μPC3220GR

LOW DISTORTION DOWN-CONVERTER IC FOR DIGITAL CATV

DESCRIPTION

The μPC3220GR is a silicon monolithic IC designed for use as IF down-converter for digital CATV. This IC consists of AGC amplifier, mixer and video amplifier.

The package is 16-pin SSOP (Shrink Small Outline Package) suitable for surface mount.

This IC is manufactured using our 10 GHz f_T NESAT II AL silicon bipolar process.

This process uses silicon nitride passivation film. This material can protect chip surface from external pollution and prevent corrosion/migration. Thus, this IC has excellent performance, uniformly and reliability.

FEATURES

- Low distortion IIP_3 = +1.0 dBm TYP.
- Wide AGC dynamic range GCR_{total} = 45.5 dB TYP.
- On chip video amplifier
- Supply voltage : 5 V
- Packaged in 16-pin SSOP suitable for high-density surface mounting

APPLICATION

- Digital CATV receivers

ORDERING INFORMATION

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Part Number	Order Number	Package	Marking	Supplying Form
μPC3220GR-E1	μPC3220GR-E1-A	16-pin plastic SSOP (5.72 mm (225)) (Pb-Free)	C3220	• Embossed tape 12 mm wide • Pin 1 indicates pull-out direction of tape • Qty 2.5 kpcs/reel

Remark To order evaluation samples, contact your nearby sales office.
Part number for sample order: μPC3220GR-A

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

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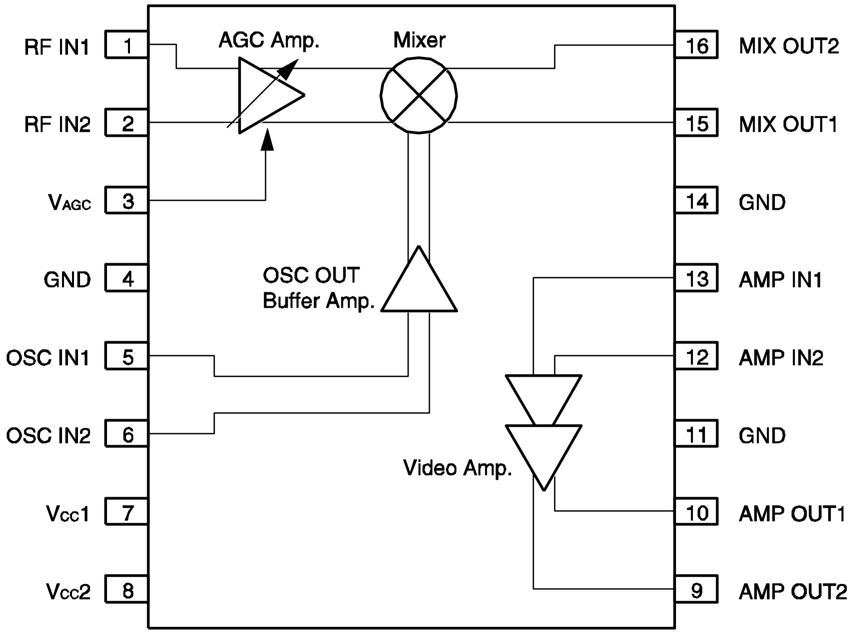
Date Published January 2005 CP(K)

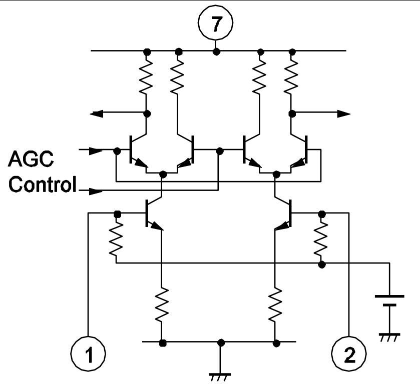
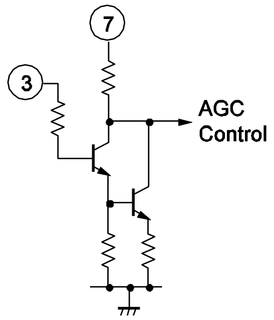
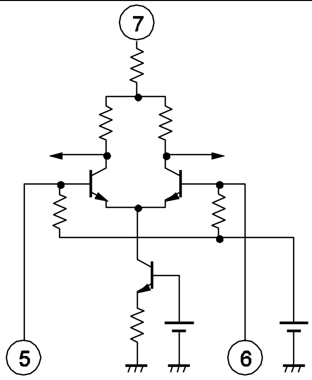
The mark ★ shows major revised points.

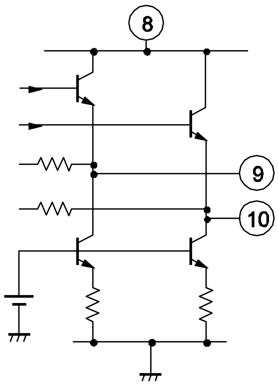
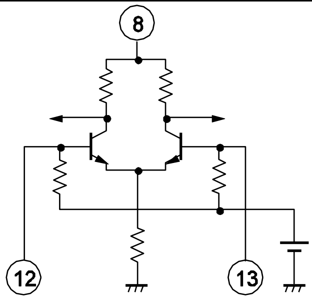
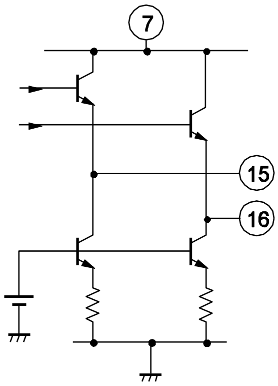
INTERNAL BLOCK DIAGRAM AND PIN CONFIGURATION

(Top View)



PIN EXPLANATIONS

PIN No.	Symbol	Pin Voltage (V, TYP.)	Explanation	Equivalent Circuit
1	RF IN1	1.46	Input pin of IF signal. 1-pin is same phase and 2-pin is opposite phase at balance input. In case of single input, 1-pin or 2-pin should be grounded through capacitor (example 10 nF).	
2	RF IN2	1.46		
3	V_{AGC}	0 to 3.5	Automatic gain control pin. This pins bias govern the AGC output level. Minimum gain at V_{AGC} = 0 V Maximum gain at V_{AGC} = 3.5 V	
4	GND	0.0	Ground pin. Must be connected to the system ground with minimum inductance. Ground pattern on the board should be formed as wide as possible.	——
5	OSC IN1	2.6	Input pin of Oscillator signal. 5-pin is same phase and 6-pin is opposite phase at balance input. In case of single input, 5-pin or 6-pin should be grounded through capacitor (ex. 10 nF).	
6	OSC IN2	2.6		
7	V_{CC1}	5.0	Power supply pin of IF down convertor block. Must be connected bypass capacitor to minimize ground impedance.	——
8	V_{CC2}	5.0	Power supply pin of video amplifier. Must be connected bypass capacitor to minimize ground impedance.	——

