NEC

BIPOLAR ANALOG INTEGRATED CIRCUIT

# μPC8187TB

## SILICON MMIC HI-IP3 FREQUENCY UP-CONVERTER FOR WIRELESS TRANSCEIVER

### DESCRIPTION

The μPC8187TB 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 μPC8163TB.

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 $IP_3$ : $OIP_3$ = +10 dBm @ $f_{RFout}$ = 1.9 GHz

### APPLICATION

- TDMA, PCS, CDMA etc.

### ORDERING INFORMATION

| Part Number | Package | Marking | Supplying Form |
|---|---|---|---|
| μPC8187TB-E3 | 6-pin super minimold | C3G | • Embossed tape 8 mm wide.<br>• Pin 1, 2, 3 face the tape perforation side.<br>• Qty 3 kpcs/reel. |

**Remark** To order evaluation samples, please contact your local NEC sales office.
(Part number for sample order: μPC8187TB)

**Caution Electro-static sensitive devices**



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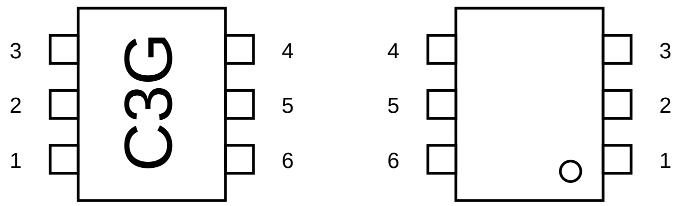
**The mark ★ shows major revised points.**

## CONTENTS

## 1. PIN CONNECTIONS

(Top View) (Bottom View)




| Pin No. | Pin Name |
|---|---|
| 1 | IFinput |
| 2 | GND |
| 3 | LOinput |
| 4 | GND |
| 5 | $V_{CC}$ |
| 6 | RFoutput |

## 2. SERIES PRODUCTS ($T_A$ = +25°C, $V_{CC}$ = $V_{PS}$ = $V_{RFout}$ = 3.0 V, $Z_S$ = $Z_L$ = 50 Ω)

| Part Number | $I_{CC}$ (mA) | $f_{RFout}$ (GHz) | CG (dB) | | |
|---|---|---|---|---|---|
| | | | @RF 0.9 GHz[Note] | @RF 1.9 GHz | @RF 2.4 GHz |
| $\mu$PC8187TB | 15 | 0.8 to 2.5 | 11 | 11 | 10 |
| $\mu$PC8106TB | 9 | 0.4 to 2.0 | 9 | 7 | – |
| $\mu$PC8172TB | 9 | 0.8 to 2.5 | 9.5 | 8.5 | 8.0 |
| $\mu$PC8109TB | 5 | 0.4 to.2.0 | 6 | 4 | – |
| $\mu$PC8163TB | 16.5 | 0.8 to 2.0 | 9 | 5.5 | – |

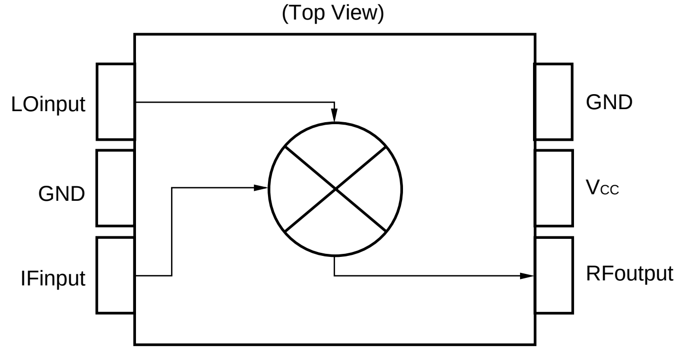
| Part Number | $P_{O(sat)}$ (dBm) | | | $OIP_3$ (dBm) | | |
|---|---|---|---|---|---|---|
| | @RF 0.9 GHz[Note] | @RF 1.9 GHz | @RF 2.4 GHz | @RF 0.9 GHz[Note] | @RF 1.9 GHz | @RF 2.4 GHz |
| $\mu$PC8187TB | +4 | +2.5 | +1 | +10 | +10 | +8.5 |
| $\mu$PC8106TB | –2 | –4 | – | +5.5 | +2.0 | – |
| $\mu$PC8172TB | +0.5 | 0 | –0.5 | +7.5 | +6.0 | +4.0 |
| $\mu$PC8109TB | –5.5 | –7.5 | – | +1.5 | –1.0 | – |
| $\mu$PC8163TB | +0.5 | –2 | – | +9.5 | +6.0 | – |

**Note** $f_{RFout}$ = 0.83 GHz @ $\mu$PC8163TB and $\mu$PC8187TB

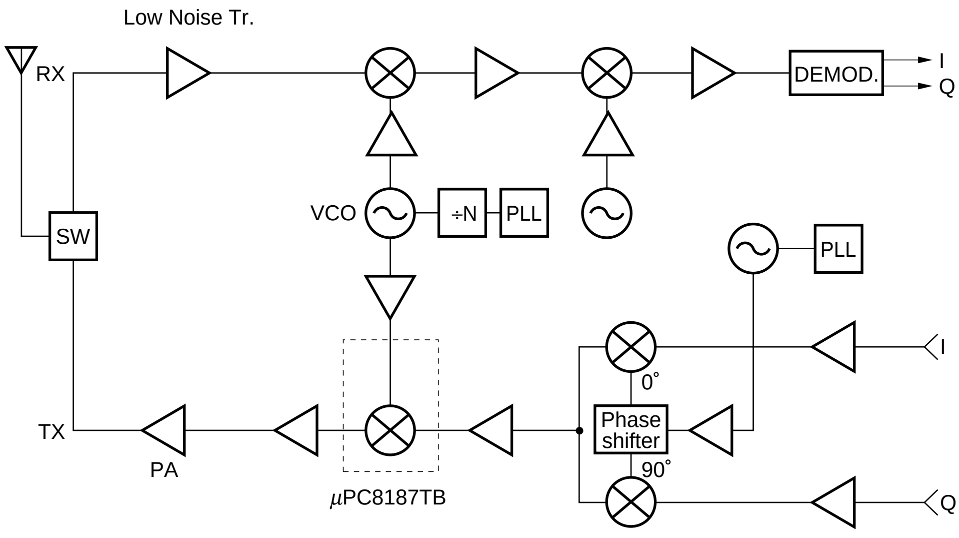
**Remark** Typical performance. Please refer to **8. ELECTRICAL CHARACTERISTICS** in detail.
To know the associated product, please refer to each latest data sheet.

## 3. BLOCK DIAGRAM

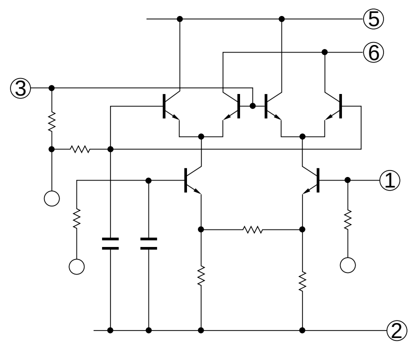
(Top View)



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



## 5. PIN EXPLANATION

| Pin No. | Pin Name | Applied Voltage (V) | Pin Voltage (V)[Note] | 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<br>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 | $V_{CC}$ | 2.7 to 3.3 | – | Supply voltage pin. | |
| 6 | RFoutput | Same bias as $V_{CC}$ 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 $V_{CC} = V_{RFout} = 2.8$ V.

## 6. ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | Test Conditions | Rating | Unit |
|---|---|---|---|---|
| Supply Voltage | $V_{CC}$ | $T_A$ = +25°C | 3.6 | V |
| Power Dissipation | $P_D$ | Mounted on double-side copperclad 50 × 50 × 1.6 mm epoxy glass PWB, $T_A$ = +85°C | 270 | mW |
| Operating Ambient Temperature | $T_A$ | | –40 to +85 | °C |
| Storage Temperature | $T_{stg}$ | | –55 to +150 | °C |
| Maximum Input Power | $P_{in}$ | | +10 | dBm |

## 7. RECOMMENDED OPERATING RANGE

| Parameter | Symbol | MIN. | TYP. | MAX. | Unit | Remarks |
|---|---|---|---|---|---|---|
| Supply Voltage | $V_{CC}$ | 2.7 | 2.8 | 3.3 | V | The same voltage should be applied to pin 5 and 6 |
| Operating Ambient Temperature | $T_A$ | –40 | +25 | +85 | °C | |
| Local Input Power | $P_{LOin}$ | –10 | –5 | 0 | dBm | $Z_S$ = 50 Ω (without matching) |
| RF Output Frequency | $f_{RFout}$ | 0.8 | – | 2.5 | GHz | With external matching circuit |
| IF Input Frequency | $f_{IFin}$ | 50 | – | 400 | MHz | |

## 8. ELECTRICAL CHARACTERISTICS

**($T_A$ = +25°C, $V_{CC}$ = $V_{RFout}$ = 2.8 V, $f_{IFin}$ = 150 MHz, $P_{LOin}$ = –5 dBm)**

| Parameter | Symbol | Test Conditions Note | MIN. | TYP. | MAX. | Unit |
|---|---|---|---|---|---|---|
| Circuit Current | $I_{CC}$ | No signal | 11 | 15 | 19 | mA |
| Conversion Gain | CG1 | $f_{RFout}$ = 0.83 GHz, $P_{IFin}$ = –20 dBm | 8 | 11 | 14 | dB |
| | CG2 | $f_{RFout}$ = 1.9 GHz, $P_{IFin}$ = –20 dBm | 8 | 11 | 14 | dB |
| | CG3 | $f_{RFout}$ = 2.4 GHz, $P_{IFin}$ = –20 dBm | 7 | 10 | 13 | dB |
| Saturated Output Power | $P_{O(sat)}1$ | $f_{RFout}$ = 0.83 GHz, $P_{IFin}$ = 0 dBm | +1.5 | +4 | – | dBm |
| | $P_{O(sat)}2$ | $f_{RFout}$ = 1.9 GHz, $P_{IFin}$ = 0 dBm | 0 | +2.5 | – | dBm |
| | $P_{O(sat)}3$ | $f_{RFout}$ = 2.4 GHz, $P_{IFin}$ = 0 dBm | –1.5 | +1 | – | dBm |

