PE42522

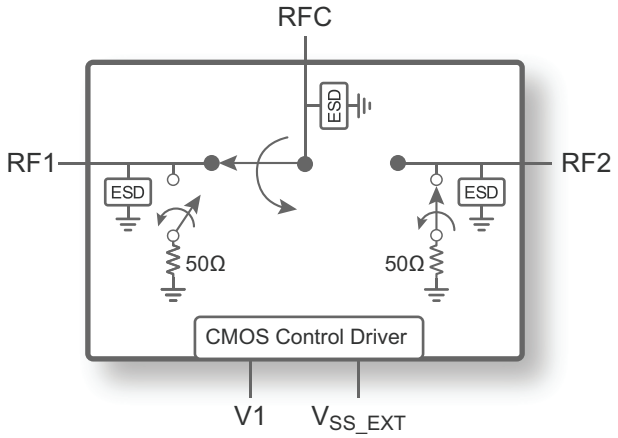
Document Category: Product Specification

UltraCMOS® SPDT RF Switch, 9 kHz–26.5 GHz

Features

- Broad frequency support from 9 kHz to 26.5 GHz
- High port-to-port isolation:
  - 63 dB @ 3 GHz
  - 58 dB @ 7.5 GHz
  - 39 dB @ 13.5 GHz
  - 28 dB @ 20 GHz
  - 22 dB @ 26.5 GHz
- HaRP™ technology enhanced:
  - Fast settling time
  - No gate and phase lag
  - No drift in insertion loss and phase
- Improved high frequency insertion loss and return loss performance with external matching
- High ESD performance: 3.0 kV HBM on all pins
- Packaging: 29-lead 4 × 4 × 0.91 mm LGA

Figure 1 ▪ PE42522 functional diagram



Applications

- Test and measurement
- Microwave backhaul
- Radar

Product description

The PE42522 is a HaRP™ technology-enhanced absorptive SPDT RF switch that supports a broad frequency range from 9 kHz to 26.5 GHz. This broadband general-purpose switch offers excellent isolation, high linearity performance, and exceptional settling time, making this device ideal for many broadband wireless applications. No blocking capacitors are required if no DC voltage is present on the RF ports.

The PE42522 is manufactured on pSemi's UltraCMOS® process, a patented variation of silicon-on-insulator (SOI) technology on a sapphire substrate.

pSemi's HaRP technology enhancements deliver high linearity and excellent harmonics performance. It is an innovative feature of the UltraCMOS process, offering the performance of GaAs with the economy and integration of conventional CMOS.

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Optional external V_{SS} control

For proper operation, the V_{SS_EXT} control pin must be grounded or tied to the V_{SS} voltage specified in **Table 2**. When the V_{SS_EXT} control pin is grounded, the FETs in the switch are biased with an internal negative voltage generator. For applications that require the lowest possible spur performance, V_{SS_EXT} can be applied externally to bypass the internal negative voltage generator.

Absolute maximum ratings

Exceeding the absolute maximum ratings listed in **Table 1** could cause permanent damage. Restrict operation to the limits in **Table 2**. Operation between the operating range maximum and the absolute maximum for extended periods could reduce reliability.

ESD precautions

When handling this UltraCMOS device, observe the same precautions as with any other ESD-sensitive devices. Although this device contains circuitry to protect it from damage due to ESD, do not exceed the rating specified in **Table 1**.

Latch-up immunity

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

Table 1 ▪ PE42522 absolute maximum ratings

Parameter/Condition	Min	Max	Unit
Supply voltage, V_{DD}	–0.3	5.5	V
Digital input voltage, V1	–0.3	3.6	V
RF input power, CW (RFC–RFx)[1] 9 kHz–2.89 MHz >2.89 MHz–18 GHz >18–26.5 GHz	–	**Fig. 2, Fig. 3** 33 **Fig. 4**	 dBm dBm dBm
RF input power, pulsed (RFC–RFx)[2] 9 kHz–2.89 MHz >2.89 MHz–18 GHz >18–26.5 GHz	–	**Fig. 2, Fig. 3** 34 **Fig. 4**	 dBm dBm dBm
RF input power into terminated ports, CW (RFx)[1] 9 kHz–1.39 MHz >1.39 MHz–18 GHz >18–26.5 GHz	–	**Fig. 2, Fig. 3** 22 **Fig. 4**	 dBm dBm dBm
Storage temperature range	–65	+150	°C
ESD voltage HBM, all pins[3]	–	3000	V
ESD voltage MM, all pins[4]	–	150	V
ESD voltage CDM, all pins[5]	–	500	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).

Recommended operating conditions

Table 2 lists the PE42522 recommending operating condition. Do not operate devices outside the recommended operating conditions listed below.

Table 2 ▪ PE42522 recommended operating conditions

Parameter	Min	Typ	Max	Unit
Normal mode (V_{SS_EXT} = 0V)[1]				
Supply voltage, V_{DD}	2.3	–	5.5	V
Supply current, I_{DD}	–	120	200	µA
Bypass mode (V_{SS_EXT} = –3.4V)[2]				
Supply voltage, V_{DD} (V_{DD} ≥3.4V for Table 3 full specification compliance)	2.7	3.4	5.5	V
Supply current, I_{DD}	–	50	80	µA
Negative supply voltage, V_{SS_EXT}	–3.6	–	–3.2	V
Negative supply current, I_{SS}	–40	–16	–	µA
Normal or bypass mode				
Digital input high, V1	1.17	–	3.6	V
Digital input low, V1	–0.3	–	0.6	V
RF input power, CW (RFC–RFx)[3] 9 kHz–2.89 MHz >2.89 MHz–18 GHz >18–26.5 GHz	–	–	 Fig. 2, Fig. 3 30 Fig. 4	dBm
RF input power, pulsed (RFC–RFx)[4] 9 kHz–2.89 MHz >2.89 MHz–18 GHz >18–26.5 GHz	–	–	 Fig. 2, Fig. 3 32 Fig. 4	dBm
RF input power into terminated ports, CW (RFx)[3] 9 kHz–1.39 MHz >1.39 MHz–18 GHz >18–26.5 GHz	–	–	 Fig. 2, Fig. 3 20 Fig. 4	dBm
Operating temperature range, T_{OP}	–40	+25	+85	°C

Notes:

1) Normal mode: connect V_{SS_EXT} (pin 29) to GND (V_{SS_EXT} = 0V) to enable internal negative voltage generator.
2) Bypass mode: use V_{SS_EXT} (pin 29) 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.

Electrical specifications

Table 3 lists the PE42522 key electrical specifications at 25 °C (Z_S = Z_L = 50Ω), unless otherwise specified.

- Normal mode[1] is at V_{DD} = 3.3V and V_{SS_EXT} = 0V.
- Bypass mode[2] is at V_{DD} = 3.4V and V_{SS_EXT} = –3.4V.

Table 3 ▪ PE42522 electrical specifications

Parameter	Path	Condition	Min	Typ	Max	Unit
Operating frequency	–	–	9 kHz	–	26.5 GHz	As shown
Insertion loss[3]	RFC–RFx	9 kHz–10 MHz 10–3000 MHz 3000–7500 MHz 7500–10000 MHz 10000–13500 MHz 13500–18000 MHz 18000–20000 MHz 20000–24000 MHz 24000–26500 MHz	–	0.70 1.05 1.15 1.70 1.70 2.55 3.20 4.50 5.30	0.85 1.40 1.50 2.15 2.40 3.25 4.50 5.80 6.95	dB
Isolation	RFx–RFx	9 kHz–10 MHz 10–3000 MHz 3000–7500 MHz 7500–10000 MHz 10000–13500 MHz 13500–18000 MHz 18000–20000 MHz 20000–24000 MHz 24000–26500 MHz	70 62 48 42 36 26 23 19 18	80 64 50 44 38 28 25 21 20	–	dB
	RFC–RFx	9 kHz–10 MHz 10–3000 MHz 3000–7500 MHz 7500–10000 MHz 10000–13500 MHz 13500–18000 MHz 18000–20000 MHz 20000–24000 MHz 24000–26500 MHz	65 61 55 48 37 28 26 21 19	73 63 58 51 39 30 28 23 22	–	dB
Return loss (active port)[3]	RFC–RFx	9 kHz–10 MHz 10–3000 MHz 3000–7500 MHz 7500–10000 MHz 10000–13500 MHz 13500–18000 MHz 18000–20000 MHz 20000–24000 MHz 24000–26500 MHz	–	23 18 16 15 20 13 7 5 6	–	dB

Table 3 ▪ PE42522 electrical specifications (cont.)

Parameter	Path	Condition	Min	Typ	Max	Unit
Return loss (RFC port)[3]	RFC–RFx	9 kHz–10 MHz 10–3000 MHz 3000–7500 MHz 7500–10000 MHz 10000–13500 MHz 13500–18000 MHz 18000–20000 MHz 20000–24000 MHz 24000–26500 MHz	–	23 19 27 27 20 23 10 6 7	–	dB
Return loss (off port)	All ports	9 kHz–10 MHz 10–3000 MHz 3000–7500 MHz 7500–10000 MHz 10000–13500 MHz 13500–18000 MHz 18000–20000 MHz 20000–24000 MHz 24000–26500 MHz	–	30 23 15 13 14 8 6 3 2	–	dB
Input 0.1dB compression point[4]	RFC–RFx	–	–	Fig. 2 Fig. 3 Fig. 4	–	dBm
Input IP2	RFC–RFx	10–18000 MHz	–	121	–	dBm
Input IP3	RFC–RFx	10–18000 MHz	–	59	–	dBm
Settling time	–	50% CTRL to 0.05 dB final value	–	7	10	µs
Switching time	–	50% CTRL to 90% or 10% of RF	–	3	4.5	µs

Notes:

1) Normal mode: connect V_{SS_EXT} (pin 29) to GND (V_{SS_EXT} = 0V) to enable the internal negative voltage generator.
2) Bypass mode: use V_{SS_EXT} (pin 29) to bypass and disable the internal negative voltage generator.
3) High frequency performance can be improved by external matching. See **Figure 19–Figure 21**.
4) The input 0.1dB compression point is a linearity figure of merit. For the RF input power (50Ω), see **Table 2**.

