

# RFSW6224

Absorptive High Isolation SPDT Switch with Negative Voltage Generator Shutdown, 5MHz to 6000MHz

The RFSW6224 is a Silicon on Insulator (SOI) single-pole, double throw (SPDT) switch designed for use in cellular, 3G, LTE, and other high performance communications systems. It offers a high isolation symmetric topology with excellent linearity and power handling capability. No blocking caps are necessary on the RF ports. The design is non-reflective such that RF ports 1 and 2 are terminated in the off-state. The  $V_{EN}$  pin allows for a terminated “all-off state”. The  $V_{SD}$  pin will turn the negative voltage generator off and allow for external negative supply input on the  $V_{NEG}$  pin.



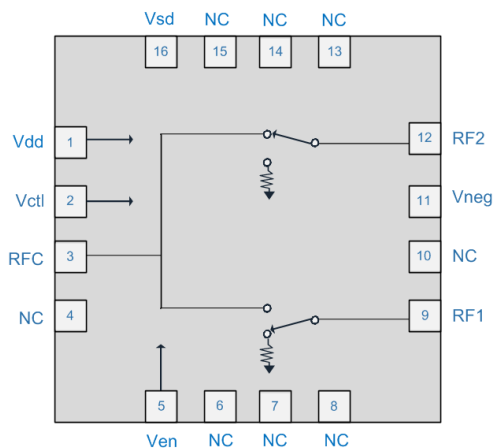
Package: QFN, 16-pin,  
4.0mm x 4.0mm

## Features

- 5MHz to 6000MHz Operation
- Symmetric SPDT
- Non-Reflective (RF1, RF2)
- Terminated All-off State
- No Blocking Caps Necessary Unless Voltage on RF Line
- High Isolation: 60dB at 2GHz
- High Input IP3: 66dBm
- Option to Turn Off Negative Voltage Generator and Supply  $V_{NEG}$  Externally
- 2kV ESD
- 1.8V Logic Compatible

## Applications

- Cellular, 3G, LTE Infrastructure
- WiBro, WiMax, LTE
- Wireless Backhaul
- High Performance Communications Systems
- Test Equipment



Functional Block Diagram

## Ordering Information

|                 |                                              |
|-----------------|----------------------------------------------|
| RFSW6224SQ      | Sample bag with 25 pieces                    |
| RFSW6224SR      | 7" Reel with 100 pieces                      |
| RFSW6224TR13    | 13" Reel with 2500 pieces                    |
| RFSW6224PCK-410 | 5MHz to 6000MHz PCBA with 5-piece sample bag |

## Absolute Maximum Ratings

| Parameter                                           | Rating      | Unit |
|-----------------------------------------------------|-------------|------|
| Control Voltage ( $V_{CTL}$ , $V_{EN}$ , $V_{SD}$ ) | 6.0         | V    |
| Supply Voltage ( $V_{DD}$ )                         | 6.0         | V    |
| External Negative Supply ( $V_{NEG}$ )              | -6.0        | V    |
| Maximum CW Input Power                              | 36          | dBm  |
| Storage Temperature Range                           | -40 to +150 | °C   |
| ESD Rating - Human Body Model (HBM)                 | 2000        | V    |
| Moisture Sensitivity Level                          | MSL2        |      |



**Caution!** ESD sensitive device.



RFMD Green: RoHS status based on EU Directive 2011/65/EU (at time of this document revision), halogen free per IEC 61249-2-21, < 1000ppm each of antimony trioxide in polymeric materials and red phosphorus as a flame retardant, and <2% antimony in solder.

Exceeding any one or a combination of the Absolute Maximum Rating conditions may cause permanent damage to the device. Extended application of Absolute Maximum Rating conditions to the device may reduce device reliability. Specified typical performance or functional operation of the device under Absolute Maximum Rating conditions is not implied.

## Recommended Operating Condition

| Parameter                      | Specification |     |      | Unit |
|--------------------------------|---------------|-----|------|------|
|                                | Min           | Typ | Max  |      |
| Operating Temperature Range    | -40           |     | +105 | °C   |
| Operating Junction Temperature |               |     | 125  | °C   |
| Supply Voltage                 | 2.5           | 3   | 5.5  | V    |

## Nominal Operating Parameters

| Parameter                                      | Specification |      |      | Unit | Condition                                                                                                                     |
|------------------------------------------------|---------------|------|------|------|-------------------------------------------------------------------------------------------------------------------------------|
|                                                | Min           | Typ  | Max  |      |                                                                                                                               |
| <b>General Performance<sup>1 &amp; 2</sup></b> |               |      |      |      | <b>Electrical Specifications, TA = 25°C, <math>V_{CTRL} = 0/+5 V_{DC}</math>, <math>V_{DD} = +5V_{DC}</math>, 50Ω system.</b> |
| Operating Frequency Range                      | 5             |      | 6000 | MHz  |                                                                                                                               |
| Insertion Loss (RFC to RF1/RF2)                |               | 0.55 |      | dB   | 0.4GHz                                                                                                                        |
|                                                |               | 0.6  |      | dB   | 1GHz                                                                                                                          |
|                                                |               | 0.75 | 1.1  | dB   | 2GHz                                                                                                                          |
|                                                |               | 0.9  |      | dB   | 3GHz                                                                                                                          |
|                                                |               | 0.9  |      | dB   | 4GHz                                                                                                                          |
|                                                |               | 1.1  |      | dB   | 5GHz                                                                                                                          |
| Isolation (RFC to RF1/RF2)                     |               | 75   |      | dB   | 0.4GHz                                                                                                                        |
|                                                |               | 63   |      | dB   | 1GHz                                                                                                                          |
|                                                | 53            | 60   |      | dB   | 2GHz                                                                                                                          |
|                                                |               | 60   |      | dB   | 3GHz                                                                                                                          |
|                                                |               | 60   |      | dB   | 4GHz                                                                                                                          |
|                                                |               | 48   |      | dB   | 5GHz                                                                                                                          |

| Parameter                                             | Specification |     |      | Unit | Condition                                                                                                                           |
|-------------------------------------------------------|---------------|-----|------|------|-------------------------------------------------------------------------------------------------------------------------------------|
|                                                       | Min           | Typ | Max  |      |                                                                                                                                     |
| <b>General Performance - Continued</b>                |               |     |      |      | <b>Electrical Specifications, TA = 25°C, V<sub>CRTL</sub> = 0/+5 V<sub>DC</sub>, V<sub>DD</sub> = +5V<sub>DC</sub>, 50Ω system.</b> |
| Isolation (RF1 to RF2)                                |               | 80  |      | dB   | 0.4GHz                                                                                                                              |
|                                                       |               | 70  |      | dB   | 1GHz                                                                                                                                |
|                                                       |               | 60  |      | dB   | 2GHz                                                                                                                                |
|                                                       |               | 53  |      | dB   | 3GHz                                                                                                                                |
|                                                       |               | 48  |      | dB   | 4GHz                                                                                                                                |
|                                                       |               | 49  |      | dB   | 5GHz                                                                                                                                |
| Return Loss (RF1/RF2 On-state)                        |               | 28  |      | dB   | 0.4GHz                                                                                                                              |
|                                                       |               | 27  |      | dB   | 1GHz                                                                                                                                |
|                                                       |               | 20  |      | dB   | 2GHz                                                                                                                                |
|                                                       |               | 20  |      | dB   | 3GHz                                                                                                                                |
|                                                       |               | 22  |      | dB   | 4GHz                                                                                                                                |
|                                                       |               | 17  |      | dB   | 5GHz                                                                                                                                |
| Return Loss (RF1/RF2 Off-state)                       |               | 37  |      | dB   | 0.4GHz                                                                                                                              |
|                                                       |               | 36  |      | dB   | 1GHz                                                                                                                                |
|                                                       |               | 30  |      | dB   | 2GHz                                                                                                                                |
|                                                       |               | 27  |      | dB   | 3GHz                                                                                                                                |
|                                                       |               | 23  |      | dB   | 4GHz                                                                                                                                |
|                                                       |               | 20  |      | dB   | 5GHz                                                                                                                                |
| Input IP3                                             |               | 65  |      | dBm  | 1GHz + 12dBm input power per tone, 1MHz tone spacing                                                                                |
|                                                       |               | 65  |      | dBm  | 2GHz + 12dBm input power per tone, 1MHz tone spacing                                                                                |
| Input 0.1dB Compression Point                         |               | 36  |      | dBm  | 1GHz                                                                                                                                |
| Input 1dB Compression Point                           |               | 36  |      | dBm  |                                                                                                                                     |
| Settling Time                                         |               | 1.5 |      | μs   | Internal NVG on, 50% control to optimum functionality                                                                               |
|                                                       |               | 40  |      | μs   | Internal NVG off, external V <sub>NEG</sub> supplied, 50% control to optimum functionality                                          |
| Switching Speed                                       |               | 250 |      | ns   | 50% control to 10/90% RF                                                                                                            |
| NVG Spurs                                             |               | -95 |      | dBm  | Internal NVG on                                                                                                                     |
| <b>Power Supply</b>                                   |               |     |      |      |                                                                                                                                     |
| Supply Current (I <sub>DD</sub> )                     |               | 140 | 200  | μA   | V <sub>DD</sub> = 5.0V                                                                                                              |
| Negative Supply (V <sub>NEG</sub> )                   | -5.5          | -5  | -3   | V    | Only for V <sub>SD</sub> = high, otherwise leave this pin open                                                                      |
| Control Current (I <sub>CTL</sub> , I <sub>EN</sub> ) |               | 0.5 | 5    | μA   | V <sub>CTL</sub> = 5.0V                                                                                                             |
| Low Control Voltage (V <sub>CTL</sub> )               | 0             |     | 0.63 | V    | 1.8V Logic compatible                                                                                                               |

