

# BIPOLAR ANALOG INTEGRATED CIRCUIT

# $\mu$ PC8001

## IF AMPLIFIER IC

### WITH ON-CHIP MIXER FOR DIGITAL CELLULAR PHONES

The  $\mu$ PC8001 is a 3-volt IF amplifier IC with an on-chip mixer developed for digital cellular phones.

The  $\mu$ PC8001 consists of a high-sensitivity limiter amplifier with an input frequency of 455 kHz, a high-speed and high-precision linear RSSI (received signal strength indicator), and a second mixer with an input frequency of 80 to 150 MHz.

The  $\mu$ PC8001 features a low 3 mA (TYP.) and 2.2  $\mu$ A (TYP.) current consumption at normal operation and power-OFF, respectively. Its high-speed charge/discharge circuit enables fast power-ON/OFF switching.

The  $\mu$ PC8001 boasts an extremely small size packaged in a 14-pin plastic shrink SOP, and low external capacitances of less than 0.01  $\mu$ F, in addition to an on-chip RSSI output resistor, and is most suitable for high-density mounting.

#### FEATURES

- Low-voltage operation...3 V  $\pm$ 10%
- Low power consumption...(V<sub>CC</sub> = 3 V)

	Mixer	IF amp. + RSSI
During operation	2.1 mA (TYP.)	0.95 mA (TYP.)
At power-OFF	0 $\mu$ A (TYP.)	2.2 $\mu$ A (TYP.)

- High limiting sensitivity...-91 dBm (TYP.)
- High-precision RSSI linearity... $\pm$ 0.5 dB (TYP.) (V<sub>IF IN</sub> = -86 to -6 dBm)
- High-speed RSSI response time

RSSI output rise time	77 $\mu$ s (TYP.)
RSSI output fall time	113 $\mu$ s (TYP.)

- High-speed power-ON/OFF switching time

Rise time at power-ON	174 $\mu$ s (TYP.)
Fall time at power-OFF	3 $\mu$ s (TYP.)

- External capacitors of less than 0.01  $\mu$ F
- On-chip RSSI output resistor (34 k $\Omega$ )
- Ultra-compact package...14-pin plastic shrink SOP

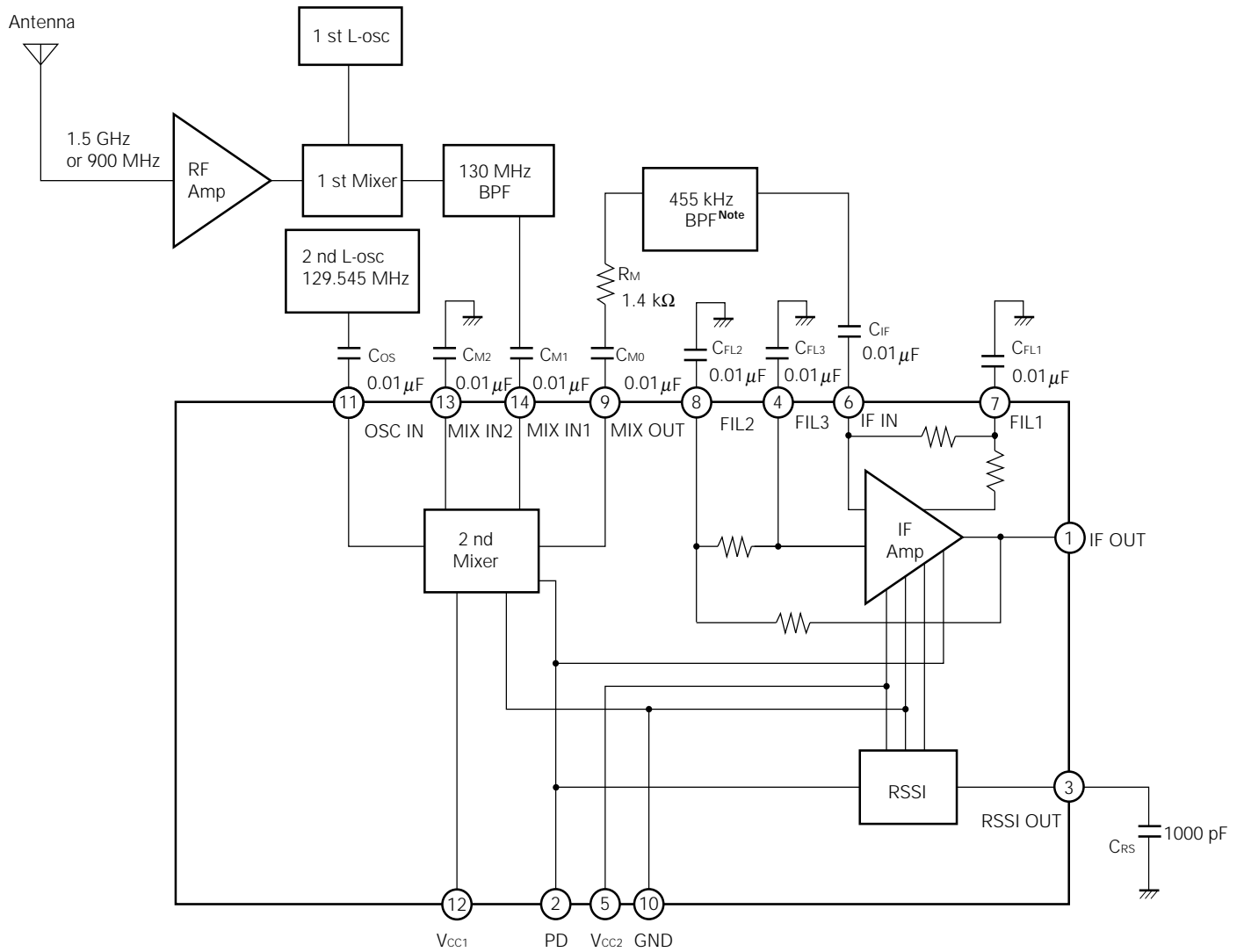
The information in this document is subject to change without notice.

The mark ★ shows revised points.

## ORDERING INFORMATION

Part number	Package
$\mu$ PC8001GR	14-pin plastic shrink SOP (225 mil)
$\mu$ PC8001GR-E1	14-pin plastic shrink SOP (225 mil) Embossed carrier taping (Pin 1 located toward tape unwind direction)
$\mu$ PC8001GR-E2	14-pin plastic shrink SOP (225 mil) Embossed carrier taping (Pin 1 located toward tape wind direction)

BLOCK DIAGRAM



**Note** Input/output impedance of 455 kHz BPF: 1.5 k Ω

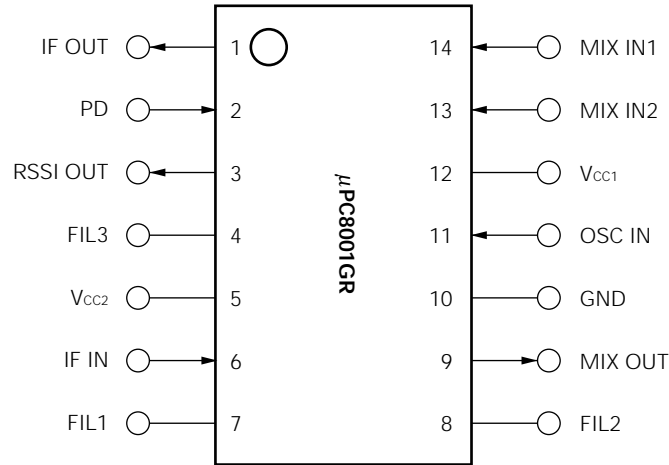
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1. PIN CONFIGURATION AND PIN FUNCTIONS

