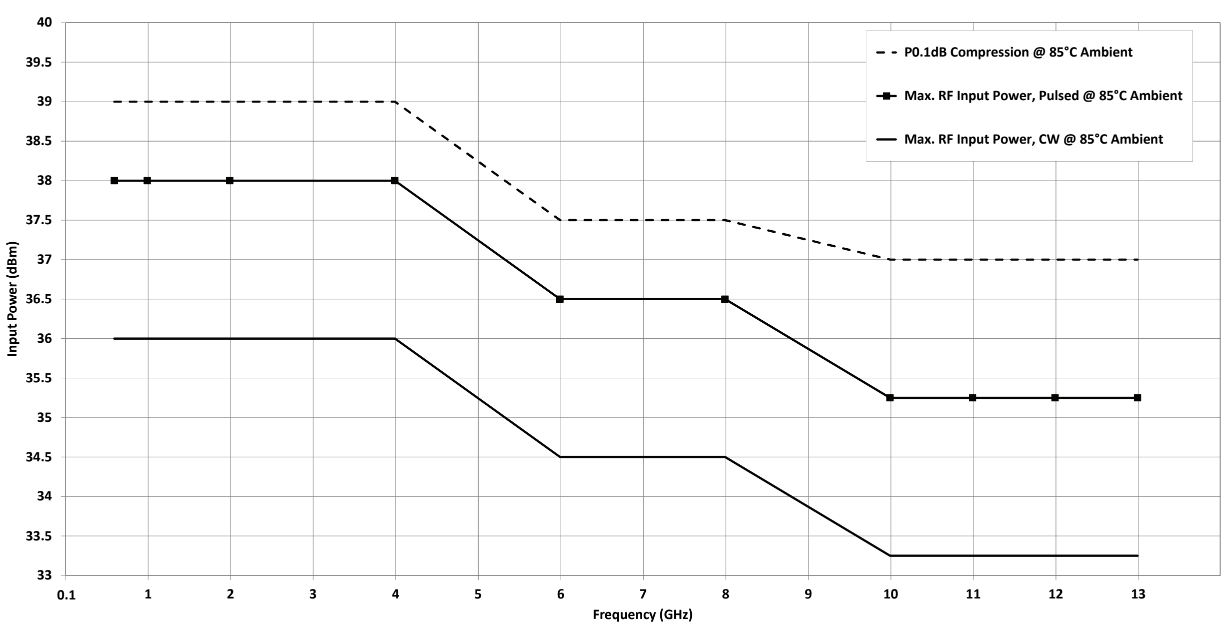


Figure 5b. Power De-rating Curve for 600 MHz – 13 GHz @ 85°C Ambient (50Ω)



Typical Performance Data @ 25°C and V_{DD} = 3.4V unless otherwise specified

Figure 6. Insertion Loss vs. Temp (RFC–RF1)

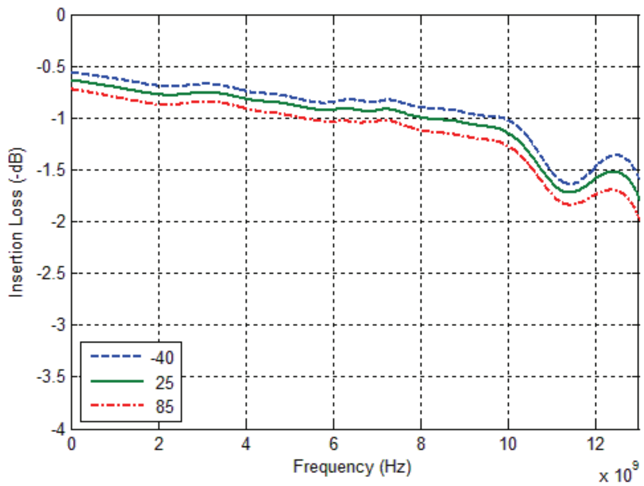


Figure 7. Insertion Loss vs. V_{DD} (RFC–RF1)

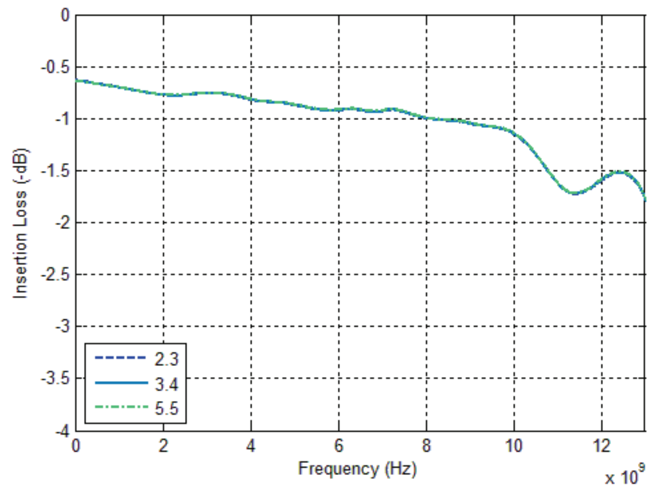


Figure 8. Insertion Loss vs. Temp (RFC–RF2)