| Parameter                                | Specification |     |     | Unit | Condition |
|------------------------------------------|---------------|-----|-----|------|-----------|
|                                          | Min           | Typ | Max |      |           |
| Power Supply - Continued                 |               |     |     |      |           |
| High Control Voltage (V <sub>CTL</sub> ) | 1.1           |     | VDD | V    |           |

Notes:

1. S-parameters have the PCB de-embedded
2. RF ports need to be at 0V DC. If voltage is present on RF lines, blocking caps are required.

### Maximum Operating Power at 85°C, CW, >300MHz

| Input                | State    | VEN         | Power                | Theta-J (°C/W)  |
|----------------------|----------|-------------|----------------------|-----------------|
| RFC, RF1/2           | On       | Low         | 33dBm <sup>1</sup>   | 97 <sup>2</sup> |
| RFC                  | Both Off | High        | 31.3dBm              | N/A             |
| RF1/2                | Off      | Low or High | 26dBm                | 100             |
| RF1/2 (Simultaneous) | Both Off | High        | 27.8dBm <sup>3</sup> | 65              |

Notes:

1. Assuming load VSWR <3:1, for high VSWR loads, this value reduces to 30.5dBm
2. Applies to resistive loss from insertion loss not including mismatch loss
3. Total power in both loads being driving simultaneously
4. For <300MHz, it is recommended to operate at least 4dB below 1dB compression point

### Truth Tables

| Control Input |     | Signal Path State |         |
|---------------|-----|-------------------|---------|
| VCTL          | VEN | RFC-RF1           | RFC-RF2 |
| 0             | 0   | Off               | On      |
| 1             | 0   | On                | Off     |
| 0             | 1   | Off               | Off     |
| 1             | 1   | Off               | Off     |

| V <sub>SD</sub> | V <sub>NEG</sub> | Mode                                 |
|-----------------|------------------|--------------------------------------|
| 0               | Open             | Internal negative voltage generation |
| 1               | -3 to -5.5       | External negative voltage supplied   |

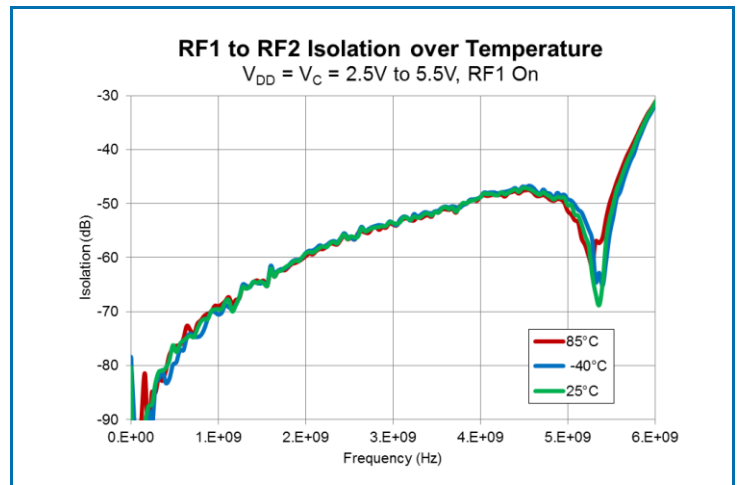
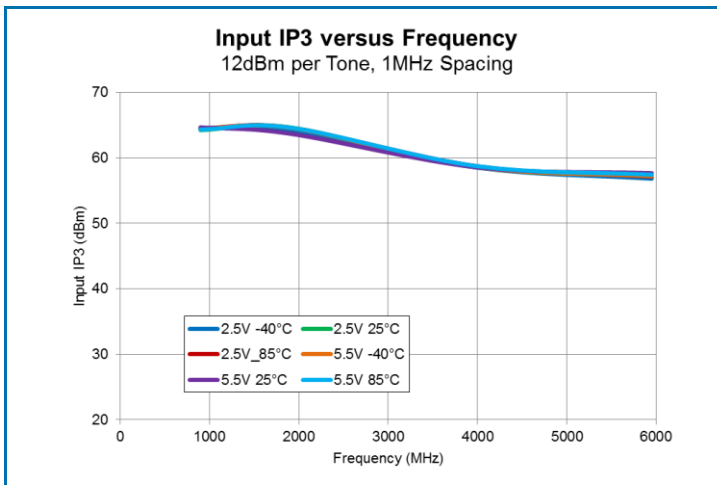
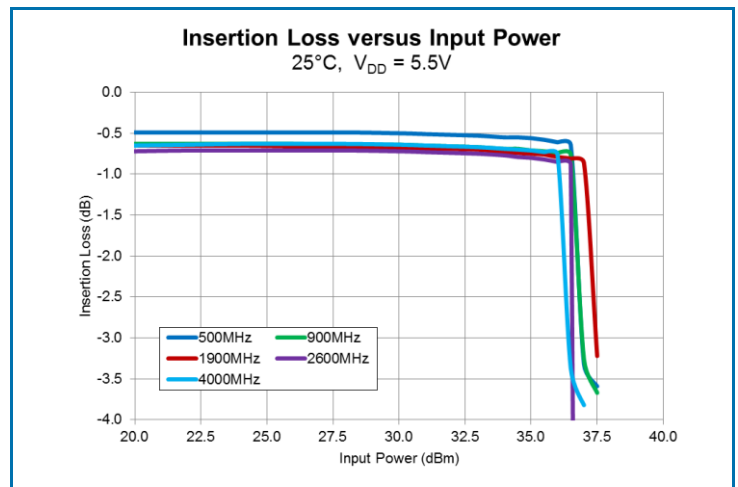
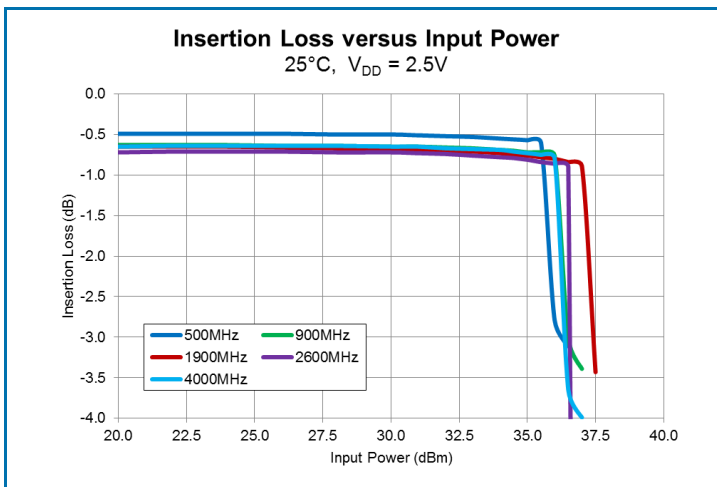
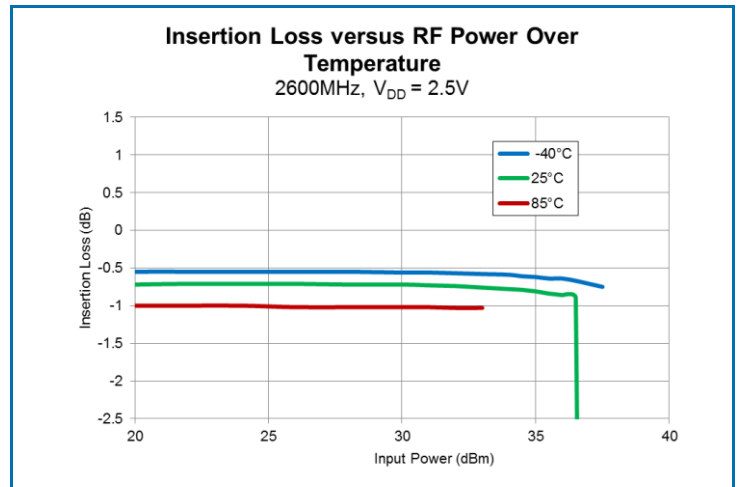
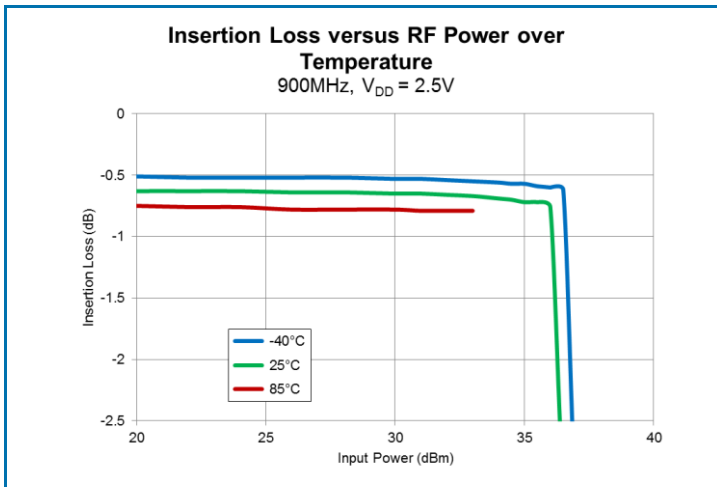
"0" = 0V to 0.63V

