

# BIPOLAR ANALOG INTEGRATED CIRCUIT

# $\mu$ PC8163TB

### SILICON MMIC 2.0 GHz FREQUENCY UP-CONVERTER FOR CELLULAR TELEPHONE

#### DESCRIPTION

The  $\mu$ PC8163TB is a silicon monolithic integrated circuit designed as frequency up-converter for cellular telephone transmitter stage. The  $\mu$ PC8163TB has improved intermodulation performance and smaller package.

The  $\mu$ PC8163TB is manufactured using NEC's 20 GHz fr NESAT™III silicon bipolar process. This process uses silicon nitride passivation film and gold electrodes. These materials can protect chip surface from external pollution and prevent corrosion/migration. Thus, this IC has excellent performance, uniformity and reliability.

#### FEATURES

- Recommended operating frequency :  $f_{RFout} = 0.8$  to  $2.0$  GHz,  $f_{Fin} = 50$  to  $300$  MHz
- Supply voltage :  $V_{CC} = 2.7$  to  $3.3$  V
- High-density surface mounting : 6-pin super minimold package
- Higher  $IP_3$  :  $OIP_3 = +9.5$  dBm @  $f_{RFout} = 830$  MHz
- Minimized carrier leakage : Due to double balanced mixer

#### APPLICATION

- Digital cellular phones

#### ORDERING INFORMATION

Part Number	Package	Marking	Supplying Form
$\mu$ PC8163TB-E3	6-pin super minimold	C2Y	Embossed tape 8 mm wide. Pin 1, 2, 3 face the tape perforation side. Qty 3 kpcs/reel

**Remark** To order evaluation samples, please contact your local NEC sales office (Part number for sample order:  $\mu$ PC8163TB).

#### 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.

**CONTENTS**

1. PIN CONNECTIONS..... 3

2. PRODUCT LINE-UP..... 3

3. INTERNAL BLOCK DIAGRAM..... 3

4. SYSTEM APPLICATION EXAMPLE..... 4

5. PIN EXPLANATION ..... 5

6. ABSOLUTE MAXIMUM RATINGS..... 6

7. RECOMMENDED OPERATING RANGE ..... 6

8. ELECTRICAL CHARACTERISTICS ..... 6

9. OTHER CHARACTERISTICS, FOR REFERENCE PURPOSES ONLY ..... 6

10. TEST CIRCUIT ..... 7

    10.1 Test Circuit 1 (f<sub>RFout</sub> = 830 MHz)..... 7

    10.2 Test Circuit 2 (f<sub>RFout</sub> = 1.9 GHz)..... 8

11. TYPICAL CHARACTERISTICS..... 9

12. S-PARAMETERS ..... 13

    12.1 S-parameters for Matched RF Output – with test circuits 1 and 2 – ..... 13

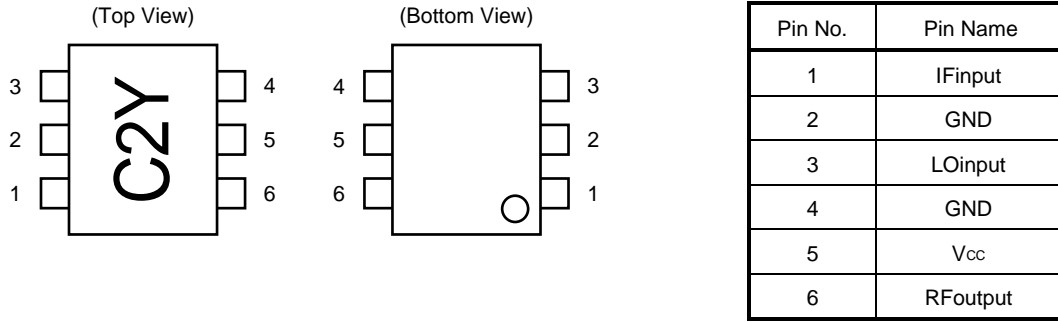
    12.2 S-parameters for Each Port ..... 14

13. PACKAGE DIMENSIONS..... 15

14. NOTE ON CORRECT USE..... 16

15. RECOMMENDED SOLDERING CONDITIONS..... 16

1. PIN CONNECTIONS



★ 2. PRODUCT LINE-UP (T<sub>A</sub> = +25°C, V<sub>CC</sub> = V<sub>RFout</sub> = 3.0 V, Z<sub>S</sub> = Z<sub>L</sub> = 50 Ω)

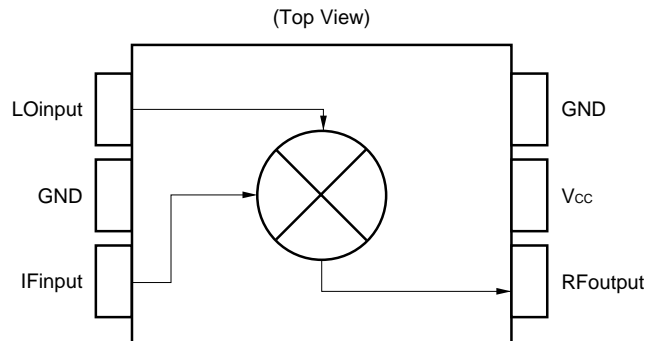
Part Number	I <sub>CC</sub> (mA)	f <sub>RFout</sub> (GHz)	CG (dB)		
			@RF 0.9 GHz <sup>Note</sup>	@RF 1.9 GHz	@RF 2.4 GHz
μPC8106TB	9	0.4 to 2.0	9	7	–
μPC8109TB	5	0.4 to 2.0	6	4	–
μPC8163TB	16.5	0.8 to 2.0	9	5.5	–
μPC8172TB	9	0.8 to 2.5	9.5	8.5	8.0
μPC8187TB	15	0.8 to 2.5	11	11	10

