50-MHz TO 6-GHz QUADRATURE MODULATOR

Check for Samples: TRF370417

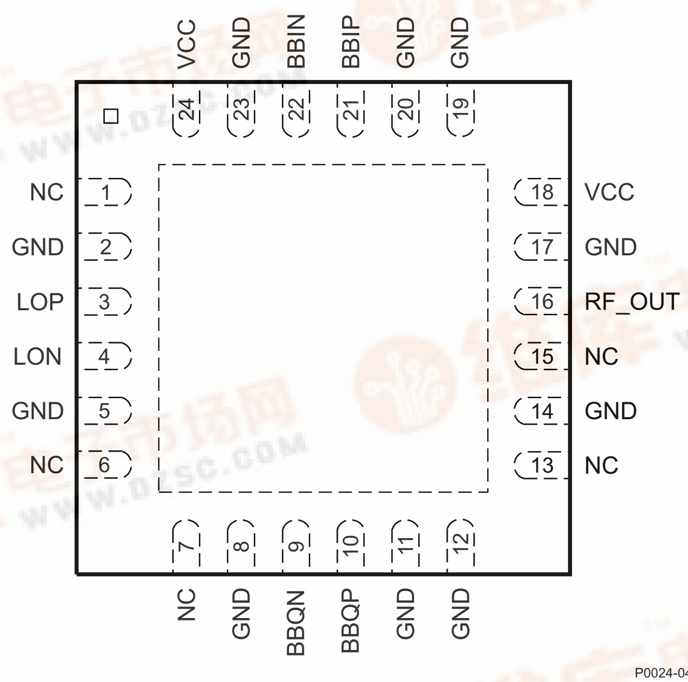
FEATURES

- 76-dBc Single-Carrier WCDMA ACPR at –8 dBm Channel Power
- Low Noise Floor: –162.3 dBm/Hz at 2140 MHz
- OIP3 of 26.5 dBm at 2140 MHz
- P1dB of 12 dBm at 2140 MHz
- Carrier Feedthrough of –38 dBm at 2140 MHz
- Side-Band Suppression of –50 dBc at 2140 MHz
- Single Supply: 4.5-V–5.5-V Operation
- Silicon Germanium Technology
- 1.7-V CM at I, Q Baseband Inputs

APPLICATIONS

- Cellular Base Station Transceiver
- CDMA: IS95, UMTS, CDMA2000, TD-SCDMA
- TDMA: GSM, IS-136, EDGE/UWC-136
- Multicarrier GSM
- WiMAX: 802.16d/e
- 3GPP: LTE
- Point-to-Point (P2P) Microwave
- Wideband Software-Defined Radio
- Public Safety: TETRA/APC025
- Communication-System Testers
- Cable Modem Termination System (CMTS)

RGE PACKAGE
(TOP VIEW)



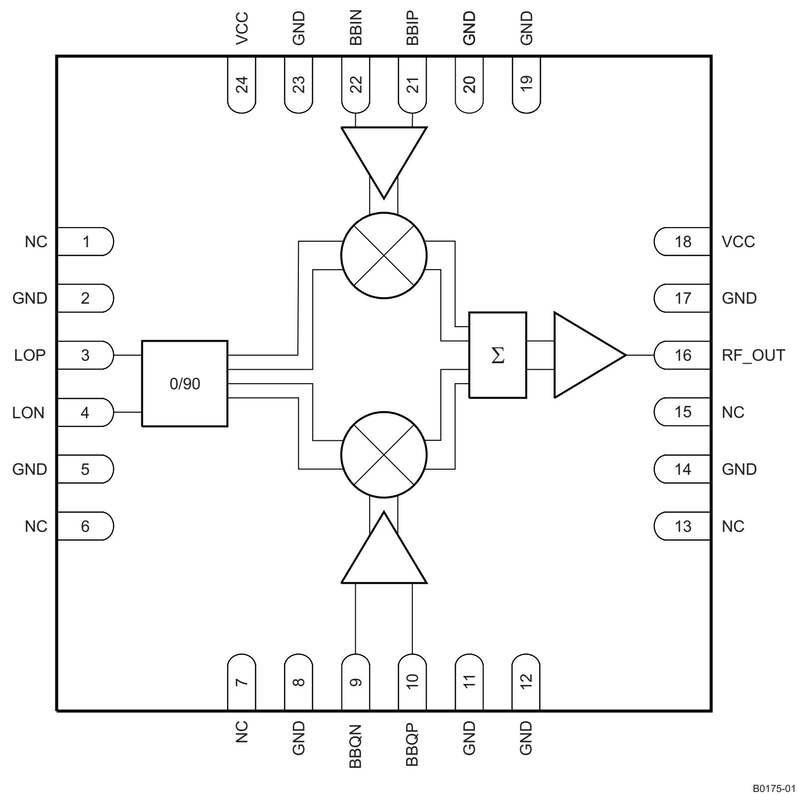
DESCRIPTION

The TRF370417 is a low-noise direct quadrature modulator, capable of converting complex modulated signals from baseband or IF directly up to RF. The TRF370417 is a high-performance, superior-linearity device that operates at RF frequencies of 50 MHz through 6 GHz. The modulator is implemented as a double-balanced mixer. The RF output block consists of a differential to single-ended converter and an RF amplifier capable of driving a single-ended 50-Ω load without any need of external components. The TRF370417 requires a 1.7-V common-mode voltage for optimum linearity performance.

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.

Functional Block Diagram



NOTE: NC = No connection

DEVICE INFORMATION

TERMINAL FUNCTIONS

TERMINAL		I/O	DESCRIPTION
NAME	NO.		
BBIN	22	I	In-phase negative input
BBIP	21	I	In-phase positive input
BBQN	9	I	Quadrature-phase negative input
BBQP	10	I	Quadrature-phase positive input
GND	2, 5, 8, 11, 12, 14, 17, 19, 20, 23	–	Ground
LON	4	I	Local oscillator negative input
LOP	3	I	Local oscillator positive input
NC	1, 6, 7, 13, 15	–	No connect
RF_OUT	16	O	RF output
VCC	18, 24	–	Power supply

ABSOLUTE MAXIMUM RATINGS(1)

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

		VALUE(2)	UNIT
	Supply voltage range	–0.3 V to 6	V
T_J	Operating virtual junction temperature range	–40 to 150	°C
T_A	Operating ambient temperature range	–40 to 85	°C
T_{stg}	Storage temperature range	–65 to 150	°C
ESD Rating	HBM	75	V
ESD Rating	CDM	75	V

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) All voltage values are with respect to network ground terminal.

RECOMMENDED OPERATING CONDITIONS

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

		MIN	NOM	MAX	UNIT
V_{CC}	Power-supply voltage	4.5	5	5.5	V

THERMAL CHARACTERISTICS

PARAMETER		TEST CONDITIONS	VALUE	UNIT
$R_{\theta JA}$	Thermal resistance, junction-to-ambient	High-K board, still air	29.4	°C/W
$R_{\theta JC}$	Thermal resistance, junction-to-case		18.6	°C/W
$R_{\theta JB}$	Thermal resistance, junction-to-board		14	°C/W

ELECTRICAL CHARACTERISTICS

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
DC Parameters						
I_{CC}	Total supply current (1.7 V CM)	T_A = 25°C		205	245	mA
LO Input (50-Ω, Single-Ended)						
f_{LO}	LO frequency range		0.05		6	GHz
	LO input power		–5	0	12	dBm
	LO port return loss			15		dB
Baseband Inputs						
V_{CM}	I and Q input dc common voltage			1.7		
BW	1-dB input frequency bandwidth			1		GHz
$Z_{I(single\ ended)}$	Input impedance, resistance			5		kΩ
	Input impedance, parallel capacitance			3		pF

RF OUTPUT PARAMETERS

over recommended operating conditions, power supply = 5 V, T_A = 25°C, V_{CM} = 1.7 V, V_{inBB} = 98 mVrms single-ended in quadrature, f_{BB} = 50 kHz (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
f_{LO} = 70 MHz at 8 dBm						
G	Voltage gain	Output rms voltage over input I (or Q) rms voltage		–8		dB
P1dB	Output compression point			7.3		dBm
IP3	Output IP3	f_{BB} = 4.5, 5.5 MHz; P_{out} = –8 dBm per tone		22		dBm
IP2	Output IP2	f_{BB} = 4.5, 5.5 MHz; P_{out} = –8 dBm per tone		69		dBm
	Carrier feedthrough	Unadjusted		–46		dBm
	Sideband suppression	Unadjusted; f_{BB} = 4.5, 5.5 MHz		–27.5		dBc
f_{LO} = 400 MHz at 8 dBm						
G	Voltage gain	Output rms voltage over input I (or Q) rms voltage		–1.9		dB
P1dB	Output compression point			11		dBm
IP3	Output IP3	f_{BB} = 4.5, 5.5 MHz; P_{out} = –8 dBm per tone		24.5		dBm
IP2	Output IP2	f_{BB} = 4.5, 5.5 MHz; P_{out} = –8 dBm per tone		68		dBm
	Carrier feedthrough	Unadjusted		–38		dBm
	Sideband suppression	Unadjusted; f_{BB} = 4.5, 5.5 MHz		–40		dBc
f_{LO} = 945.6 MHz at 8 dBm						
G	Voltage gain	Output rms voltage over input I (or Q) rms voltage		–2.5		dB
P1dB	Output compression point			11		dBm
IP3	Output IP3	f_{BB} = 4.5, 5.5 MHz; P_{out} = –8 dBm per tone		25		dBm
IP2	Output IP2	f_{BB} = 4.5, 5.5 MHz; P_{out} = –8 dBm per tone		65		dBm
	Carrier feedthrough	Unadjusted		–40		dBm
	Sideband suppression	Unadjusted; f_{BB} = 4.5, 5.5 MHz		–42		dBc
	Output return loss			9		dB
	Output noise floor	≥13 MHz offset from f_{LO}; P_{out} = –5 dBm		–161.2		dBm/Hz
f_{LO} = 1800 MHz at 8 dBm						
G	Voltage gain	Output rms voltage over input I (or Q) rms voltage		–2.5		dB
P1dB	Output compression point			12		dBm
IP3	Output IP3	f_{BB} = 4.5, 5.5 MHz; P_{out} = –8 dBm per tone		26		dBm
IP2	Output IP2	f_{BB} = 4.5, 5.5 MHz; P_{out} = –8 dBm per tone		60		dBm
	Carrier feedthrough	Unadjusted		–40		dBm
	Sideband suppression	Unadjusted; f_{BB} = 4.5, 5.5 MHz		–50		dBc
	Output return loss			8		dB
	Output noise floor	≥13 MHz offset from f_{LO}; P_{out} = –5 dBm		–161.5		dBm/Hz

RF OUTPUT PARAMETERS (continued)

over recommended operating conditions, power supply = 5 V, T_A = 25°C, V_{CM} = 1.7 V, V_{inBB} = 98 mVrms single-ended in quadrature, f_{BB} = 50 kHz (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
f_{LO} = 1960 MHz at 8 dBm						
G	Voltage gain	Output rms voltage over input I (or Q) rms voltage		–2.5		dB
P1dB	Output compression point			12		dBm
IP3	Output IP3	f_{BB} = 4.5, 5.5 MHz; P_{out} = –8 dBm per tone		26.5		dBm
IP2	Output IP2	f_{BB} = 4.5, 5.5 MHz; P_{out} = –8 dBm per tone		60		dBm
	Carrier feedthrough	Unadjusted		–38		dBm
	Sideband suppression	Unadjusted; f_{BB} = 4.5, 5.5 MHz		–50		dBc
	Output return loss			8		dB
	Output noise floor	≥13 MHz offset from f_{LO}; P_{out} = –5 dBm		–162		dBm/Hz
EVM	Error vector magnitude (rms)	1 EDGE signal, P_{out} = –5 dBm (1)		0.43%		
ACPR	Adjacent-channel power ratio	1 WCDMA signal; P_{out} = –8 dBm (2)		–76		dBc
		1 WCDMA signal; P_{out} = –8 dBm (3)		–74		
		2 WCDMA signals; P_{out} = –11 dBm per carrier (3)		–68		
		4 WCDMA signals; P_{out} = –14 dBm per carrier (3)		–67		
	Alternate-channel power ratio	1 WCDMA signal; P_{out} = –8 dBm (2)		–80		dBc
		1 WCDMA signal; P_{out} = –8 dBm (3)		–78		
		2 WCDMA signals; P_{out} = –11 dBm per carrier (3)		–72		
		4 WCDMA signals; P_{out} = –14 dBm per carrier (3)		–69		
f_{LO} = 2140 MHz at 8 dBm						
G	Voltage gain	Output rms voltage over input I (or Q) rms voltage		–2.4		dB
P1dB	Output compression point			12		dBm
IP3	Output IP3	f_{BB} = 4.5, 5.5 MHz; P_{out} = –8 dBm per tone		26.5		dBm
IP2	Output IP2	f_{BB} = 4.5, 5.5 MHz; P_{out} = –8 dBm per tone		66		dBm
	Carrier feedthrough	Unadjusted		–38		dBm
	Sideband suppression	Unadjusted; f_{BB} = 4.5, 5.5 MHz		–50		dBc
	Output return loss			8.5		dB
	Output noise floor	≥13 MHz offset from f_{LO} ; P_{out} = –5 dBm		–162.3		dBm/Hz
ACPR	Adjacent-channel power ratio	1 WCDMA signal; P_{out} = –8 dBm (2)		–76		dBc
		1 WCDMA signal; P_{out} = –8 dBm (3)		–72		
		2 WCDMA signal; P_{out} = –11 dBm per carrier (3)		–67		
		4 WCDMA signals; P_{out} = –14 dBm per carrier (3)		–66		
	Alternate-channel power ratio	1 WCDMA signal; P_{out} = –8 dBm (2)		–80		dBc
		1 WCDMA signal; P_{out} = –8 dBm (3)		–78		
		2 WCDMA signal; P_{out} = –11 dBm (3)		–74		
		4 WCDMA signals; P_{out} = –14 dBm per carrier (3)		–68		

(1) The contribution from the source of about 0.28% is not de-embedded from the measurement.
(2) Measured with DAC5687 as source generator; with 2.5 MHz LPF.
(3) Measured with DAC5687 as source generator; no external BB filters are used.