"1" = 1.1V to V<sub>DD</sub>V<sub>DD</sub> = 2.5 to 5.5V, must be applied for all valid states

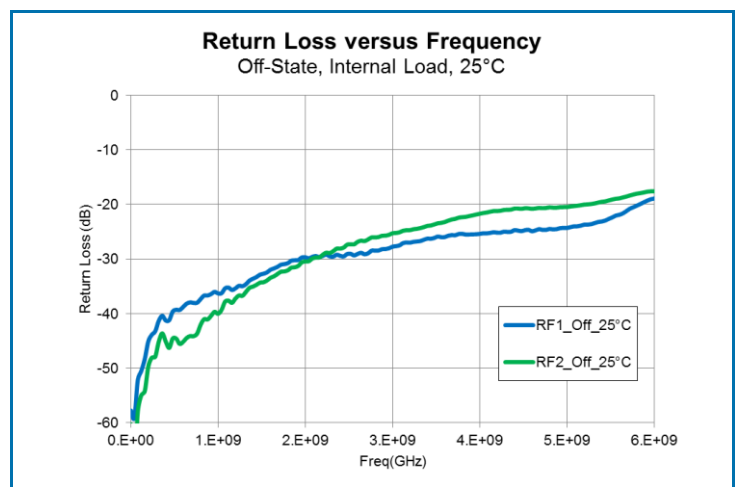
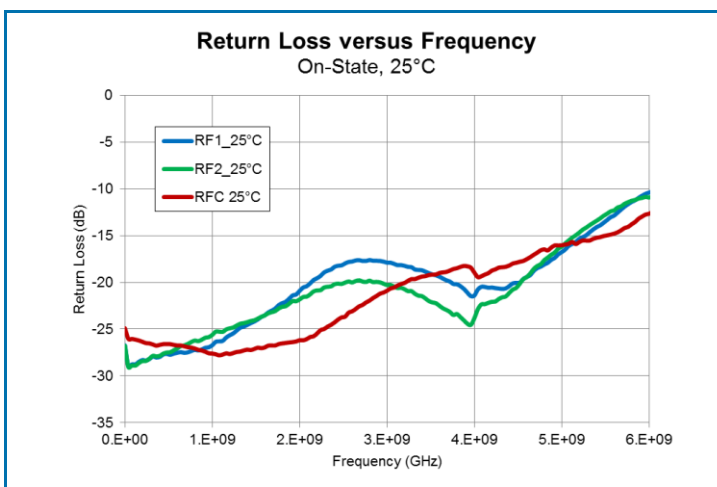
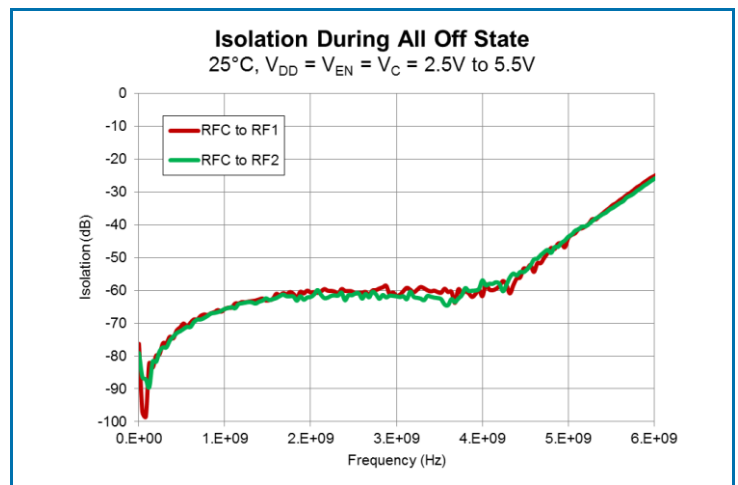
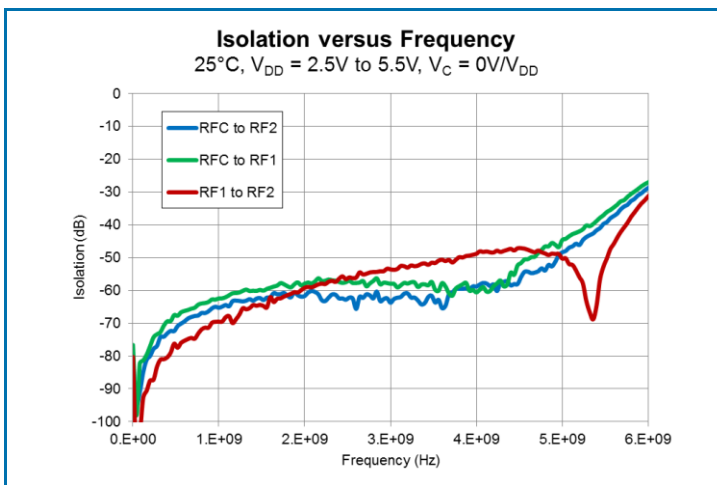
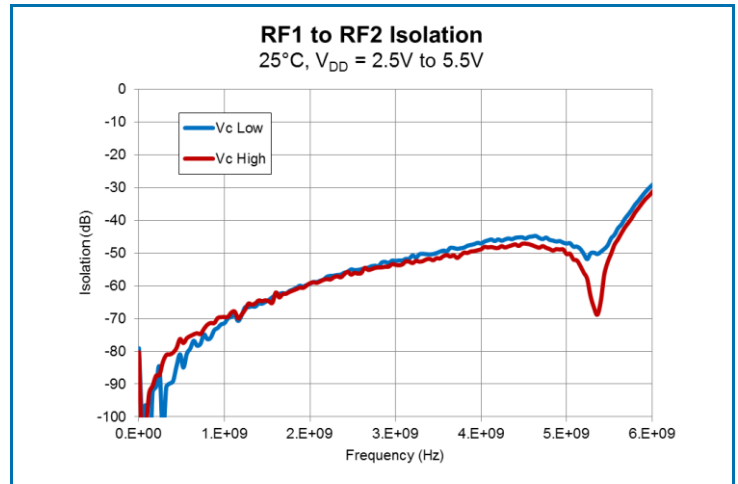
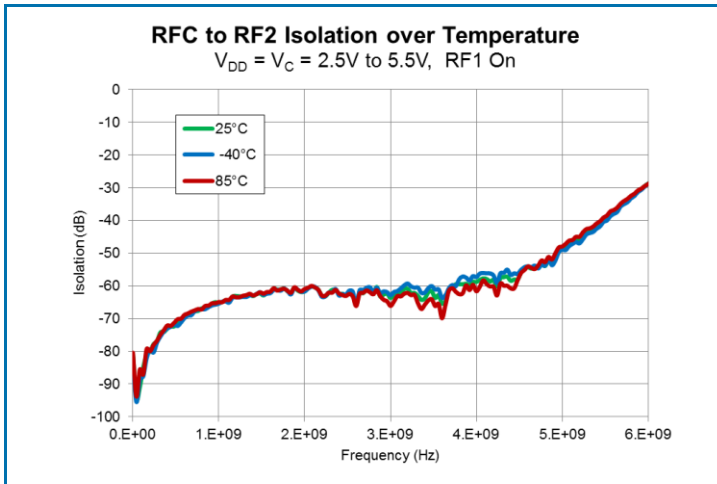
### Turn on sequence for external V<sub>NEG</sub> operation