**Note** $f_{RFout} < f_{LOin}$ @ $f_{RFout}$ = 0.83 GHz
$f_{LOin} < f_{RFout}$ @ $f_{RFout}$ = 1.9 GHz/2.4 GHz

## 9. OTHER CHARACTERISTICS, FOR REFERENCE PURPOSES ONLY

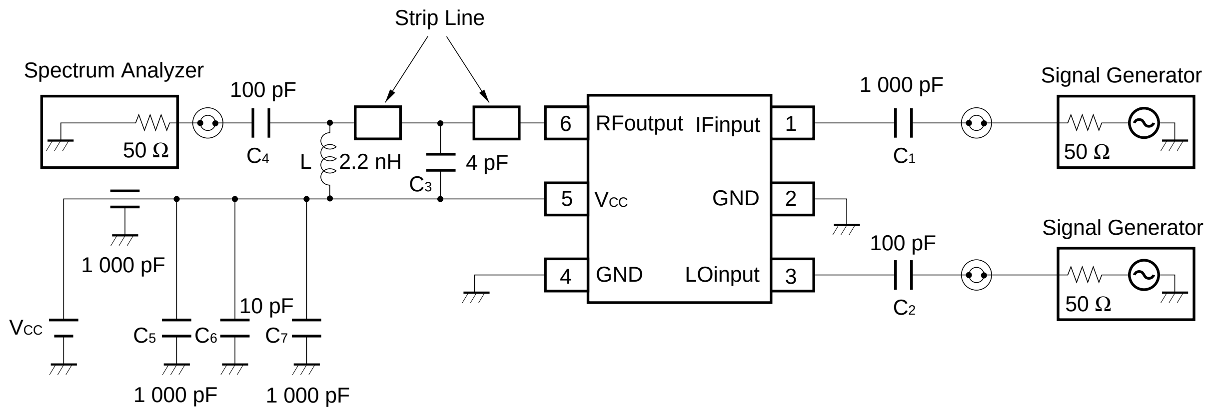
**($T_A$ = +25°C, $V_{CC}$ = $V_{RFout}$ = 2.8 V, $P_{LOin}$ = –5 dBm)**

| Parameter | Symbol | Test Conditions[Note] | | Value | Unit |
|---|---|---|---|---|---|
| Output 3rd Order Distortion Intercept Point | OIP₃1 | $f_{RFout}$ = 0.83 GHz | $f_{IFin}1$ = 150 MHz, $f_{IFin}2$ = 151 MHz | +10 | dBm |
| | OIP₃2 | $f_{RFout}$ = 1.9 GHz | | +10 | dBm |
| | OIP₃3 | $f_{RFout}$ = 2.4 GHz | | +8.5 | dBm |
| Input 3rd Order Distortion Intercept Point | IIP₃1 | $f_{RFout}$ = 0.83 GHz | $f_{IFin}1$ = 150 MHz, $f_{IFin}2$ = 151 MHz | –1.0 | dBm |
| | IIP₃2 | $f_{RFout}$ = 1.9 GHz | | –1.0 | dBm |
| | IIP₃3 | $f_{RFout}$ = 2.4 GHz | | –1.5 | dBm |
| SSB Noise Figure | SSB•NF1 | $f_{RFout}$ = 0.83 GHz | $f_{IFin}$ = 150 MHz | 11 | dB |
| | SSB•NF2 | $f_{RFout}$ = 1.9 GHz | | 12 | dB |
| | SSB•NF3 | $f_{RFout}$ = 2.4 GHz | | 12.5 | dB |

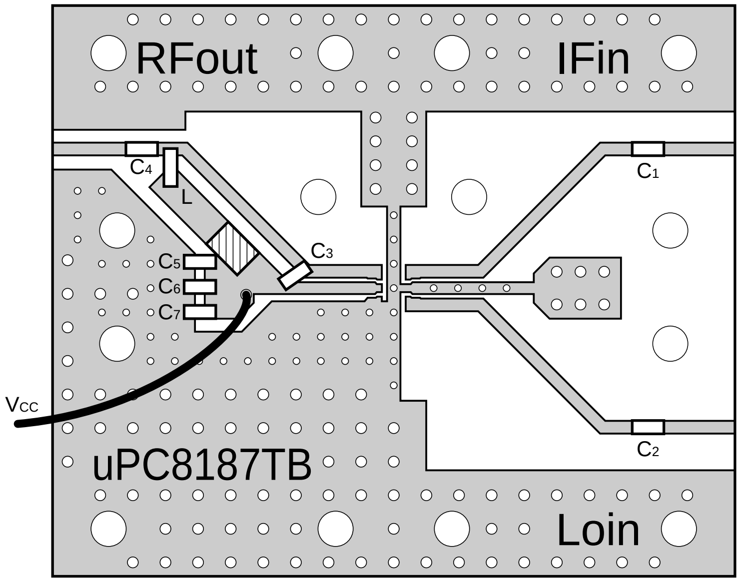
**Note** $f_{RFout} < f_{LOin}$ @ $f_{RFout}$ = 0.83 GHz
$f_{LOin} < f_{RFout}$ @ $f_{RFout}$ = 1.9 GHz/2.4 GHz

## ★ 10. TEST CIRCUITS

### 10.1 TEST CIRCUIT 1 ($f_{RFout}$ = 0.83 GHz)




### EXAMPLE OF TEST CIRCUIT 1 ASSEMBLED ON EVALUATION BOARD



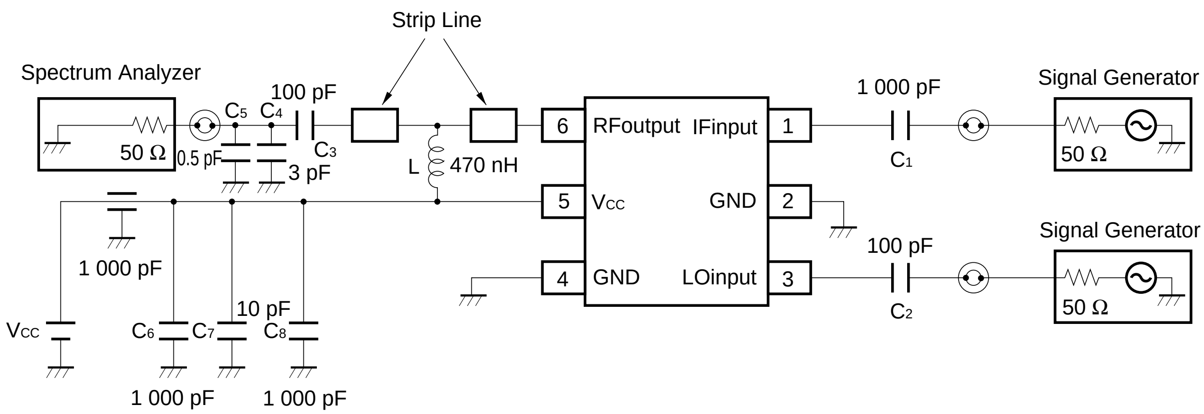

### COMPONENT LIST

| Form | Symbol | Value |
|---|---|---|
| Chip capacitor | C1, C5, C7 | 1 000 pF |
| | C2, C4 | 100 pF |
| | C6 | 10 pF |
| | C3 | 4 pF |
| Chip inductor | L | 2.2 nH[Note] |

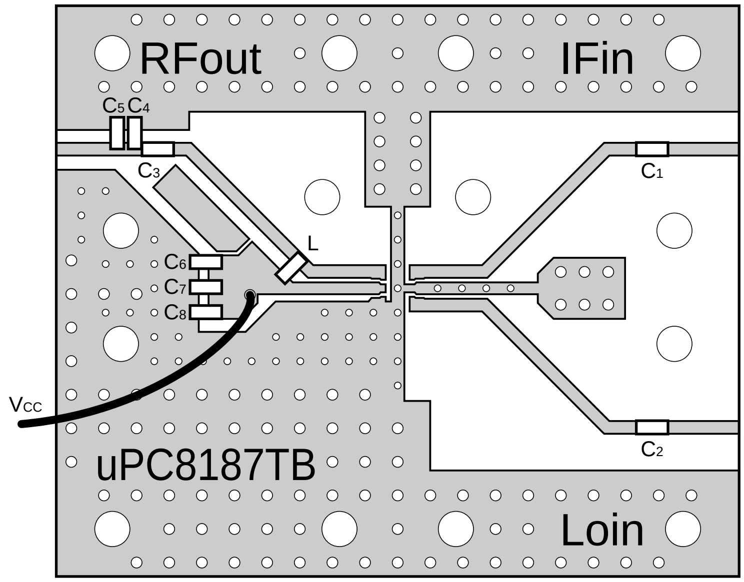
**Note** 2.2 nH: LL1608-FH2N25 (TOKO Co., Ltd.)

(∗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
(∗5) ▧ : Join patterns with electrical tape

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




### EXAMPLE OF TEST CIRCUIT 2 ASSEMBLED ON EVALUATION BOARD




### COMPONENT LIST

| Form | Symbol | Value |
|---|---|---|
| Chip capacitor | C1, C6, C8 | 1 000 pF |
| | C2, C3 | 100 pF |
| | C7 | 10 pF |
| | C4 | 3 pF |
| | C5 | 0.5 pF |
| Chip inductor | L | 470 nH[Note] |

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

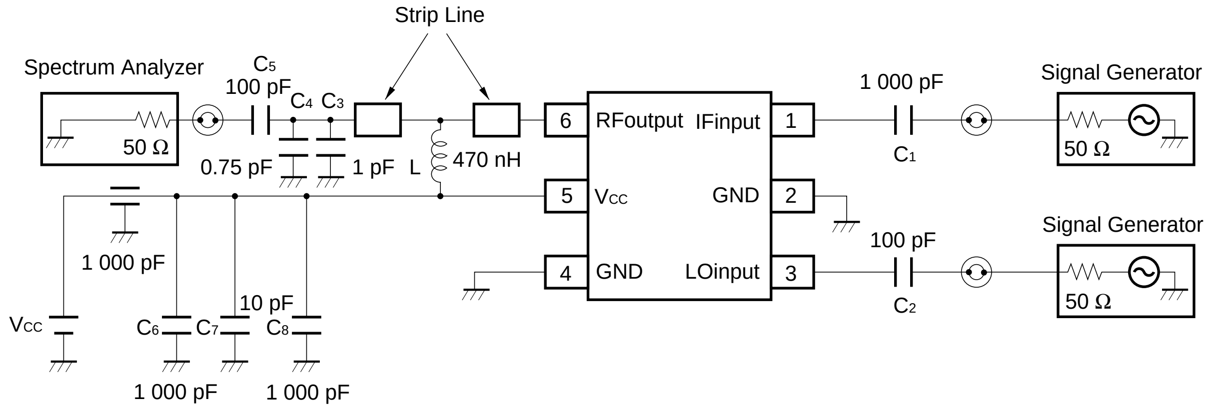
(∗1) 35 × 42 × 0.4 mm polyimide board, double-sided copper clad