Switching frequency

The PE42522 has a maximum 25 kHz switching rate in normal mode (pin 29 tied to ground). A faster switching rate is available in bypass mode, with pin 29 tied to V_{SS_EXT}. The rate at which the PE42522 can be switched is then limited to the switching time as specified in **Table 3**.

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

Spur-free performance

The PE42522 typical spurious performance in normal mode is –125 dBm with V_{SS_EXT} (pin 29) tied to ground. For spur-free performance, disable the internal negative voltage generator by applying a negative voltage to V_{SS_EXT} (pin 29).

Hot-switching capability

The PE42522 maximum hot-switching capability is 20 dBm from 1.4 MHz to 18 GHz. The maximum hot-switching capability below 1.4 MHz and above 18 GHz does not exceed the maximum RF CW terminated power. See **Figure 2**–**Figure 4**. Hot switching occurs when the RF power is applied while switching between the RF ports.

Control logic

Table 4 lists the PE42522 control logic truth table.

Table 4 ▪ PE42522 truth table

State	V1
RF1 ON	0
RF2 ON	1

Figure 2 ▪ Power de-rating curve (9 kHz–18 GHz) @ 25 °C ambient (50Ω)

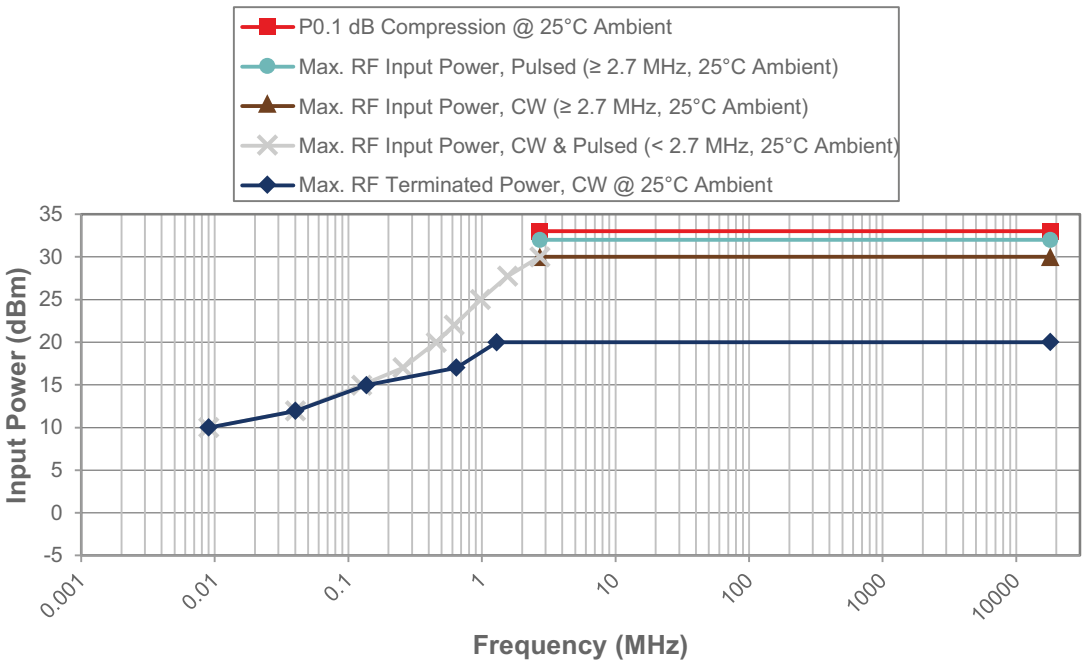


Figure 3 ▪ Power de-rating curve (9 kHz–18 GHz) @ 85 °C ambient (50Ω)

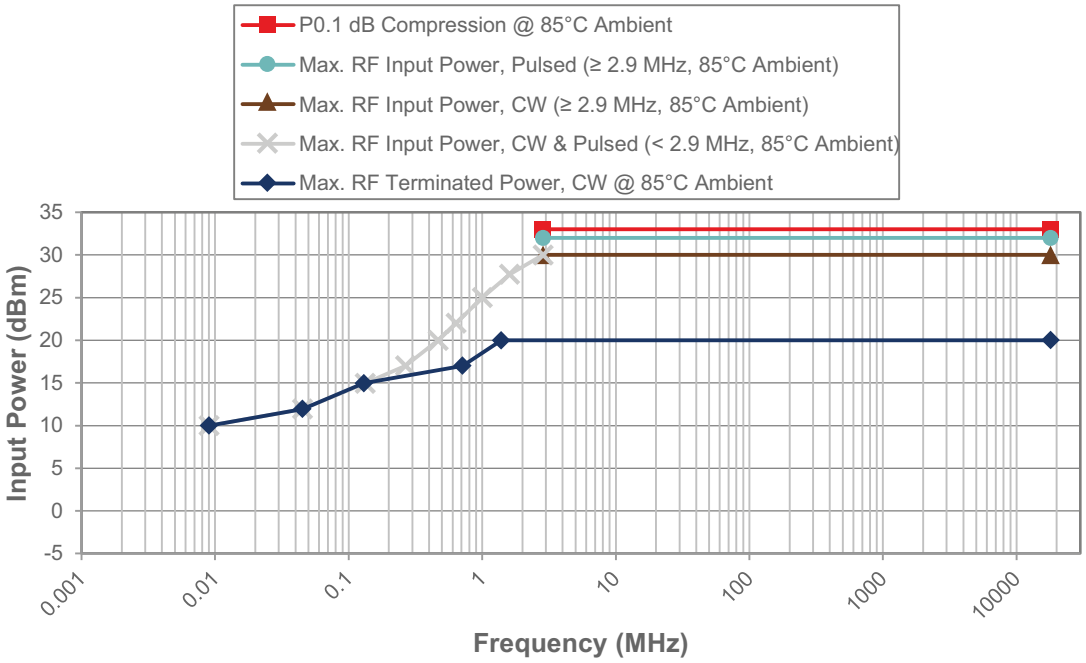
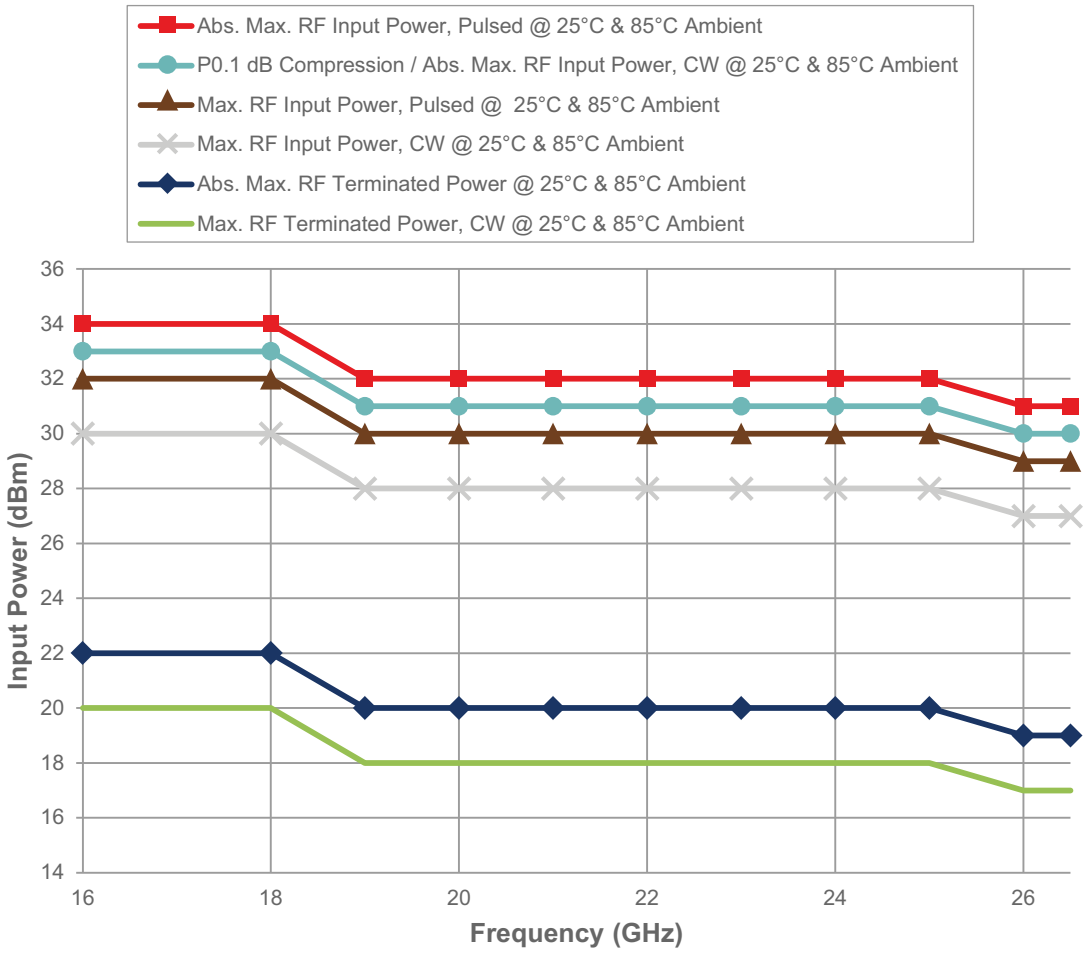


Figure 4 ▪ Power de-rating curve (16–26.5 GHz) @ 25 °C and 85 °C ambient (50Ω)



Typical performance data

Figure 5–Figure 17 show the typical performance data at 25 °C and V_{DD} = 3.3V (Z_S = Z_L = 50Ω), unless otherwise specified.