Turn on V<sub>DD</sub>, then allow 50μsec before turning on control lines and V<sub>NEG</sub>.

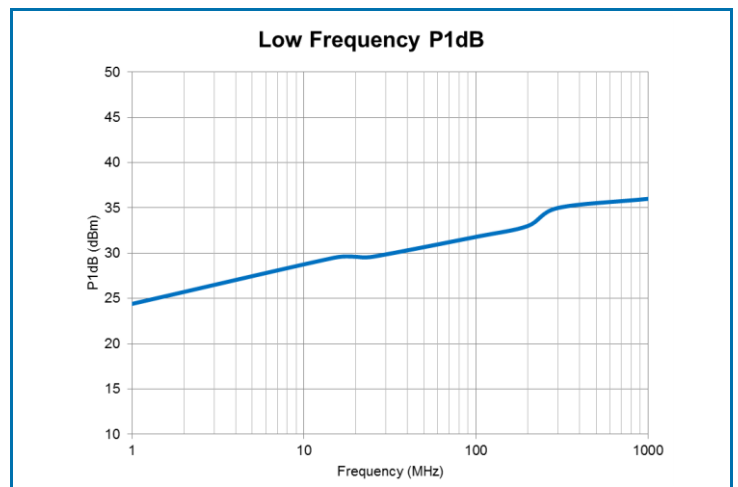
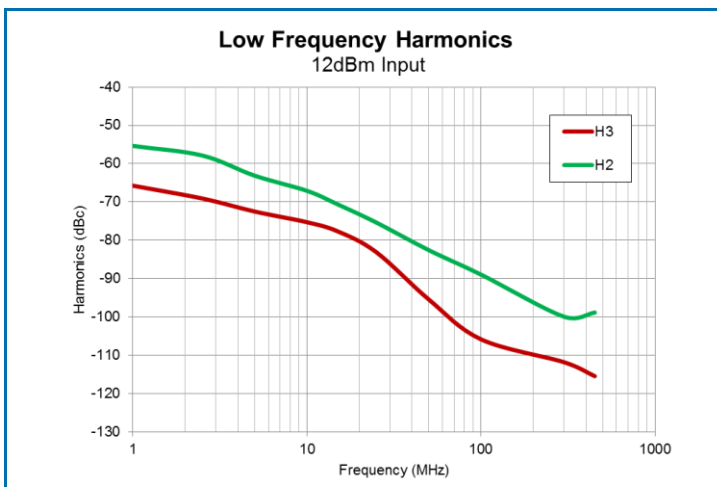
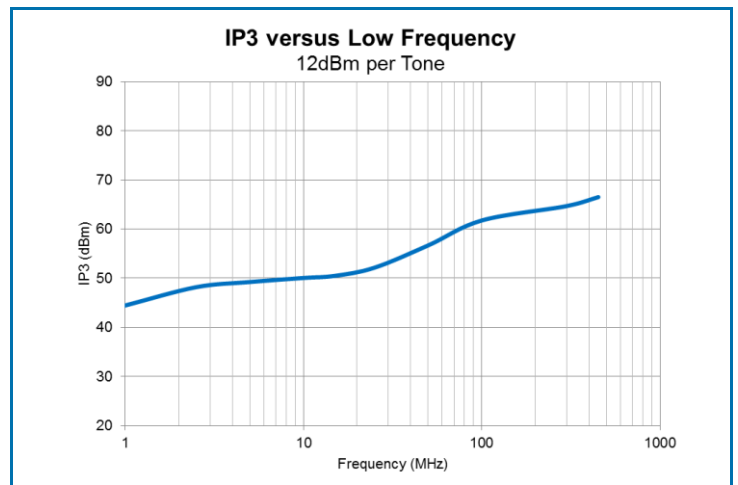
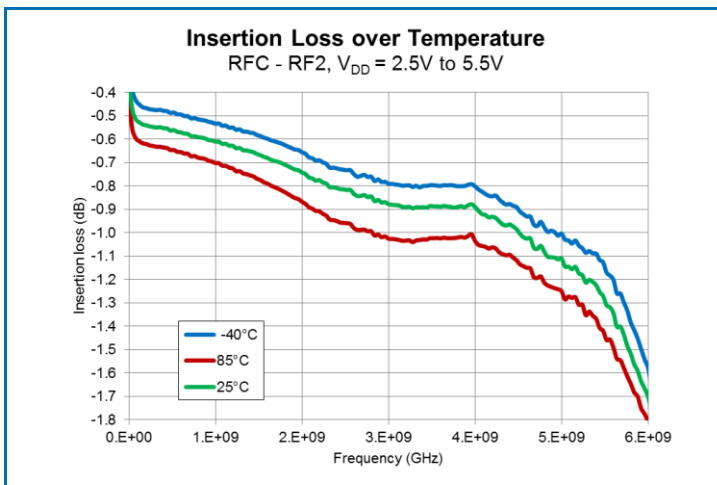
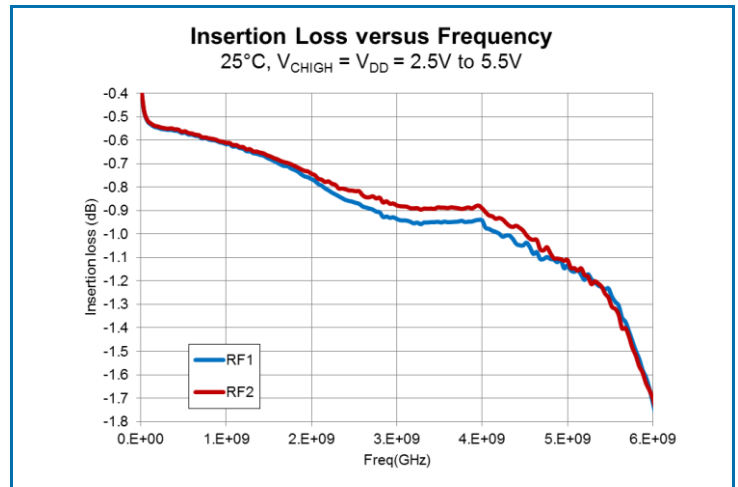
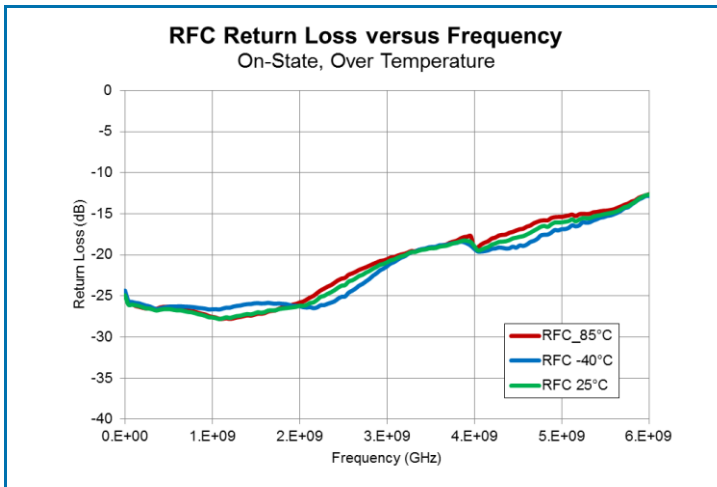
Typical Performance:  $T = 25^{\circ}\text{C}$ ,  $V_{\text{DD}} = 3\text{V}$  unless otherwise noted



