

# 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 ±10%
- Low power consumption...(Vcc = 3 V)

	Mixer	IF amp. + RSSI
During operation	2.1 mA (TYP.)	0.95 mA (TYP.)
At power-OFF	0 μA (TYP.)	2.2 <i>μ</i> Α (TYP.)

- High limiting sensitivity...-91 dBm (TYP.)
- High-precision RSSI linearity...±0.5 dB (TYP.) (VIF IN = -86 to -6 dBm)
- · High-speed RSSI response time

RSSI output rise time	77μs (TYP.)		
RSSI output fall time	113 μs (TYP.)		

· High-speed power-ON/OFF switching time

Rise time at power-ON	174 μs (TYP.)
Fall time at power-OFF	3 μs (TYP.)

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

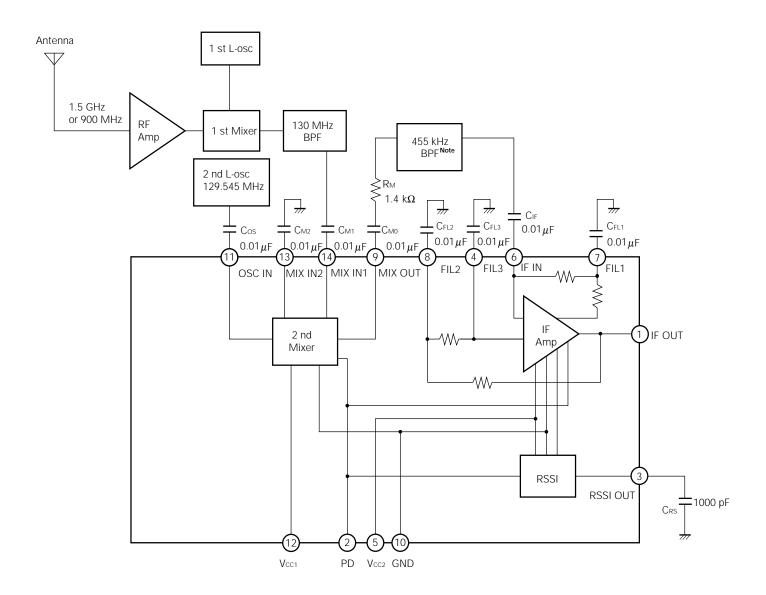
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# ORDERING INFORMATION

Part number	Package
μPC8001GR	14-pin plastic shrink SOP (225 mil)
μPC8001GR-E1	14-pin plastic shrink SOP (225 mil) Embossed carrier taping (Pin 1 located toward tape unwind direction)
μPC8001GR-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  $\,\Omega$ 



# **CONTENTS**

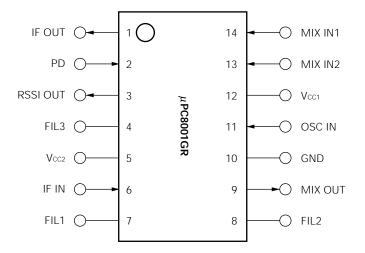
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#### 1. PIN CONFIGURATION AND PIN FUNCTIONS