Figure 5 ▪ Insertion loss (RFC–RFx)[*]

Note: * High frequency performance can be improved by external matching (see **Figure 19–Figure 21**).

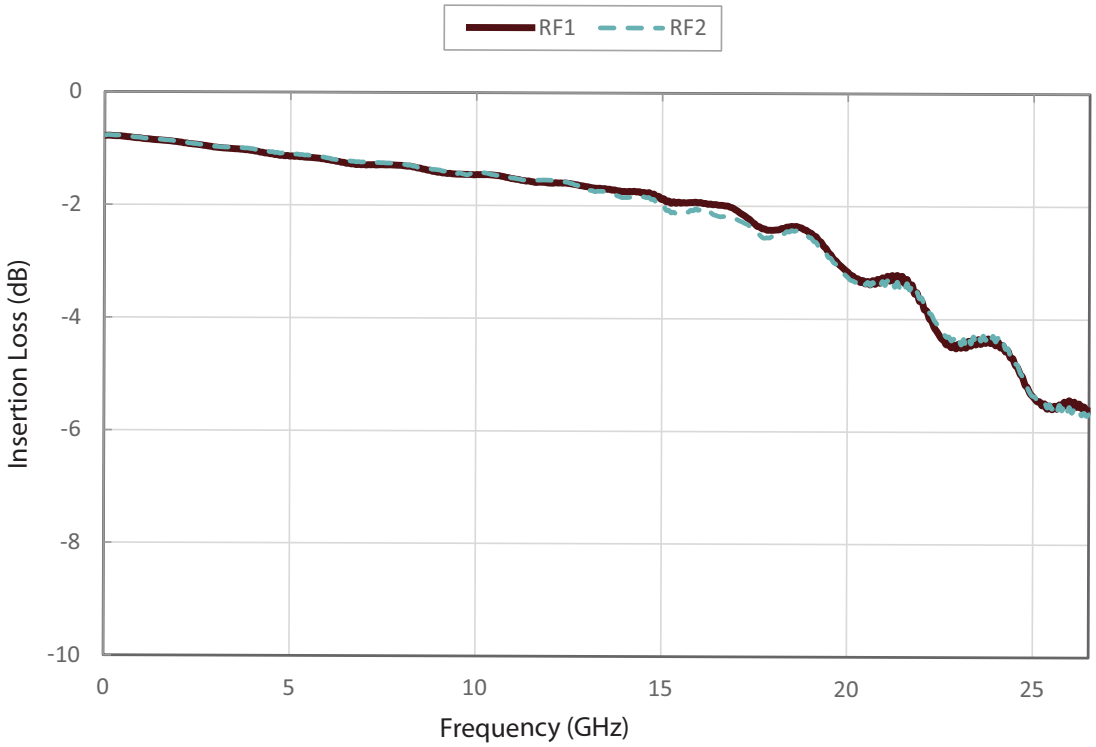


Figure 6 ▪ Insertion loss vs. temperature (RFC–RFx)(*)

Note: * High frequency performance can be improved by external matching (see **Figure 19–Figure 21**).

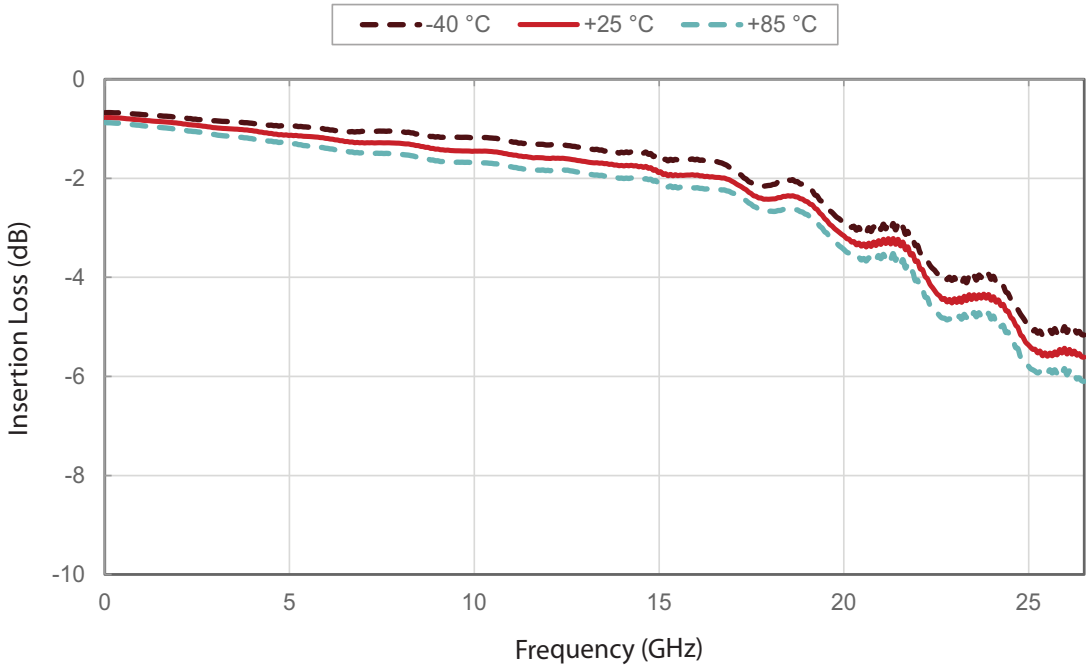


Figure 7 ▪ Insertion loss vs. V_{DD} (RFC–RFx)(*)

Note: * High frequency performance can be improved by external matching (see **Figure 19–Figure 21**).

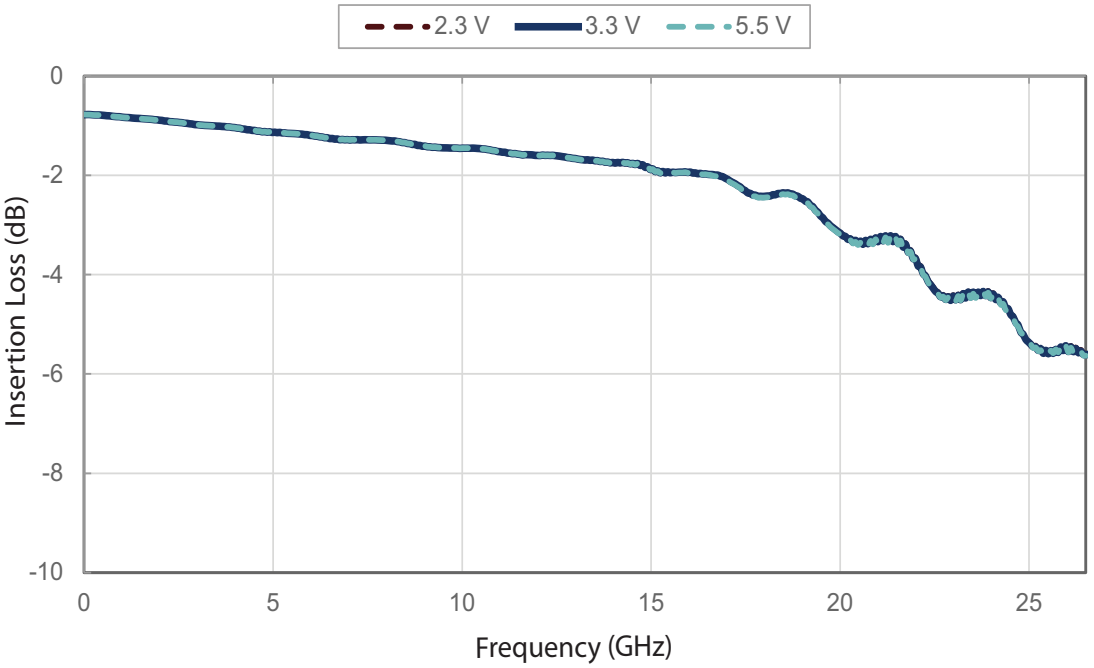


Figure 8 ▪ RFC port return loss vs. temperature(*)

Note: * High frequency performance can be improved by external matching (see Figure 19–Figure 21).