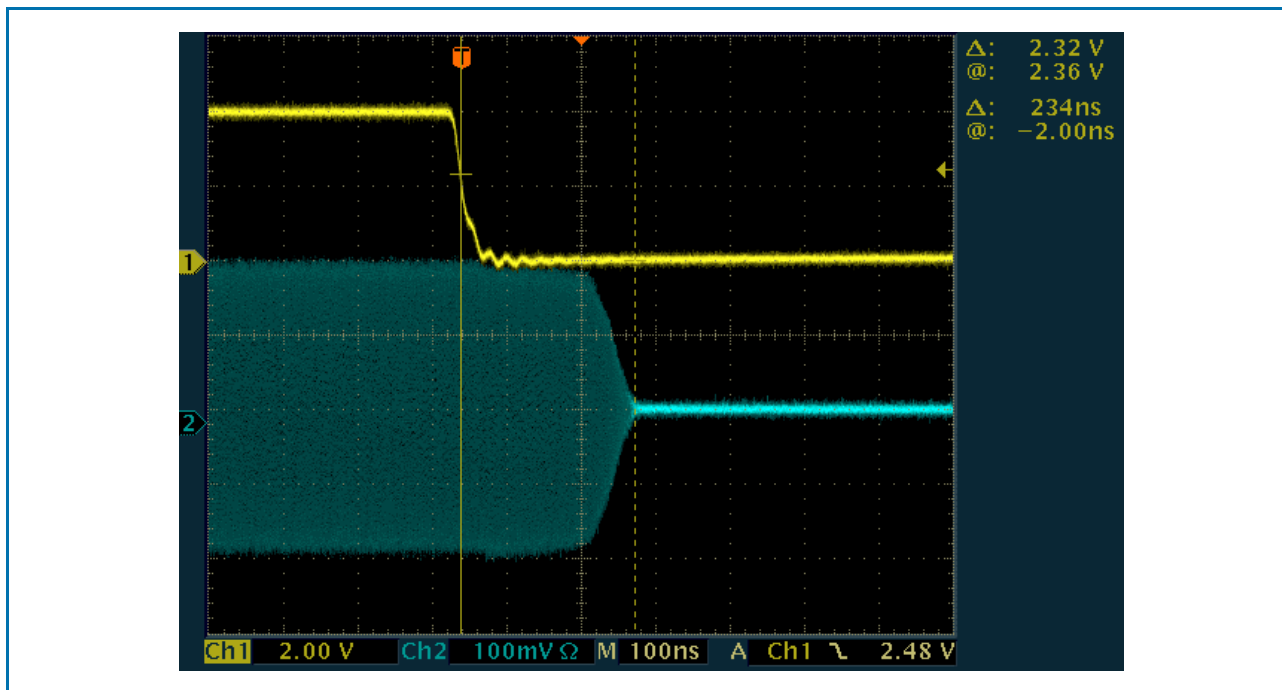
Typical Performance:  $T = 25^{\circ}\text{C}$ ,  $V_{\text{DD}} = 3\text{V}$  unless otherwise noted



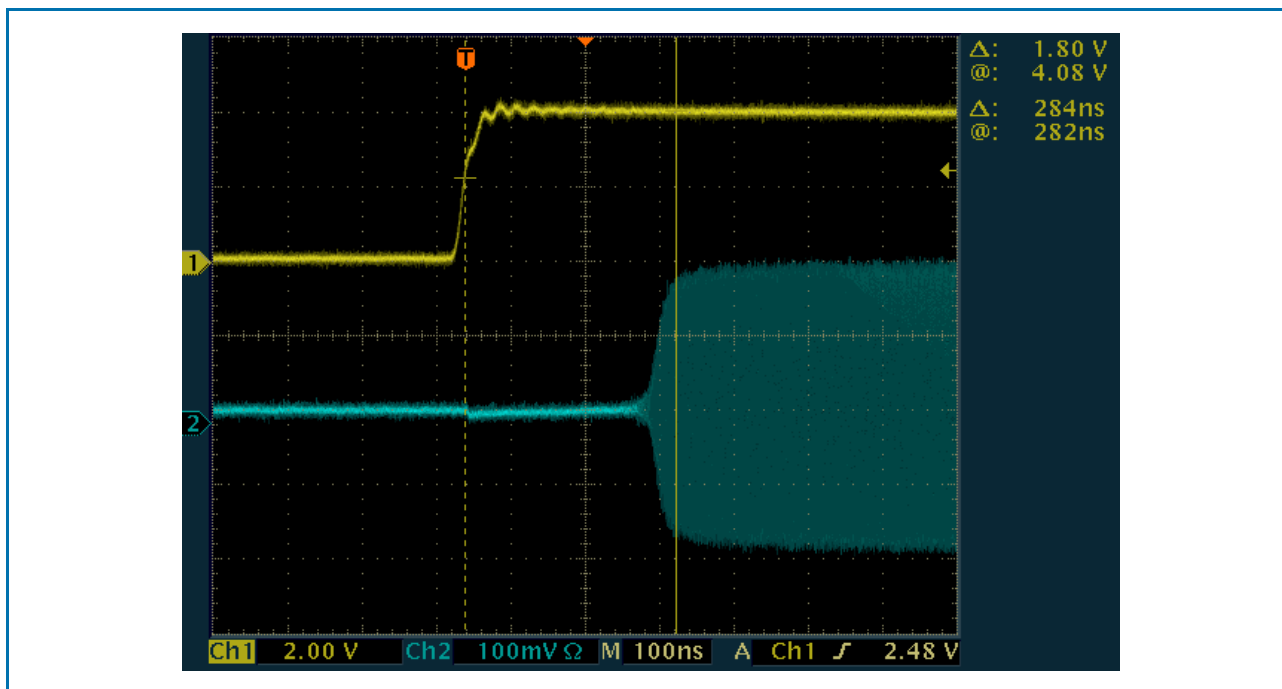
### Typical Performance: $T = 25^{\circ}\text{C}$ , $V_{\text{DD}} = 3\text{V}$ unless otherwise noted