PIN No.	Symbol	Pin Voltage (V, TYP.)	Explanation	Equivalent Circuit
9	AMP OUT2	2.5	Output pin of video amplifier. OUT1 and IN1 are same phase. OUT2 and IN2 are same phase.	
10	AMP OUT1	2.5		
11	GND	0.0	Ground pin. Must be connected to the system ground with minimum inductance. Ground pattern on the board should be formed as wide as possible.	———
12	AMP IN2	1.45	Signal input pin of video amplifier. This pin is high impedance.	
13	AMP IN1	1.45		
14	GND	0.0	Ground pin. Must be connected to the system ground with minimum inductance. Ground pattern on the board should be formed as wide as possible.	———
15	MIX OUT1	3.7	Output pin of mixer. This output pin features low-impedance because of its emitter-follower output port.	
16	MIX OUT2	3.7		

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Conditions	Ratings	Unit
Supply Voltage	V_{CC}	T_A = +25°C	6.0	V
Power Dissipation	P_D	T_A = +85°C **Note**	433	mW
Operating Ambient Temperature	T_A		–40 to +85	°C
Storage Temperature	T_{stg}		–55 to +150	°C

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

RECOMMENDED OPERATING RENGE

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Supply Voltage	V_{CC}		4.5	5.0	5.5	V
Operating Ambient Temperature	T_A	V_{CC} = 4.5 to 5.5 V	–40	+25	+85	°C
Gain Control Voltage Range	V_{AGC}		0	–	V_{CC}	V

ELECTRICAL CHARACTERISTICS (T_A = +25°C, V_{CC} = 5 V)

Parameter	Symbol	Test Conditions	MIN.	TYP.	MAX.	Unit
DC Characteristics						
Circuit Current 1 (Total Block)	$I_{CC}1$	No input signal, $V_{CC}1$ = $V_{CC}2$ = 5 V **Note 4**	33.0	42.0	53.5	mA
Circuit Current 2 (AGC Amplifier Block + Mixer Block)	$I_{CC}2$	No input signal, $V_{CC}1$ = 5 V **Note 4**	15.0	20.0	25.5	mA
Circuit Current 3 (Video Amplifier Block)	$I_{CC}3$	No input signal, $V_{CC}2$ = 5 V **Note 4**	18.0	22.0	28.0	mA
AGC Voltage High Level	$V_{AGC\,(H)}$	@ Maximum gain **Note 1**	3.0	–	V_{CC}	V
AGC Voltage Low Level	$V_{AGC\,(L)}$	@ Minimum gain **Note 1**	0	–	0.5	V
RF Characteristics (AGC Amplifier Block + Mixer Block: f_{RF} = 84 MHz, f_{LO} = 134 MHz, P_{LO} = −15 dBm, f_{IF} = 50 MHz, Z_S = 50 Ω, Z_L = 1 kΩ)						
RF Input Frequency Range	f_{RF}	f_{IF} = 50 MHz constant **Note 1**	30	–	250	MHz
IF Output Frequency Range	f_{IF}	f_{RF} = 84 MHz constant **Note 1**	0.1	–	150	MHz
Maximum Conversion Gain	CG_{MAX}	V_{AGC} = 3.0 V, P_{in} = −50 dBm **Note 1**	30.5	33.0	35.5	dB
Minimum Conversion Gain	CG_{MIN}	V_{AGC} = 0.5 V, P_{in} = −20 dBm **Note 1**	−18.0	−12.5	−3.5	dB
AGC Dynamic Range	GCR_{AGC}	V_{AGC} = 0.5 to 3.0 V **Note 1**	36.0	45.5	–	dB
Noise Figure	NF	DSB, V_{AGC} = 3.0 V (@ Maximum gain) **Note 2**	–	7.0	8.5	dB
3rd Order Intermodulaion Distortion	IM_3	V_{out} = 0.236 V_{p-p} × 2 tone, (single-ended output), P_{in} −30 dBm/tone f_{RF1} = 84 MHz, f_{RF2} = 85 MHz **Note 1**	24.0	26.5	–	dBc
RF Characteristics (Video Amplifier Block: f = 50 MHz, Z_S = 50 Ω, Z_L = 1 kΩ)						
Differential Gain	G_{diff}	P_{in} = −55 dBm **Note 3**	48.0	50.5	53.5	dB
Maximum Output Voltage 2	V_{oclip2}	P_{in} = −25 dBm **Note 3**	2.95	3.70	–	V_{p-p}

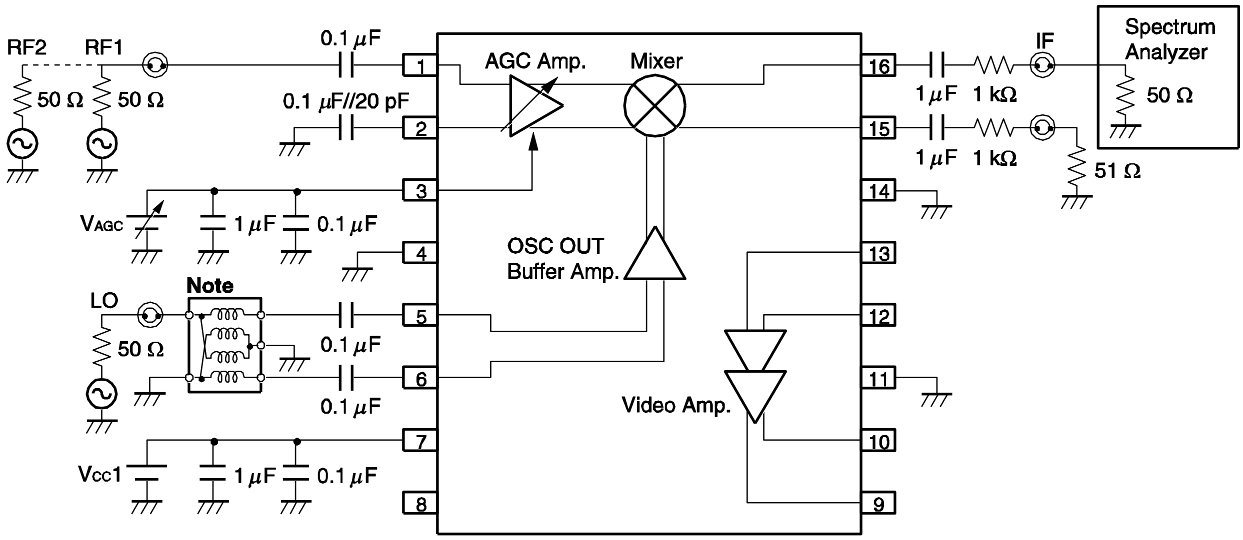
Notes 1. By measurement circuit 1
2. By measurement circuit 2
3. By measurement circuit 4
4. By measurement circuit 6

