



# BIPOLAR ANALOG INTEGRATED CIRCUIT

# $\mu$ PC8204TK

## VARIABLE GAIN AMPLIFIER FOR TRANSMITTER AGC

### DESCRIPTION

The  $\mu$ PC8204TK is a silicon monolithic integrated circuit designed as variable gain amplifier. The package is 6-pin lead-less minimold suitable for surface mount.

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

This IC is as same circuit current as conventional  $\mu$ PC8119T and  $\mu$ PC8120T, but operates at higher frequency and wider gain control range.

### FEATURES

- Gain control range : GCR = 40 dB TYP. @ f = 1.9 GHz  
: GCR = 40 dB TYP. @ f = 2.4 GHz
- Maximum power gain : G<sub>PMAX</sub> = 14.5 dB TYP. @ f = 1.9 GHz  
: G<sub>PMAX</sub> = 14.0 dB TYP. @ f = 2.4 GHz
- Operating frequency :  $f_{in}$  = 0.8 to 2.5 GHz
- Supply voltage :  $V_{CC}$  = 2.7 to 3.3 V
- High-density surface mounting : 6-pin lead-less minimold package

### APPLICATION

- 0.8 to 2.5 GHz transmitter/receiver system (PHS, WLAN and so on)

### ★ ORDERING INFORMATION

Part Number	Order Number	Package	Marking	Supplying Form
$\mu$ PC8204TK-E2	$\mu$ PC8204TK-E2-A	6-pin lead-less minimold (1511 PKG) (Pb-Free) <sup>Note</sup>	6E	<ul style="list-style-type: none"><li>Embossed tape 8 mm wide</li><li>Pin 1, 6 face the perforation side of the tape</li><li>Qty 5 kpcs/reel</li></ul>

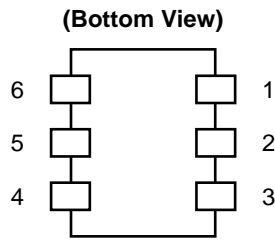
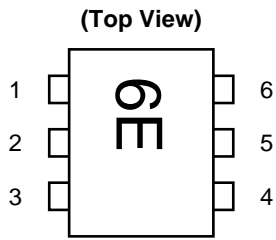
**Note** With regards to terminal solder (the solder contains lead) plated products (conventionally plated), contact your nearby sales office.

**Remark** To order evaluation samples, contact your nearby sales office.  
Part number for sample order:  $\mu$ PC8204TK

**Caution** Observe precautions when handling because these devices are sensitive to electrostatic discharge.

The information in this document is subject to change without notice. Before using this document, please confirm that this is the latest version.

**PIN CONNECTIONS**



Pin No.	Pin Name
1	INPUT
2	GND
3	GND
4	OUTPUT
5	V <sub>CC</sub>
6	V <sub>AGC</sub>

**VARIABLE GAIN AMPLIFIER PRODUCT LINE-UP**

Parameter Part No.	I <sub>CC</sub> (mA)	0.95 GHz output port matching frequency			1.44 GHz output port matching frequency			1.9 GHz output port matching frequency			2.4 GHz output port matching frequency		
		G <sub>PMAX</sub> (dB)	G <sub>CR</sub> (dB)	NF (dB)	G <sub>PMAX</sub> (dB)	G <sub>CR</sub> (dB)	NF (dB)	G <sub>PMAX</sub> (dB)	G <sub>CR</sub> (dB)	NF (dB)	G <sub>PMAX</sub> (dB)	G <sub>CR</sub> (dB)	NF (dB)
μPC8204TK	11.5	-	-	-	-	-	-	14.5	40	7.5	14.0	40	7.5
μPC8119T	11.0	12.5	50	8.5	13.0	45	7.5	(12.5)	(22)	(7.2)	-	-	-
μPC8120T	11.0	13.0	50	9.0	13.5	45	7.5	(13.0)	(22)	(7.3)	-	-	-

- Remarks 1.** Typical performance. Please refer to **ELECTRICAL CHARACTERISTICS** in detail. ( ): reference.  
**2.** To know the associated product, please refer to each latest data sheet.

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1. PIN EXPLANATION

Pin No.	Pin Name	Applied Voltage (V)	Pin Voltage (V) <small>Note</small>	Function and Applications	Internal Equivalent Circuit
1	INPUT	–	1.2	RF input pin. This pin should be coupled with capacitor (example 100 pF) for DC cut. Input return loss can be improved with external impedance matching circuit.	
2 3	GND	0	–	Ground pin. This pin should be connected to system ground with minimum inductance. Ground pattern on the board should be formed as wide as possible. Ground pins must be connected together with wide ground pattern to decrease impedance difference.	
4	OUTPUT	Voltage as same as V <sub>CC</sub> through external inductor	–	RF output pin. This pin is designed as open collector of high impedance. This pin must be externally equipped with matching circuits.	
5	V <sub>CC</sub>	2.7 to 3.3	–	Supply voltage pin. This pin must be equipped with bypass capacitor (example 1 000 pF) to minimize its RF impedance.	—————
6	V <sub>AGC</sub>	0 to 3.3	–	Gain control pin.	

**Note** Pin voltage is measured at V<sub>CC</sub> = 3.0 V

**2. ABSOLUTE MAXIMUM RATINGS**

Parameter	Symbol	Test Conditions	Ratings	Unit
Supply Voltage	V <sub>CC</sub>	T <sub>A</sub> = +25°C, Pin 4, 5	3.6	V
Total Circuit Current	I <sub>CC</sub>	T <sub>A</sub> = +25°C	30	mA
Gain Control Voltage	V <sub>AGC</sub>	T <sub>A</sub> = +25°C	3.6	V
Power Dissipation	P <sub>D</sub>	T <sub>A</sub> = +85°C <b>Note</b>	203	mW
Operating Ambient Temperature	T <sub>A</sub>		-40 to +85	°C
Storage Temperature	T <sub>stg</sub>		-55 to +150	°C
Input Power	P <sub>in</sub>		+5	dBm

**Note** Mounted on double-sided copper-clad 50 × 50 × 1.6 mm epoxy glass PWB

**3. RECOMMENDED OPERATING RANGE**

Parameter	Symbol	MIN.	TYP.	MAX.	Unit	Remarks
Supply Voltage	V <sub>CC</sub>	2.7	3.0	3.3	V	Same voltage should be applied to pin 4 and pin 5.
Operating Ambient Temperature	T <sub>A</sub>	-40	+25	+85	°C	
Operating Frequency	f <sub>in</sub>	0.8	-	2.5	GHz	With external output-matching
Gain Control Voltage	V <sub>AGC</sub>	0	-	3.3	V	

**4. ELECTRICAL CHARACTERISTICS (T<sub>A</sub> = +25°C, V<sub>CC</sub> = V<sub>out</sub> = 3.0 V, Z<sub>s</sub> = Z<sub>L</sub> = 50 Ω, external matched output port, unless otherwise specified)**

Parameter	Symbol	Test Conditions	MIN.	TYP.	MAX.	Unit
Circuit Current	I <sub>CC</sub>	No signal	8.5	11.5	15.0	mA
Maximum Power Gain	G <sub>PMAX</sub>	f = 1.9 GHz, P <sub>in</sub> = -20 dBm f = 2.4 GHz, P <sub>in</sub> = -20 dBm	11.5 11.0	14.5 14.0	17.5 17.0	dB
Gain Control Range <sup>Note</sup>	GCR	f = 1.9 GHz, P <sub>in</sub> = -20 dBm f = 2.4 GHz, P <sub>in</sub> = -20 dBm	35 35	40 40	- -	dB
Gain 1 dB Compression Output Power	P <sub>O(1 dB)</sub>	f = 1.9 GHz, G <sub>PMAX</sub> f = 2.4 GHz, G <sub>PMAX</sub>	+2.0 +2.0	+5.0 +5.0	- -	dBm
Input Return Loss	RL <sub>in</sub>	f = 1.9 GHz, G <sub>PMAX</sub> f = 2.4 GHz, G <sub>PMAX</sub>	8 9	11 13	- -	dB
Isolation	ISL	f = 1.9 GHz, G <sub>PMAX</sub> f = 2.4 GHz, G <sub>PMAX</sub>	25 25	30 30	- -	dB
Noise Figure	NF	f = 1.9 GHz, G <sub>PMAX</sub> f = 2.4 GHz, G <sub>PMAX</sub>	- -	7.5 7.5	10.0 10.0	dB

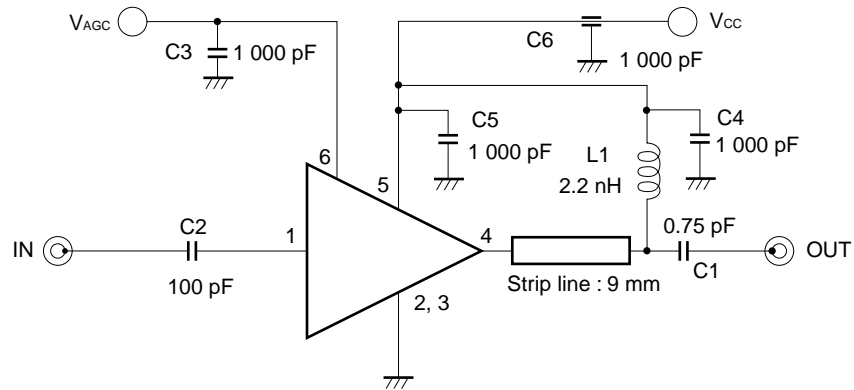
**Note** Gain control range GCR specification : GCR = G<sub>PMAX</sub> - G<sub>PMIN</sub> (dB)

Conditions G<sub>PMAX</sub>@V<sub>AGC</sub> = V<sub>CC</sub>, G<sub>PMIN</sub>@V<sub>AGC</sub> = 0 V

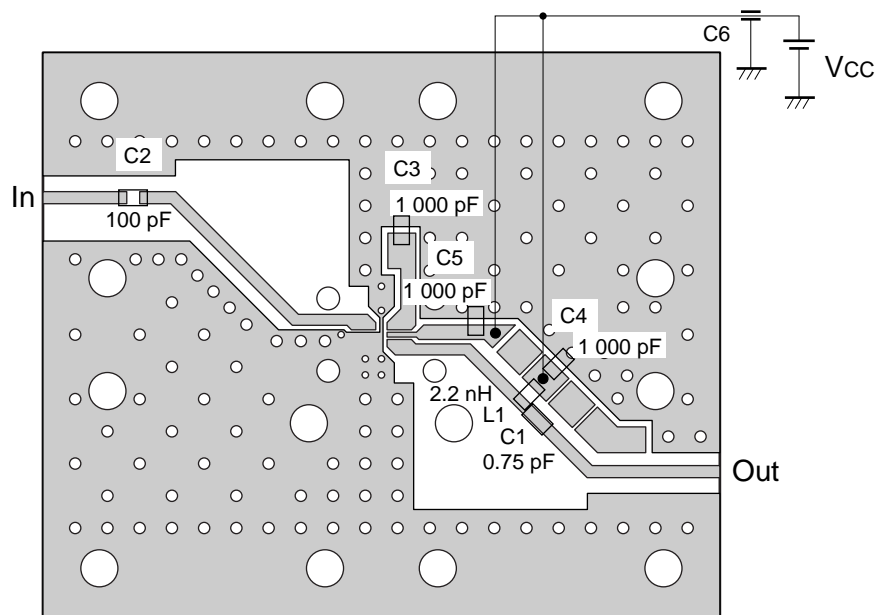
★ 5. TEST CIRCUITS

5.1 f = 1.9 GHz

5.1.1 Test circuit 1



5.1.2 Illustration of the test circuit 1 assembled on evaluation board

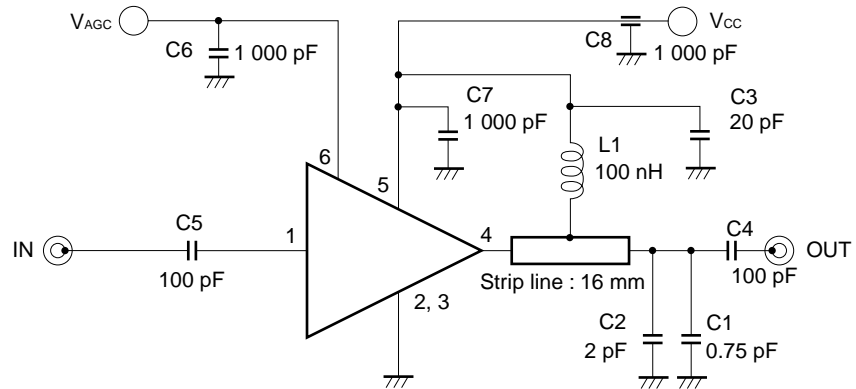


5.1.3 Component list

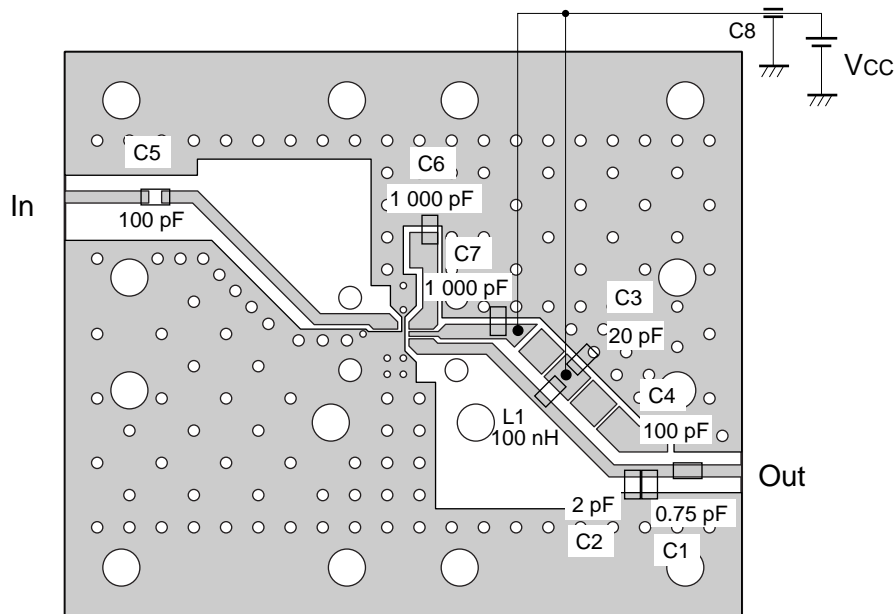
Symbol	Form	Rating	Part Number	Maker
C1	Chip Capacitor	0.75 pF	GRM39	Murata
C2	Chip Capacitor	100 pF	GRM39	Murata
C3, C4	Chip Capacitor	1 000 pF	GRM39	Murata
C5	Chip Capacitor	1 000 pF	GRM40	Murata
C6	Feed-through Capacitor	1 000 pF	DFT301-801X7R102S50	Murata
L1	Chip Inductor	2.2 nH	LL-2012	TOKO

