

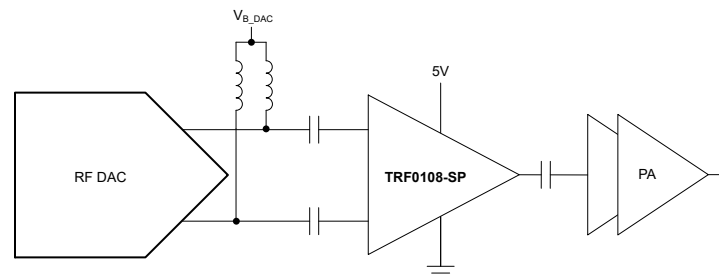
# TRF0108-SP Radiation-Hardness-Assured (RHA), Near-DC to 12GHz, Differential to Single-Ended RF Amplifier

## 1 Features

- Standard microcircuit drawing (SMD), 5962-25201
- Radiation:
  - Total ionizing dose (TID)
    - Radiation hardness assurance (RHA) up to 100krad (Si) TID
    - Enhanced low dose rate sensitivity (ELDRS) free process
    - High dose rate radiation lot acceptance testing (HDR RLAT) up to 100krad (Si) TID
  - Single event effects (SEE)
    - Single event latch-up (SEL) immune to linear energy transfer (LET) of 75MeV-cm<sup>2</sup>/mg
    - Single event transient (SET) characterized to LET of 75MeV-cm<sup>2</sup>/mg
- Space-grade QML-P
  - Lead-free construction
  - Extended temperature range: –55°C to +125°C
- Differential to single-ended (D2S) RF amplifier
- Near-DC to 12GHz
- Gain: 15.2dB at 2GHz
- OP1dB: 11.4dBm (2GHz), 9.4dBm (6GHz)
- OIP3: 27dBm (2GHz), 28.5dBm (6GHz)
- NF: 10.9dB (2GHz), 12.1dB (6GHz)
- HD2 (1GHz): –57dBc at 2dBm
- HD3 (1GHz): –57dBc at 2dBm
- Additive (residual) phase noise (1GHz):
  - –154.6dBc/Hz at 10kHz offset
- Gain and phase imbalance: ±0.6dB and ±3°
- Differential input matched to 100Ω, Single-ended output matched to 50Ω
- Power-down feature
- 5V supply
- Active current: 170mA

## 2 Applications

- Directly interfaces with RF DACs



**TRF0108-SP Driven by an RF DAC**

- [Aerospace and defense](#)
- [Phased array radar](#)
- [Communications payload](#)
- [Radar imaging payload](#)

## 3 Description

The TRF0108-SP is a very high performance, differential-to-single-ended (D2S) amplifier optimized for radio-frequency (RF) applications. The device is an excellent choice for applications that require a D2S conversion when driven by a digital-to-analog converter (DAC) such as the high-performance [DAC39RF10-SP](#) or [AFE7950-SP](#). The on-chip matching components simplify printed circuit board (PCB) implementation and provide the highest performance over the usable bandwidth. The device is fabricated using Texas Instruments' advanced complementary BiCMOS process and is available in a space-saving, WQFN-FCRLF 2mm x 2mm package.

The TRF0108-SP operates on a single 5V supply and consumes about 170mA of active current. A power-down feature is also available for power savings.

### Device Information

| PART NUMBER <sup>(1)</sup> | GRADE <sup>(2)</sup>               | BODY SIZE <sup>(3)</sup>    |
|----------------------------|------------------------------------|-----------------------------|
| 5962R2520101PXE            | QML-P                              | 2mm × 2mm<br>Mass = 7.558mg |
| TRF0108RPVTSP/EM           | Engineering samples <sup>(4)</sup> |                             |

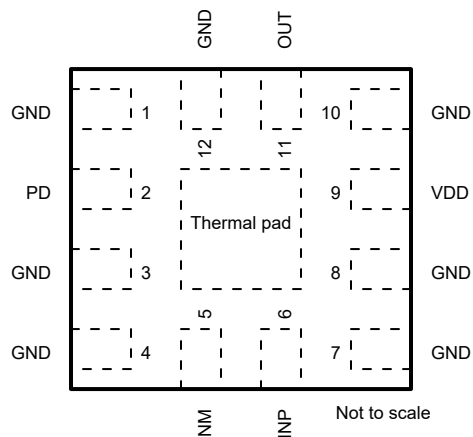
- (1) For more information, see [Section 10](#).
- (2) For additional information about the part grade, view [part ratings](#).
- (3) The body size (length × width) is a nominal value and includes pins. Mass is a nominal value.
- (4) These units are intended for engineering evaluation only. These samples are processed to a non-compliant flow. These units are not for qualification, production, radiation testing, or flight use. Parts are not warranted for performance over the full MIL specified temperature range, or operating life.



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## 4 Pin Configuration and Functions



**Figure 4-1. RPV Package, 12-Pin WQFN-FCRLF (Top View)**

**Table 4-1. Pin Functions**

| PIN         |                       | TYPE   | DESCRIPTION                                                                                              |
|-------------|-----------------------|--------|----------------------------------------------------------------------------------------------------------|
| NAME        | NO.                   |        |                                                                                                          |
| INM         | 5                     | Input  | Differential signal input, negative                                                                      |
| INP         | 6                     | Input  | Differential signal input, positive                                                                      |
| OUT         | 11                    | Output | Single-ended output                                                                                      |
| PD          | 2                     | Input  | Power-down signal. Supports 1.8V and 3.3V logic referenced to GND.<br>0 = Chip enabled<br>1 = Power down |
| VDD         | 9                     | Power  | Positive supply pin                                                                                      |
| GND         | 1, 3, 4, 7, 8, 10, 12 | Power  | Ground                                                                                                   |
| Thermal pad | Pad                   | —      | Thermal pad, connect to GND                                                                              |

## 5 Specifications

### 5.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)<sup>(1)</sup>

|                  |                        | MIN   | MAX                | UNIT |
|------------------|------------------------|-------|--------------------|------|
| V <sub>DD</sub>  | Supply voltage         | – 0.3 | 5.5                | V    |
| V <sub>PD</sub>  | Power-down pin voltage | – 0.3 | 3.7 <sup>(2)</sup> | V    |
| INP, INM         | Input pin power        |       | 20 <sup>(3)</sup>  | dBm  |
| T <sub>J</sub>   | Junction temperature   |       | 150                | °C   |
| T <sub>stg</sub> | Storage temperature    | –65   | 150                | °C   |

- (1) Operation outside the *Absolute Maximum Ratings* may cause permanent device damage. *Absolute Maximum Ratings* do not imply functional operation of the device at these or any other conditions beyond those listed under *Recommended Operating Conditions*. If used outside the *Recommended Operating Conditions* but within the *Absolute Maximum Ratings*, the device may not be fully functional, and this may affect device reliability, functionality, performance, and shorten the device lifetime.
- (2) When V<sub>DD</sub> is present; otherwise, maximum value is 0.3V.
- (3) When device supplies are present; otherwise, limit swing at the device pins to ± 0.3V.

### 5.2 ESD Ratings

|                    |                         |                                                                                 | VALUE | UNIT |
|--------------------|-------------------------|---------------------------------------------------------------------------------|-------|------|
| V <sub>(ESD)</sub> | Electrostatic discharge | Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, all pins <sup>(1)</sup>     | ±1000 | V    |
|                    |                         | Charged device model (CDM), per ANSI/ESDA/JEDEC JS-002, all pins <sup>(2)</sup> | ±250  |      |

- (1) JEDEC document JEP155 states that 500V HBM allows safe manufacturing with a standard ESD control process.
- (2) JEDEC document JEP157 states that 250V CDM allows safe manufacturing with a standard ESD control process.

### 5.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

|                 |                         | MIN  | NOM | MAX  | UNIT |
|-----------------|-------------------------|------|-----|------|------|
| V <sub>DD</sub> | Supply voltage          | 4.75 | 5   | 5.25 | V    |
| T <sub>A</sub>  | Ambient air temperature | –55  | 25  |      | °C   |
| T <sub>J</sub>  | Junction temperature    |      |     | 125  | °C   |

### 5.4 Thermal Information

| THERMAL METRIC <sup>(1)</sup> |                                              | Device           | UNIT |
|-------------------------------|----------------------------------------------|------------------|------|
|                               |                                              | RPV (WQFN-FCRLF) |      |
|                               |                                              | 12 PINS          |      |
| R <sub>θJA</sub>              | Junction-to-ambient thermal resistance       | 66.7             | °C/W |
| R <sub>θJC(top)</sub>         | Junction-to-case (top) thermal resistance    | 35.3             | °C/W |
| R <sub>θJB</sub>              | Junction-to-board thermal resistance         | 31.1             | °C/W |
| Ψ <sub>JT</sub>               | Junction-to-top characterization parameter   | 0.6              | °C/W |
| Ψ <sub>JB</sub>               | Junction-to-board characterization parameter | 31.1             | °C/W |
| R <sub>θJC(bot)</sub>         | Junction-to-case (bottom) thermal resistance | 10.7             | °C/W |

- (1) For more information about traditional and new thermal metrics, see the [Semiconductor and IC Package Thermal Metrics](#) application report.

## 5.5 Electrical Characteristics

at  $T_A = 25^\circ\text{C}$ ,  $V_{DD} = 5\text{V}$ , 100nF ac-coupling capacitors at input and output, differential input with  $R_S = 100\Omega$ , output with  $R_L = 50\Omega$  (unless otherwise noted)

| PARAMETER             |                                     | TEST CONDITIONS                                               | SUBGROUP | MIN  | TYP  | MAX  | UNIT    |
|-----------------------|-------------------------------------|---------------------------------------------------------------|----------|------|------|------|---------|
| <b>AC PERFORMANCE</b> |                                     |                                                               |          |      |      |      |         |
| Ssd21                 | Gain                                | f = 0.5GHz                                                    |          |      | 15.2 |      | dB      |
|                       |                                     | f = 1.29G                                                     | [4]      | 13.8 | 15.3 | 16.8 |         |
|                       |                                     |                                                               | [5]      | 13.6 |      | 16.6 |         |
|                       |                                     |                                                               | [6]      | 13.6 |      | 17.6 |         |
|                       |                                     | f = 2GHz                                                      |          |      | 15.2 |      |         |
|                       |                                     | f = 2.58G                                                     | [4]      | 13.6 | 15.6 | 17.6 |         |
|                       |                                     |                                                               | [5]      | 13.5 |      | 17.5 |         |
|                       |                                     |                                                               | [6]      | 13.4 |      | 18.4 |         |
|                       |                                     | f = 4GHz                                                      |          |      | 15.9 |      |         |
|                       |                                     | f = 6GHz                                                      |          |      | 16.8 |      |         |
|                       |                                     | f = 8GHz                                                      |          |      | 17.1 |      |         |
| Sdd11                 | Input return loss                   | f = 10MHz to 8GHz                                             |          |      | –16  |      | dB      |
| Sss22                 | Output return loss                  | f = 10MHz to 8GHz                                             |          |      | –12  |      | dB      |
| Sds12                 | Reverse isolation                   | f = 10MHz to 8GHz                                             |          |      | –48  |      | dB      |
| lmb <sub>GAIN</sub>   | Gain imbalance                      | f = 10MHz to 8GHz                                             |          |      | ±0.6 |      | dB      |
| lmb <sub>PHASE</sub>  | Phase imbalance                     | f = 10MHz to 8GHz                                             |          |      | ±3   |      | degrees |
| CMRR                  | Common-mode rejection ratio         | f = 2GHz                                                      |          |      | –45  |      | dB      |
| OP1dB                 | Output 1dB compression point        | f = 0.5GHz                                                    |          |      | 11   |      | dBm     |
|                       |                                     | f = 2GHz                                                      |          |      | 11.4 |      |         |
|                       |                                     | f = 4GHz                                                      |          |      | 11   |      |         |
|                       |                                     | f = 6GHz                                                      |          |      | 9.4  |      |         |
|                       |                                     | f = 8GHz                                                      |          |      | 7    |      |         |
| NF                    | Noise figure                        | f = 0.5GHz                                                    |          |      | 10   |      | dB      |
|                       |                                     | f = 2GHz                                                      |          |      | 10.9 |      |         |
|                       |                                     | f = 4GHz                                                      |          |      | 11   |      |         |
|                       |                                     | f = 6GHz                                                      |          |      | 12.1 |      |         |
|                       |                                     | f = 8GHz                                                      |          |      | 12.3 |      |         |
| OIP2                  | Output second-order intercept point | f = 0.5GHz, $P_{out} = -4\text{dBm}$ per tone (10MHz spacing) |          |      | 56   |      | dBm     |
|                       |                                     | f = 1GHz, $P_{out} = -4\text{dBm}$ per tone (10MHz spacing)   |          |      | 51   |      |         |
|                       |                                     | f = 2GHz, $P_{out} = -4\text{dBm}$ per tone (10MHz spacing)   |          |      | 43   |      |         |
|                       |                                     | f = 4GHz, $P_{out} = -4\text{dBm}$ per tone (10MHz spacing)   |          |      | 34   |      |         |
| OIP3                  | Output third-order intercept point  | f = 0.5GHz, $P_{out} = -4\text{dBm}$ per tone (10MHz spacing) |          |      | 30.5 |      | dBm     |
|                       |                                     | f = 2GHz, $P_{out} = -4\text{dBm}$ per tone (10MHz spacing)   |          |      | 27   |      |         |
|                       |                                     | f = 4GHz, $P_{out} = -4\text{dBm}$ per tone (10MHz spacing)   |          |      | 26.5 |      |         |
|                       |                                     | f = 6GHz, $P_{out} = -4\text{dBm}$ per tone (10MHz spacing)   |          |      | 28.5 |      |         |
|                       |                                     | f = 8GHz, $P_{out} = -4\text{dBm}$ per tone (10MHz spacing)   |          |      | 19.5 |      |         |