STANDARD CHARACTERISTICS (T_A = +25°C, V_{CC} = 5 V, Z_S = 50 Ω)

Parameter	Symbol	Test Conditions	Reference Value	Unit
AGC Amplifier Block + Mixer Block (f_{RF} = 84 MHz, f_{LO} = 134 MHz, P_{LO} = –15 dBm, f_{IF} = 50 MHz, Z_S = 50 Ω, Z_L = 1 kΩ)				
Input 3rd Order Distortion Intercept Point	IIP_3	V_{AGC} = 0.5 V (@ Minimum gain) f_{RF1} = 84 MHz, f_{RF2} = 85 MHz **Note 1**	+1.0	dBm
Maximum Output Voltage1	V_{oclip1}	V_{AGC} = 3.0 V, P_{in} = –20 dBm **Note 1**	0.65	V_{p-p}
RF IN Impedance	Z_{RFin}	V_{AGC} = 3.0 V, f = 84 MHz **Note 2**	440 – j1100	Ω
OSC IN Impedance	Z_{OSCin}	V_{AGC} = 3.0 V, f = 134 MHz **Note 2**	280 – j810	Ω
MIXER OUT Impedance	Z_{MIXout}	V_{AGC} = 3.0 V, f = 50 MHz **Note 2**	30.2 + j2.5	Ω
Video Amplifier Block (f = 50 MHz, Z_S = 50 Ω, Z_L = 1 kΩ)				
Frequency Range	f_{BW}	P_{in} = –55 dBm, G (f = 10 MHz) –1 dB **Note 3**	60	MHz
Input Impedance	Z_{AMPin}	f = 50 MHz **Note 4**	330 – j480	Ω
Output Impedance	Z_{AMPout}	f = 50 MHz **Note 4**	21.9 + j22.6	Ω
3rd Order Intermodulaion Distortion	IM_3	V_{out} = 0.7 V_{p-p} × 2 tone, f_{in1} = 49 MHz, f_{in2} = 50 MHz **Note 3**	55.0	dBc
Total Block (f_{RF} = 84 MHz, f_{LO} = 134 MHz, P_{LO} = –15 dBm, f_{IF} = 50 MHz, Z_S = 50 Ω, Z_L = 1 kΩ)				
Maximum Conversion Gain	CG_{MAX}	V_{AGC} = 3.0 V, P_{in} = –70 dBm **Note 5**	67.5	dB
Minimum Conversion Gain	CG_{MIN}	V_{AGC} = 0.5 V, P_{in} = –40 dBm **Note 5**	22.0	dB
Total Dynamic Range	GCR	V_{AGC} = 0.5 to 3.0 V **Note 5**	45.5	dB
Noise Figure	NF	DSB, V_{AGC} = 3.0 V (@ Maximum gain) **Note 6**	7.0	dB
Maximum Output Voltage	V_{oclip}	V_{AGC} = 3.0 V (@ Minimum gain) **Note 5**	3.7	V_{p-p}
Input 3rd Order Distortion Intercept Point	IIP_{3total}	V_{AGC} = 0.5 V (@ Minimum gain) f_{RF1} = 84 MHz, f_{RF2} = 85 MHz **Note 5**	+1.0	dBm
3rd Order Intermodulaion Distortion	IM_{3total}	V_{out} = 0.7 V_{p-p} × 2 tone, P_{in} –40 dBm/tone f_{RF1} = 84 MHz, f_{RF2} = 85 MHz **Note 5**	51.0	dBc

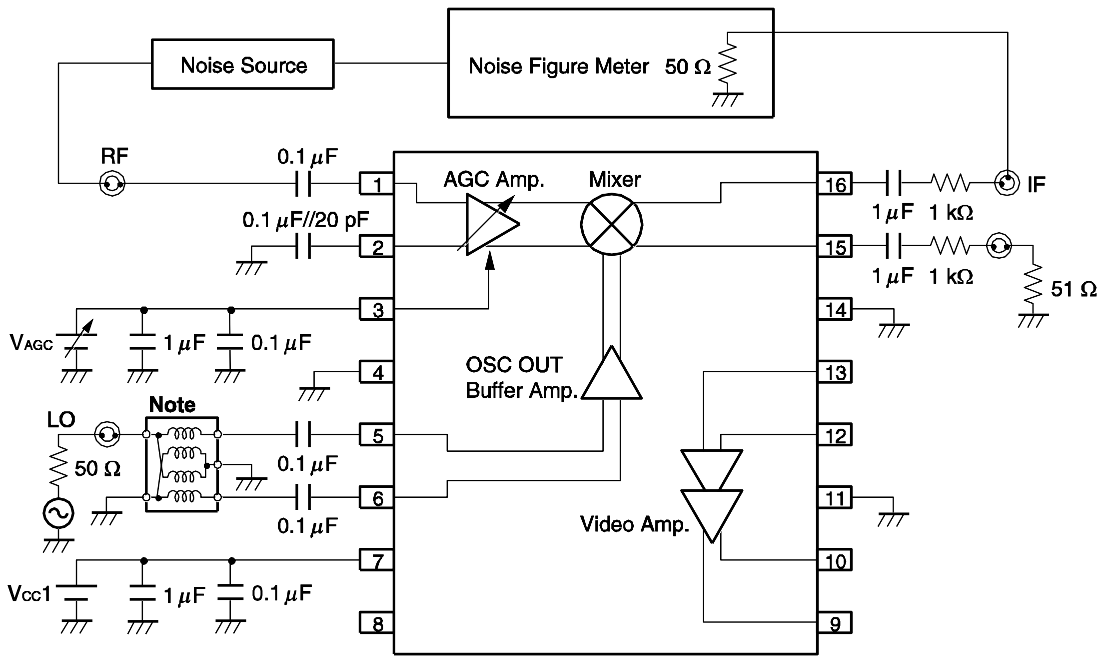
Notes 1. By measurement circuit 1
2. By measurement circuit 3
3. By measurement circuit 4
4. By measurement circuit 5
5. By measurement circuit 6
6. By measurement circuit 7