RF OUTPUT PARAMETERS (continued)

over recommended operating conditions, power supply = 5 V, T_A = 25°C, V_{CM} = 1.7 V, V_{inBB} = 98 mVrms single-ended in quadrature, f_{BB} = 50 kHz (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
f_{LO} = 2500 MHz at 8 dBm						
G	Voltage gain	Output rms voltage over input I (or Q) rms voltage		–1.6		dB
P1dB	Output compression point			13		dBm
IP3	Output IP3	f_{BB} = 4.5, 5.5 MHz; P_{out} = –8 dBm per tone		29		dBm
IP2	Output IP2	f_{BB} = 4.5, 5.5 MHz; P_{out} = –8 dBm per tone		65		dBm
	Carrier feedthrough	Unadjusted		–37		dBm
	Sideband suppression	Unadjusted; f_{BB} = 4.5, 5.5 MHz		–47		dBc
EVM	Error vector magnitude (rms)	WiMAX 5-MHz carrier, P_{out} = –8 dBm(4)		–47		dB
		WiMAX 5-MHz carrier, P_{out} = 0 dBm(4)		–45		dB
f_{LO} = 3500 MHz at 8 dBm						
G	Voltage gain	Output rms voltage over input I (or Q) rms voltage		0.6		dB
P1dB	Output compression point			13.5		dBm
IP3	Output IP3	f_{BB} = 4.5, 5.5 MHz		25		dBm
IP2	Output IP2	f_{BB} = 4.5, 5.5 MHz		65		dBm
	Carrier feedthrough	Unadjusted		–35		dBm
	Sideband suppression	Unadjusted; f_{BB} = 4.5, 5.5 MHz		–36		dBc
EVM	Error vector magnitude (rms)	WiMAX 5-MHz carrier, P_{out} = –8 dBm(4)		–47		dB
		WiMAX 5-MHz carrier, P_{out} = 0 dBm(4)		–43		dB
f_{LO} = 4000 MHz at 8 dBm						
G	Voltage gain	Output rms voltage over input I (or Q) rms voltage		0.2		dB
P1dB	Output compression point			12		dBm
IP3	Output IP3	f_{BB} = 4.5, 5.5 MHz		22.5		dBm
IP2	Output IP2	f_{BB} = 4.5, 5.5 MHz		60		dBm
	Carrier feedthrough	Unadjusted		–36		dBm
	Sideband suppression	Unadjusted; f_{BB} = 4.5, 5.5 MHz		–36		dBc
f_{LO} = 5800 MHz at 4 dBm						
G	Voltage gain	Output rms voltage over input I (or Q) rms voltage		–5.5		dB
P1dB	Output compression point			12.9		dBm
IP3	Output IP3	f_{BB} = 4.5, 5.5 MHz		25		dBm
IP2	Output IP2	f_{BB} = 4.5, 5.5 MHz		55		dBm
	Carrier feedthrough	Unadjusted		–31		dBm
	Sideband suppression	Unadjusted; f_{BB} = 4.5, 5.5 MHz		–36		dBc
EVM	Error-vector magnitude	WiMAX 5-MHz carrier, P_{out} = –12 dBm(4)		–40		dB

(4) Sideband suppression optimized with LO drive level; EVM contribution from instrument is not accounted for.

TYPICAL CHARACTERISTICS

V_{CM} = 1.7 V, V_{inBB} = 98 mVrms single-ended sine wave in quadrature, V_{CC} = 5 V, LO power = 4 dBm (single-ended), f_{BB} = 50 kHz (unless otherwise noted).

OUTPUT POWER vs BASEBAND VOLTAGE

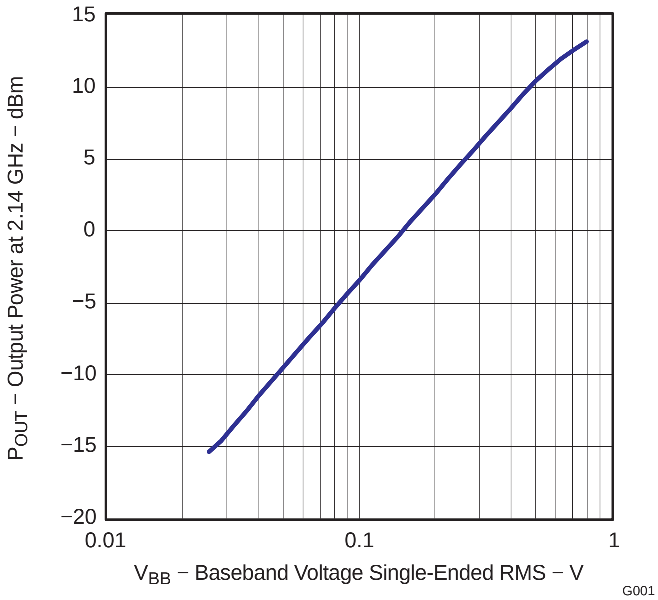


Figure 1.

OUTPUT POWER vs FREQUENCY AND TEMPERATURE

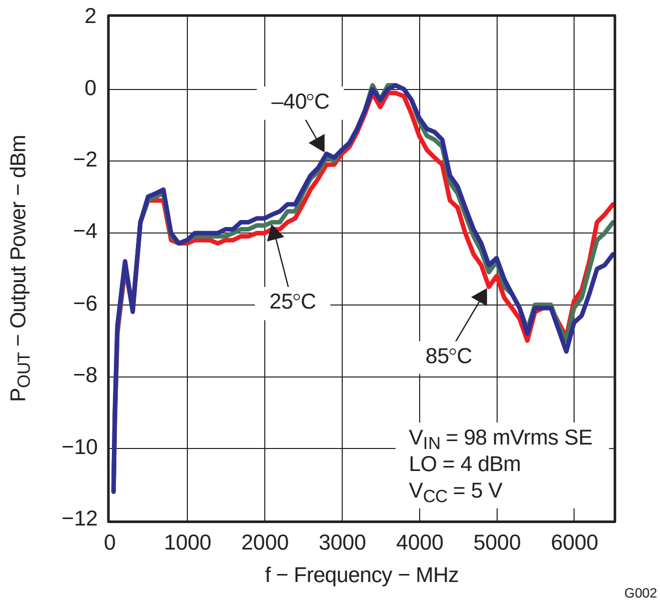


Figure 2.

OUTPUT POWER vs FREQUENCY AND SUPPLY VOLTAGE

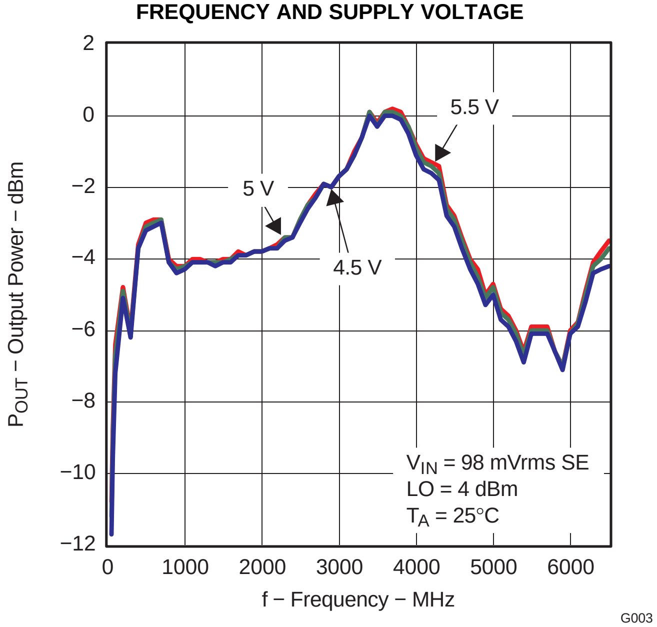


Figure 3.

OUTPUT POWER vs FREQUENCY AND LO POWER

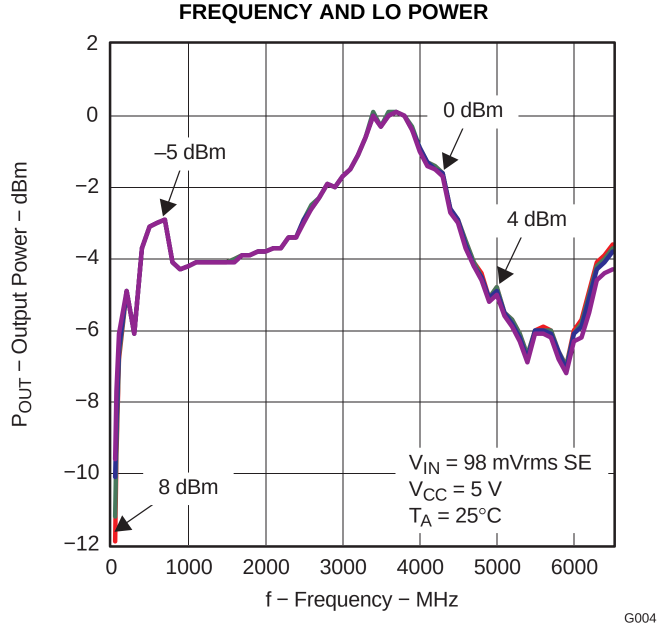


Figure 4.

TYPICAL CHARACTERISTICS (continued)

V_{CM} = 1.7 V, V_{inBB} = 98 mVrms single-ended sine wave in quadrature, V_{CC} = 5 V, LO power = 4 dBm (single-ended), f_{BB} = 50 kHz (unless otherwise noted).

P1dB vs FREQUENCY AND TEMPERATURE

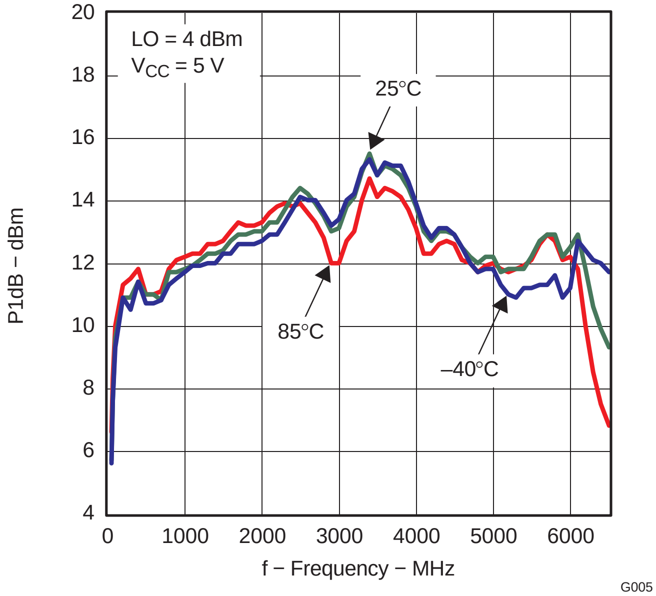


Figure 5.

P1dB vs FREQUENCY AND SUPPLY VOLTAGE

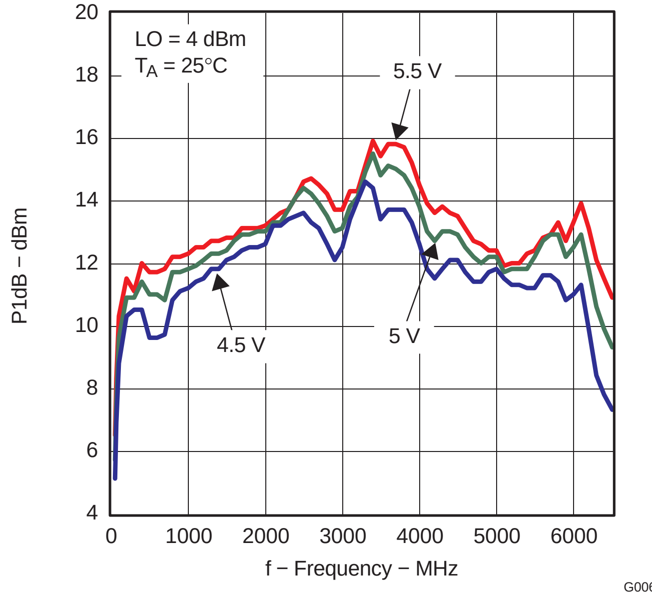


Figure 6.

P1dB vs FREQUENCY AND LO POWER

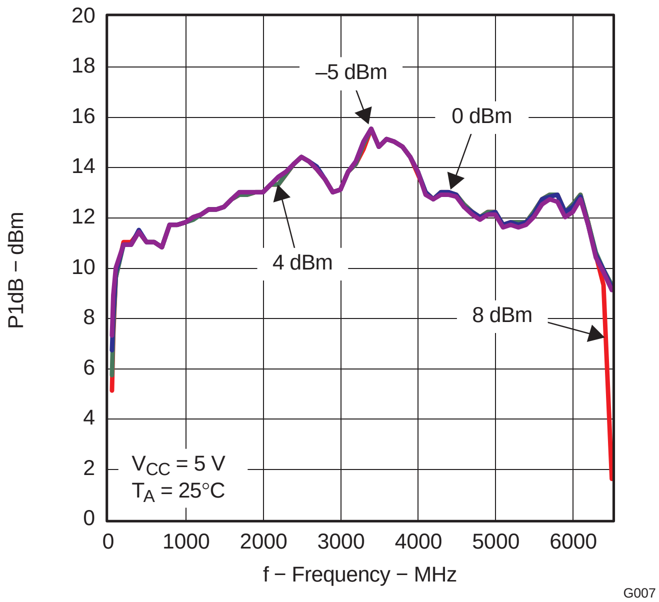


Figure 7.

OIP3 vs FREQUENCY AND TEMPERATURE

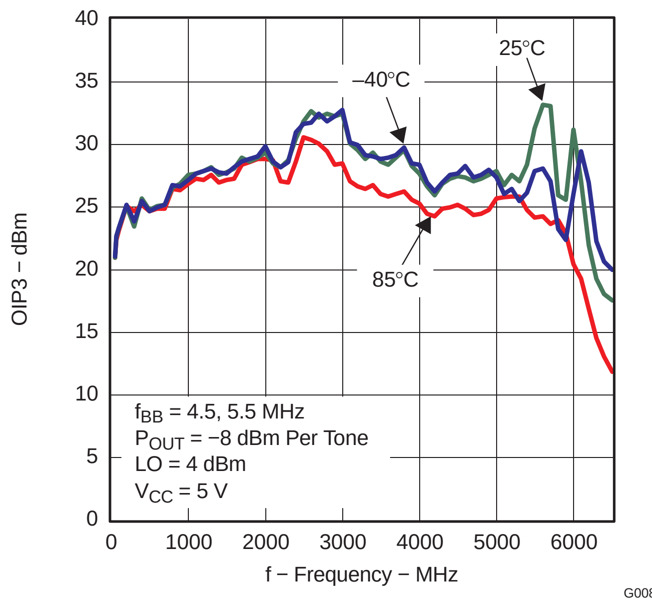


Figure 8.

TYPICAL CHARACTERISTICS (continued)

V_{CM} = 1.7 V, V_{inBB} = 98 mVrms single-ended sine wave in quadrature, V_{CC} = 5 V, LO power = 4 dBm (single-ended), f_{BB} = 50 kHz (unless otherwise noted).

OIP3 vs FREQUENCY AND SUPPLY VOLTAGE

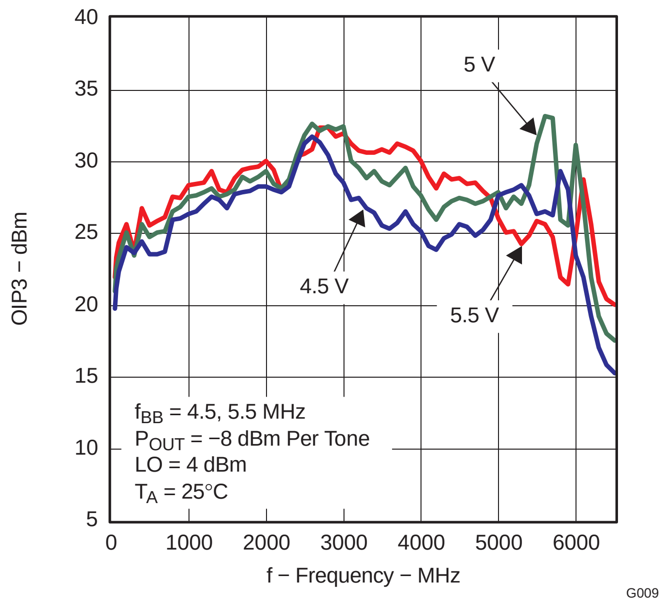


Figure 9.