at  $T_A = 25^\circ\text{C}$ ,  $V_{DD} = 5\text{V}$ , 100nF ac-coupling capacitors at input and output, differential input with  $R_S = 100\Omega$ , output with  $R_L = 50\Omega$  (unless otherwise noted)

| PARAMETER                                                   |                                         | TEST CONDITIONS                                               | SUBGROUP  | MIN  | TYP    | MAX  | UNIT   |
|-------------------------------------------------------------|-----------------------------------------|---------------------------------------------------------------|-----------|------|--------|------|--------|
| HD2                                                         | Second-order harmonic distortion        | f = 0.5GHz, P <sub>out</sub> = 2dBm                           |           |      | −61    |      | dBc    |
|                                                             |                                         | f = 1GHz, P <sub>out</sub> = 2dBm                             |           |      | −57    |      |        |
|                                                             |                                         | f = 2GHz, P <sub>out</sub> = 2dBm                             |           |      | −49    |      |        |
|                                                             |                                         | f = 4GHz, P <sub>out</sub> = 2dBm                             |           |      | −39    |      |        |
| HD3                                                         | Third-order harmonic distortion         | f = 0.5GHz, P <sub>out</sub> = 2dBm                           |           |      | −61    |      | dBc    |
|                                                             |                                         | f = 1GHz, P <sub>out</sub> = 2dBm                             |           |      | −57    |      |        |
|                                                             |                                         | f = 2GHz, P <sub>out</sub> = 2dBm                             |           |      | −50    |      |        |
|                                                             |                                         | f = 4GHz, P <sub>out</sub> = 2dBm                             |           |      | −43    |      |        |
| IMD2                                                        | Second-order intermodulation distortion | f = 0.5GHz, P <sub>out</sub> = −4dBm per tone (10MHz spacing) |           |      | −60    |      | dBc    |
|                                                             |                                         | f = 1GHz, P <sub>out</sub> = −4dBm per tone (10MHz spacing)   |           |      | −55    |      |        |
|                                                             |                                         | f = 2GHz, P <sub>out</sub> = −4dBm per tone (10MHz spacing)   |           |      | −47    |      |        |
|                                                             |                                         | f = 4GHz, P <sub>out</sub> = −4dBm per tone (10MHz spacing)   |           |      | −38    |      |        |
| IMD3                                                        | Third-order intermodulation distortion  | f = 0.5GHz, P <sub>out</sub> = −4dBm per tone (10MHz spacing) |           |      | −69    |      | dBc    |
|                                                             |                                         | f = 1.29GHz, P <sub>O</sub> = −4dBm per tone (10MHz spacing)  | [4]       |      | −57.5  |      |        |
|                                                             |                                         |                                                               | [5]       |      | −54.1  |      |        |
|                                                             |                                         |                                                               | [6]       |      | −58.5  |      |        |
|                                                             |                                         | f = 2GHz, P <sub>out</sub> = −4dBm per tone (10MHz spacing)   |           |      | −62    |      |        |
|                                                             |                                         | f = 2.58GHz, P <sub>O</sub> = −4dBm per tone (10MHz spacing)  | [4]       |      | −48.7  |      |        |
|                                                             |                                         |                                                               | [5]       |      | −46.3  |      |        |
|                                                             |                                         |                                                               | [6]       |      | −50.5  |      |        |
|                                                             |                                         | f = 4GHz, P <sub>out</sub> = −4dBm per tone (10MHz spacing)   |           |      | −61    |      |        |
|                                                             |                                         | f = 6GHz, P <sub>out</sub> = −4dBm per tone (10MHz spacing)   |           |      | −65    |      |        |
| f = 8GHz, P <sub>out</sub> = −4dBm per tone (10MHz spacing) |                                         |                                                               | −47       |      |        |      |        |
| PN                                                          | Additive (residual) phase noise         | f = 1GHz, P <sub>out</sub> = 6dBm, 100Hz offset               |           |      | −138.9 |      | dBc/Hz |
|                                                             |                                         | f = 1GHz, P <sub>out</sub> = 6dBm, 1kHz offset                |           |      | −148   |      |        |
|                                                             |                                         | f = 1GHz, P <sub>out</sub> = 6dBm, 10kHz offset               |           |      | −154.6 |      |        |
| IMPEDANCE                                                   |                                         |                                                               |           |      |        |      |        |
| Z <sub>I</sub>                                              | Differential input impedance            | f = dc (internal to the device)                               |           |      | 100    |      | Ω      |
| Z <sub>O</sub>                                              | Single-ended output impedance           | f = dc (internal to the device)                               |           |      | 30     |      | Ω      |
| TRANSIENT                                                   |                                         |                                                               |           |      |        |      |        |
| t <sub>REC</sub>                                            | Overdrive recovery time                 | Using a 0.9Vp differential input pulse duration of 1.5ns      |           |      | 2      |      | ns     |
| POWER SUPPLY                                                |                                         |                                                               |           |      |        |      |        |
| I <sub>QA</sub>                                             | Active current                          | Current on V <sub>DD</sub> pin, PD = 0                        | [1, 2, 3] | 140  | 170    | 215  | mA     |
| I <sub>QPD</sub>                                            | Power-down quiescent current            | Current on V <sub>DD</sub> pin, PD = 1                        | [1, 2, 3] |      | 13     | 16.5 | mA     |
| POWER DOWN                                                  |                                         |                                                               |           |      |        |      |        |
| V <sub>PDHIGH</sub>                                         | PD pin logic high                       |                                                               | [1, 2, 3] | 1.45 |        |      | V      |
| V <sub>PDLOW</sub>                                          | PD pin logic low                        |                                                               | [1, 2, 3] |      |        | 0.8  | V      |

at  $T_A = 25^\circ\text{C}$ ,  $V_{DD} = 5\text{V}$ , 100nF ac-coupling capacitors at input and output, differential input with  $R_S = 100\Omega$ , output with  $R_L = 50\Omega$  (unless otherwise noted)

| PARAMETER    |                    | TEST CONDITIONS                           | SUBGROUP  | MIN | TYP | MAX | UNIT          |
|--------------|--------------------|-------------------------------------------|-----------|-----|-----|-----|---------------|
| $I_{PDBIAS}$ | PD bias current    | Current on PD pin, PD = high (1.8V logic) | [1, 2, 3] |     | 40  | 75  | $\mu\text{A}$ |
|              |                    | Current on PD pin, PD = high (3.3V logic) | [1, 2, 3] |     | 200 | 250 | $\mu\text{A}$ |
| $C_{PD}$     | PD pin capacitance |                                           |           |     | 2   |     | pF            |

## 5.6 Quality Conformance Inspection

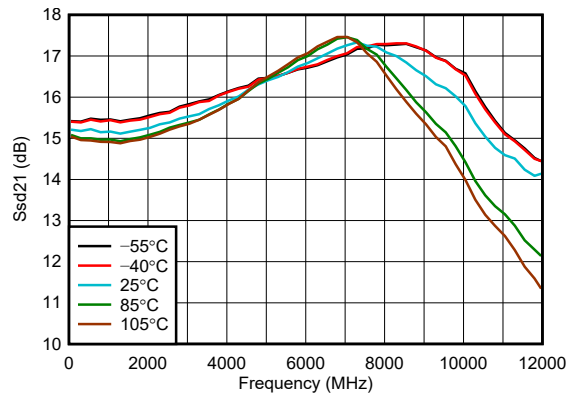
### Quality Conformance Inspection

| SUBGROUP | DESCRIPTION                                          |
|----------|------------------------------------------------------|
| 1        | Static tests at $+25^\circ\text{C}$                  |
| 2        | Static tests at maximum rated operating temperature  |
| 3        | Static tests at minimum rated operating temperature  |
| 4        | Dynamic tests at $+25^\circ\text{C}$                 |
| 5        | Dynamic tests at maximum rated operating temperature |
| 6        | Dynamic tests at minimum rated operating temperature |

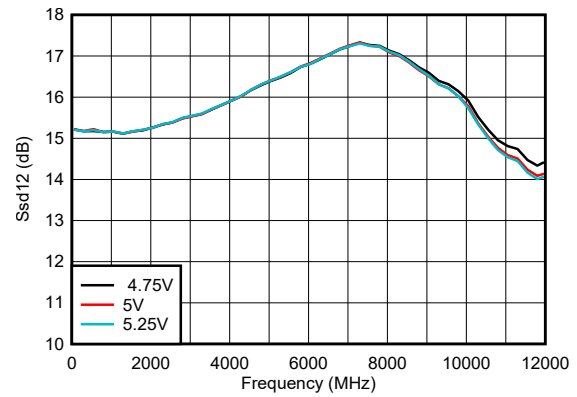
1. MIL-STD-883, Method 5005 - Group A (electrical tests)

## 5.7 Typical Characteristics

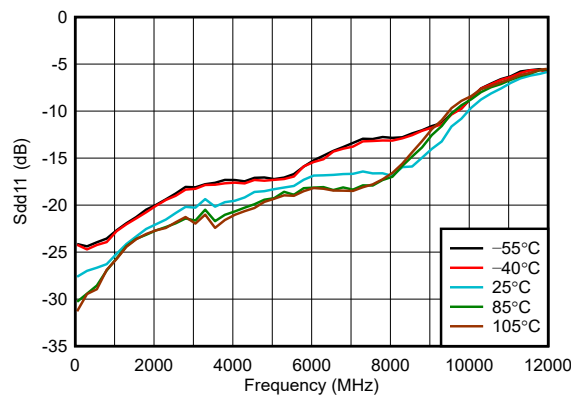
at  $T_A = 25^\circ\text{C}$ , temperature curves specify ambient temperature,  $V_{DD} = 5\text{V}$ , 100nF ac-coupling capacitors at input and output, differential input with  $R_S = 100\Omega$ , output with  $R_L = 50\Omega$  (unless otherwise noted)



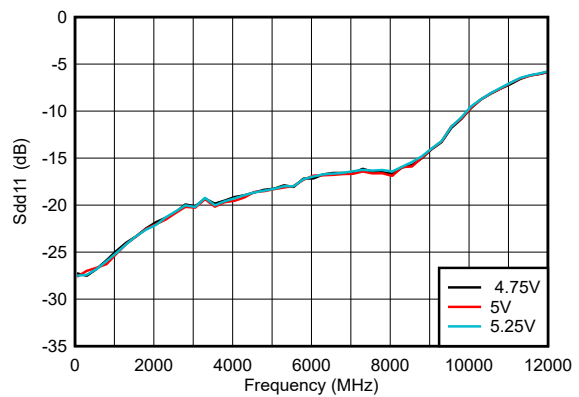
**Figure 5-1. Gain Across Temperature**



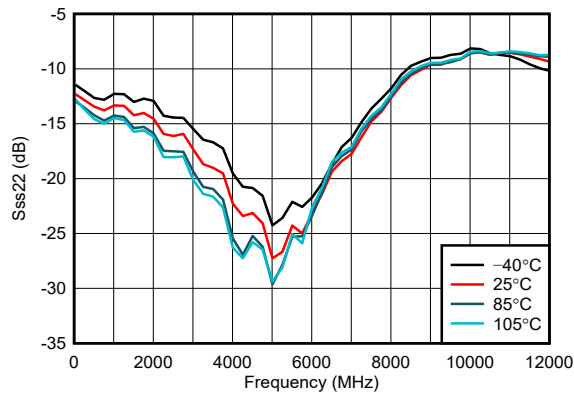
**Figure 5-2. Gain Across Supply Voltage**



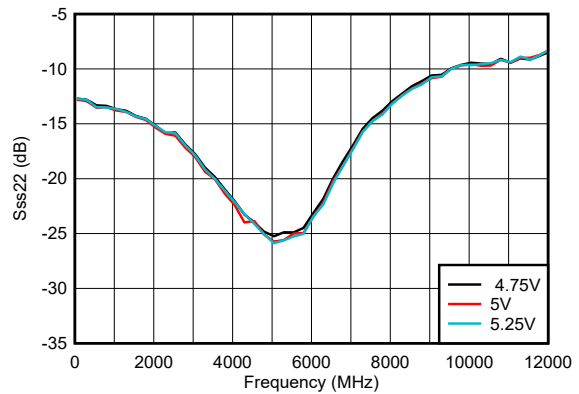
**Figure 5-3. Input Return Loss Across Temperature**