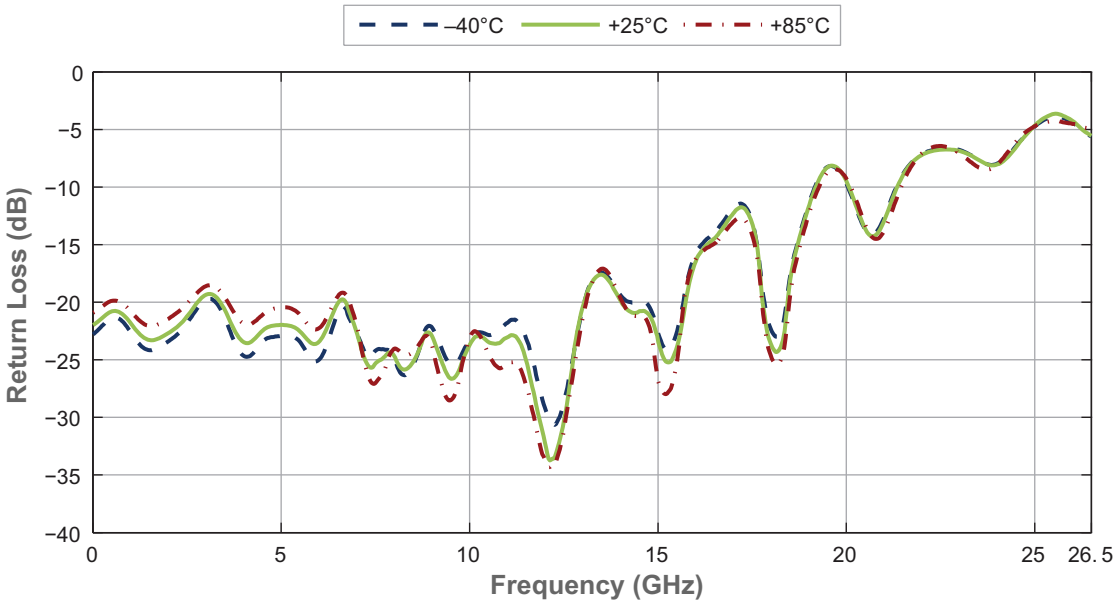


Figure 9 ▪ RFC port return loss vs. V_{DD}(*)

Note: * High frequency performance can be improved by external matching (see Figure 19–Figure 21).

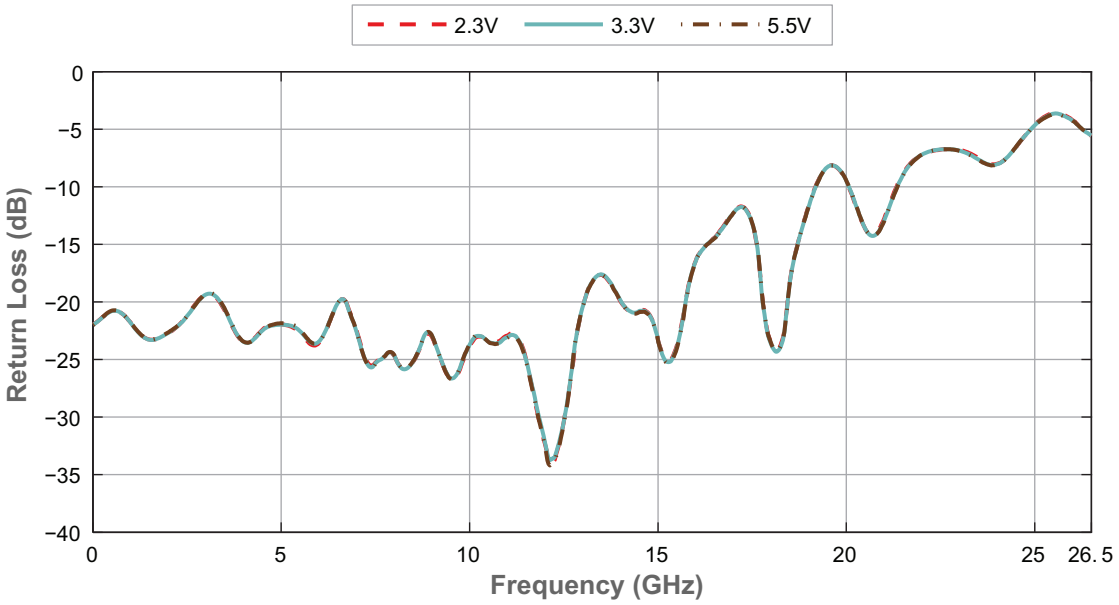


Figure 10 ▪ Active port return loss vs. temperature(*)

Note: * High frequency performance can be improved by external matching (see Figure 19–Figure 21).

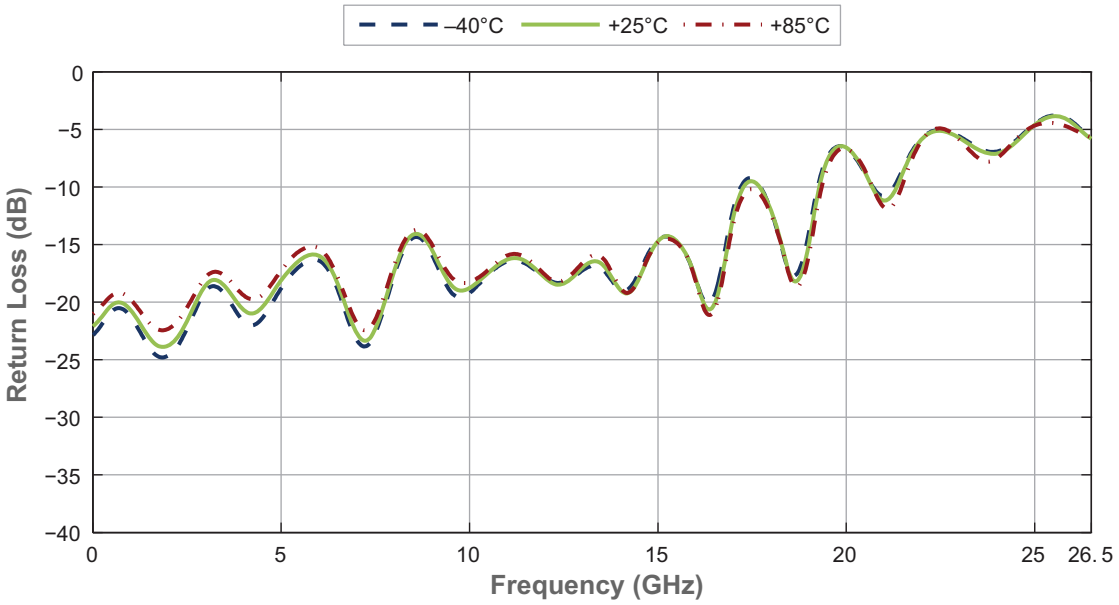


Figure 11 ▪ Active port return loss vs. V_{DD}(*)

Note: * High frequency performance can be improved by external matching (see Figure 19–Figure 21).