OIP3 vs FREQUENCY AND LO POWER

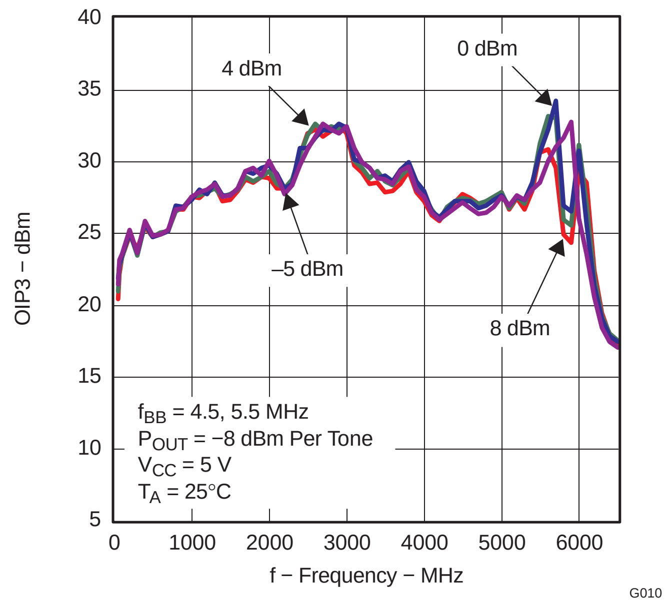


Figure 10.

OIP2 vs FREQUENCY AND TEMPERATURE

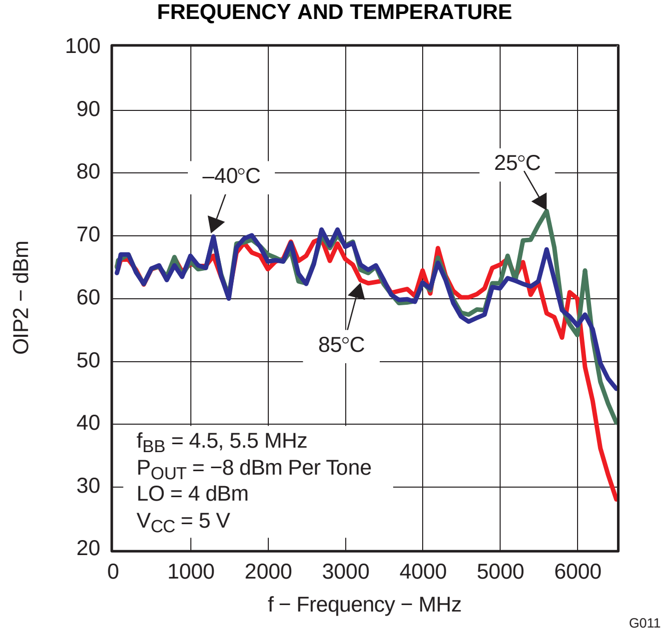


Figure 11.

OIP2 vs FREQUENCY AND SUPPLY VOLTAGE

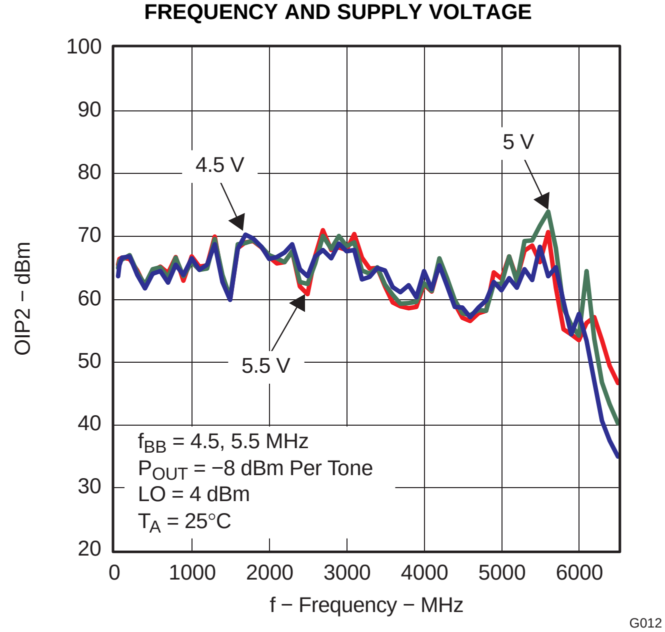


Figure 12.

TYPICAL CHARACTERISTICS (continued)

V_{CM} = 1.7 V, V_{inBB} = 98 mVrms single-ended sine wave in quadrature, V_{CC} = 5 V, LO power = 4 dBm (single-ended), f_{BB} = 50 kHz (unless otherwise noted).

OIP2 vs FREQUENCY AND LO POWER

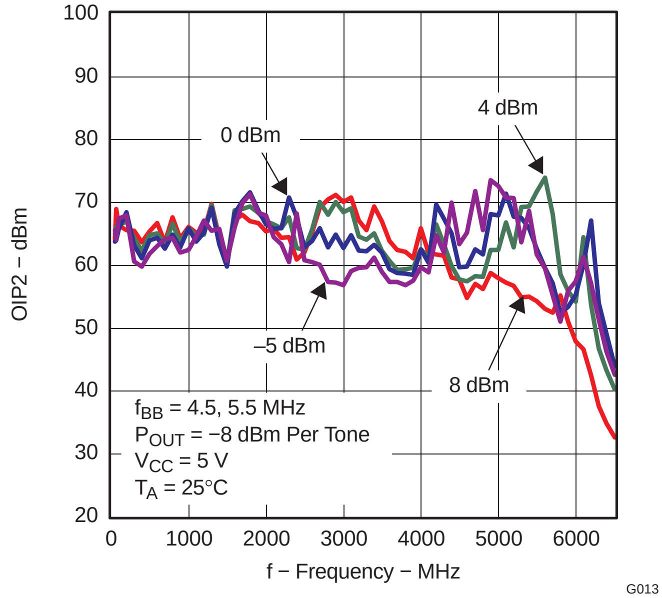


Figure 13.

UNADJUSTED CARRIER FEEDTHROUGH vs FREQUENCY AND TEMPERATURE

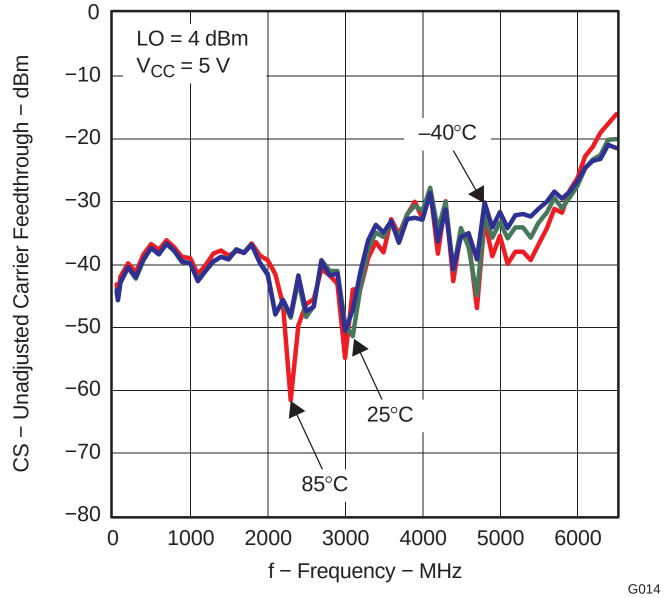


Figure 14.

UNADJUSTED CARRIER FEEDTHROUGH vs FREQUENCY AND SUPPLY VOLTAGE

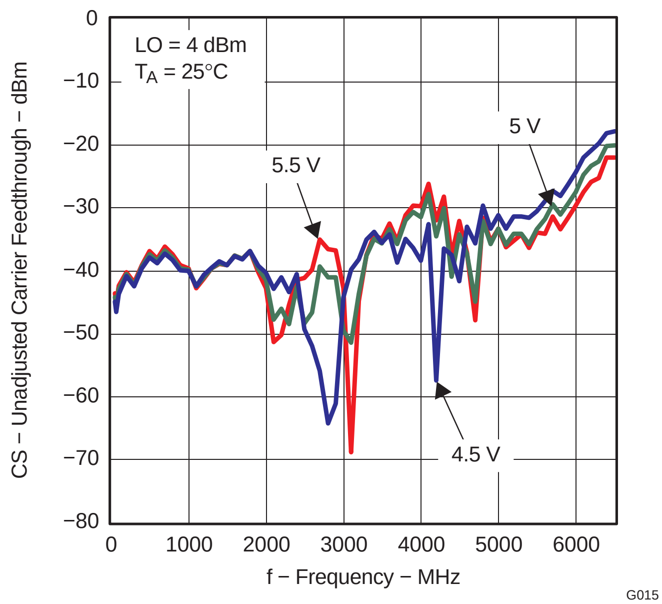


Figure 15.

UNADJUSTED CARRIER FEEDTHROUGH vs FREQUENCY AND LO POWER

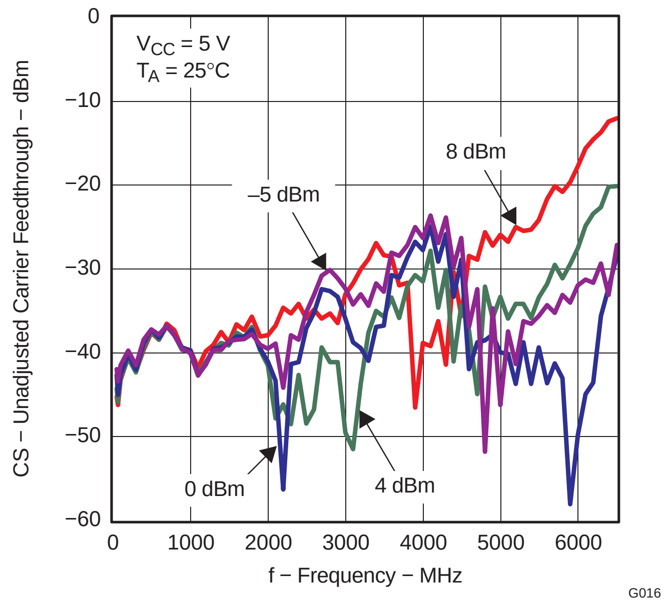


Figure 16.

TYPICAL CHARACTERISTICS (continued)

V_{CM} = 1.7 V, V_{inBB} = 98 mVrms single-ended sine wave in quadrature, V_{CC} = 5 V, LO power = 4 dBm (single-ended), f_{BB} = 50 kHz (unless otherwise noted).

UNADJUSTED SIDEBAND SUPPRESSION vs FREQUENCY AND TEMPERATURE

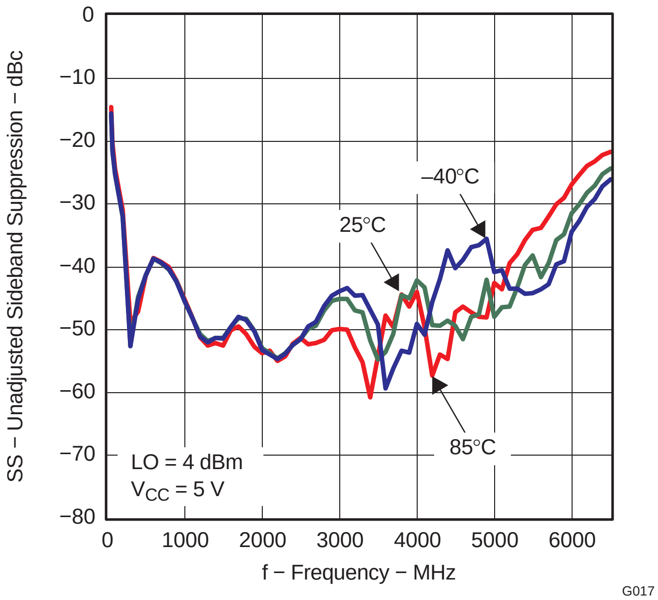


Figure 17.

UNADJUSTED SIDEBAND SUPPRESSION vs FREQUENCY AND SUPPLY VOLTAGE

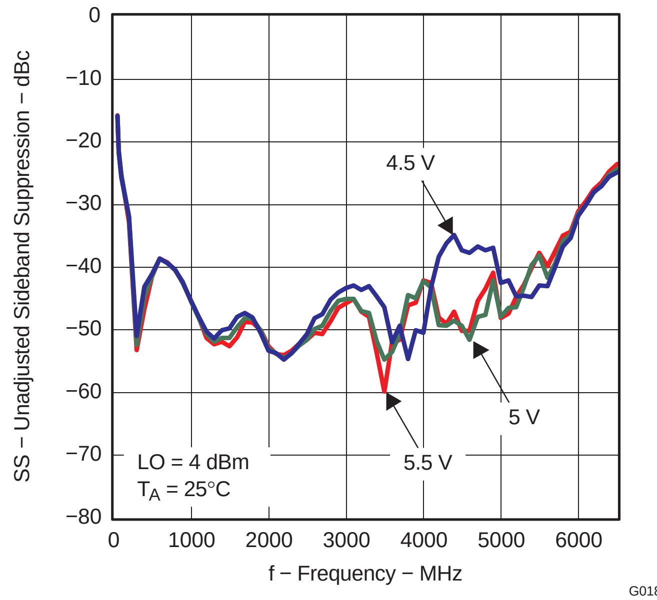


Figure 18.

UNADJUSTED SIDEBAND SUPPRESSION vs FREQUENCY AND LO POWER

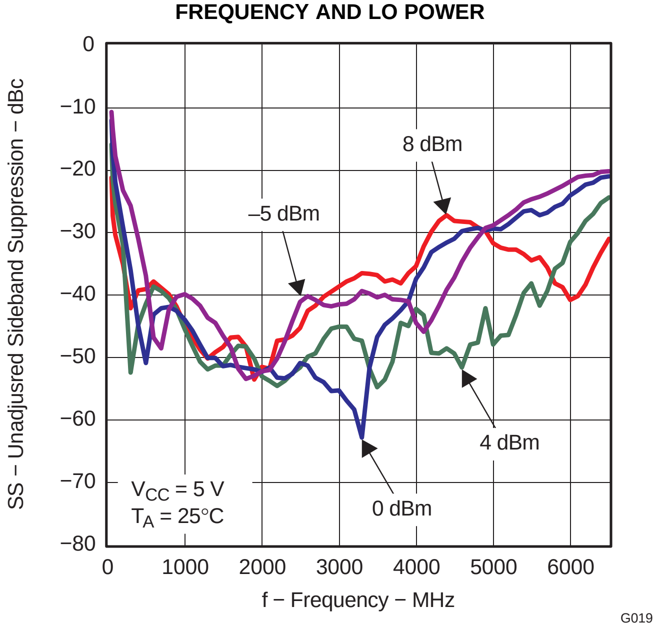


Figure 19.