(1) PIN CONFIGURATION (Top View)

- 14-pin plastic shrink SOP (225 mil)

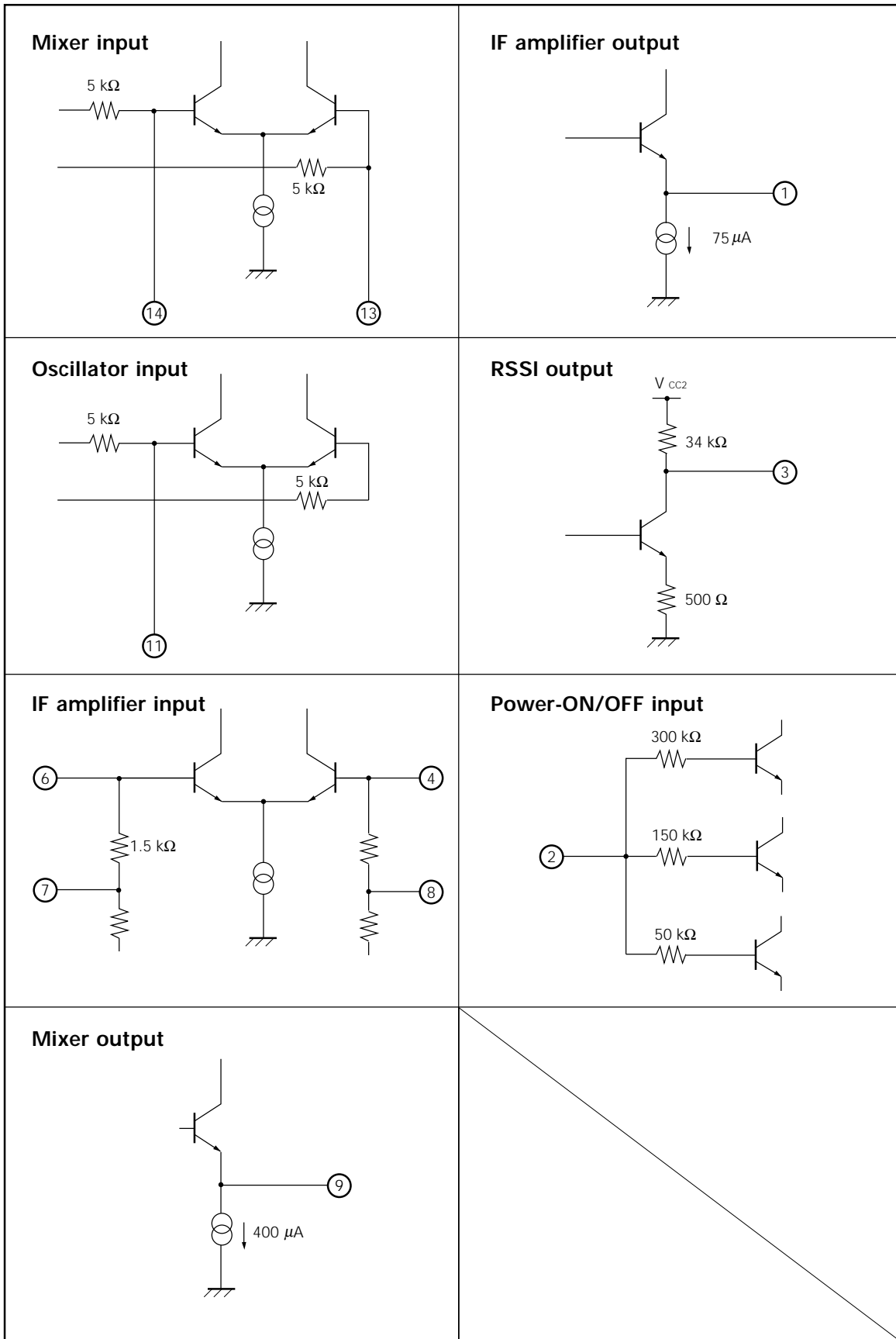


- FIL1-FIL3 : Filter
- GND : Ground
- IF IN : Intermediate Frequency Input
- IF OUT : Intermediate Frequency Output
- MIX IN1, MIX IN2 : Mixer Input
- MIX OUT : Mixer Output
- OSC IN : Oscillator Input
- PD : Power Down
- RSSI OUT : Received Signal Strength Indicator Output
- V<sub>cc1</sub>, V<sub>cc2</sub> : Power Supply

## (2) PIN FUNCTIONS

Number	Pin Name	I/O	Function
1	IF OUT	O	IF amplifier output
2	PD	I	Power-ON/OFF control signal input High level: Power-ON; Low level: Power-OFF
3	PSSI OUT	O	RSSI output
4	FIL3	—	Connect capacitor for filter.
5	V <sub>CC2</sub>	—	IF amplifier and RSSI power pin
6	IF IN	I	IF amplifier input
7	FIL1	—	Connect capacitor for filter.
8	FIL2	—	Connect capacitor for filter.
9	MIX OUT	O	Mixer output
10	GND	—	Ground pin
11	OSC IN	I	Oscillator input
12	V <sub>CC1</sub>	—	Mixer power pin
13	MIX IN2	I	Connect capacitor for filter.
14	MIX IN1	I	Mixer input

2. I/O EQUIVALENT CIRCUIT



### 3. ELECTRICAL SPECIFICATIONS

#### Absolute Maximum Ratings (T<sub>A</sub> = 25°C)

Parameter	Symbol	Conditions	Rating	Unit
Supply voltage	V <sub>CC</sub>		7	V
Total power dissipation	P <sub>T</sub>		300	mW
Operating ambient temperature	T <sub>A</sub>		-30 to +85	°C
Storage temperature	T <sub>stg</sub>		-40 to +125	°C

**Caution** Exposure to Absolute Maximum Ratings for extended periods may affect device reliability; exceeding the ratings could cause permanent damage. The parameters apply independently. The device should be operated within the limits specified under DC and AC Characteristics.

#### Recommended Operating Conditions (T<sub>A</sub> = 25°C)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit	
Supply voltage	V <sub>CC</sub>		2.7	3.0	3.3	V	
Mixer input level	V <sub>MIX IN</sub>	See Figure 3-1.	50 Ω termination	-100		-20	dBm <sup>Note1</sup>
			LC matching	-113 <sup>Note2</sup>		-33 <sup>Note2</sup>	dBm <sup>Note1</sup>
IF amplifier input level	V <sub>IF IN</sub>		-86		-6	dBm <sup>Note1</sup>	
Oscillator input level	V <sub>OSC IN</sub>		-30	-15	-5	dBm <sup>Note1</sup>	
IF amplifier input frequency	f <sub>IF IN</sub>		400	455	500	kHz	
Mixer input frequency	f <sub>MIX IN</sub>		80	130	150	MHz	
Mixer output frequency	f <sub>MIX OUT</sub>		400	455	500	kHz	

- Notes**
1. Assuming a conversion value of 50 Ω, 0 dBm = 0.2236 V<sub>rms</sub>.
  2. Depends on board wiring pattern, use as reference value.



