

# BIPOLAR ANALOG INTEGRATED CIRCUIT

# $\mu$ PC8187TB

## SILICON MMIC HI-IP<sub>3</sub> FREQUENCY UP-CONVERTER FOR WIRELESS TRANSCEIVER

### DESCRIPTION

The  $\mu$ PC8187TB is a silicon monolithic integrated circuit designed as frequency up-converter for wireless transceiver. This IC is higher operating frequency, lower distortion and higher conversion gain than conventional  $\mu$ PC8163TB.

This IC is manufactured using NEC's 30 GHz  $f_{max}$  UHS0 (Ultra High Speed Process) silicon bipolar process.

### FEATURES

- High output frequency :  $f_{RFout} = 0.8$  to  $2.5$  GHz
- High-density surface mounting : 6-pin super minimold package
- Supply voltage :  $V_{CC} = 2.7$  to  $3.3$  V
- Higher IP<sub>3</sub> : OIP<sub>3</sub> =  $+10$  dBm @  $f_{RFout} = 1.9$  GHz

### APPLICATION

- TDMA, PCS, CDMA etc.

### ORDERING INFORMATION

Part Number	Package	Marking	Supplying Form
$\mu$ PC8187TB-E3	6-pin super minimold	C3G	<ul style="list-style-type: none"> <li>• Embossed tape 8 mm wide.</li> <li>• Pin 1, 2, 3 face the tape perforation side.</li> <li>• Qty 3 kpcs/reel.</li> </ul>

**Remark** To order evaluation samples, please contact your local NEC sales office.  
(Part number for sample order:  $\mu$ PC8187TB)

**Caution Electro-static sensitive devices**

The information in this document is subject to change without notice. Before using this document, please confirm that this is the latest version.  
Not all devices/types available in every country. Please check with local NEC representative for availability and additional information.

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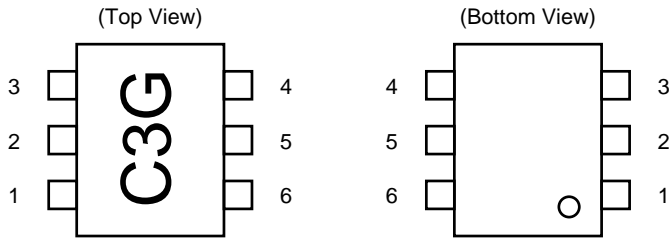
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1. PIN CONNECTIONS



Pin No.	Pin Name
1	IFinput
2	GND
3	LOinput
4	GND
5	V <sub>CC</sub>
6	RFoutput

2. SERIES PRODUCTS (T<sub>A</sub> = +25°C, V<sub>CC</sub> = V<sub>PS</sub> = V<sub>RFout</sub> = 3.0 V, Z<sub>S</sub> = Z<sub>L</sub> = 50 Ω)

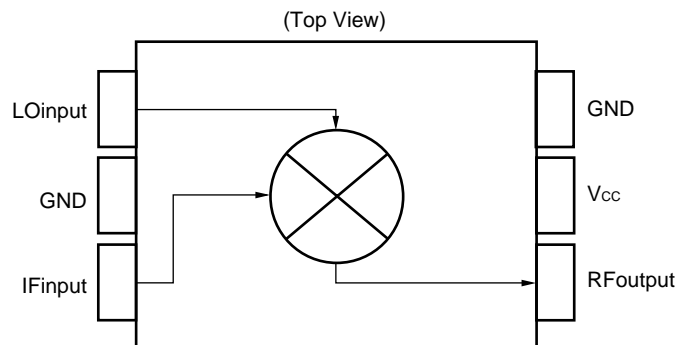
Part Number	I <sub>CC</sub> (mA)	f <sub>RFout</sub> (GHz)	CG (dB)		
			@RF 0.9 GHz <sup>Note</sup>	@RF 1.9 GHz	@RF 2.4 GHz
μPC8187TB	15	0.8 to 2.5	11	11	10
μPC8106TB	9	0.4 to 2.0	9	7	–
μPC8172TB	9	0.8 to 2.5	9.5	8.5	8.0
μPC8109TB	5	0.4 to 2.0	6	4	–
μPC8163TB	16.5	0.8 to 2.0	9	5.5	–

Part Number	P <sub>O(sat)</sub> (dBm)			OIP <sub>3</sub> (dBm)		
	@RF 0.9 GHz <sup>Note</sup>	@RF 1.9 GHz	@RF 2.4 GHz	@RF 0.9 GHz <sup>Note</sup>	@RF 1.9 GHz	@RF 2.4 GHz
μPC8187TB	+4	+2.5	+1	+10	+10	+8.5
μPC8106TB	–2	–4	–	+5.5	+2.0	–
μPC8172TB	+0.5	0	–0.5	+7.5	+6.0	+4.0
μPC8109TB	–5.5	–7.5	–	+1.5	–1.0	–
μPC8163TB	+0.5	–2	–	+9.5	+6.0	–

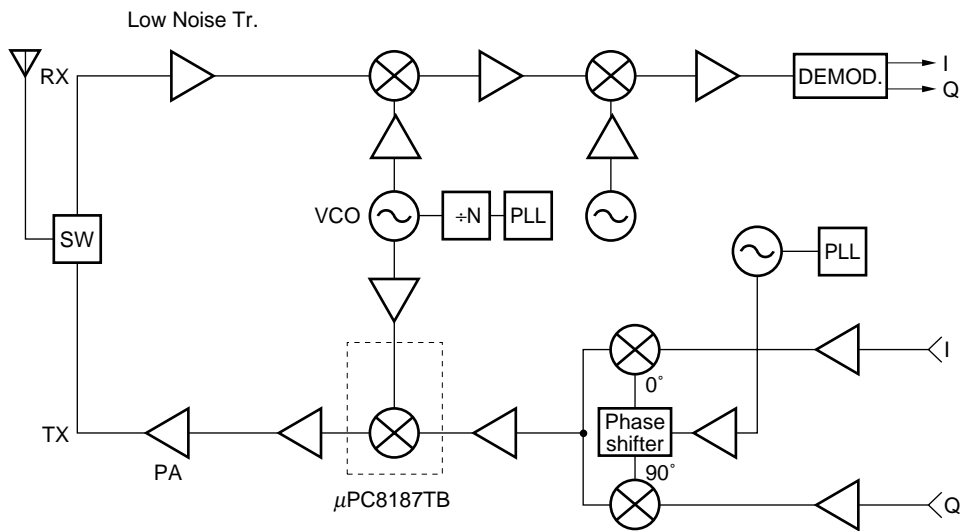
**Note** f<sub>RFout</sub> = 0.83 GHz @ μPC8163TB and μPC8187TB

**Remark** Typical performance. Please refer to 8. ELECTRICAL CHARACTERISTICS in detail.  
To know the associated product, please refer to each latest data sheet.

3. BLOCK DIAGRAM



4. SYSTEM APPLICATION EXAMPLES (SCHEMATICS OF IC LOCATION IN THE SYSTEM)



5. PIN EXPLANATION

Pin No.	Pin Name	Applied Voltage (V)	Pin Voltage (V) <sup>Note</sup>	Function and Explanation	Equivalent Circuit
1	IFinput	–	1.2	This pin is IF input to double balanced mixer (DBM). The input is designed as high impedance. The circuit contributes to suppress spurious signal. Also this symmetrical circuit can keep specified performance insensitive to process-condition distribution. For above reason, double balanced mixer is adopted.	
2 4	GND	GND	–	GND pin. Ground pattern on the board should be formed as wide as possible. Track Length should be kept as short as possible to minimize ground impedance.	
3	LOinput	–	2.1	Local input pin. Recommendable input level is –10 to 0 dBm.	
5	V <sub>cc</sub>	2.7 to 3.3	–	Supply voltage pin.	
6	RFoutput	Same bias as V <sub>cc</sub> through external inductor	–	This pin is RF output from DBM. This pin is designed as open collector. Due to the high impedance output, this pin should be externally equipped with LC matching circuit to next stage.	

**Note** Each pin voltage is measured at V<sub>CC</sub> = V<sub>RFout</sub> = 2.8 V.

**6. ABSOLUTE MAXIMUM RATINGS**

Parameter	Symbol	Test Conditions	Rating	Unit
Supply Voltage	V <sub>CC</sub>	T <sub>A</sub> = +25°C	3.6	V
Power Dissipation	P <sub>D</sub>	Mounted on double-side copperclad 50 × 50 × 1.6 mm epoxy glass PWB, T <sub>A</sub> = +85°C	270	mW
Operating Ambient Temperature	T <sub>A</sub>		-40 to +85	°C
Storage Temperature	T <sub>stg</sub>		-55 to +150	°C
Maximum Input Power	P <sub>in</sub>		+10	dBm

**7. RECOMMENDED OPERATING RANGE**

Parameter	Symbol	MIN.	TYP.	MAX.	Unit	Remarks
Supply Voltage	V <sub>CC</sub>	2.7	2.8	3.3	V	The same voltage should be applied to pin 5 and 6
Operating Ambient Temperature	T <sub>A</sub>	-40	+25	+85	°C	
Local Input Power	P <sub>LOin</sub>	-10	-5	0	dBm	Z <sub>s</sub> = 50 Ω (without matching)
RF Output Frequency	f <sub>RFout</sub>	0.8	-	2.5	GHz	With external matching circuit
IF Input Frequency	f <sub>IFin</sub>	50	-	400	MHz	

**8. ELECTRICAL CHARACTERISTICS**

(T<sub>A</sub> = +25°C, V<sub>CC</sub> = V<sub>RFout</sub> = 2.8 V, f<sub>IFin</sub> = 150 MHz, P<sub>LOin</sub> = -5 dBm)

Parameter	Symbol	Test Conditions <sup>Note</sup>	MIN.	TYP.	MAX.	Unit
Circuit Current	I <sub>CC</sub>	No signal	11	15	19	mA
Conversion Gain	CG1	f <sub>RFout</sub> = 0.83 GHz, P <sub>IFin</sub> = -20 dBm	8	11	14	dB
	CG2	f <sub>RFout</sub> = 1.9 GHz, P <sub>IFin</sub> = -20 dBm	8	11	14	dB
	CG3	f <sub>RFout</sub> = 2.4 GHz, P <sub>IFin</sub> = -20 dBm	7	10	13	dB
Saturated Output Power	P <sub>O(sat)1</sub>	f <sub>RFout</sub> = 0.83 GHz, P <sub>IFin</sub> = 0 dBm	+1.5	+4	-	dBm
	P <sub>O(sat)2</sub>	f <sub>RFout</sub> = 1.9 GHz, P <sub>IFin</sub> = 0 dBm	0	+2.5	-	dBm
	P <sub>O(sat)3</sub>	f <sub>RFout</sub> = 2.4 GHz, P <sub>IFin</sub> = 0 dBm	-1.5	+1	-	dBm