# (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

Vcc1, Vcc2 : Power Supply

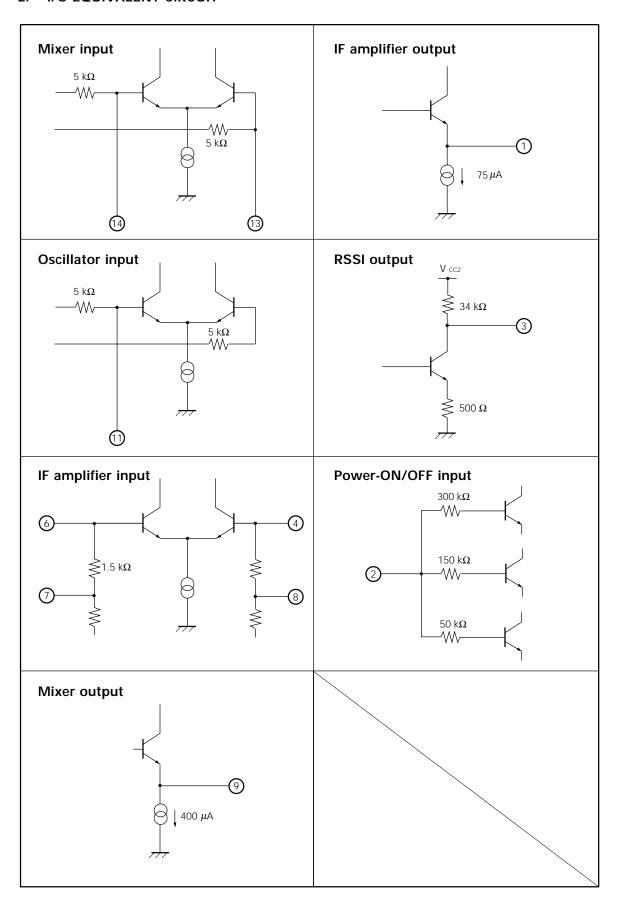


# (2) PIN FUNCTIONS

Number	Pin Name	I/O	Function
1	IF OUT	0	IF amplifier output
2	PD	1	Power-ON/OFF control signal input High level: Power-ON; Low level: Power-OFF
3	PSSI OUT	0	RSSI output
4	FIL3		Connect capacitor for filter.
5	Vcc2		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	0	Mixer output
10	GND	_	Ground pin
11	OSC IN	I	Oscillator input
12	Vcc1		Mixer power pin
13	MIX IN2	1	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	Vcc		7	٧
Total power dissipation	Рт		300	mW
Operating ambient temperature	Та		-30 to +85	°C
Storage temperature	Tstg		-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 (TA = 25°C)

Parameter	Symbol	Conditions		MIN.	TYP.	MAX.	Unit
Supply voltage	<b>V</b> cc			2.7	3.0	3.3	V
Mixer input level	V <sub>MIX IN</sub>	See Figure 3-1.	50 $\Omega$ termination	-100		-20	dBmNote1
iviixei iriput ievei	V IVIIX IIV	See Figure 3-1.	LC matching	-113 <sup>Note2</sup>		-33 <sup>Note2</sup>	dBmNote1
IF amplifier input level	V <sub>IF</sub> IN			-86		-6	dBm <sup>Note1</sup>
Oscillator input level	Vosc in			-30	-15	-5	dBmNote1
IF amplifier input frequency	fif in			400	455	500	kHz
Mixer input frequency	fmix in			80	130	150	MHz
Mixer output frequency	<b>f</b> міх оит			400	455	500	kHz

Notes 1. Assuming a conversion value of 50  $\Omega$ , 0 dBm = 0.2236 V<sub>rms</sub>.

2. Depends on board wiring pattern, use as reference value.



#### **ELECTRICAL CHARACTERISTICS**

(TA = 25°C, Vcc1 = Vcc2 = 3 V, fmix in = 130 MHz, fosc in = 129.545 MHz, fif in = 455 kHz, Crs = 1000pF, Cos = Cm1 = Cm2 = Cm0 = Cif = Cfl1 = Cfl2 = Cfl3 =  $0.01\mu$ F, 0 dBm = 0.2236 Vrms)

#### (1) Mixer

Parameter	Symbol	Cond	itions	MIN.	TYP.	MAX.	Unit
Supply current	Icc1	No signal			2.1	3.0	mA
Conversion sain	CG	VMIN IN = -50dBm	$50\Omega$ termination	15	20	23	dB
Conversion gain	CG	Vosc IN = -15 dBm See Figure 3-1.	LC matching		33Note 1		uВ
Third order intercept	IC <sub>3</sub>	See Figure 3-2.		-13	-8		dBm
-1dB compression output level	Vomix	Vosc IN=-15dBm		-5	0		dBm
- as compression curput to to	Commix	See Figure 3-3.					3
Cut-off frequency	fc	-3 dB point		200	470		MHz
Noise figure	NF	See Figure 3-6.			10 <sup>Note 1</sup>		dB
Local isolation	ISL			20	26		dB
Mixer input impedance	Zıм				48-j383		Ω
Local input impedance	ZıL				80-j425		Ω
Output resistance	Rом			60	120	180	Ω
Power-ON rise time Note2	tonm	Von = 3 V			33	600	μs
1 OWEI - OIV 113C time	tomin	Rise time of PD signal : 10 ns			33	000	μ
Power-OFF fall time Note3 topm		Vof = 0 V			3	200	μs
TOWER-OFF Tall tillic	LOFINI	Fall time of PD signal : 10 ns				200	μο
Power-OFF supply current	Іьм	Vof = 0 V			0	10	μΑ

Notes 1. Depends on board wiring pattern, use as reference value.