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
μPC8106TB	–2	–4	–	+5.5	+2.0	–
μPC8109TB	–5.5	–7.5	–	+1.5	–1.0	–
μPC8163TB	+0.5	–2	–	+9.5	+6.0	–
μPC8172TB	+0.5	0	–0.5	+7.5	+6.0	+4.0
μPC8187TB	+4	+2.5	+1	+10	+10	+8.5

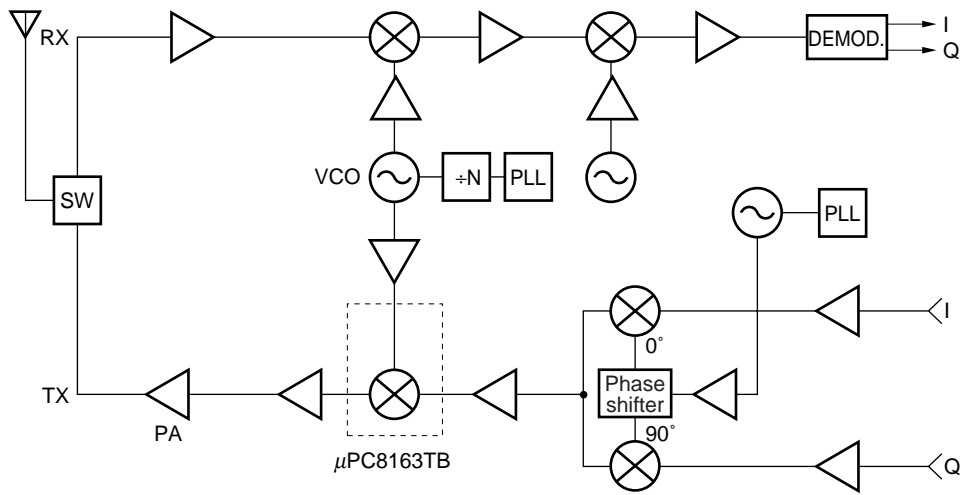
**Note** f<sub>RFout</sub> = 0.83 GHz @ μPC8163TB and μPC8187TB

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

3. INTERNAL BLOCK DIAGRAM (for the μPC8163TB)



4. SYSTEM APPLICATION EXAMPLE (schematics of IC location in the system)



5. PIN EXPLANATION

Pin No.	Pin Name	Applied Voltage (V)	Pin Voltage (V) <small>Note</small>	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	Vcc	2.7 to 3.3	—	Supply voltage pin.	
6	RFoutput	Same bias as Vcc 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  $V_{CC} = V_{RFout} = 3.0 V$ .

**6. ABSOLUTE MAXIMUM RATINGS**

Parameter	Symbol	Test Conditions	Rating	Unit
Supply Voltage	V <sub>CC</sub>	T <sub>A</sub> = +25°C, Pin 5 and 6	3.6	V
★ Package Power Dissipation	P <sub>D</sub>	Mounted on double-sided 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	3.0	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	-	2.0	GHz	With external matching circuit
IF Input Frequency	f <sub>IFin</sub>	50	-	300	MHz	

**8. ELECTRICAL CHARACTERISTICS (T<sub>A</sub> = +25°C, V<sub>CC</sub> = V<sub>RFout</sub> = 3.0 V, f<sub>IFin</sub> = 150 MHz, P<sub>LOin</sub> = -5 dBm)**

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Circuit Current	I <sub>CC</sub>	No input signal	11.5	16.5	23	mA
Conversion Gain 1	CG1	f <sub>RFout</sub> = 830 MHz, P <sub>IFin</sub> = -20 dBm	6	9	12	dB
Conversion Gain 2	CG2	f <sub>RFout</sub> = 1.9 GHz, P <sub>IFin</sub> = -20 dBm	2.5	5.5	8.5	dB
Saturated Output Power 1	P <sub>O(sat)</sub> 1	f <sub>RFout</sub> = 830 MHz, P <sub>IFin</sub> = 0 dBm	-1.5	+0.5	-	dBm
Saturated Output Power 2	P <sub>O(sat)</sub> 2	f <sub>RFout</sub> = 1.9 GHz, P <sub>IFin</sub> = 0 dBm	-4.5	-2	-	dBm

**9. OTHER CHARACTERISTICS, FOR REFERENCE PURPOSES ONLY**

(T<sub>A</sub> = +25°C, V<sub>CC</sub> = V<sub>RFout</sub> = 3.0 V, P<sub>LOin</sub> = -5 dBm)

Parameter	Symbol	Conditions	Reference Value	Unit	
3rd Order Distortion Input Intercept Point	IIP <sub>3</sub> 1	f <sub>IFin</sub> 1 = 150.0 MHz	f <sub>RFout</sub> = 830 MHz	+0.5	dBm
	IIP <sub>3</sub> 2	f <sub>IFin</sub> 2 = 150.4 MHz	f <sub>RFout</sub> = 1.9 GHz	+0.5	
3rd Order Distortion Output Intercept Point	OIP <sub>3</sub> 1	f <sub>IFin</sub> 1 = 150.0 MHz	f <sub>RFout</sub> = 830 MHz	+9.5	dBm
	OIP <sub>3</sub> 2	f <sub>IFin</sub> 2 = 150.4 MHz	f <sub>RFout</sub> = 1.9 GHz	+6.0	
SSB Noise Figure	SSB • NF	f <sub>RFout</sub> = 830 MHz, f <sub>IFin</sub> = 150 MHz	12.5	dB	