NOISE AT 13-MHz OFFSET (dBm/Hz) vs FREQUENCY AND TEMPERATURE

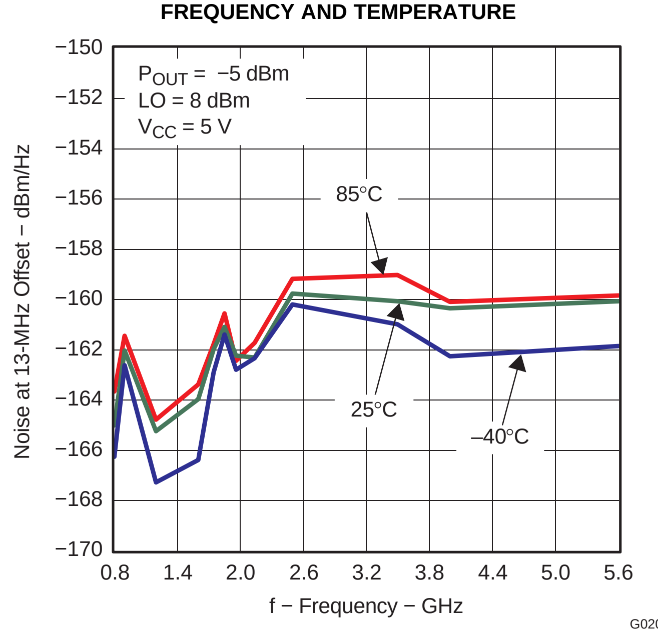


Figure 20.

TYPICAL CHARACTERISTICS (continued)

V_{CM} = 1.7 V, V_{inBB} = 98 mVrms single-ended sine wave in quadrature, V_{CC} = 5 V, LO power = 4 dBm (single-ended), f_{BB} = 50 kHz (unless otherwise noted).

NOISE AT 13-MHz OFFSET (dBm/Hz) vs FREQUENCY AND SUPPLY VOLTAGE

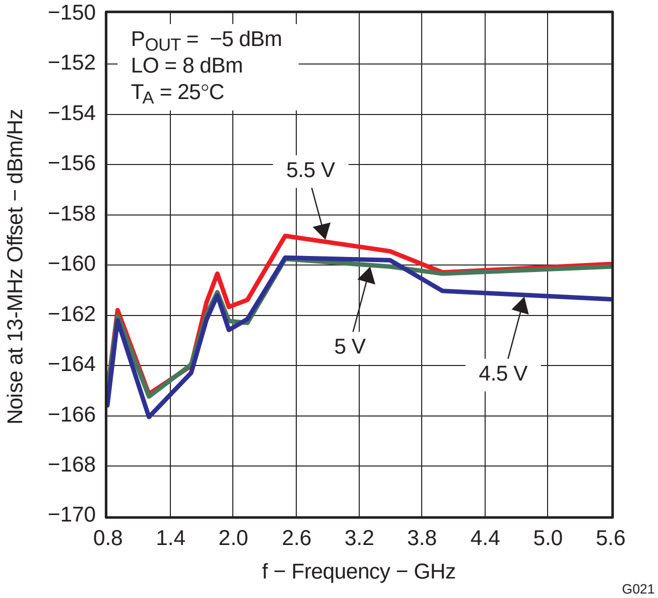


Figure 21.

NOISE AT 13-MHz OFFSET (dBm/Hz) vs OUTPUT POWER

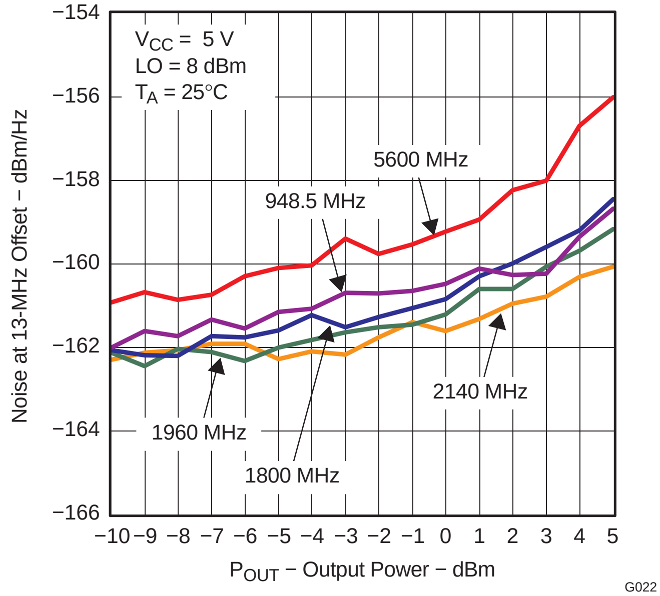


Figure 22.

ADJUSTED CARRIER FEEDTHROUGH vs FREQUENCY AND TEMPERATURE

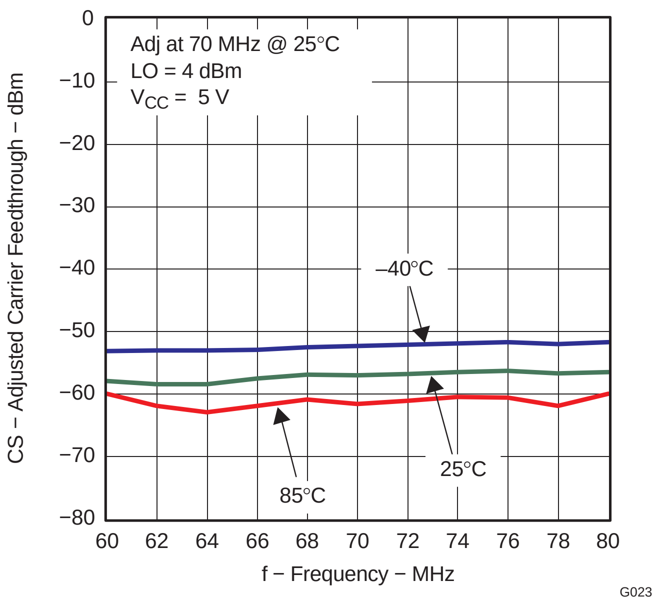


Figure 23.

ADJUSTED CARRIER FEEDTHROUGH vs FREQUENCY AND TEMPERATURE

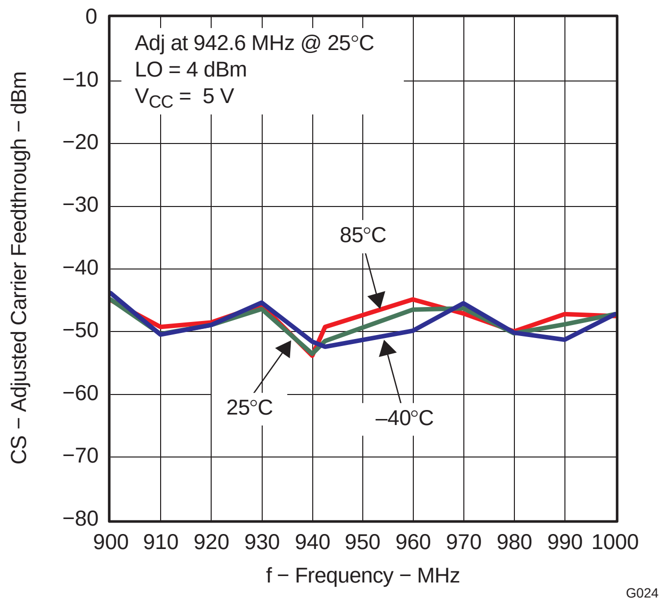


Figure 24.

TYPICAL CHARACTERISTICS (continued)

V_{CM} = 1.7 V, V_{inBB} = 98 mVrms single-ended sine wave in quadrature, V_{CC} = 5 V, LO power = 4 dBm (single-ended), f_{BB} = 50 kHz (unless otherwise noted).

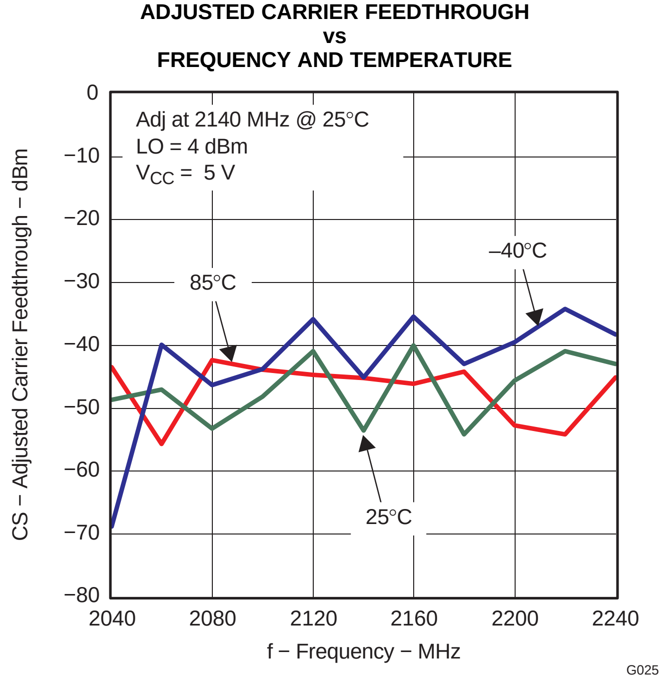


Figure 25.

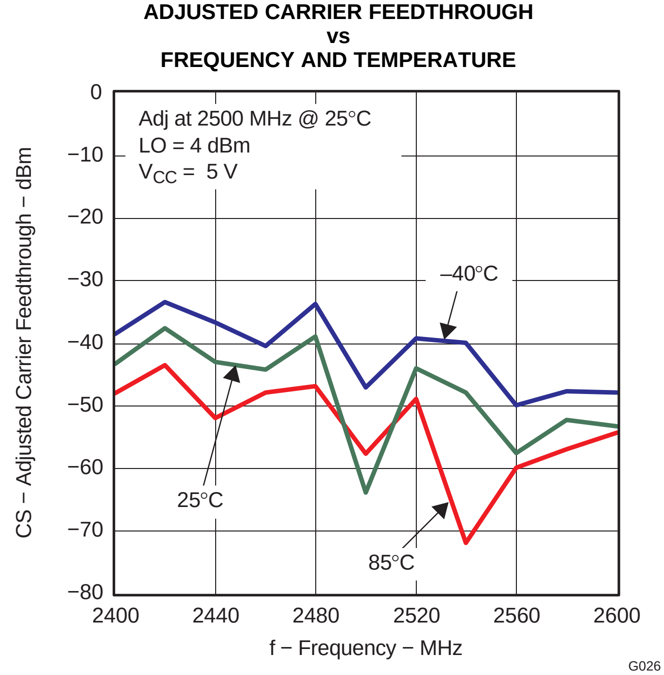


Figure 26.

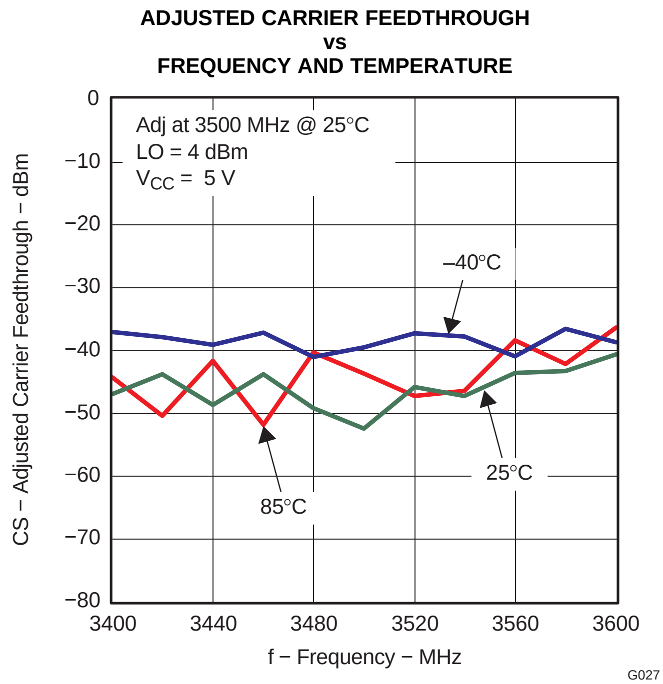


Figure 27.

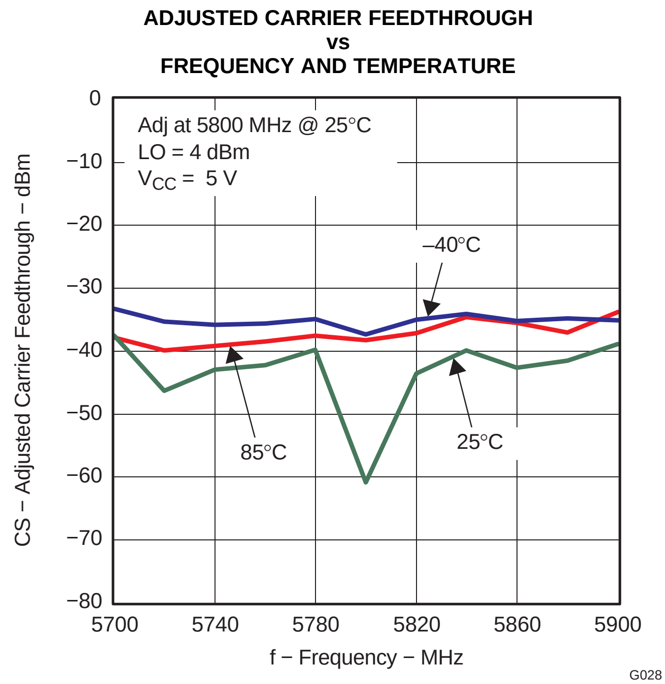


Figure 28.

TYPICAL CHARACTERISTICS (continued)

V_{CM} = 1.7 V, V_{inBB} = 98 mVrms single-ended sine wave in quadrature, V_{CC} = 5 V, LO power = 4 dBm (single-ended), f_{BB} = 50 kHz (unless otherwise noted).