- 2. Time until DC voltage of mixer output reaches  $\pm 10\%$  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	Von	Power-ON over Von and under Vcc		1.2	2.4	٧
Power-OFF input voltage	Vof	Power-OFF over GND and under VoF	0.6	1.2		V
Power-ON input current	Ion	Von = 3 V		48	75	μΑ

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# (3) IF Amplifier/RSSI

Parameter	Symbol	Conditions		MIN.	TYP.	MAX.	Unit
Supply current	Icc2	No signal			0.95	1.3	mA
IF amplifier output amplitude	Vo	Vif in = -20 dBm		1.2	1.5	1.8	V <sub>p-p</sub>
Limiting sensitivity	LS	-3dB point, see Figu	re 4-5.		-91	-86	dBm
IF amplifier input impedance	Zın			1.2	1.5	1.8	kΩ
IF amplifier phase variation	$\Delta\phi$	V <sub>IF IN</sub> =-86 to -6 dBm See <b>Figure 4-6</b> Note1.			11		deg
RSSI linearity	Lrs	$V_{IF IN} = -86 \text{ to } -6 \text{ dBm}$ Recursive calculation with $V_{IF IN} = -60 \text{ to } $	1		±0.5	±2	dB
RSSI slope	SLRS	Recursive calculation with V <sub>IF IN</sub> = -60 to -6		22.3	24.4	30.1	mV/dB
RSSI intercept	ICrs	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>	Vif in = -86 dBm		0.50	0.79	0.98	V
RSSI output voltage 2	V <sub>R2</sub>	Vif in = -46 dBm		1.60	1.79	1.90	V
RSSI output voltage 3	V <sub>R3</sub>	Vif in = -6 dBm		2.70	2.75	2.82	V
RSSI output temperature stability	ST	V <sub>IF IN</sub> = -86 to -6 dBm T <sub>A</sub> = -30 to +85 °C	1,		1		dB
RSSI rise time	trRS	V <sub>IF IN</sub> = -6 dBm See <b>Figure 3-5</b> .			77	300	μs
RSSI fall time	trRS	V <sub>IF IN</sub> = -6 dBm See <b>Figure 3-5</b> .			113	300	μs
RSSI output ripple	VRRS	VIF IN = -6 dBm			3	12	mV <sub>p-p</sub>
Power-OFF supply current	lu	Vof = 0 V			2.2	10	μΑ
Power-ON rise time Note2	toni	Von = 3 V, ViF in = -86 dBm PD signal rise time: 10 ns			174	600	μs
Power-OFF fall time Note3	tori	VoF = 0 V PD signal fall time: 1	0 ns		3	200	μs
IF amplifier output slew rate	SRo	VIF IN = -20 dBm	Rise Note4		3.4		\// -
		VIF IIV = -20 UDIII	Fall Note5		3.8		V/μs
RSSI output resistance	Ror			27	34	41	kΩ

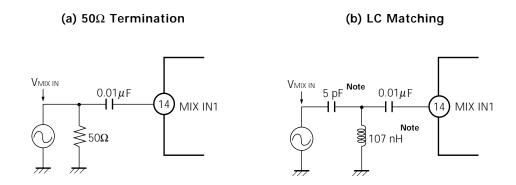
**★ Notes 1.** Use the network analyzer at RBW = 3 Hz.

2. Time until RSSI output reaches  $\pm 10\%$  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



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  $50\Omega$ .