10. TEST CIRCUIT

10.1 Test Circuit 1 (f<sub>RFout</sub> = 830 MHz)

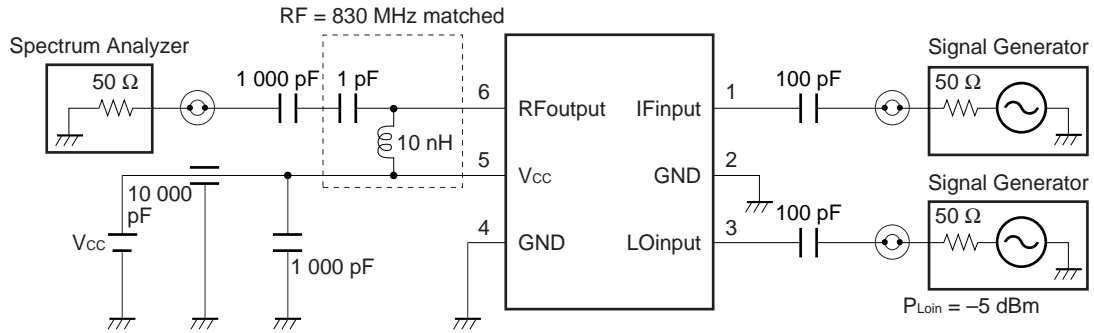
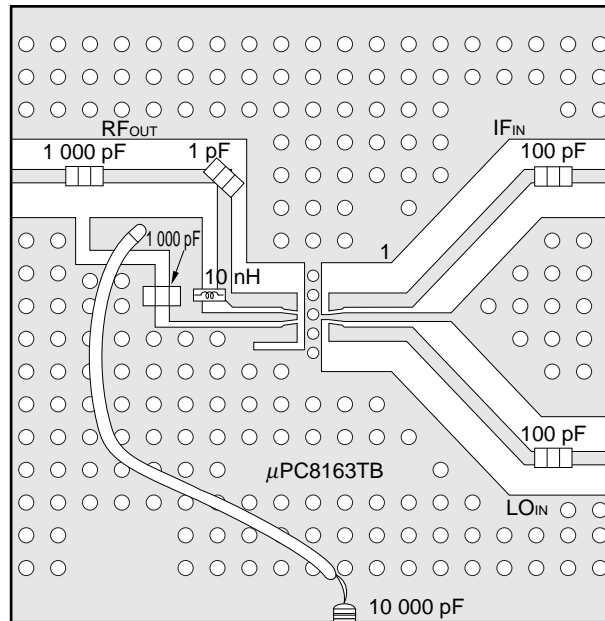


ILLUSTRATION OF TEST CIRCUIT 1 ASSEMBLED ON EVALUATION BOARD



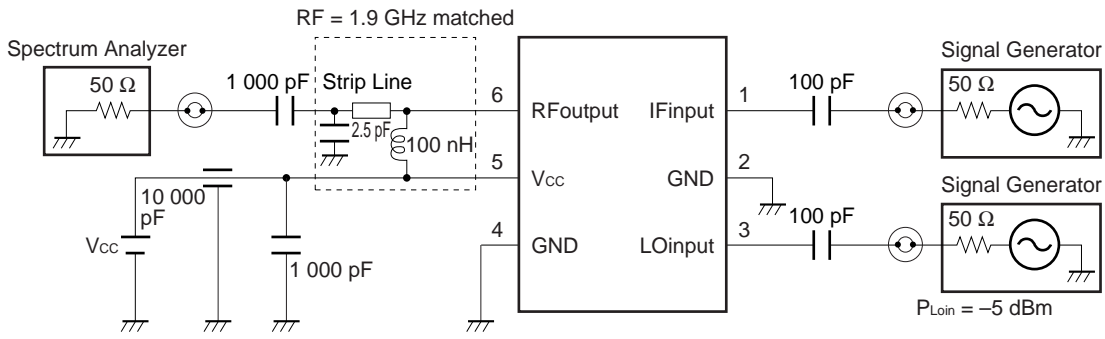
EVALUATION BOARD CHARACTERS

- (1) Double-sided copper clad 35 × 42 × 0.4 mm polyimide board
- (2) Back side: GND pattern
- (3) Solder plated patterns
- (4) ○: Through holes

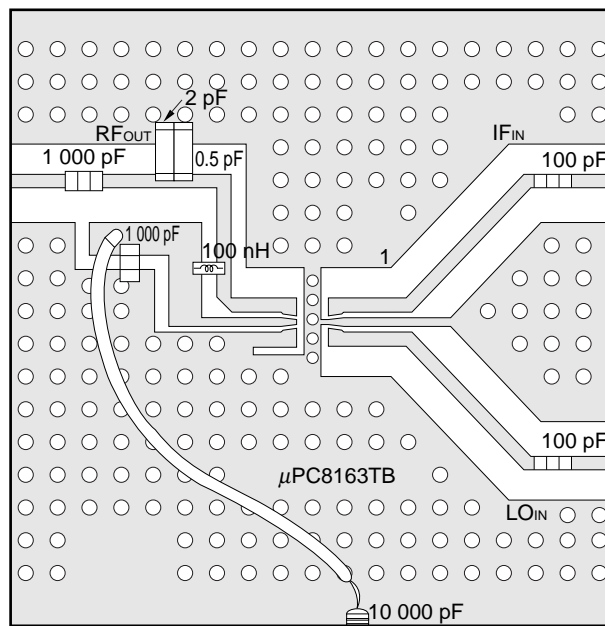
**Caution** Test circuit or print pattern in this sheet is for testing IC characteristics.

In the case of actual system application, external circuits including print pattern and matching circuit constant of output port should be designed in accordance with IC's S parameters and environmental components.