**Note** f<sub>RFout</sub> < f<sub>LOin</sub> @ f<sub>RFout</sub> = 0.83 GHz

f<sub>LOin</sub> < f<sub>RFout</sub> @ f<sub>RFout</sub> = 1.9 GHz/2.4 GHz

9. OTHER CHARACTERISTICS, FOR REFERENCE PURPOSES ONLY

(T<sub>A</sub> = +25°C, V<sub>CC</sub> = V<sub>RFout</sub> = 2.8 V, P<sub>LOin</sub> = -5 dBm)

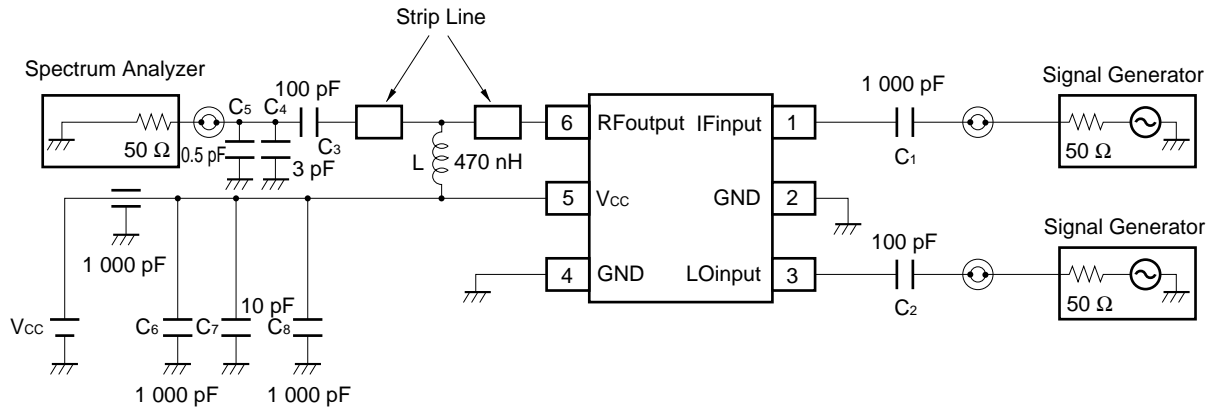
Parameter	Symbol	Test Conditions <sup>Note</sup>		Value	Unit
Output 3rd Order Distortion Intercept Point	OIP <sub>31</sub>	f <sub>RFout</sub> = 0.83 GHz	f <sub>Fin1</sub> = 150 MHz f <sub>Fin2</sub> = 151 MHz	+10	dBm
	OIP <sub>32</sub>	f <sub>RFout</sub> = 1.9 GHz		+10	dBm
	OIP <sub>33</sub>	f <sub>RFout</sub> = 2.4 GHz		+8.5	dBm
Input 3rd Order Distortion Intercept Point	IIP <sub>31</sub>	f <sub>RFout</sub> = 0.83 GHz	f <sub>Fin1</sub> = 150 MHz f <sub>Fin2</sub> = 151 MHz	-1.0	dBm
	IIP <sub>32</sub>	f <sub>RFout</sub> = 1.9 GHz		-1.0	dBm
	IIP <sub>33</sub>	f <sub>RFout</sub> = 2.4 GHz		-1.5	dBm
SSB Noise Figure	SSB•NF1	f <sub>RFout</sub> = 0.83 GHz	f <sub>Fin</sub> = 150 MHz	11	dB
	SSB•NF2	f <sub>RFout</sub> = 1.9 GHz		12	dB
	SSB•NF3	f <sub>RFout</sub> = 2.4 GHz		12.5	dB

**Note** f<sub>RFout</sub> < f<sub>LOin</sub> @ f<sub>RFout</sub> = 0.83 GHz  
 f<sub>LOin</sub> < f<sub>RFout</sub> @ f<sub>RFout</sub> = 1.9 GHz/2.4 GHz

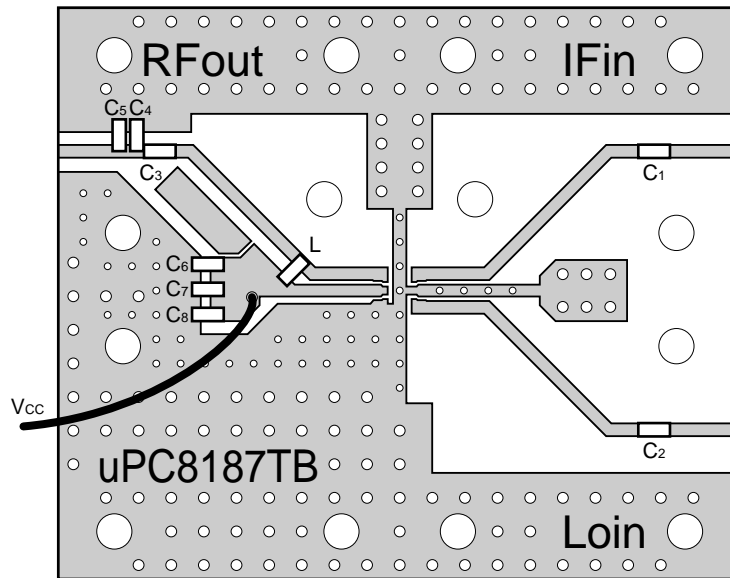




10.2 TEST CIRCUIT 2 ( $f_{RFout} = 1.9\text{ GHz}$ )



EXAMPLE OF TEST CIRCUIT 2 ASSEMBLED ON EVALUATION BOARD



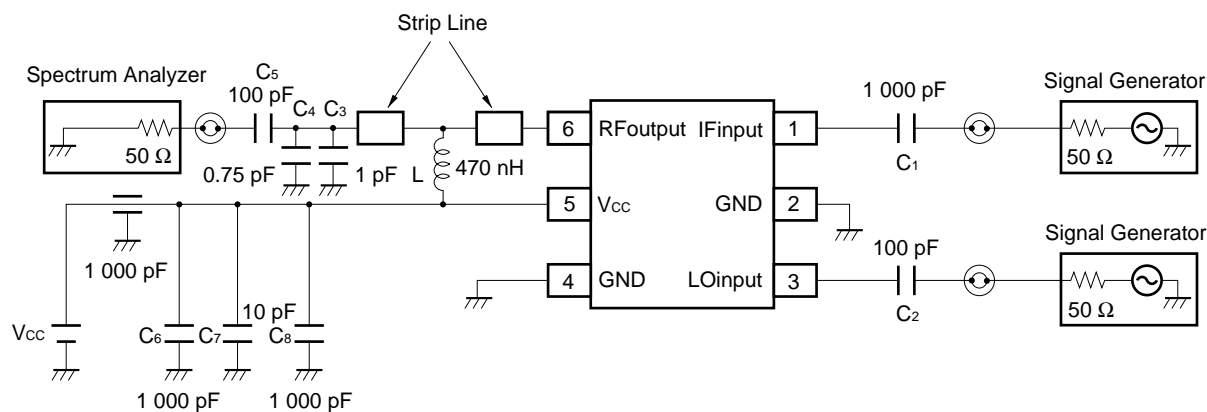
COMPONENT LIST

Form	Symbol	Value
Chip capacitor	C <sub>1</sub> , C <sub>6</sub> , C <sub>8</sub>	1 000 pF
	C <sub>2</sub> , C <sub>3</sub>	100 pF
	C <sub>7</sub>	10 pF
	C <sub>4</sub>	3 pF
	C <sub>5</sub>	0.5 pF
Chip inductor	L	470 nH <sup>Note</sup>

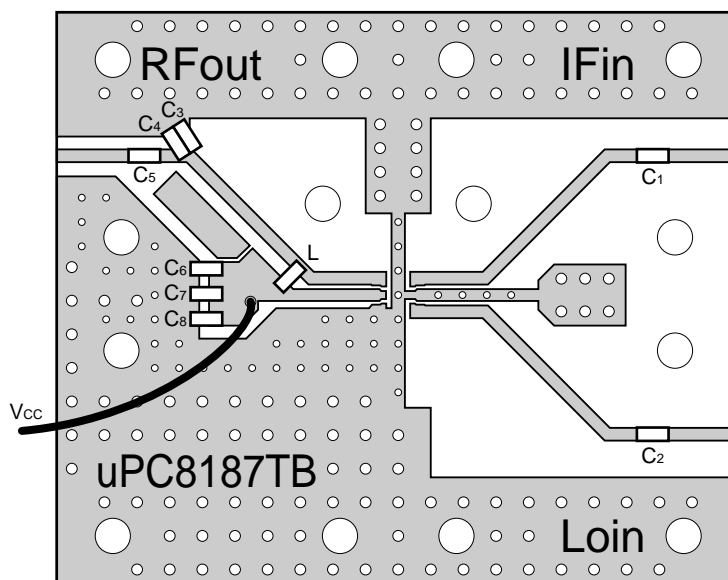
- (\*1) 35 × 42 × 0.4 mm polyimide board, double-sided copper clad
- (\*2) Ground pattern on rear of the board
- (\*3) Solder plated patterns
- (\*4) ○○○ : Through holes

Note 470 nH: LL2012-FR47 (TOKO Co., Ltd.)