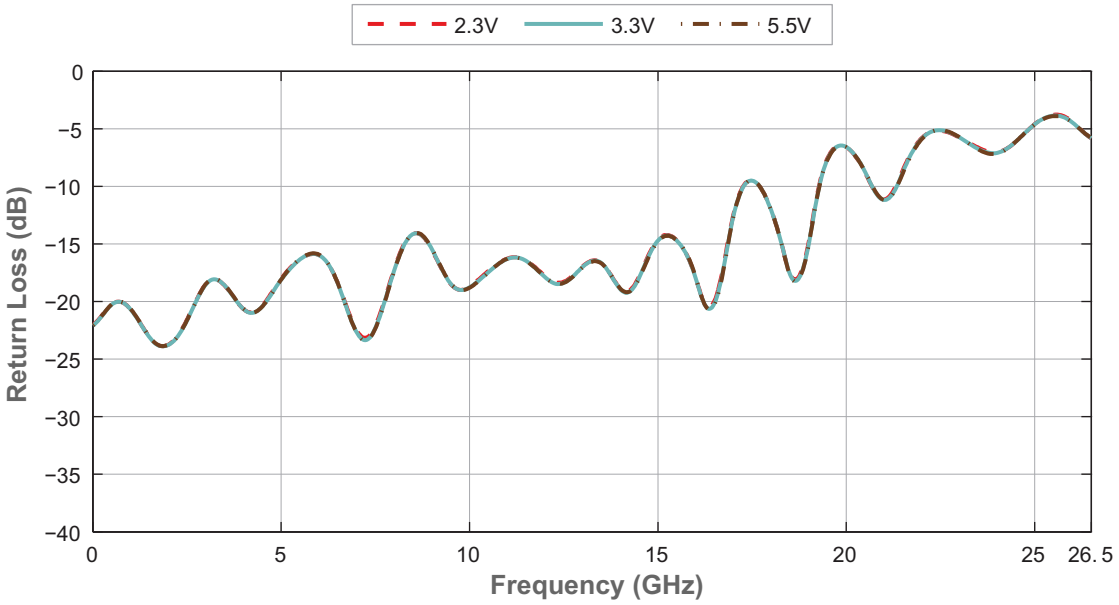


Figure 12 ▪ Terminated port return loss vs. temperature

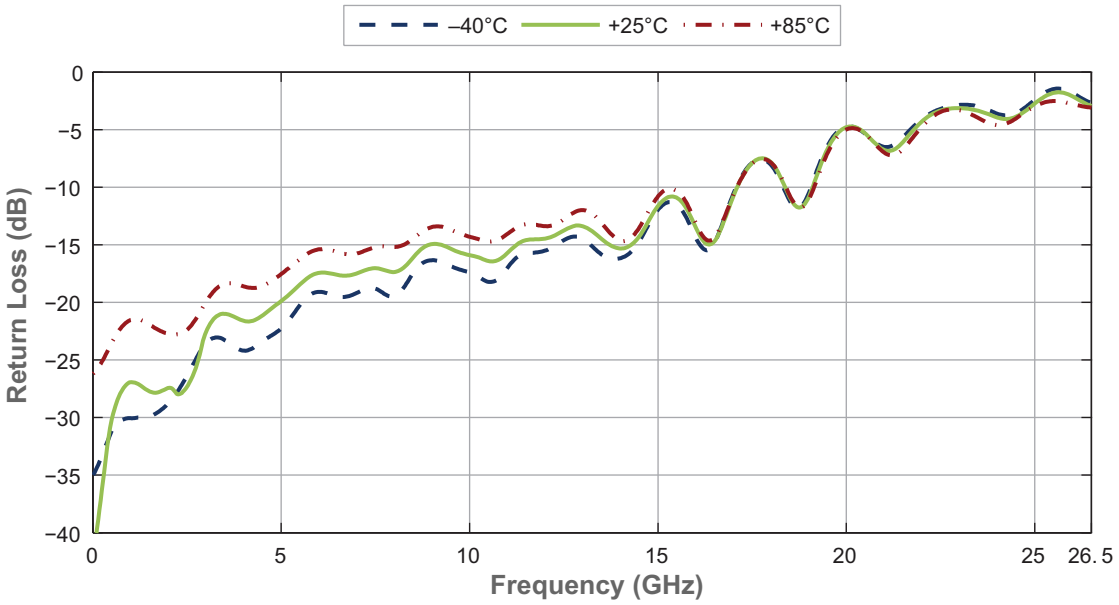


Figure 13 ▪ Terminated port return loss vs V_{DD}

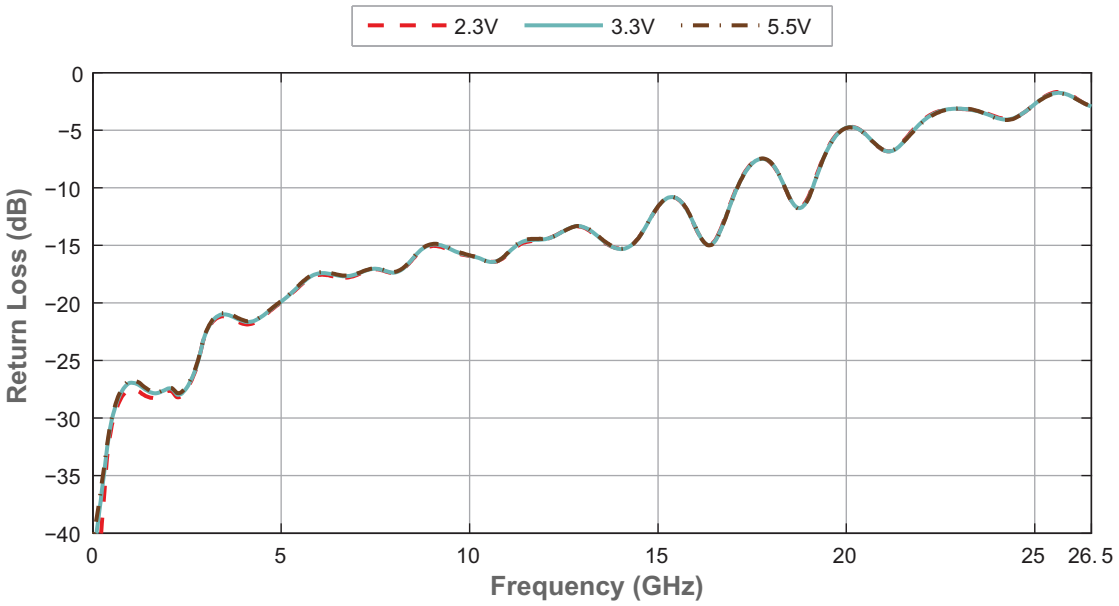


Figure 14 ▪ Isolation vs. temperature (RFx–RFx)

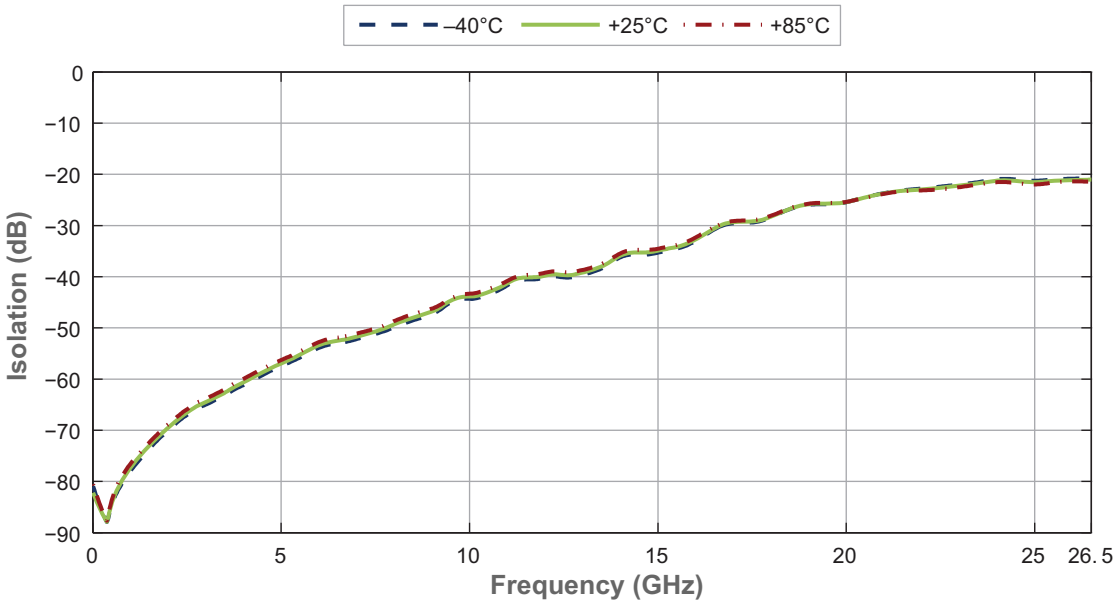


Figure 15 ▪ Isolation vs. V_{DD} (RFx–RFx)

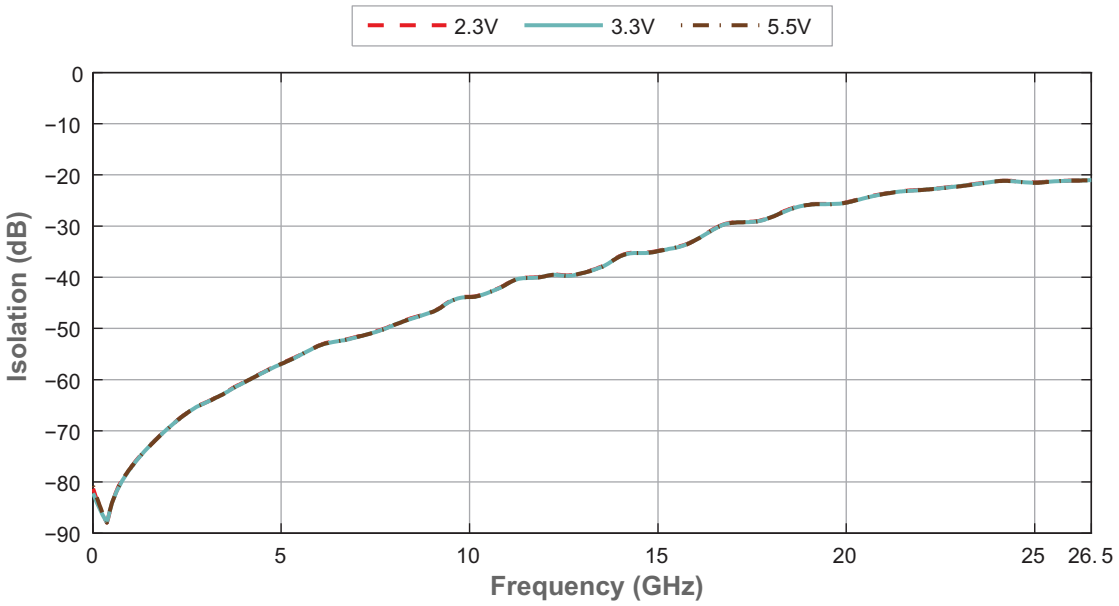


Figure 16 ▪ Isolation vs. temperature (RFC–RFx)