5.2 f = 2.4 GHz

5.2.1 Test circuit 2



5.2.2 Illustration of the test circuit 2 assembled on evaluation board

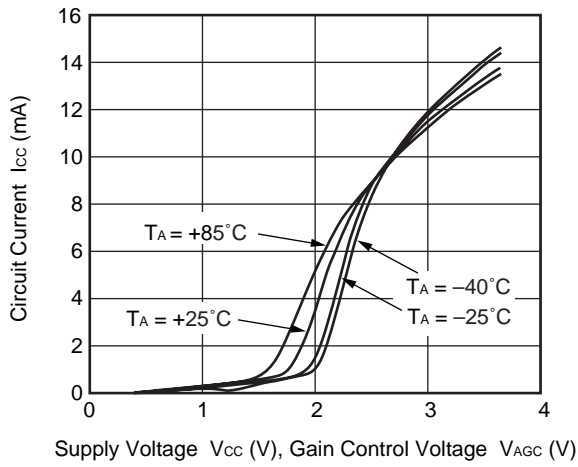


5.2.3 Component list

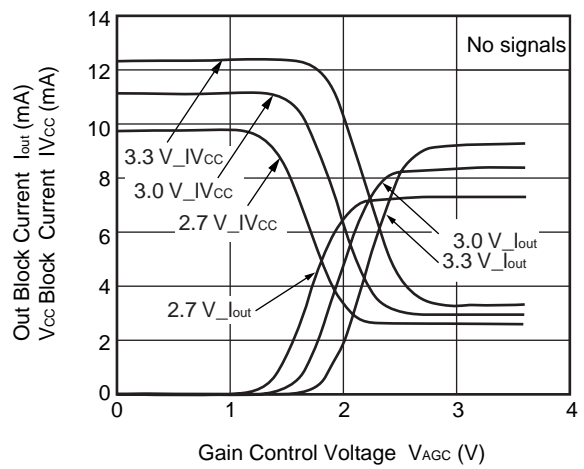
Symbol	Form	Rating	Part Number	Maker
C1	Chip Capacitor	0.75 pF	GRM39	Murata
C2	Chip Capacitor	2 pF	GRM39	Murata
C3	Chip Capacitor	20 pF	GRM39	Murata
C4, C5	Chip Capacitor	100 pF	GRM39	Murata
C6	Chip Capacitor	1 000 pF	GRM39	Murata
C7	Chip Capacitor	1 000 pF	GRM40	Murata
C8	Feed-through Capacitor	1 000 pF	DFT301-801X7R102S50	Murata
L1	Chip Inductor	100 nH	LL-1608	TOKO

★ 6. TYPICAL CHARACTERISTICS ( $T_A = +25^\circ\text{C}$ , unless otherwise specified)

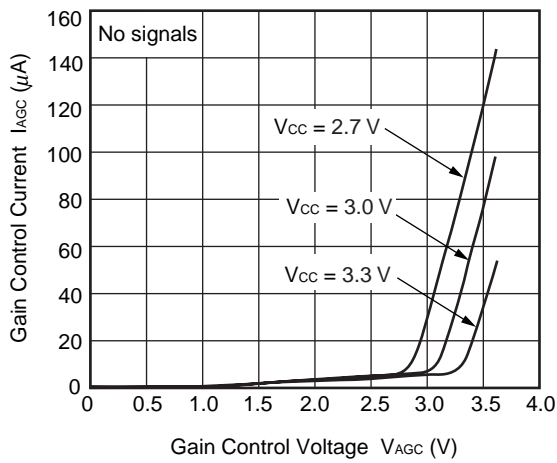
CIRCUIT CURRENT vs. SUPPLY VOLTAGE, GAIN CONTROL VOLTAGE



OUT BLOCK CURRENT AND  $V_{CC}$  BLOCK CURRENT vs. GAIN CONTROL VOLTAGE



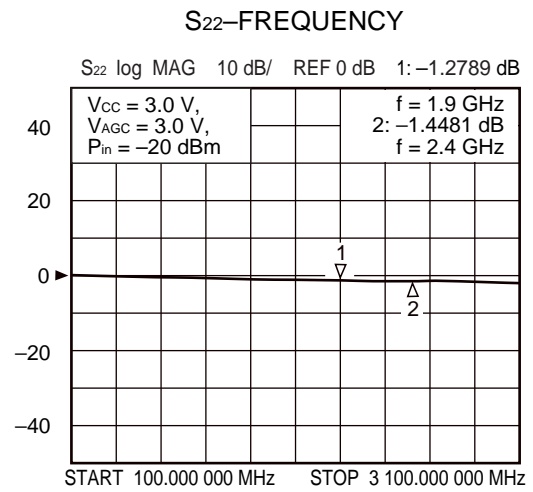
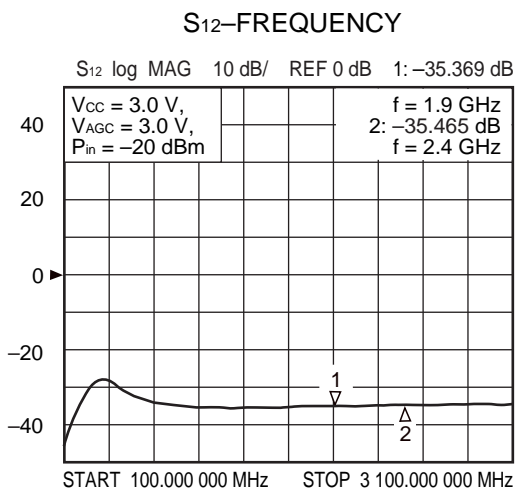
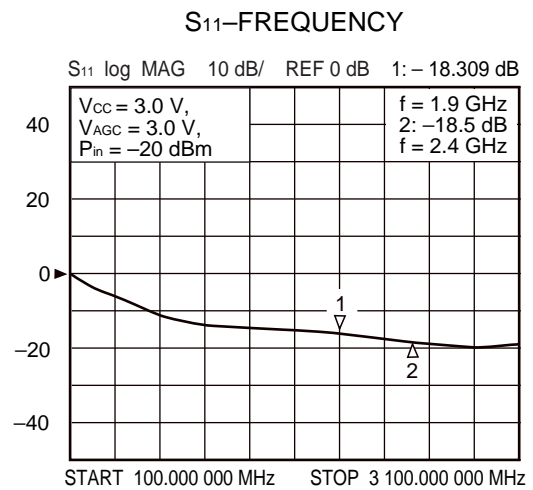
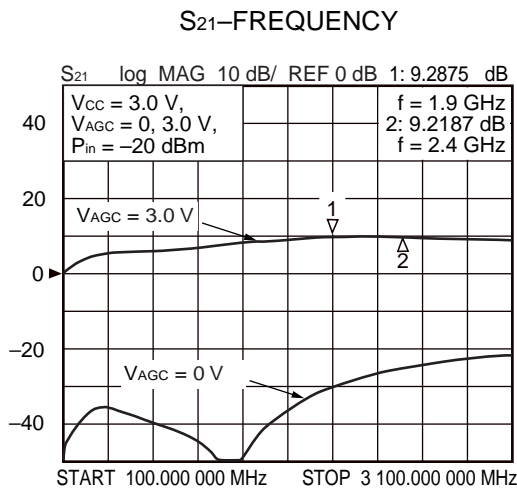
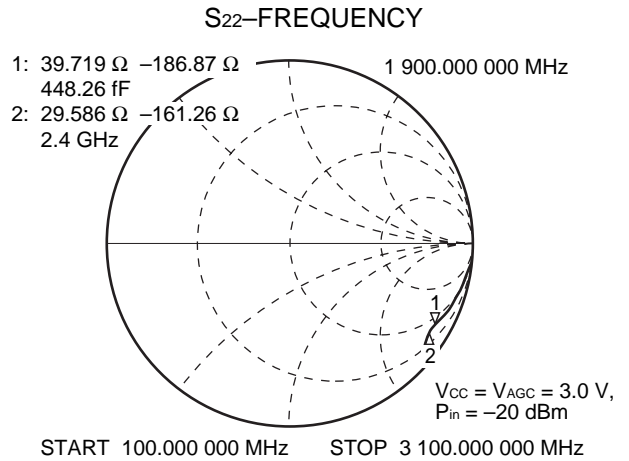
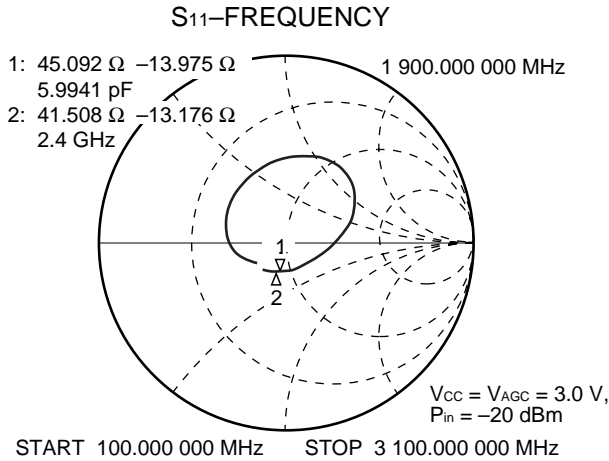
GAIN CONTROL CURRENT vs. GAIN CONTROL VOLTAGE



**Remark** The graphs indicate nominal characteristics.

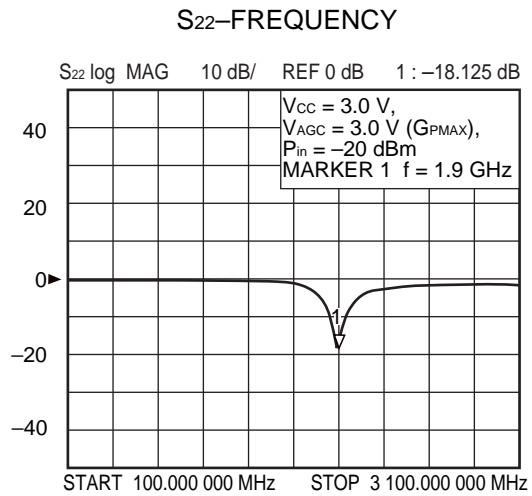
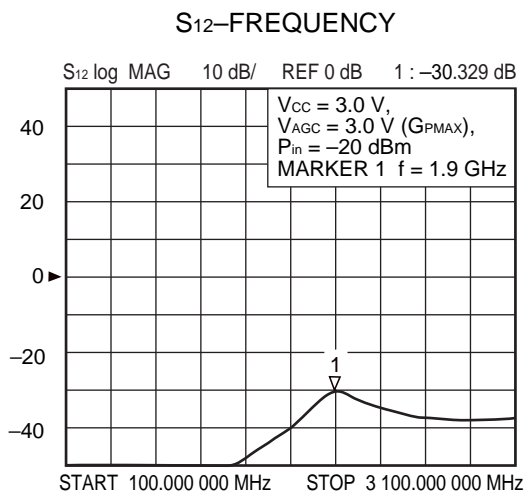
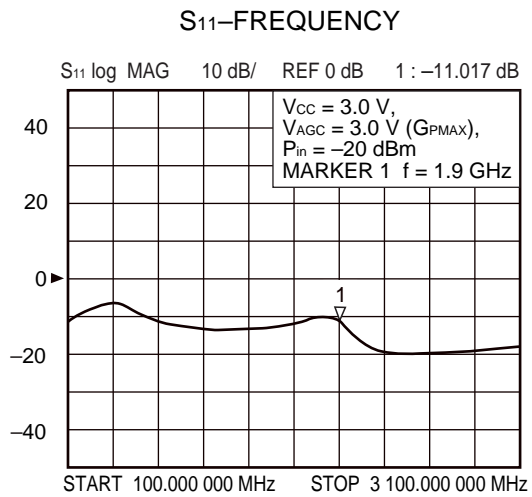
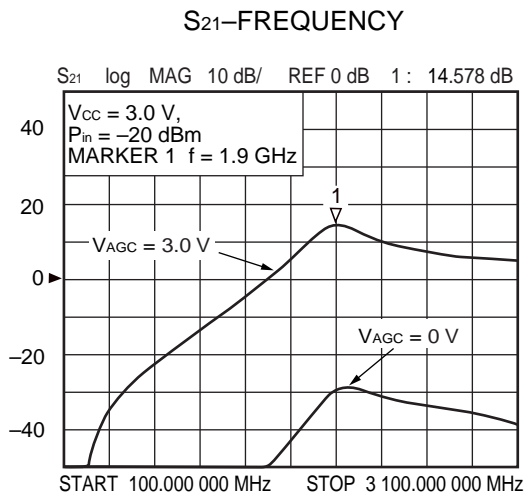
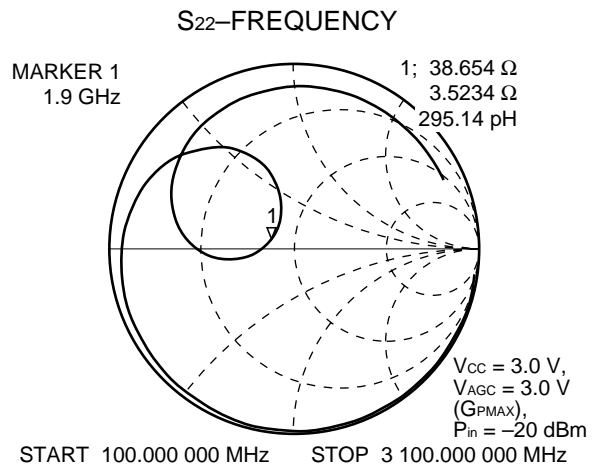
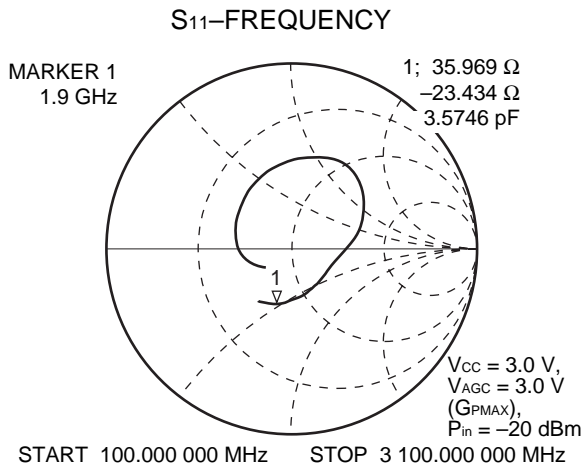


6.1 Inductor loading with external bias tee at output port



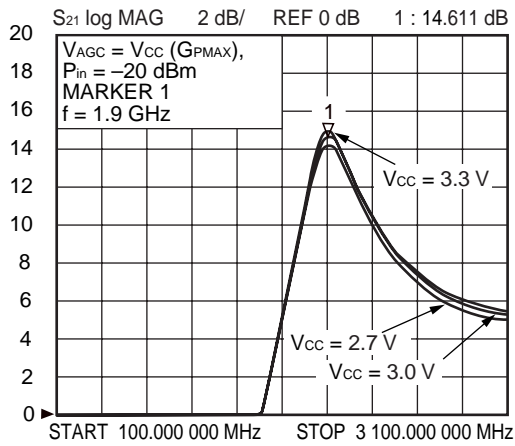
**Remark** The graphs indicate nominal characteristics.