**Figure 5-4. Input Return Loss Across Supply Voltage**



**Figure 5-5. Output Return Loss Across Temperature**

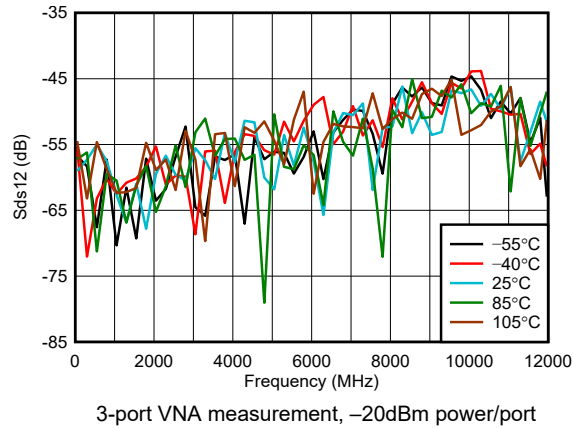


**Figure 5-6. Output Return Loss Across Supply Voltage**

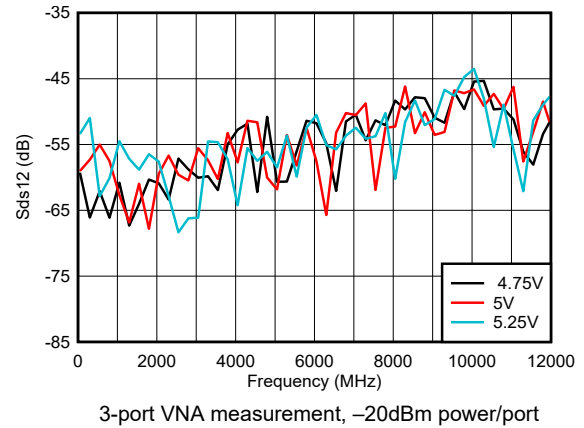


## 5.7 Typical Characteristics (continued)

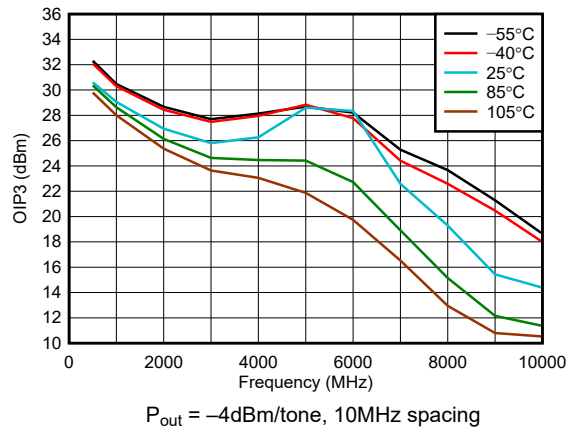
at  $T_A = 25^\circ\text{C}$ , temperature curves specify ambient temperature,  $V_{DD} = 5\text{V}$ , 100nF ac-coupling capacitors at input and output, differential input with  $R_S = 100\Omega$ , output with  $R_L = 50\Omega$  (unless otherwise noted)



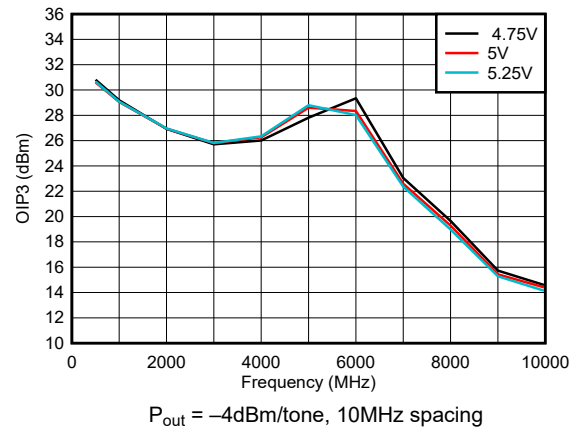
**Figure 5-7. Reverse Isolation Across Temperature**



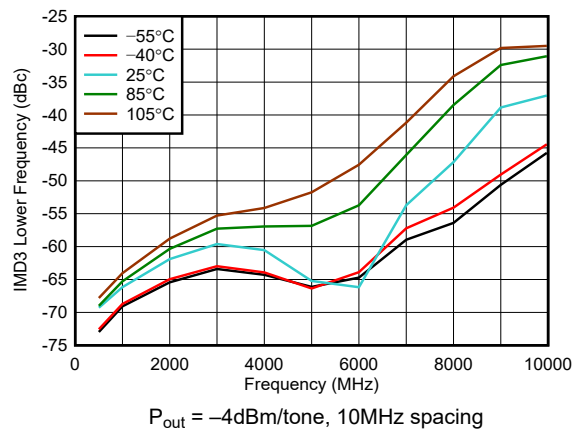
**Figure 5-8. Reverse Isolation Across Supply Voltage**



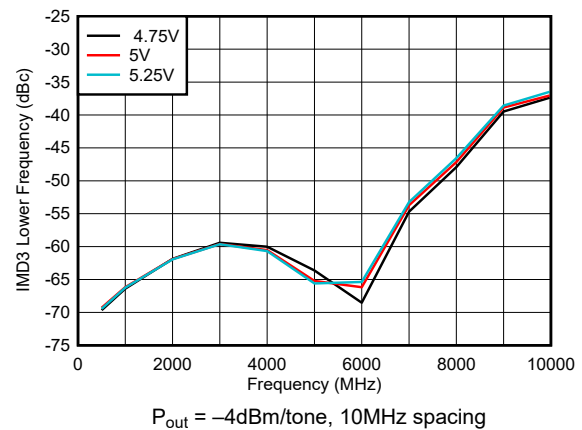
**Figure 5-9. OIP3 Across Temperature**



**Figure 5-10. OIP3 Across Supply Voltage**



**Figure 5-11. IMD3 Lower Across Temperature**



**Figure 5-12. IMD3 Lower Across Supply Voltage**

## 5.7 Typical Characteristics (continued)

at  $T_A = 25^\circ\text{C}$ , temperature curves specify ambient temperature,  $V_{DD} = 5\text{V}$ , 100nF ac-coupling capacitors at input and output, differential input with  $R_S = 100\Omega$ , output with  $R_L = 50\Omega$  (unless otherwise noted)

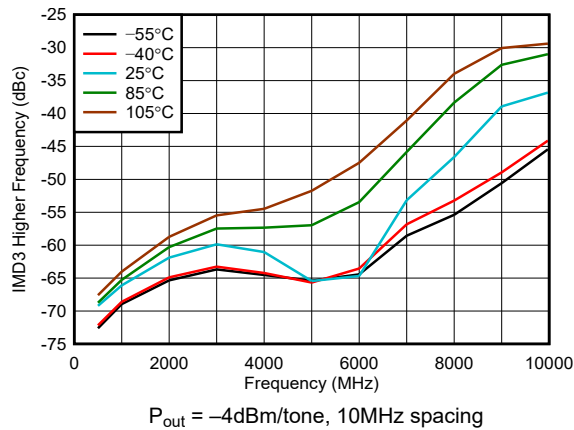


Figure 5-13. IMD3 Higher Across Temperature

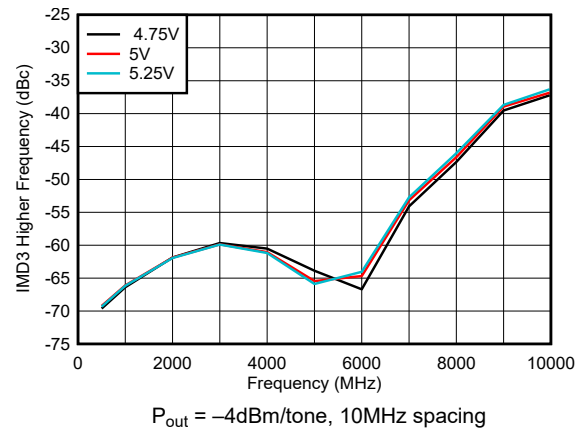


Figure 5-14. IMD3 Higher Across Supply Voltage

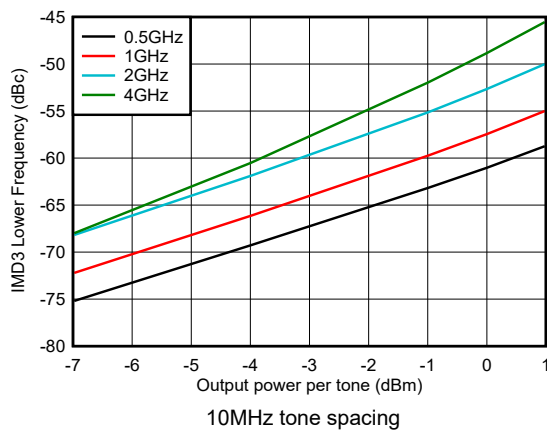


Figure 5-15. IMD3 Lower Across Output Power

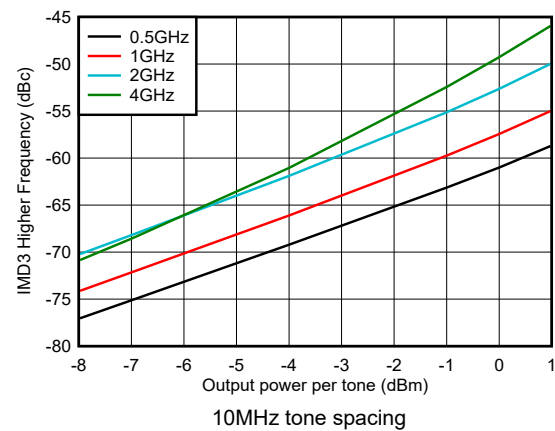


Figure 5-16. IMD3 Higher Across Output Power

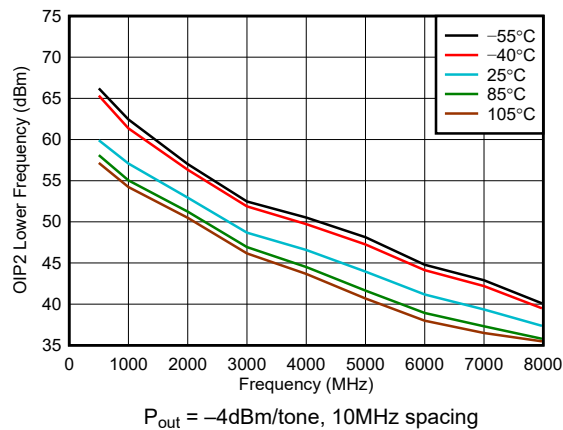


Figure 5-17. OIP2 Lower Across Temperature

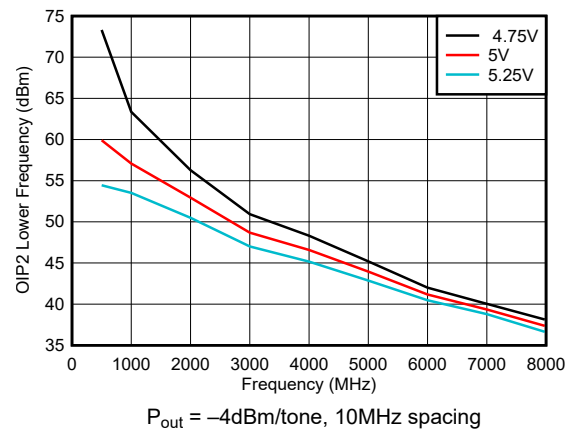
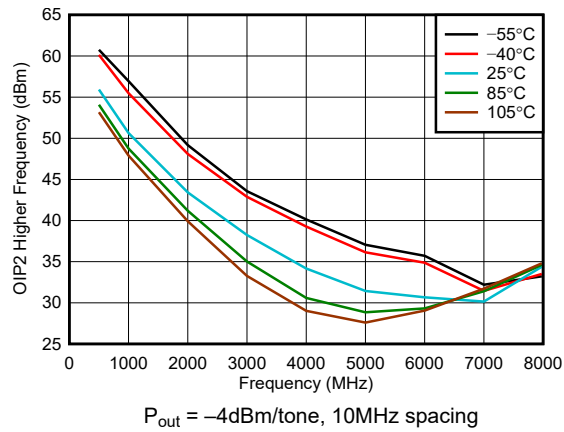


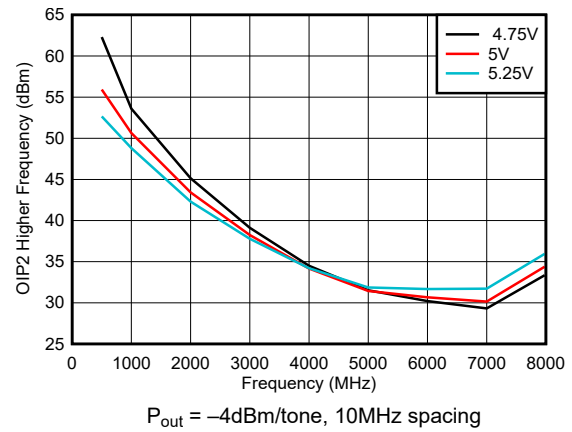
Figure 5-18. OIP2 Lower Across Supply Voltage