ADJUSTED SIDEBAND SUPPRESSION vs FREQUENCY AND TEMPERATURE

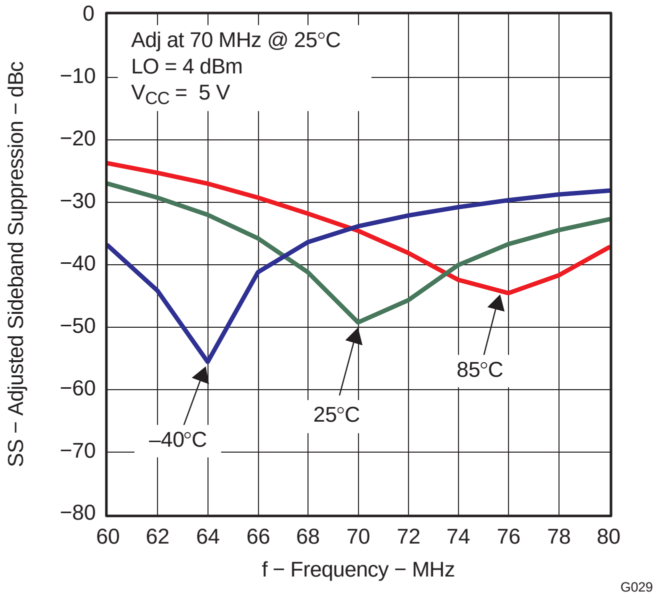


Figure 29.

ADJUSTED SIDEBAND SUPPRESSION vs FREQUENCY AND TEMPERATURE

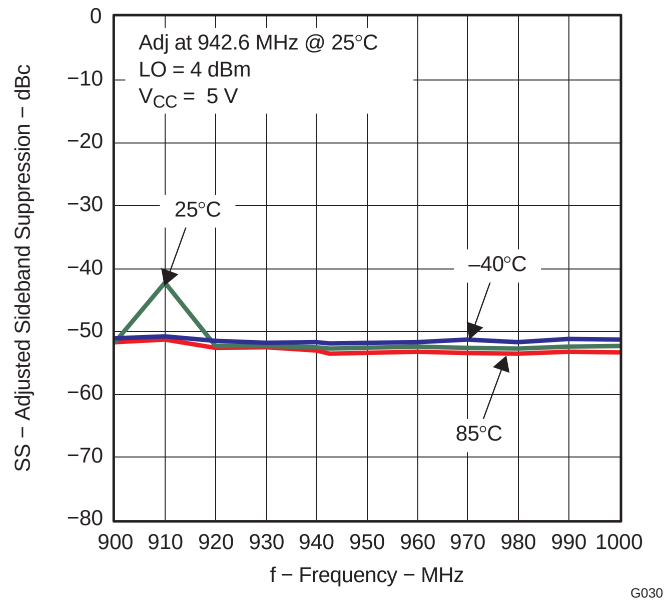


Figure 30.

ADJUSTED SIDEBAND SUPPRESSION vs FREQUENCY AND TEMPERATURE

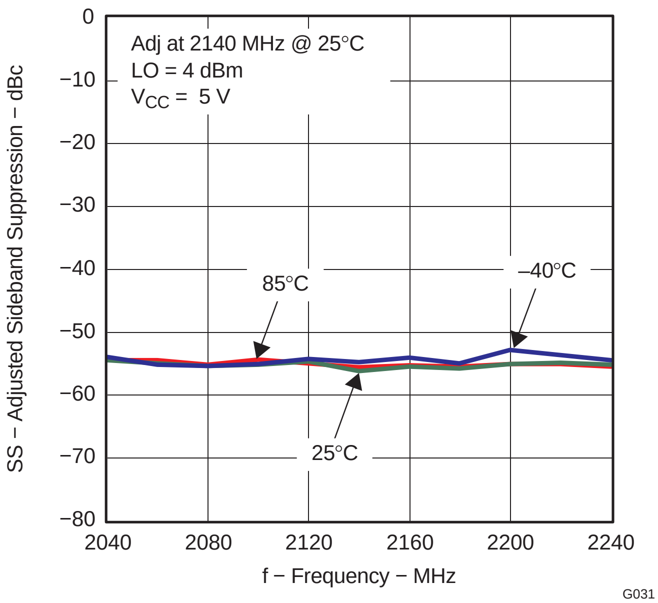


Figure 31.

ADJUSTED SIDEBAND SUPPRESSION vs FREQUENCY AND TEMPERATURE

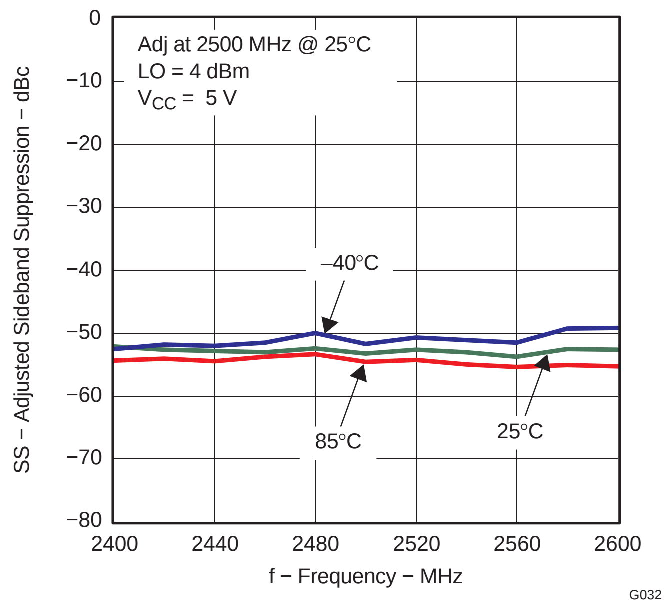


Figure 32.

TYPICAL CHARACTERISTICS (continued)

V_{CM} = 1.7 V, V_{inBB} = 98 mVrms single-ended sine wave in quadrature, V_{CC} = 5 V, LO power = 4 dBm (single-ended), f_{BB} = 50 kHz (unless otherwise noted).

ADJUSTED SIDEBAND SUPPRESSION vs FREQUENCY AND TEMPERATURE

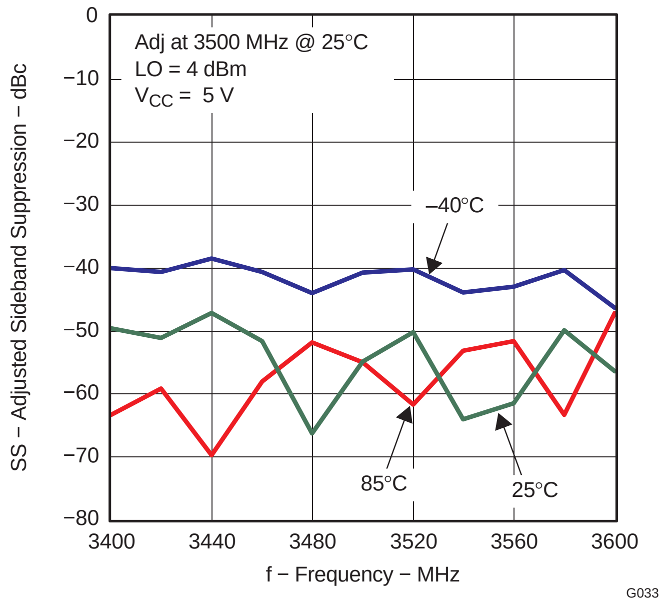


Figure 33.

ADJUSTED SIDEBAND SUPPRESSION vs FREQUENCY AND TEMPERATURE

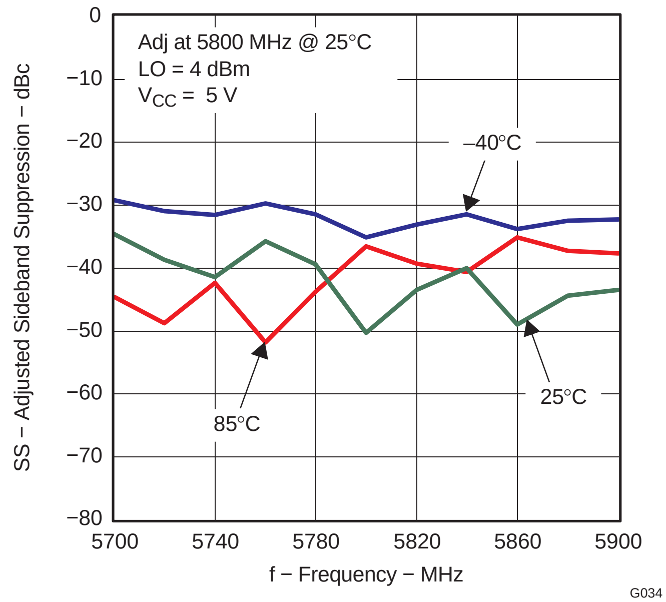


Figure 34.

OIP3 vs COMMON-MODE VOLTAGE at 948.5 MHz

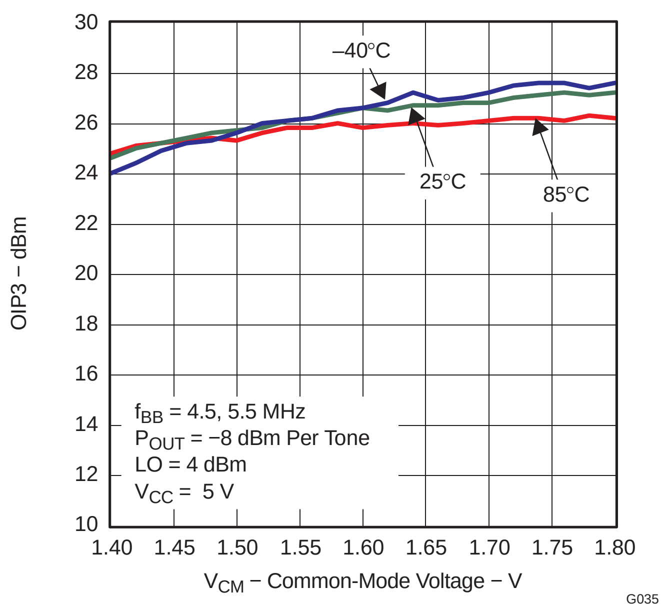


Figure 35.

OIP3 vs COMMON-MODE VOLTAGE at 1800 MHz

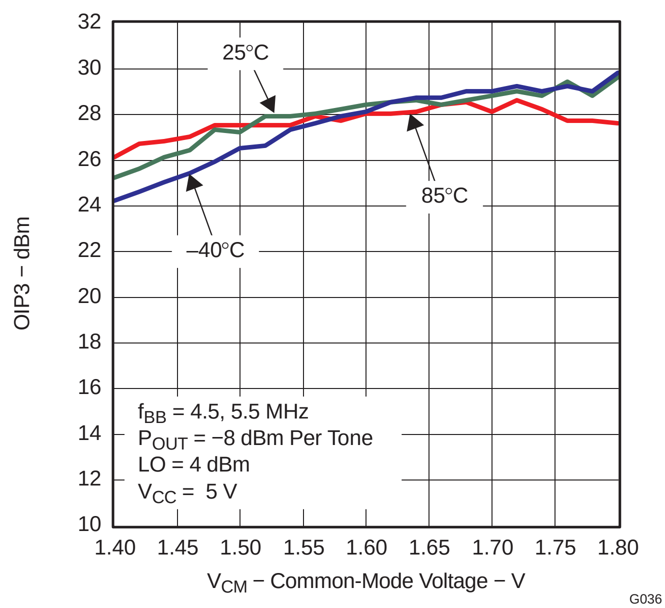


Figure 36.

TYPICAL CHARACTERISTICS (continued)

V_{CM} = 1.7 V, V_{inBB} = 98 mVrms single-ended sine wave in quadrature, V_{CC} = 5 V, LO power = 4 dBm (single-ended), f_{BB} = 50 kHz (unless otherwise noted).

OIP3 vs COMMON-MODE VOLTAGE at 2140 MHz

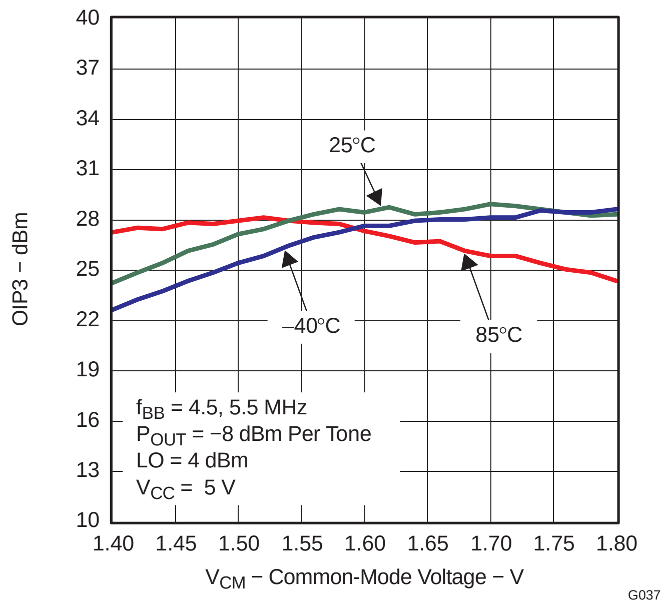


Figure 37.

OIP3 vs COMMON-MODE VOLTAGE at 5800 MHz

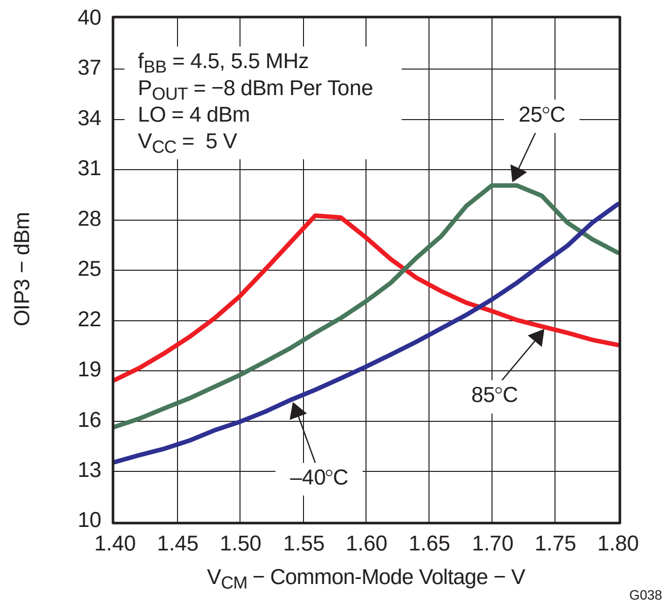


Figure 38.

OIP3 vs TOTAL OUTPUT POWER

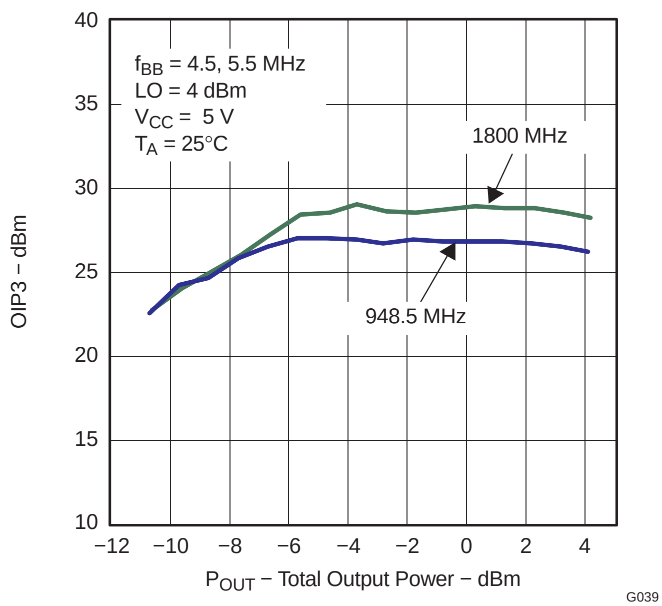


Figure 39.