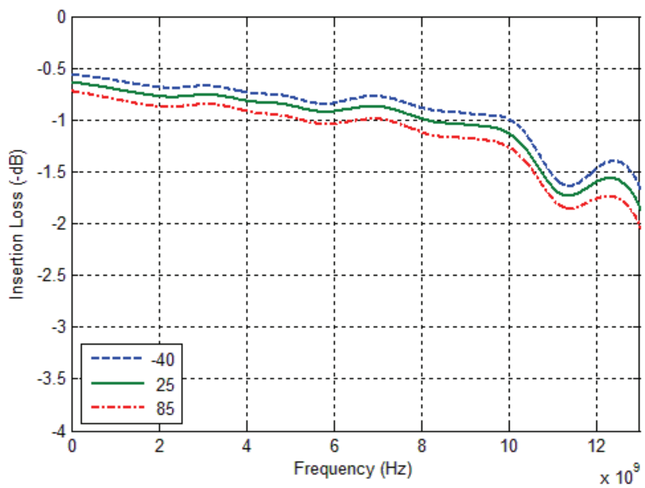
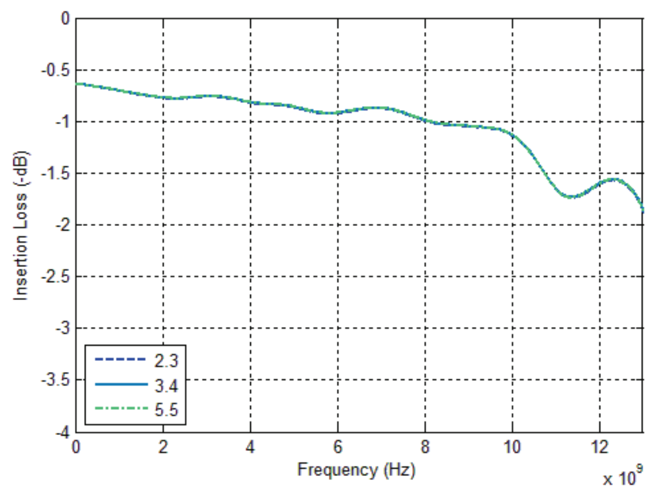


Figure 9. Insertion Loss vs. V_{DD} (RFC–RF2)



Typical Performance Data @ 25°C and V_{DD} = 3.4V unless otherwise specified

Figure 10. RFC Port Return Loss vs. Temp (RF1 Active)

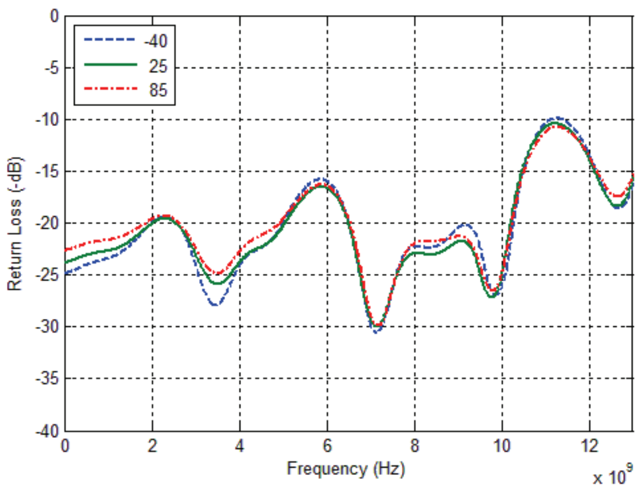


Figure 11. RFC Port Return Loss vs. V_{DD} (RF1 Active)

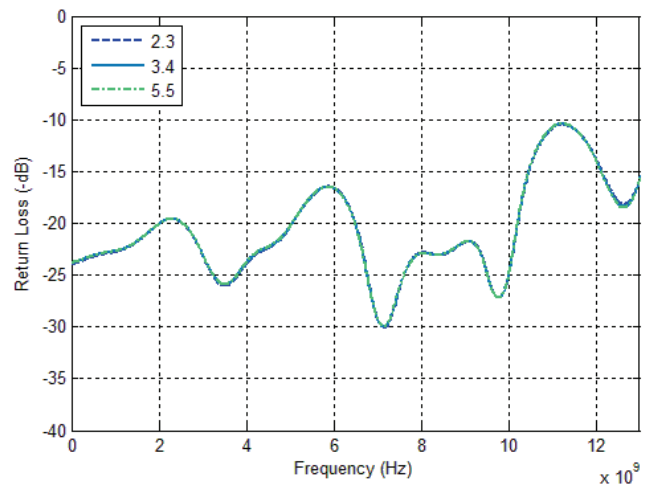


Figure 12. RFC Port Return Loss vs. Temp (RF2 Active)

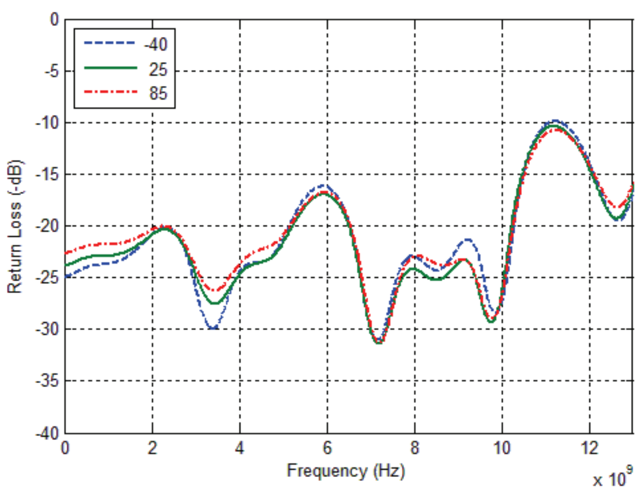
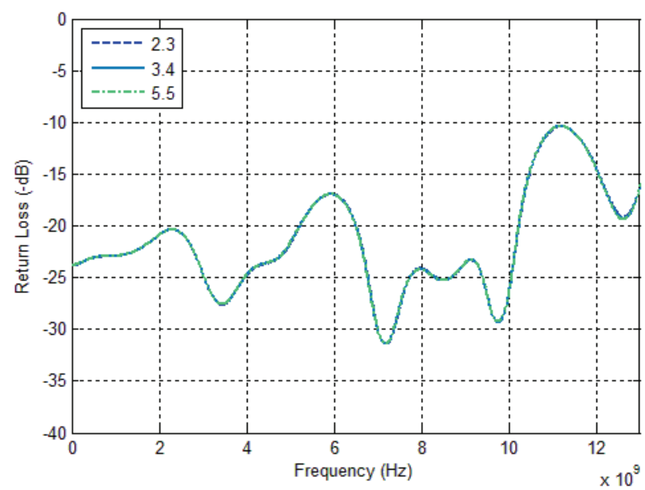