10.3 TEST CIRCUIT 3 (f<sub>RfOut</sub> = 2.4 GHz)



EXAMPLE OF TEST CIRCUIT 3 ASSEMBLED ON EVALUATION BOARD



COMPONENT LIST

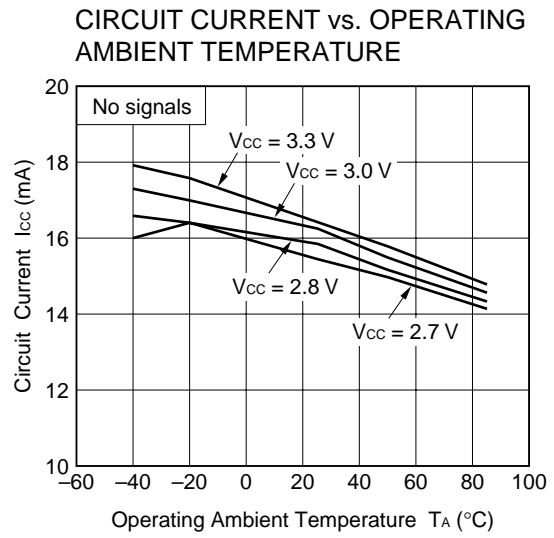
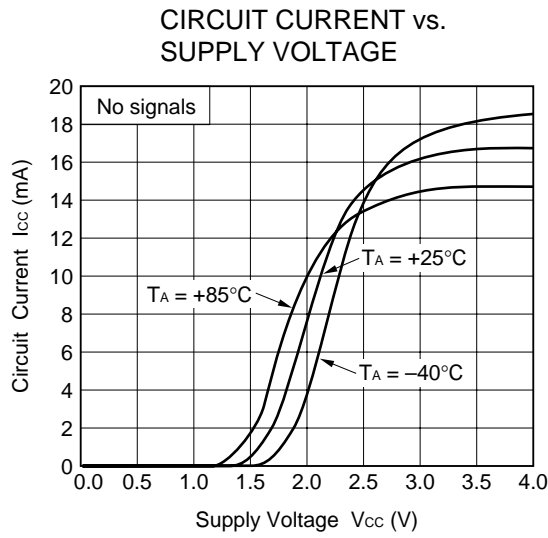
Form	Symbol	Value
Chip capacitor	C <sub>1</sub> , C <sub>6</sub> , C <sub>8</sub>	1 000 pF
	C <sub>2</sub> , C <sub>5</sub>	100 pF
	C <sub>7</sub>	10 pF
	C <sub>3</sub>	1 pF
	C <sub>4</sub>	0.75 pF
Chip inductor	L	470 nH <sup>Note</sup>

- (\*1) 35 × 42 × 0.4 mm polyimide board, double-sided copper clad
- (\*2) Ground pattern on rear of the board
- (\*3) Solder plated patterns
- (\*4) ○○○: Through holes

**Note** 470 nH: LL2012-FR47 (TOKO Co., Ltd.)

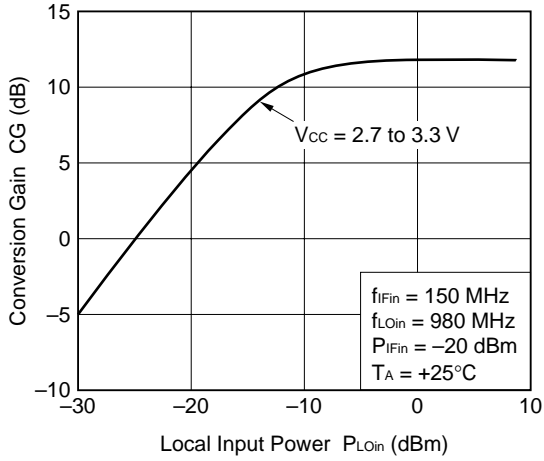
**Caution** The test circuits and board pattern on data sheet are for performance evaluation use only (They are not recommended circuits). In the case of actual design-in, matching circuit should be determined using S-parameter of desired frequency in accordance to actual mounting pattern.

★ 11. TYPICAL CHARACTERISTICS (Unless otherwise specified,  $T_A = +25^\circ\text{C}$ ,  $V_{CC} = V_{RFout}$ )

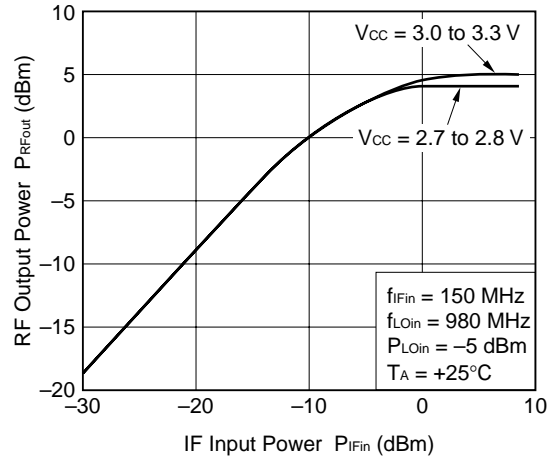


11.1  $f_{RFout} = 0.83$  GHz

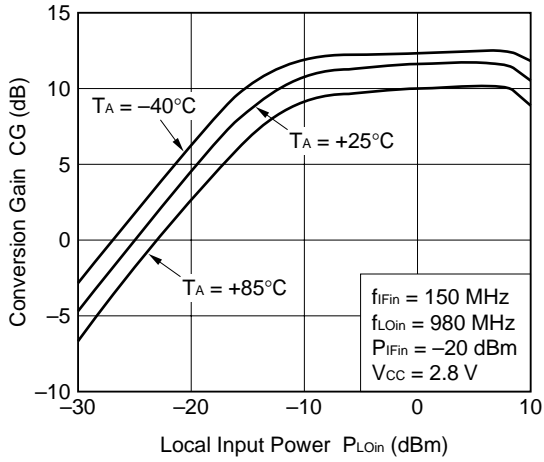
CONVERSION GAIN vs. LOCAL INPUT POWER



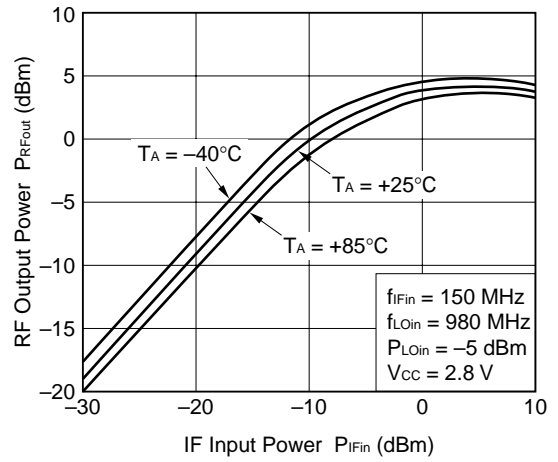
RF OUTPUT POWER vs. IF INPUT POWER

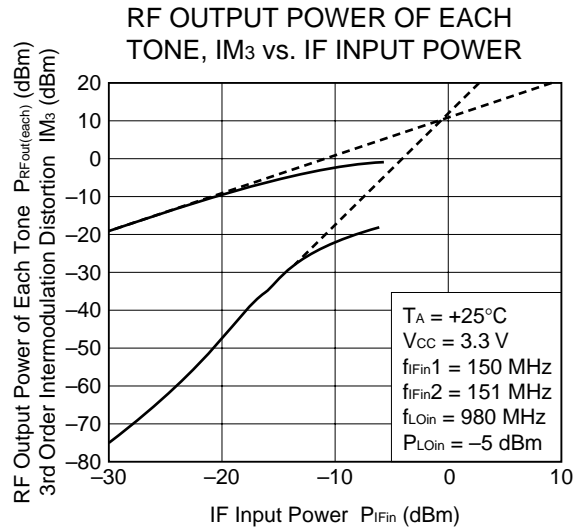
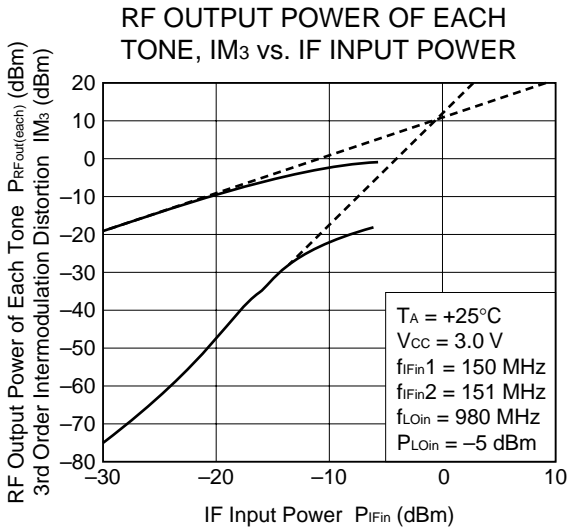
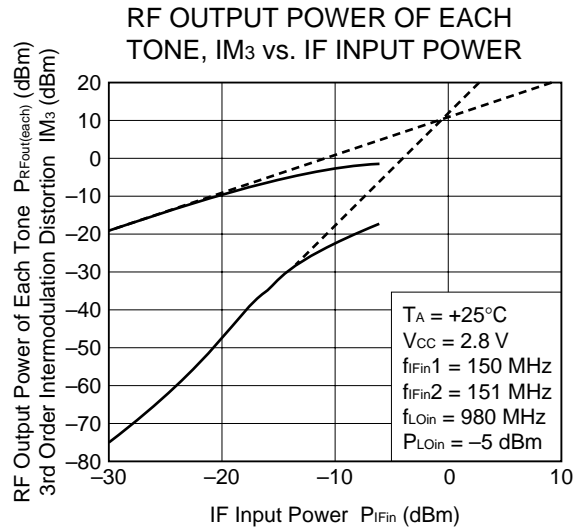
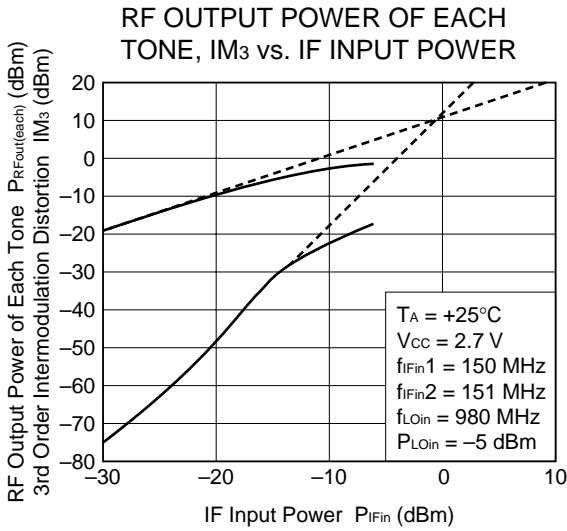