(∗2) Ground pattern on rear of the board

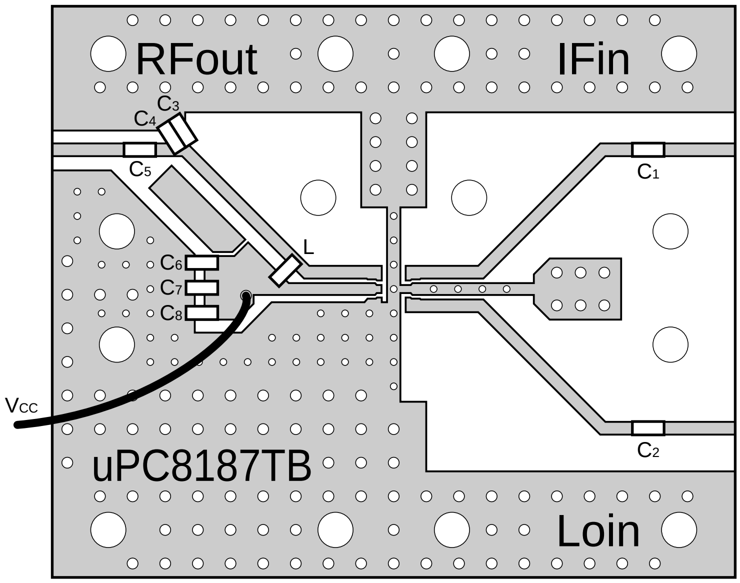
(∗3) Solder plated patterns

(∗4) ∘○◯ : Through holes

### 10.3 TEST CIRCUIT 3 ($f_{RFout}$ = 2.4 GHz)




### EXAMPLE OF TEST CIRCUIT 3 ASSEMBLED ON EVALUATION BOARD




### COMPONENT LIST

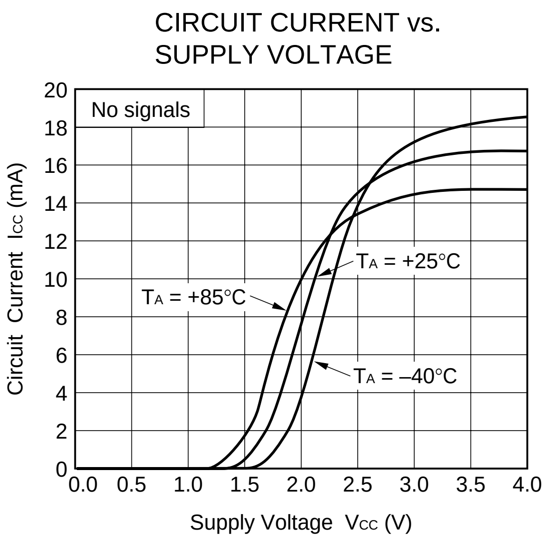
| Form | Symbol | Value |
|---|---|---|
| Chip capacitor | C1, C6, C8 | 1 000 pF |
| | C2, C5 | 100 pF |
| | C7 | 10 pF |
| | C3 | 1 pF |
| | C4 | 0.75 pF |
| Chip inductor | L | 470 nH[Note] |

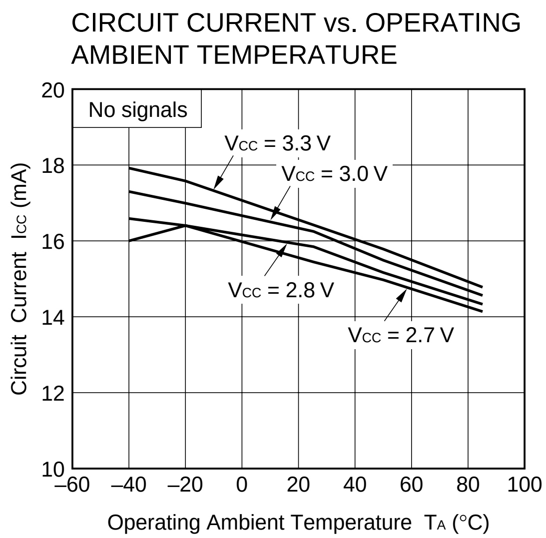
**Note** 470 nH: LL2012-FR47 (TOKO Co., Ltd.)

(*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

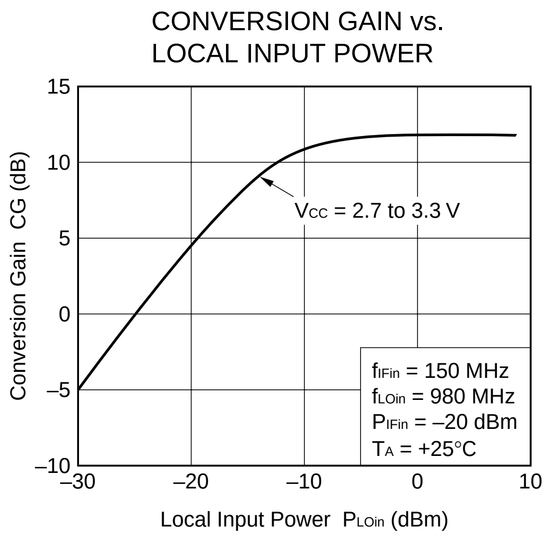
**Caution The test circuits and board pattern on data sheet are for performance evaluation use only (They are not recommended circuits). In the case of actual design-in, matching circuit should be determined using S-parameter of desired frequency in accordance to actual mounting pattern.**

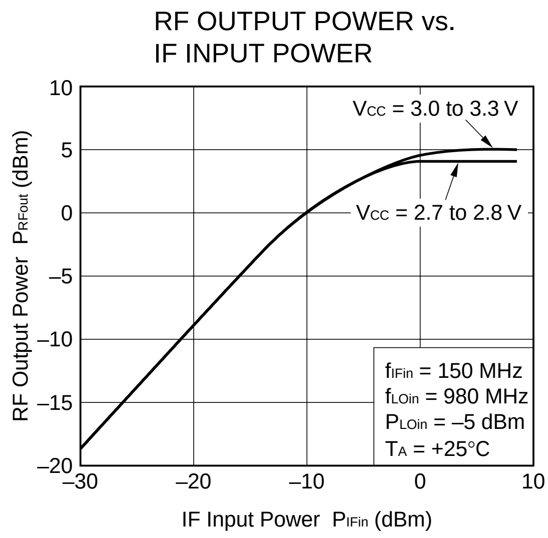
## ★ 11. TYPICAL CHARACTERISTICS (Unless otherwise specified, $T_A$ = +25°C, $V_{CC}$ = $V_{RFout}$)

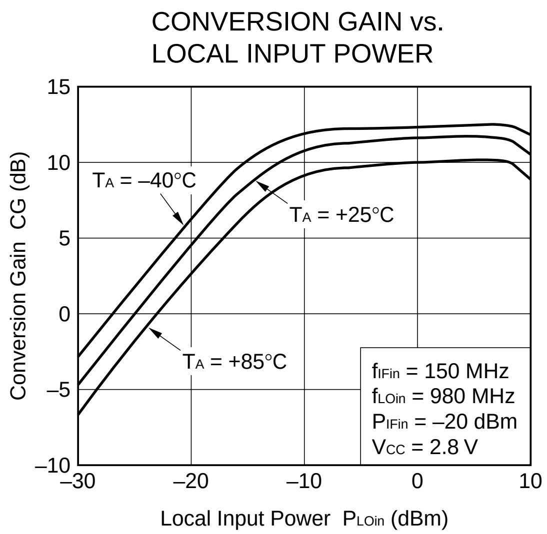


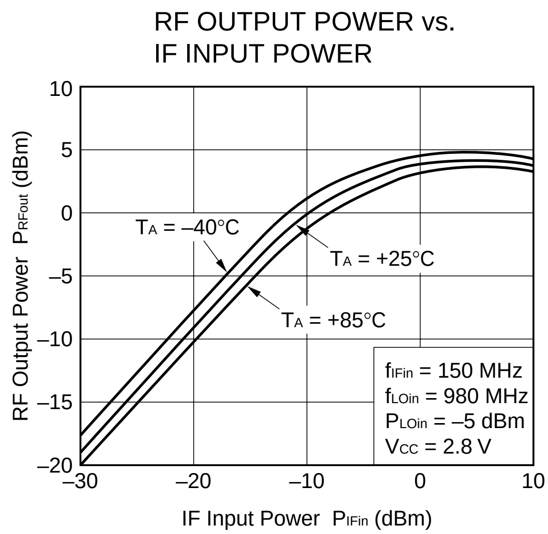



### 11.1 $f_{RFout}$ = 0.83 GHz

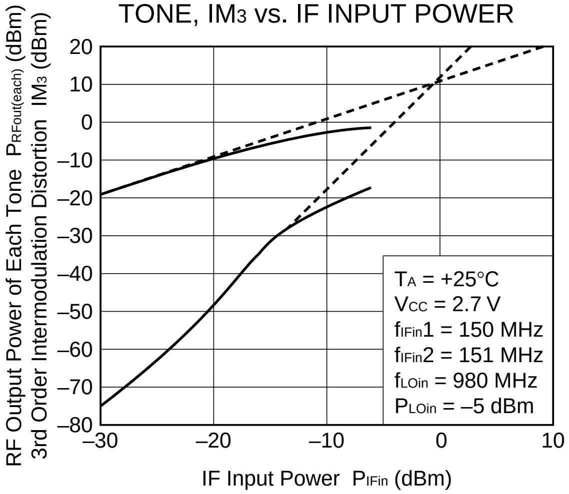


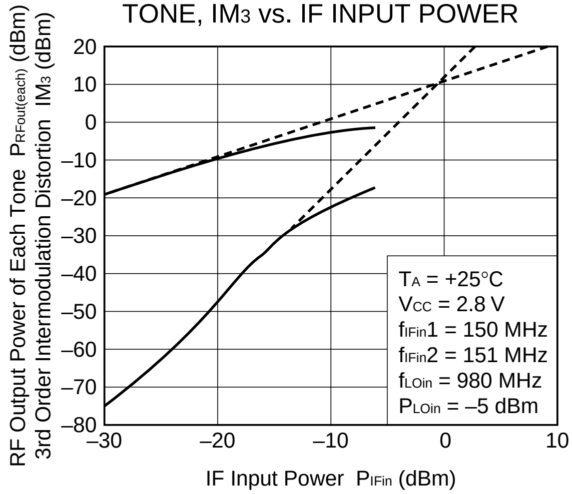



RF OUTPUT POWER OF EACH TONE, IM3 vs. IF INPUT POWER




RF OUTPUT POWER OF EACH TONE, IM3 vs. IF INPUT POWER

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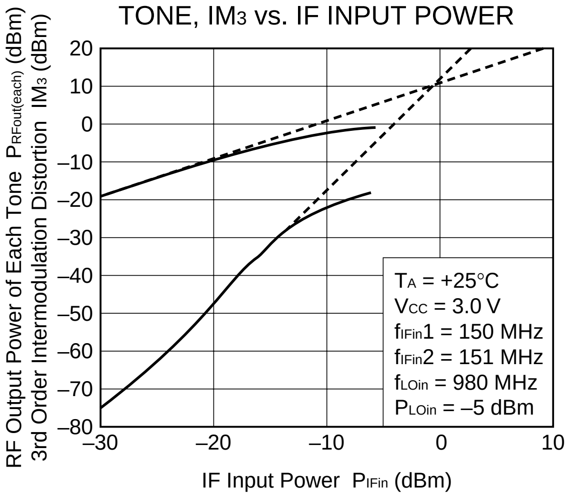
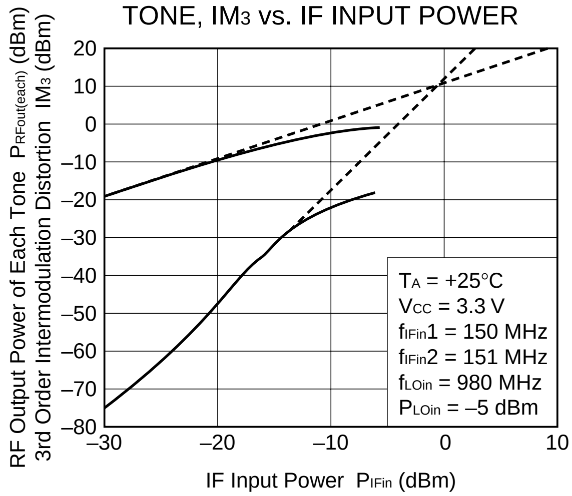
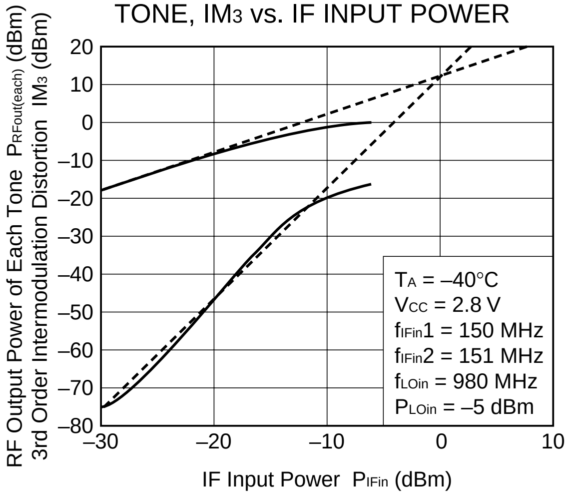