ADJACENT CHANNEL POWER RATIO vs OUTPUT POWER at 1960 MHz

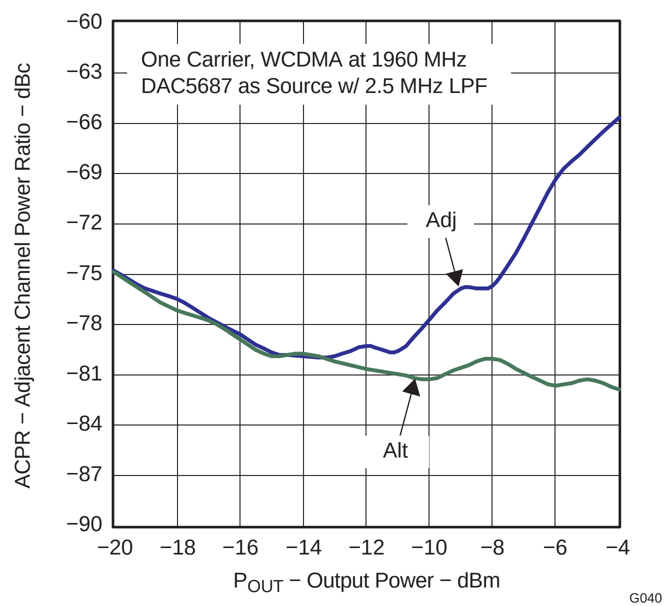


Figure 40.

TYPICAL CHARACTERISTICS (continued)

V_{CM} = 1.7 V, V_{inBB} = 98 mVrms single-ended sine wave in quadrature, V_{CC} = 5 V, LO power = 4 dBm (single-ended), f_{BB} = 50 kHz (unless otherwise noted).

ADJACENT CHANNEL POWER RATIO vs OUTPUT POWER at 2140 MHz

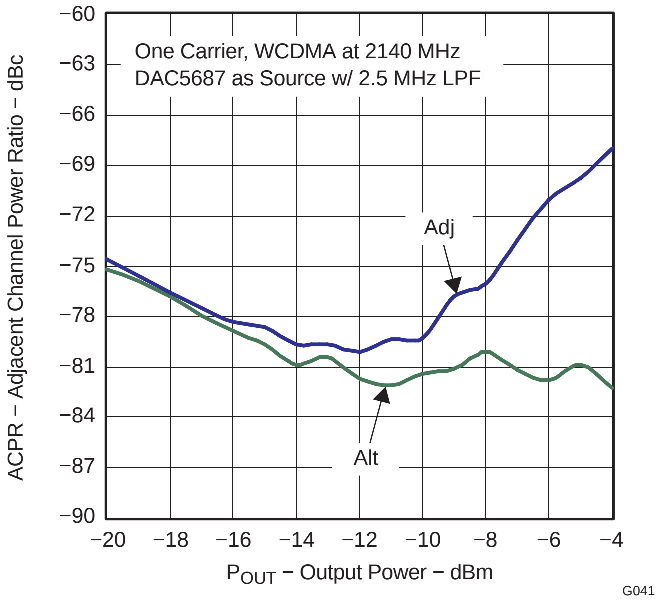


Figure 41.

OIP3 at 1960 MHz DISTRIBUTION

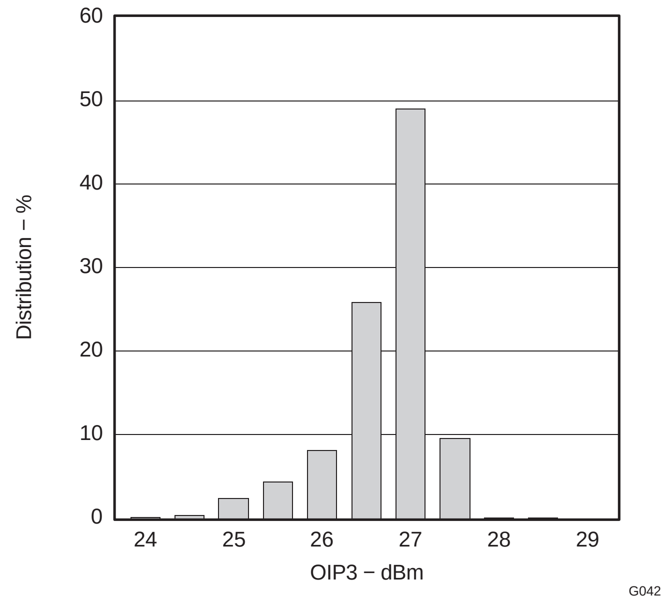


Figure 42.

OIP2 at 1960 MHz DISTRIBUTION

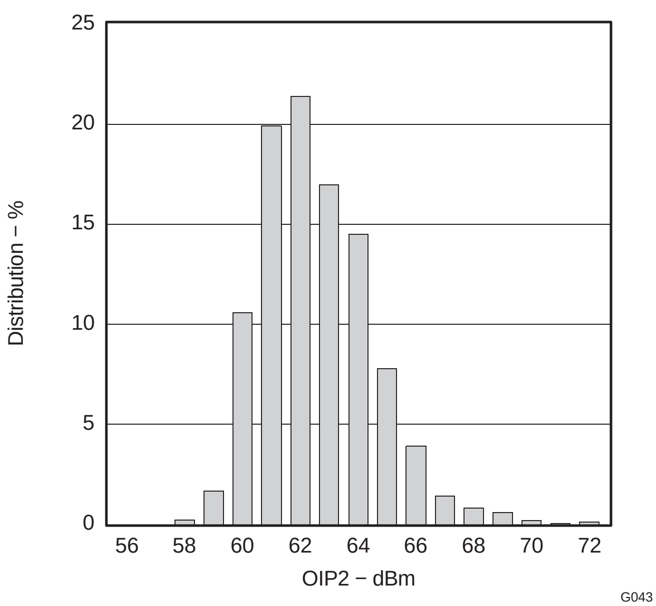


Figure 43.

UNADJUSTED CARRIER FEEDTHROUGH at 1960 MHz DISTRIBUTION

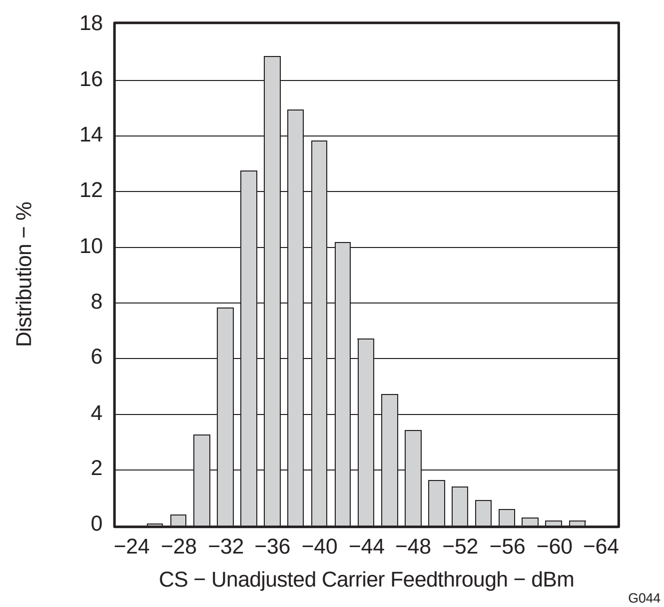


Figure 44.

TYPICAL CHARACTERISTICS (continued)

V_{CM} = 1.7 V, V_{inBB} = 98 mVrms single-ended sine wave in quadrature, V_{CC} = 5 V, LO power = 4 dBm (single-ended), f_{BB} = 50 kHz (unless otherwise noted).

UNADJUSTED SIDEBAND SUPPRESSION at 1960 MHz DISTRIBUTION

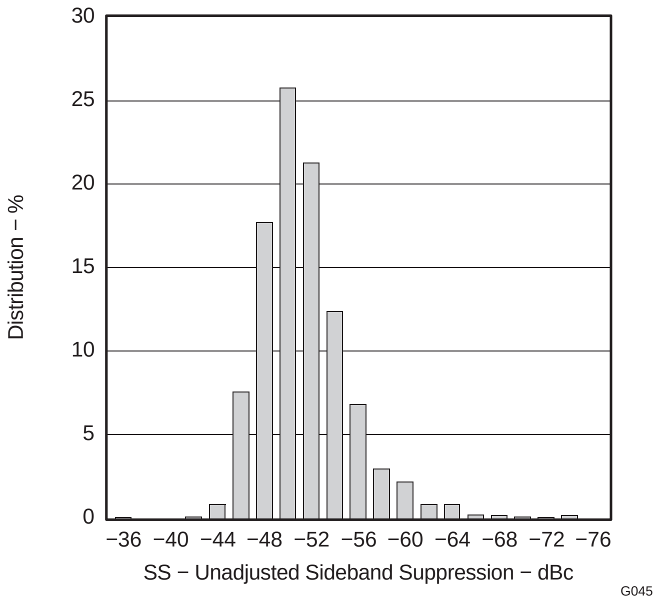


Figure 45.

P1dB at 1800 MHz DISTRIBUTION

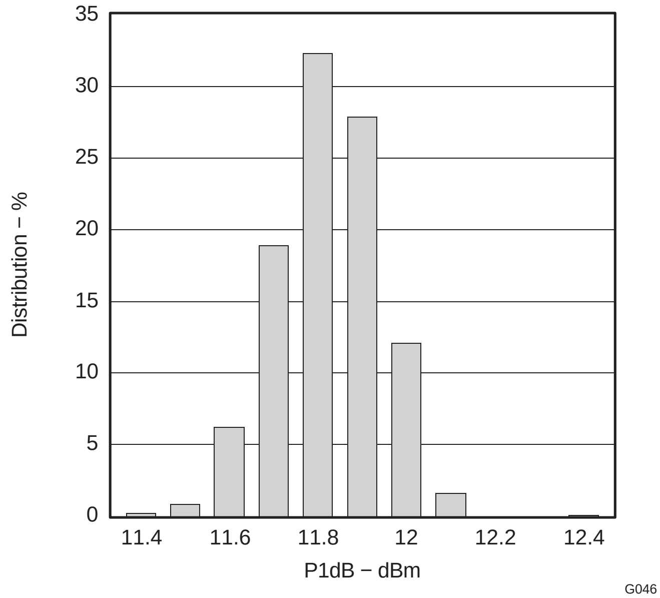


Figure 46.

APPLICATION INFORMATION AND EVALUATION BOARD

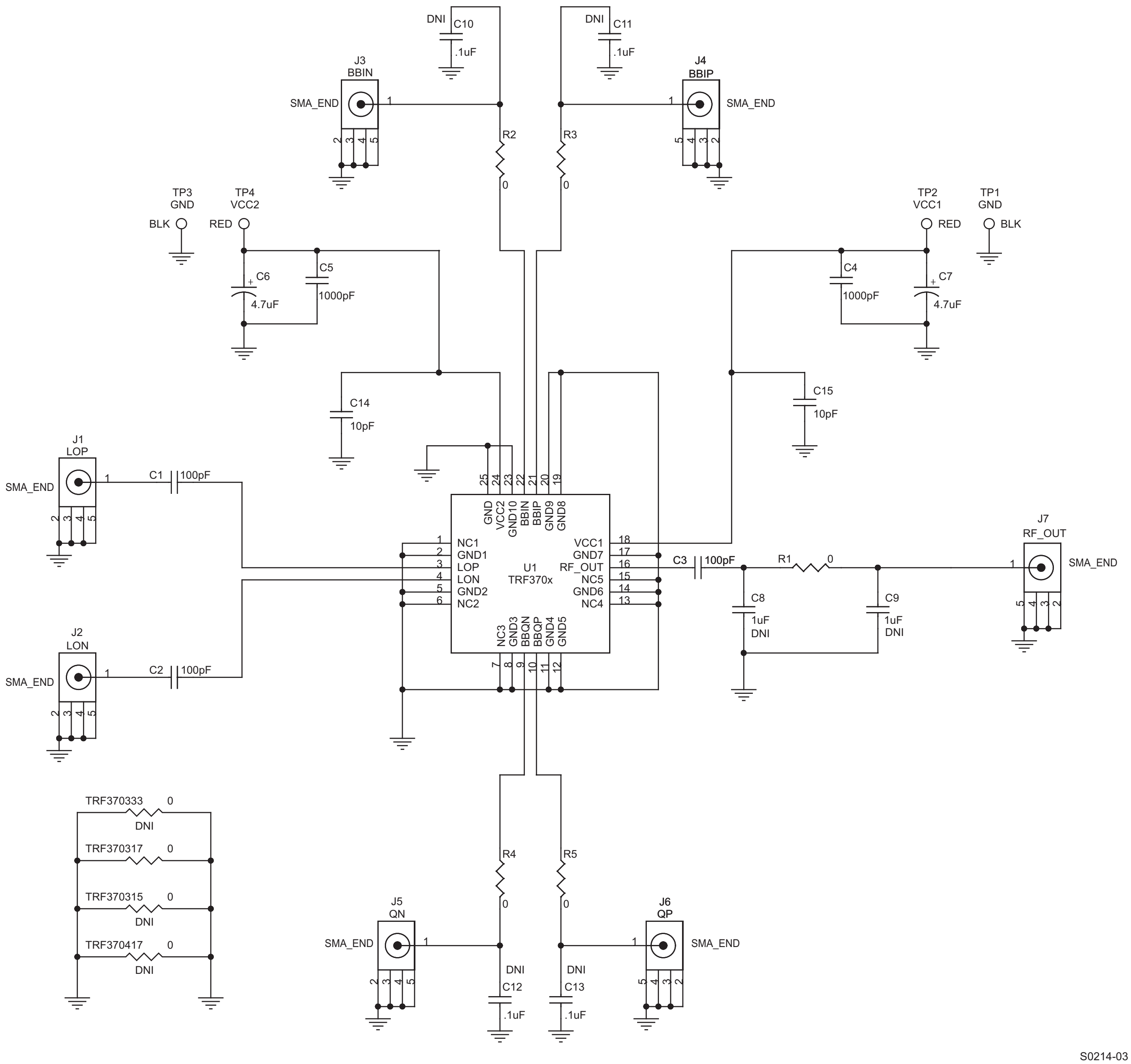
Basic Connections

- See Figure 47 for proper connection of the TRF3704 modulator.
- Connect a single power supply (4.5 V–5.5 V) to pins 18 and 24. These pins should be decoupled as shown on pins 4, 5, 6, and 7.
- Connect pins 2, 5, 8, 11, 12, 14, 17, 19, 20, and 23 to GND.
- Connect a single-ended LO source of desired frequency to LOP (amplitude between –5 dBm and 12 dBm). This should be ac-coupled through a 100-pF capacitor.
- Terminate the ac-coupled LON with 50 Ω to GND.
- Connect a baseband signal to pins 21 = I, 22 = $\overline{I}$, 10 = Q, and 9 = $\overline{Q}$.
- The differential baseband inputs should be set to the proper common-mode voltage of 1.7V.
- RF_OUT, pin 16, can be fed to a spectrum analyzer set to the desired frequency, LO ± baseband signal. This pin should also be ac-coupled through a 100-pF capacitor.
- All NC pins can be left floating.