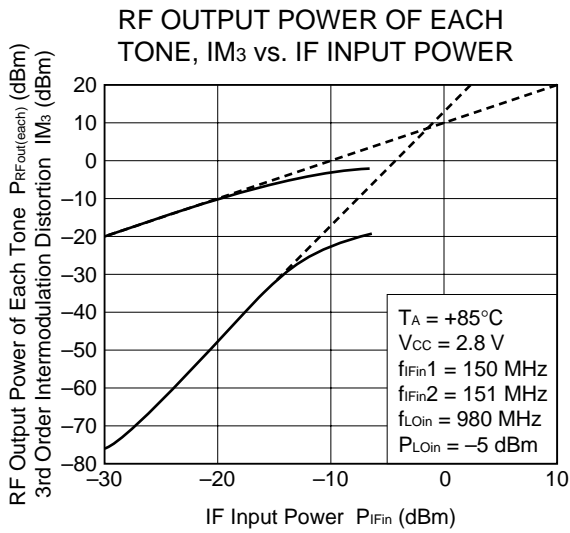
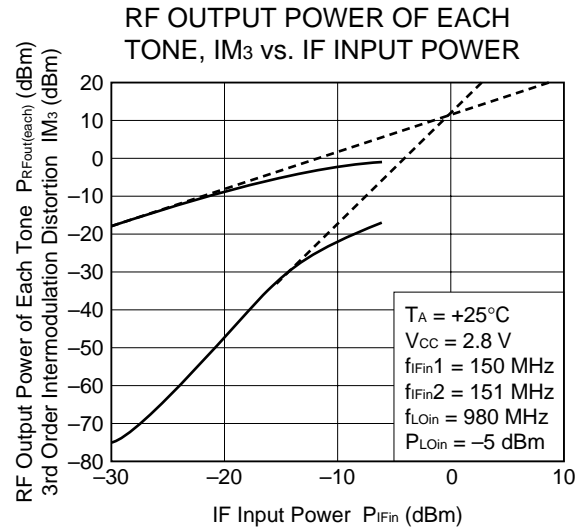
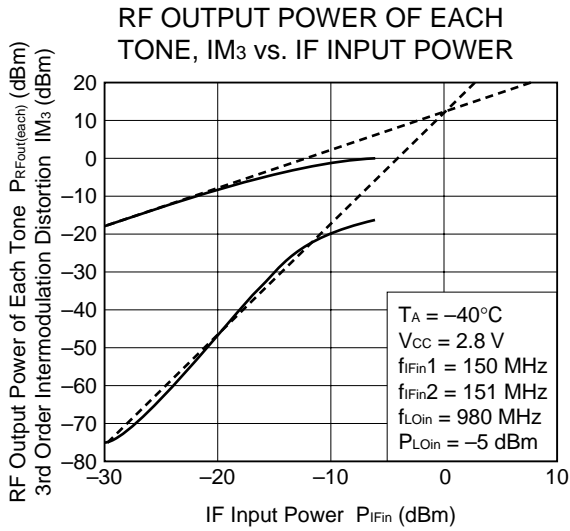
CONVERSION GAIN vs. LOCAL INPUT POWER



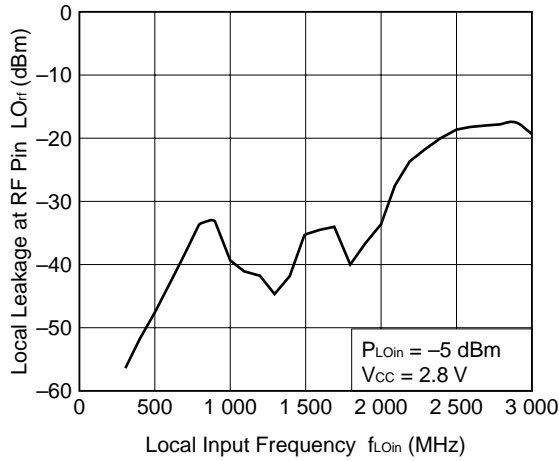
RF OUTPUT POWER vs. IF INPUT POWER



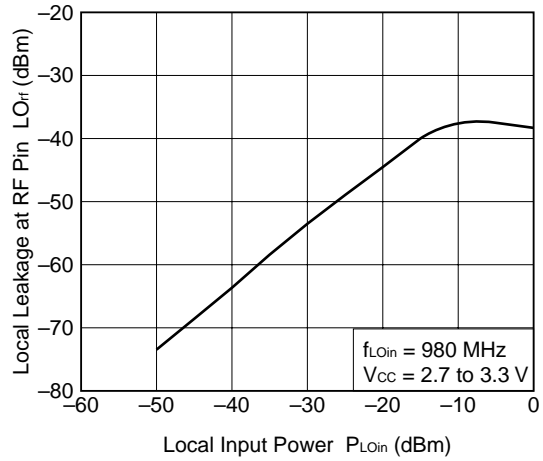




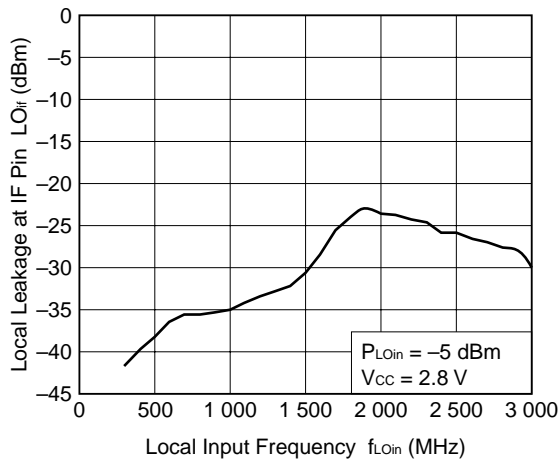
LOCAL LEAKAGE AT RF PIN vs. LOCAL INPUT FREQUENCY



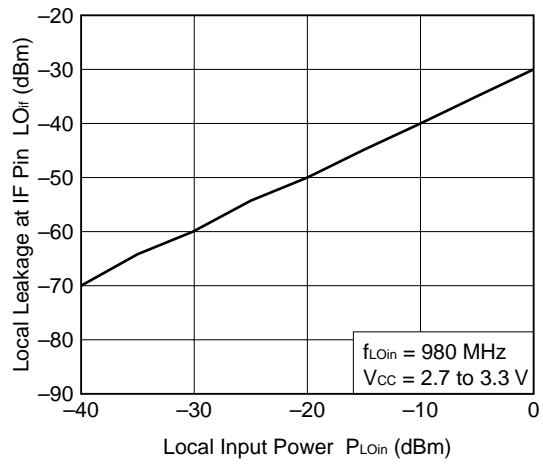
LOCAL LEAKAGE AT RF PIN vs. LOCAL INPUT POWER



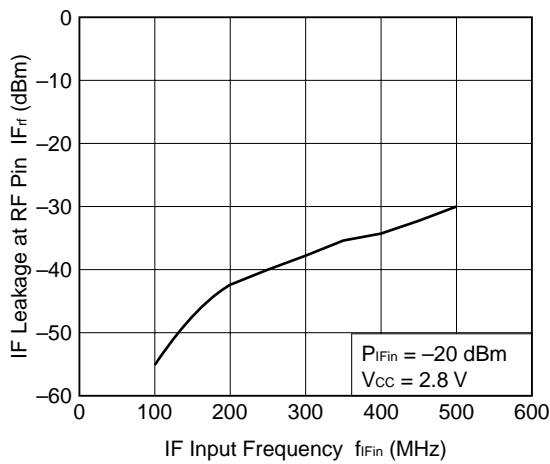
LOCAL LEAKAGE AT IF PIN vs. LOCAL INPUT FREQUENCY



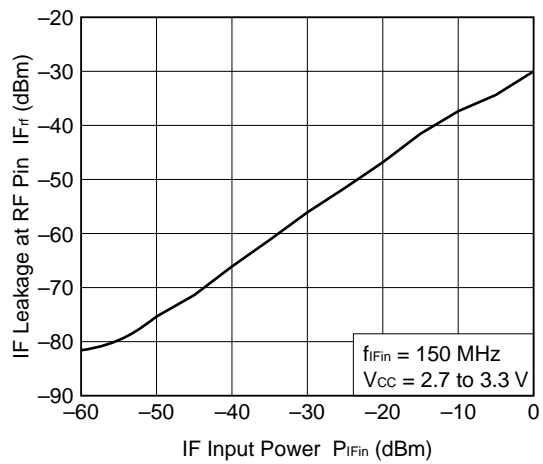
LOCAL LEAKAGE AT IF PIN vs. LOCAL INPUT POWER