6.2 Output port matching at f = 1.9 GHz

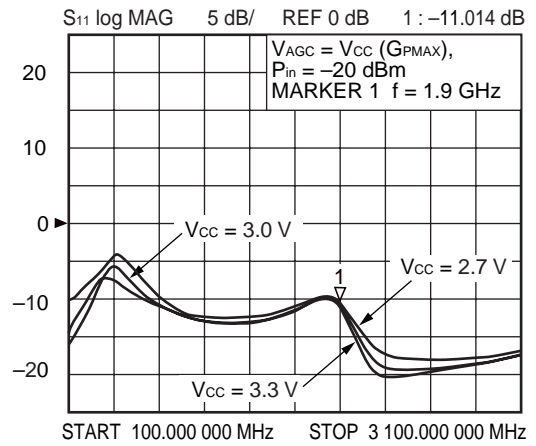


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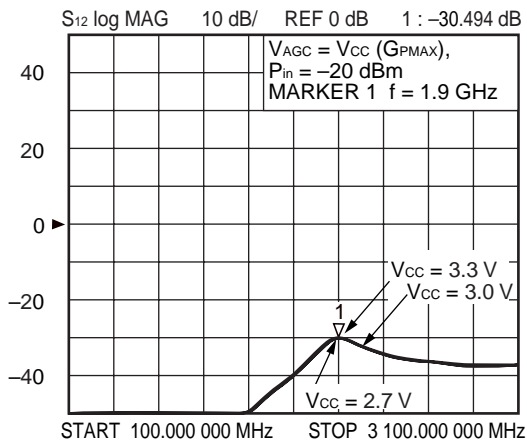
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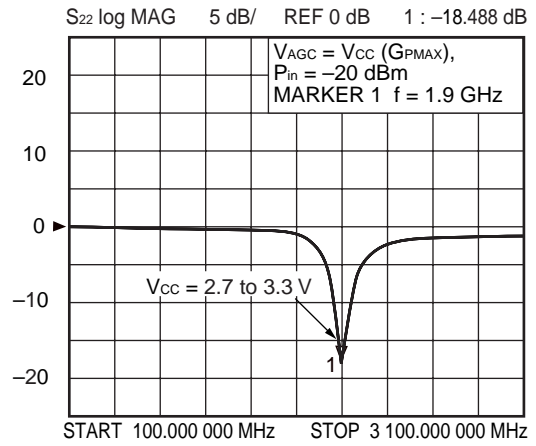
S11-FREQUENCY



S12-FREQUENCY

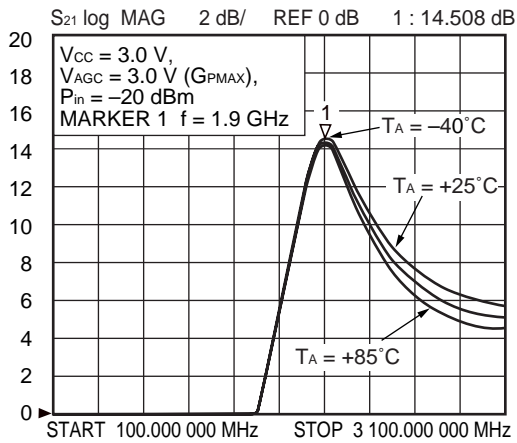


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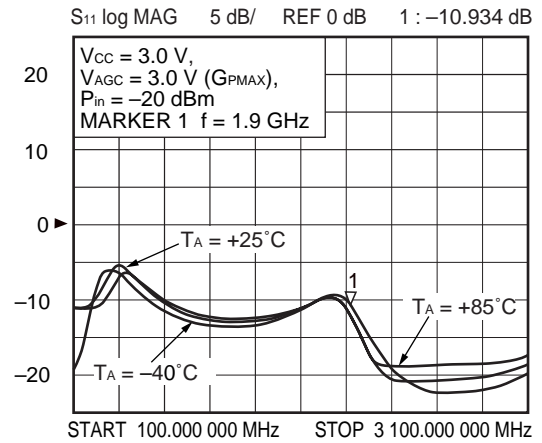


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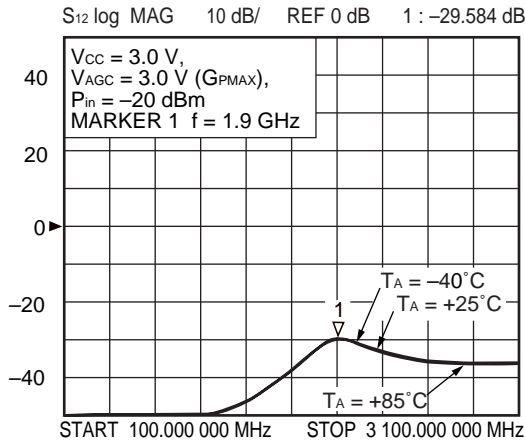
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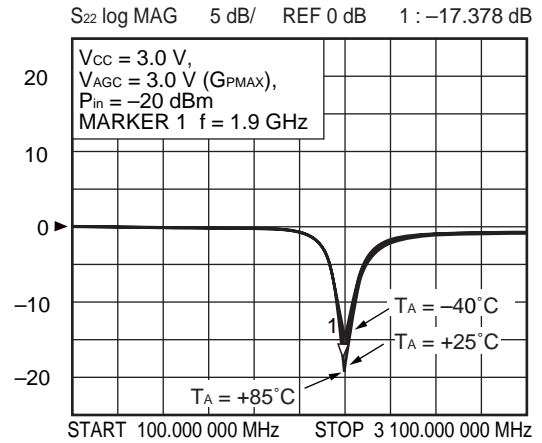
S<sub>11</sub>-FREQUENCY



S<sub>12</sub>-FREQUENCY

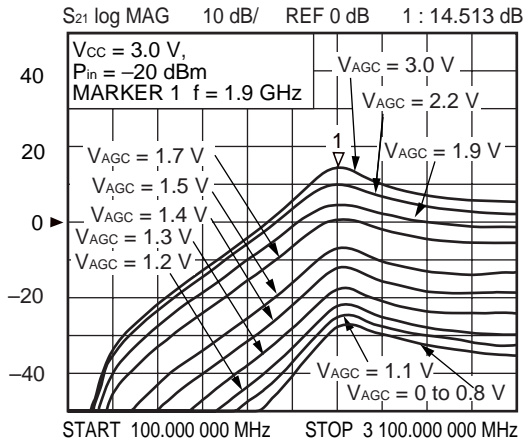


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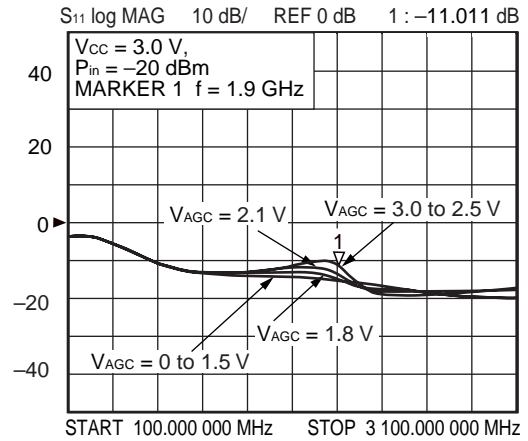


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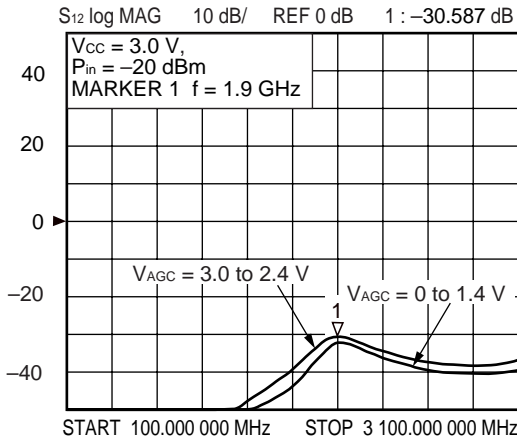
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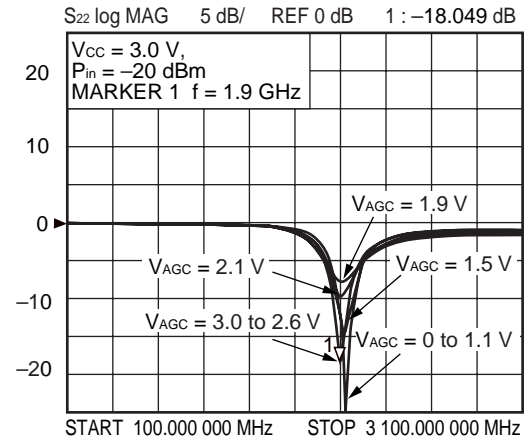
S11-FREQUENCY



S12-FREQUENCY

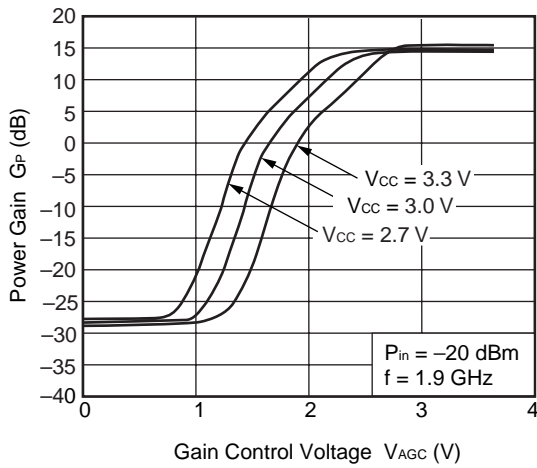


S22-FREQUENCY

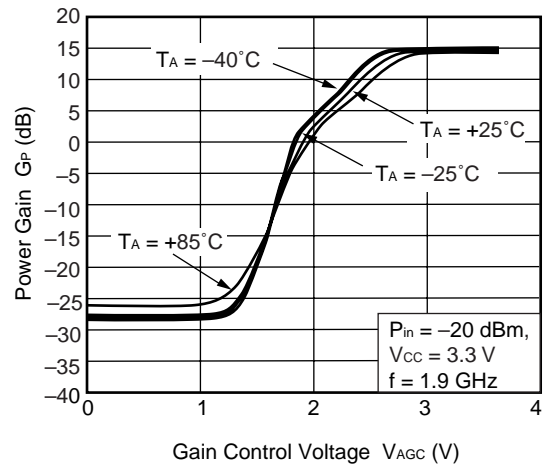


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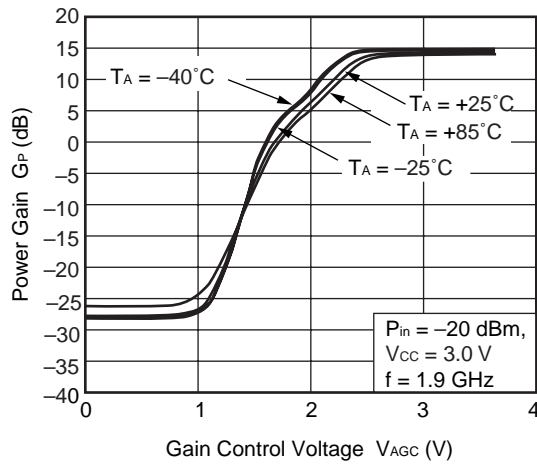
POWER GAIN vs. GAIN CONTROL VOLTAGE



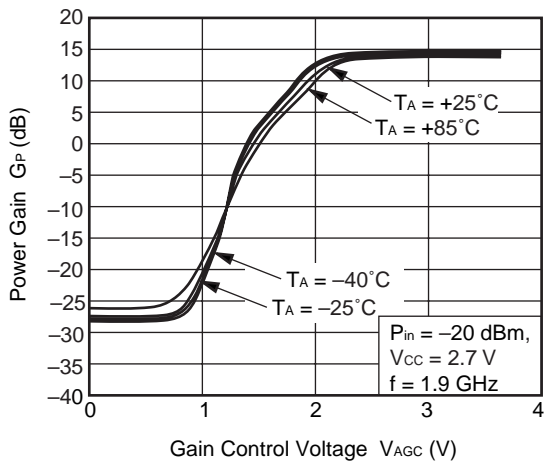
POWER GAIN vs. GAIN CONTROL VOLTAGE



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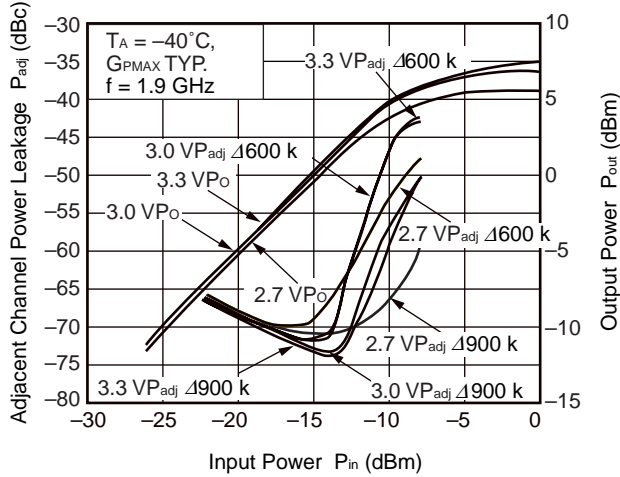