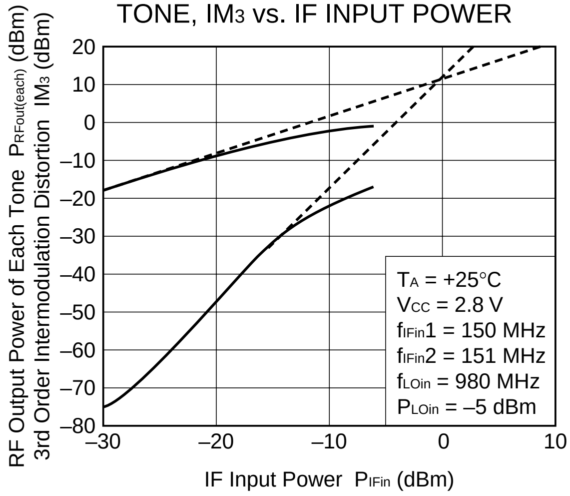

RF OUTPUT POWER OF EACH TONE, IM3 vs. IF INPUT POWER



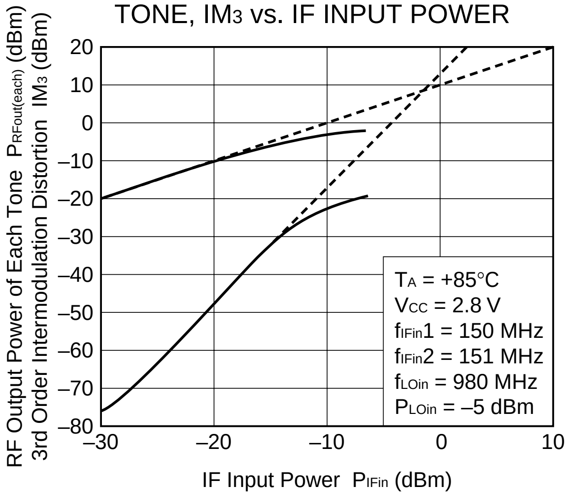
RF OUTPUT POWER OF EACH TONE, $IM_3$ vs. IF INPUT POWER



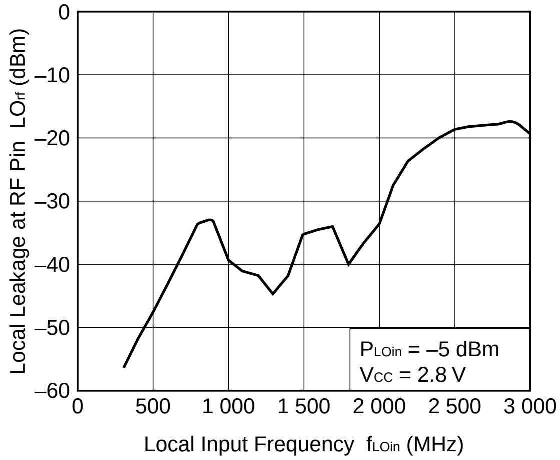

RF OUTPUT POWER OF EACH TONE, $IM_3$ vs. IF INPUT POWER



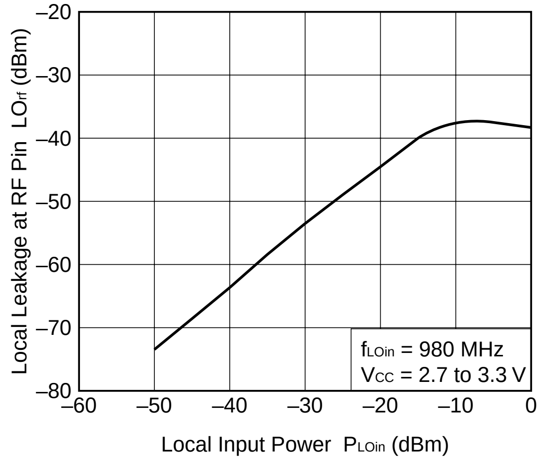

RF OUTPUT POWER OF EACH TONE, $IM_3$ vs. IF INPUT POWER



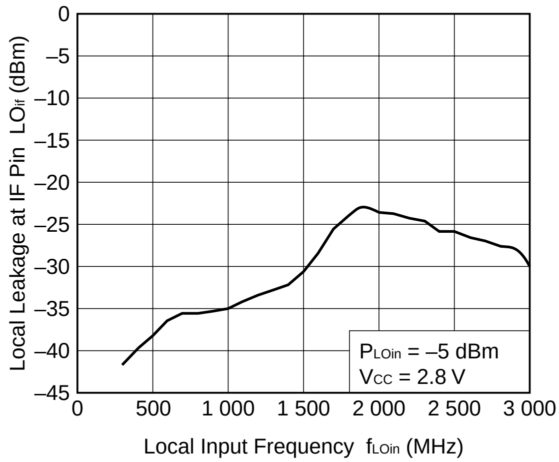
LOCAL LEAKAGE AT RF PIN vs.
LOCAL INPUT FREQUENCY