Temp = 85°C, Switching Speed ( $t_{OFF}$ ) = 234ns, 50% CTL to 10%RF

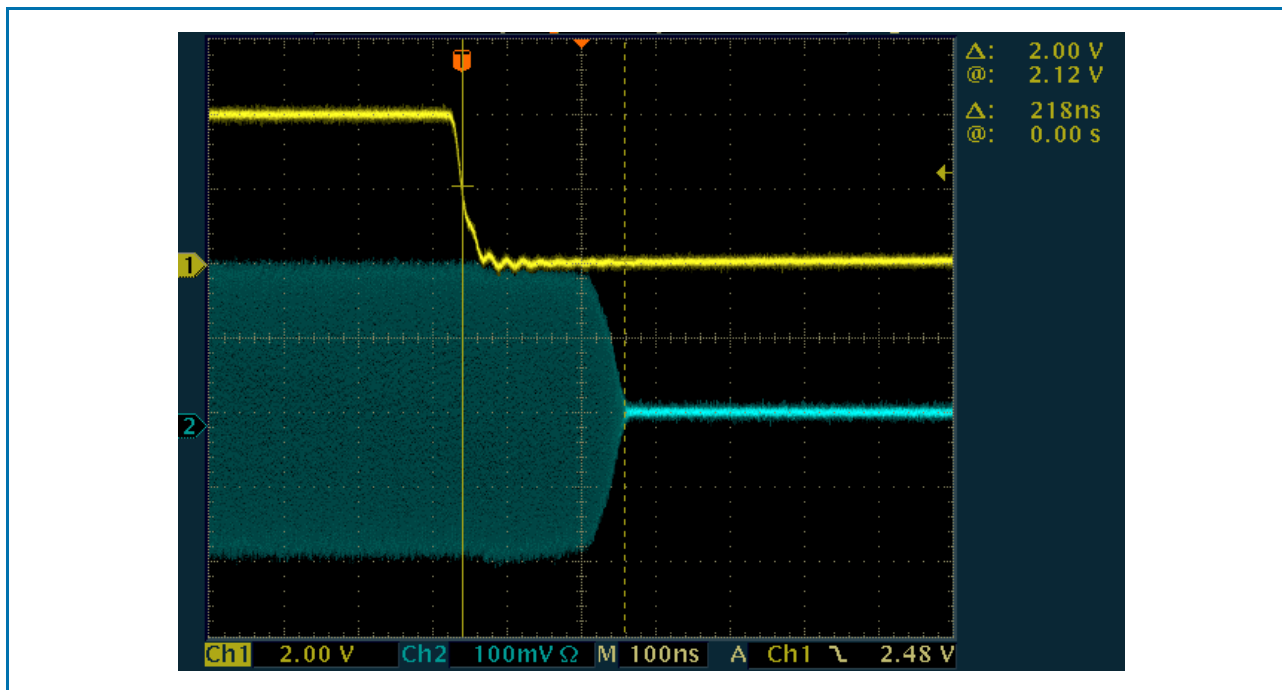


Temp = 85°C, Switching Speed ( $t_{ON}$ ) = 284ns, 50% CTL to 90%RF

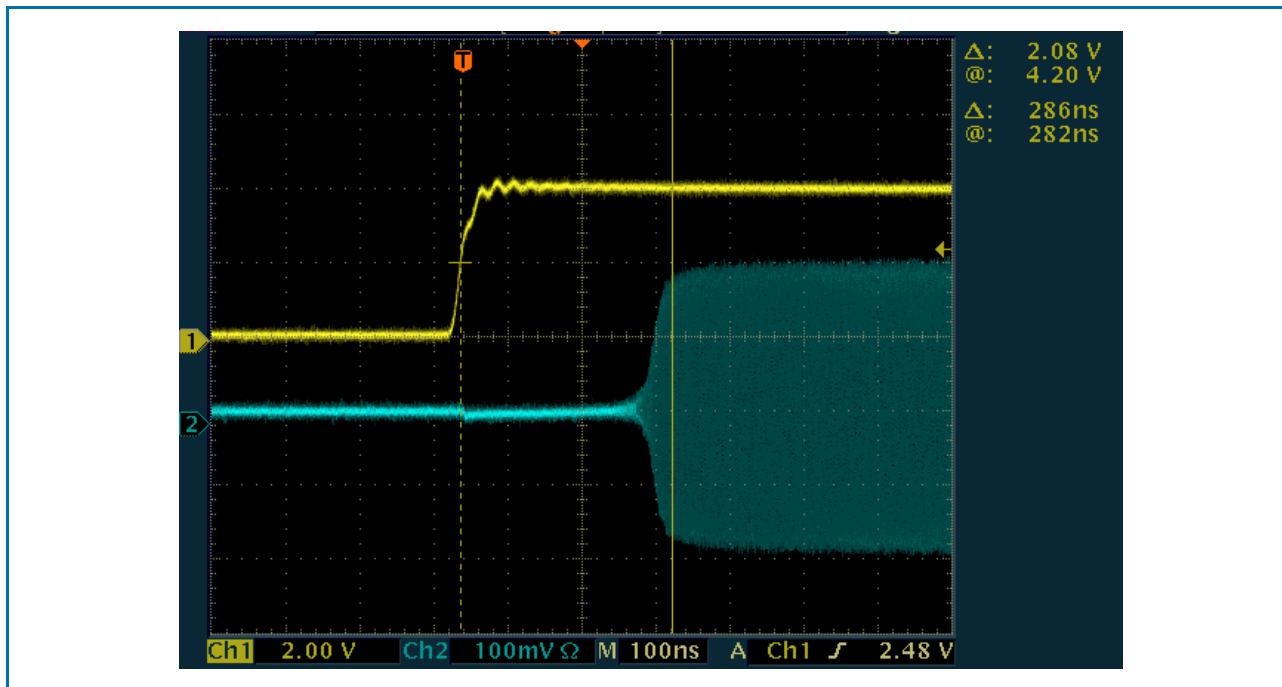




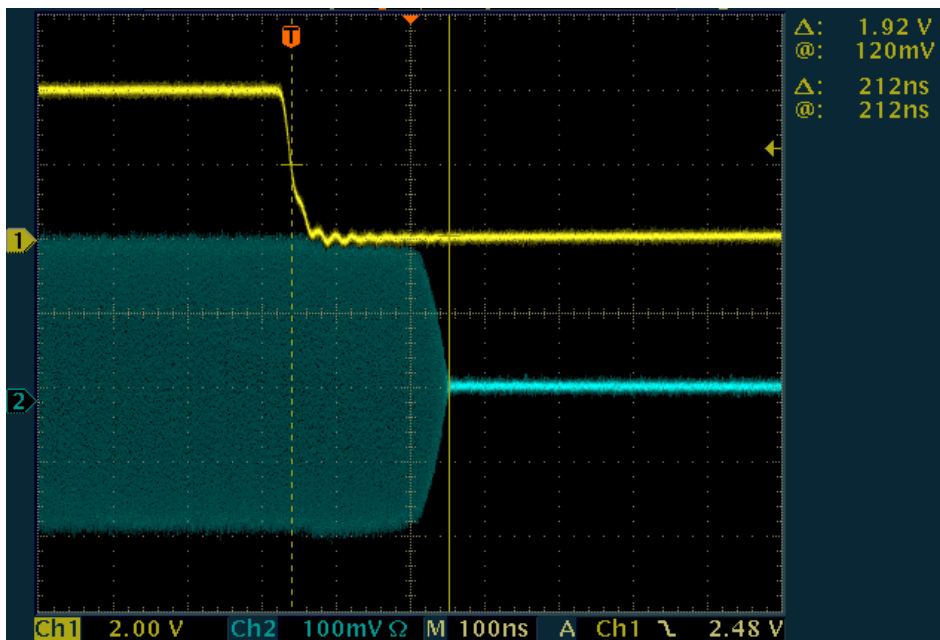
Temp = 25°C, Switching Speed ( $t_{OFF}$ ) = 218ns, 50% CTL to 10%RF