ESD Sensitivity

RF devices may be extremely sensitive to electrostatic discharge (ESD). To prevent damage from ESD, devices should be stored and handled in a way that prevents the build-up of electrostatic voltages that exceed the rated level. Rated ESD levels should also not be exceeded while the device is installed on a printed circuit board (PCB). Follow these guidelines for optimal ESD protection:

- Low ESD performance is not uncommon in RF ICs; see the *Absolute Maximum Ratings* table. Therefore, customers' ESD precautions should be consistent with these ratings.
- The device should be robust once assembled onto the PCB ***unless*** external inputs (connectors, etc.) directly connect the device pins to off-board circuits.



NOTE: DNI = Do not install.

Figure 47. TRF3704 EVM Schematic

Figure 48 shows the top view of the TRF3704 EVM board.

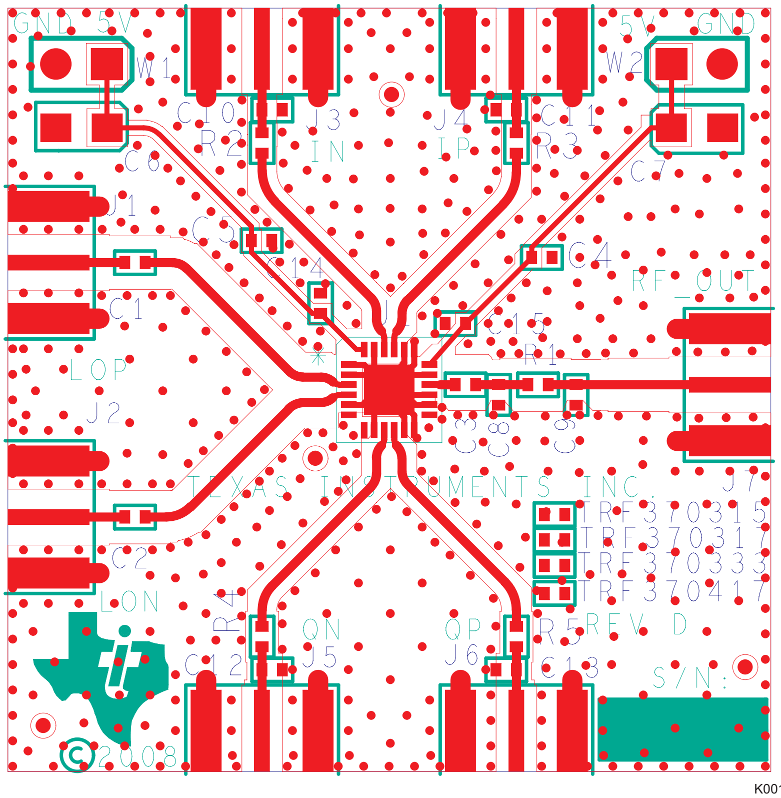


Figure 48. TRF3704 EVM Board Layout

Table 1. Bill of Materials for TRF370x EVM

Item Number	Quantity	Reference Designator	Value	PCB Footprint	Mfr. Name	Mfr. Part Number	Note
1	3	C1, C2, C3	100 pF	0402	PANASONIC	ECJ-0EC1H101J	
2	2	C4, C5	1000 pF	0402	PANASONIC	ECJ-0VC1H102J	
3	2	C6, C7	4.7 µF	TANT_A	KERMET	T491A475K016AS	
4	0	C8, C9	1 µF	0402	PANASONIC	ECJ-0EC1H010C_DNI	DNI
5	0	C10, C11, C12, C13	0.1 µF	0402	PANASONIC	ECJ-0EB1A104K_DNI	DNI
6	2	C14, C15	10 pF	0402	MURATA	GRM1555C1H100 JZ01D	
7	7	J1, J2, J3, J4, J5, J6, J7	LOP	SMA_SMEL_250x215	JOHNSON COMPONENTS	142-0711-821	
8	2	R1	0	0402	PANASONIC	ERJ-2GE0R00	OR EQUIVALENT
9	4	R2, R3, R4, R5	0	0402	PANASONIC	ERJ-2GE0R00	OR EQUIVALENT

Table 1. Bill of Materials for TRF370x EVM (continued)

Item Number	Quantity	Reference Designator	Value	PCB Footprint	Mfr. Name	Mfr. Part Number	Note
10	1	U1	TRF370333	QFN_24_163x163_0p50mm	TI	TRF370333	For TRF370333 EVM, TI supplied
			TRF370317	QFN_24_163x163_0p50mm	TI	TRF370317	For TRF370317 EVM, TI supplied
			TRF370315	QFN_24_163x163_0p50mm	TI	TRF370315	For TRF370315 EVM, TI supplied
			TRF370417	QFN_24_163x163_0p50mm	TI	TRF370417	For TRF370417 EVM, TI supplied
11	2	TP1, TP3	BLK	TP_THVT_100_RND	KEYSTONE	5001K	
12	2	TP2, TP4	RED	TP_THVT_100_RND	KEYSTONE	5000K	

GSM Applications

The TRF370417 is suited for GSM and multicarrier GSM applications because of its high linearity and low noise level over the entire recommended operating range. It also has excellent EVM performance, which makes it ideal for the stringent GSM/EDGE applications.

WCDMA Applications

The TRF370417 is also optimized for WCDMA applications where both adjacent-channel power ratio (ACPR) and noise density are critically important. Using Texas instruments' DAC568X series of high-performance digital-to-analog converters as depicted in Figure 49, excellent ACPR levels were measured with one-, two-, and four-WCDMA carriers. See *Electrical Characteristics*, f_{LO} = 1960 MHz and f_{LO} = 2140 MHz for exact ACPR values.

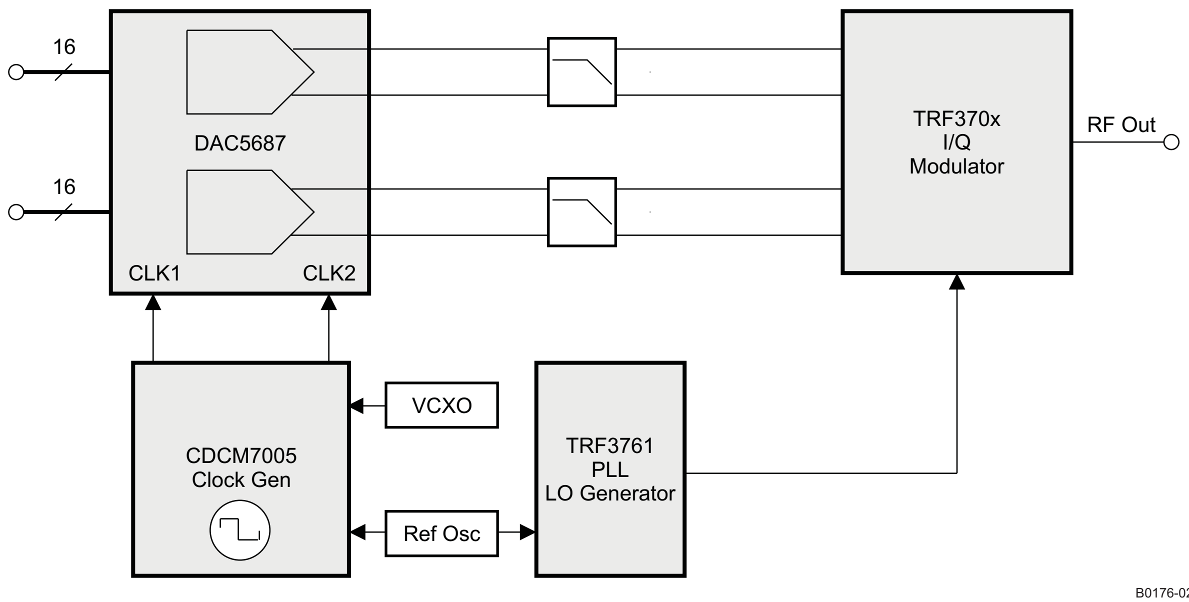


Figure 49. Typical Transmit Setup Block Diagram

DAC-to-Modulator Interface Network

For optimum linearity and dynamic range, the digital-to-analog converter (DAC) can interface directly with the modulator; however, the common-mode voltage of each device must be maintained. A passive interface circuit is used to transform the common-mode voltage of the DAC to the desired set-point of the modulator. The passive circuit invariably introduces some insertion loss between the two devices. In general, it is desirable to keep the insertion loss as low as possible to achieve the best dynamic range. Figure 50 shows the passive interconnect circuit for two different topologies. One topology is used when the DAC (e.g., DAC568x) common mode is larger than the modulator. The voltage V_{ee} is nominally set to ground, but can be set to a negative voltage to reduce the insertion loss of the network. The second topology is used when the DAC (e.g., DAC56x2) common mode is smaller than the modulator. Note that this passive interconnect circuit is duplicated for each of the differential I/Q branches.

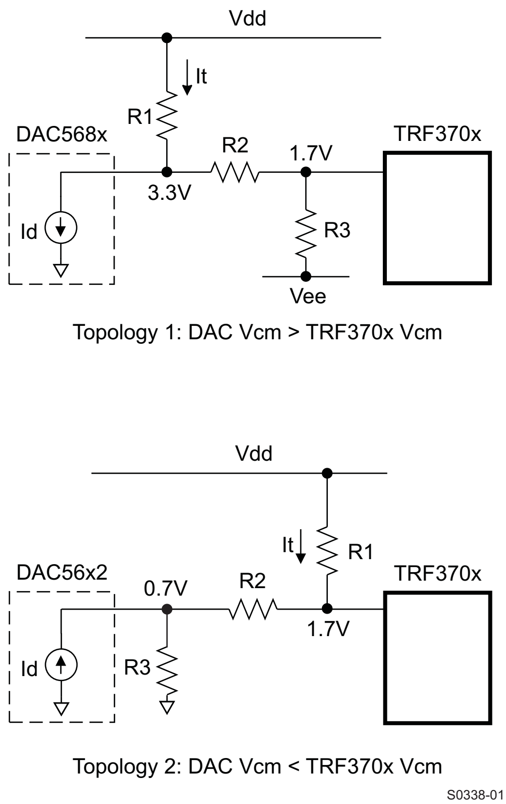


Figure 50. Passive DAC-to-Modulator Interface Network

Table 2. DAC-to-Modulator Interface Network Values

	Topology 1		**Topology 2**
	With Vee = 0 V	**With Vee = –5 V**	
DAC Vcm [V]	3.3	3.3	0.7
TRF370x Vcm [V]	1.7	1.7	1.7
Vdd [V]	5	5	5
Vee [V]	Gnd	–5	N/A
R1 [Ω]	66	56	960
R2 [Ω]	100	80	290
R3 [Ω]	108	336	52
Insertion loss [dB]	5.8	1.9	2.3

DEFINITION OF SPECIFICATIONS

Unadjusted Carrier Feedthrough

This specification measures the amount by which the local oscillator component is suppressed in the output spectrum of the modulator. If the common mode voltage at each of the baseband inputs is exactly the same and there was no dc imbalance introduced by the modulator, the LO component would be naturally suppressed. DC offset imbalances in the device allow some of the LO component to feed through to the output. Because this phenomenon is independent of the RF output power and the injected LO input power, the parameter is expressed in absolute power, dBm.

Adjusted (Optimized) Carrier Feedthrough

This differs from the unadjusted suppression number in that the baseband input dc offsets are iteratively adjusted around their theoretical value of VCM to yield the maximum suppression of the LO component in the output spectrum. This is measured in dBm.

Unadjusted Sideband Suppression

This specification measures the amount by which the unwanted sideband of the input signal is suppressed in the output of the modulator, relative to the wanted sideband. If the amplitude and phase within the I and Q branch of the modulator were perfectly matched, the unwanted sideband (or image) would be naturally suppressed. Amplitude and phase imbalance in the I and Q branches results in the increase of the unwanted sideband. This parameter is measured in dBc relative to the desired sideband.

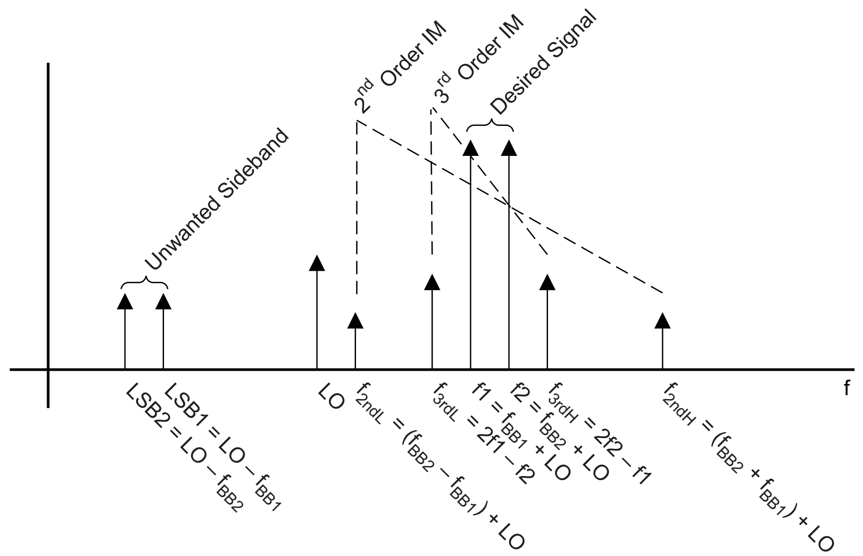
Adjusted (Optimized) Sideband Suppression

This differs from the unadjusted sideband suppression in that the gain and phase of the baseband inputs are iteratively adjusted around their theoretical values to maximize the amount of sideband suppression. This is measured in dBc.

Suppressions Over Temperature

This specification assumes that the user has gone though the optimization process for the suppression in question, and set the optimal settings for the I, Q inputs. This specification then measures the suppression when temperature conditions change after the initial calibration is done.