**Remark** The signal source impedance is  $50\Omega$ .

MIX IN1 MIX OUT OSC IN 14 Vosc IN = -15 dBm $0.01 \mu F$ \_0.01µF 0.01μ F  $50 \Omega$ 50 Ω  $16.7 \Omega \leq$ fosc in = 129.545 MHz Measure 455 kHz component level with spectrum analyzer  $16.7 \Omega \lesssim$  $\leq$  16.7  $\Omega$ f = 130 MHzVміхо∪т [dBm] 6 dB/OCT  $f_1 = 130.1 \text{ MHz}$  $f_1 = 130.1 \text{ MHz}, f_2 = 130.2 \text{ MHz}$  $f_2 = 130.2 \text{ MHz}$ 18 dB/OCT VMIX IN [dBm]

Figure 3-2. Third Order Intercept

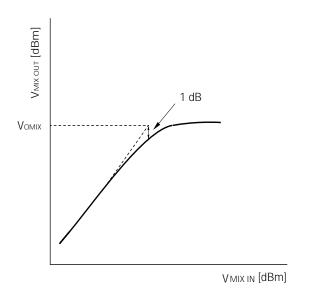
**Remark** Signal source impedance is  $50\Omega$ .

Third order intercept



Figure 3-3. -1 dB Compression Output Level

Figure 3-4. RSSI Intercept



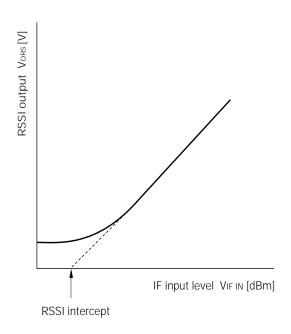


Figure 3-5. RSSI Response Time

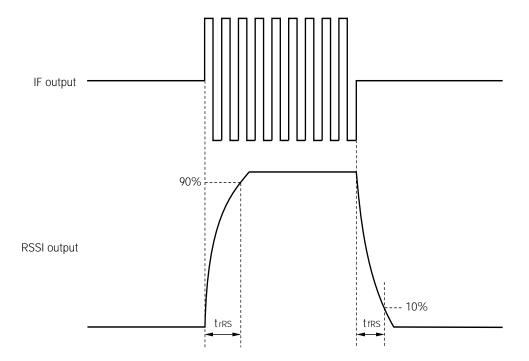
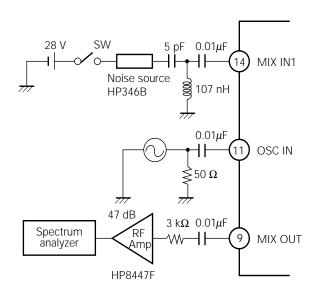


Figure 3-6. Noise Figure Measurement



The noise figure is calculated as follows:

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

NF (dB): Noise figure

ENR (dB): ENR of noise source

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

 $\ensuremath{\mathsf{N}}_1$  (dBm): Spectrum analyzer indication value at SW OFF.

N2 (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

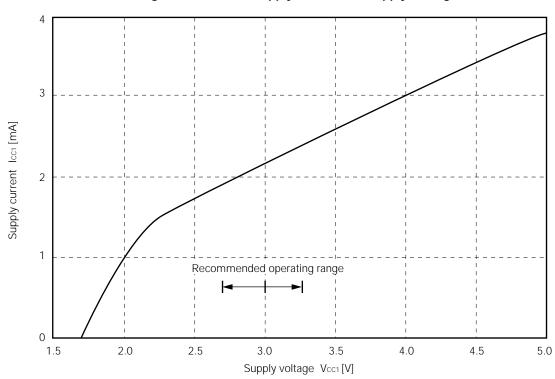
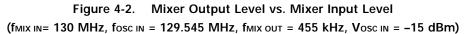


Figure 4-1. Mixer Supply Current vs. Supply Voltage



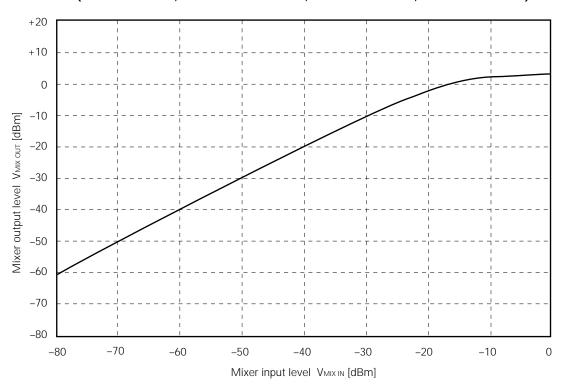


Figure 4-3. Mixer Conversion Gain vs. Mixer Input Frequency (VMIX IN= -30 dBm, Vosc IN = -15 dBm, fosc IN = fMIX IN - fMIX OUT, fMIX OUT = 455 kHz)