## 5.7 Typical Characteristics (continued)

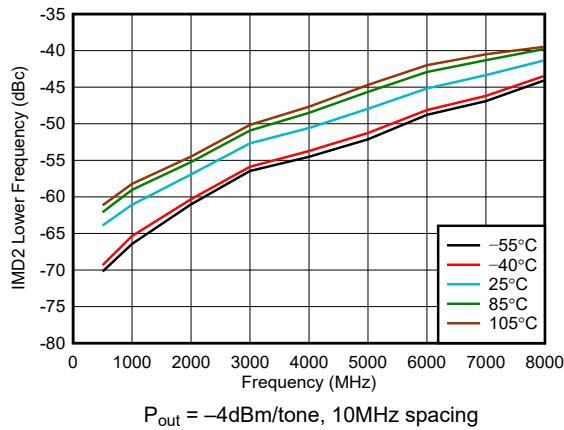
at  $T_A = 25^\circ\text{C}$ , temperature curves specify ambient temperature,  $V_{DD} = 5\text{V}$ , 100nF ac-coupling capacitors at input and output, differential input with  $R_S = 100\Omega$ , output with  $R_L = 50\Omega$  (unless otherwise noted)



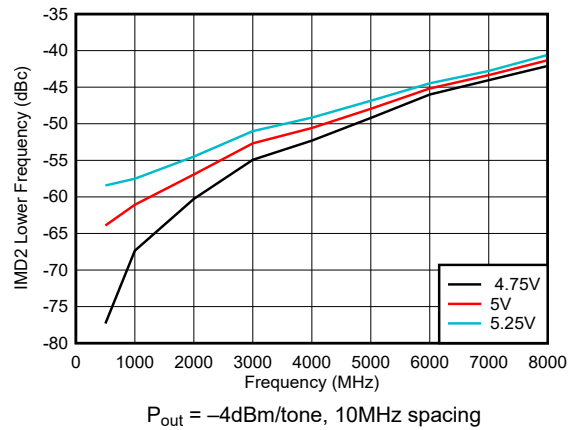
**Figure 5-19. OIP2 Higher Across Temperature**



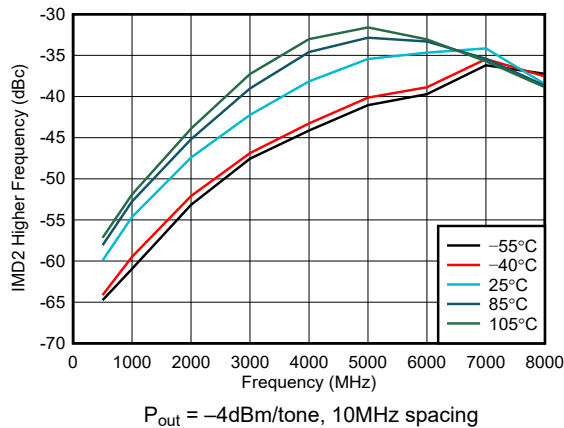
**Figure 5-20. OIP2 Higher Across Supply Voltage**



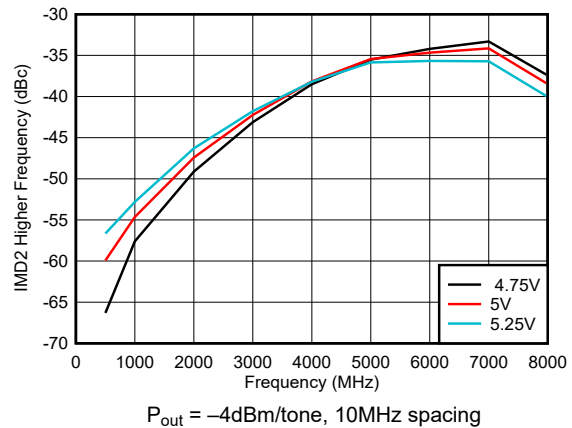
**Figure 5-21. IMD2 Lower Across Temperature**



**Figure 5-22. IMD2 Lower Across Supply Voltage**



**Figure 5-23. IMD2 Higher Across Temperature**



**Figure 5-24. IMD2 Higher Across Supply Voltage**

## 5.7 Typical Characteristics (continued)

at  $T_A = 25^\circ\text{C}$ , temperature curves specify ambient temperature,  $V_{DD} = 5\text{V}$ , 100nF ac-coupling capacitors at input and output, differential input with  $R_S = 100\Omega$ , output with  $R_L = 50\Omega$  (unless otherwise noted)

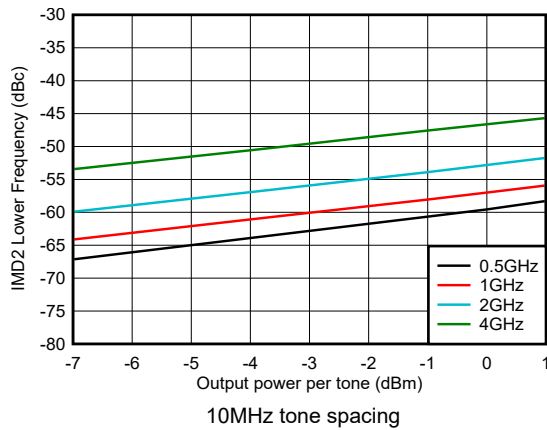


Figure 5-25. IMD2 Lower Across Output Power

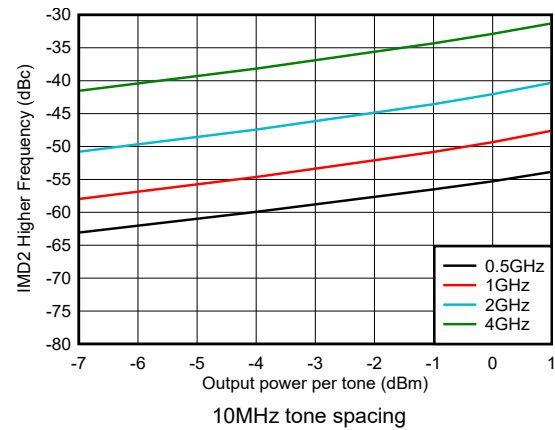


Figure 5-26. IMD2 Higher Across Output Power

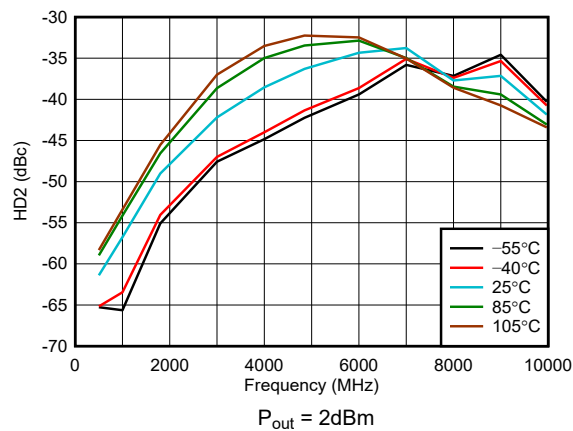


Figure 5-27. HD2 Across Temperature

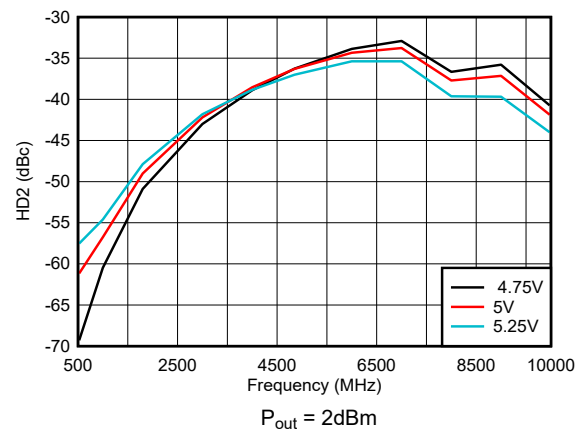


Figure 5-28. HD2 Across Supply Voltage

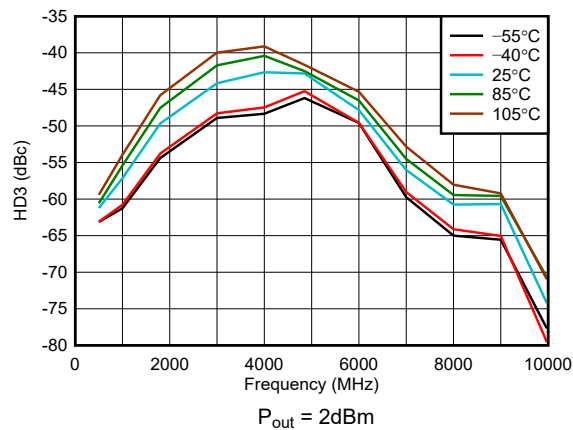


Figure 5-29. HD3 Across Temperature

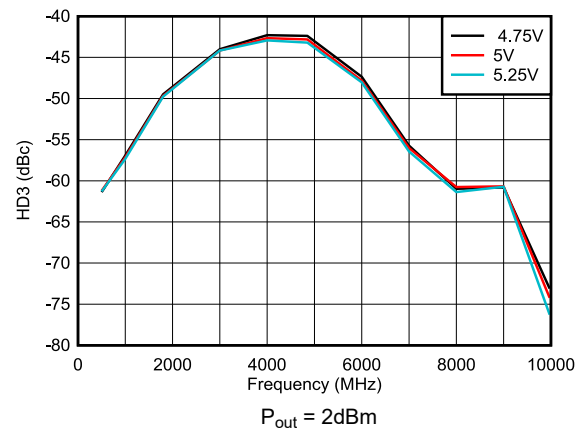


Figure 5-30. HD3 Across Supply Voltage

## 5.7 Typical Characteristics (continued)

at  $T_A = 25^\circ\text{C}$ , temperature curves specify ambient temperature,  $V_{DD} = 5\text{V}$ , 100nF ac-coupling capacitors at input and output, differential input with  $R_S = 100\Omega$ , output with  $R_L = 50\Omega$  (unless otherwise noted)