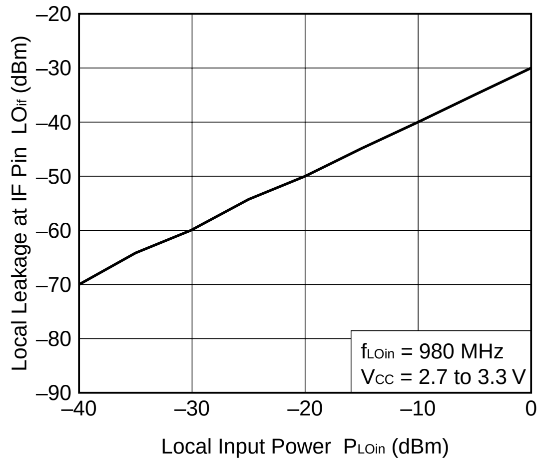

LOCAL LEAKAGE AT RF PIN vs.
LOCAL INPUT POWER



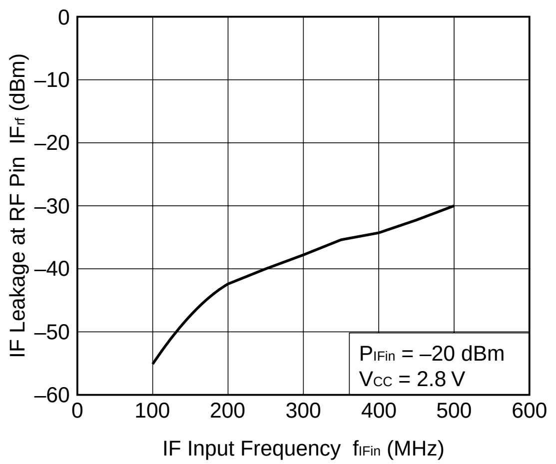

LOCAL LEAKAGE AT IF PIN vs.
LOCAL INPUT FREQUENCY



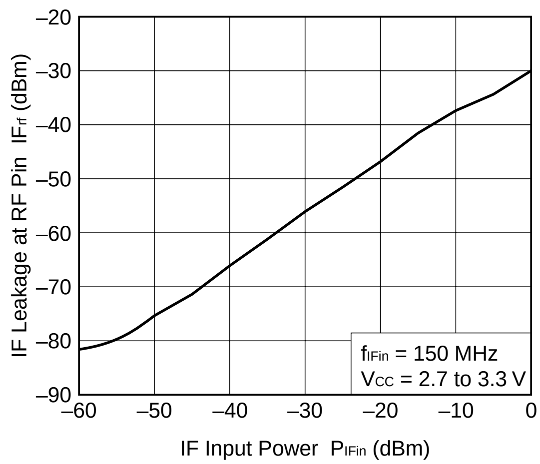

LOCAL LEAKAGE AT IF PIN vs.
LOCAL INPUT POWER




IF LEAKAGE AT RF PIN vs.
IF INPUT FREQUENCY

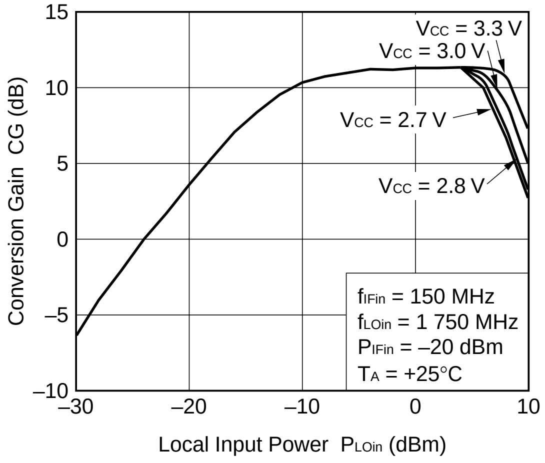



IF LEAKAGE AT RF PIN vs.
IF INPUT POWER

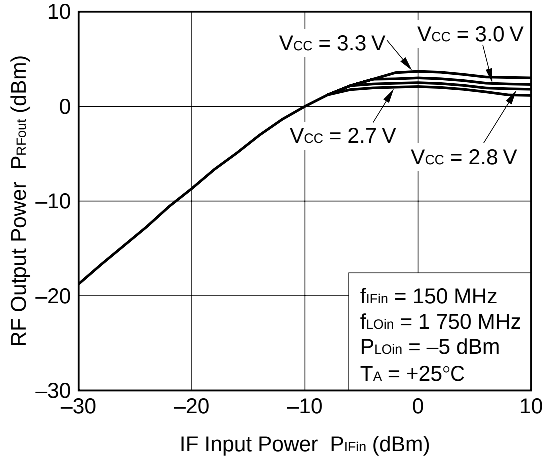


### 11.2 $f_{RFout}$ = 1.9 GHz

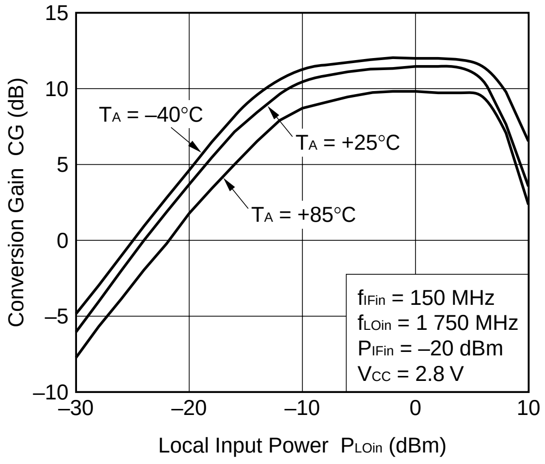
CONVERSION GAIN vs.
LOCAL INPUT POWER



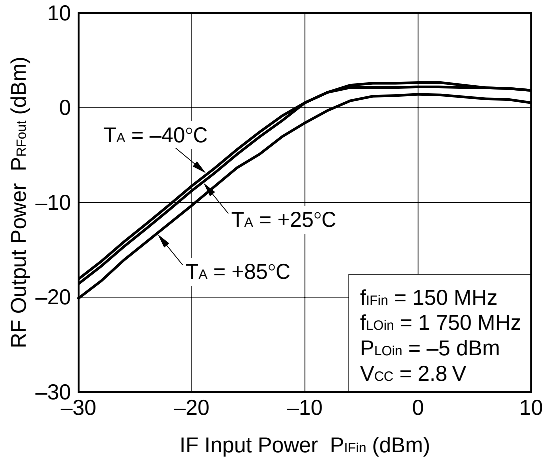

RF OUTPUT POWER vs.
IF INPUT POWER



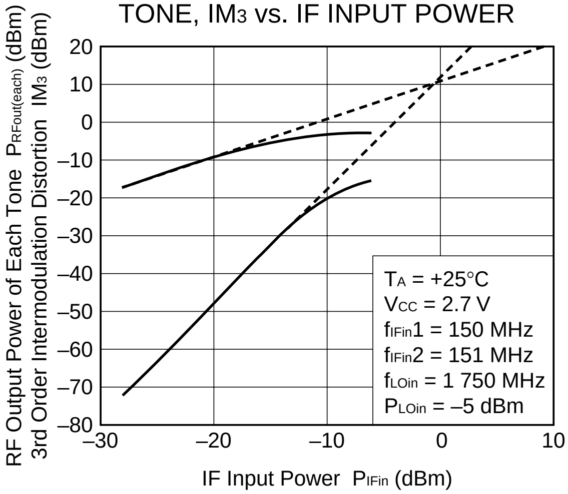

CONVERSION GAIN vs.
LOCAL INPUT POWER



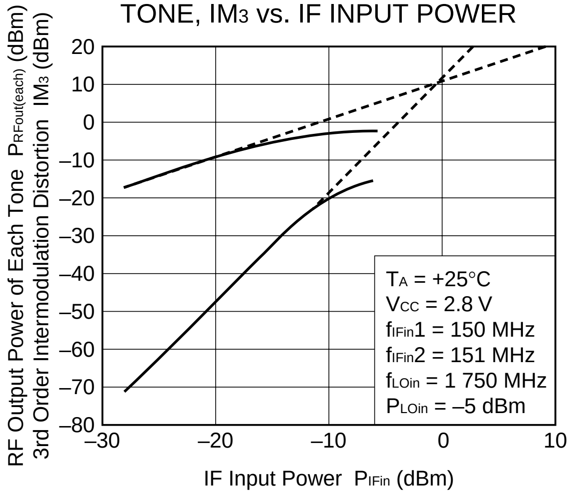

RF OUTPUT POWER vs.
IF INPUT POWER



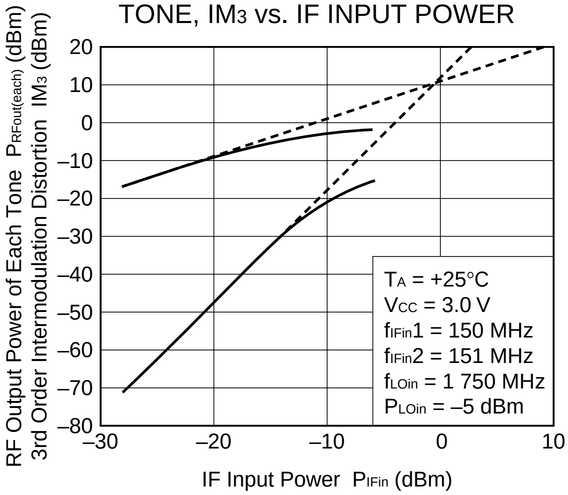
RF OUTPUT POWER OF EACH TONE, $IM_3$ vs. IF INPUT POWER



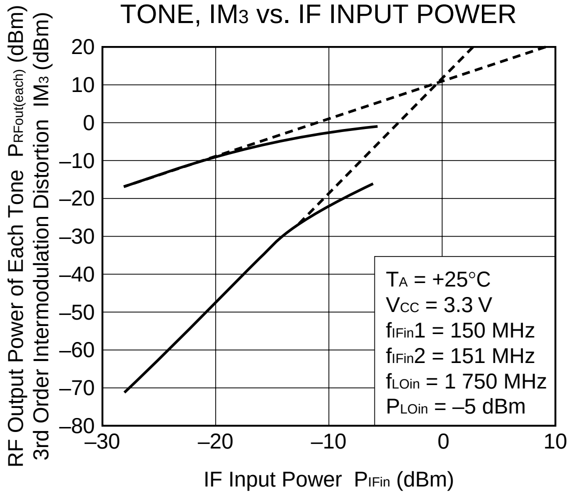

RF OUTPUT POWER OF EACH TONE, $IM_3$ vs. IF INPUT POWER



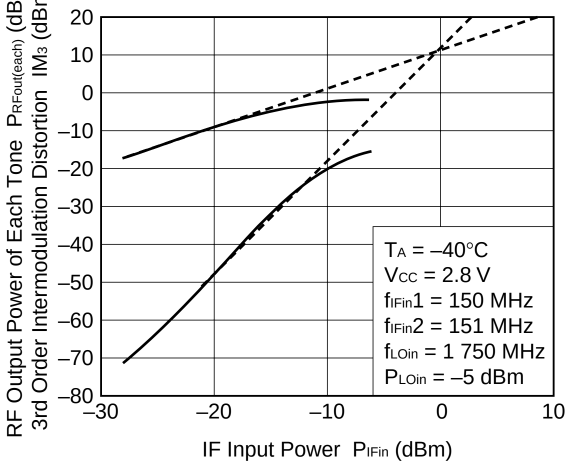

RF OUTPUT POWER OF EACH TONE, $IM_3$ vs. IF INPUT POWER



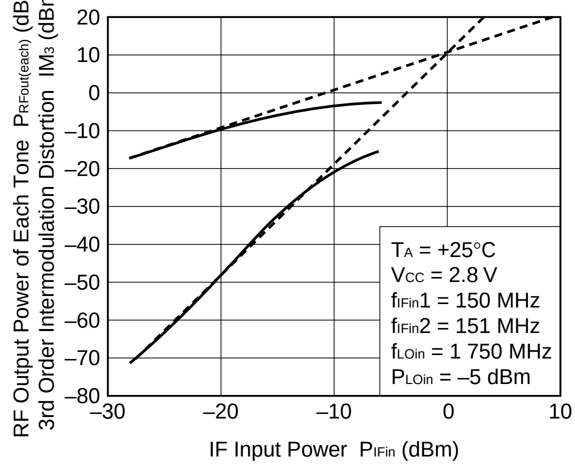

RF OUTPUT POWER OF EACH TONE, $IM_3$ vs. IF INPUT POWER



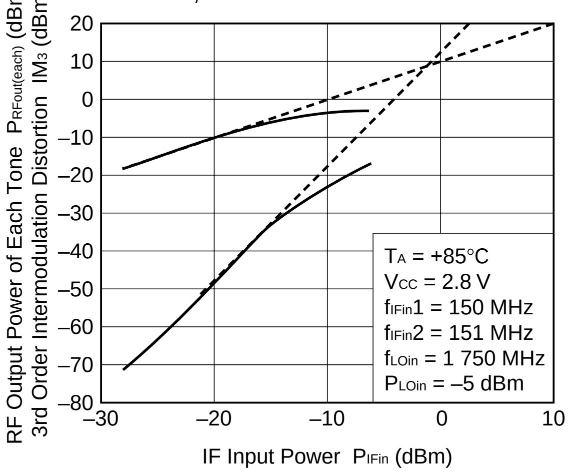
RF OUTPUT POWER OF EACH TONE, IM3 vs. IF INPUT POWER



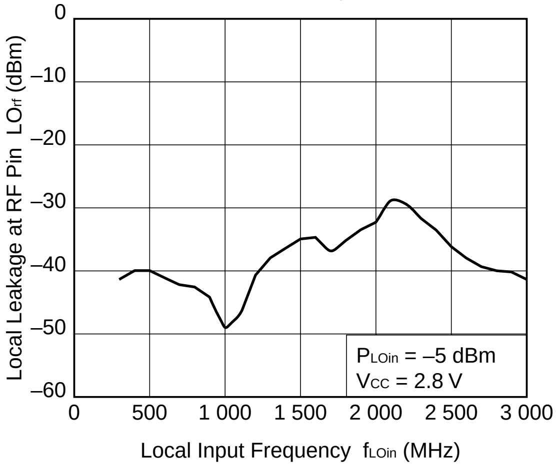

RF OUTPUT POWER OF EACH TONE, IM3 vs. IF INPUT POWER



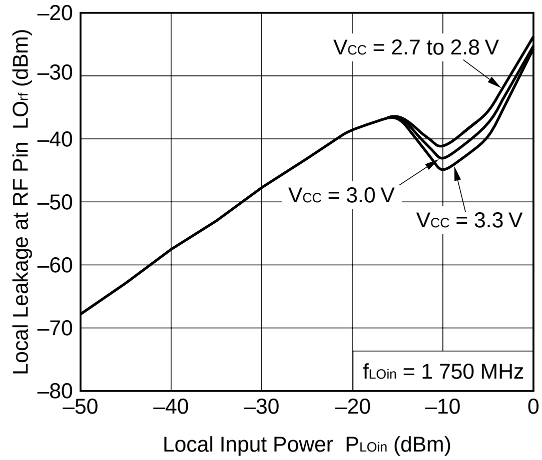

RF OUTPUT POWER OF EACH TONE, IM3 vs. IF INPUT POWER



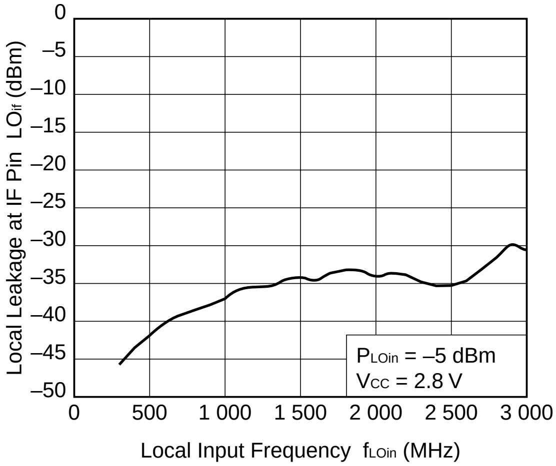
LOCAL LEAKAGE AT RF PIN vs.
LOCAL INPUT FREQUENCY