IF LEAKAGE AT RF PIN vs. IF INPUT FREQUENCY



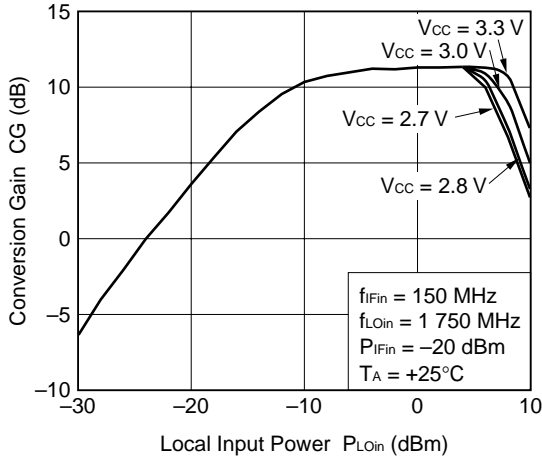
IF LEAKAGE AT RF PIN vs. IF INPUT POWER



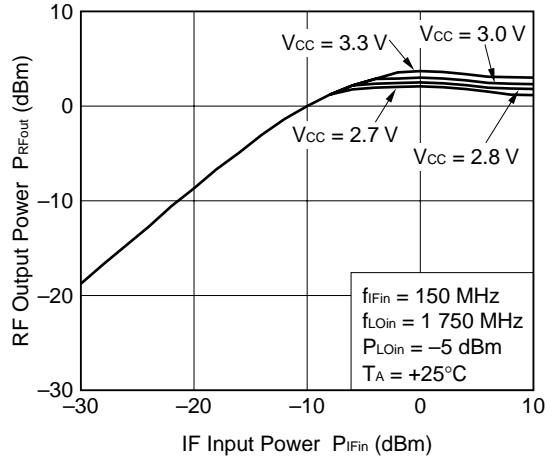


11.2  $f_{RFout} = 1.9$  GHz

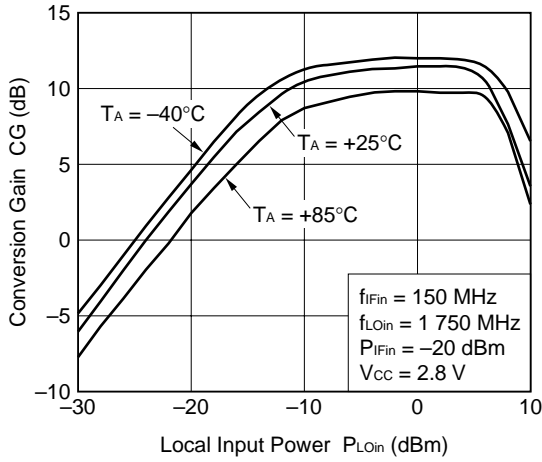
CONVERSION GAIN vs. LOCAL INPUT POWER



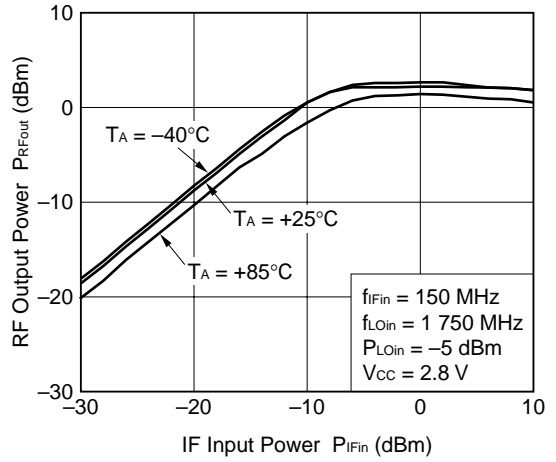
RF OUTPUT POWER vs. IF INPUT POWER



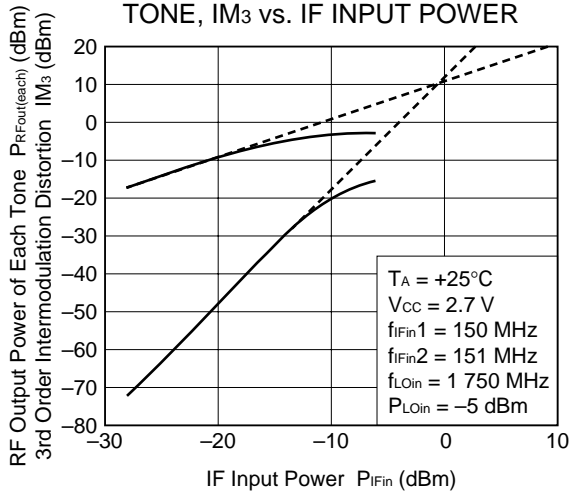
CONVERSION GAIN vs. LOCAL INPUT POWER



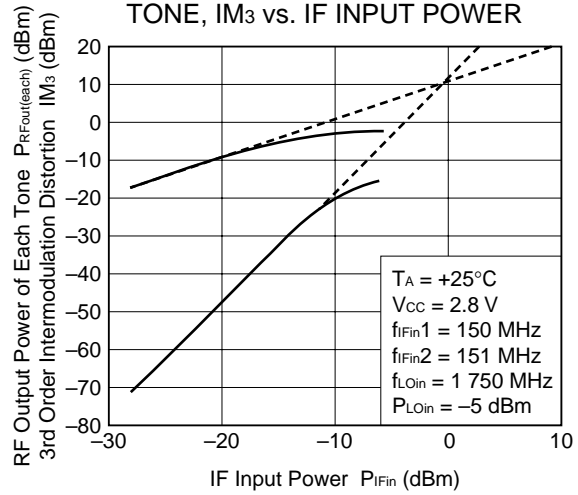
RF OUTPUT POWER vs. IF INPUT POWER



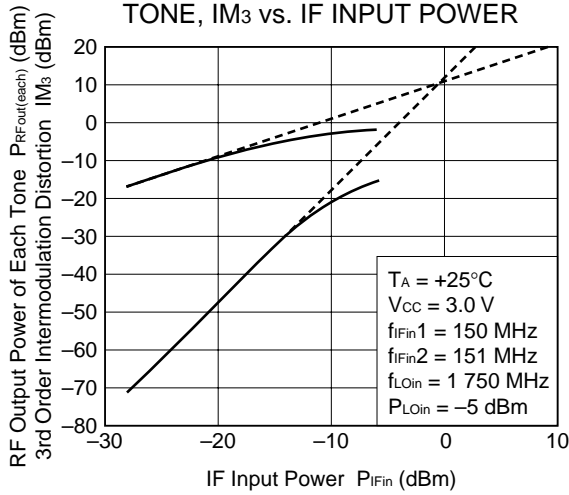
RF OUTPUT POWER OF EACH TONE, IM<sub>3</sub> vs. IF INPUT POWER



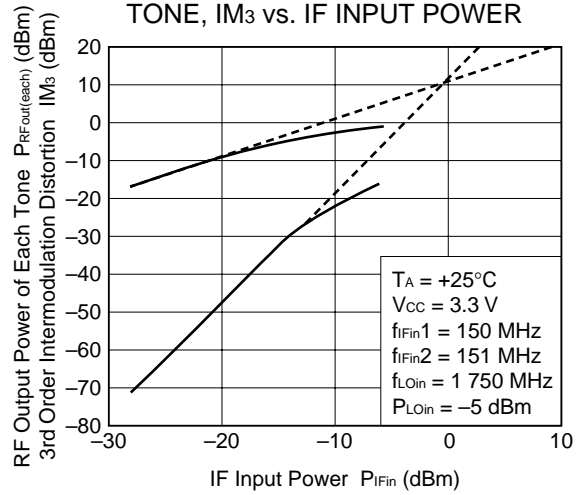
RF OUTPUT POWER OF EACH TONE, IM<sub>3</sub> vs. IF INPUT POWER



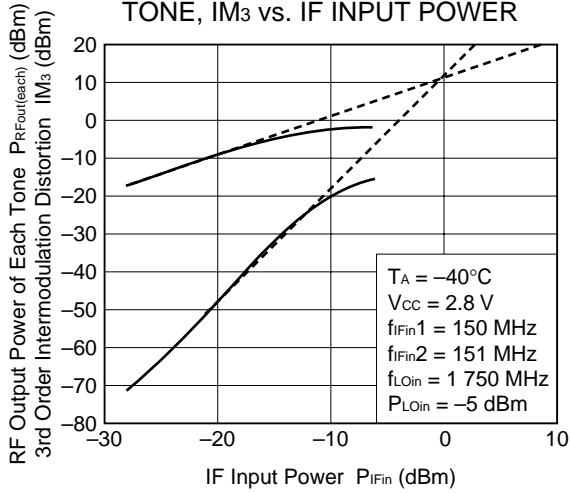
RF OUTPUT POWER OF EACH TONE, IM<sub>3</sub> vs. IF INPUT POWER



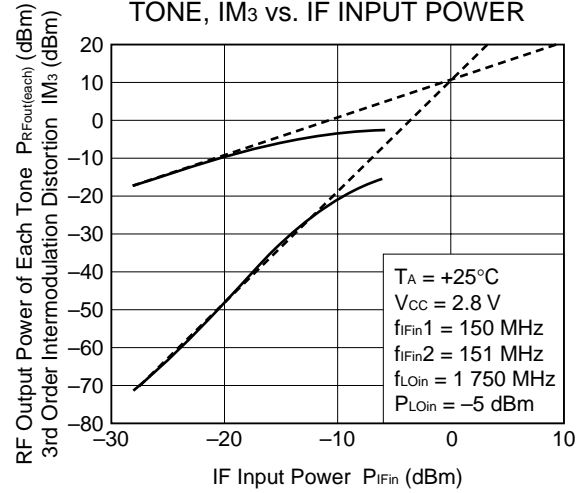
RF OUTPUT POWER OF EACH TONE, IM<sub>3</sub> vs. IF INPUT POWER



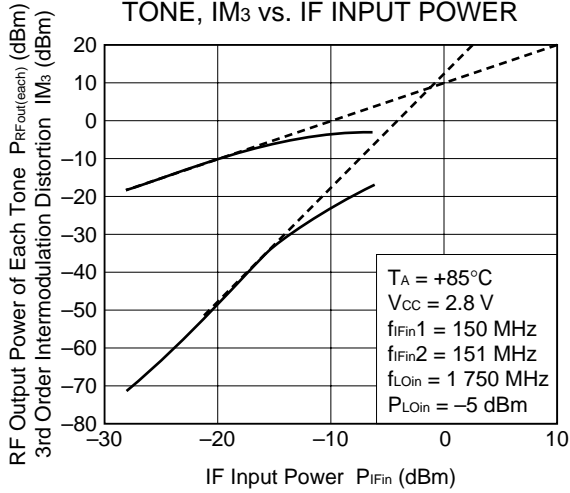
RF OUTPUT POWER OF EACH TONE, IM<sub>3</sub> vs. IF INPUT POWER



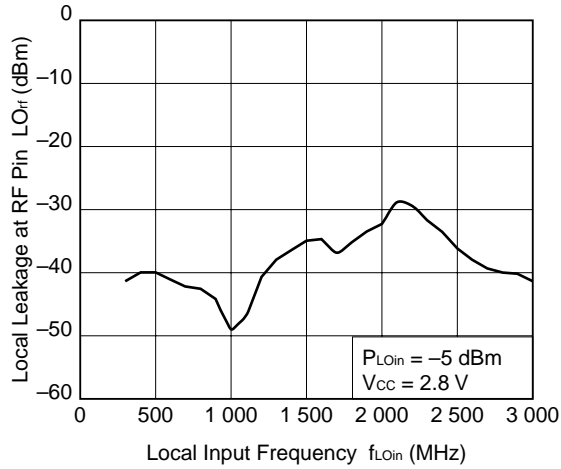
RF OUTPUT POWER OF EACH TONE, IM<sub>3</sub> vs. IF INPUT POWER



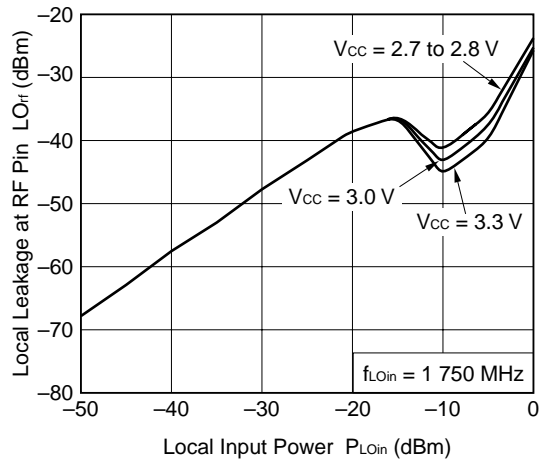
RF OUTPUT POWER OF EACH TONE, IM<sub>3</sub> vs. IF INPUT POWER



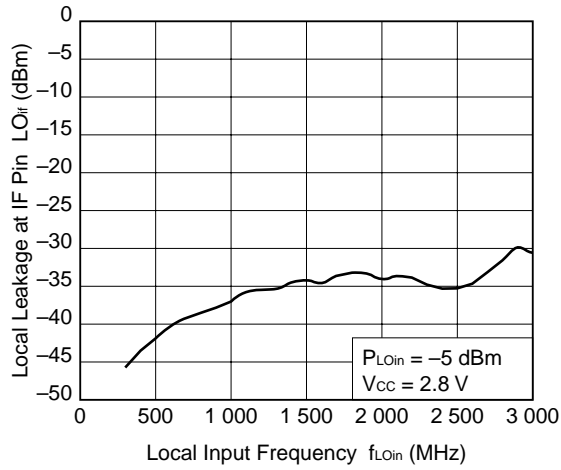
LOCAL LEAKAGE AT RF PIN vs. LOCAL INPUT FREQUENCY