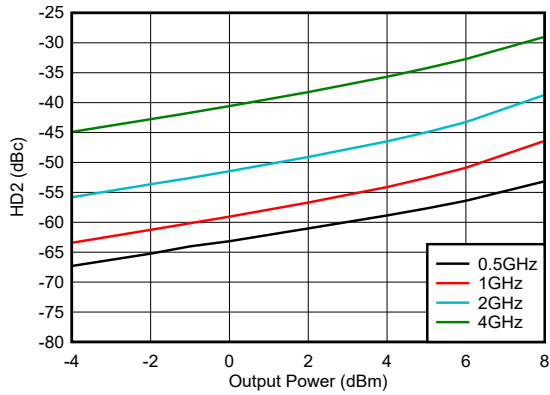


Figure 5-31. HD2 Across Output Power

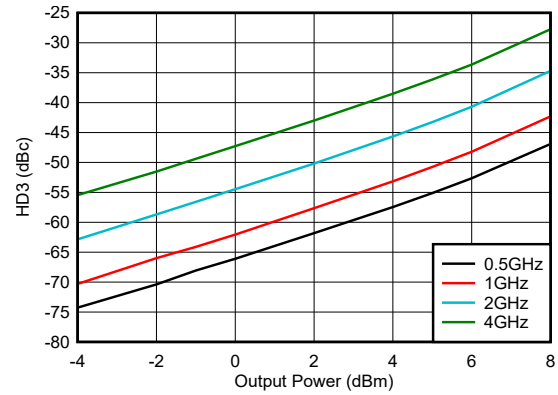


Figure 5-32. HD3 Across Output Power

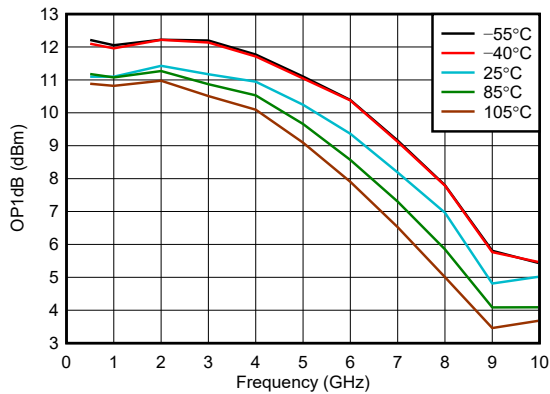


Figure 5-33. OP1dB Across Temperature

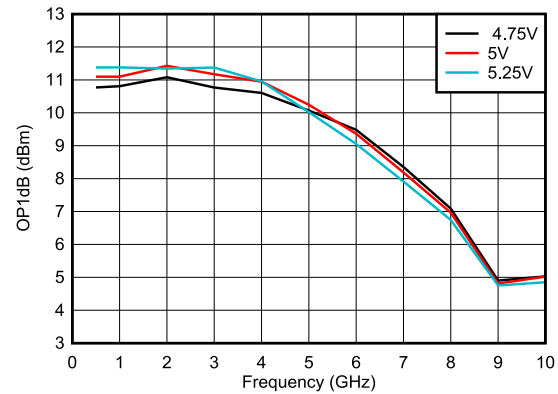


Figure 5-34. OP1dB Across Supply Voltage

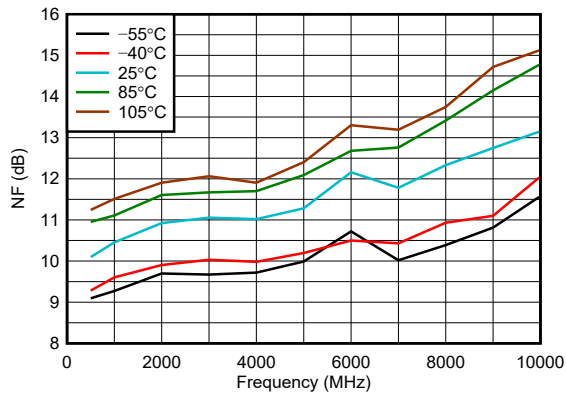


Figure 5-35. NF Across Temperature

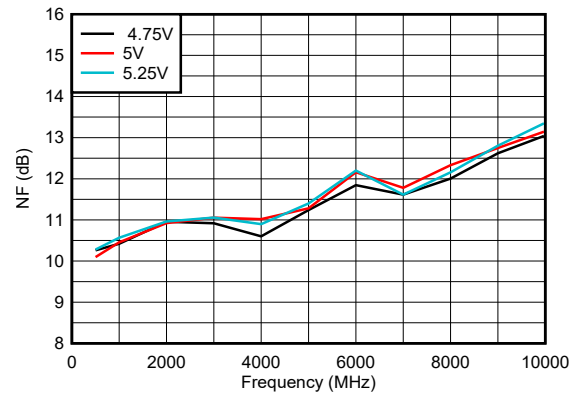


Figure 5-36. NF Across Supply Voltage

## 5.7 Typical Characteristics (continued)

at  $T_A = 25^\circ\text{C}$ , temperature curves specify ambient temperature,  $V_{DD} = 5\text{V}$ , 100nF ac-coupling capacitors at input and output, differential input with  $R_S = 100\Omega$ , output with  $R_L = 50\Omega$  (unless otherwise noted)

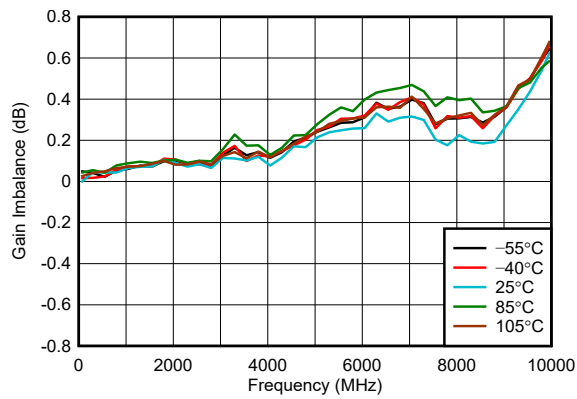


Figure 5-37. Gain Imbalance Across Temperature

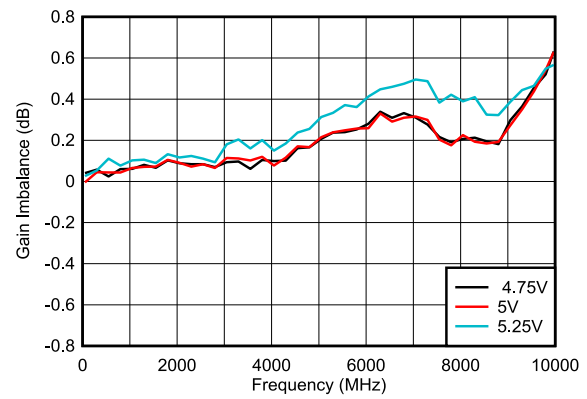


Figure 5-38. Gain Imbalance Across Supply Voltage

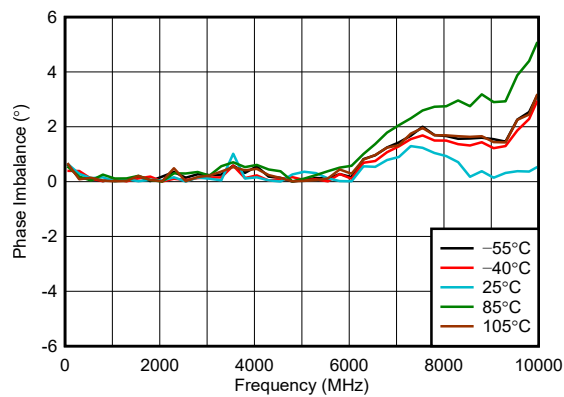


Figure 5-39. Phase Imbalance Across Temperature

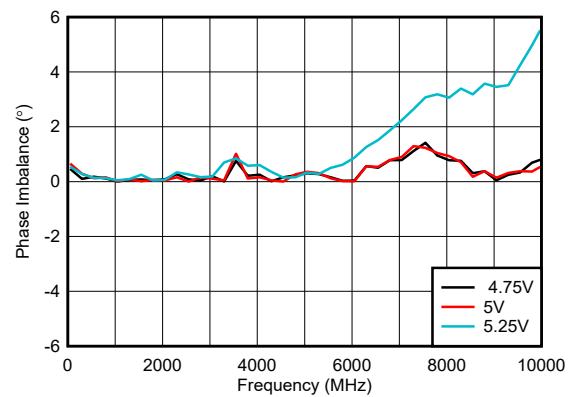


Figure 5-40. Phase Imbalance Across Supply Voltage

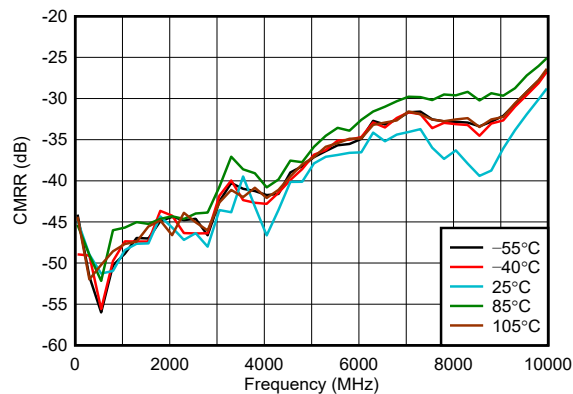


Figure 5-41. CMRR Across Temperature

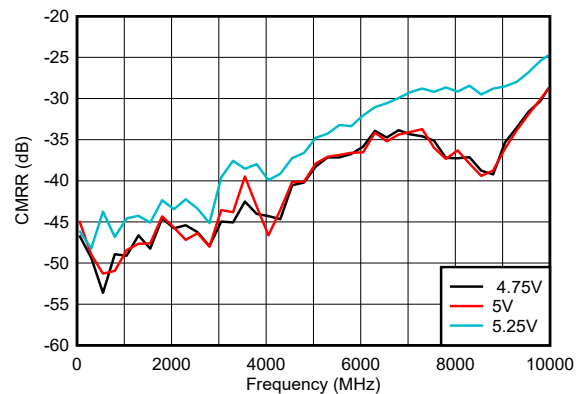
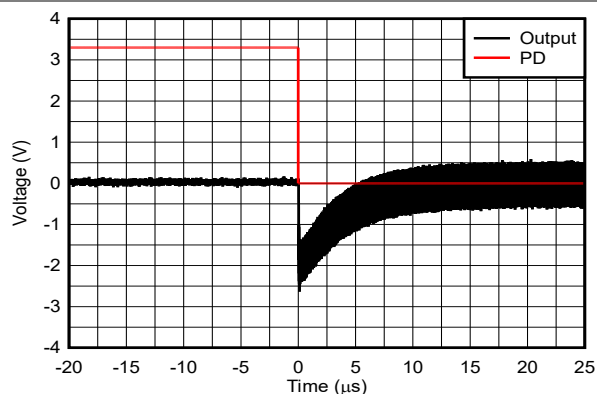


Figure 5-42. CMRR Across Supply Voltage

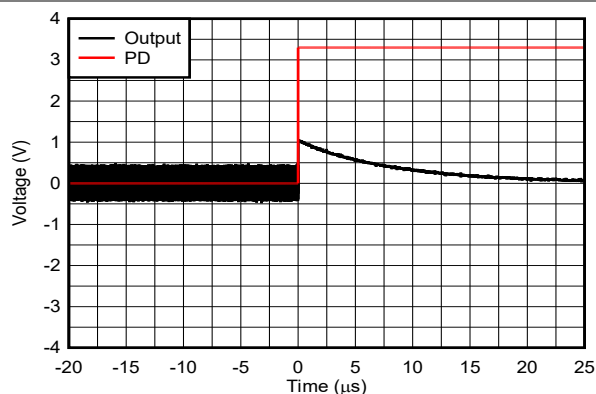
## 5.7 Typical Characteristics (continued)

at  $T_A = 25^\circ\text{C}$ , temperature curves specify ambient temperature,  $V_{DD} = 5\text{V}$ , 100nF ac-coupling capacitors at input and output, differential input with  $R_S = 100\Omega$ , output with  $R_L = 50\Omega$  (unless otherwise noted)



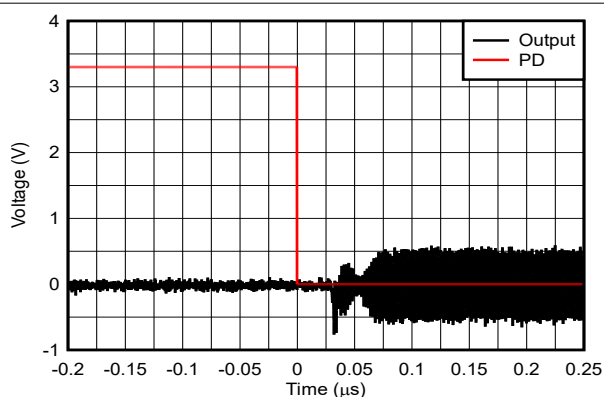
$f = 500\text{MHz}$ , 100nF ac-coupling capacitors

**Figure 5-43. Turn On Time**



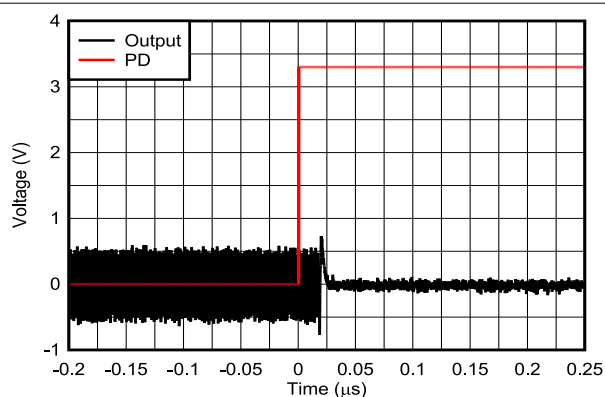
$f = 500\text{MHz}$ , 100nF ac-coupling capacitors

**Figure 5-44. Turn Off Time**



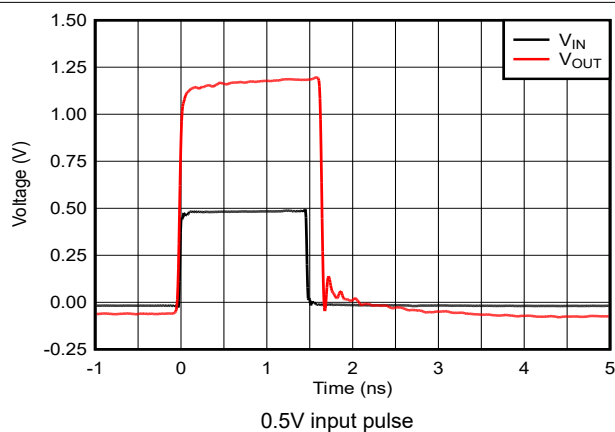
$f = 500\text{MHz}$ , 22pF ac-coupling capacitors

**Figure 5-45. Turn On Time**



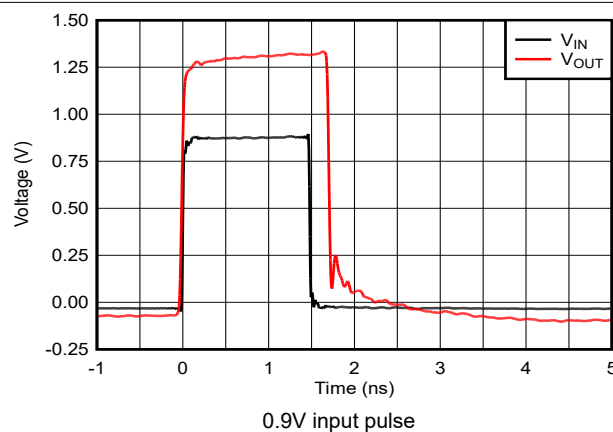
$f = 500\text{MHz}$ , 22pF ac-coupling capacitors