**10.2 Test Circuit 2 ( $f_{RFout} = 1.9$  GHz)**



**ILLUSTRATION OF TEST CIRCUIT 2 ASSEMBLED ON EVALUATION BOARD**

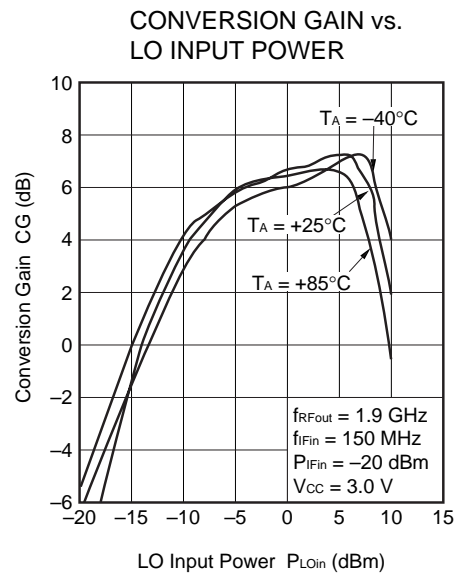
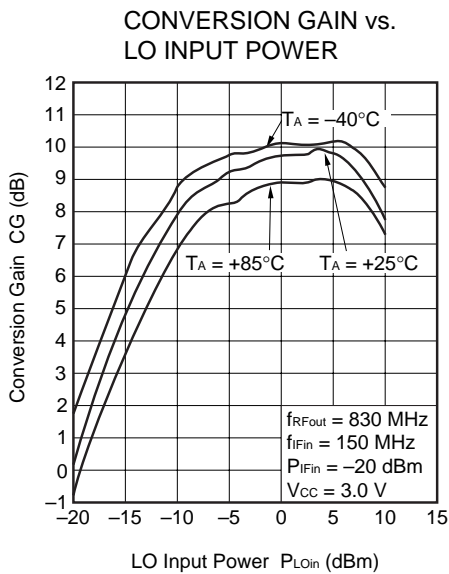
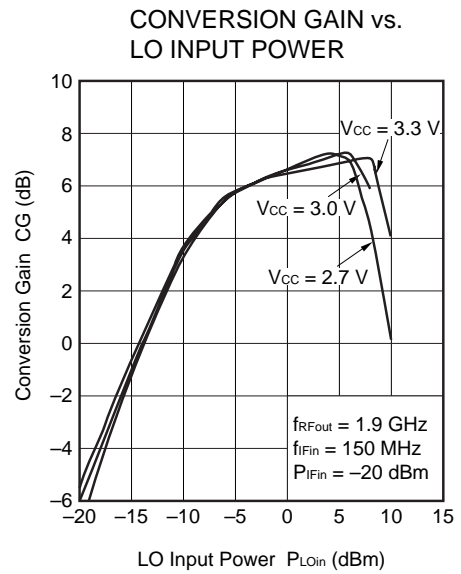
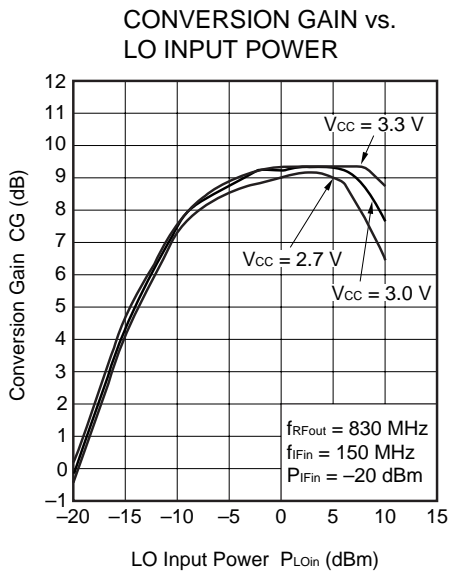
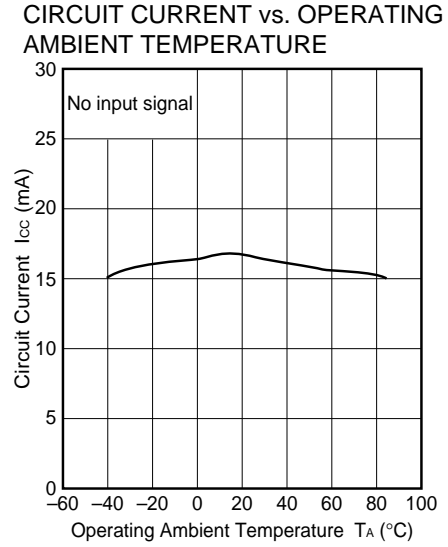
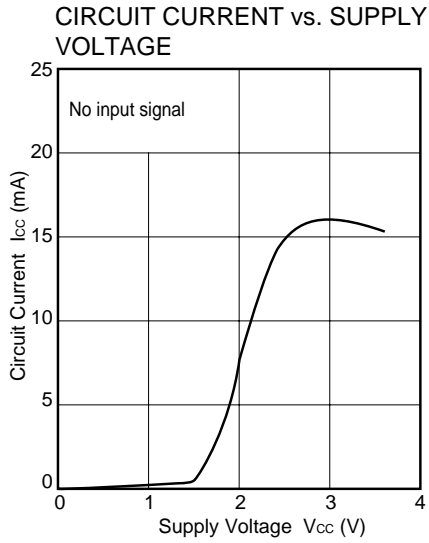


**EVALUATION BOARD CHARACTERS**

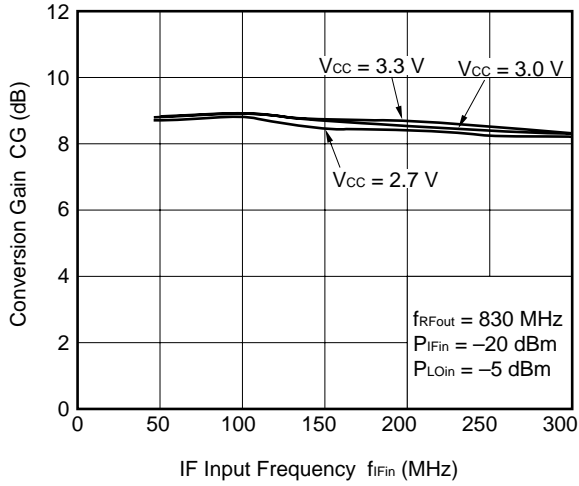
- (1) Double-sided copper clad 35 × 42 × 0.4 mm polyimide board
- (2) Back side: GND pattern
- (3) Solder plated patterns
- (4) ○: Through holes