MEASUREMENT CIRCUIT 1



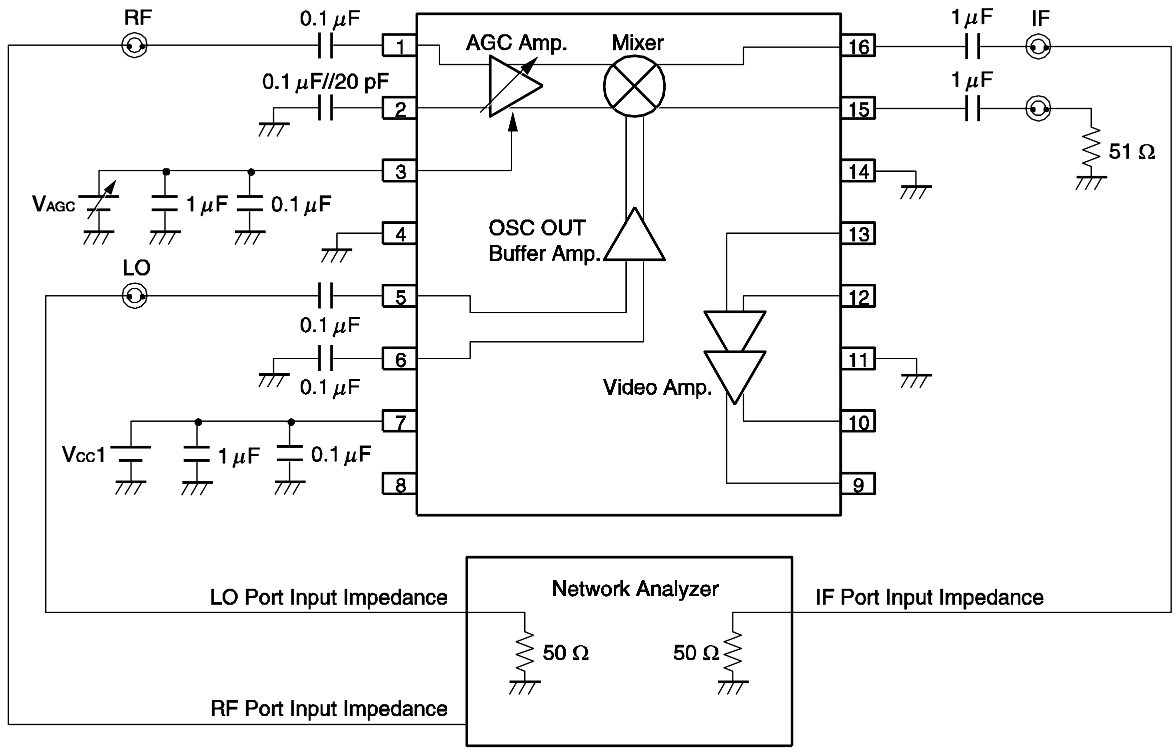
Note Balun Transformer : TOKO 617DB-1010 B4F (Double balanced type)

MEASUREMENT CIRCUIT 2

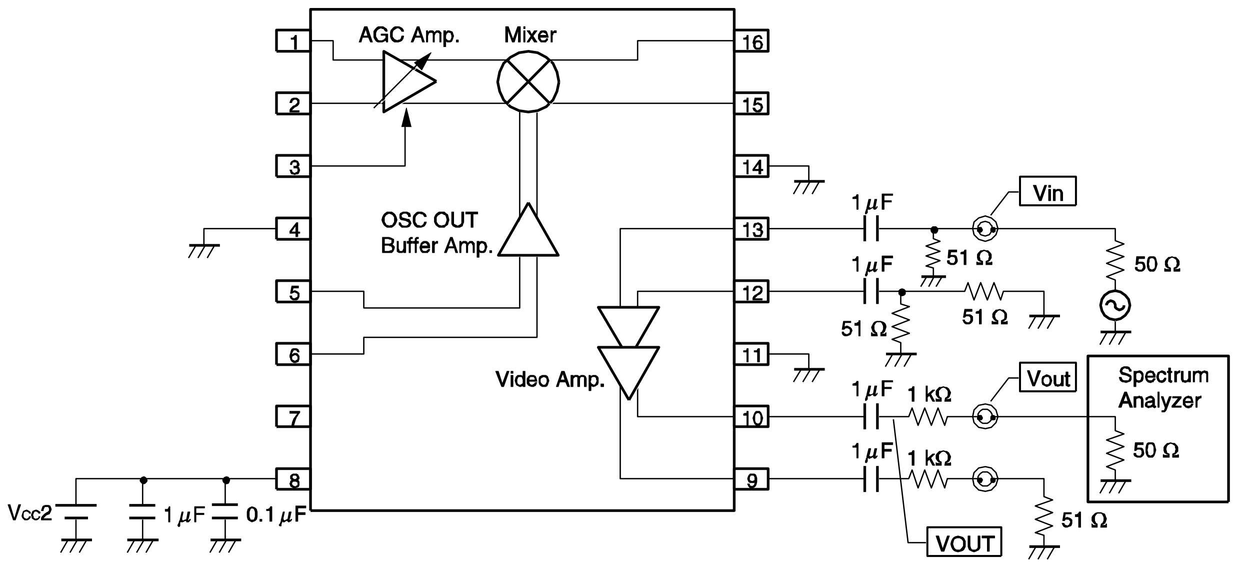


Note Balun Transformer : TOKO 617DB-1010 B4F (Double balanced type)