**Figure 5-46. Turn Off Time**



0.5V input pulse

**Figure 5-47. Overload Recovery**



0.9V input pulse

**Figure 5-48. Overload Recovery**

## 5.7 Typical Characteristics (continued)

at  $T_A = 25^\circ\text{C}$ , temperature curves specify ambient temperature,  $V_{DD} = 5\text{V}$ , 100nF ac-coupling capacitors at input and output, differential input with  $R_S = 100\Omega$ , output with  $R_L = 50\Omega$  (unless otherwise noted)

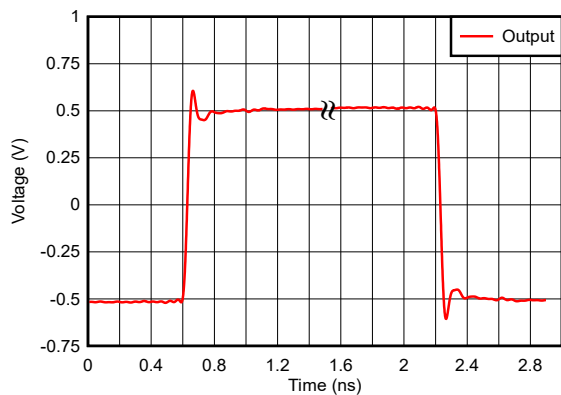


Figure 5-49. Step Response

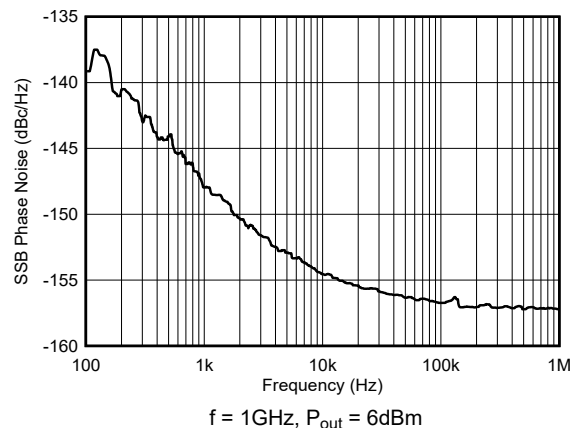


Figure 5-50. Additive (Residual) Phase Noise

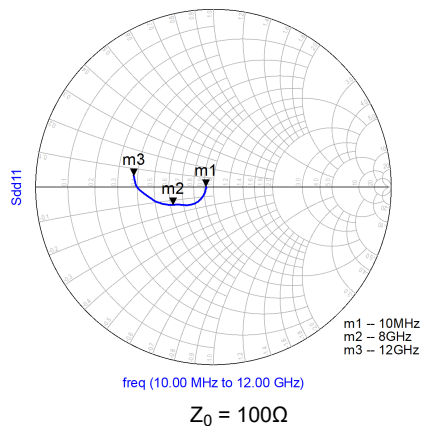


Figure 5-51. Input Return Loss, Sdd11

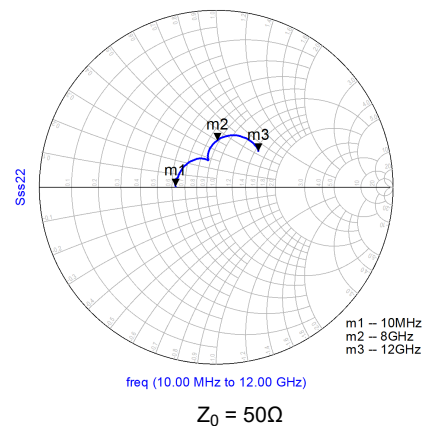


Figure 5-52. Output Return Loss, Sss22



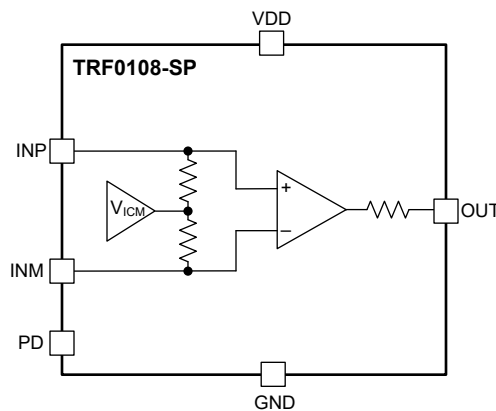
## 6 Detailed Description

### 6.1 Overview

The TRF0108-SP is a very high-performance differential-to-single-ended (D2S) amplifier optimized for radio frequency (RF) and intermediate frequency (IF) applications with signal bandwidths up to 12GHz. The device is an excellent choice for conversion of differential output of an RF DAC to a single-ended output. The device has a two-stage architecture and provides approximately 15.2dB of gain at 2GHz. The on-chip matching components simplify printed circuit board (PCB) implementation and provide the highest performance over the usable bandwidth. A power-down feature is also available for power savings.

### 6.2 Functional Block Diagram

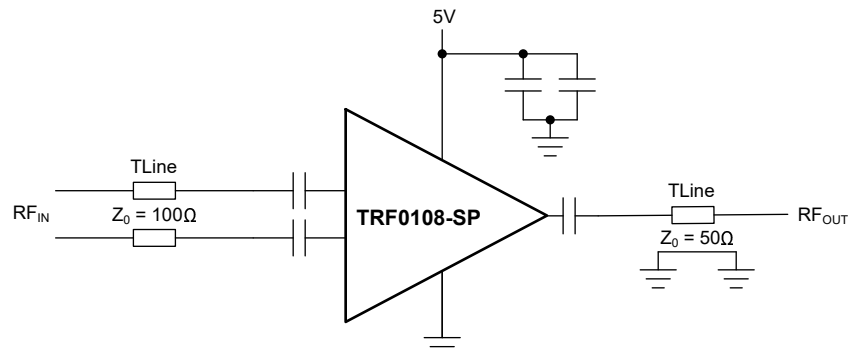
The following figure shows the functional block diagram of TRF0108-SP. The differential inputs are matched to 100Ω, and single ended output is matched to 50Ω. The input common-mode voltage is internally set, simplifying ac-coupled applications.



### 6.3 Feature Description

#### 6.3.1 AC-Coupled Configuration

Figure 6-1 shows the TRF0108-SP in an ac-coupled configuration with single 5V supply operation. The input common-mode voltage is internally set simplifying biasing of the device. The value of the ac-coupling capacitors at the inputs and output set the lower cutoff frequency for the gain. If the lowest signal frequency is 10MHz, use 100nF ac-coupling capacitors. If the lowest signal frequency is 9kHz, use a 4.7μF capacitor in parallel with 100nF capacitor on each input and output pin.



**Figure 6-1. The TRF0108-SP Used in an AC-Coupled Configuration**

### 6.4 Device Functional Modes

TRF0108-SP has two functional modes: active and power-down. These functional modes are controlled by the PD pin as described in the next section.

#### **6.4.1 Power-Down Mode**

The device features a power-down option. The PD pin is used to power down the amplifier. This pin supports both 1.8V and 3.3V digital logic, and is referenced to GND. A logic 1 turns the device off and places the device into a low-quiescent-current state.

When disabled, the signal path is still present through the internal circuits. Input signals applied to a disabled device still appear at the outputs at a lower level through this path.

## 7 Application and Implementation

### Note

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes, as well as validating and testing their design implementation to confirm system functionality.

### 7.1 Application Information

#### 7.1.1 Thermal Considerations

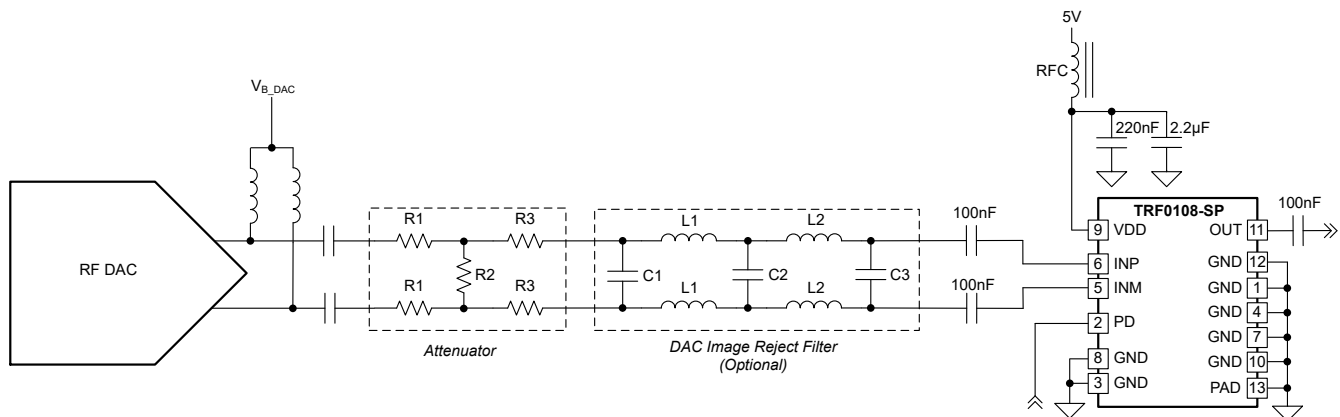
The TRF0108-SP is packaged in a 2mm × 2mm WQFN-FCRLF package that has excellent thermal properties. Connect the thermal pad under the chip to a wide ground plane. Short the ground plane to the other GND pins of the chip at four corners, if possible, to allow heat propagation to the top layer of PCB. Use a thermal via to connect the thermal pad plane on the top layer of PCB to inner layer ground planes to allow heat dissipation to the inner layers.

### 7.2 Typical Application

#### 7.2.1 RF DAC Buffer Amplifier

A common application of the TRF0108-SP is to function as a buffer amplifier for an RF DAC, such as the DAC39RF10-SP or AFE7950-SP, which have differential outputs. Conventionally, passive baluns are used to interface with RF DACs as a result of the low-availability of high-bandwidth, linear amplifiers. The TRF0108-SP is a differential-to-single-ended amplifier that has excellent gain and phase imbalance, input and output return loss, and exceeds the performance of bulky and expensive passive baluns for DAC buffer applications. The TRF0108-SP integrates the functionality of a wide-band passive balun and gain-block in a single 2mm x 2mm package, reducing PCB area for high channel count RF systems.

The following figure shows the schematic where the TRF0108-SP is used as a D2S RF amplifier converting the differential DAC output to single ended and providing RF gain.



**Figure 7-1. Interfacing With an RF DAC**

### 7.2.1.1 Design Requirements

The TRF0108-SP is required to convert differential output of an RF DAC to single-ended output, over a wide bandwidth of 4GHz, delivering 6dBm power into a 50Ω load with good output return loss.

**Table 7-1. Design Parameters**

| PARAMETER                 | VALUE         |
|---------------------------|---------------|
| RF signal frequency range | 10MHz to 4GHz |
| DAC sampling rate         | 10GSPS        |
| Output power at 2GHz      | 6dBm          |
| Output return loss, S22   | -12dB         |

### 7.2.1.2 Detailed Design Procedure

Select an RF DAC such as the DAC39RF10-SP for this application because the DAC supports sampling at 10GSPS and the required RF signal frequency range of 4GHz. The DAC39RF10-SP outputs a signal level of -0.4dBm at 2GHz when operated at -1dBFS. The TRF0108-SP has a gain of 15.2dB and OP1dB of 11.4dBm at 2GHz; therefore, add an 8.8dB attenuator pad at the output of the DAC to get 6dBm output power. A 5GHz low-pass filter can optionally be added to reject the DAC images in the second Nyquist zone. From the TRF0108-SP specifications, the device meets the design requirement of output return loss.

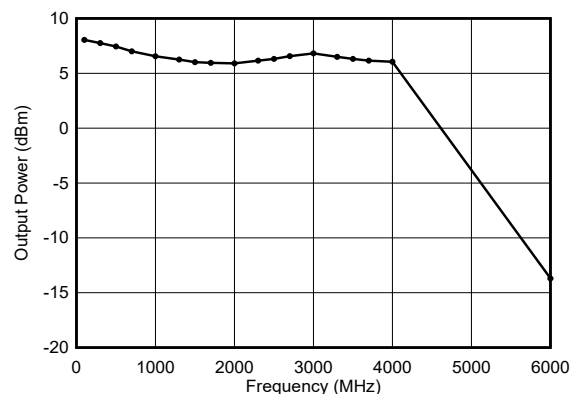
Table 7-2 shows the component values for attenuator and low-pass filter for the design.

**Table 7-2. Component Values for Attenuator and Low-Pass Filter for the DAC39RF10-SP Interface**

| SECTION         | DESIGNATOR | TYPE      | VALUE |
|-----------------|------------|-----------|-------|
| Attenuator      | R1         | Resistor  | 24Ω   |
| Attenuator      | R2         | Resistor  | 80Ω   |
| Attenuator      | R3         | Resistor  | 24Ω   |
| Low-pass filter | C1         | Capacitor | 0.5pF |
| Low-pass filter | C2         | Capacitor | 0.8pF |
| Low-pass filter | C3         | Capacitor | 0.5pF |
| Low-pass filter | L1         | Inductor  | 2nH   |
| Low-pass filter | L2         | Inductor  | 2nH   |

### 7.2.1.3 Application Performance Plots

Figure 7-2 shows the output response measured on a spectrum analyzer for the design in the previous section.