POWER GAIN vs. GAIN CONTROL VOLTAGE

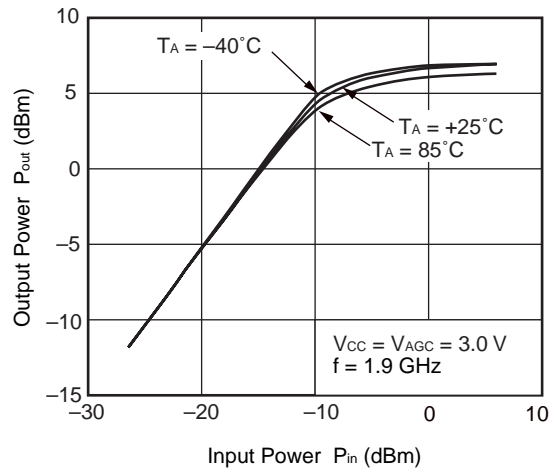


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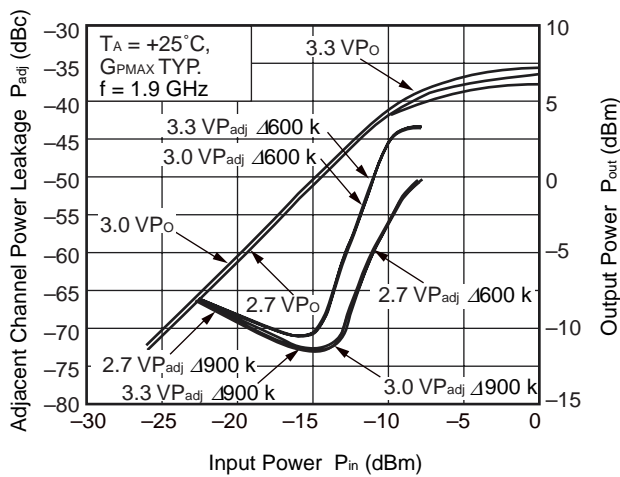
ADJACENT CHANNEL POWER LEAKAGE, OUTPUT POWER vs. INPUT POWER



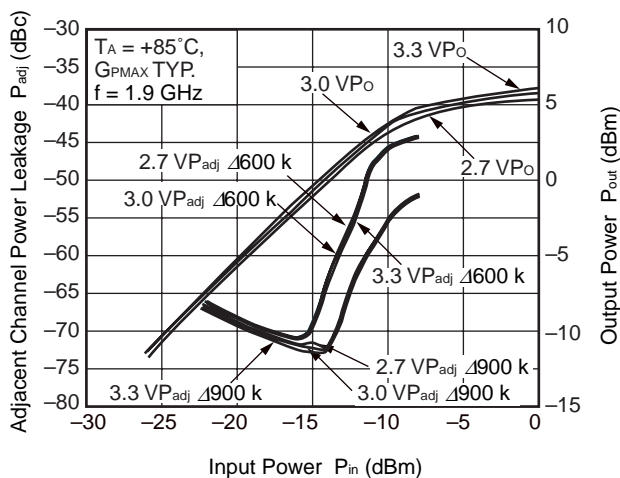
OUTPUT POWER vs. INPUT POWER



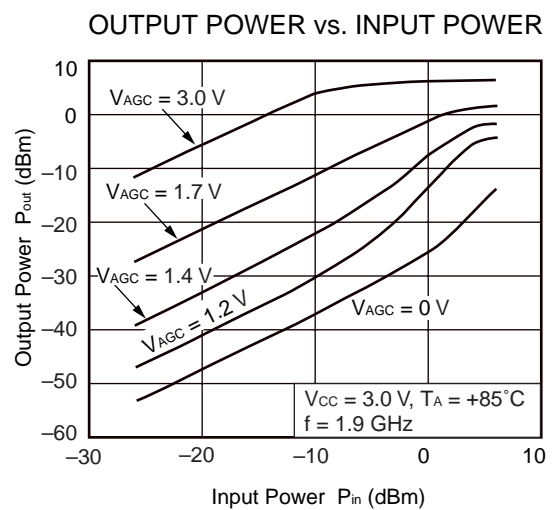
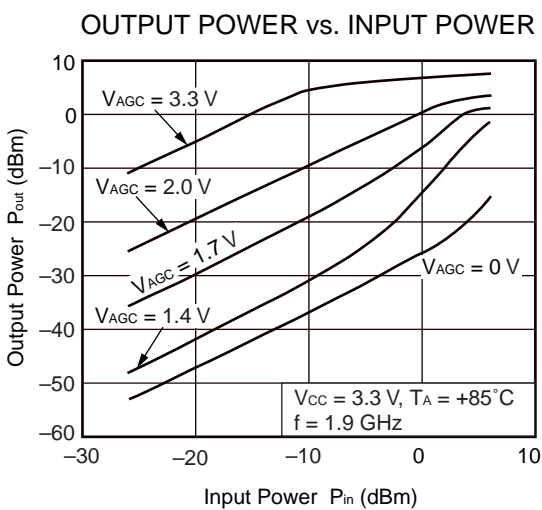
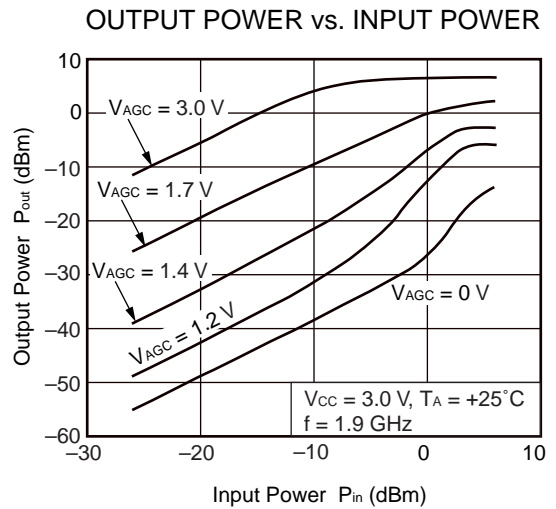
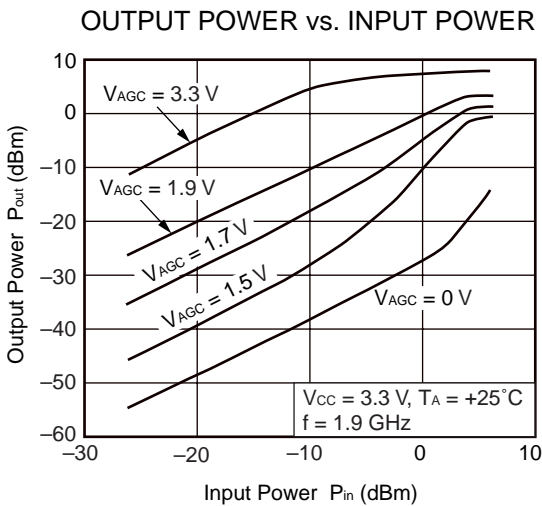
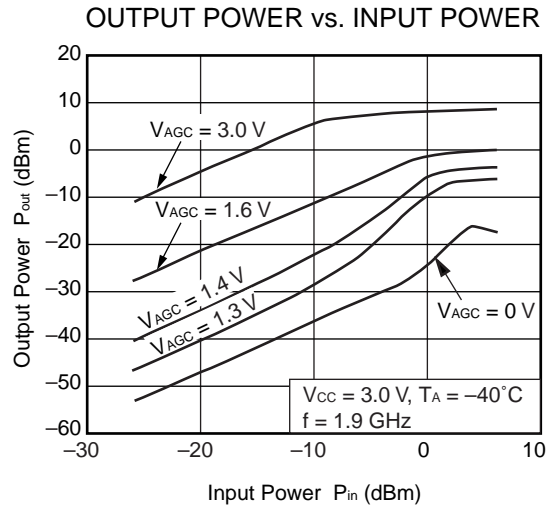
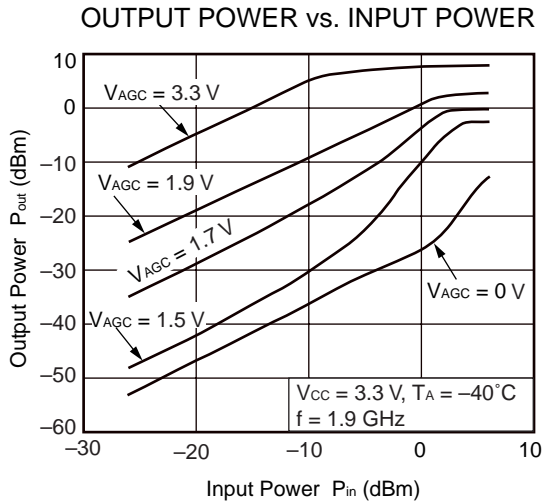
ADJACENT CHANNEL POWER LEAKAGE, OUTPUT POWER vs. INPUT POWER



ADJACENT CHANNEL POWER LEAKAGE, OUTPUT POWER vs. INPUT POWER

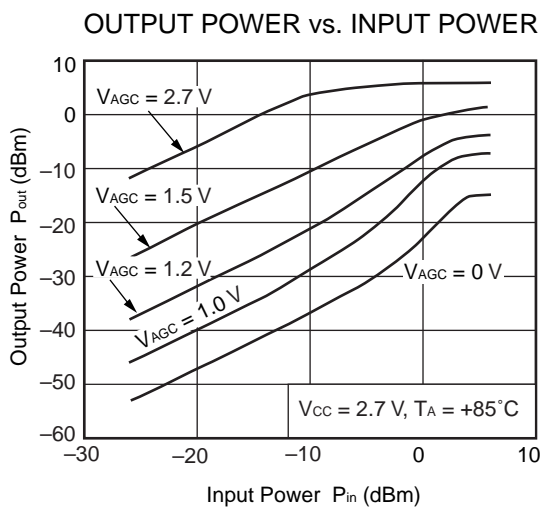
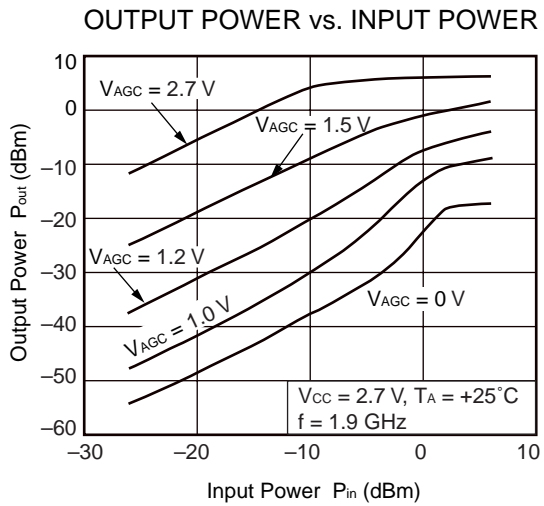
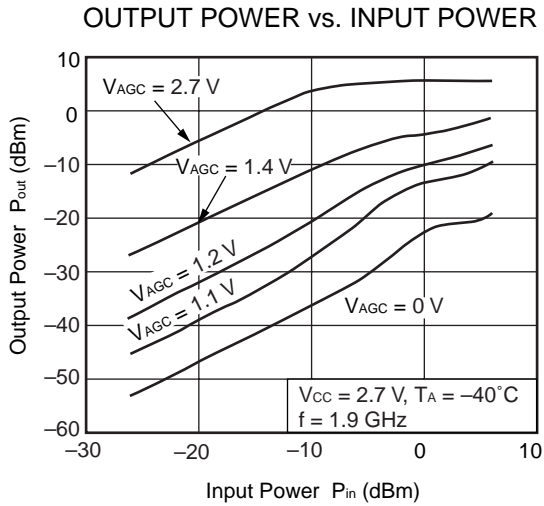


**Remark** The graphs indicate nominal characteristics.

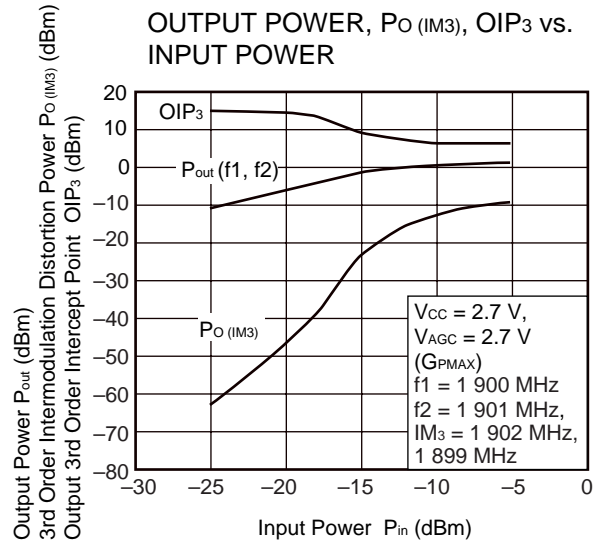
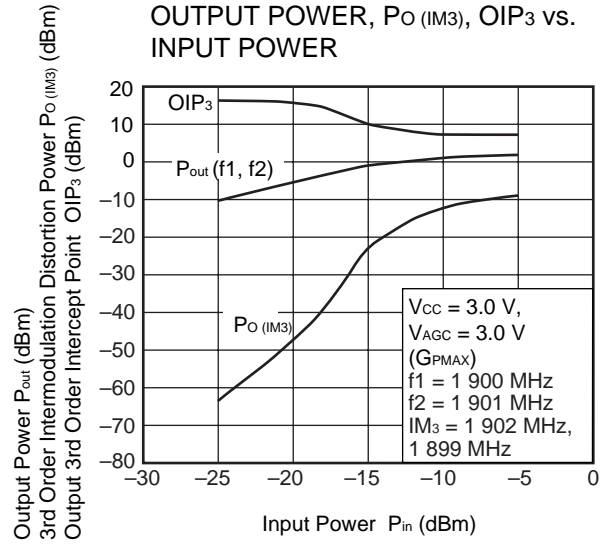
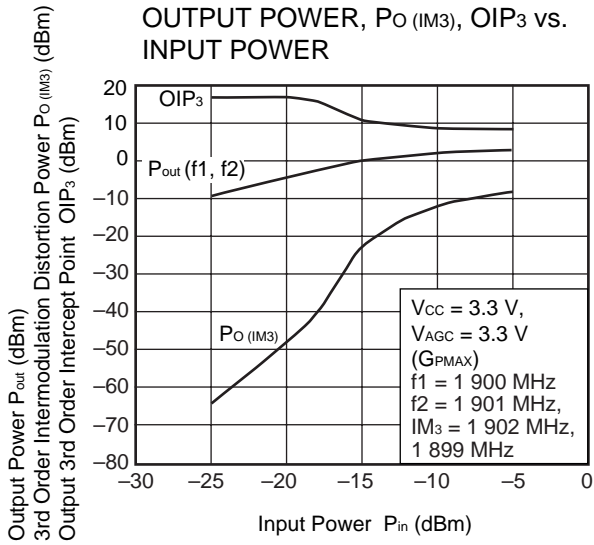