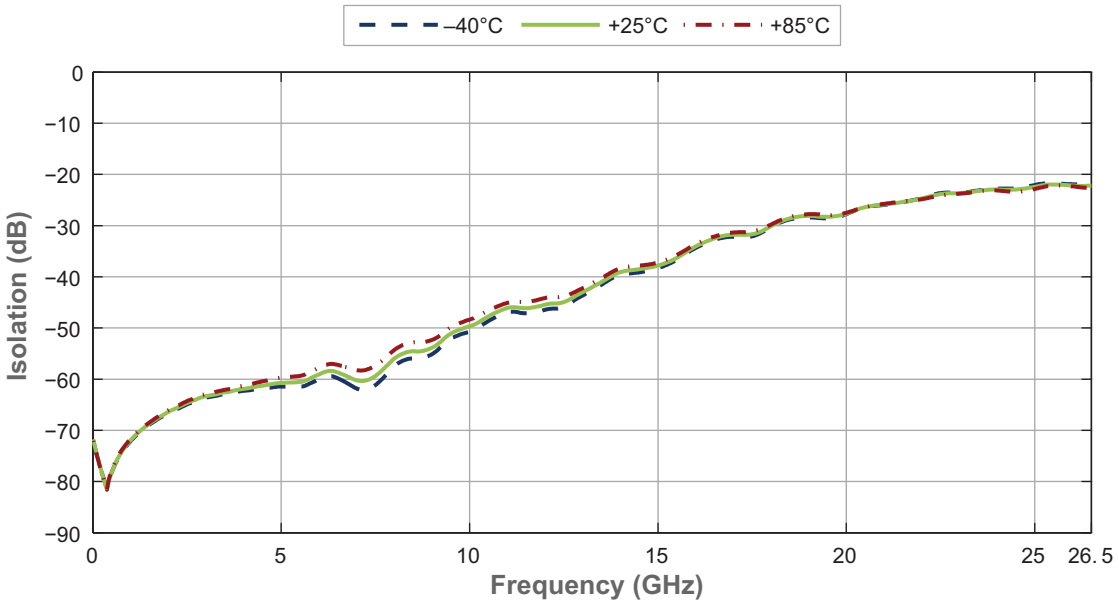
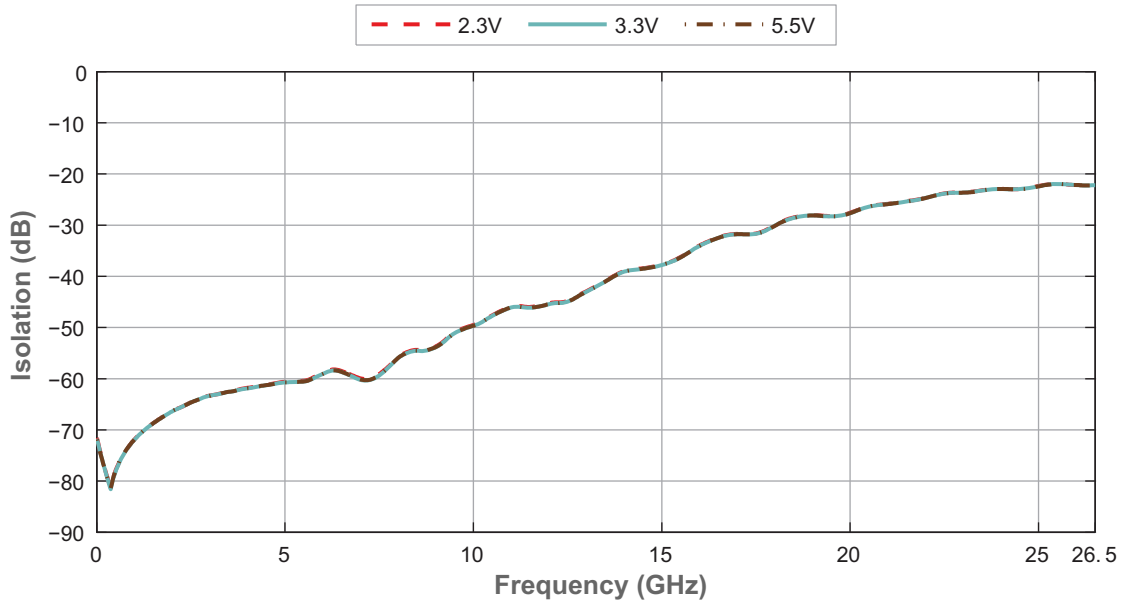


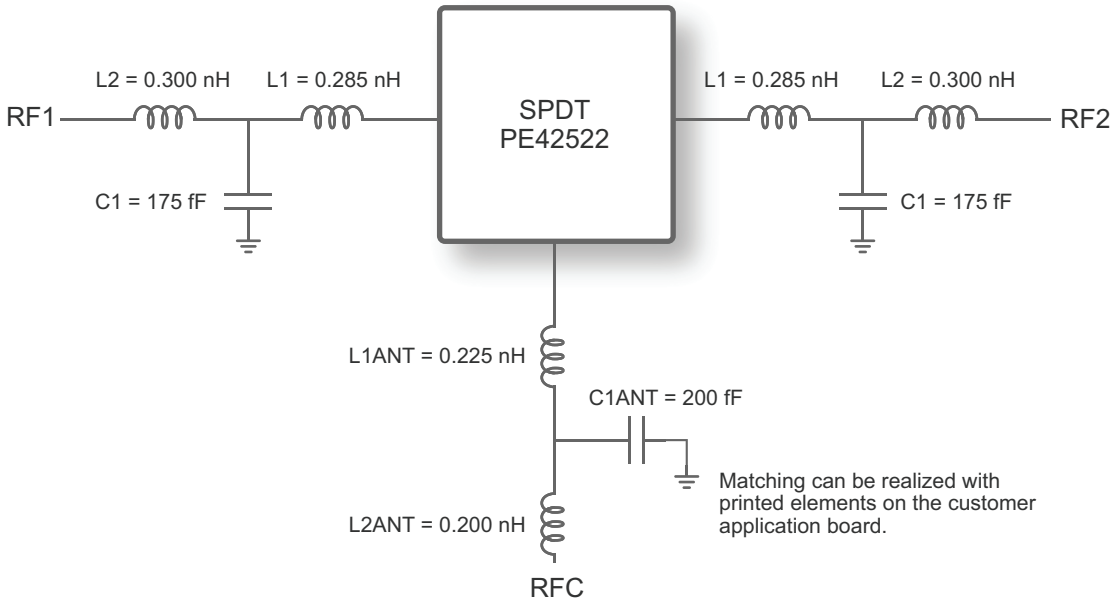
Figure 17 ▪ Isolation vs. V_{DD} (RFC–RFx)



High-frequency performance with external matching

To improve high-frequency insertion loss and return loss, use external tuning traces in the application board layout. **Figure 18** shows a sample matching network using ideal elements. **Figure 19–Figure 21** show the simulated insertion loss and return loss improvement using the matching network.

Figure 18 ▪ PE42522 matching network



For additional information on high-frequency performance with external matching, see Application Note 41, *PE42522 High Frequency Performance Improvement Through Narrowband Matching*.

Figure 19 ▪ Insertion loss (RFC–RFx) with or without matching(*)

Note: * For reference only.

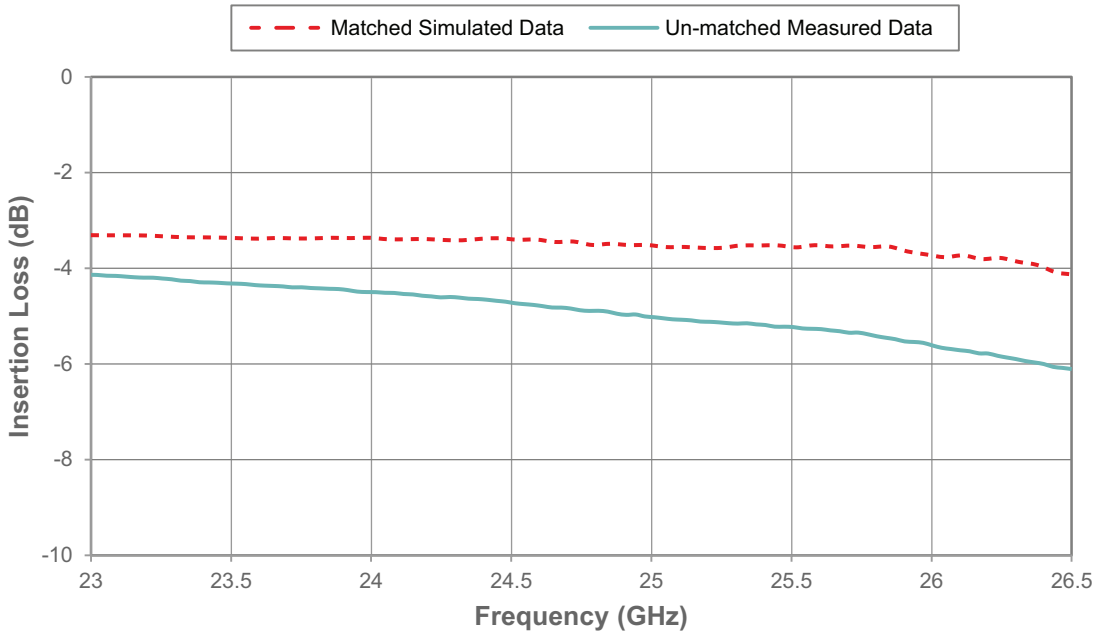


Figure 20 ▪ Active port return loss with or without matching(*)

Note: * For reference only.