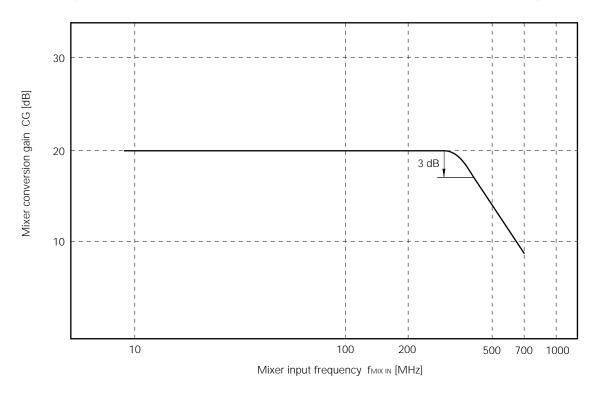
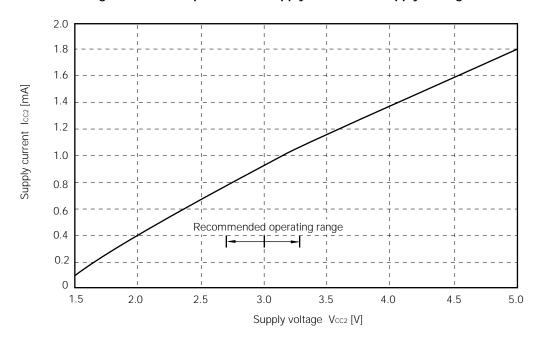


Figure 4-4. IF Amplifier/RSSI Supply Current vs. Supply Voltage





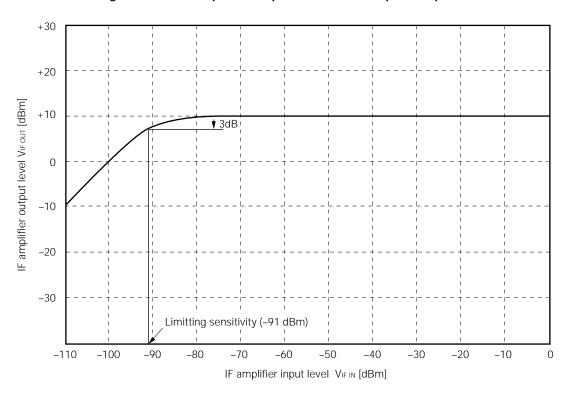
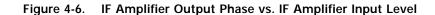


Figure 4-5. IF Amplifier Output Level vs. IF Amplifier Input Level



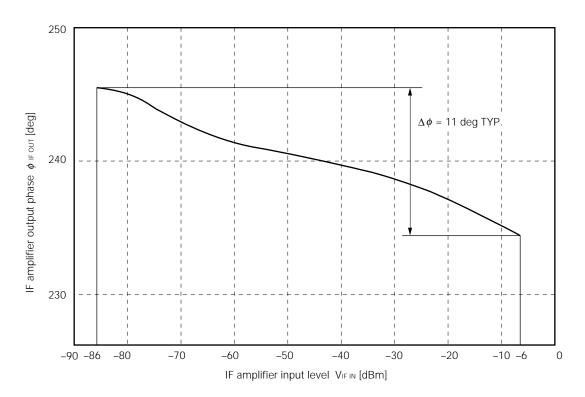
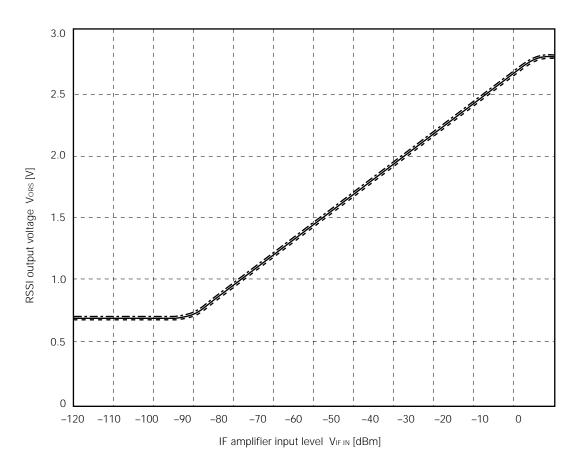