**Remark** The graphs indicate nominal characteristics.

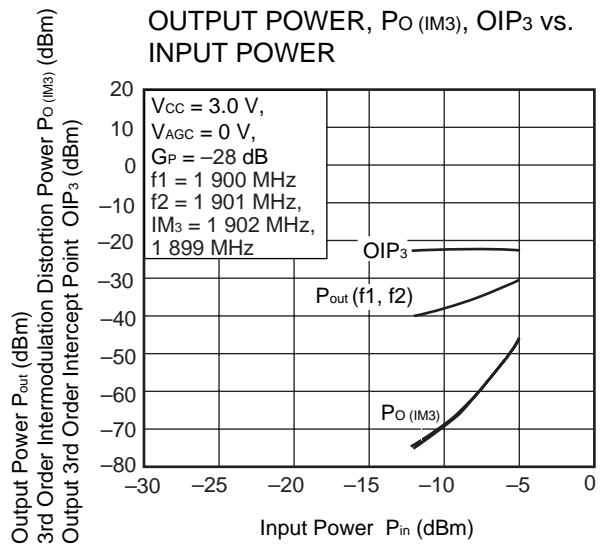
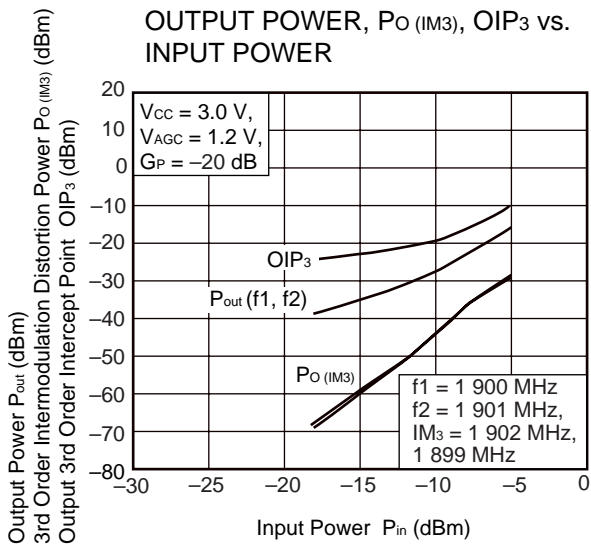
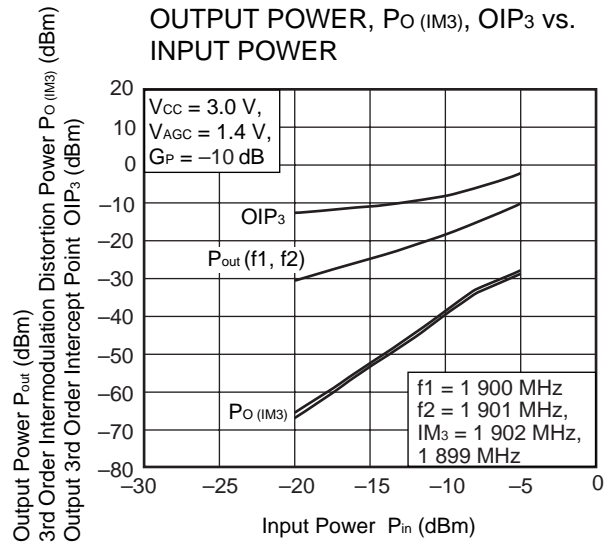
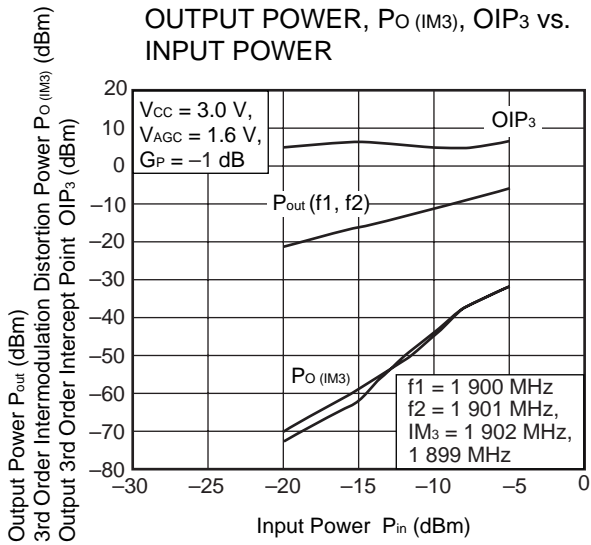




**Remark** The graphs indicate nominal characteristics.

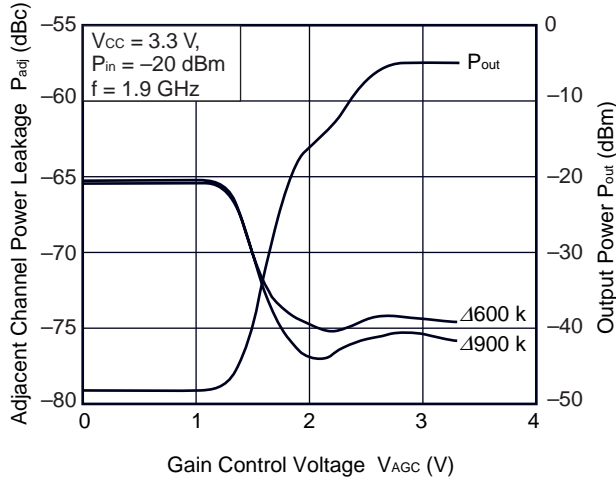


**Remark** The graphs indicate nominal characteristics.

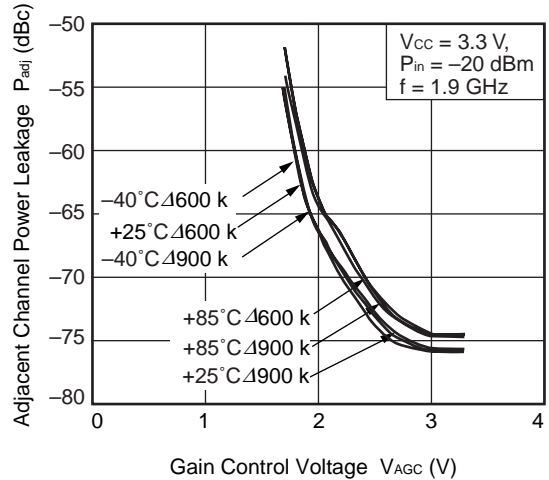


**Remark** The graphs indicate nominal characteristics.

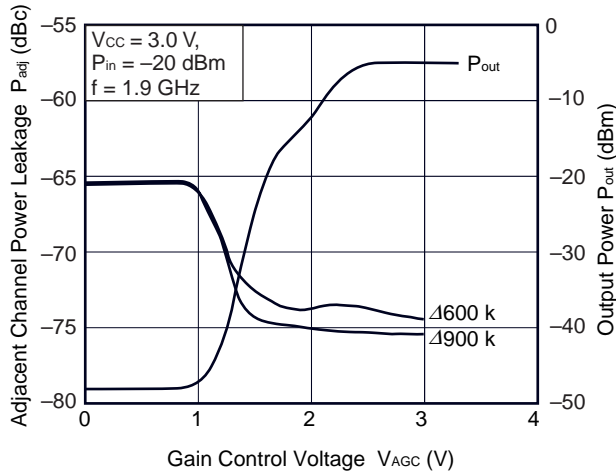
ADJACENT CHANNEL POWER LEAKAGE, OUTPUT POWER vs. GAIN CONTROL VOLTAGE



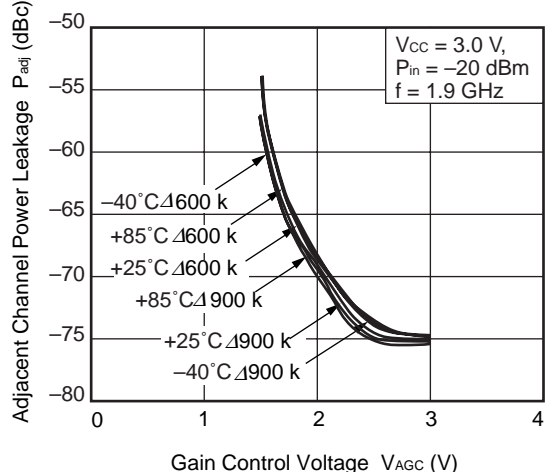
ADJACENT CHANNEL POWER LEAKAGE vs. GAIN CONTROL VOLTAGE



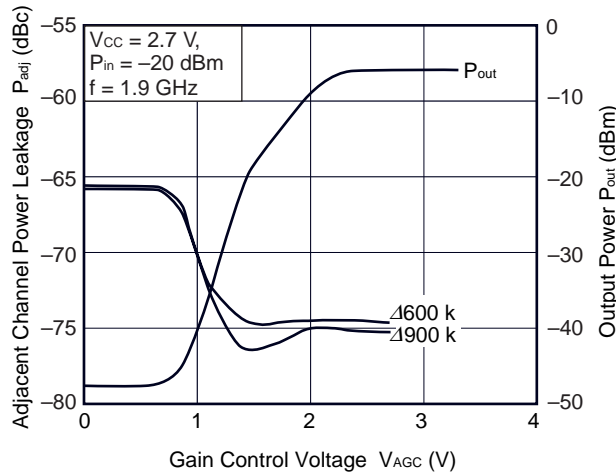
ADJACENT CHANNEL POWER LEAKAGE, OUTPUT POWER vs. GAIN CONTROL VOLTAGE



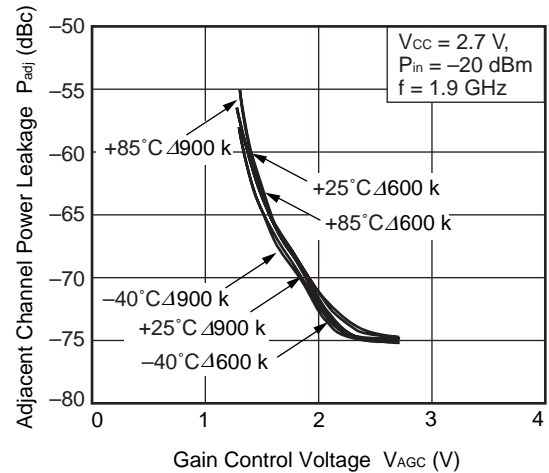
ADJACENT CHANNEL POWER LEAKAGE vs. GAIN CONTROL VOLTAGE



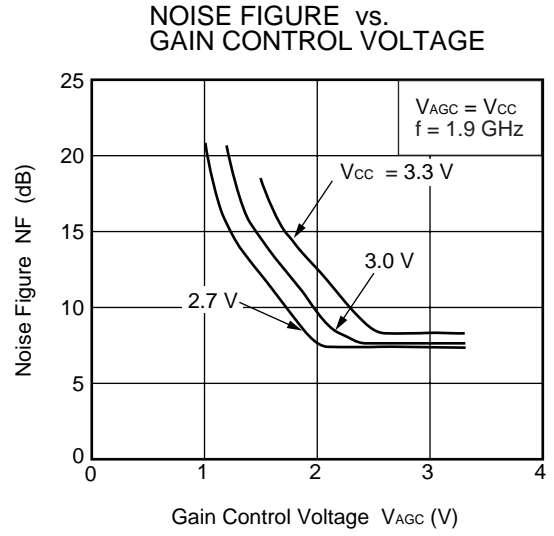
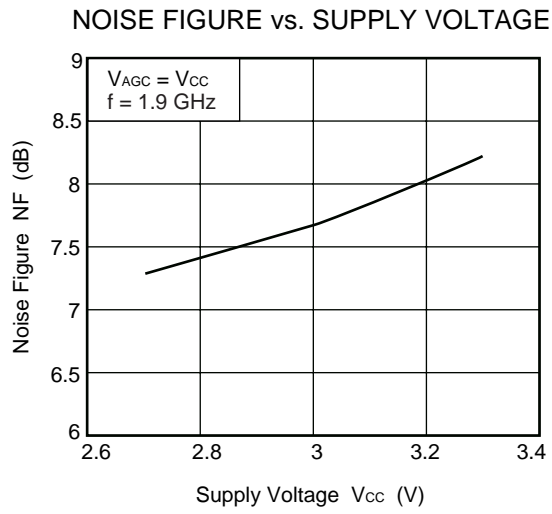
ADJACENT CHANNEL POWER LEAKAGE, OUTPUT POWER vs. GAIN CONTROL VOLTAGE