**Figure 7-2. Output Response Including Filter**

## 7.3 Power Supply Recommendations

### 7.3.1 Single-Supply Operation

The TRF0108-SP supports single 5V supply operation for ac-coupled applications. Supply decoupling is critical to high-frequency performance. Typically, two or three capacitors are used for VDD supply decoupling. Use a 220nF, small-form-factor, 0201-size component placed closest to the VDD pin of the device. Use 0402-size, 2.2μF bulk decoupling capacitors placed next to the small capacitor. A ferrite bead can be further used to filter power-supply noise. Additional layout recommendations are given in [Section 7.4](#).

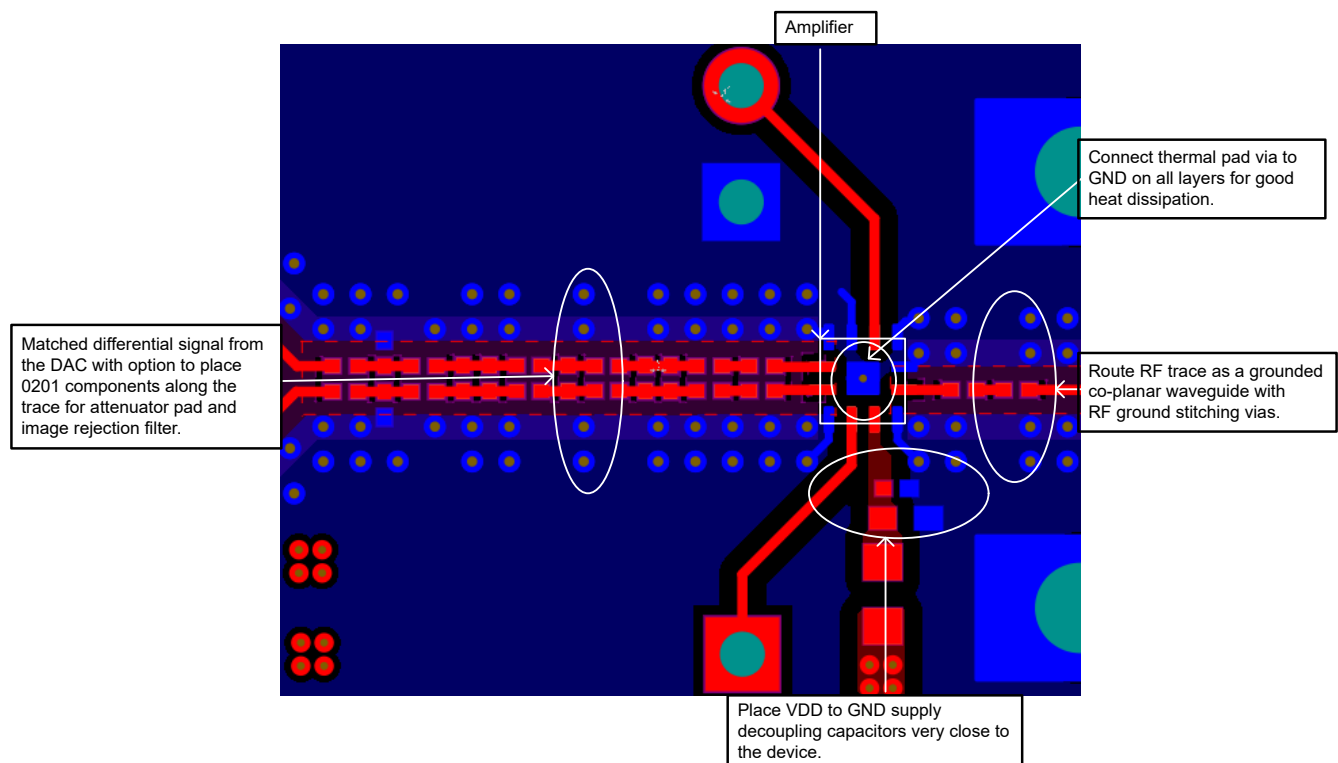
## 7.4 Layout

### 7.4.1 Layout Guidelines

The TRF0108-SP is a wide-band feedback amplifier with approximately 15.2dB of gain. When designing with a wide-band RF amplifier with relatively high gain, follow these printed circuit board (PCB) layout guidelines to maintain stability and optimized performance:

- Use a multilayer board to maintain signal and power integrity, and thermal performance.
- Route the RF input and output lines as grounded coplanar waveguide (GCPW) lines. For the second layer, use a continuous ground plane below the RF traces, and continuous ground plane below the amplifier area.
- Match the input differential lines in length to minimize phase imbalance.
- Use small-footprint, passive components wherever possible.
- Connect the ground planes on all the layers with well stitched vias.
- Place a thermal via under the device that connects the top thermal pad with ground planes in the inner layers of PCB. Also, connect the thermal pad to the top layer ground plane through the GND pins for improved heat dissipation.

### 7.4.2 Layout Example



**Figure 7-3. Layout Example: Placement and Top Layer**

Evaluate the TRF0108-SP using the [TRF0108SP-EVM](#) that can be ordered from [www.ti.com](#). Additional information about the evaluation board construction and test setup is given in the [TRF0108-SP EVM user's guide](#).

## 8 Device and Documentation Support

### 8.1 Documentation Support

#### 8.1.1 Related Documentation

For related documentation see the following:

- Texas Instruments, [TRF0108-SP EVM user's guide](#)
- Texas Instruments, [TRF0108-SP Total Ionizing Dose \(TID\) Report](#)
- Texas Instruments, [TRF0108-SP Single-Event Effects Test Report](#)

### 8.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on [ti.com](#). Click on *Notifications* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

### 8.3 Support Resources

[TI E2E™ support forums](#) are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

Linked content is provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

### 8.4 Trademarks

TI E2E™ is a trademark of Texas Instruments.

All trademarks are the property of their respective owners.

### 8.5 Electrostatic Discharge Caution



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

### 8.6 Glossary

[TI Glossary](#) This glossary lists and explains terms, acronyms, and definitions.

## 9 Revision History

| DATE      | REVISION | NOTES           |
|-----------|----------|-----------------|
| July 2026 | *        | Initial release |

## 10 Mechanical, Packaging, and Orderable Information

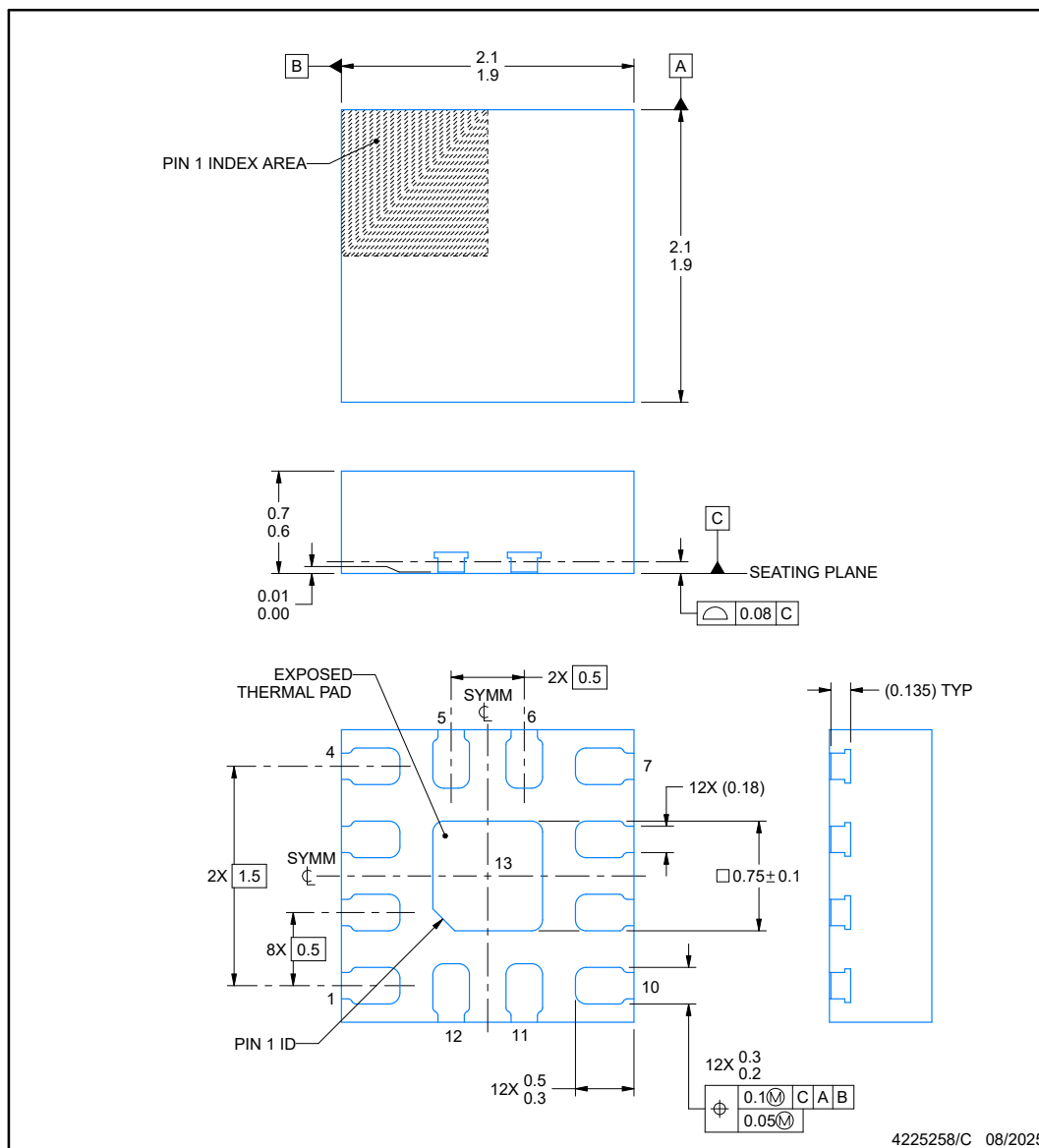
The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

## 10.1 Mechanical Data

**RPV0012A**



**PACKAGE OUTLINE**  
**WQFN-FCRLF - 0.7 mm max height**  
PLASTIC QUAD FLATPACK - NO LEAD



## NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.

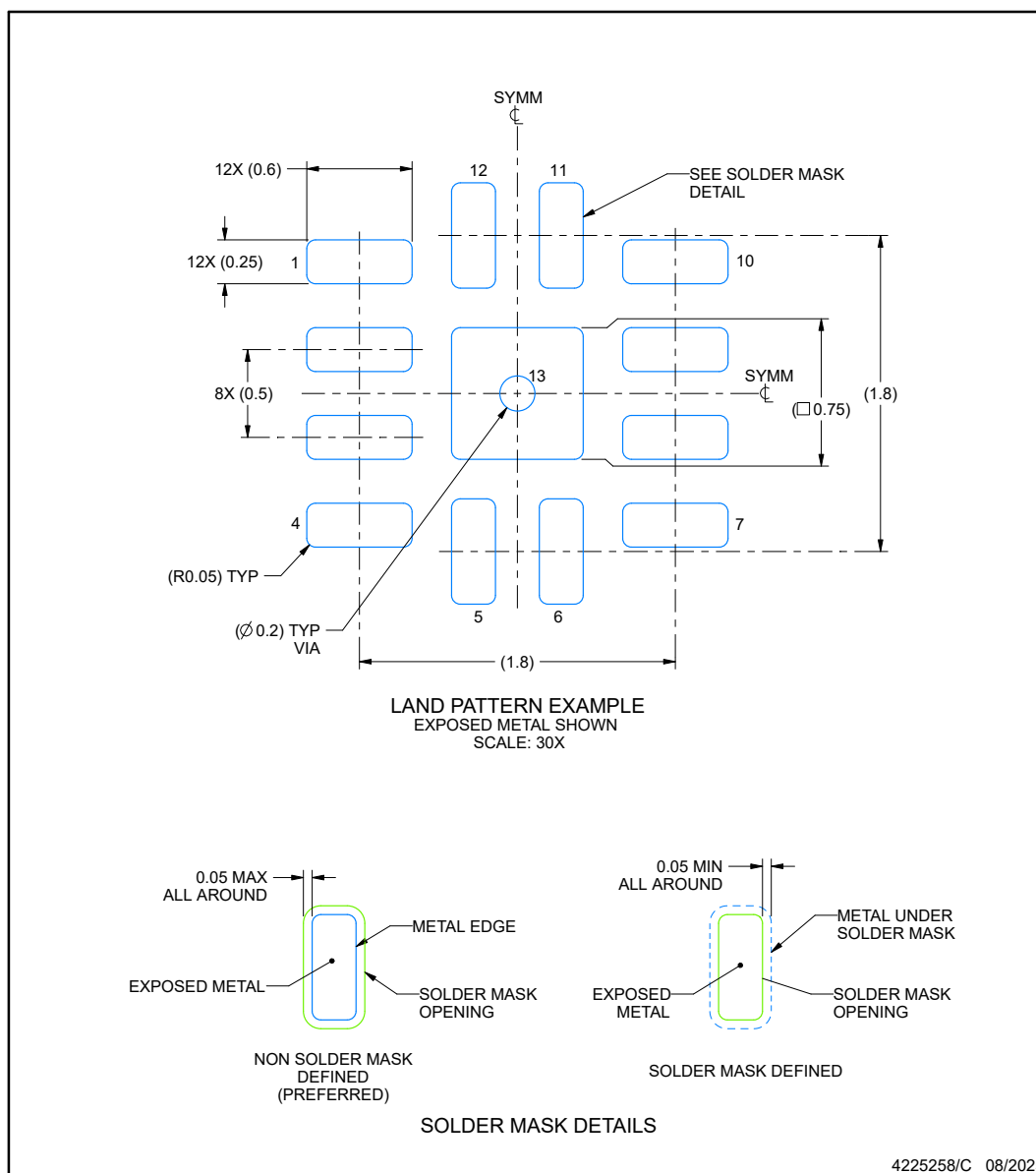


## EXAMPLE BOARD LAYOUT

**RPV0012A**

**WQFN-FCRLF - 0.7 mm max height**

PLASTIC QUAD FLATPACK - NO LEAD



NOTES: (continued)

- This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 ([www.ti.com/lit/sluea271](http://www.ti.com/lit/sluea271)).
- Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.