Figure 13. RFC Port Return Loss vs. V_{DD} (RF2 Active)



Typical Performance Data @ 25°C and V_{DD} = 3.4V unless otherwise specified

Figure 14. Active Port Return Loss vs. Temp (RF1 Active)

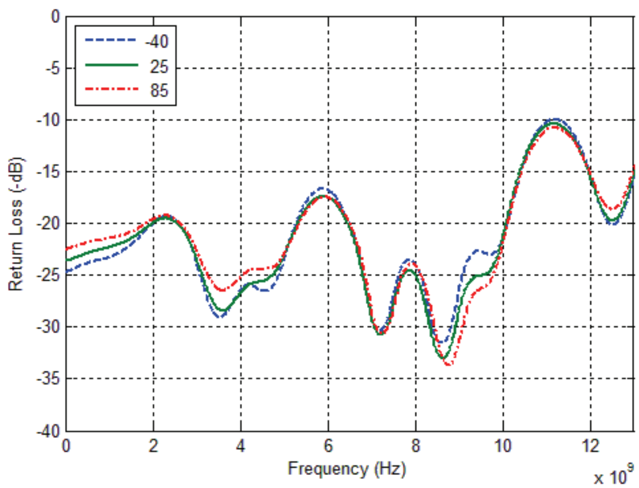


Figure 15. Active Port Return Loss vs. V_{DD} (RF1 Active)

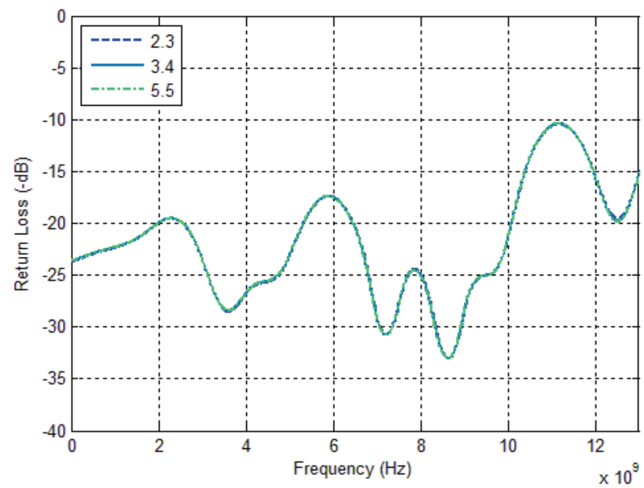


Figure 16. Active Port Return Loss vs. Temp (RF2 Active)

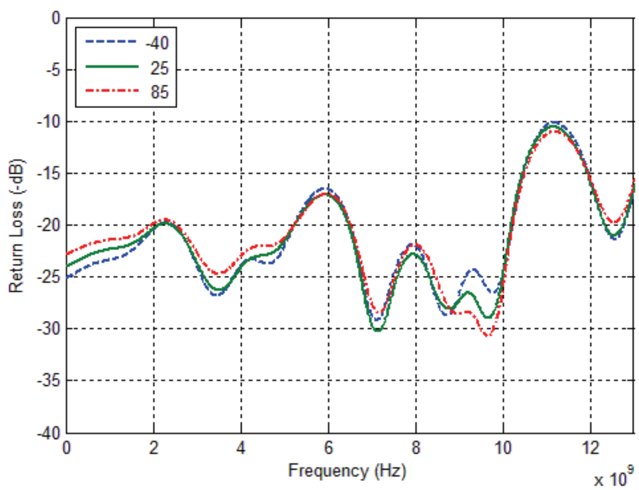
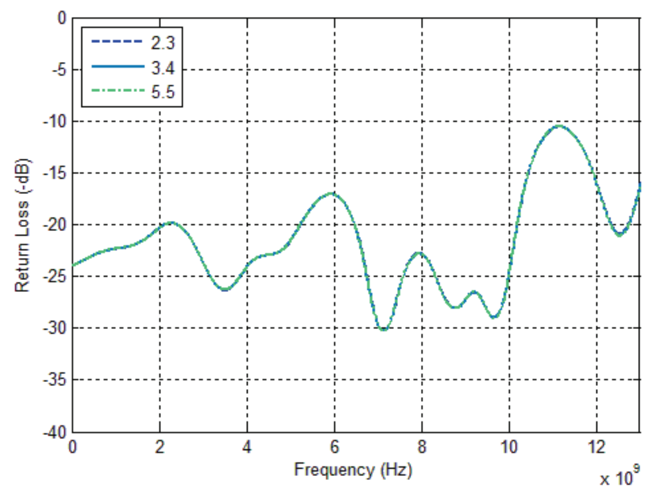


Figure 17. Active Port Return Loss vs. V_{DD} (RF2 Active)