ADJACENT CHANNEL POWER LEAKAGE vs. GAIN CONTROL VOLTAGE

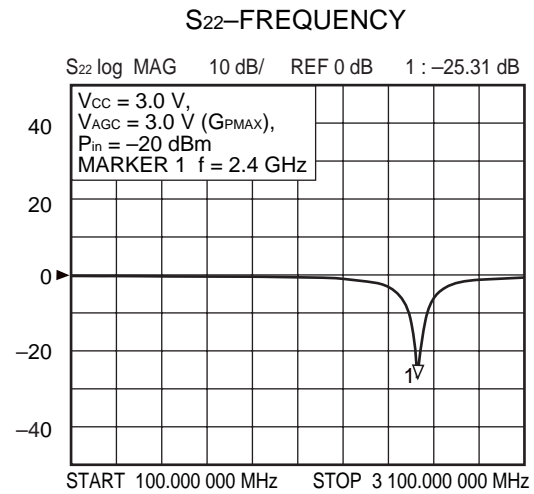
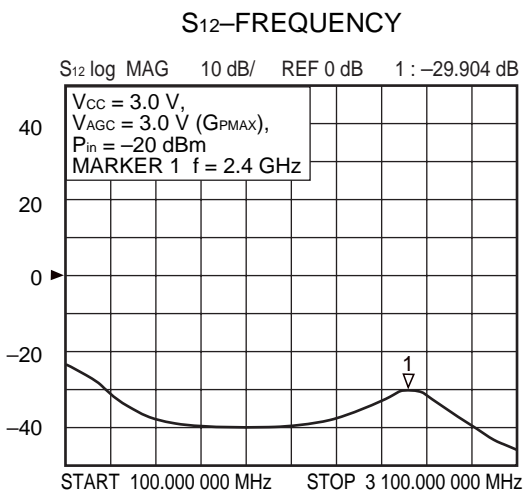
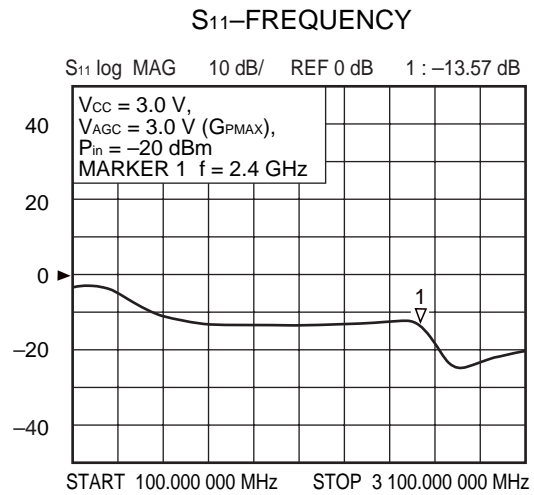
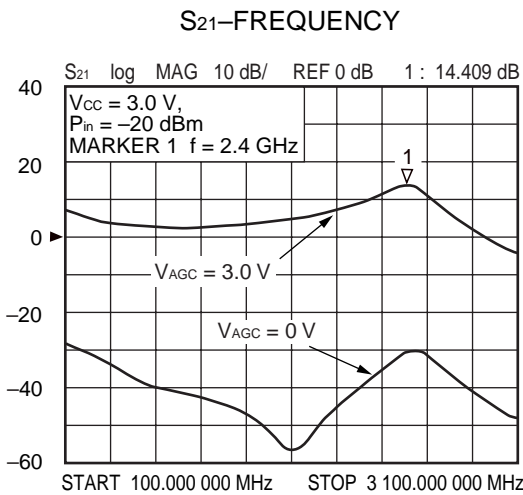
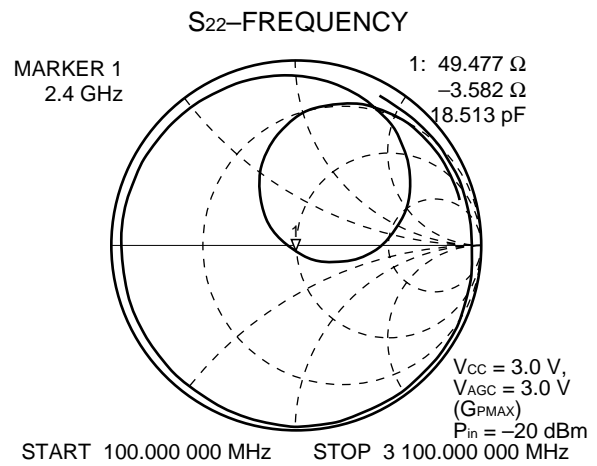
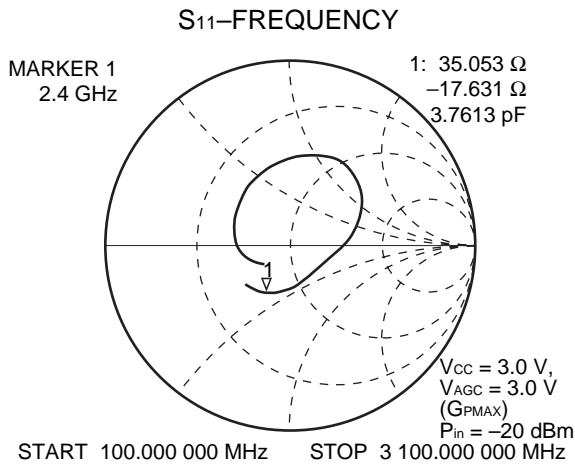


**Remark** The graphs indicate nominal characteristics.



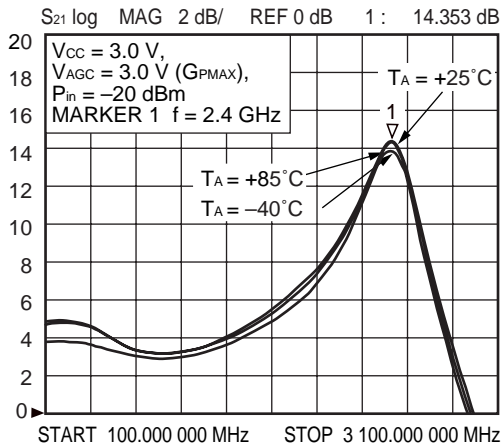
**Remark** The graphs indicate nominal characteristics.

6.3 Output port matching at f = 2.4 GHz

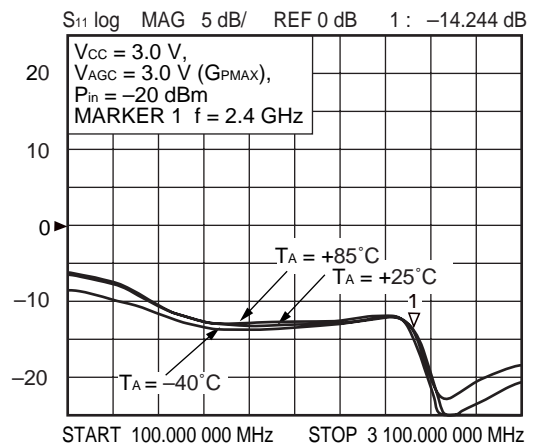


**Remark** The graphs indicate nominal characteristics.

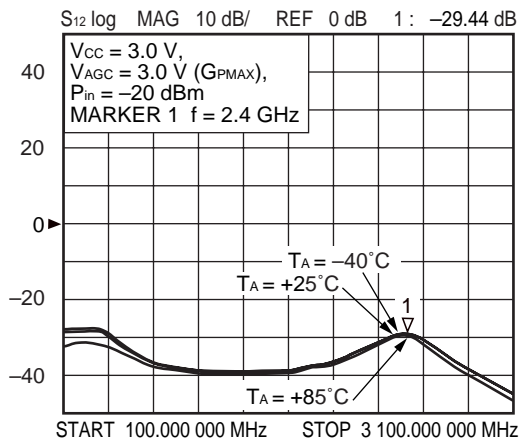
S<sub>21</sub>-FREQUENCY



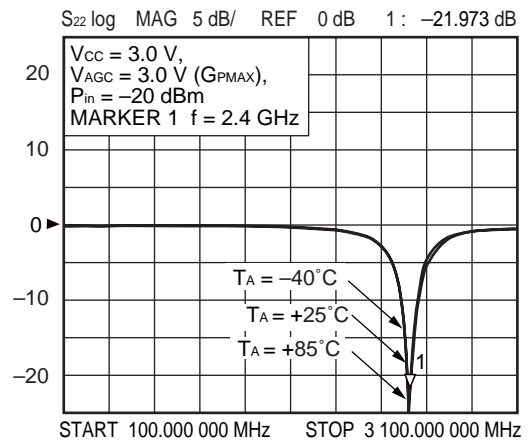
S<sub>11</sub>-FREQUENCY



S<sub>12</sub>-FREQUENCY

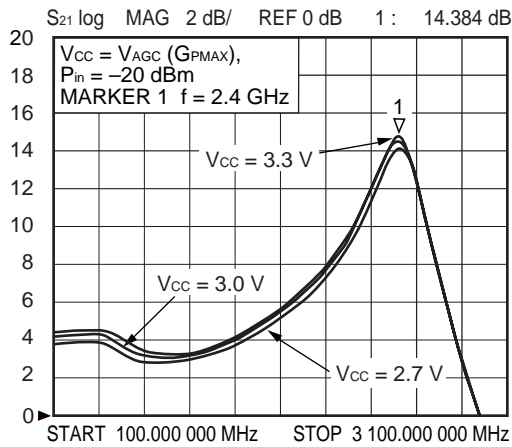


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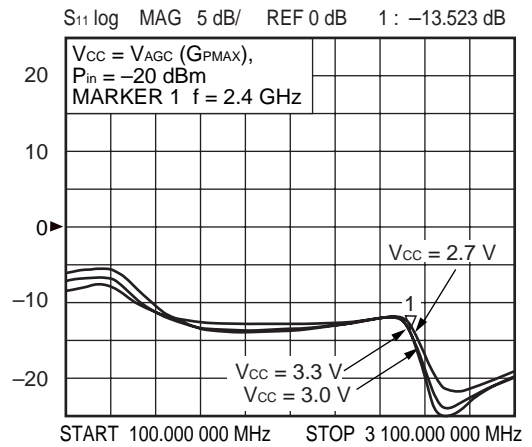


**Remark** The graphs indicate nominal characteristics.

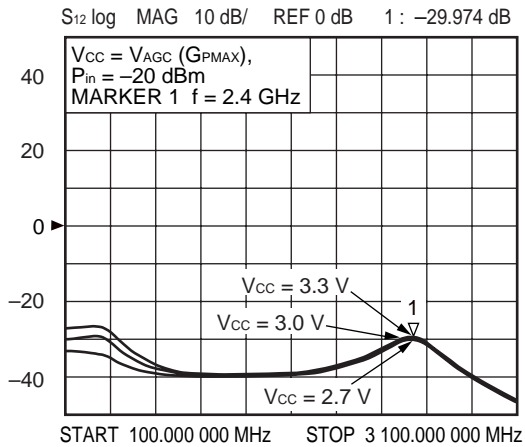
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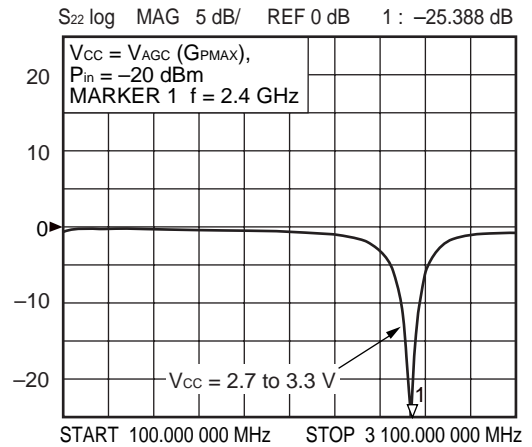
S<sub>11</sub>-FREQUENCY



S<sub>12</sub>-FREQUENCY



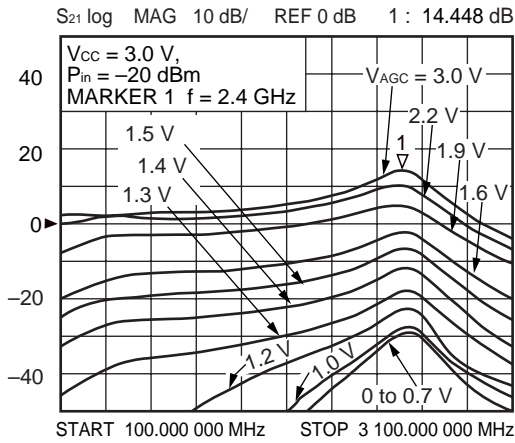
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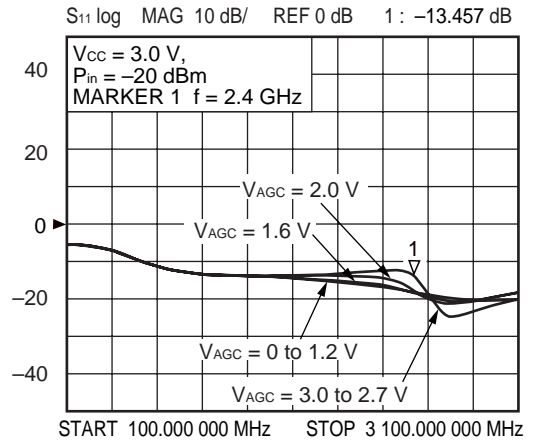
**Remark** The graphs indicate nominal characteristics.