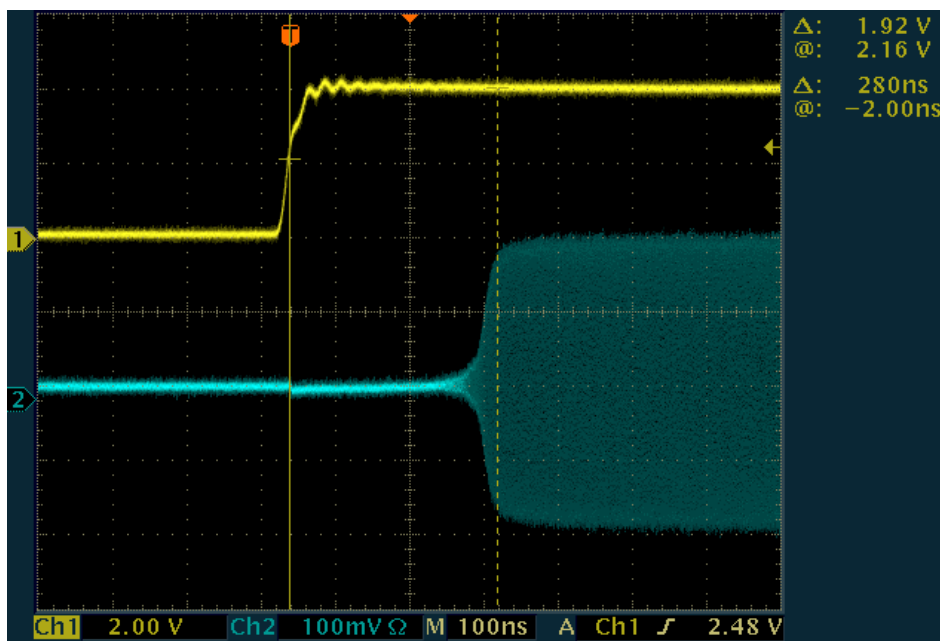
Temp = 25°C, Switching Speed ( $t_{ON}$ ) = 286ns, 50% CTL to 90%RF



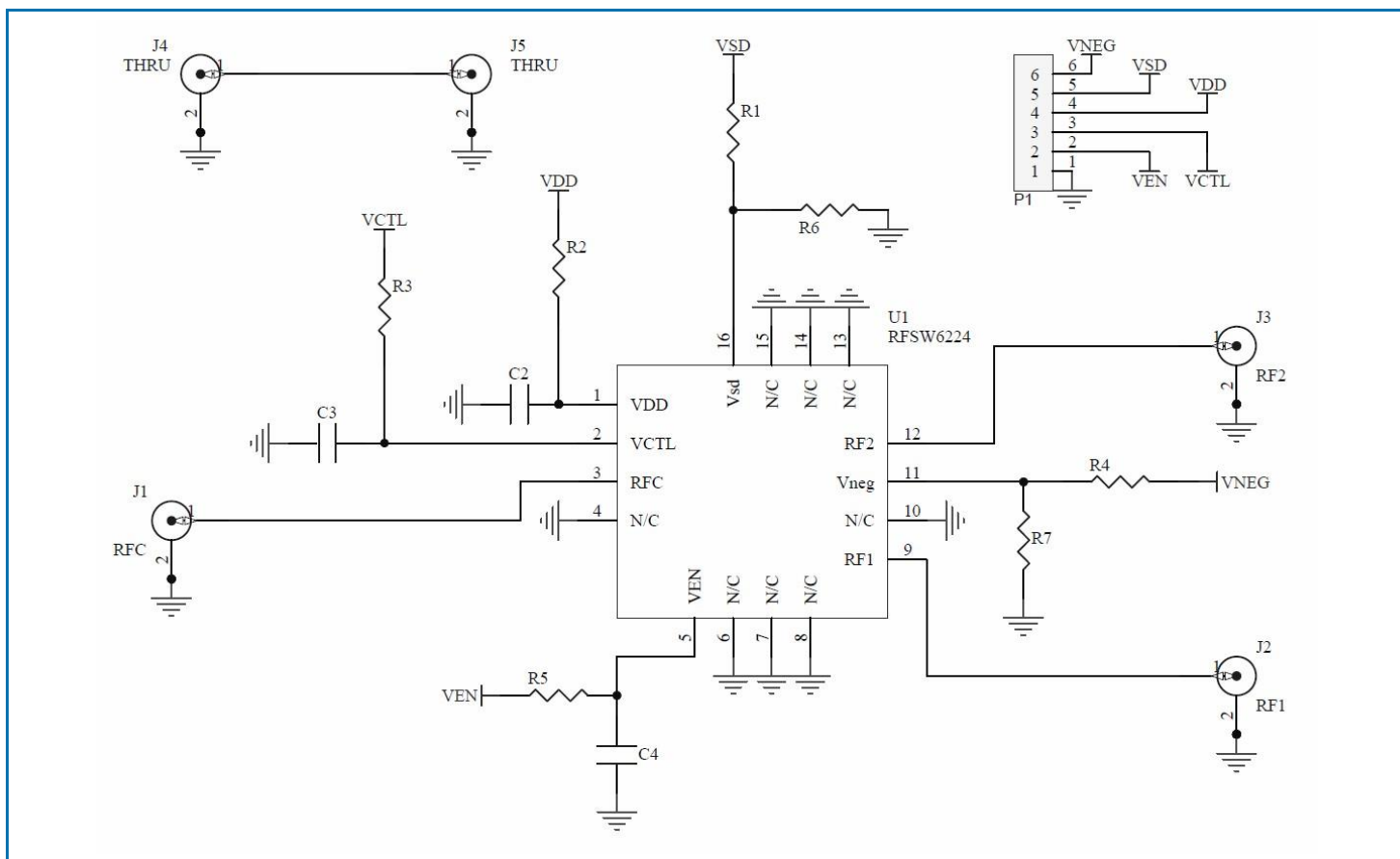
Temp = -40°C, Switching Speed ( $t_{OFF}$ ) = 212ns, 50% CTL to 10%RF