MEASUREMENT CIRCUIT 3



MEASUREMENT CIRCUIT 4

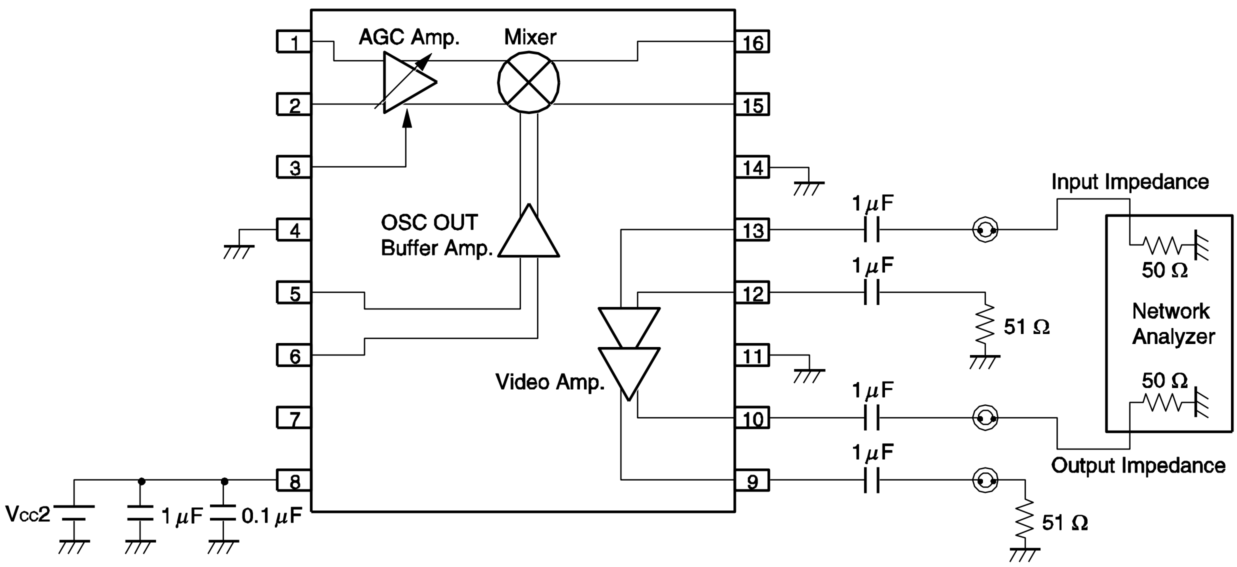


Remarks 1. Voltage Gain (Single Ended) = 20 log (VOUT/Vin) (dB)

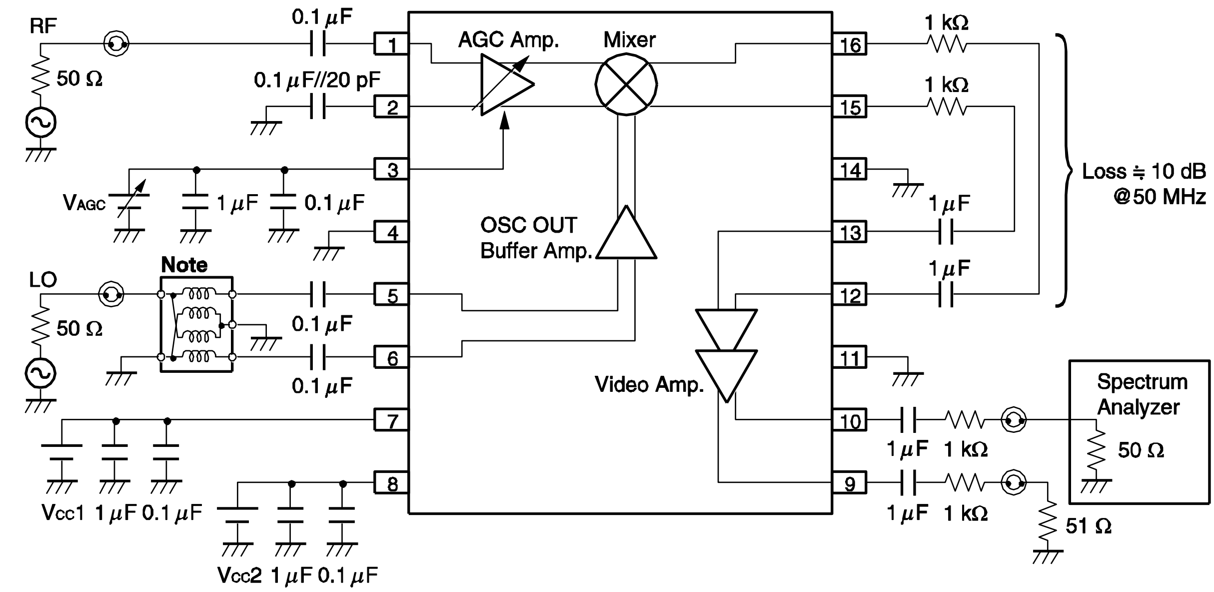
2. Differential Gain (Differential-out) = 20 log (2 × VOUT/Vin) (dB)

3. VOUT = Vout (Measured Value) × (1 050/50)

MEASUREMENT CIRCUIT 5

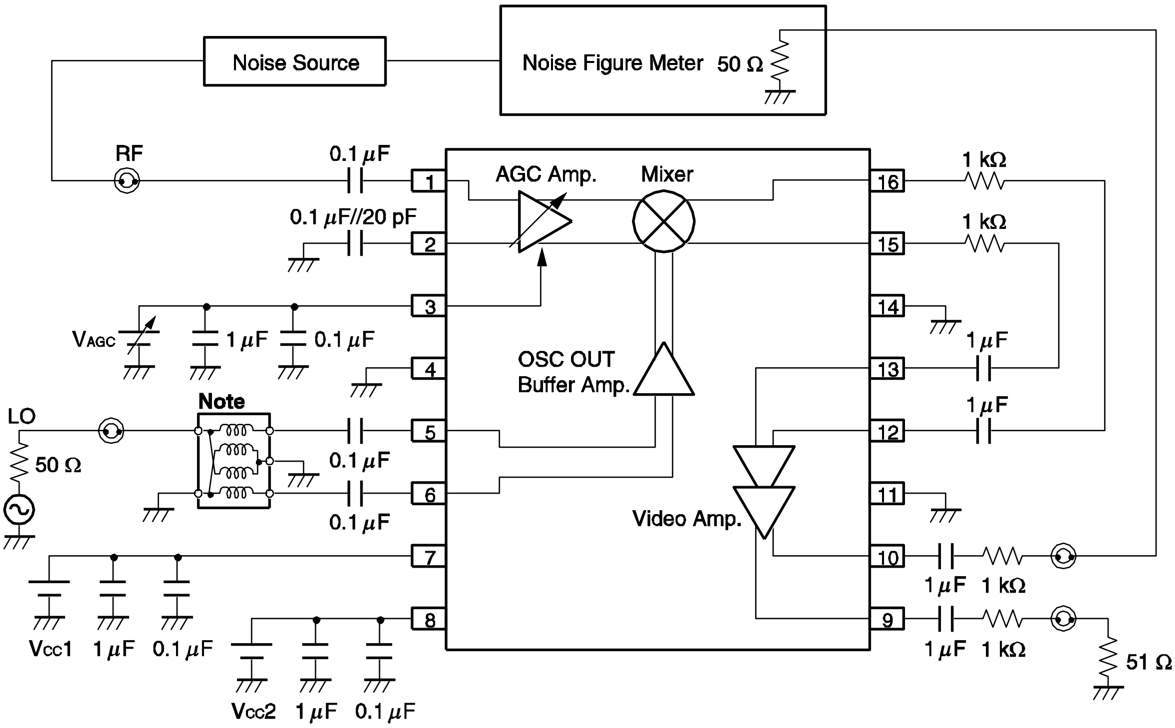


MEASUREMENT CIRCUIT 6



Note Balun Transformer : TOKO 617DB-1010 B4F (Double balanced type)