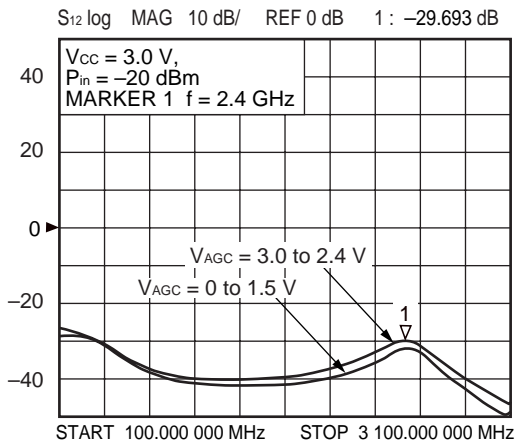
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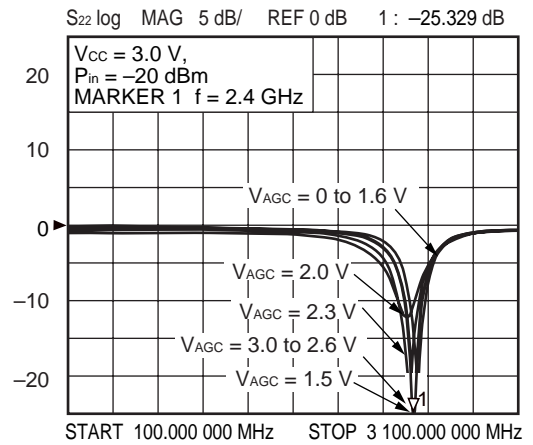
S<sub>11</sub>-FREQUENCY



S<sub>12</sub>-FREQUENCY

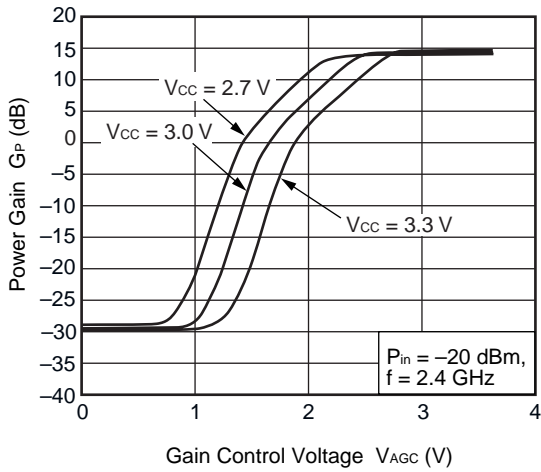


S<sub>22</sub>-FREQUENCY

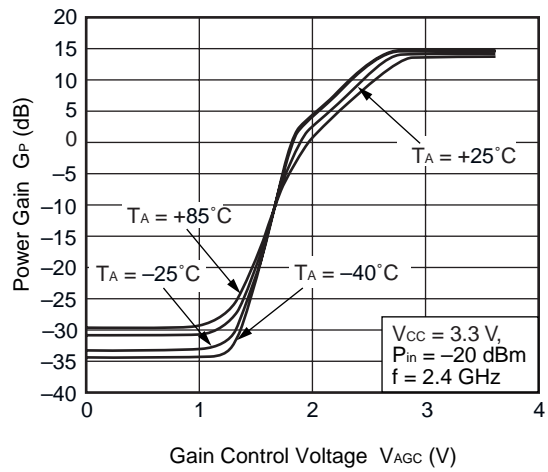


**Remark** The graphs indicate nominal characteristics.

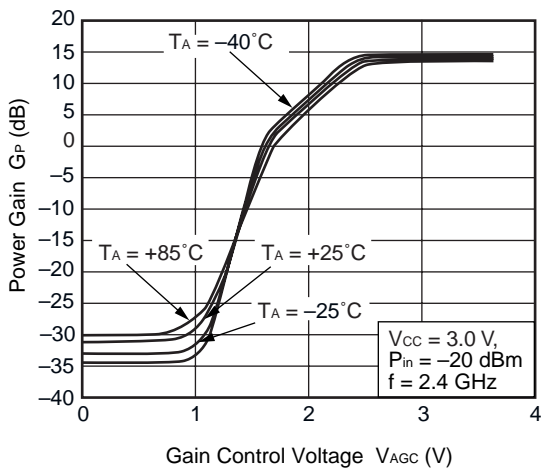
POWER GAIN vs. GAIN CONTROL VOLTAGE



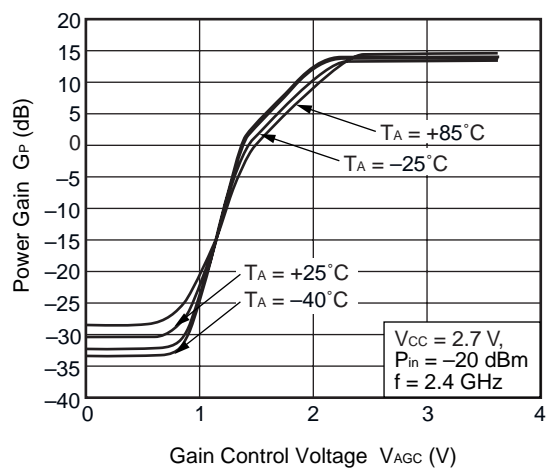
POWER GAIN vs. GAIN CONTROL VOLTAGE



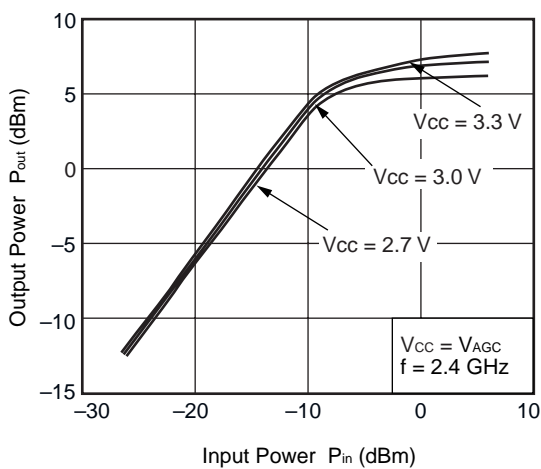
POWER GAIN vs. GAIN CONTROL VOLTAGE



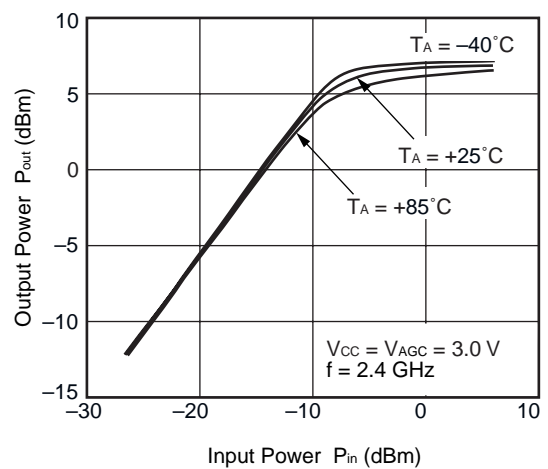
POWER GAIN vs. GAIN CONTROL VOLTAGE



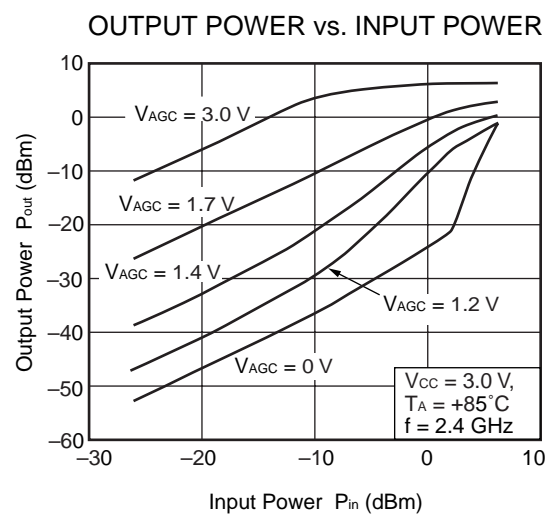
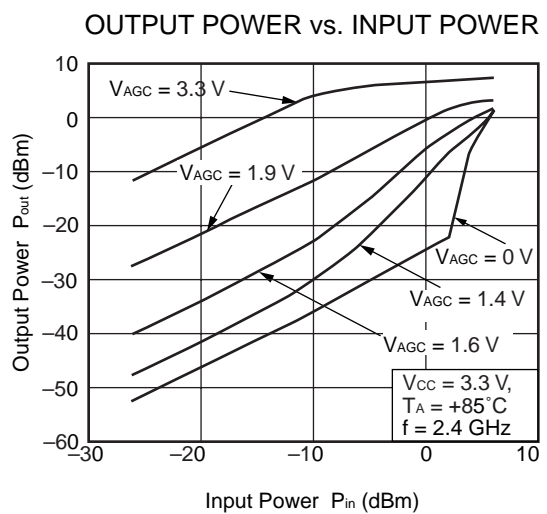
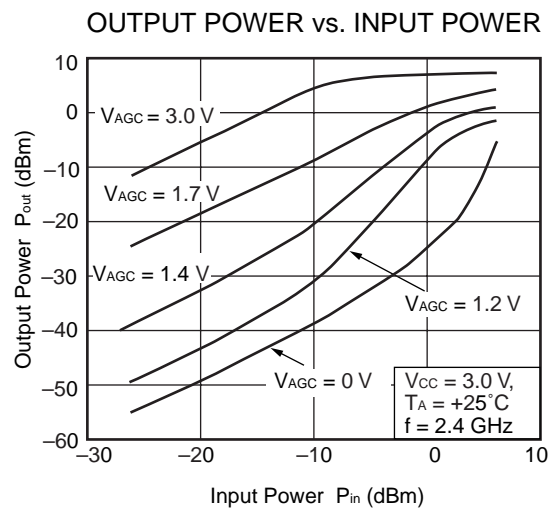
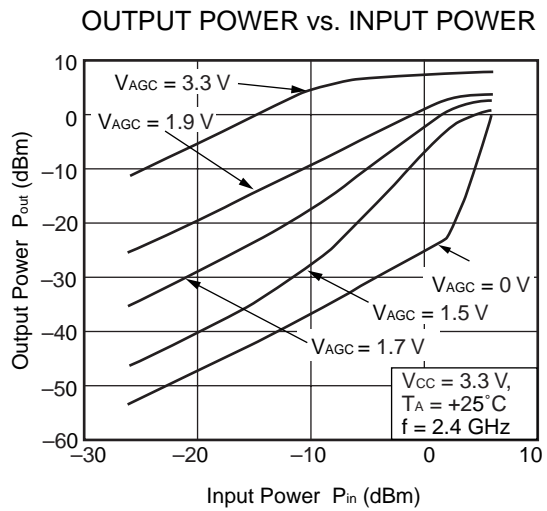
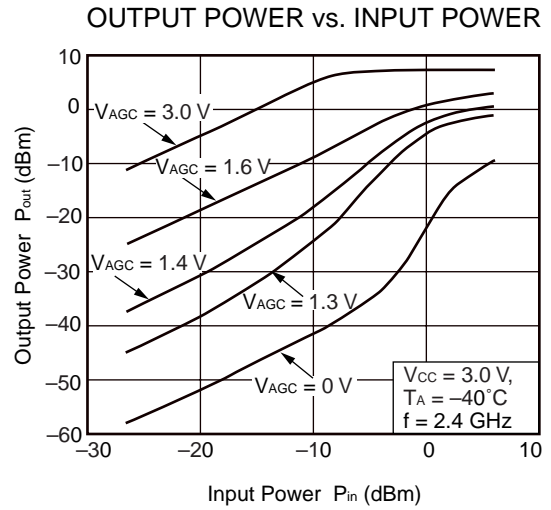
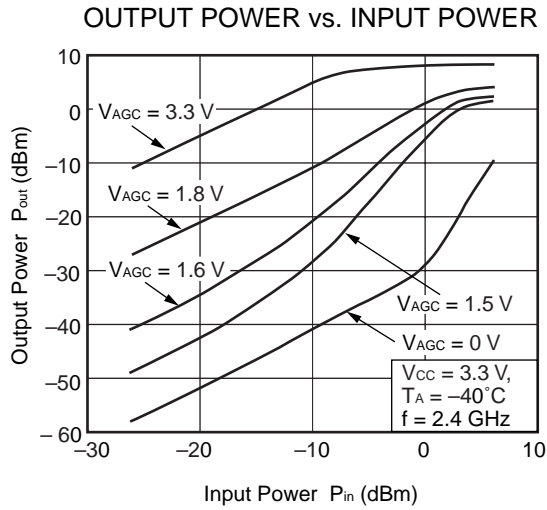
OUTPUT POWER vs. INPUT POWER



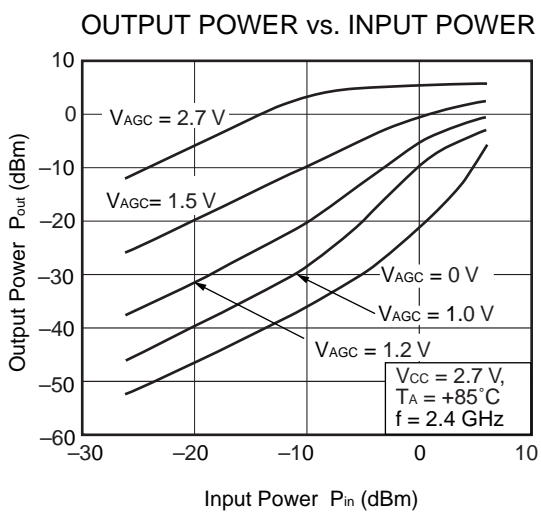
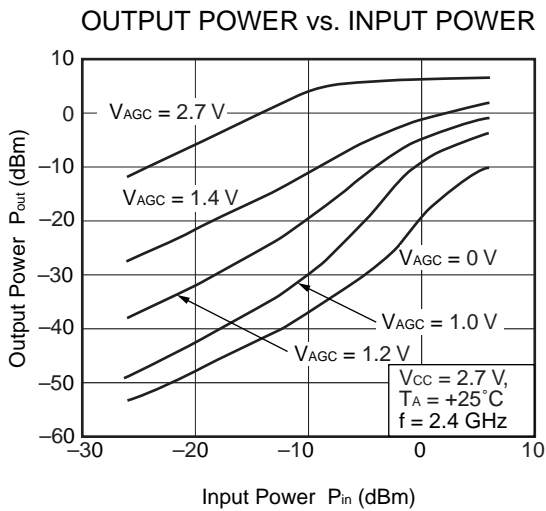
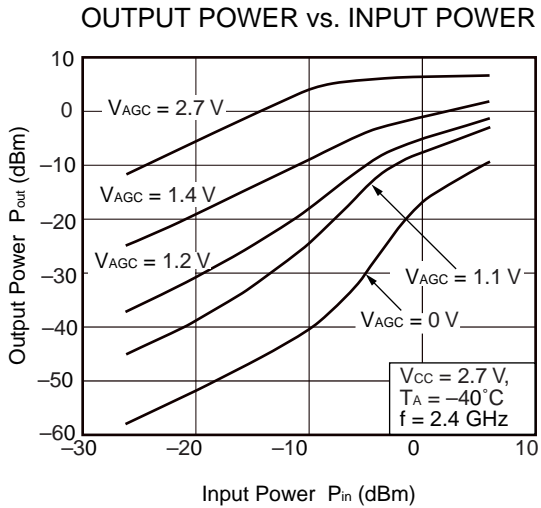
OUTPUT POWER vs. INPUT POWER