Typical Performance Data @ 25°C and V_{DD} = 3.4V unless otherwise specified

Figure 18. Terminated Port Return Loss vs. Temp (RF1 Active)

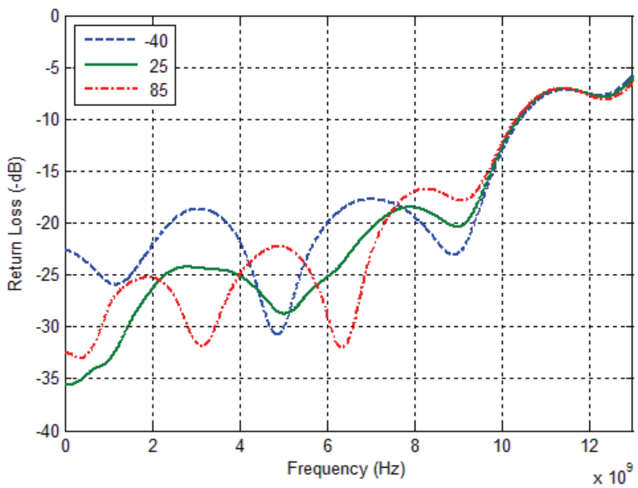


Figure 19. Terminated Port Return Loss vs. V_{DD} (RF1 Active)

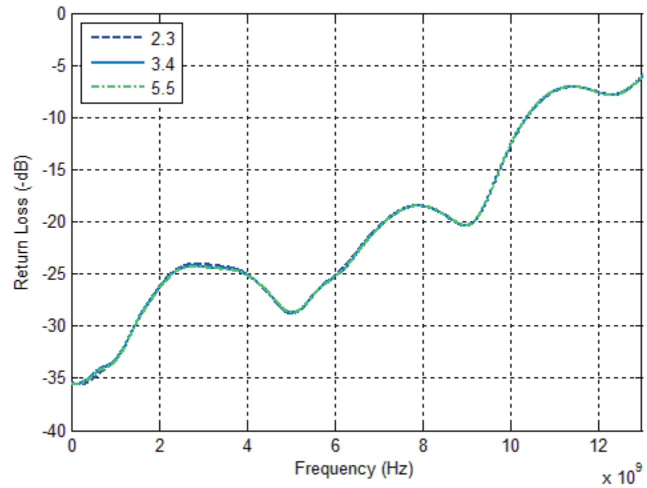


Figure 20. Terminated Port Return Loss vs. Temp (RF2 Active)

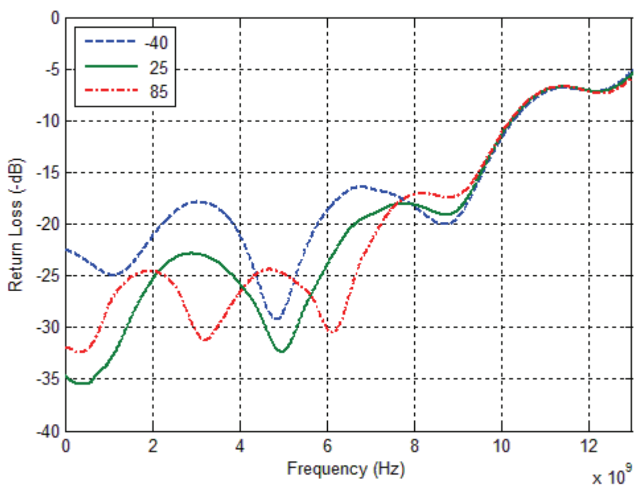
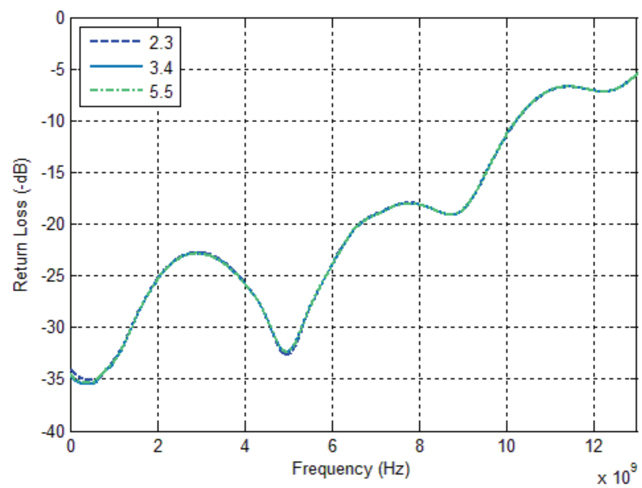


Figure 21. Terminated Port Return Loss vs. V_{DD} (RF2 Active)



Typical Performance Data @ 25°C and V_{DD} = 3.4V unless otherwise specified

Figure 22. Isolation vs. Temp (RF1–RF2, RF1 Active)

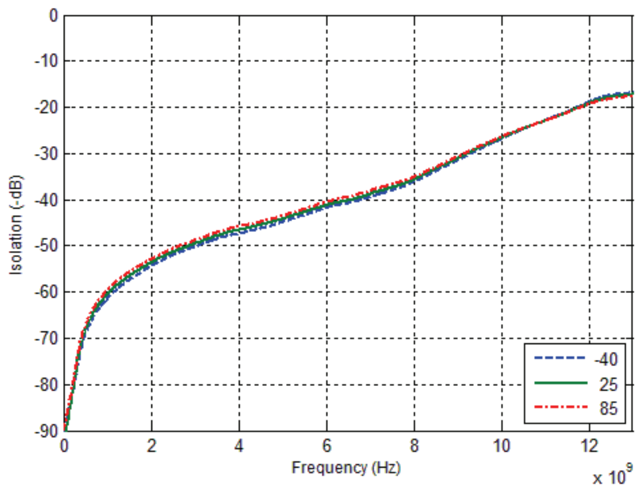


Figure 23. Isolation vs. V_{DD} (RF1–RF2, RF1 Active)