**ELECTRICAL CHARACTERISTICS**

( $T_A = 25^\circ\text{C}$ ,  $V_{CC1} = V_{CC2} = 3\text{ V}$ ,  $f_{MIX\ IN} = 130\text{ MHz}$ ,  $f_{OSC\ IN} = 129.545\text{ MHz}$ ,  $f_{IF\ IN} = 455\text{ kHz}$ ,  $C_{RS} = 1000\text{ pF}$ ,  $C_{OS} = C_{M1} = C_{M2} = C_{M0} = C_{IF} = C_{FL1} = C_{FL2} = C_{FL3} = 0.01\mu\text{F}$ ,  $0\text{ dBm} = 0.2236\text{ V}_{\text{rms}}$ )

**(1) Mixer**

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit	
Supply current	$I_{CC1}$	No signal		2.1	3.0	mA	
Conversion gain	CG	$V_{MIN\ IN} = -50\text{ dBm}$ $V_{OSC\ IN} = -15\text{ dBm}$ See <b>Figure 3-1</b> .	50Ω termination	15	20	23	dB
			LC matching		33 <sup>Note 1</sup>		
Third order intercept	$IC_3$	See <b>Figure 3-2</b> .	-13	-8		dBm	
-1dB compression output level	$V_{OMIX}$	$V_{OSC\ IN} = -15\text{ dBm}$ See <b>Figure 3-3</b> .	-5	0		dBm	
Cut-off frequency	$f_c$	-3 dB point	200	470		MHz	
Noise figure	NF	See <b>Figure 3-6</b> .		10 <sup>Note 1</sup>		dB	
Local isolation	ISL		20	26		dB	
Mixer input impedance	$Z_{IM}$			48-j383		Ω	
Local input impedance	$Z_{IL}$			80-j425		Ω	
Output resistance	$R_{OM}$		60	120	180	Ω	
Power-ON rise time <sup>Note2</sup>	$t_{ONM}$	$V_{ON} = 3\text{ V}$ Rise time of PD signal : 10 ns		33	600	μs	
Power-OFF fall time <sup>Note3</sup>	$t_{OFM}$	$V_{OF} = 0\text{ V}$ Fall time of PD signal : 10 ns		3	200	μs	
Power-OFF supply current	$I_{LM}$	$V_{OF} = 0\text{ V}$		0	10	μA	

- Notes**
1. Depends on board wiring pattern, use as reference value.
  2. Time until DC voltage of mixer output reaches ±10% of power-ON value.
  3. Time until supply current reaches 10% of power-ON value.

**(2) Power-ON/OFF**

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Power-ON input voltage	$V_{ON}$	Power-ON over $V_{ON}$ and under $V_{CC}$		1.2	2.4	V
Power-OFF input voltage	$V_{OF}$	Power-OFF over GND and under $V_{OF}$	0.6	1.2		V
Power-ON input current	$I_{ON}$	$V_{ON} = 3\text{ V}$		48	75	μA

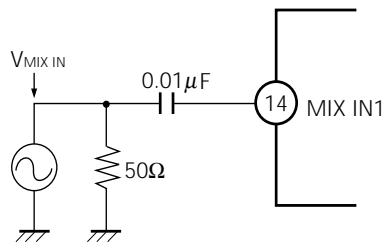
(3) IF Amplifier/RSSI

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Supply current	I <sub>CC2</sub>	No signal		0.95	1.3	mA
IF amplifier output amplitude	V <sub>O</sub>	V <sub>IF IN</sub> = -20 dBm	1.2	1.5	1.8	V <sub>p-p</sub>
Limiting sensitivity	LS	-3dB point, see <b>Figure 4-5</b> .		-91	-86	dBm
IF amplifier input impedance	Z <sub>IN</sub>		1.2	1.5	1.8	kΩ
IF amplifier phase variation	Δφ	V <sub>IF IN</sub> = -86 to -6 dBm See <b>Figure 4-6</b> <sup>Note1</sup> .		11		deg
★ RSSI linearity	L <sub>RS</sub>	V <sub>IF IN</sub> = -86 to -6 dBm Recursive calculation with V <sub>IF IN</sub> = -60 to -6 dBm		±0.5	±2	dB
RSSI slope	SL <sub>RS</sub>	Recursive calculation with V <sub>IF IN</sub> = -60 to -6 dBm	22.3	24.4	30.1	mV/dB
★ RSSI intercept	IC <sub>RS</sub>	Recursive calculation with V <sub>IF IN</sub> = -60 to -6 dBm See <b>Figure 3-4</b> .	-135	-118	-104	dBm
RSSI output voltage1	V <sub>R1</sub>	V <sub>IF IN</sub> = -86 dBm	0.50	0.79	0.98	V
★ RSSI output voltage 2	V <sub>R2</sub>	V <sub>IF IN</sub> = -46 dBm	1.60	1.79	1.90	V
RSSI output voltage 3	V <sub>R3</sub>	V <sub>IF IN</sub> = -6 dBm	2.70	2.75	2.82	V
RSSI output temperature stability	S <sub>T</sub>	V <sub>IF IN</sub> = -86 to -6 dBm, T <sub>A</sub> = -30 to +85 °C		1		dB
★ RSSI rise time	t <sub>rRS</sub>	V <sub>IF IN</sub> = -6 dBm See <b>Figure 3-5</b> .		77	300	μs
★ RSSI fall time	t <sub>fRS</sub>	V <sub>IF IN</sub> = -6 dBm See <b>Figure 3-5</b> .		113	300	μs
★ RSSI output ripple	V <sub>RRS</sub>	V <sub>IF IN</sub> = -6 dBm		3	12	mV <sub>p-p</sub>
Power-OFF supply current	I <sub>LI</sub>	V <sub>OF</sub> = 0 V		2.2	10	μA
Power-ON rise time <sup>Note2</sup>	t <sub>ONI</sub>	V <sub>ON</sub> = 3 V, V <sub>IF IN</sub> = -86 dBm PD signal rise time: 10 ns		174	600	μs
Power-OFF fall time <sup>Note3</sup>	t <sub>OFI</sub>	V <sub>OF</sub> = 0 V PD signal fall time: 10 ns		3	200	μs
IF amplifier output slew rate	SR <sub>O</sub>	V <sub>IF IN</sub> = -20 dBm	Rise <sup>Note4</sup>	3.4		V/μs
			Fall <sup>Note5</sup>	3.8		
RSSI output resistance	R <sub>OR</sub>		27	34	41	kΩ

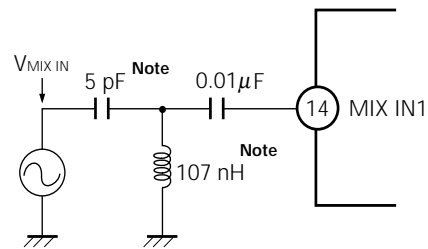
- ★ **Notes**
1. Use the network analyzer at RBW = 3 Hz.
  2. Time until RSSI output reaches ±10% of power-ON value.
  3. Time until supply current reaches 10% of power-ON value.
  4. Rise: 10% to 90%
  5. Fall: 90% to 10%