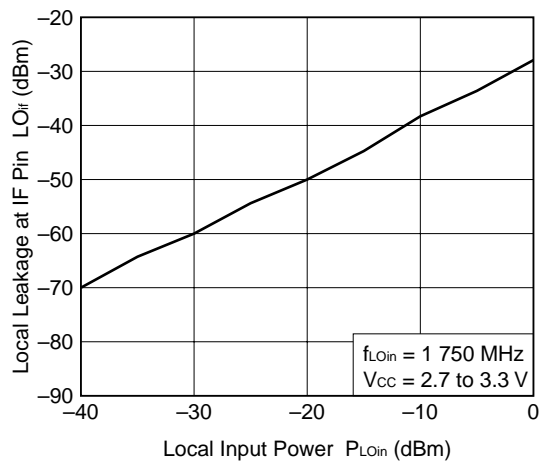
LOCAL LEAKAGE AT RF PIN vs. LOCAL INPUT POWER



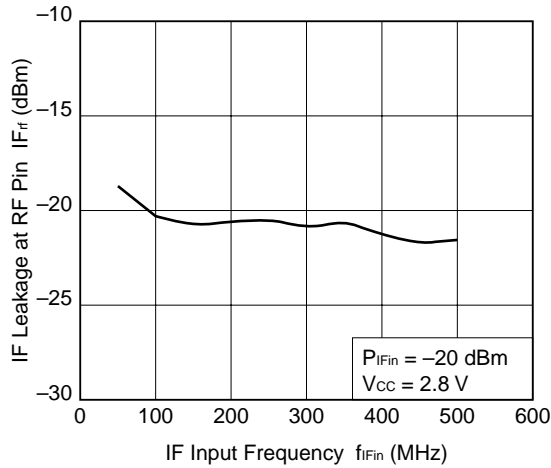
LOCAL LEAKAGE AT IF PIN vs. LOCAL INPUT FREQUENCY



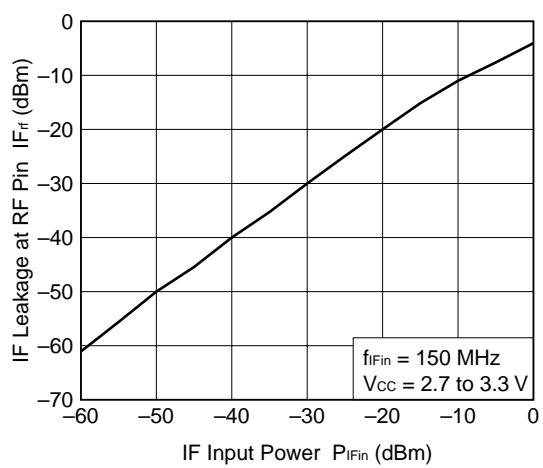
LOCAL LEAKAGE AT IF PIN vs. LOCAL INPUT POWER



IF LEAKAGE AT RF PIN vs. IF INPUT FREQUENCY

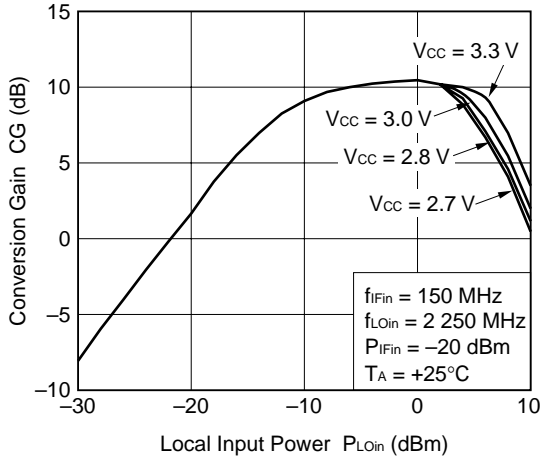


IF LEAKAGE AT RF PIN vs. IF INPUT POWER

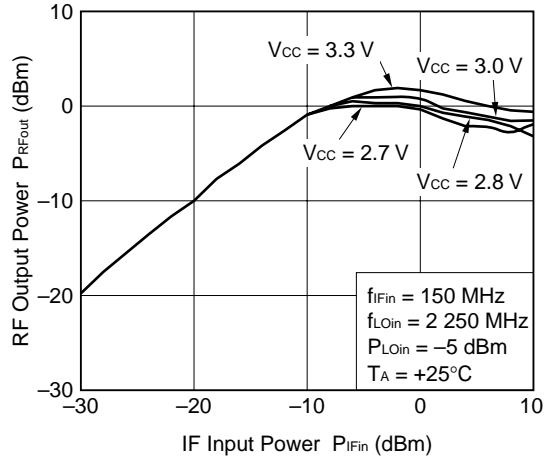


11.3  $f_{RFout} = 2.4 \text{ GHz}$

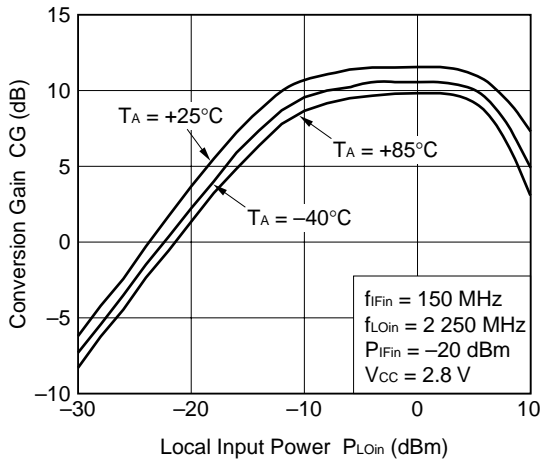
CONVERSION GAIN vs. LOCAL INPUT POWER



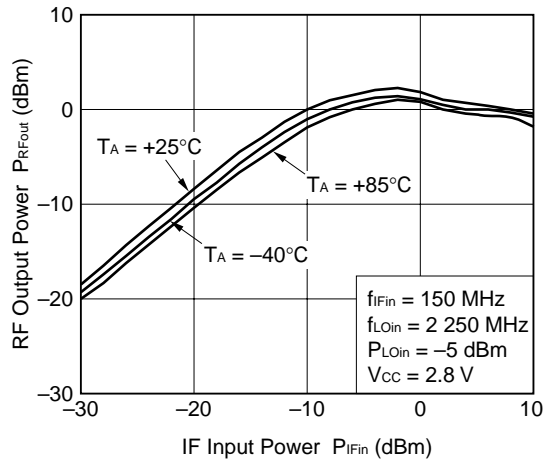
RF OUTPUT POWER vs. IF INPUT POWER

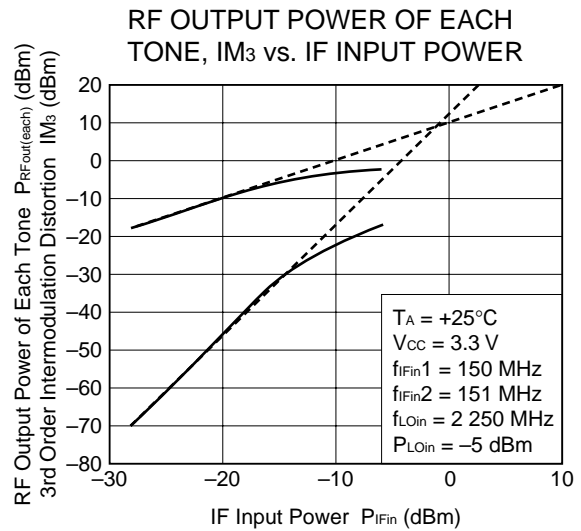
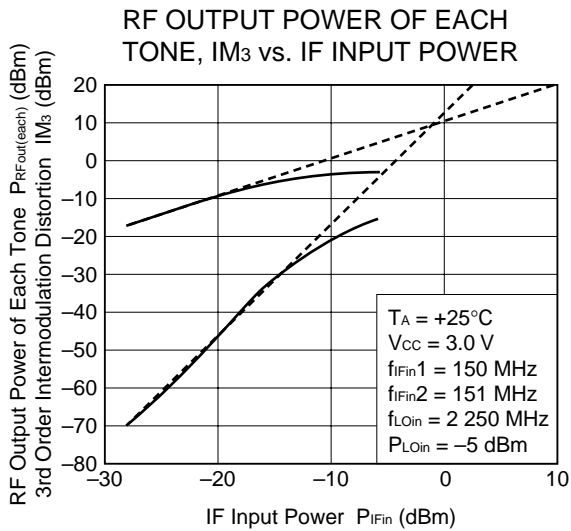
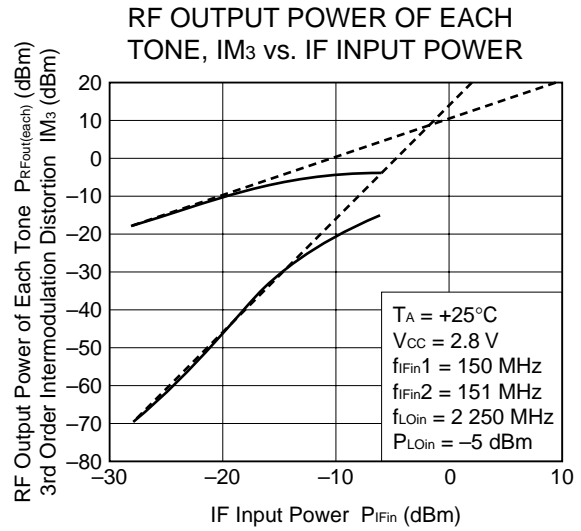
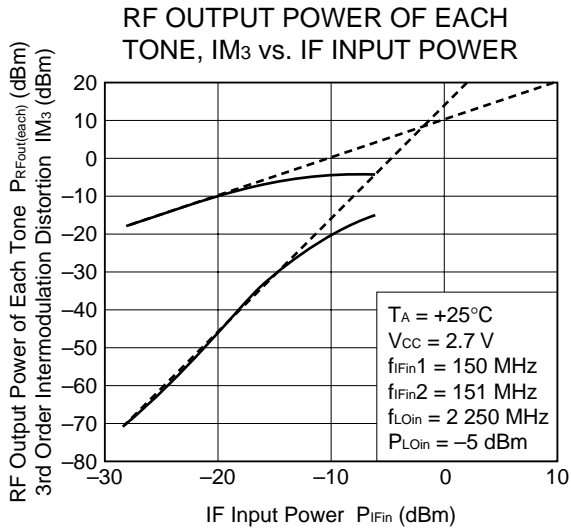