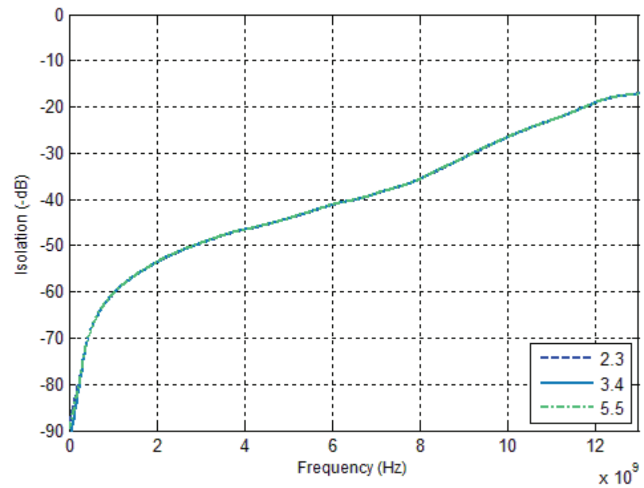


Figure 24. Isolation vs. Temp (RF2–RF1, RF2 Active)

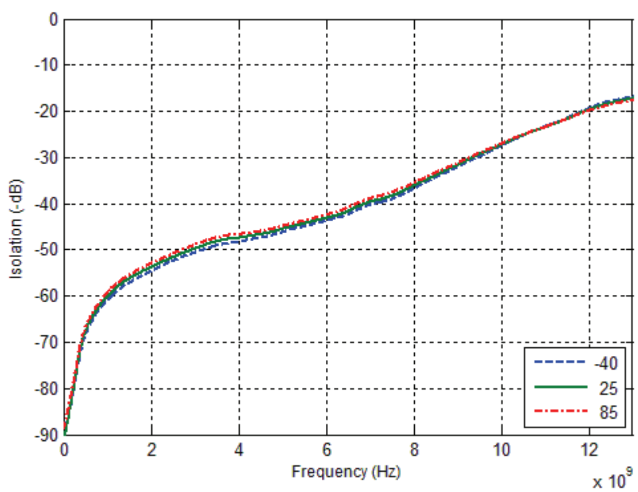
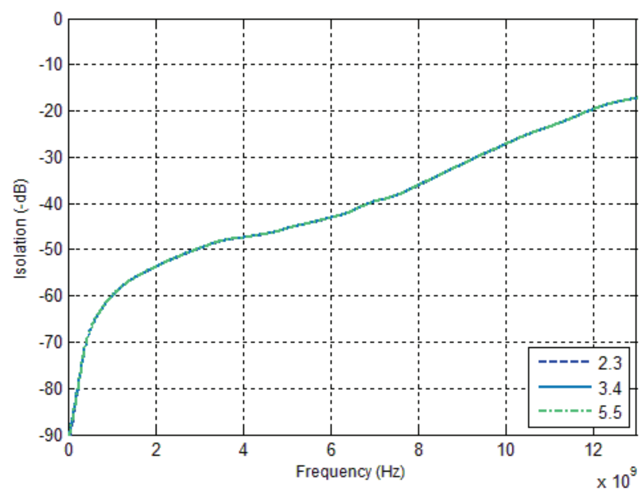


Figure 25. Isolation vs. V_{DD} (RF2–RF1, RF2 Active)



Typical Performance Data @ 25°C and V_{DD} = 3.4V unless otherwise specified

Figure 26. Isolation vs. Temp (RFC–RF2, RF1 Active)

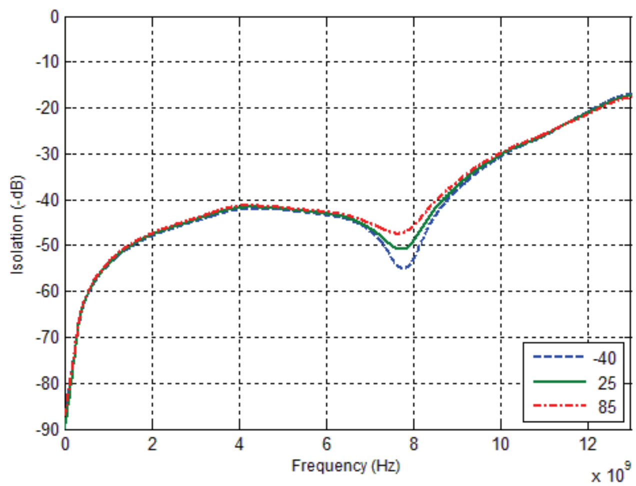


Figure 27. Isolation vs. V_{DD} (RFC–RF2, RF1 Active)