Figure 3-1. Mixer Input

(a) 50Ω Termination



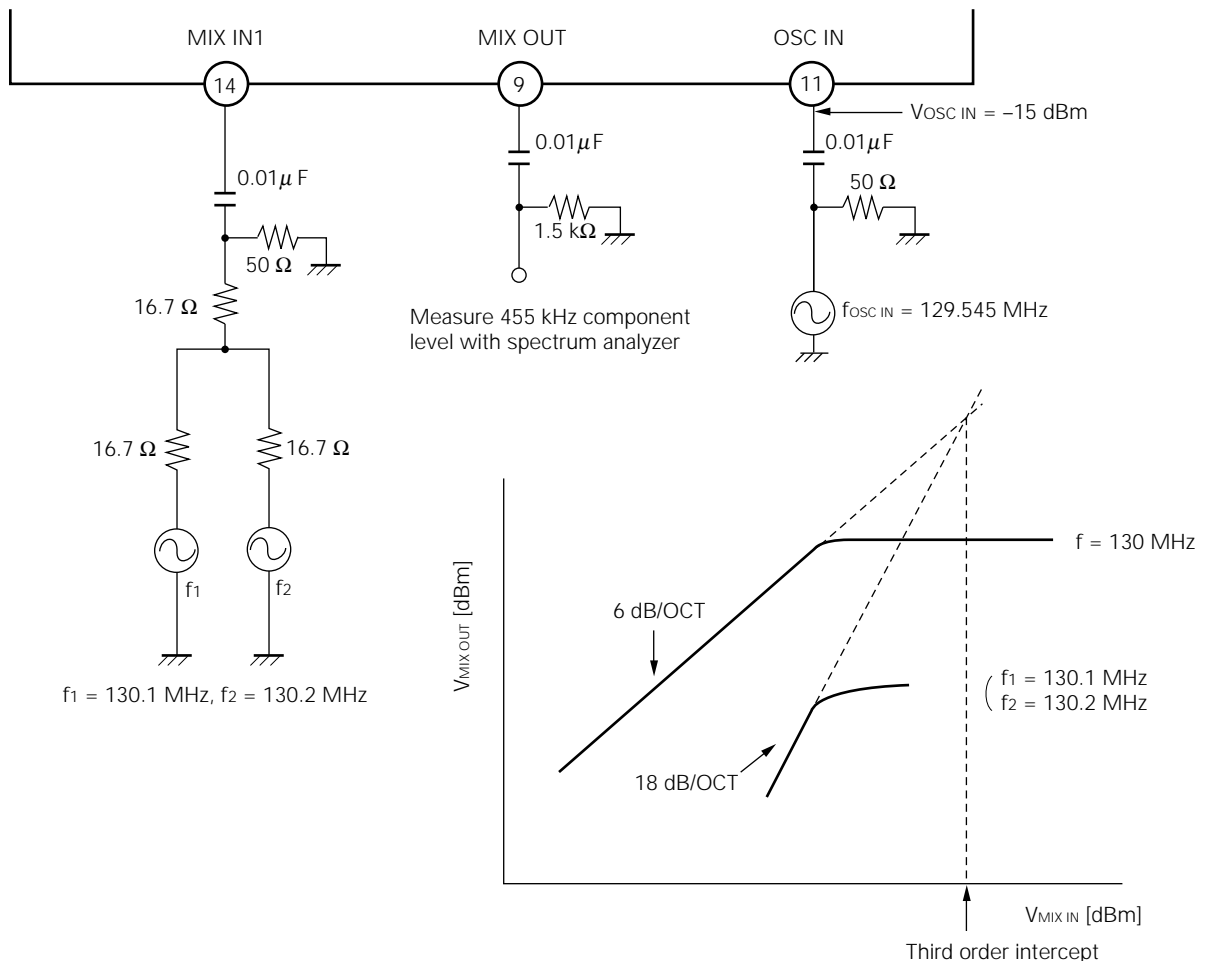
(b) LC Matching



**Note** The values L and C are affected by the parasitic capacitance and inductance of the board. Therefore, adjust L and C so that the impedance at the MIX IN pin from the signal source equals 50Ω.

**Remark** The signal source impedance is 50Ω.

Figure 3-2. Third Order Intercept



**Remark** Signal source impedance is 50Ω.

Figure 3-3. -1 dB Compression Output Level

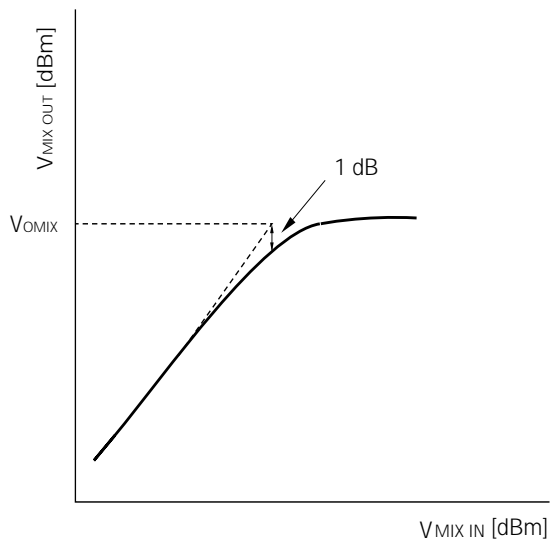


Figure 3-4. RSSI Intercept

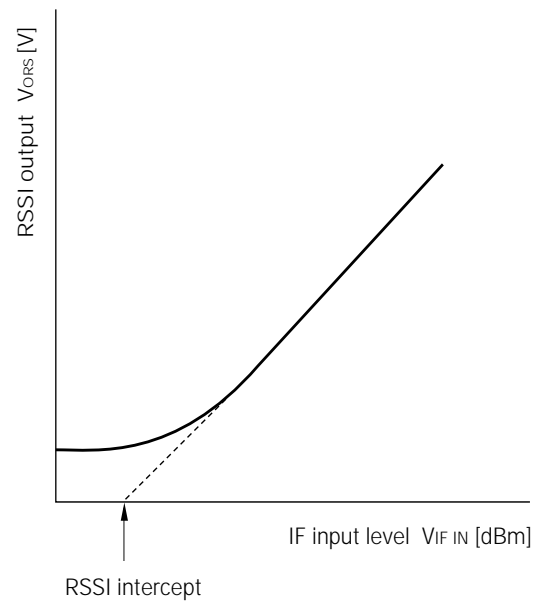


Figure 3-5. RSSI Response Time

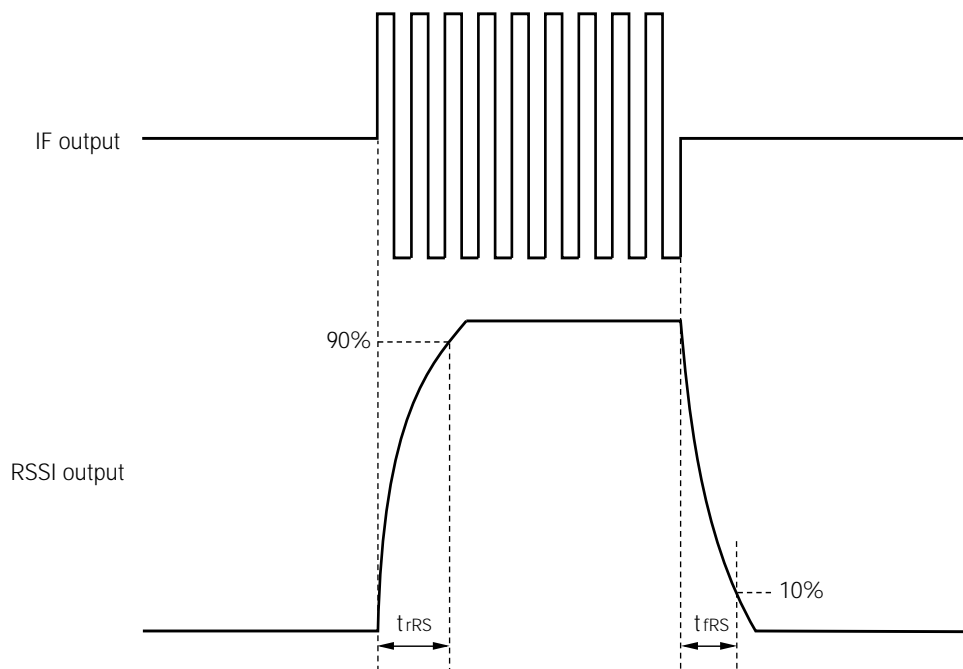
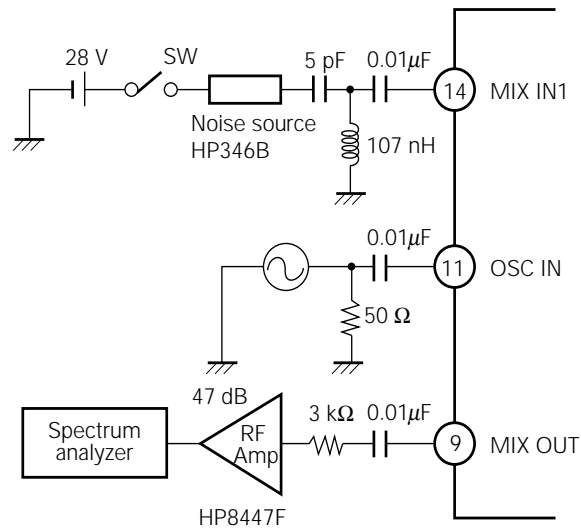