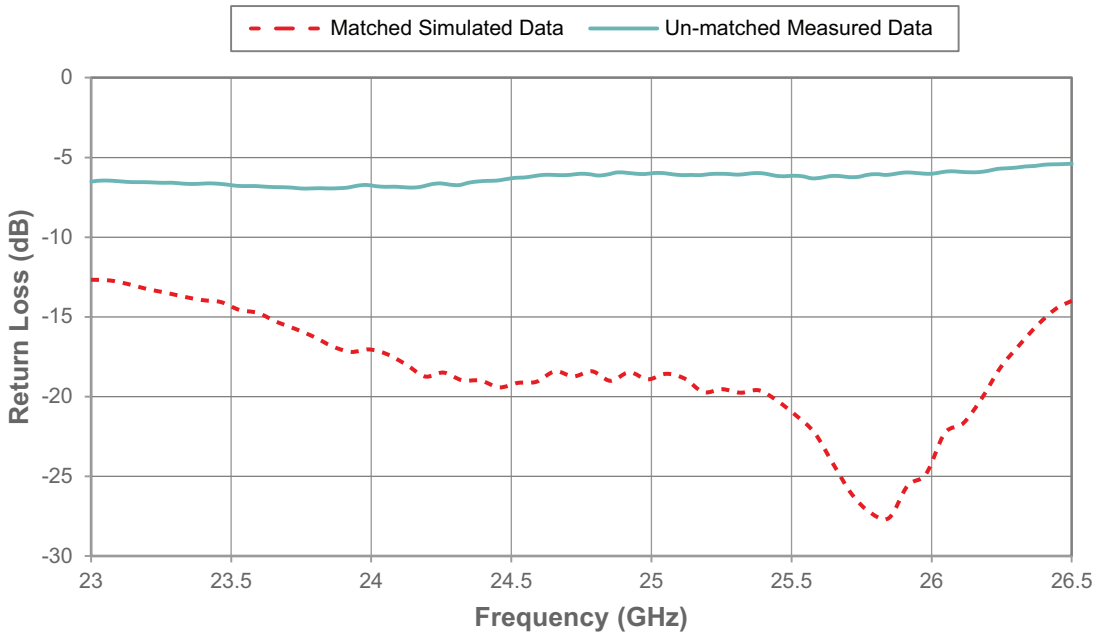
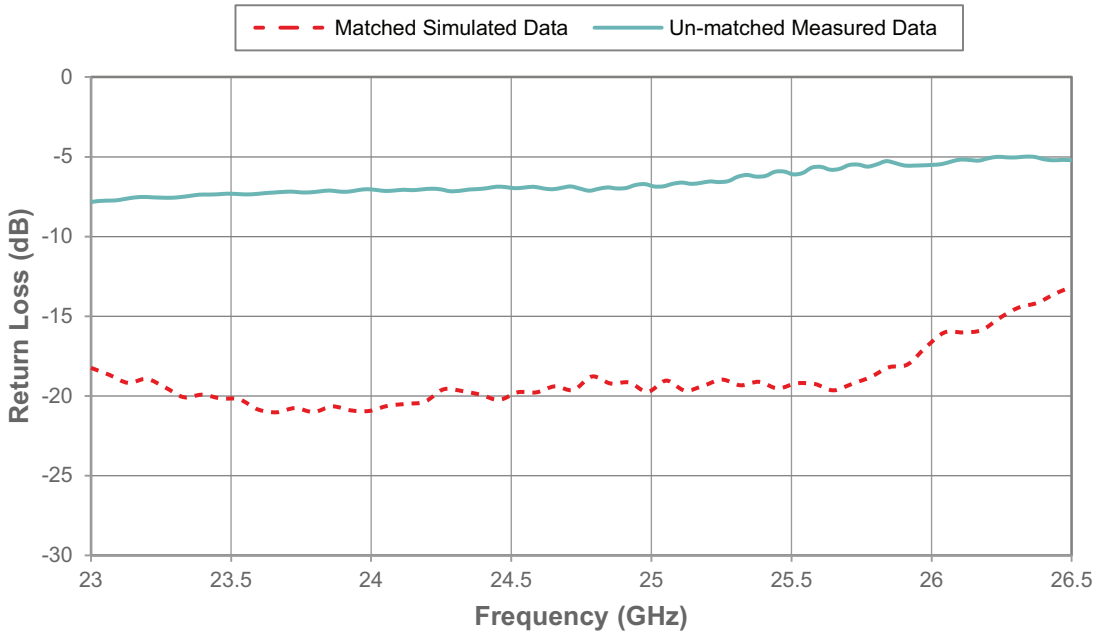


Figure 21 ▪ RFC port return loss with or without matching(*)

Note: * For reference only.



Evaluation kit

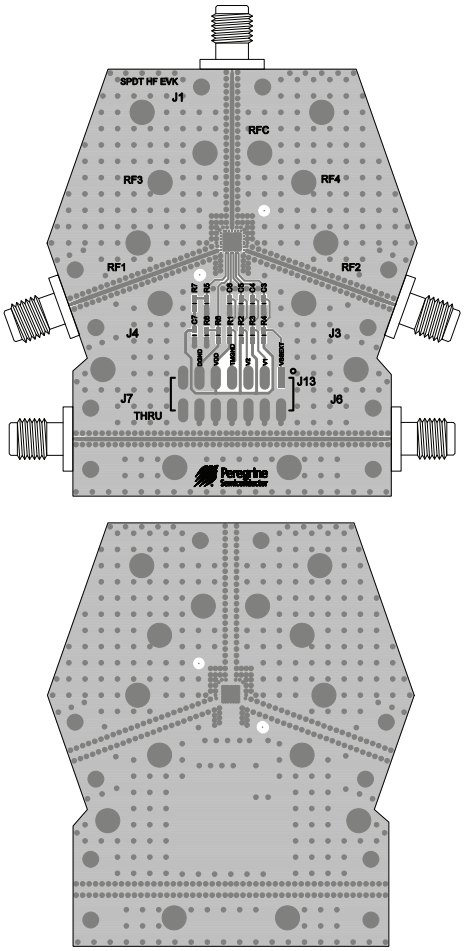
pSemi designed the SPDT switch evaluation board to ease your evaluation of pSemi's PE42522. The RF common port connects through a 50Ω transmission line via the SMA connector, J1. The RF1 and RF2 ports connect through 50Ω transmission lines via SMA connectors J4 and J3, respectively. A 50Ω through transmission line is available via SMA connectors J6 and J7, which you can use to de-embed the loss of the PCB. J13 provides DC and digital inputs to the device.

The board is constructed of a two metal layer material with a total thickness of 38 mils. The top RF layer is Rogers 4360 material with a thickness of 32 mils and the ε_r = 6.4. The bottom layer provides ground for the transmission lines. The transmission lines were designed using a coplanar waveguide with ground plane model using a trace width of 18 mils, trace gaps of 7 mils and metal thickness of 2.1 mils.

To realize the true performance of the PE42522, design the PCB so that the RF transmission lines and sensitive DC I/O traces are well isolated from one another. You can improve high frequency insertion loss and return loss with external tuning traces in the customer application board layout. For further details, see **"High-frequency performance with external matching"**.

Figure 22 shows a generic PCB used for multiple parts. The V2 pin is GND.

Figure 22 ▪ PE42522 evaluation kit layout



Pin configuration

Figure 23 shows the PE42522 pin map for the 29-lead 4 × 4 × 0.91 mm LGA package, and **Table 5** lists the description for each pin.

Figure 23 ▪ Pin configuration (top view)

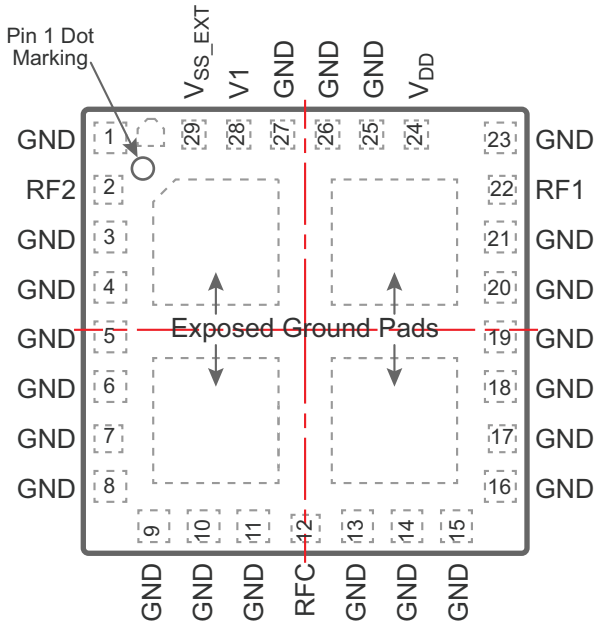


Table 5 ▪ PE42522 pin descriptions

Pin no.	Pin name	Description
1, 3–11, 13–21, 23, 25–27	GND	Ground
2	RF2(1)	RF port 2
12	RFC(1)	RF common
22	RF1(1)	RF port 1
24	V_{DD}	Supply voltage (nominal 3.3V)
28	V1	Digital control logic input 1
29	V_{SS_EXT}(2)	External V_{SS} negative voltage control
Pad	GND	Exposed pad. Ground for proper operation.

Notes:

1) RF pins 2, 12, and 22 must be at 0 VDC. These RF pins do not require DC blocking capacitors for proper operation if the 0 VDC requirement is met.
2) Use V_{SS_EXT} (pin 29) to bypass and disable the internal negative voltage generator. To enable the internal negative voltage generator, connect V_{SS_EXT} (pin 29) to GND (V_{SS_EXT} = 0V).