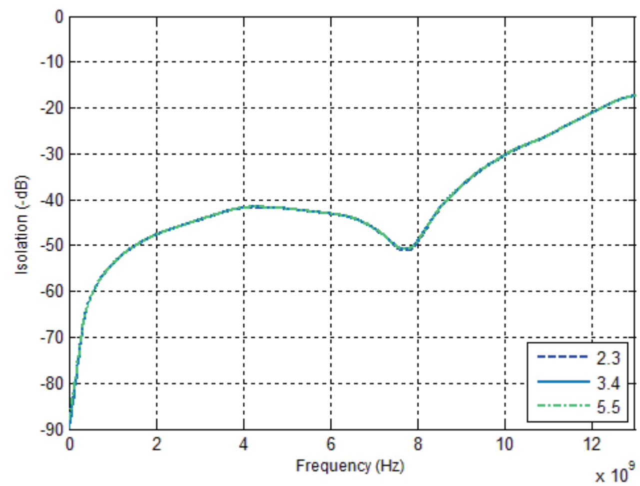


Figure 28. Isolation vs. Temp (RFC–RF1, RF2 Active)

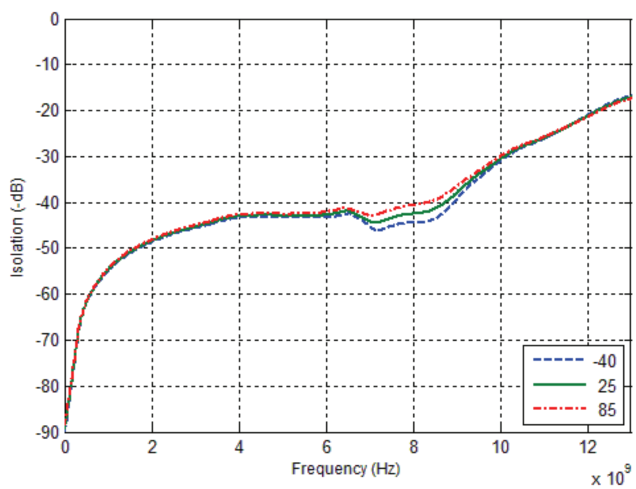
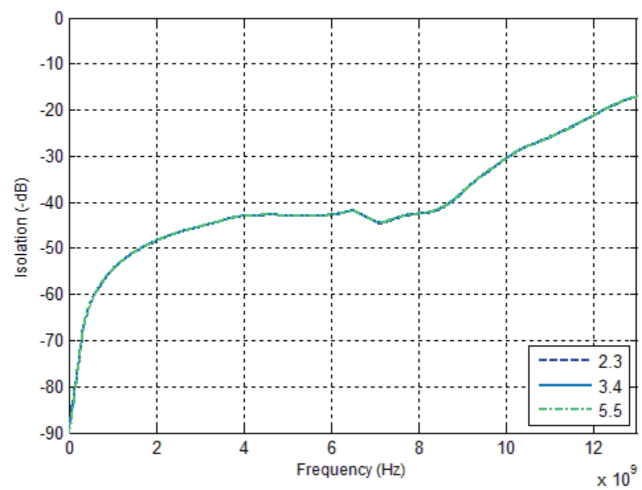


Figure 29. Isolation vs. V_{DD} (RFC–RF1, RF2 Active)

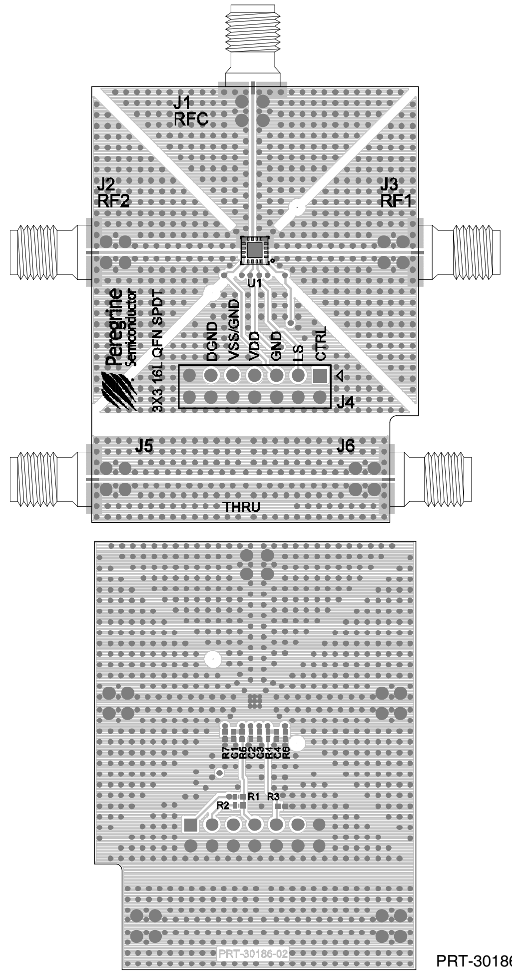


Evaluation Kit

The SPDT switch evaluation board was designed to ease customer evaluation of Peregrine's PE42521. The RF common port is connected through a 50Ω transmission line via the SMA connector, J1. RF1 and RF2 ports are connected through 50Ω transmission lines via SMA connectors J2 and J3, respectively. A 50Ω through transmission line is available via SMA connectors J5 and J6, which can be used to de-embed the loss of the PCB. J4 provides DC and digital inputs to the device.