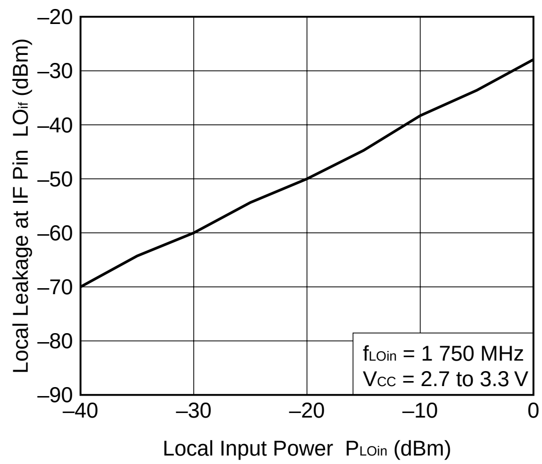

LOCAL LEAKAGE AT RF PIN vs.
LOCAL INPUT POWER



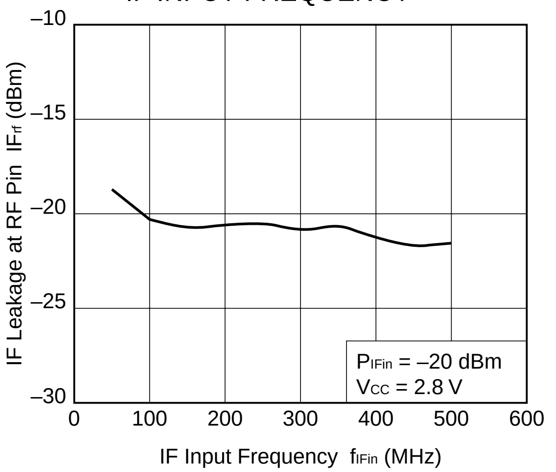

LOCAL LEAKAGE AT IF PIN vs.
LOCAL INPUT FREQUENCY



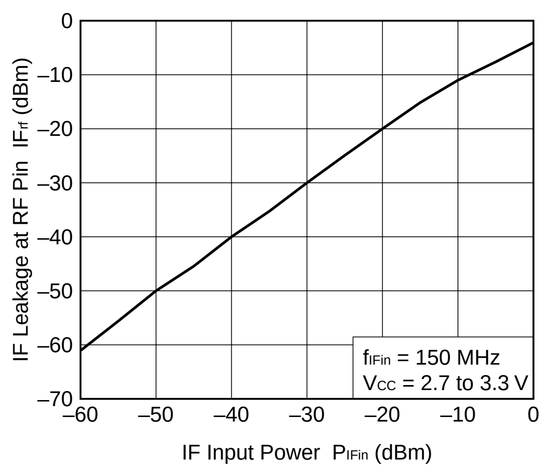

LOCAL LEAKAGE AT IF PIN vs.
LOCAL INPUT POWER



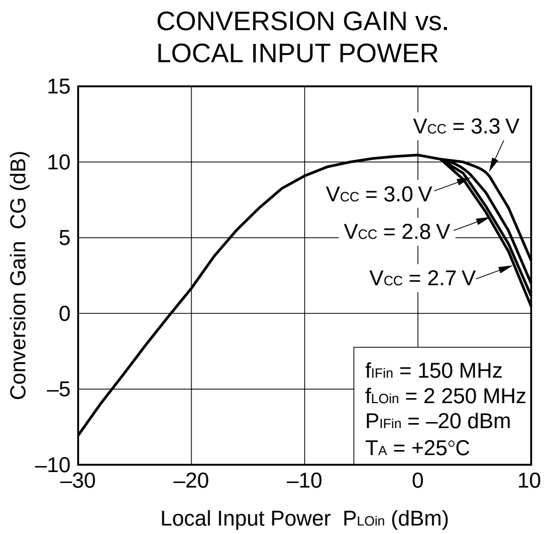

IF LEAKAGE AT RF PIN vs.
IF INPUT FREQUENCY

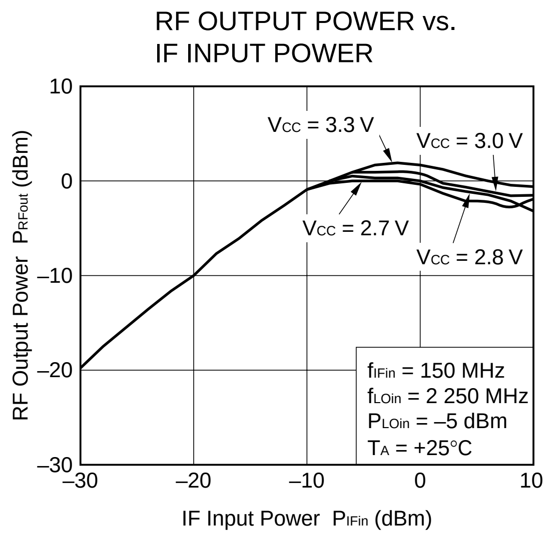


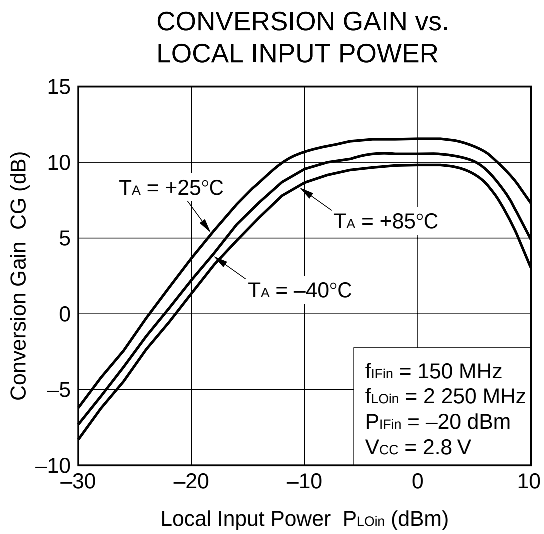

IF LEAKAGE AT RF PIN vs.
IF INPUT POWER

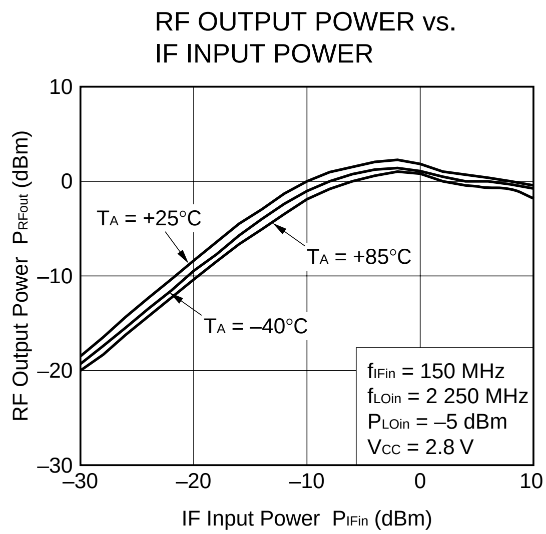


### 11.3 $f_{RFout}$ = 2.4 GHz

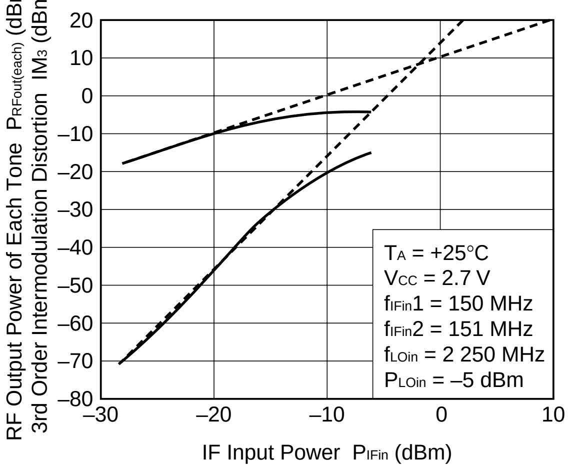


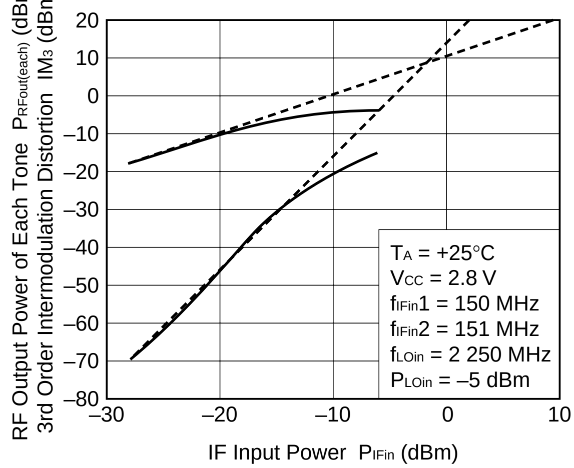



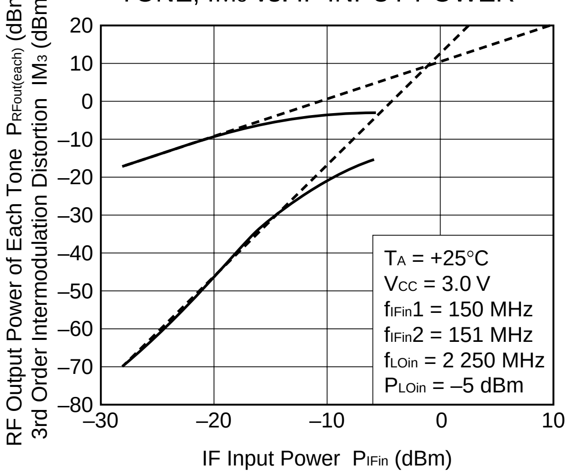
RF OUTPUT POWER OF EACH TONE, IM3 vs. IF INPUT POWER