Packaging information

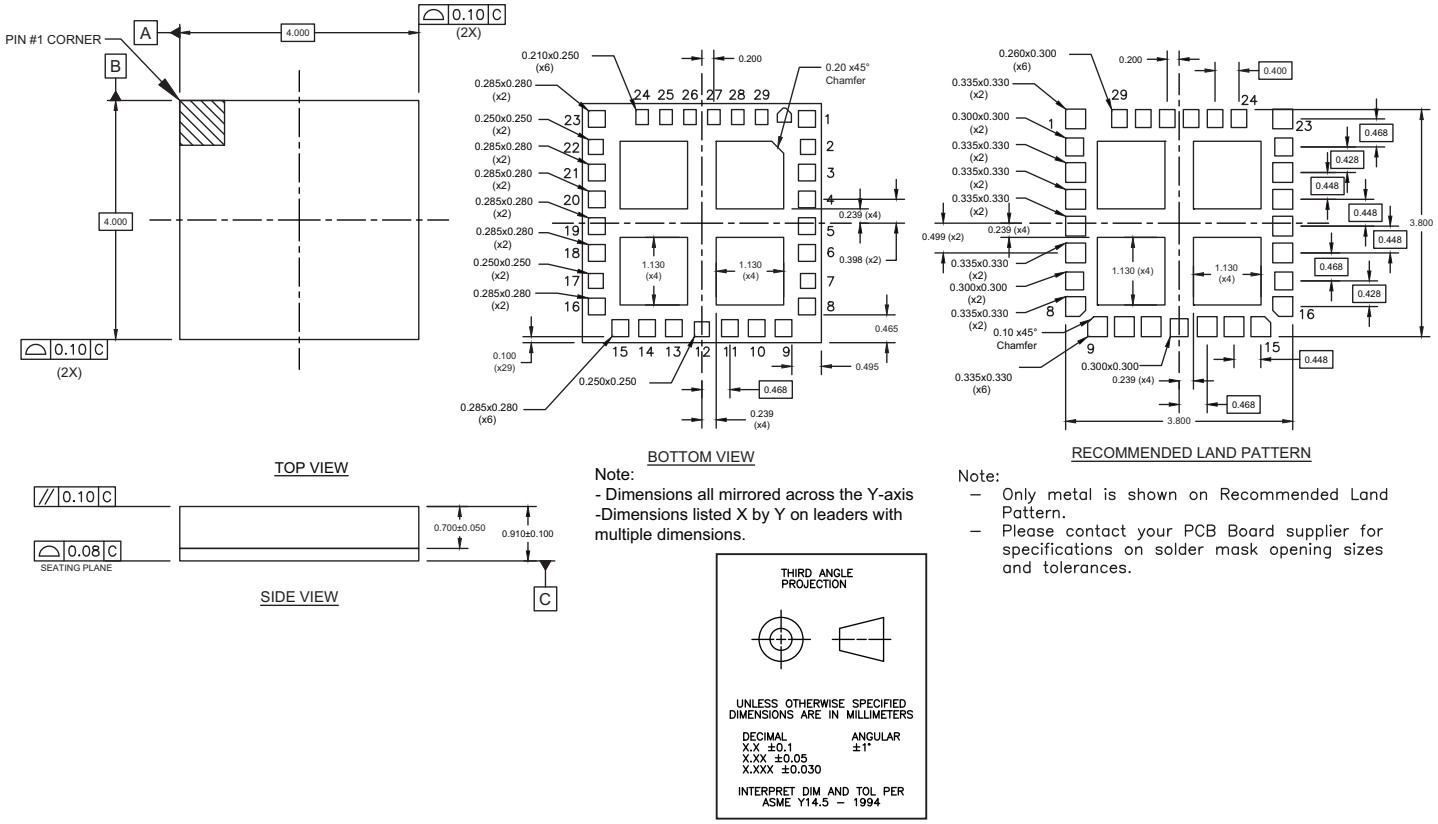
This section provides packaging data, including the moisture sensitivity level, package drawing, package marking, and tape-and-reel information.

Moisture sensitivity level

The PE42522 moisture sensitivity level rating for the 29-lead 4 × 4 × 0.91 mm LGA package is MSL3.

Package drawing

Figure 24 ▪ Package mechanical drawing for the 29-lead 4 × 4 × 0.91 mm LGA package



Note:
- Dimensions all mirrored across the Y-axis
-Dimensions listed X by Y on leaders with multiple dimensions.

Note:
- Only metal is shown on Recommended Land Pattern.
- Please contact your PCB Board supplier for specifications on solder mask opening sizes and tolerances.

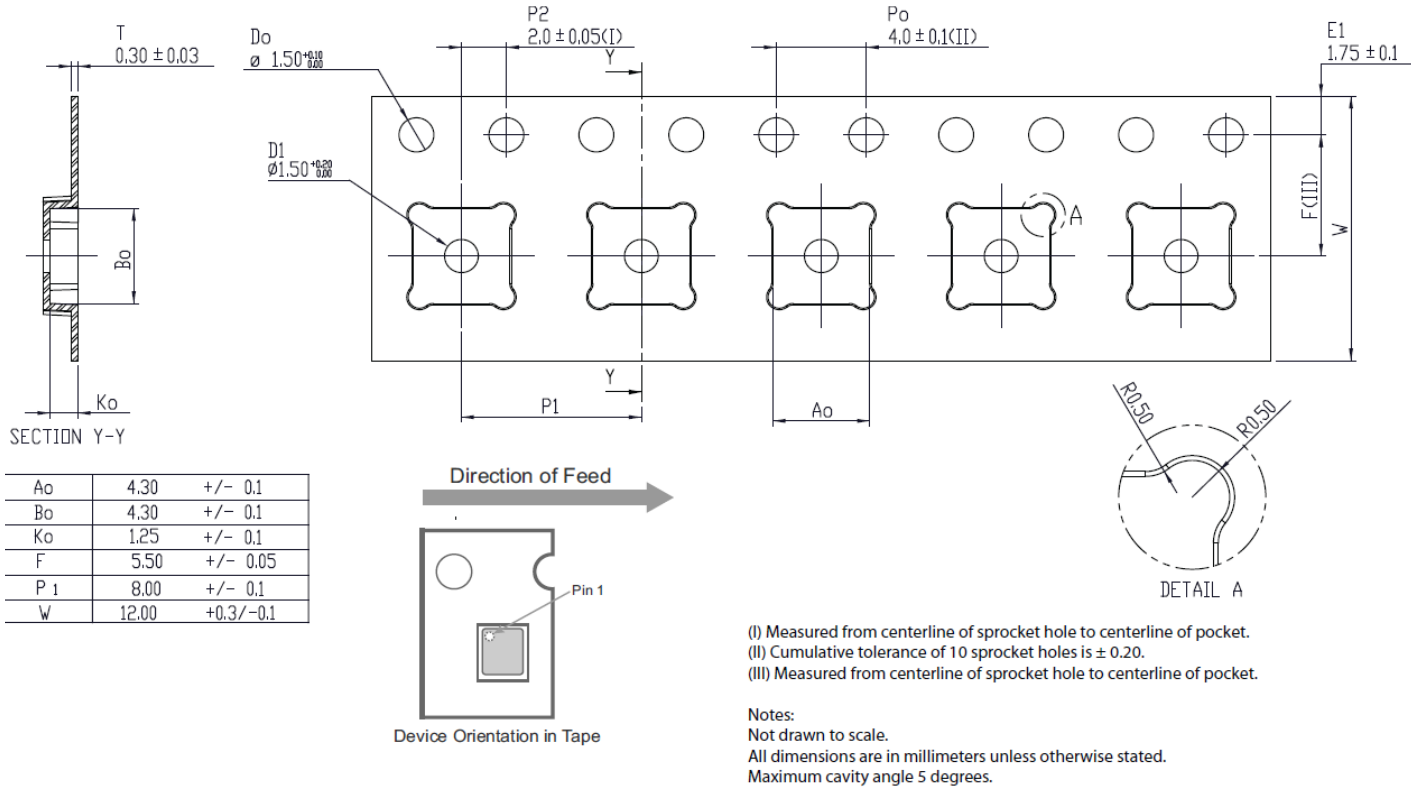
Figure 25 ▪ PE42522 package marking specification



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

Tape and reel specification

Figure 26 ▪ Tape and reel specification for the 29-lead 4 × 4 × 0.91 mm LGA package



Ao	4.30	+/− 0.1
Bo	4.30	+/− 0.1
Ko	1.25	+/− 0.1
F	5.50	+/− 0.05
P 1	8.00	+/− 0.1
W	12.00	+0.3/−0.1

(I) Measured from centerline of sprocket hole to centerline of pocket.
(II) Cumulative tolerance of 10 sprocket holes is ± 0.20.
(III) Measured from centerline of sprocket hole to centerline of pocket.

Notes:
Not drawn to scale.
All dimensions are in millimeters unless otherwise stated.
Maximum cavity angle 5 degrees.

Ordering information

Table 6 lists the PE42522 order codes and shipping methods.

Table 6 ▪ PE42522 order codes and shipping methods

Order code	Description	Packaging	Shipping method
PE42522C-X	PE42522 SPDT RF switch	29-lead 4 × 4 × 0.91 mm LGA	500 units / T&R
PE42522C-Z	PE42522 SPDT RF switch	29-lead 4 × 4 × 0.91 mm LGA	3000 units / T&R
EK42522-04	PE42522 Evaluation kit	Evaluation kit	1 / box

Document Categories

Advance Information

The product is in a formative or design stage. The datasheet contains design target specifications for product development. Specifications and features may change in any manner without notice.

Preliminary Specification

The datasheet contains preliminary data. Additional data may be added at a later date. pSemi reserves the right to change specifications at any time without notice in order to supply the best possible product.

Product Specification

The datasheet contains final data. In the event pSemi decides to change the specifications, pSemi will notify customers of the intended changes by issuing a CNF (Customer Notification Form).

Product Brief

This document contains a shortened version of the datasheet. For the full datasheet, contact sales@psemi.com.

Sales Contact

For additional information, contact Sales at sales@psemi.com.

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