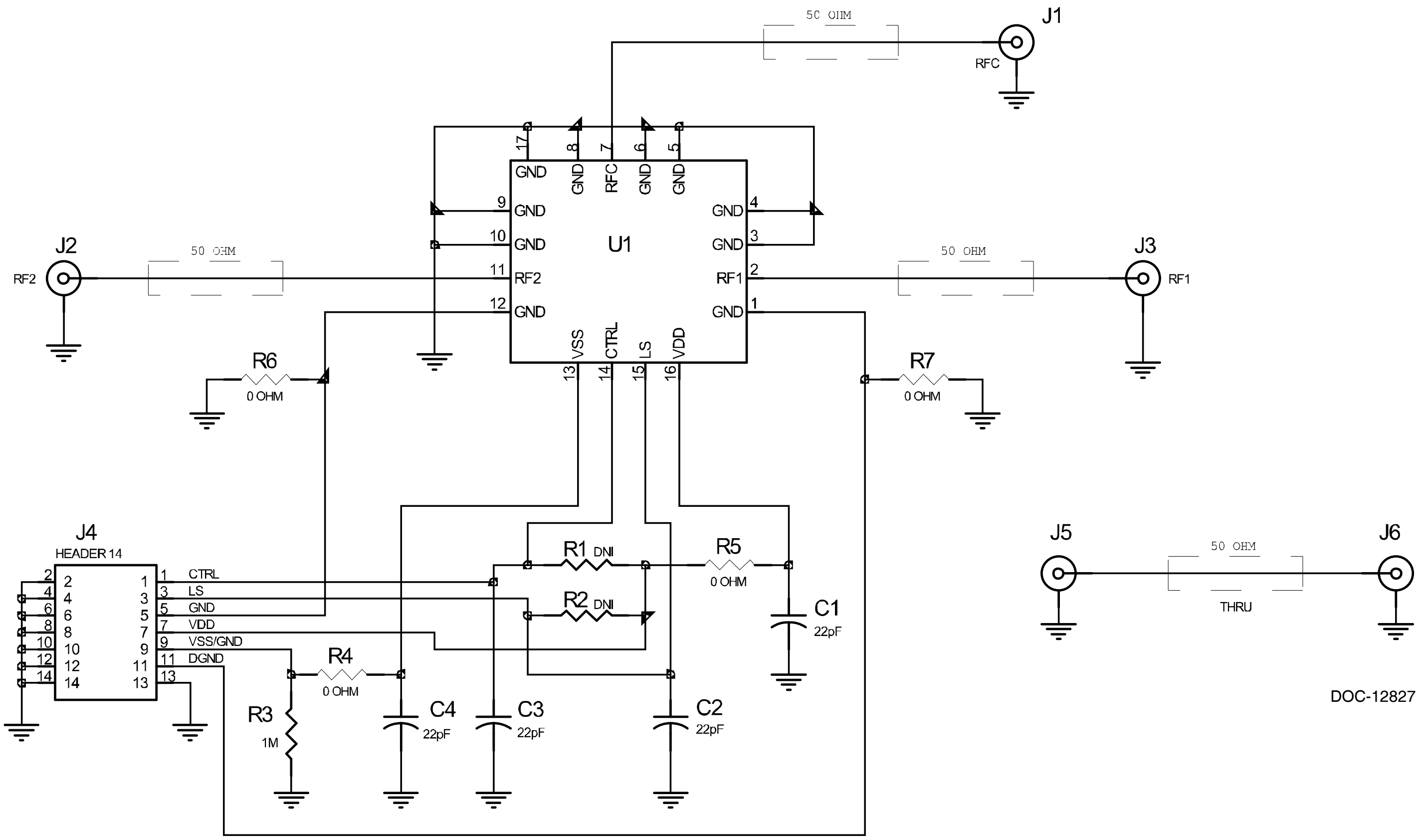
For the true performance of the PE42521 to be realized, the PCB should be designed in such a way that RF transmission lines and sensitive DC I/O traces are heavily isolated from one another.

Figure 30. Evaluation Kit Layout



PRT-30186

Figure 31. Evaluation Board Schematic



Notes: 1. Use PRT-30186-02 PCB
2. CAUTION: Contains parts and assemblies susceptible to damage by electrostatic discharge (ESD)