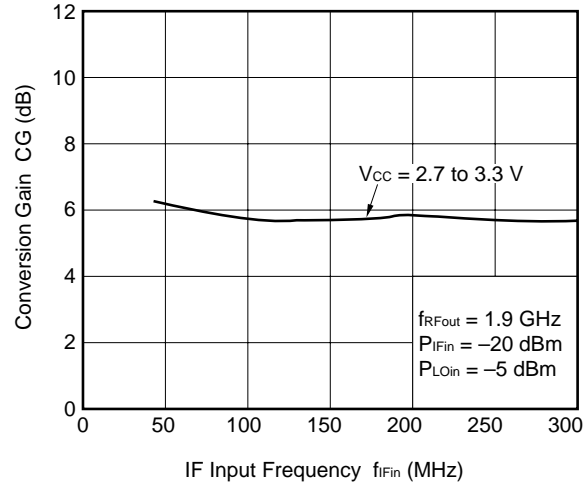
11. TYPICAL CHARACTERISTICS ( $T_A = +25^\circ\text{C}$ , unless otherwise specified  $V_{CC} = V_{RFout}$ )



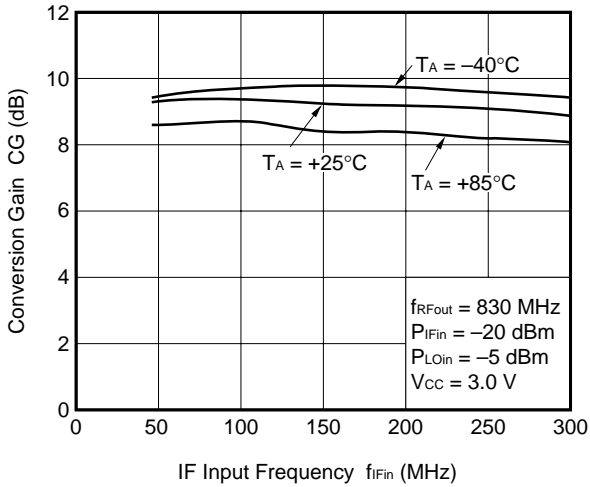
CONVERSION GAIN vs. IF INPUT FREQUENCY



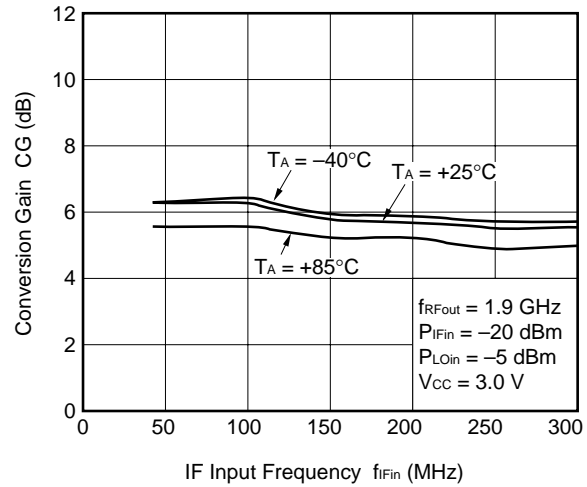
CONVERSION GAIN vs. IF INPUT FREQUENCY



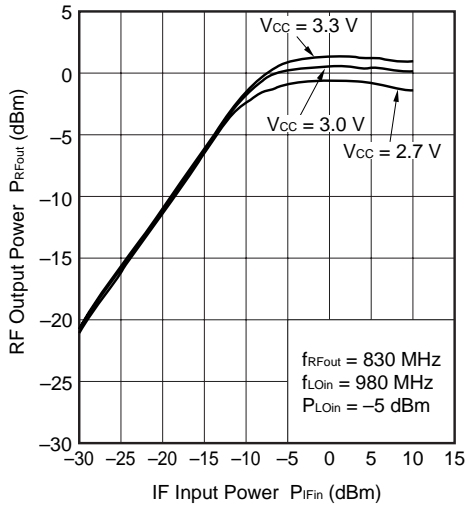
CONVERSION GAIN vs. IF INPUT FREQUENCY



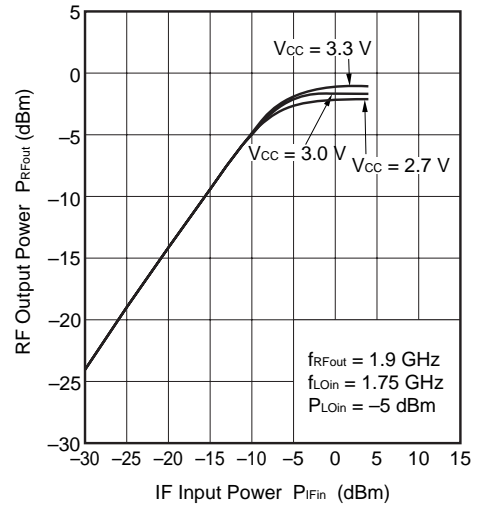
CONVERSION GAIN vs. IF INPUT FREQUENCY



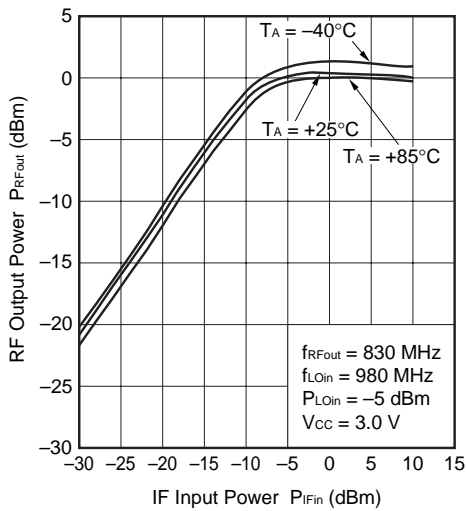