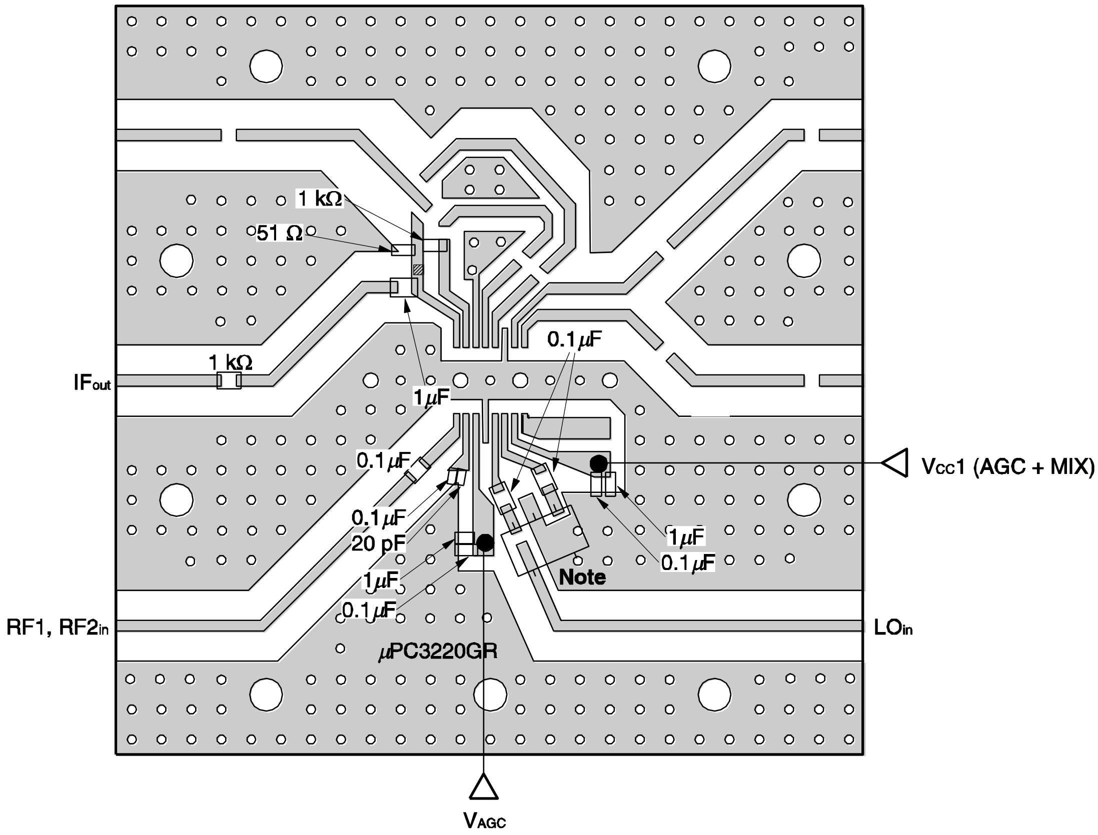
MEASUREMENT CIRCUIT 7



Note Balun Transformer : TOKO 617DB-1010 B4F (Double balanced type)

The application circuits and their parameters are for reference only and are not intended for use in actual design-ins.