Figure 32. Package Drawing
16-lead 3x3 mm QFN

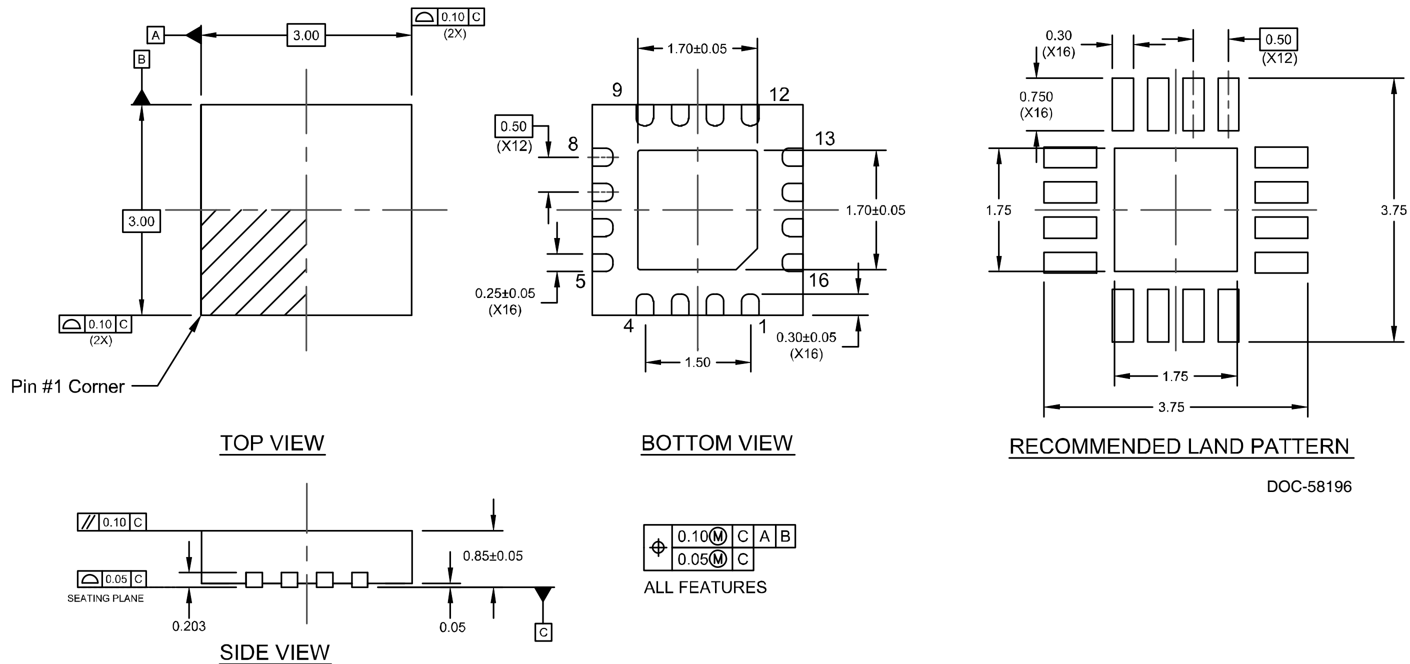
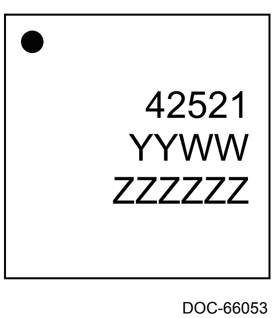
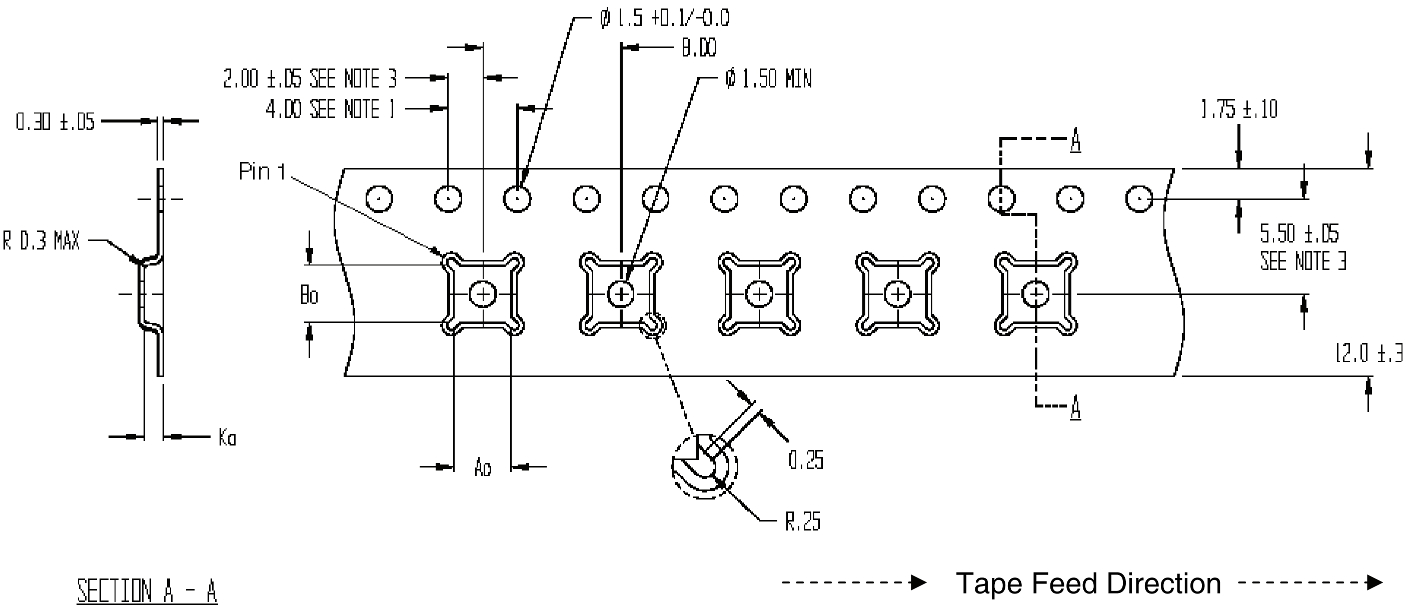


Figure 33. Top Marking Specifications



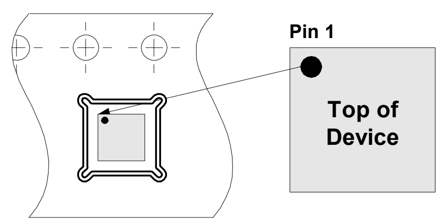
● = Pin 1 designator
YY = Last two digits of assembly year
WW = Assembly work week
ZZZZZZ = Assembly lot code (maximum six characters)

Figure 34. Tape and Reel Specifications



Notes: 1. 10 sprocket hole pitch cumulative tolerance ±0.2
2. Camber in compliance with EIA 481
3. Pocket position relative to sprocket hole measured as true position of pocket, not pocket hole

Ao = 3.30
Bo = 3.30
Ko = 1.10



Device Orientation in Tape

Table 6. Ordering Information

Order Code	Description	Package	Shipping Method
PE42521C-Z	PE42521 SPDT RF switch	Green 16-lead 3x3 mm QFN	3000 units/T&R
EK42521-03	PE42521 Evaluation kit	Evaluation kit	1/Box

Sales Contact and Information

For sales and contact information please visit www.psemi.com.