CONVERSION GAIN vs. LOCAL INPUT POWER

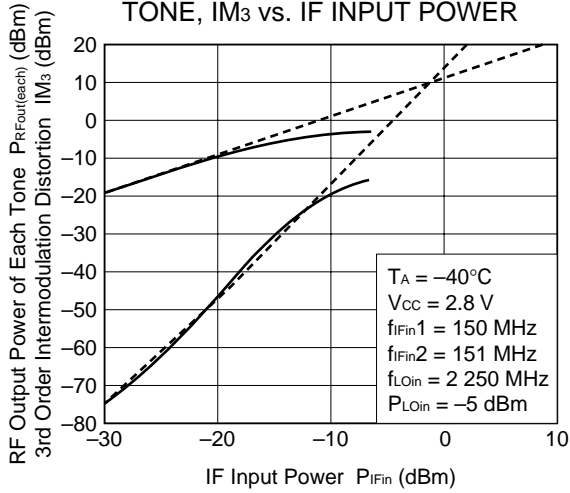


RF OUTPUT POWER vs. IF INPUT POWER

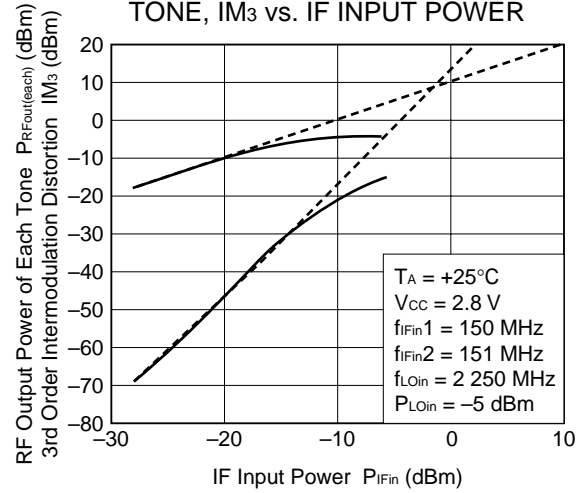




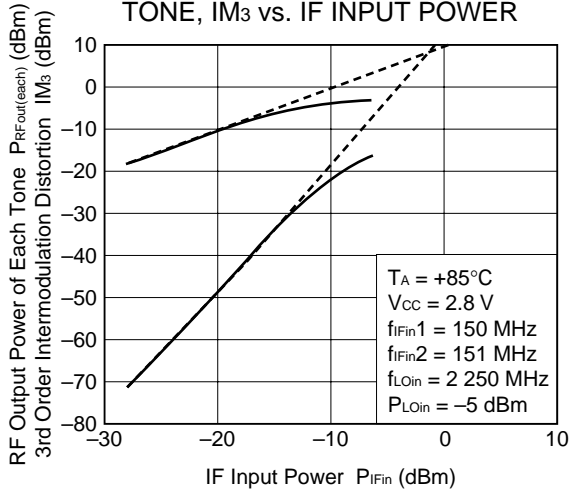
RF OUTPUT POWER OF EACH TONE, IM<sub>3</sub> vs. IF INPUT POWER



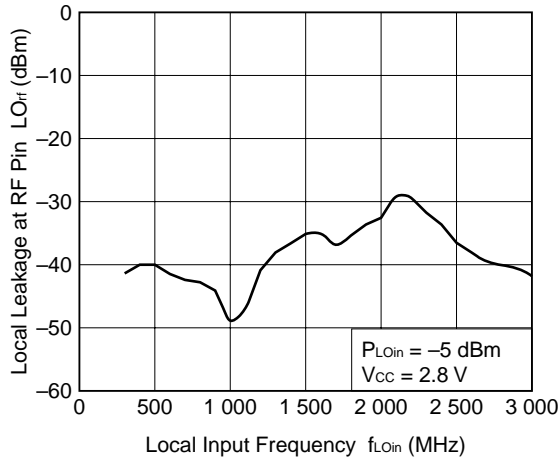
RF OUTPUT POWER OF EACH TONE, IM<sub>3</sub> vs. IF INPUT POWER



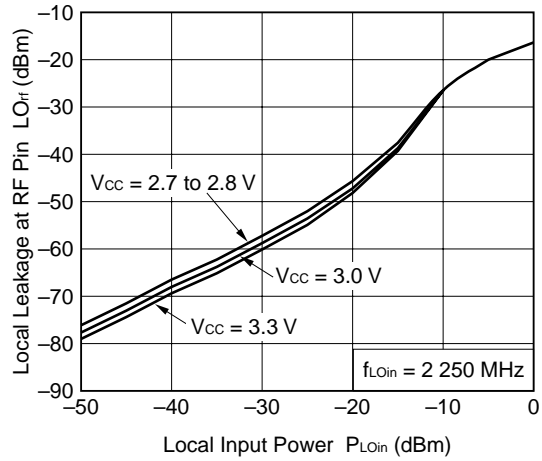
RF OUTPUT POWER OF EACH TONE, IM<sub>3</sub> vs. IF INPUT POWER



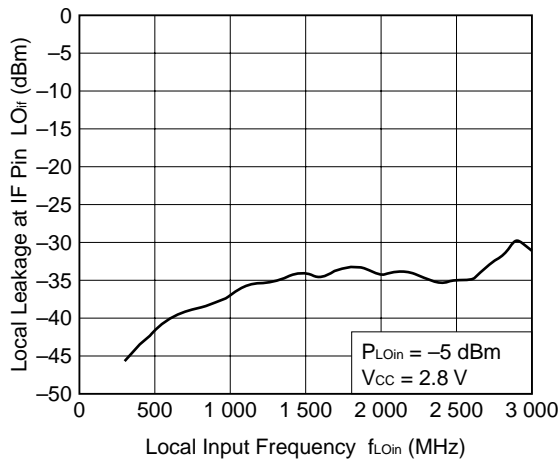
LOCAL LEAKAGE AT RF PIN vs. LOCAL INPUT FREQUENCY



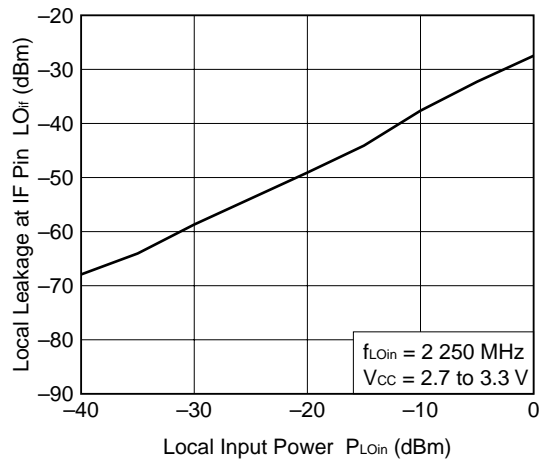
LOCAL LEAKAGE AT RF PIN vs. LOCAL INPUT POWER



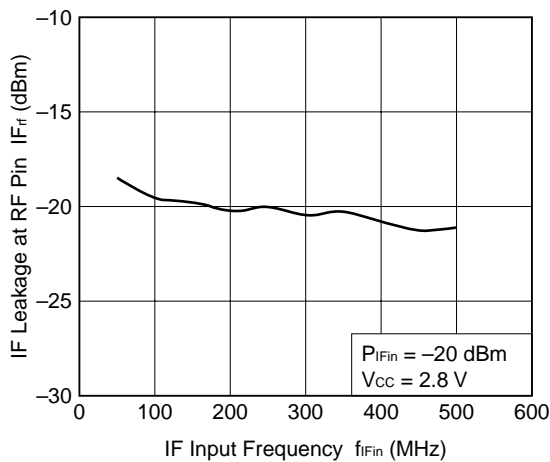
LOCAL LEAKAGE AT IF PIN vs. LOCAL INPUT FREQUENCY



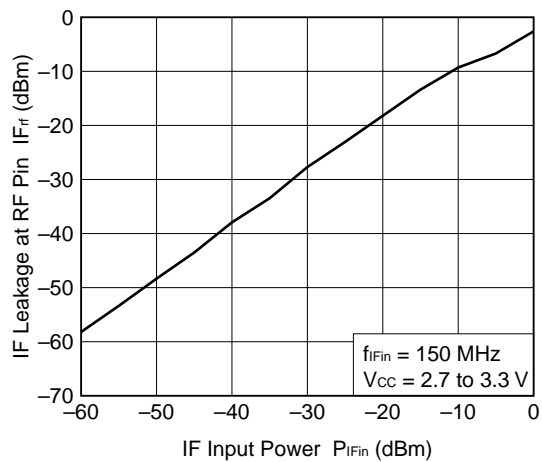
LOCAL LEAKAGE AT IF PIN vs. LOCAL INPUT POWER



IF LEAKAGE AT RF PIN vs. IF INPUT FREQUENCY



IF LEAKAGE AT RF PIN vs. IF INPUT POWER



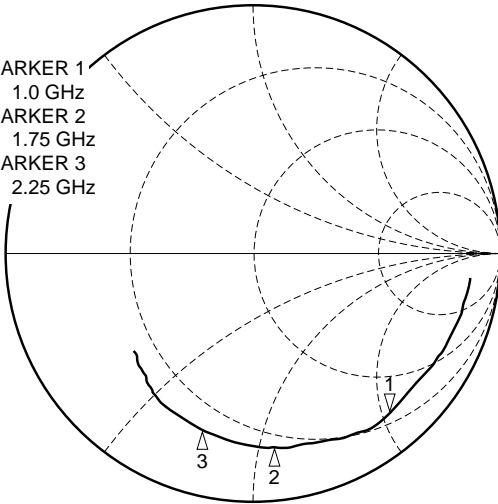


★ 12. S-PARAMETERS FOR EACH PORT ( $V_{CC} = V_{RFout} = 2.8 V$ )  
 (The parameters are monitored at DUT pins)

LO port

$S_{11}$  Z  
 REF 1.0 Units  
 1 200.0 mUnits/  
 $\nabla_{hp}$  22.762  $\Omega$  -104.25  $\Omega$

MARKER 1  
 1.0 GHz  
 MARKER 2  
 1.75 GHz  
 MARKER 3  
 2.25 GHz

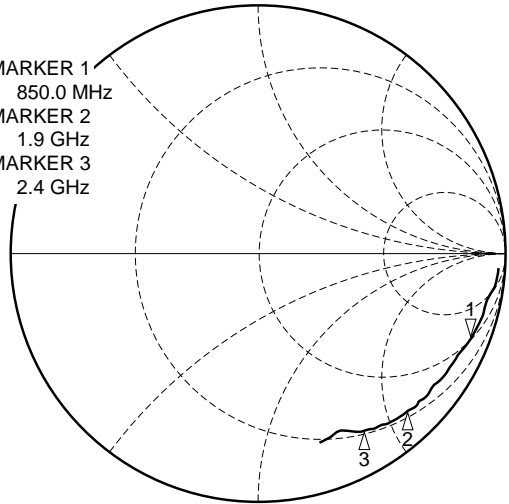


START 0.100000000 GHz  
 STOP 3.100000000 GHz

RF port (without matching)

$S_{22}$  Z  
 REF 1.0 Units  
 1 200.0 mUnits/  
 $\nabla_{hp}$  51.172  $\Omega$  -252.0  $\Omega$