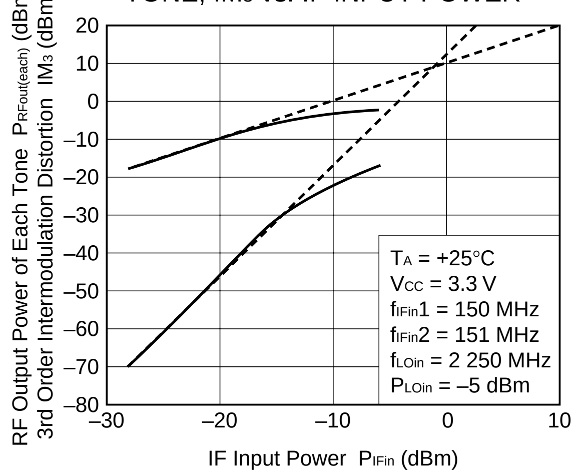

RF OUTPUT POWER OF EACH TONE, IM3 vs. IF INPUT POWER

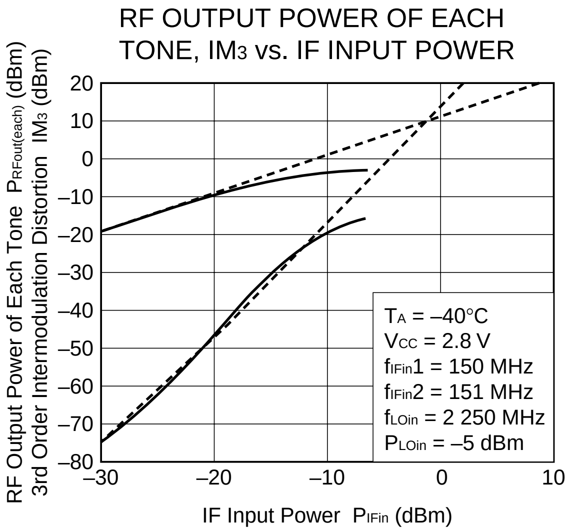


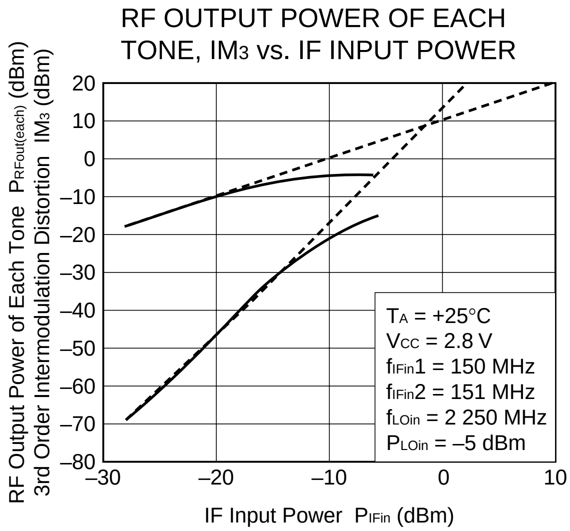

RF OUTPUT POWER OF EACH TONE, IM3 vs. IF INPUT POWER

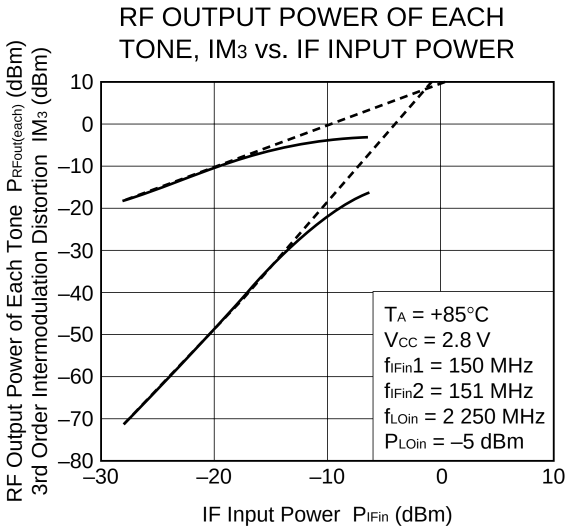



RF OUTPUT POWER OF EACH TONE, IM3 vs. IF INPUT POWER

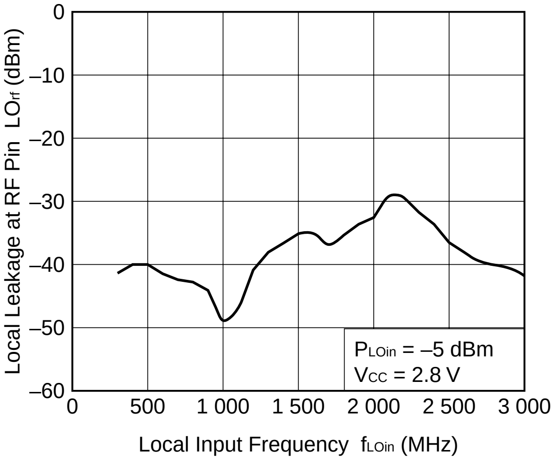



RF OUTPUT POWER OF EACH
TONE, IM3 vs. IF INPUT POWER
RF Output Power of Each Tone PRFout(each) (dBm)
3rd Order Intermodulation Distortion IM3 (dBm)
20
10
0
–10
–20
–30
–40
–50
–60
–70
–80
–30
–20
–10
0
10
IF Input Power PIFin (dBm)
TA = –40°C
VCC = 2.8 V
fIFin1 = 150 MHz
fIFin2 = 151 MHz
fLOin = 2 250 MHz
PLOin = –5 dBm

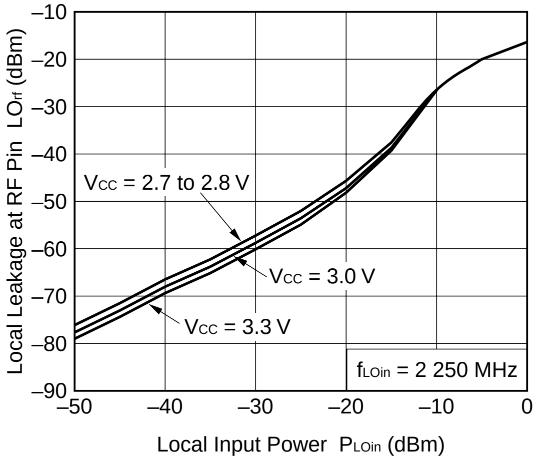

RF OUTPUT POWER OF EACH
TONE, IM3 vs. IF INPUT POWER
RF Output Power of Each Tone PRFout(each) (dBm)
3rd Order Intermodulation Distortion IM3 (dBm)
20
10
0
–10
–20
–30
–40
–50
–60
–70
–80
–30
–20
–10
0
10
IF Input Power PIFin (dBm)
TA = +25°C
VCC = 2.8 V
fIFin1 = 150 MHz
fIFin2 = 151 MHz
fLOin = 2 250 MHz
PLOin = –5 dBm


RF OUTPUT POWER OF EACH
TONE, IM3 vs. IF INPUT POWER
RF Output Power of Each Tone PRFout(each) (dBm)
3rd Order Intermodulation Distortion IM3 (dBm)
10
0
–10
–20
–30
–40
–50
–60
–70
–80
–30
–20
–10
0
10
IF Input Power PIFin (dBm)
TA = +85°C
VCC = 2.8 V
fIFin1 = 150 MHz
fIFin2 = 151 MHz
fLOin = 2 250 MHz
PLOin = –5 dBm

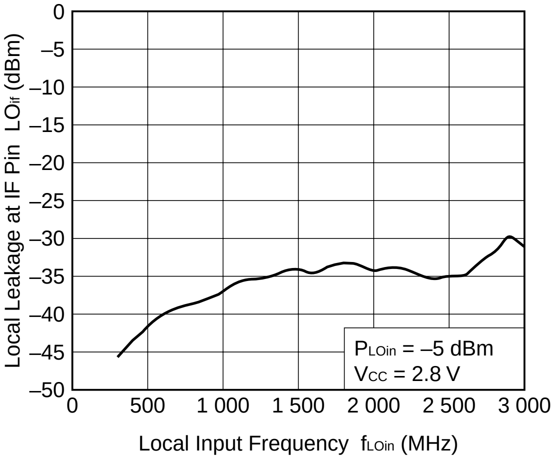
LOCAL LEAKAGE AT RF PIN vs.
LOCAL INPUT FREQUENCY



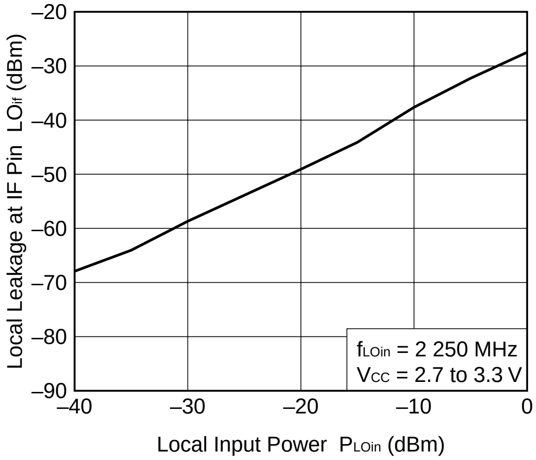

LOCAL LEAKAGE AT RF PIN vs.
LOCAL INPUT POWER



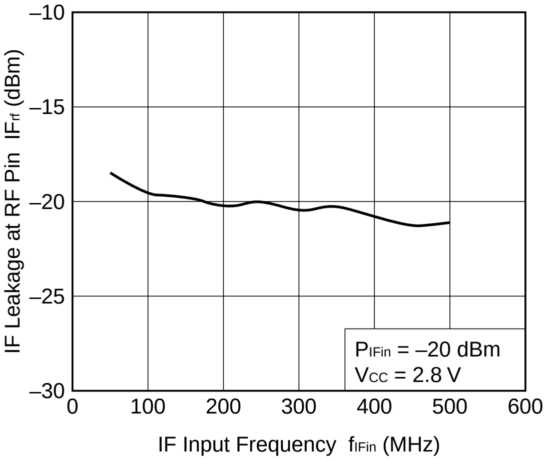

LOCAL LEAKAGE AT IF PIN vs.
LOCAL INPUT FREQUENCY



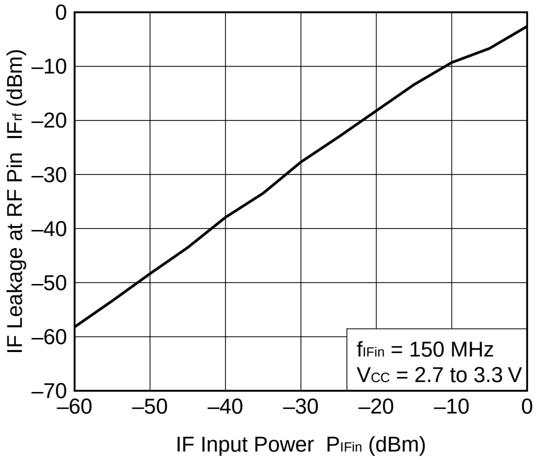

LOCAL LEAKAGE AT IF PIN vs.
LOCAL INPUT POWER




IF LEAKAGE AT RF PIN vs.
IF INPUT FREQUENCY

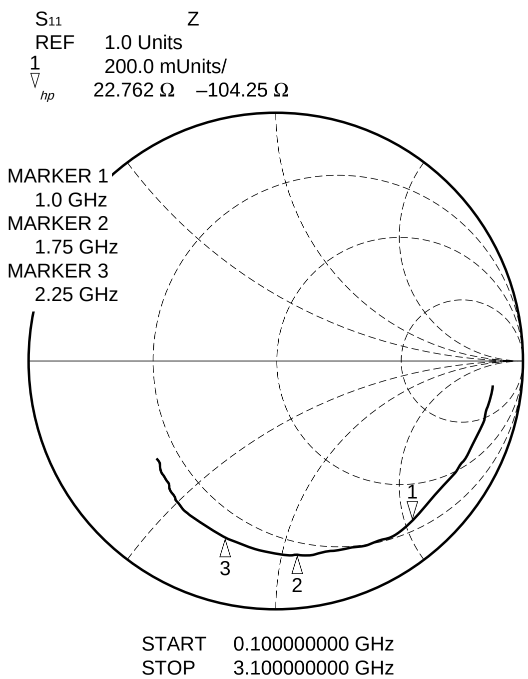



IF LEAKAGE AT RF PIN vs.
IF INPUT POWER

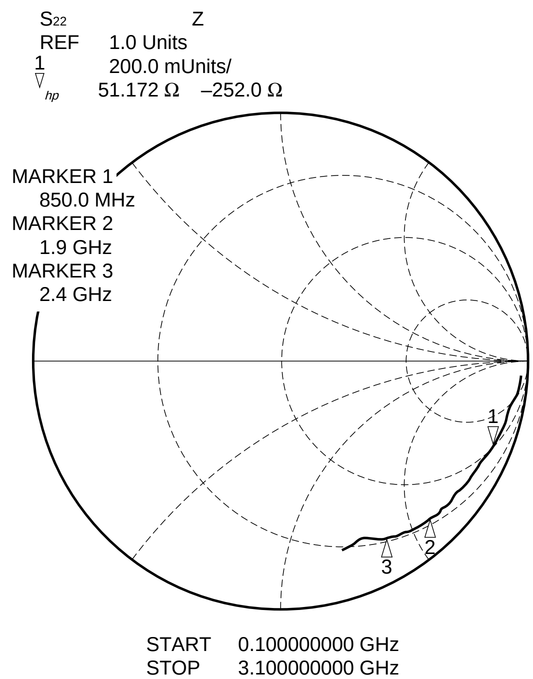


★ **12. S-PARAMETERS FOR EACH PORT ($V_{CC} = V_{RFout}$ = 2.8 V)**
**(The parameters are monitored at DUT pins)**