Figure 3-6. Noise Figure Measurement



The noise figure is calculated as follows:

$$NF = ENR - 10 \log (Y - 1)$$

NF (dB): Noise figure

ENR (dB): ENR of noise source

$$Y: Y = 10^{\frac{N_2 - N_1}{10}}$$

N<sub>1</sub> (dBm): Spectrum analyzer indication value at SW OFF.

N<sub>2</sub> (dBm): Spectrum analyzer indication value at SW ON.

**Remark** This measurement measures DSB. To measure SSB, add 3 dB to NF above.

4. CHARACTERISTIC CURVES

Figure 4-1. Mixer Supply Current vs. Supply Voltage

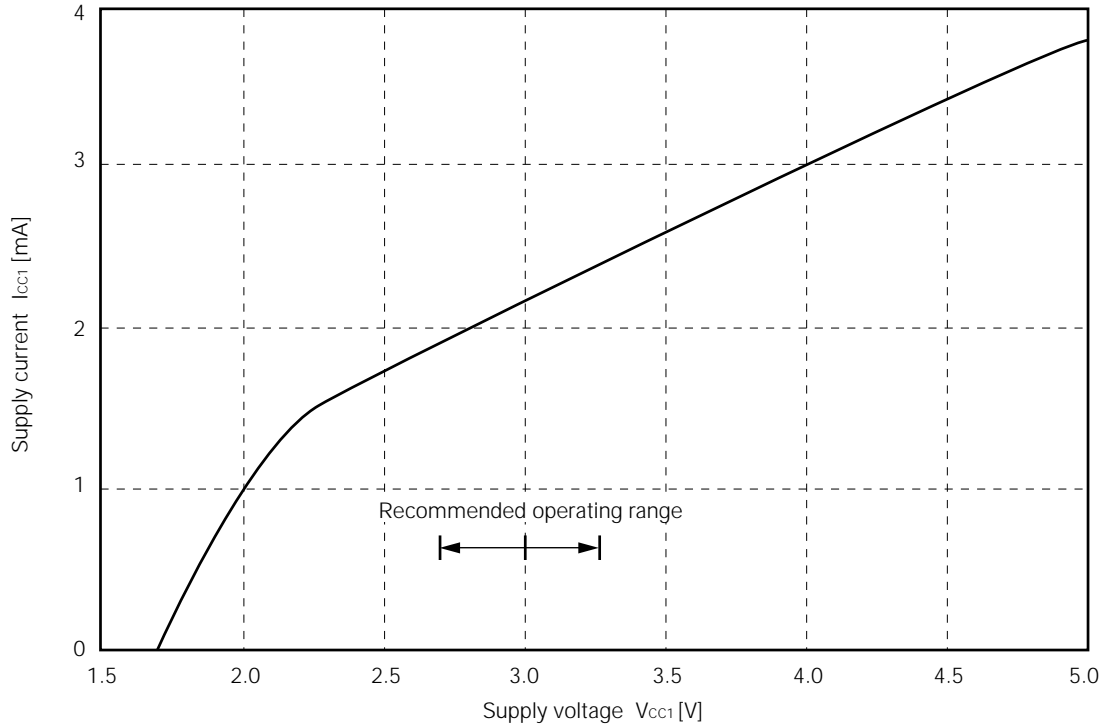
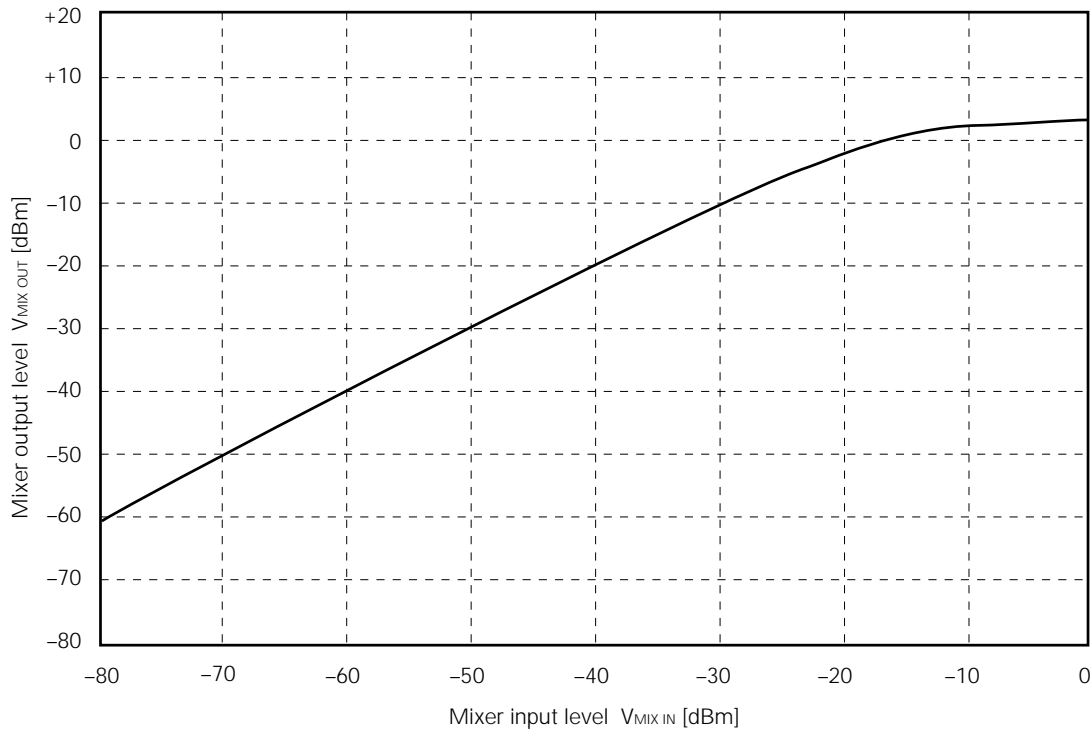
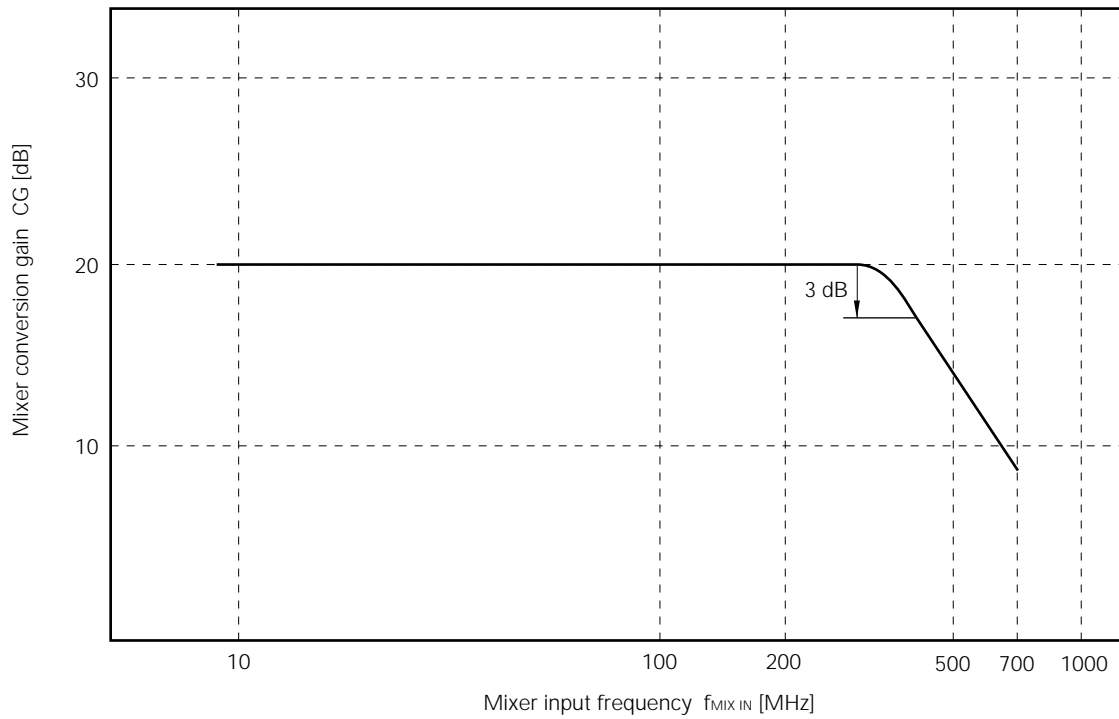