Figure 51 shows a simulated output and illustrates the respective definitions of various terms used in this data sheet.



f_{BBn} = Baseband Frequency

fn = RF Frequency

$f_{3rdH/L}$ = 3rd Order Intermodulation Product Frequency (High Side/Low Side)

$f_{2ndH/L}$ = 2nd Order Intermodulation Product (High Side/Low Side)

LO = Local Oscillator Frequency

LSBn = Lower Sideband Frequency

M0104-01

Figure 51. Graphical Illustration of Common Terms

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PACKAGING INFORMATION

Orderable Device	Status [1]	Package Type	Package Drawing	Pins	Package Qty	Eco Plan [2]	Lead/ Ball Finish	MSL Pea
TRF370417IRGER	ACTIVE	VQFN	RGE	24	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260
TRF370417IRGET	ACTIVE	VQFN	RGE	24	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260

[1] The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

[2] Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.t
information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all
lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable fo
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package,
the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retard
in homogeneous material)

[3] MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate inf
continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical an
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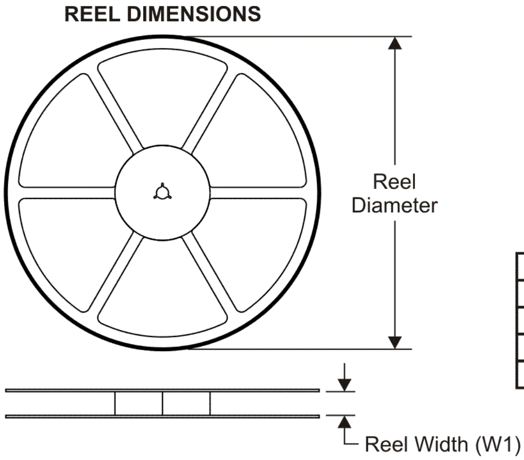
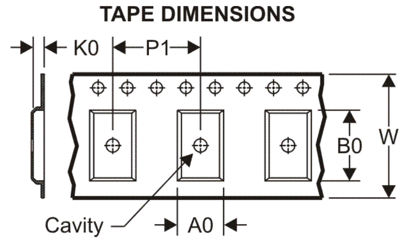
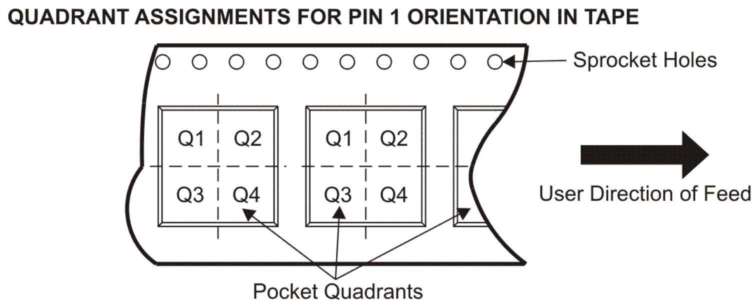
TAPE AND REEL INFORMATION





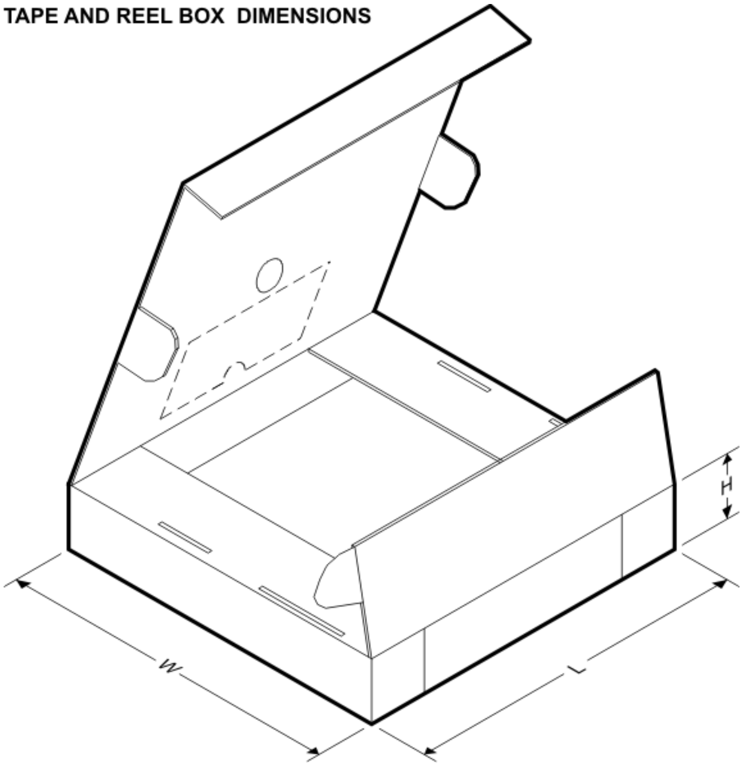
A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TRF370417IRGER	VQFN	RGE	24	3000	330.0	12.4	4.3	4.3	1.5	8.0	12.0	Q1
TRF370417IRGET	VQFN	RGE	24	250	330.0	12.4	4.3	4.3	1.5	8.0	12.0	Q1

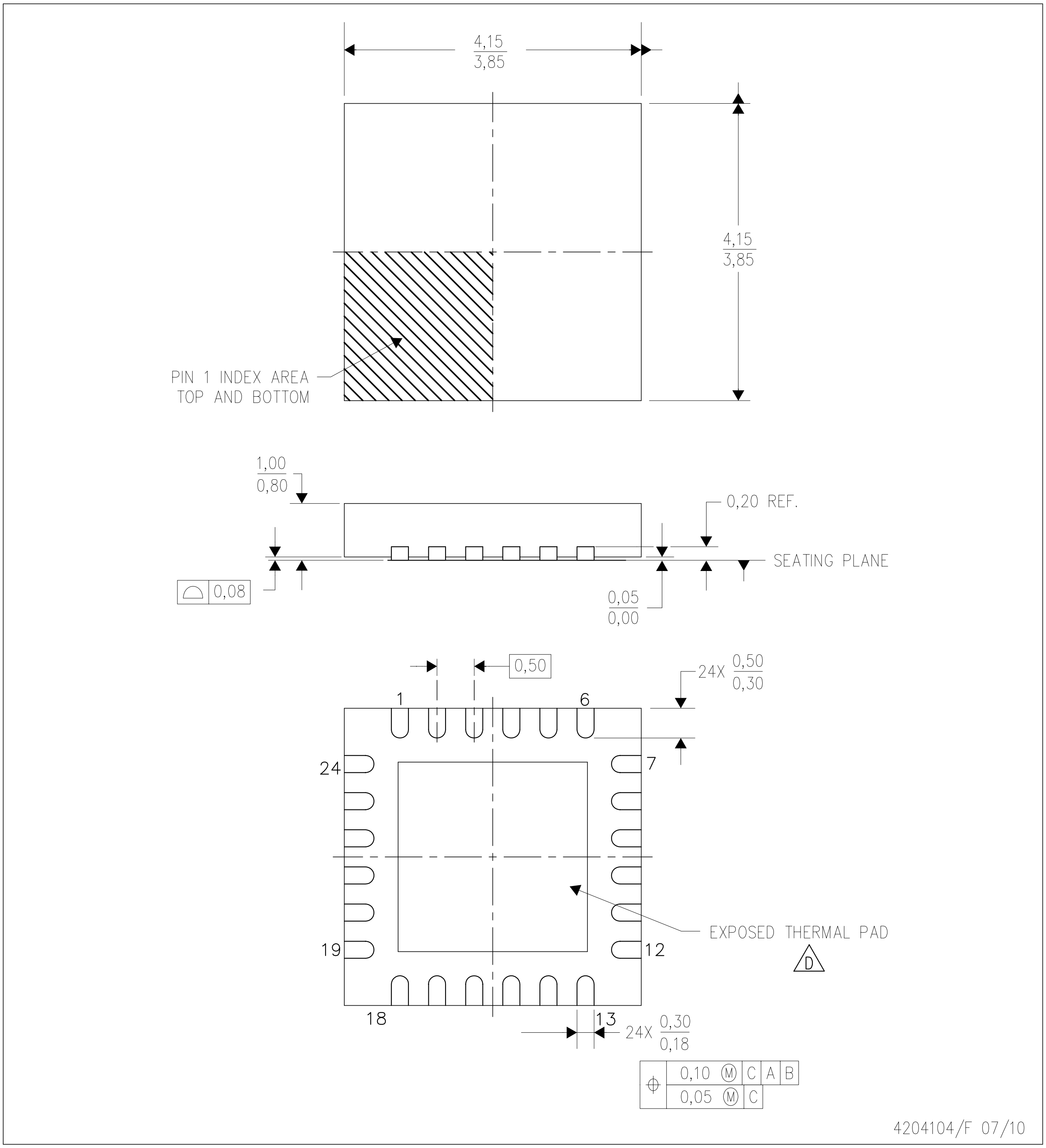
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TRF370417IRGER	VQFN	RGE	24	3000	340.5	333.0	20.6
TRF370417IRGET	VQFN	RGE	24	250	340.5	333.0	20.6

RGE (S-PVQFN-N24) PLASTIC QUAD FLATPACK NO-LEAD



NOTES:
A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M–1994.
B. This drawing is subject to change without notice.
C. Quad Flatpack, No–Leads (QFN) package configuration.
D. The package thermal pad must be soldered to the board for thermal and mechanical performance. See the Product Data Sheet for details regarding the exposed thermal pad dimensions.
E. Falls within JEDEC MO–220.

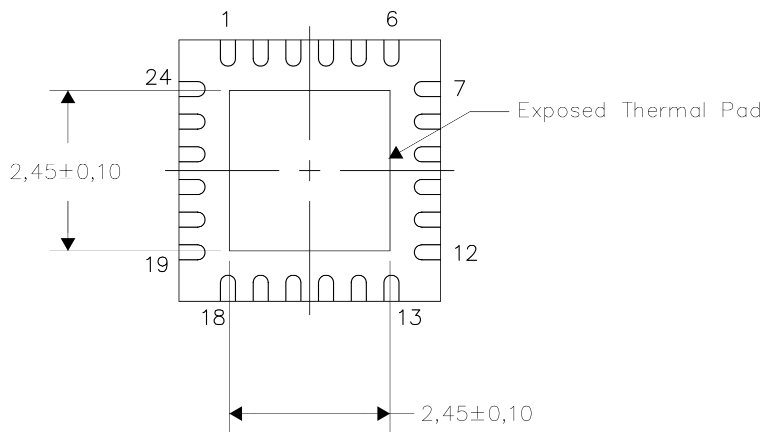
RGE (S-PVQFN-N24) PLASTIC QUAD FLATPACK NO-LEAD

THERMAL INFORMATION

This package incorporates an exposed thermal pad that is designed to be attached directly to an external heatsink. The thermal pad must be soldered directly to the printed circuit board (PCB). After soldering, the PCB can be used as a heatsink. In addition, through the use of thermal vias, the thermal pad can be attached directly to the appropriate copper plane shown in the electrical schematic for the device, or alternatively, can be attached to a special heatsink structure designed into the PCB. This design optimizes the heat transfer from the integrated circuit (IC).

For information on the Quad Flatpack No-Lead (QFN) package and its advantages, refer to Application Report, QFN/SON PCB Attachment, Texas Instruments Literature No. SLUA271. This document is available at www.ti.com.

The exposed thermal pad dimensions for this package are shown in the following illustration.



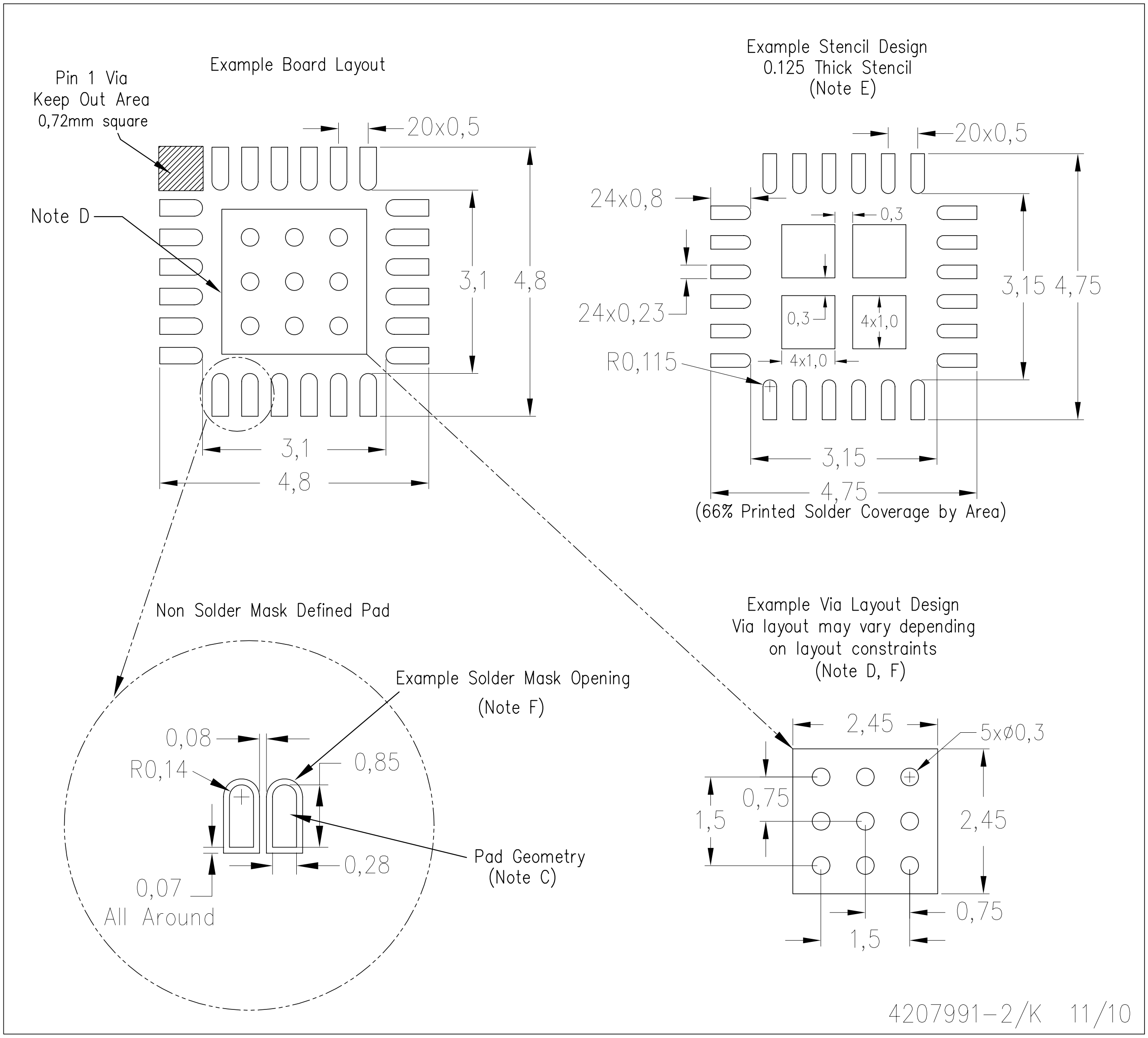
Bottom View

Exposed Thermal Pad Dimensions

4206344-3/V 11/10

NOTES: A. All linear dimensions are in millimeters

RGE (S-PVQFN-N24) PLASTIC QUAD FLATPACK NO-LEAD



NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Publication IPC-7351 is recommended for alternate designs.
D. This package is designed to be soldered to a thermal pad on the board. Refer to Application Note, Quad Flat-Pack Packages, Texas Instruments Literature No. SLUA271, and also the Product Data Sheets for specific thermal information, via requirements, and recommended board layout. These documents are available at www.ti.com <http: //www.ti.com>.
E. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC 7525 for stencil design considerations.
F. Customers should contact their board fabrication site for recommended solder mask tolerances and via tenting recommendations for vias placed in the thermal pad.

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