Temp = -40°C, Switching Speed ( $t_{ON}$ ) = 280ns, 50% CTL to 90%RF



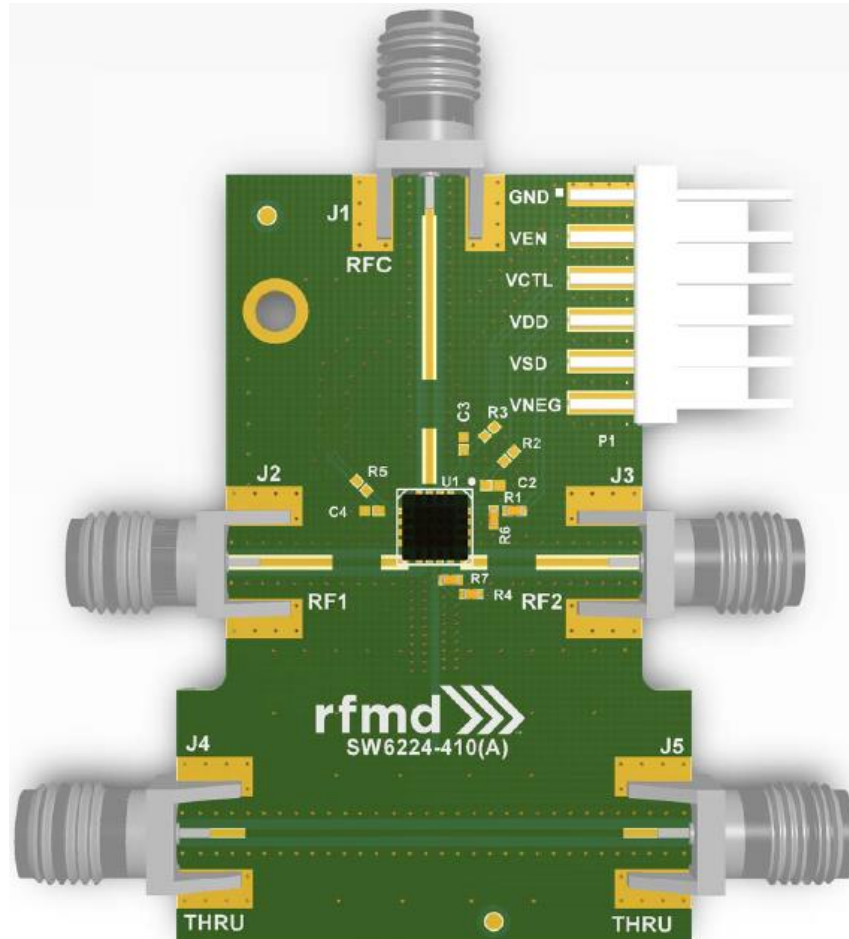
## Evaluation Board Schematic



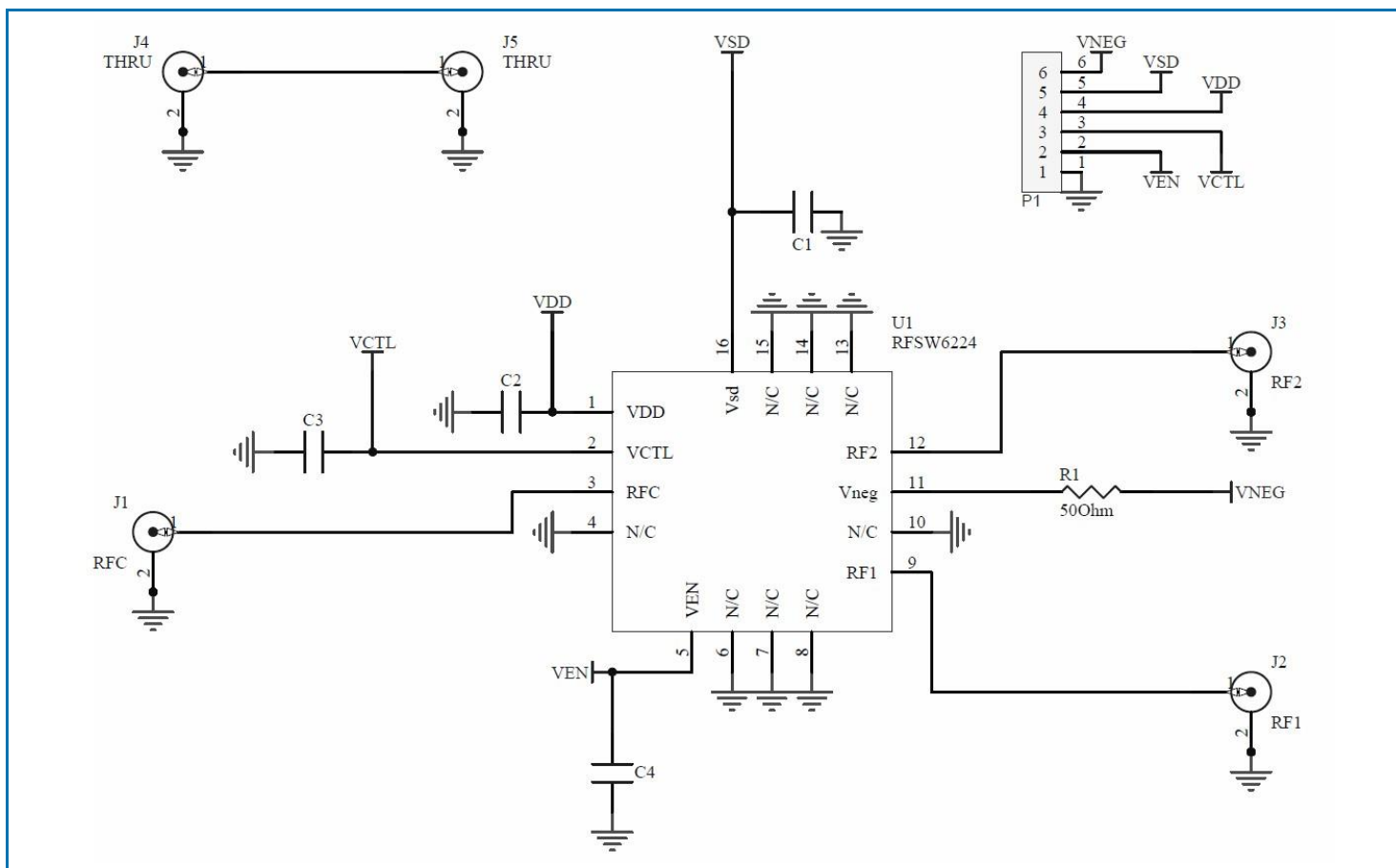
## Evaluation Board Bill of Materials (BOM)

| Description                               | Reference Designator | Manufacturer                     | Manufacturer's P/N  |
|-------------------------------------------|----------------------|----------------------------------|---------------------|
| RFSW6224 Evaluation Board                 |                      | Viasystems Sales, Inc. (Toronto) | RFSW6224-410(1)     |
| CAP, 100pF, 5%, 50V, C0G, 0402 (optional) | C2-C4                | Taiyo Yuden (USA), Inc.          | RM UMK105 CG101JV-F |
| 0Ω, 50mΩ MAX, 0402 LEAD FREE              | R1-R5                | KOA Speer Electronics, Inc.      | RK73Z1ETTP          |
| Do Not Install                            | R6-R7                |                                  |                     |
| CONN, HDR, ST, PLRZD, 6-PIN, 0.100"       | P1                   | AMP                              | 640454-6            |
| CONN, SMA, EL MINI FLT 0.068" SPE-000303  | J1-J5                | Aliner Industries, Inc.          | 20-001CF-T          |
| RFSW6224SB                                | U1                   | RFMD                             | RFSW6224            |

## Evaluation Board Assembly Drawing



## Application Schematic



Note: RFSW6224 has internal filtering. Caps only required for excessively noisy conditions

## Pin Names and Descriptions

| Pin  | Name | Description                                                                                                                                                                                                                                      |
|------|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1    | VDD  | Supply Voltage                                                                                                                                                                                                                                   |
| 2    | VCTL | Logic Control Input                                                                                                                                                                                                                              |
| 3    | RFC  | RF Common Port                                                                                                                                                                                                                                   |
| 4    | NC   | Grounding this pin is recommended for performance                                                                                                                                                                                                |
| 5    | VEN  | Logic input for putting switch in “all-off state”. Logic high for “all-off state”.                                                                                                                                                               |
| 6    | NC   | Grounding this pin is recommended for performance                                                                                                                                                                                                |
| 7    | NC   | Grounding this pin is recommended for performance                                                                                                                                                                                                |
| 8    | NC   | Grounding this pin is recommended for performance                                                                                                                                                                                                |
| 9    | RF1  | RF Port 1                                                                                                                                                                                                                                        |
| 10   | NC   | Grounding this pin is recommended for performance                                                                                                                                                                                                |
| 11   | VNEG | External Negative Supply Voltage Input -3V to -5.5V. Leave open for on chip negative voltage generator. When using external supply, apply negative voltage at least 50μs after V <sub>DD</sub> is applied. 50Ω series resistance is recommended. |
| 12   | RF2  | RF Port 2                                                                                                                                                                                                                                        |
| 13   | NC   | Grounding this pin is recommended for performance                                                                                                                                                                                                |
| 14   | NC   | Grounding this pin is recommended for performance                                                                                                                                                                                                |
| 15   | NC   | Grounding this pin is recommended for performance                                                                                                                                                                                                |
| 16   | VSD  | Negative Voltage Generator Shutdown; Apply 0V for on chip negative voltage generator. Pull high for external negative supply operation.                                                                                                          |
| EPAD | GND  | RF and DC Ground: Must be soldered to EVB ground plane over a bed of vias                                                                                                                                                                        |

Note: RFMD recommends that the NC pins be grounded on the EVB to maximize isolation.

### Package Outline (Dimensions in millimeters)