**WQFN-FCRLF - 0.7 mm max height**

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6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

## PACKAGING INFORMATION

| Orderable part number            | Status<br>(1) | Material type<br>(2) | Package   Pins     | Package qty   Carrier | RoHS<br>(3) | Lead finish/<br>Ball material<br>(4) | MSL rating/<br>Peak reflow<br>(5) | Op temp (°C) | Part marking<br>(6) |
|----------------------------------|---------------|----------------------|--------------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| <a href="#">5962R2520101PXE</a>  | Active        | Production           | WQFN-HR (RPV)   12 | 250   SMALL T&R       | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -55 to 125   | 201                 |
| <a href="#">TRF0108RPVTSP/EM</a> | Active        | Production           | WQFN-HR (RPV)   12 | 250   SMALL T&R       | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | 25 to 25     | 201                 |

<sup>(1)</sup> **Status:** For more details on status, see our [product life cycle](#).

<sup>(2)</sup> **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

<sup>(3)</sup> **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

<sup>(4)</sup> **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

<sup>(5)</sup> **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

<sup>(6)</sup> **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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### OTHER QUALIFIED VERSIONS OF TRF0108-SP :

- Catalog : [TRF0108-SEP](#)

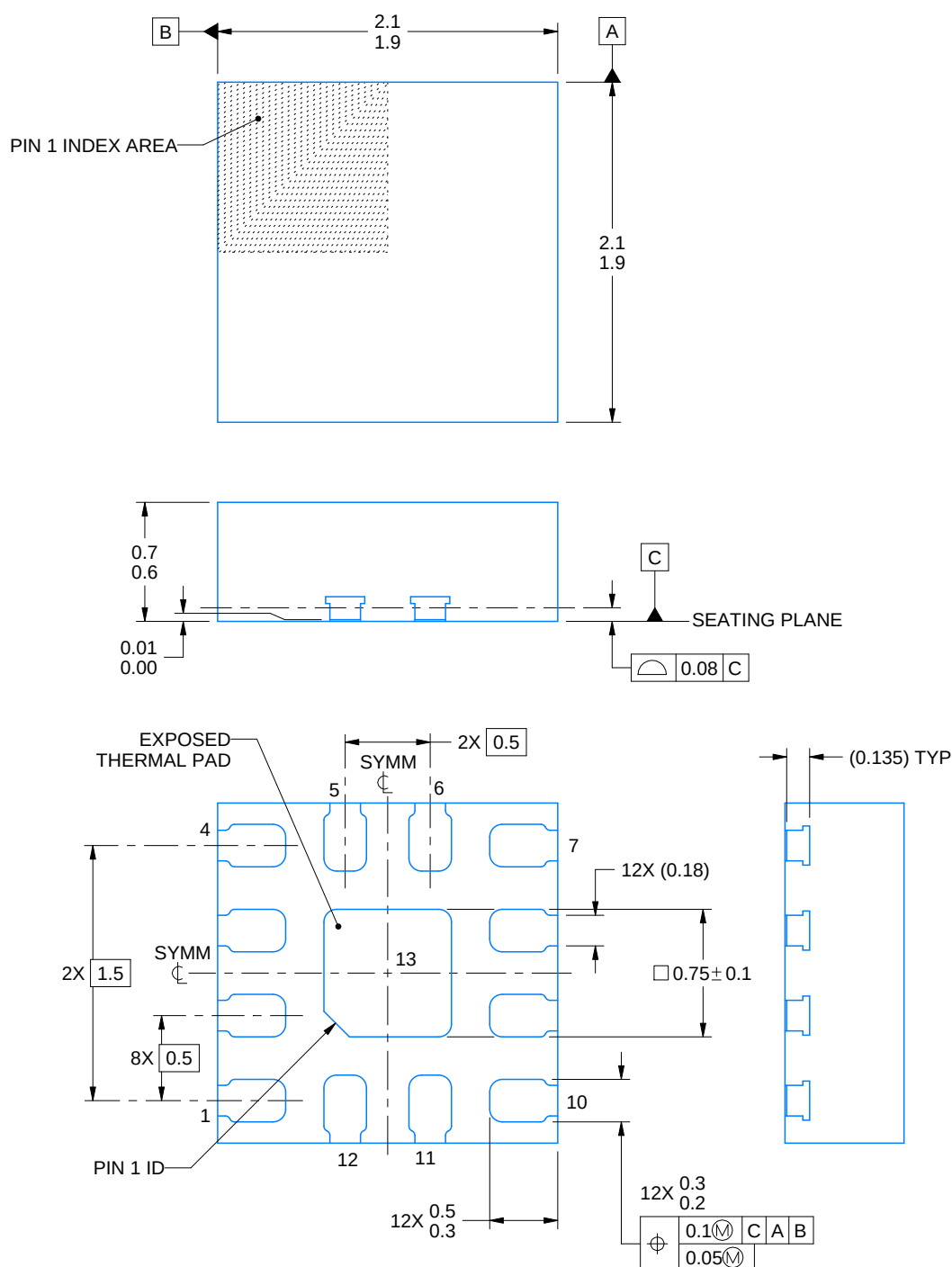
NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product



## WQFN-FCRLF - 0.7 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



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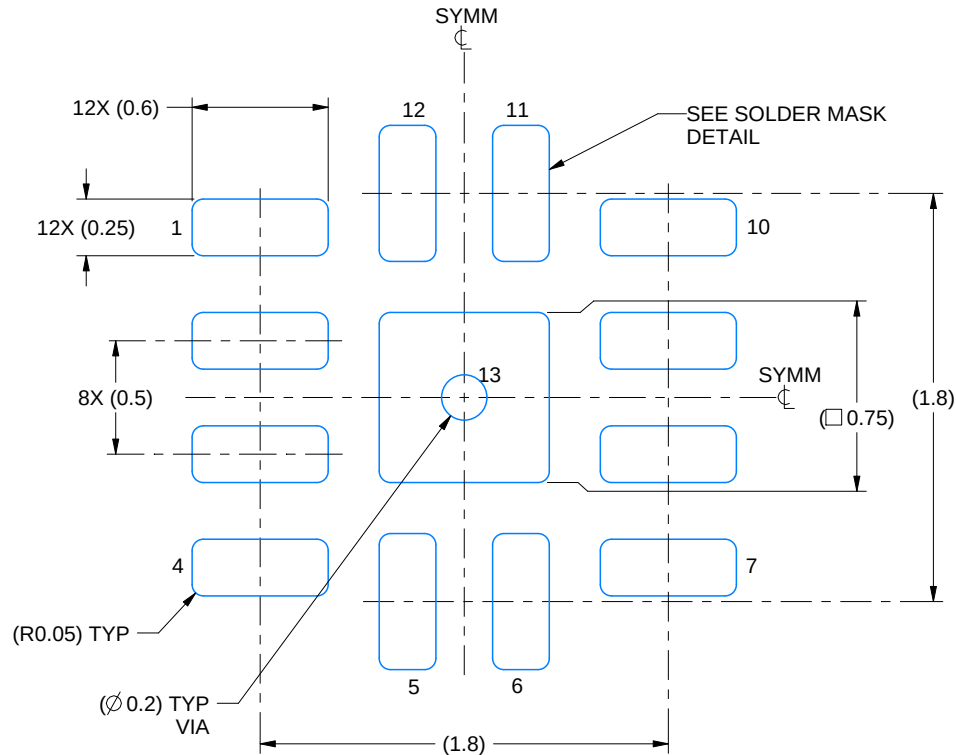
NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.

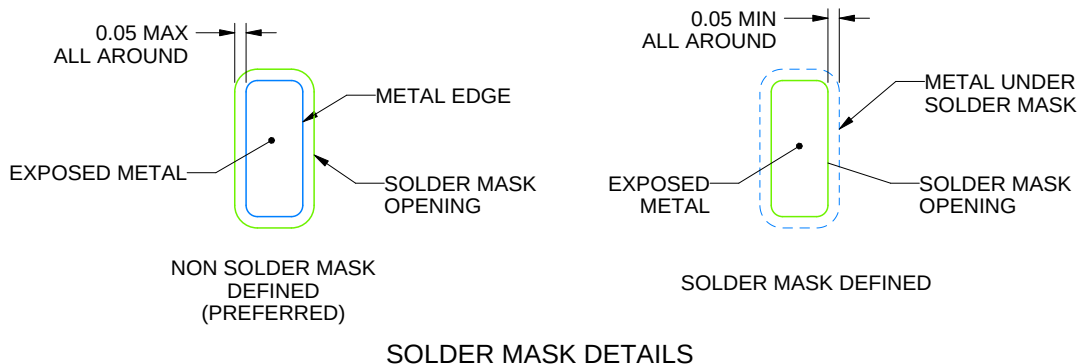
**RPV0012A**

## WQFN-FCRLF - 0.7 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE: 30X



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NOTES: (continued)

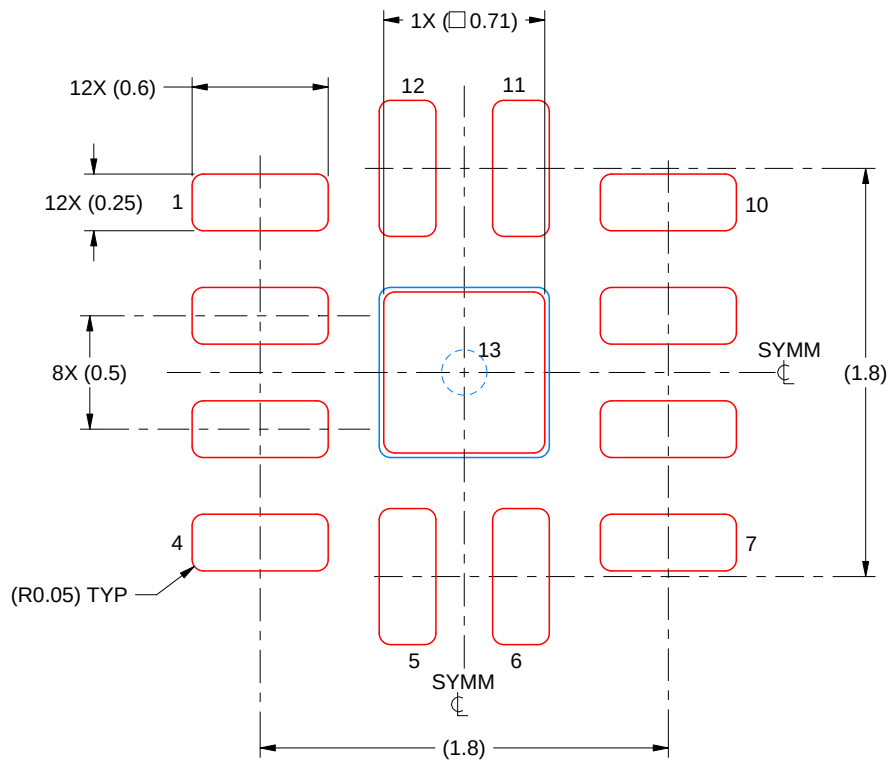
4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 ([www.ti.com/lit/slue271](http://www.ti.com/lit/slue271)).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.

# EXAMPLE STENCIL DESIGN

RPV0012A

WQFN-FCRLF - 0.7 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



SOLDER PASTE EXAMPLE  
BASED ON 0.125 MM THICK STENCIL  
SCALE: 30X

EXPOSED PAD 13  
90% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE

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NOTES: (continued)

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