ILLUSTRATION OF THE MEASUREMENT CIRCUIT1, 2 ASSEMBLED ON EVALUATION BOARD

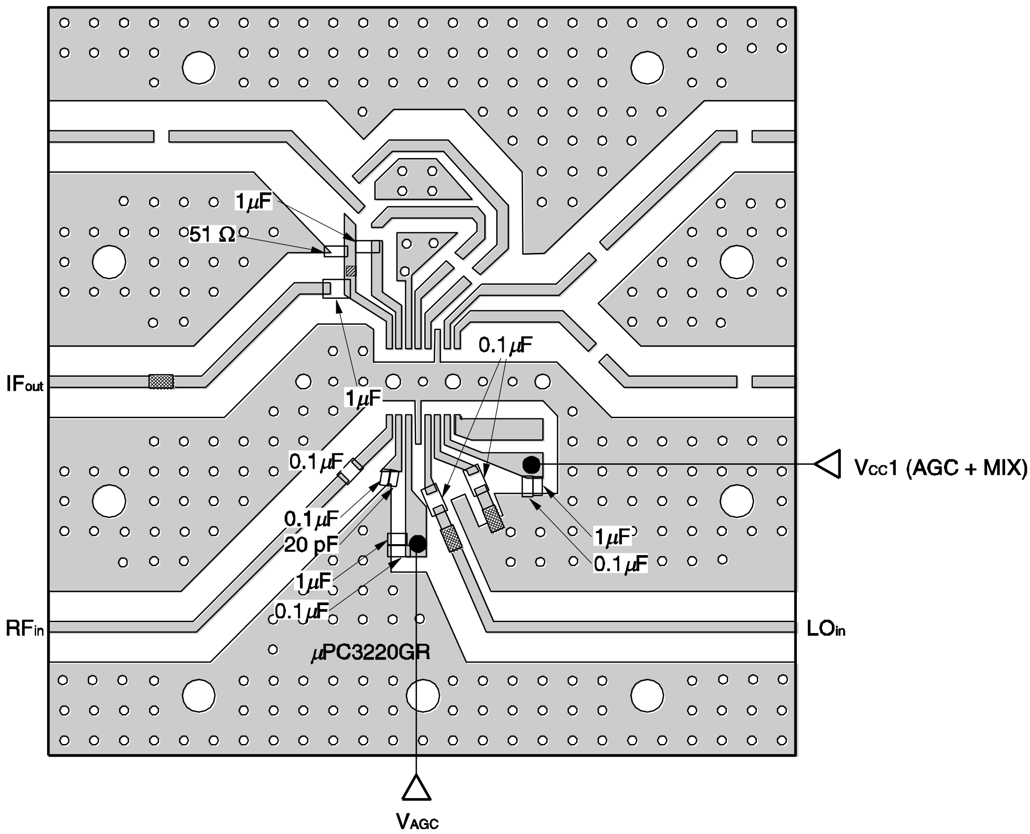


Note Balun Transformer

Remarks

1. Back side: GND pattern
2. Solder plated on pattern
3. ○ ◯ : Through hole
4. ▨ : Represents cutout

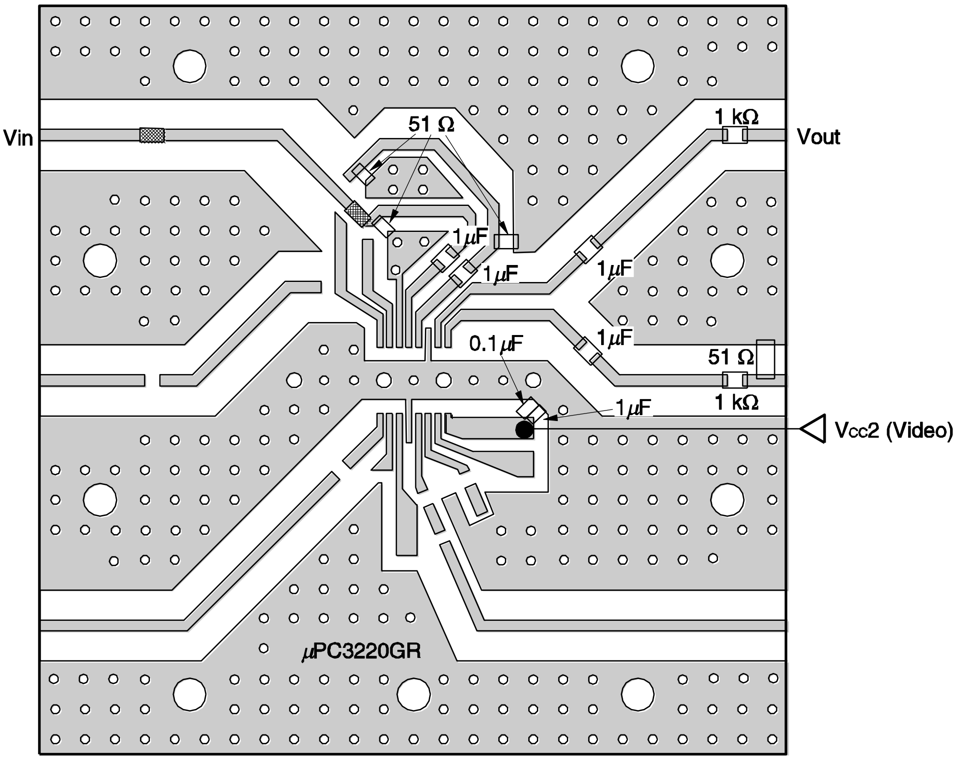
ILLUSTRATION OF THE MEASUREMENT CIRCUIT3 ASSEMBLED ON EVALUATION BOARD



Remarks

1. Back side: GND pattern
2. Solder plated on pattern
3. o O : Through hole
4. ▨ : Represents cutout
5. ▩ : Represents short-circuit strip