MARKER 1  
 850.0 MHz  
 MARKER 2  
 1.9 GHz  
 MARKER 3  
 2.4 GHz

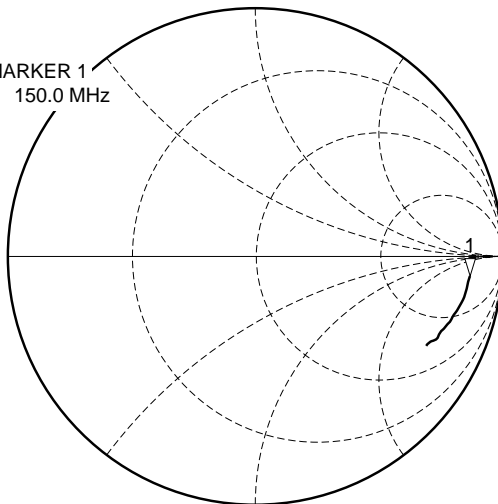


START 0.100000000 GHz  
 STOP 3.100000000 GHz

IF port

$S_{11}$  Z  
 REF 1.0 Units  
 1 200.0 mUnits/  
 $\nabla_{hp}$  518.97  $\Omega$  -321.09  $\Omega$

MARKER 1  
 150.0 MHz

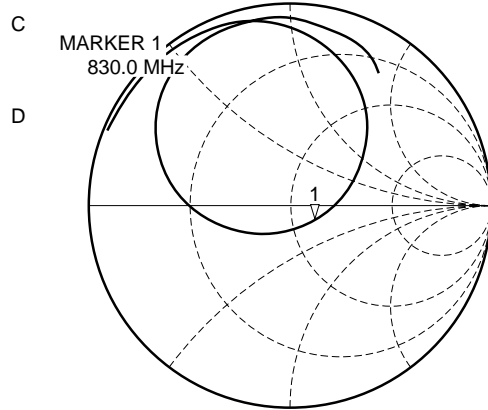


START 0.100000000 GHz  
 STOP 1.000000000 GHz

★ 13. S-PARAMETERS FOR MATCHED RF OUTPUT ( $V_{CC} = V_{RFout} = 2.8\text{ V}$ )  
 – ON EVALUATION BOARD – ( $S_{22}$  data are monitored at RF connector on board)

0.83 GHz (matched in test circuit 1)

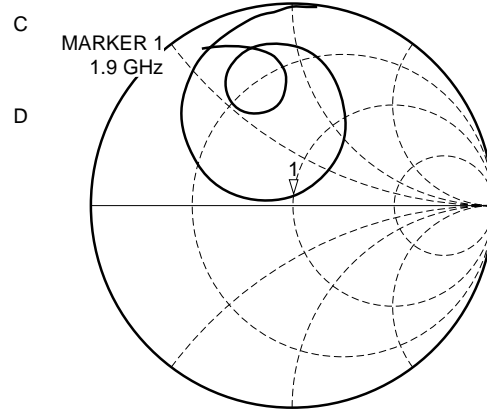
$S_{22}$  Z  
 REF 1.0 Units  
 1 200.0 mUnits/  
 $\nabla_{hp}$  62.424  $\Omega$  -9.7871  $\Omega$



START 0.330000000 GHz  
 STOP 1.330000000 GHz

1.9 GHz (matched in test circuit 2)

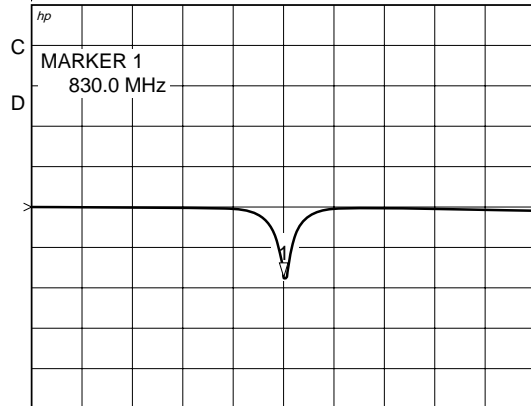
$S_{22}$  Z  
 REF 1.0 Units  
 1 200.0 mUnits/  
 $\nabla_{hp}$  51.719  $\Omega$  5.6523  $\Omega$



START 1.400000000 GHz  
 STOP 2.400000000 GHz

log MAG

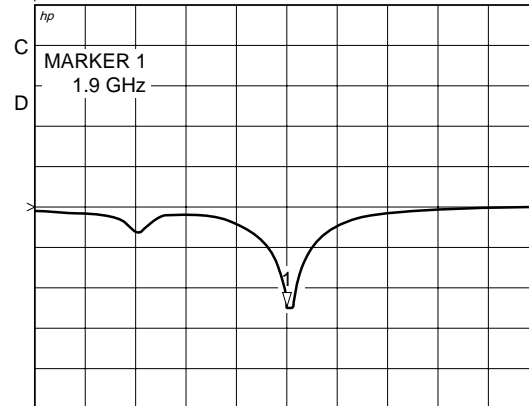
$S_{22}$   
 REF 0.0 dB  
 1 10.0 dB  
 $\nabla_{hp}$  -17.772 dB



START 0.330000000 GHz  
 STOP 1.330000000 GHz

log MAG

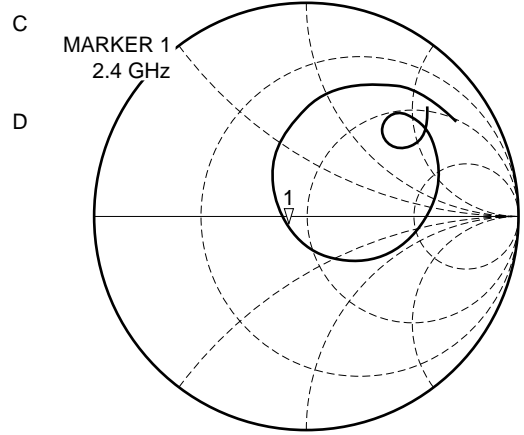
$S_{22}$   
 REF 0.0 dB  
 1 10.0 dB  
 $\nabla_{hp}$  -24.939 dB



START 1.400000000 GHz  
 STOP 2.400000000 GHz

2.4 GHz (matched in test circuit 3)

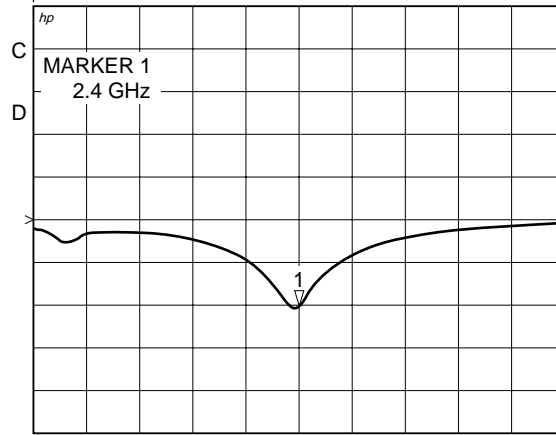
S<sub>22</sub> Z  
 REF 1.0 Units  
 1 200.0 mUnits/  
 hp 41.41 Ω -3.2695 Ω



START 1.900000000 GHz  
 STOP 2.900000000 GHz

log MAG

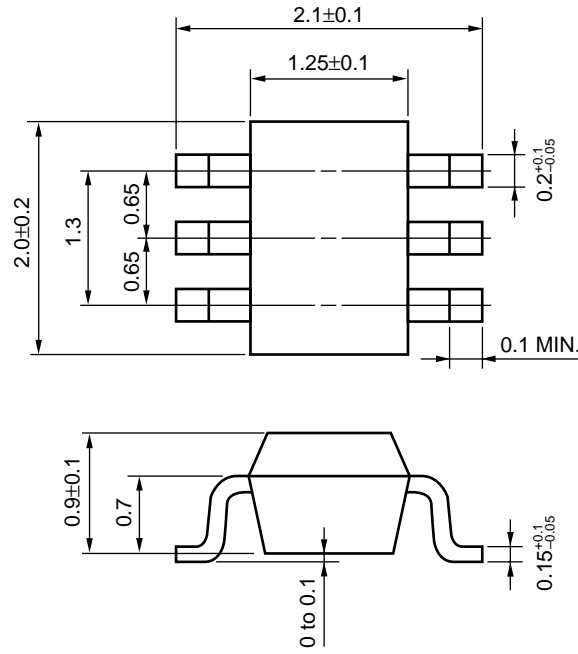
S<sub>22</sub> 0.0 dB  
 REF 10.0 dB  
 1 -20.203 dB  
 hp



START 1.900000000 GHz  
 STOP 2.900000000 GHz

14. PACKAGE DIMENSIONS

6-PIN SUPER MINIMOLD (UNIT: mm)



**15. NOTE ON CORRECT USE**

- (1) Observe precautions for handling because of electrostatic sensitive devices.
- (2) Form a ground pattern as wide as possible to minimize ground impedance (to prevent undesired oscillation).
- (3) Connect a bypass capacitor to the V<sub>CC</sub> pin.
- (4) Connect a matching circuit to the RF output pin.
- (5) The DC cut capacitor must be each attached to the input and output pins.

**16. RECOMMENDED SOLDERING CONDITIONS**

This product should be soldered under the following recommended conditions. For soldering methods and conditions other than those recommended below, contact your NEC sales representative.

Soldering Method	Soldering Conditions	Recommended Condition Symbol
Infrared Reflow	Package peak temperature: 235°C or below Time: 30 seconds or less (at 210°C) Count: 3, Exposure limit: None <sup>Note</sup>	IR35-00-3
VPS	Package peak temperature: 215°C or below Time: 40 seconds or less (at 200°C) Count: 3, Exposure limit: None <sup>Note</sup>	VP15-00-3
Wave Soldering	Soldering bath temperature: 260°C or below Time: 10 seconds or less Count: 1, Exposure limit: None <sup>Note</sup>	WS60-00-1
Partial Heating	Pin temperature: 300°C Time: 3 seconds or less (per side of device) Exposure limit: None <sup>Note</sup>	—

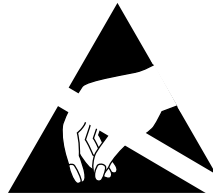
**Note** After opening the dry pack, keep it in a place below 25°C and 65% RH for the allowable storage period.

**Caution** Do not use different soldering methods together (except for partial heating).

For details of recommended soldering conditions for surface mounting, refer to information document **SEMICONDUCTOR DEVICE MOUNTING TECHNOLOGY MANUAL (C10535E)**.

[MEMO]

[MEMO]



## ATTENTION

OBSERVE PRECAUTIONS  
FOR HANDLING  
ELECTROSTATIC  
SENSITIVE  
DEVICES

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