RF OUTPUT POWER vs. IF INPUT POWER



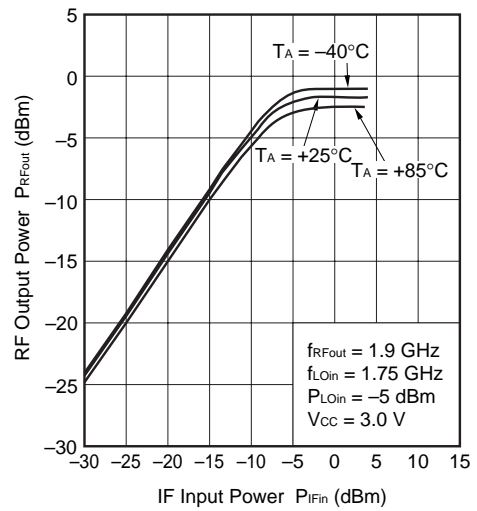
RF OUTPUT POWER vs. IF INPUT POWER



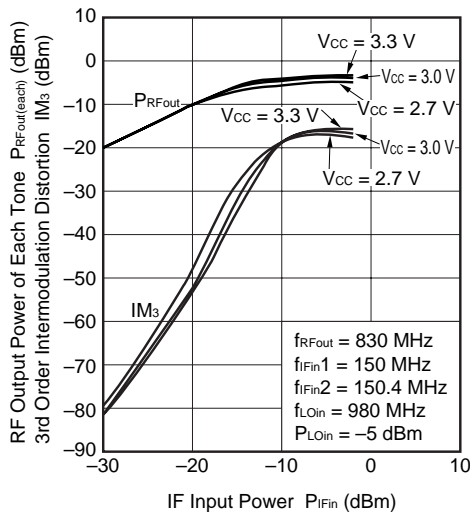
RF OUTPUT POWER vs. IF INPUT POWER



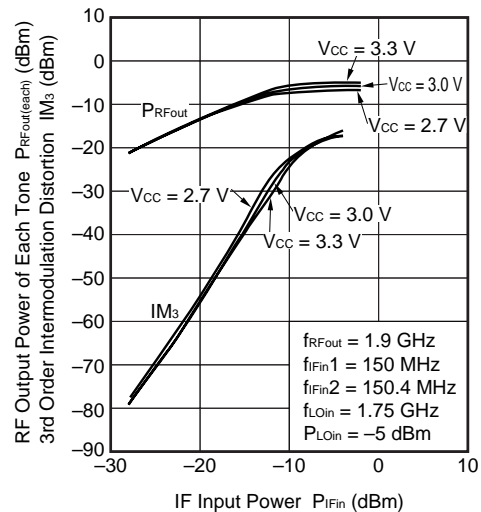
RF OUTPUT POWER vs. IF INPUT POWER



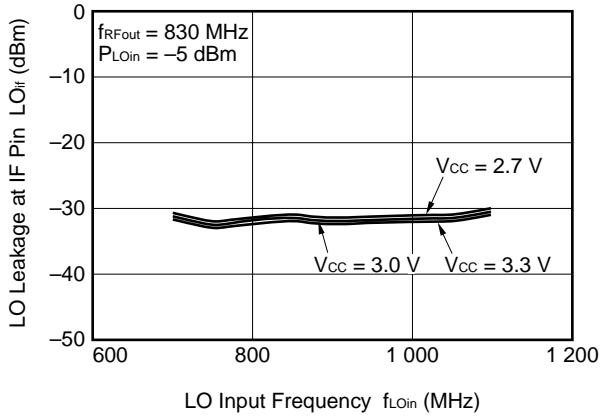
RF OUTPUT POWER OF EACH TONE, IM3 vs. IF INPUT POWER



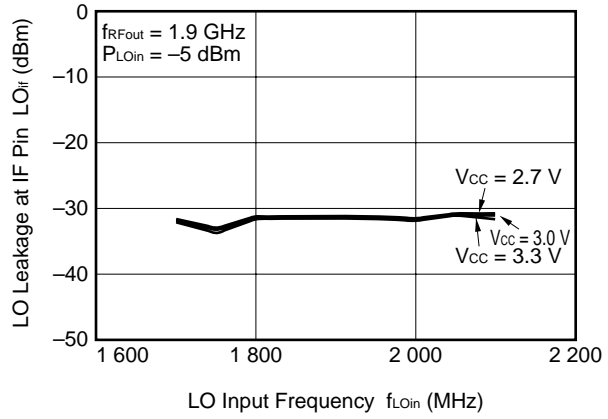
RF OUTPUT POWER OF EACH TONE, IM3 vs. IF INPUT POWER



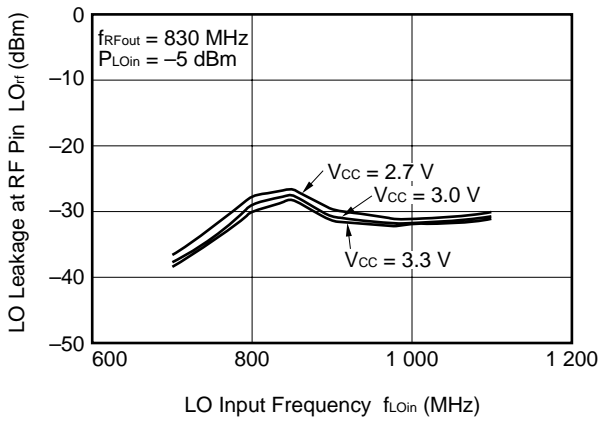
LO LEAKAGE AT IF PIN vs. LO INPUT FREQUENCY