Figure 4-2. Mixer Output Level vs. Mixer Input Level  
 ( $f_{MIX IN} = 130$  MHz,  $f_{OSC IN} = 129.545$  MHz,  $f_{MIX OUT} = 455$  kHz,  $V_{OSC IN} = -15$  dBm)



**Figure 4-3. Mixer Conversion Gain vs. Mixer Input Frequency**  
 ( $V_{MIX IN} = -30$  dBm,  $V_{OSC IN} = -15$  dBm,  $f_{OSC IN} = f_{MIX IN} - f_{MIX OUT}$ ,  $f_{MIX OUT} = 455$  kHz)



**Figure 4-4. IF Amplifier/RSSI Supply Current vs. Supply Voltage**

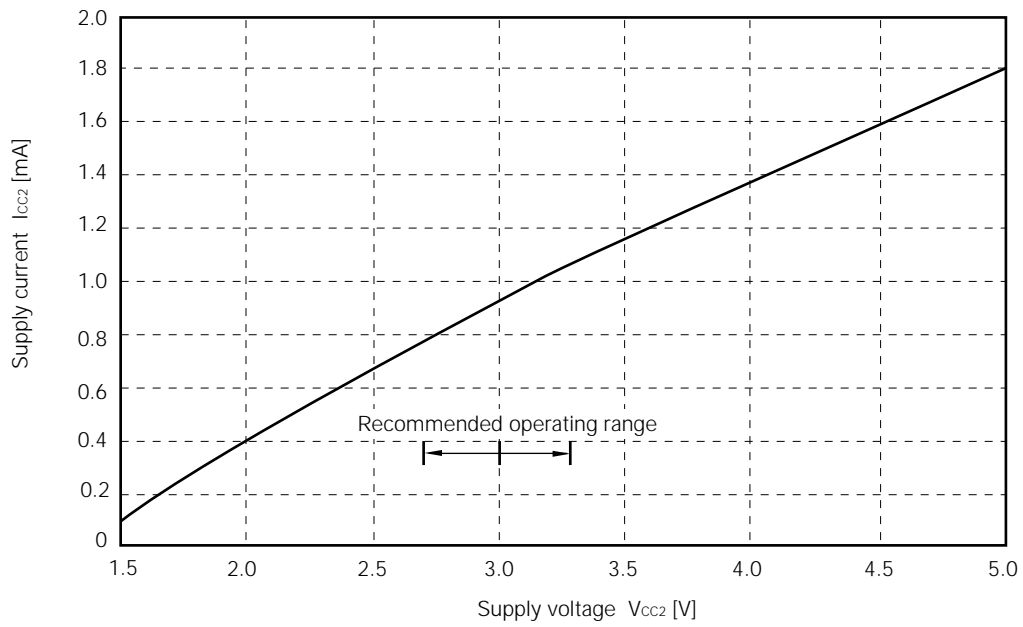


Figure 4-5. IF Amplifier Output Level vs. IF Amplifier Input Level

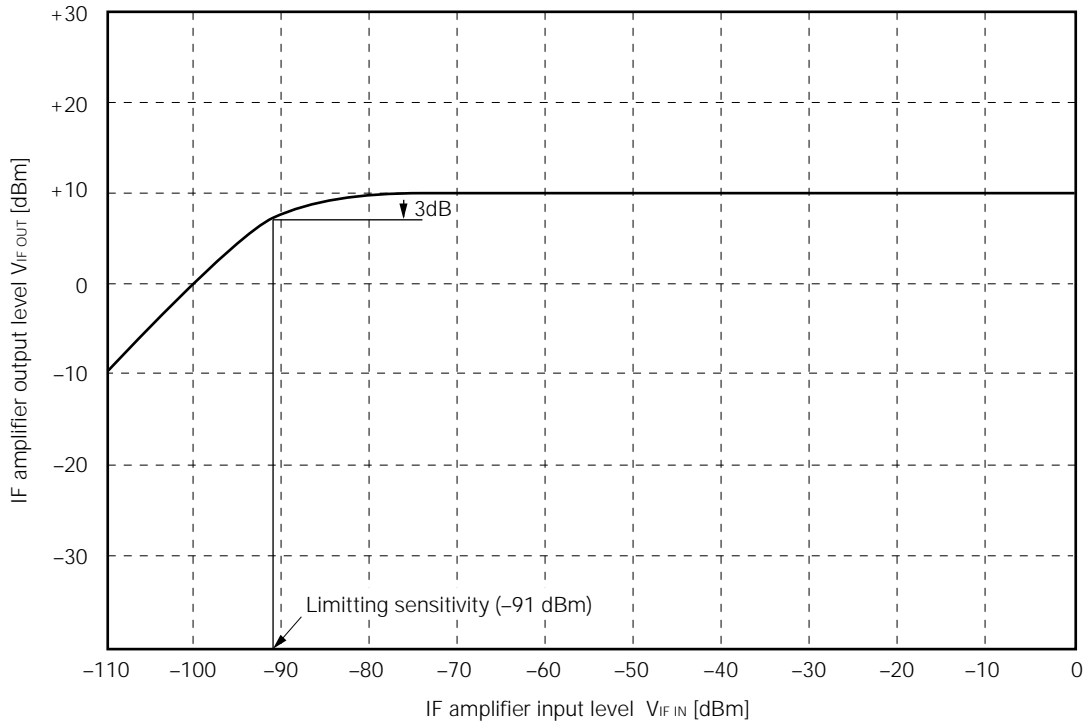


Figure 4-6. IF Amplifier Output Phase vs. IF Amplifier Input Level

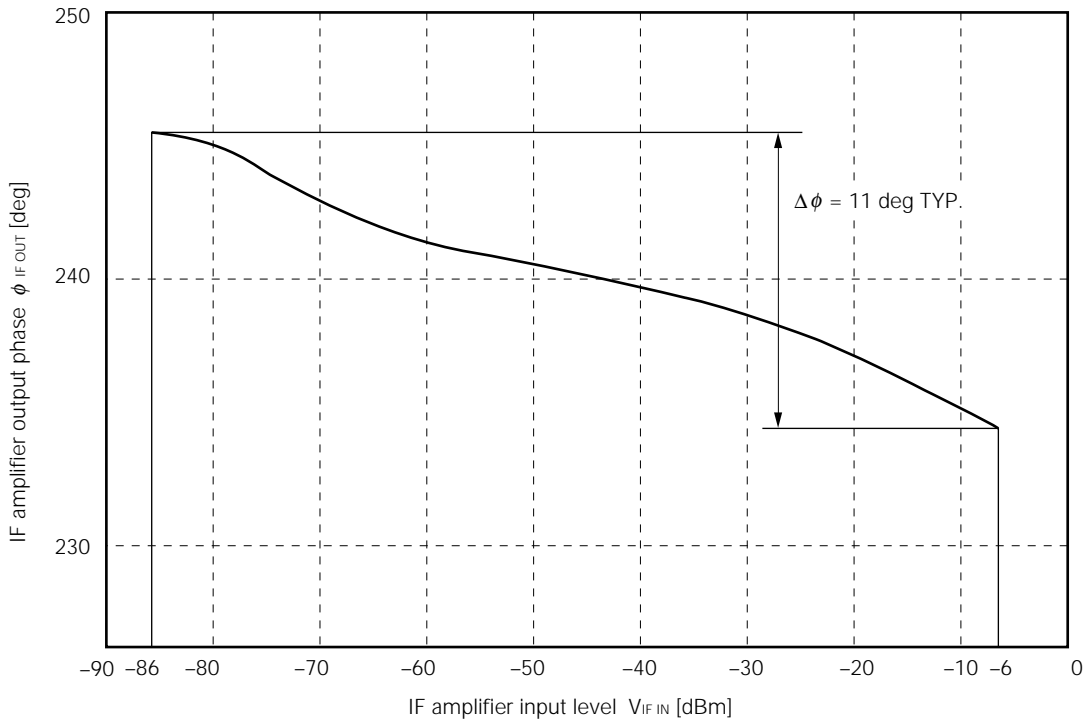
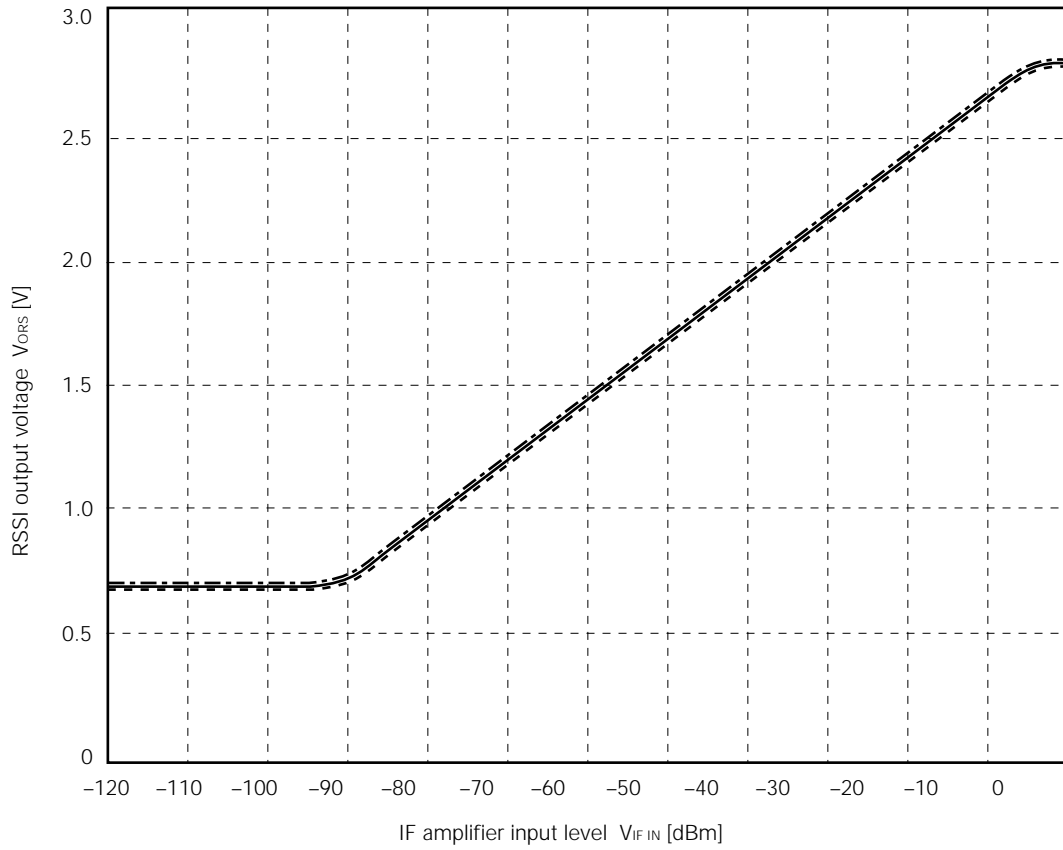