Figure 4-7. RSSI Output Voltage vs. IF Amplifier Input Level (The temperature characteristics curves)

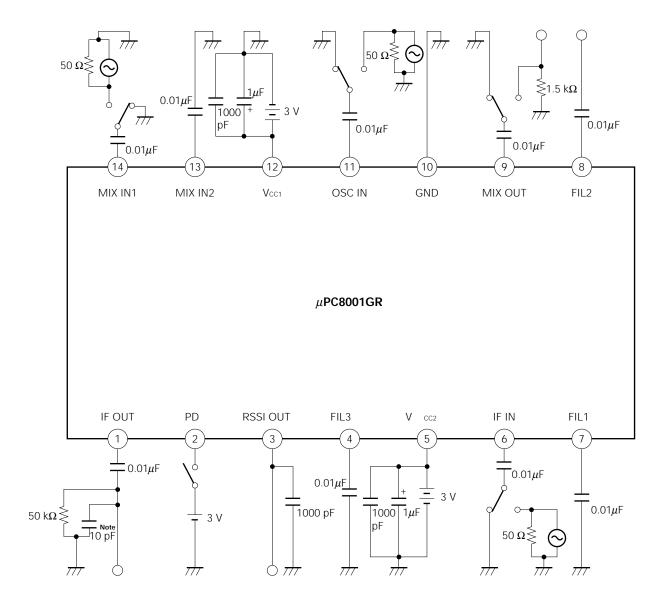


Remarks 1. ----- TA = -30 °C ---- TA = +25 °C ---- TA = +85 °C

**2.** The three temperature characteristic curves are virtually identical.



# **★** 5. TEST CIRCUIT EXAMPLE



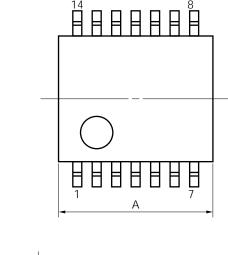
**Note** The value of the capacitance connected to the IF OUT pin (No. 1) includes the capacitances of PCB wiring patterns and the tester.

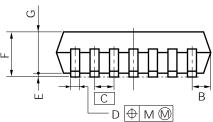
**Remark** In three cases of Mixer Input, Third Order Intercept and Noise Figure Measurement, refer to Figures 3-1, 3-2, and 3-6.



# 6. PACKAGE DRAWINGS

# 14 PIN PLASTIC SHRINK SOP (225 mil)

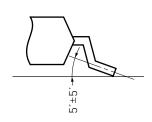


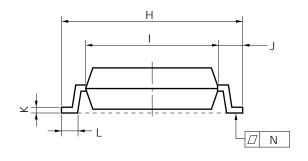


NOTE

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
Α	5.40 MAX.	0.213 MAX.
В	0.75 MAX.	0.030 MAX.
С	0.65 (T.P.)	0.026 (T.P.)
D	$0.30^{+0.10}_{-0.05}$	0.012+0.004
Е	0.125±0.075	0.005±0.003
F	1.8 MAX.	0.071MAX.
G	1.44	0.057
Н	6.2±0.3	0.244±0.012
1	4.4	0.173
J	0.9	0.035
K	$0.15^{+0.10}_{-0.05}$	$0.006^{+0.004}_{-0.002}$
L	0.5±0.2	0.020+0.008
М	0.10	0.004
N	0.10	0.004



#### 7. RECOMMENDED SOLDERING CONDITIONS

The following conditions must be met for soldering conditions of the  $\mu$ PC8001. For more details, refer to our document "SEMICONDUCTOR DEVICE MOUNTING TECHNOLOGY MANUAL" (IEI-1207).

Please consolt 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**

 $\mu$ PC8001GR: 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  [Remark]  (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**

pins.

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

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Anti-radioactive design is not implemented in this product.

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