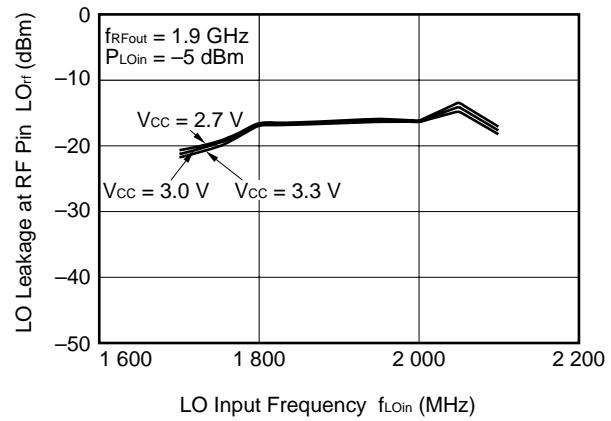
LO LEAKAGE AT IF PIN vs. LO INPUT FREQUENCY



LO LEAKAGE AT RF PIN vs. LO INPUT FREQUENCY



LO LEAKAGE AT RF PIN vs. LO INPUT FREQUENCY



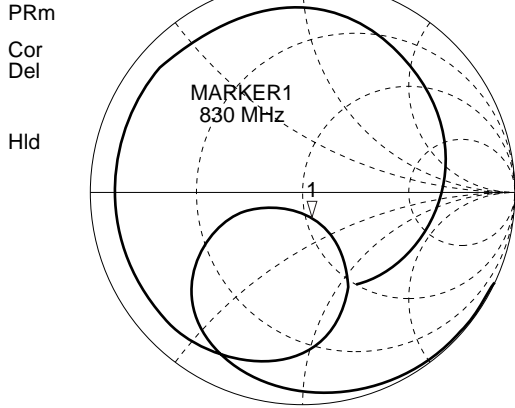
**Remark** The graphs indicate nominal characteristics.

12. S-PARAMETERS

12.1 S-parameters for Matched RF Output ( $V_{CC} = V_{RFout} = 3.0\text{ V}$ ) – with test circuits 1 and 2 – (monitored at RF connector on board)

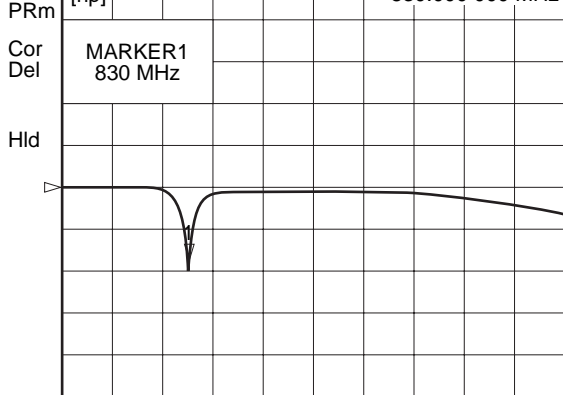
- RF output matched at 830 MHz

CH1 S<sub>11</sub> 1 U FS 1; 53.422 Ω -14.973 Ω 12.807 pF  
[hp] 830.000 000 MHz



START 100.000 000 MHz STOP 3 000.000 000 MHz

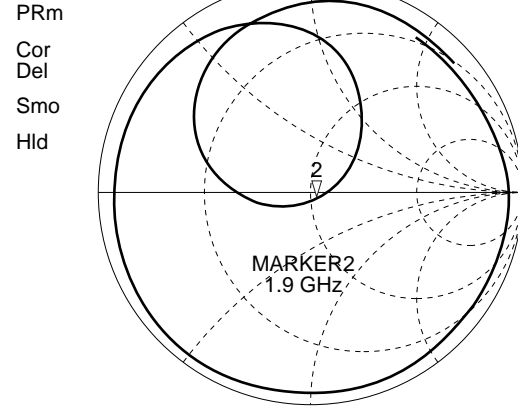
CH1 S<sub>11</sub> log MAG 10 dB/ REF 0 dB 1; -17.331 dB  
[hp] 830.000 000 MHz



START 100.000 000 MHz STOP 3 000.000 000 MHz

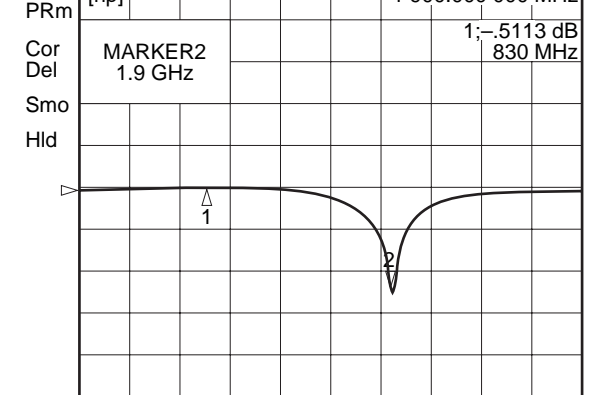
- RF output matched at 1.9 GHz

CH1 S<sub>11</sub> 1 U FS 2; 53.846 Ω -3.7441 Ω 22.373 pF  
[hp] 1 900.000 000 MHz