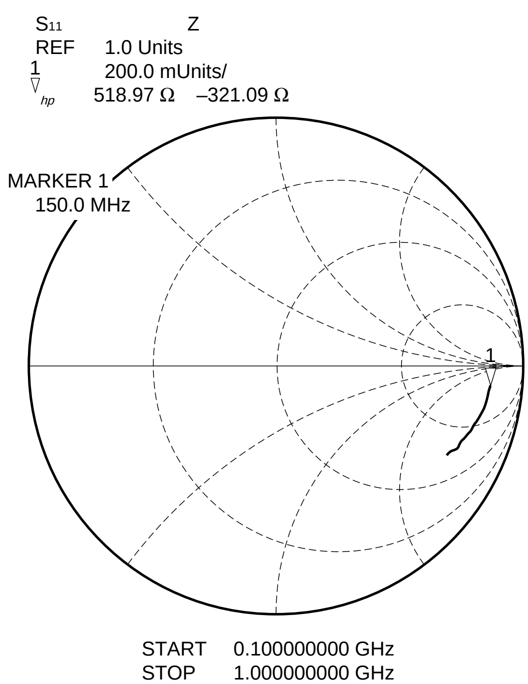
**LO port**




**RF port (without matching)**

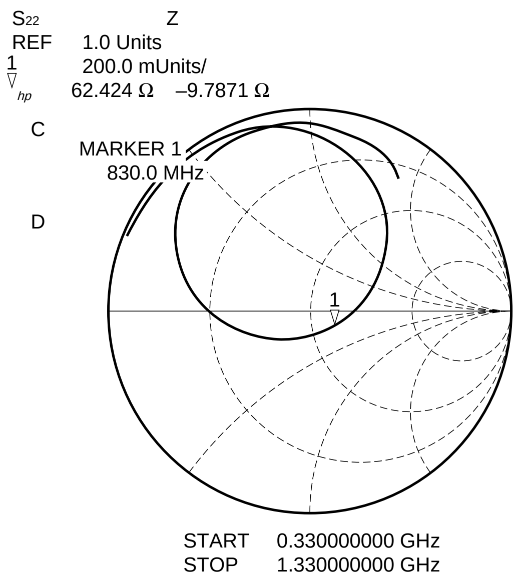


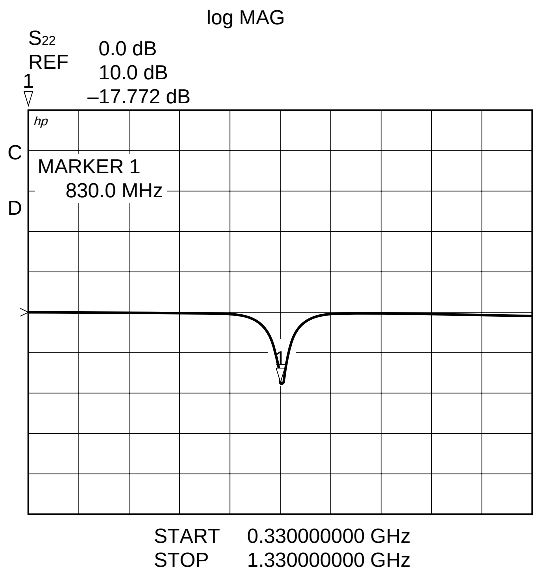

**IF port**



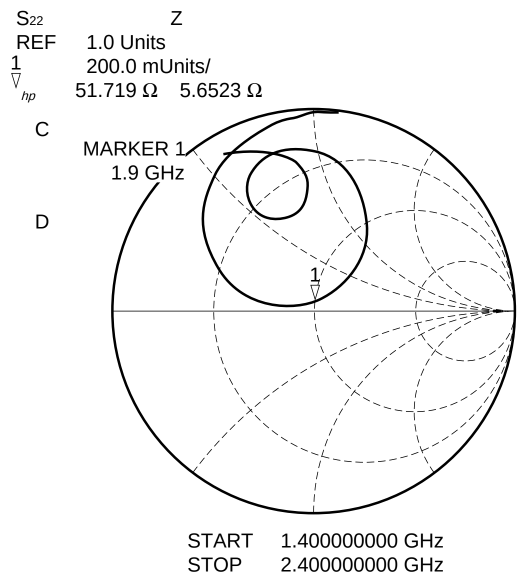
## ★ 13. S-PARAMETERS FOR MATCHED RF OUTPUT ($V_{CC} = V_{RFout} = 2.8$ V) – ON EVALUATION BOARD – ($S_{22}$ data are monitored at RF connector on board)

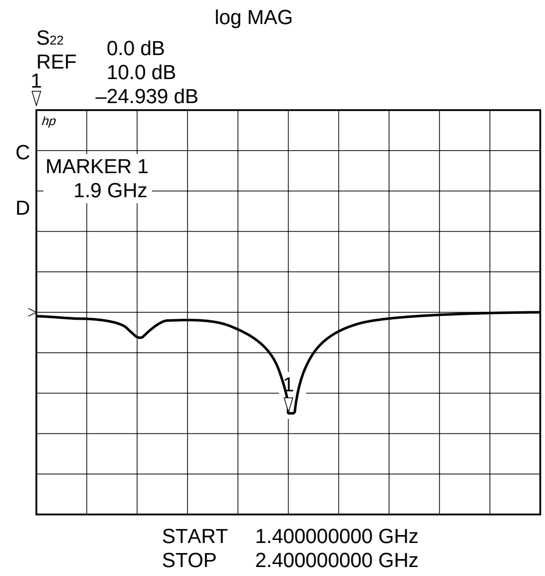
**0.83 GHz (matched in test circuit 1)**



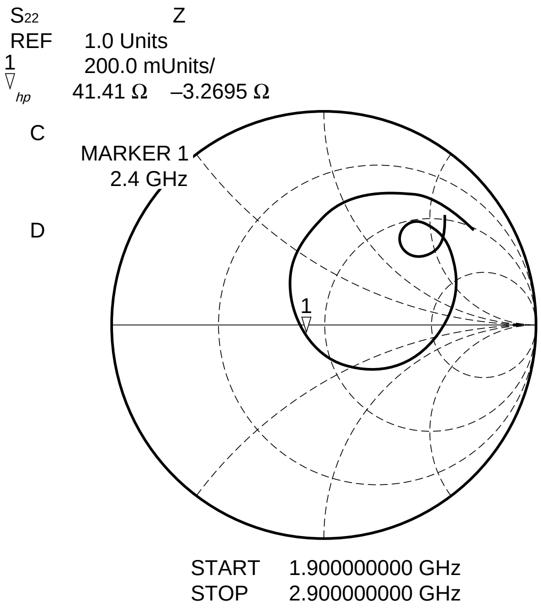



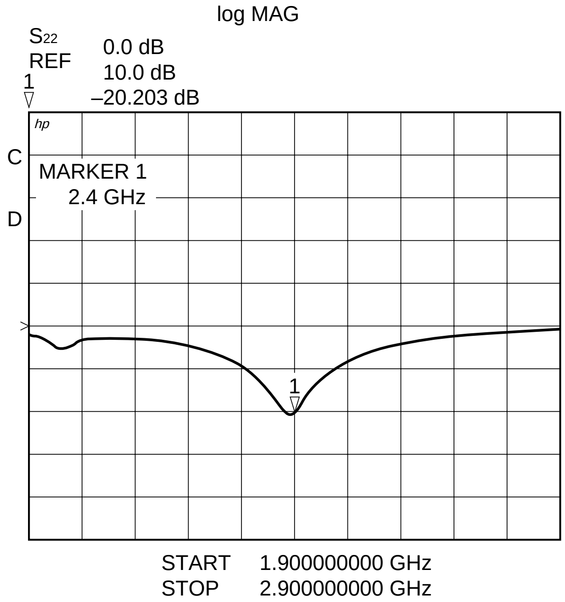

**1.9 GHz (matched in test circuit 2)**



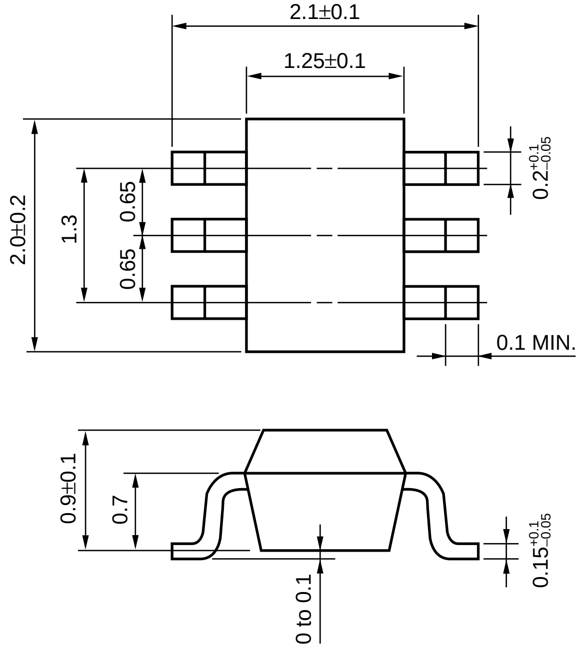
**2.4 GHz (matched in test circuit 3)**



## 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 $V_{CC}$ 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<br>Time: 30 seconds or less (at 210°C)<br>Count: 3, Exposure limit: None[Note] | IR35-00-3 |
| VPS | Package peak temperature: 215°C or below<br>Time: 40 seconds or less (at 200°C)<br>Count: 3, Exposure limit: None[Note] | VP15-00-3 |
| Wave Soldering | Soldering bath temperature: 260°C or below<br>Time: 10 seconds or less<br>Count: 1, Exposure limit: None[Note] | WS60-00-1 |
| Partial Heating | Pin temperature: 300°C<br>Time: 3 seconds or less (per side of device)<br>Exposure limit: None[Note] | – |

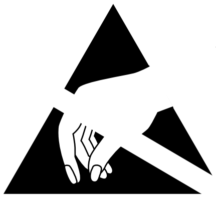
**Note** After opening the dry pack, keep it in a place below 25°C and 65% RH for the allowable storage period.

**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