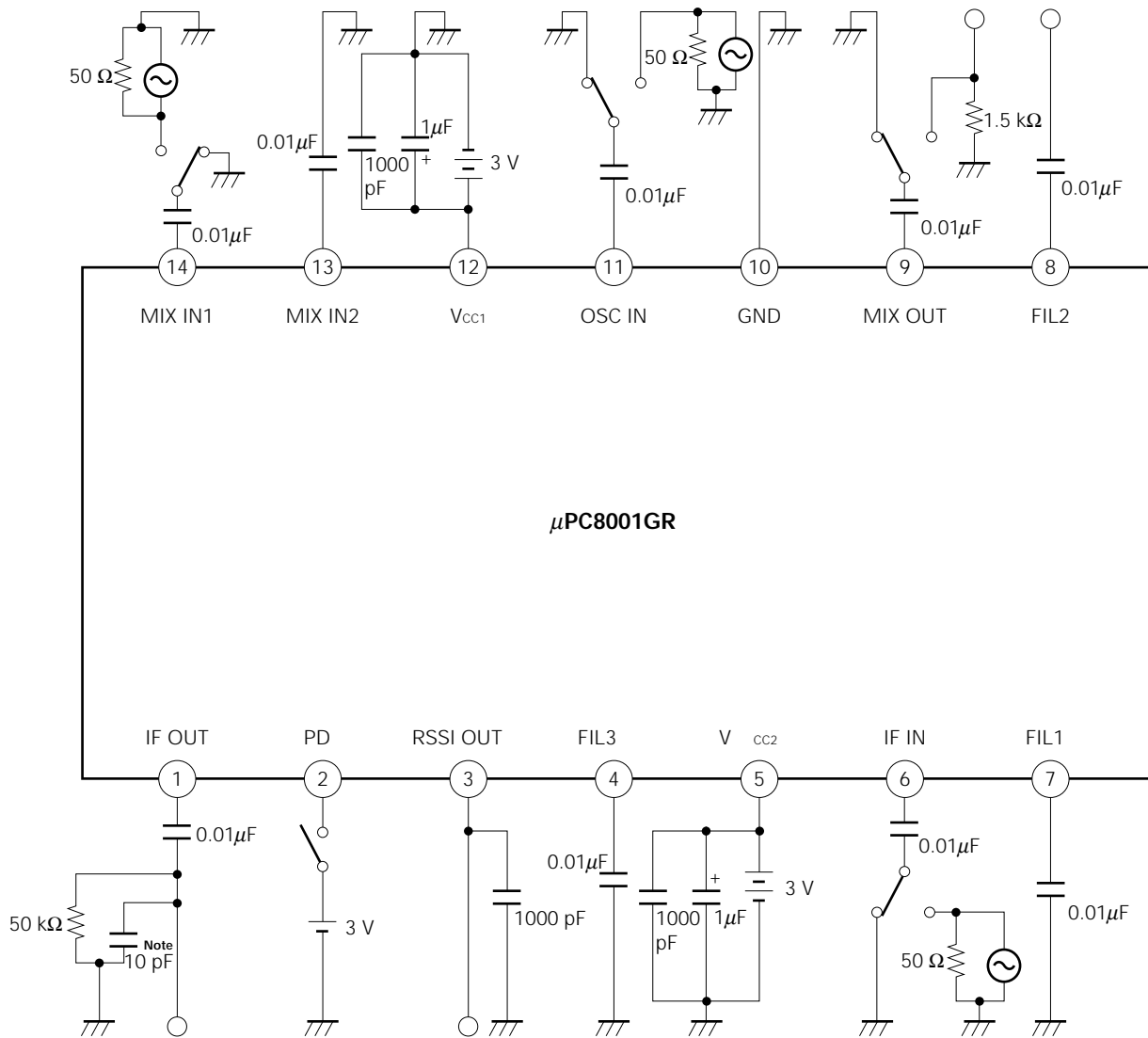


Figure 4-7. RSSI Output Voltage vs. IF Amplifier Input Level  
(The temperature characteristics curves)



- Remarks 1.   
 - - - - -  $T_A = -30\text{ °C}$   
 ———  $T_A = +25\text{ °C}$   
 - · - · -  $T_A = +85\text{ °C}$
2. The three temperature characteristic curves are virtually identical.

★ 5. TEST CIRCUIT EXAMPLE

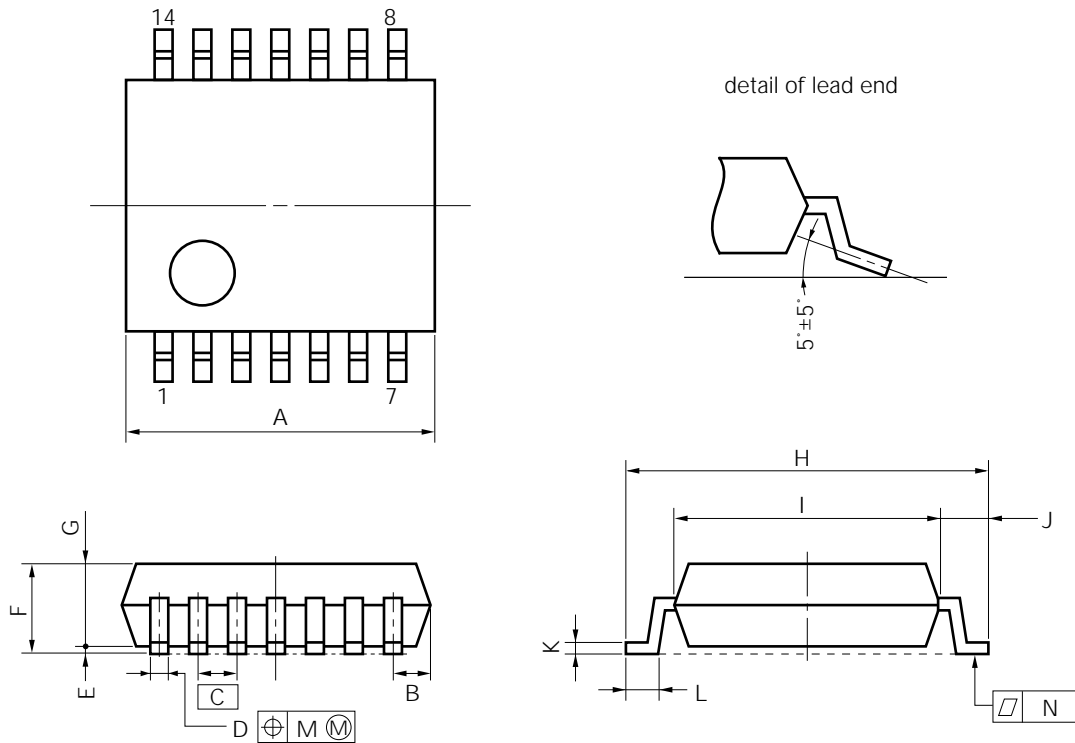


**Note** The value of the capacitance connected to the IF OUT pin (No. 1) includes the capacitances of PCB wiring patterns and the tester.

**Remark** In three cases of Mixer Input, Third Order Intercept and Noise Figure Measurement, refer to Figures 3-1, 3-2, and 3-6.

6. PACKAGE DRAWINGS

14 PIN PLASTIC SHRINK SOP (225 mil)



**NOTE**

Each lead centerline is located within 0.10 mm (0.004 inch) of its true position (T.P.) at maximum material condition.

P14GM-65-225B-2

ITEM	MILLIMETERS	INCHES
A	5.40 MAX.	0.213 MAX.
B	0.75 MAX.	0.030 MAX.
C	0.65 (T.P.)	0.026 (T.P.)
D	0.30 <sup>+0.10</sup> <sub>-0.05</sub>	0.012 <sup>+0.004</sup> <sub>-0.003</sub>
E	0.125±0.075	0.005±0.003
F	1.8 MAX.	0.071 MAX.
G	1.44	0.057
H	6.2±0.3	0.244±0.012
I	4.4	0.173
J	0.9	0.035
K	0.15 <sup>+0.10</sup> <sub>-0.05</sub>	0.006 <sup>+0.004</sup> <sub>-0.002</sub>
L	0.5±0.2	0.020 <sup>+0.008</sup> <sub>-0.009</sub>
M	0.10	0.004
N	0.10	0.004

**7. RECOMMENDED SOLDERING CONDITIONS**

The following conditions must be met for soldering conditions of the μPC8001. For more details, refer to our document “SEMICONDUCTOR DEVICE MOUNTING TECHNOLOGY MANUAL” (IEI-1207).

Please consult with our sales offices in case other soldering process is used, or in case the soldering is done under different conditions.

**Types of Surface Mount Device**

**μPC8001GR: 14-pin plastic shrink SOP (225 mil)**

Soldedering process	Soldering conditions	Symbol
Infrared ray reflow	Peak temperature of package surface: 235 °C or below, Reflow time: 30 seconds or below (210 °C or higher), Number of reflow processes: MAX. 2  <b>[Remark]</b> (1) Please start the second reflow process after the temperature, raised by the first reflow process, returns to normal. (2) Please avoid removing the residual flux with water after the first reflow process.	IR35-107-2
Partial heating method	Terminal temperature: 300 °C or below, Time: 3 seconds or below (Per one side of the device).	-----

### Precautions Against Static Electricity

**Caution** When handling the device, be careful to protect it from static electricity. exposure to a strong static electricity charge may destroy internal transistor junctions. During transportation and storage, place the device in the conductive tray or case originally provided by NEC for shipping, or conductive shock absorbing material, metal case, etc. During assembly, be sure to ground the device. Be careful not to place the device on a plastic board and do not touch the device's pins.

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Special: Transportation equipment (automobiles, trains, ships, etc.), traffic control systems, anti-disaster systems, anti-crime systems, safety equipment and medical equipment (not specifically designed for life support)

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