START 100.000 000 MHz STOP 3 000.000 000 MHz

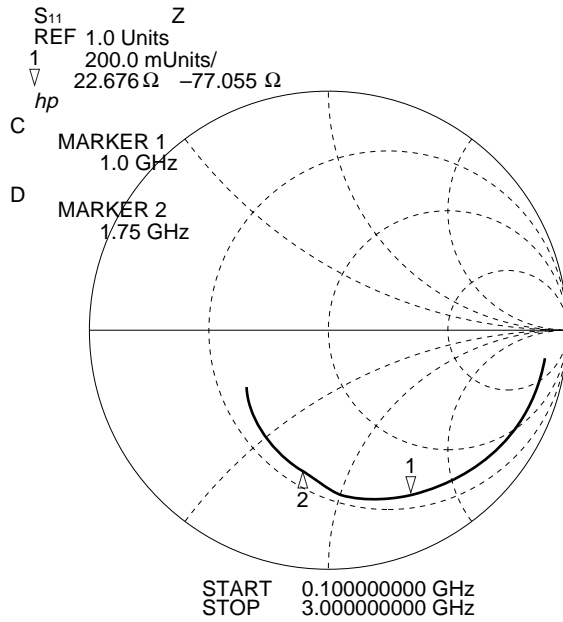
CH1 S<sub>11</sub> log MAG 10 dB/ REF 0 dB 2; -24.741 dB  
[hp] 1 900.000 000 MHz



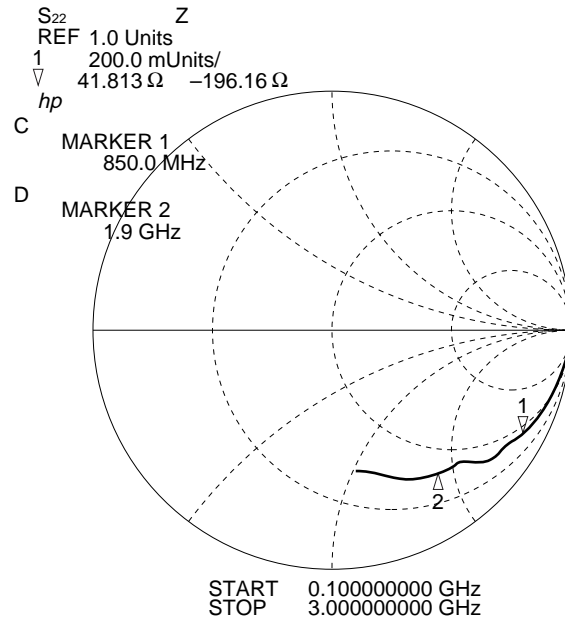
START 100.000 000 MHz STOP 3 000.000 000 MHz

12.2 S-parameters for Each Port ( $V_{CC} = V_{RFout} = 3.0\text{ V}$ )

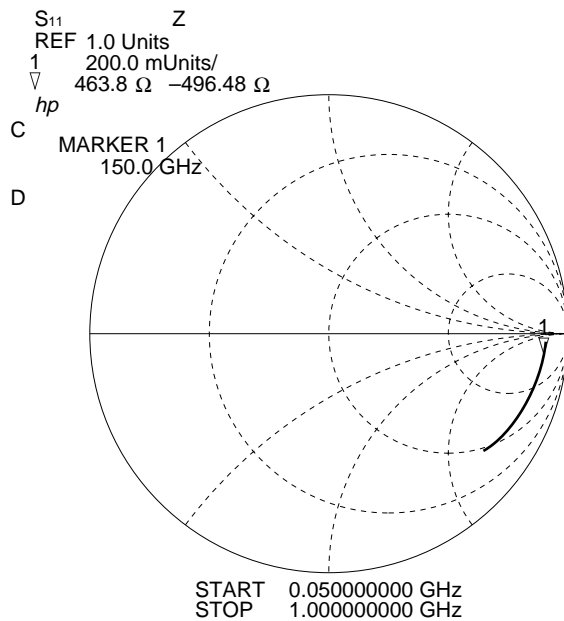
LO port



RF port (no matching)

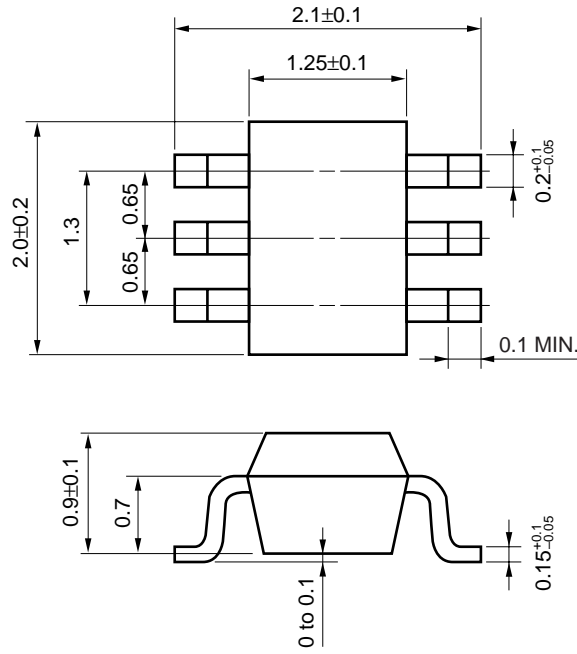


IF port



★ 13. PACKAGE DIMENSIONS

6-PIN SUPER MINIMOLD (UNIT: mm)



**14. NOTE ON CORRECT USE**

- (1) Observe precautions for handling because of electrostatic sensitive devices.
- (2) Form a ground pattern as widely as possible to minimize ground impedance (to prevent undesired oscillation).
- (3) Keep the track length of the ground pins as short as possible.
- (4) Connect a bypass capacitor (example: 1 000 pF) to the Vcc pin.

**15. 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).

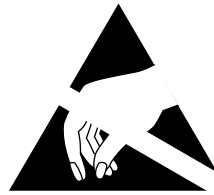
For details of recommended soldering conditions for surface mounting, refer to information document SEMICONDUCTOR DEVICE MOUNTING TECHNOLOGY MANUAL (C10535E).



[MEMO]

[MEMO]

[MEMO]



## ATTENTION

OBSERVE PRECAUTIONS  
FOR HANDLING  
ELECTROSTATIC  
SENSITIVE  
DEVICES

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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)

"Specific": Aircraft, aerospace equipment, submersible repeaters, nuclear reactor control systems, life support systems and medical equipment for life support, etc.

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