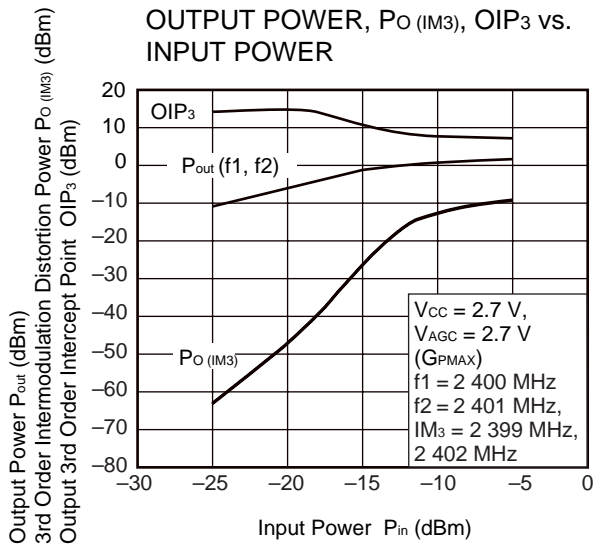
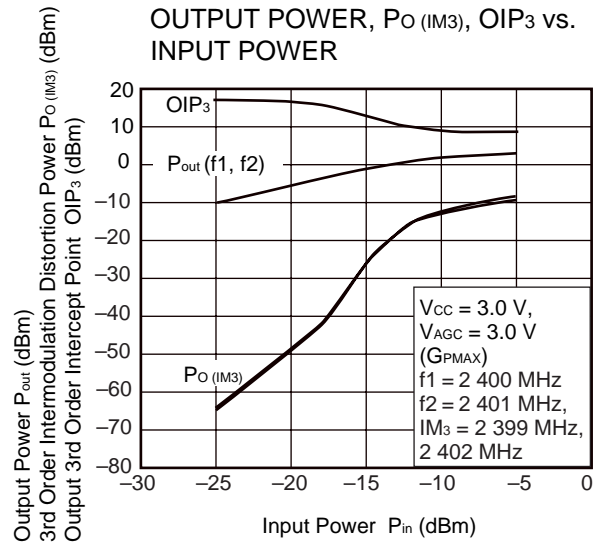
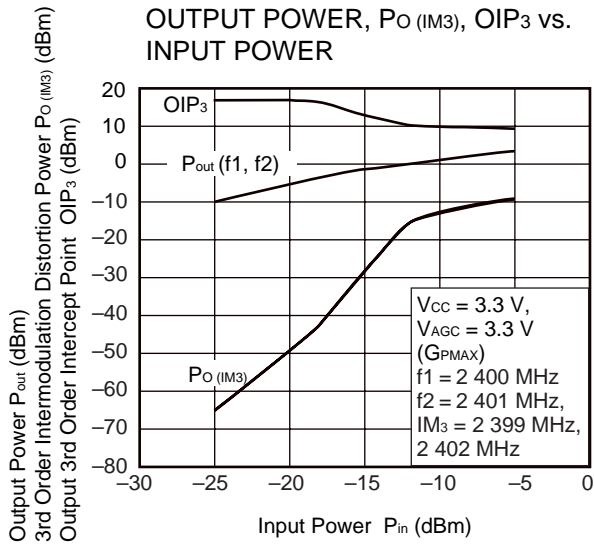
**Remark** The graphs indicate nominal characteristics.



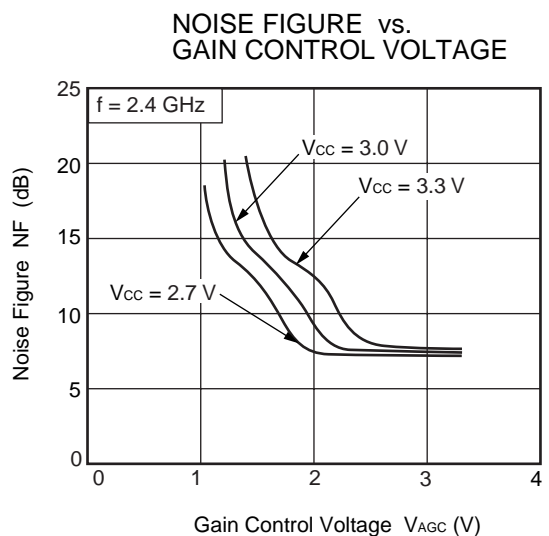
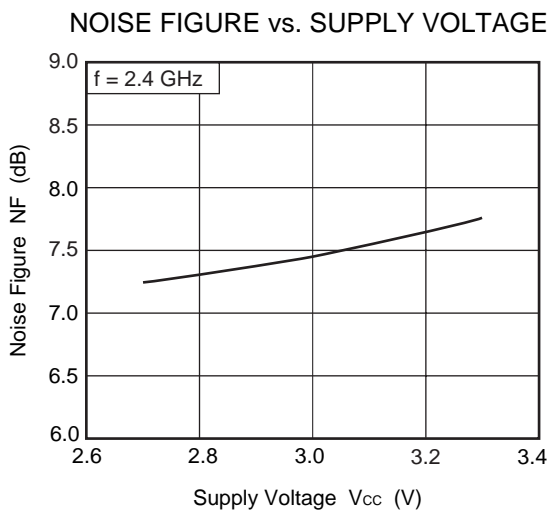
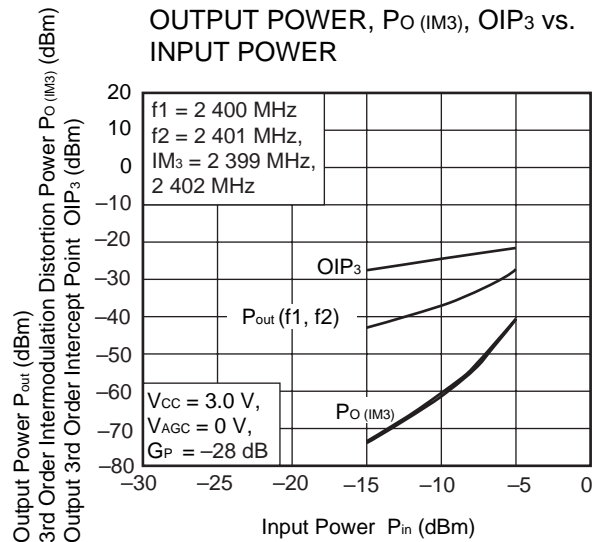
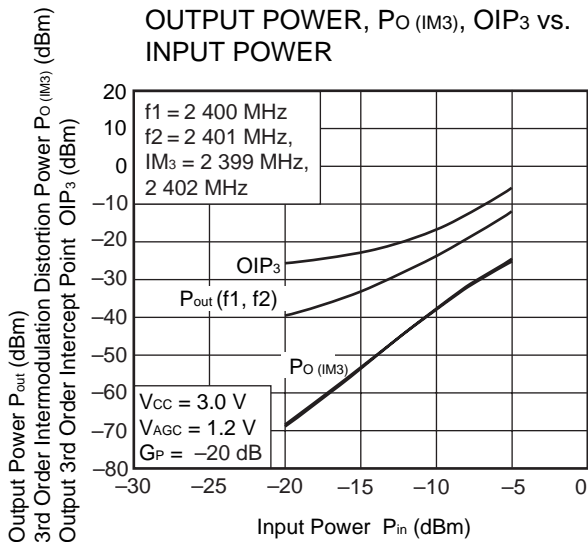
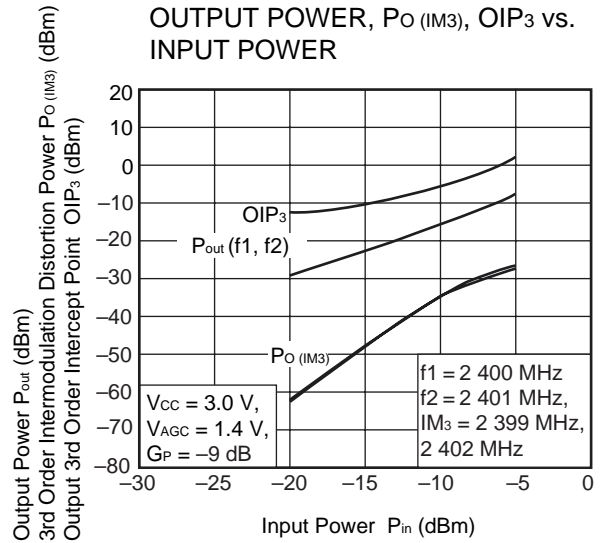
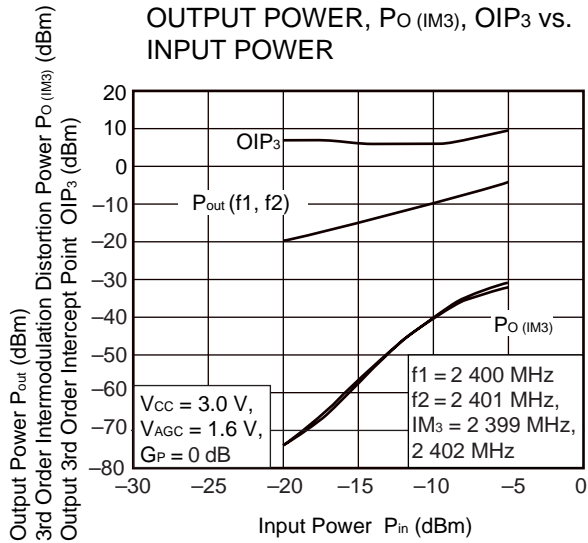
**Remark** The graphs indicate nominal characteristics.



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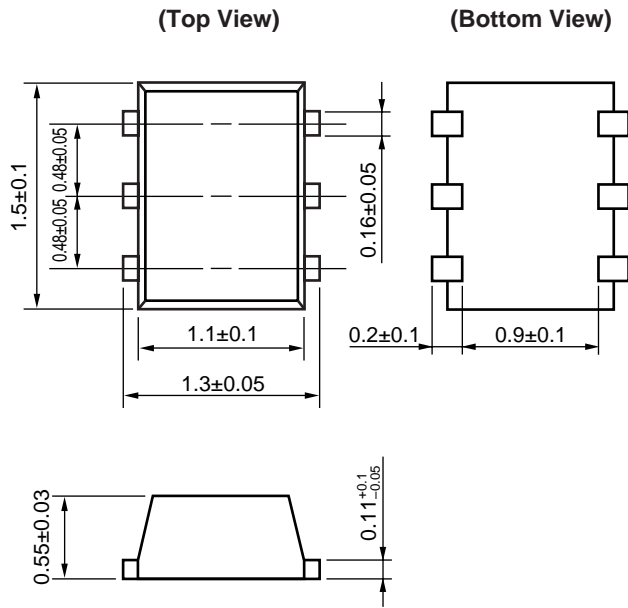
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★ 7. PACKAGE DIMENSIONS

6-PIN LEAD-LESS MINIMOLD (1511 PKG) (UNIT: mm)



**8. NOTES ON CORRECT USE**

- (1) Observe precautions for handling because of electro-static sensitive devices.
- (2) Form a ground pattern as wide as possible to minimize ground impedance (to prevent undesired oscillation).  
All the ground pins must be connected together with wide ground pattern to decrease impedance difference.
- (3) The bypass capacitor should be attached to the V<sub>CC</sub> terminal.
- (4) Impedance matching circuit must be each externally attached to input and output ports.
- (5) The DC capacitor must be attached to input terminal.

**★ 9. RECOMMENDED SOLDERING CONDITIONS**

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

Soldering Method	Soldering Conditions	Condition Symbol
Infrared Reflow	Peak temperature (package surface temperature) : 260°C or below Time at peak temperature : 10 seconds or less Time at temperature of 220°C or higher : 60 seconds or less Preheating time at 120 to 180°C : 120±30 seconds Maximum number of reflow processes : 3 times Maximum chlorine content of rosin flux (% mass) : 0.2%(Wt.) or below	IR260
Wave Soldering	Peak temperature (molten solder temperature) : 260°C or below Time at peak temperature : 10 seconds or less Preheating temperature (package surface temperature) : 120°C or below Maximum number of flow processes : 1 time Maximum chlorine content of rosin flux (% mass) : 0.2%(Wt.) or below	WS260
Partial Heating	Peak temperature (terminal temperature) : 350°C or below Soldering time (per side of device) : 3 seconds or less Maximum chlorine content of rosin flux (% mass) : 0.2%(Wt.) or below	HS350

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



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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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(2) "NEC semiconductor products" means any semiconductor product developed or manufactured by or for NEC (as defined above).

M8E 00.4-0110

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► For further information, please contact

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TEL: +1-408-988-3500 FAX: +1-408-988-0279

Subject: Compliance with EU Directives

CEL certifies, to its knowledge, that semiconductor and laser products detailed below are compliant with the requirements of European Union (EU) Directive 2002/95/EC Restriction on Use of Hazardous Substances in electrical and electronic equipment (RoHS) and the requirements of EU Directive 2003/11/EC Restriction on Penta and Octa BDE.

CEL Pb-free products have the same base part number with a suffix added. The suffix –A indicates that the device is Pb-free. The –AZ suffix is used to designate devices containing Pb which are exempted from the requirement of RoHS directive (\*). In all cases the devices have Pb-free terminals. All devices with these suffixes meet the requirements of the RoHS directive.

This status is based on CEL’s understanding of the EU Directives and knowledge of the materials that go into its products as of the date of disclosure of this information.

Restricted Substance per RoHS	Concentration Limit per RoHS (values are not yet fixed)	Concentration contained in CEL devices	
		-A	-AZ
Lead (Pb)	< 1000 PPM	Not Detected	(*)
Mercury	< 1000 PPM	Not Detected	
Cadmium	< 100 PPM	Not Detected	
Hexavalent Chromium	< 1000 PPM	Not Detected	
PBB	< 1000 PPM	Not Detected	
PBDE	< 1000 PPM	Not Detected	

If you should have any additional questions regarding our devices and compliance to environmental standards, please do not hesitate to contact your local representative.

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