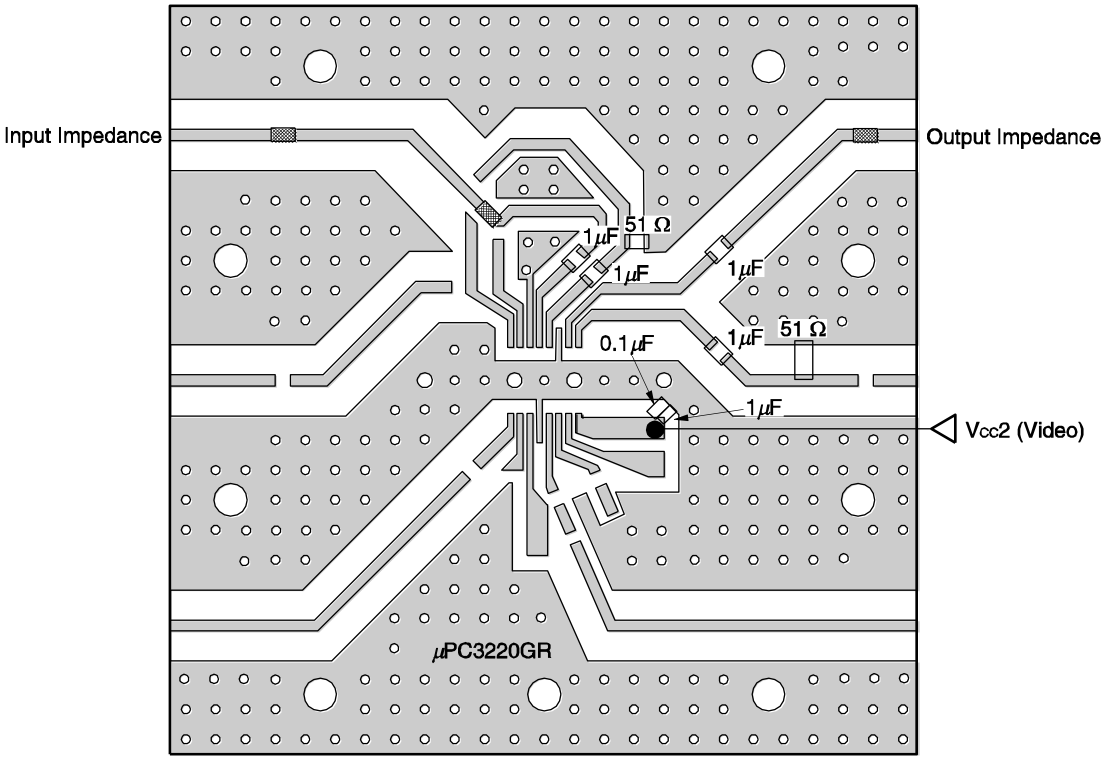
ILLUSTRATION OF THE MEASUREMENT CIRCUIT4 ASSEMBLED ON EVALUATION BOARD



Remarks

1. Back side: GND pattern
2. Solder plated on pattern
3. ∘ ○ : Through hole
4. ▩ : Represents short-circuit strip

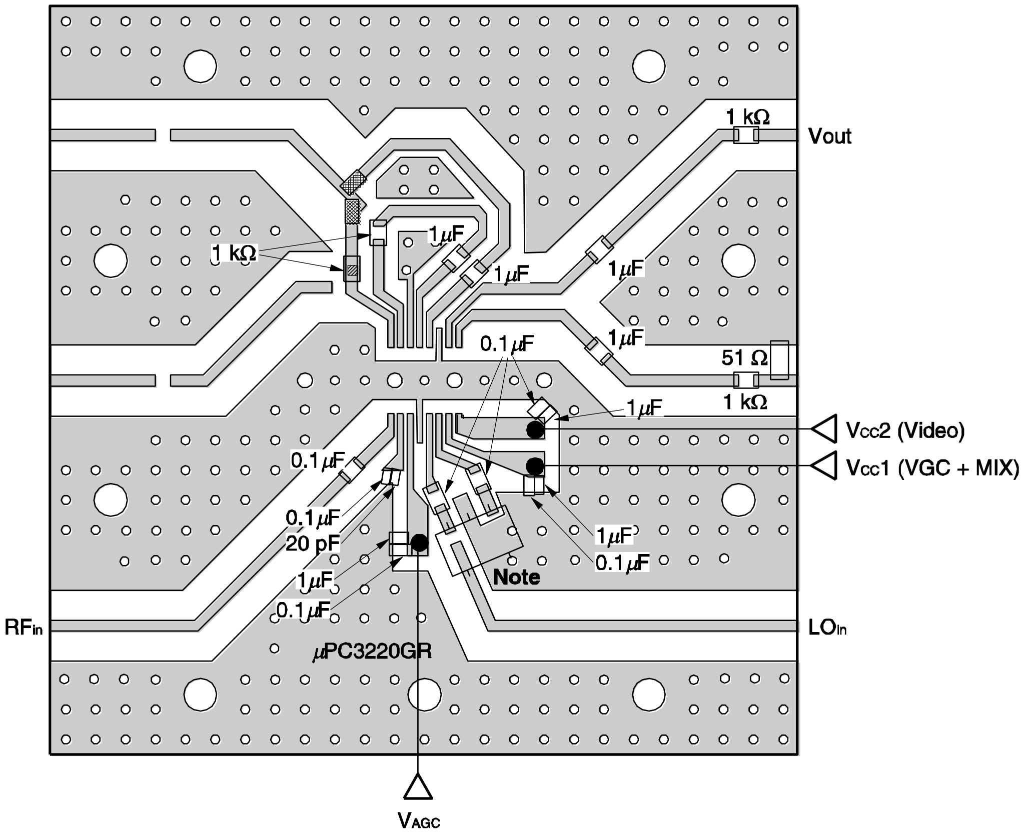
ILLUSTRATION OF THE MEASUREMENT CIRCUIT5 ASSEMBLED ON EVALUATION BOARD



Remarks

1. Back side: GND pattern
2. Solder plated on pattern
3. ○ ◯ : Through hole
4. ▩ : Represents short-circuit strip

ILLUSTRATION OF THE MEASUREMENT CIRCUIT6, 7 ASSEMBLED ON EVALUATION BOARD

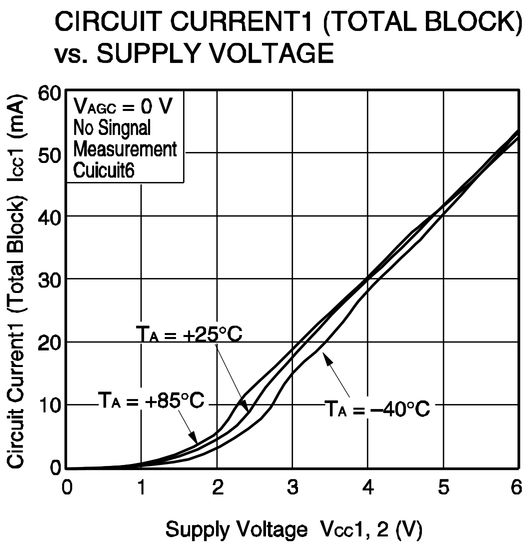


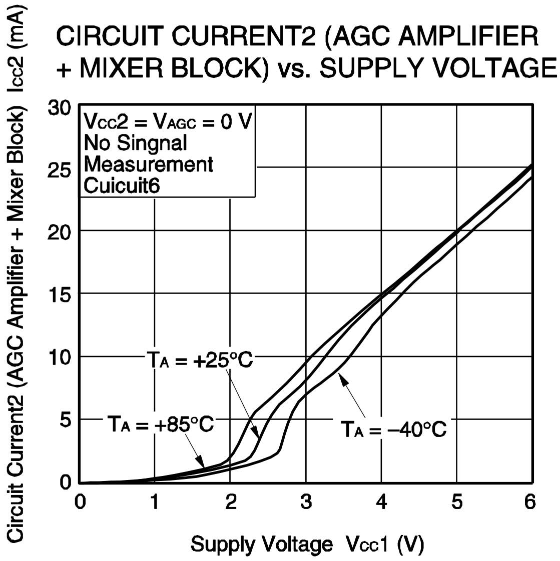
Note Balun Transformer

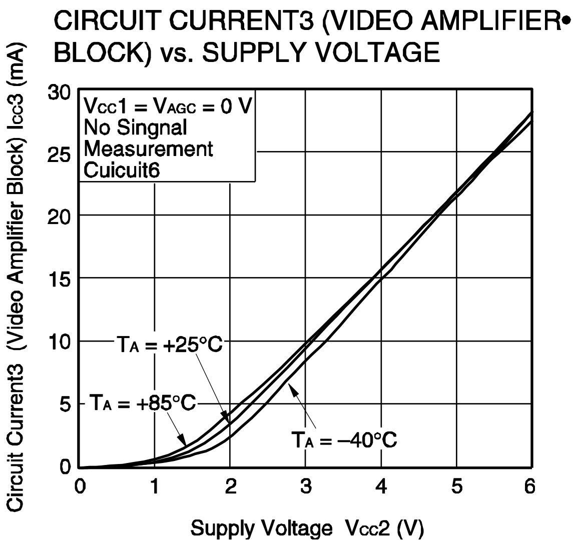
Remarks

1. Back side: GND pattern
2. Solder plated on pattern
3. ○ ◯ : Through hole
4. ▨ : Represents cutout
5. ▩ : Represents short-circuit strip

TYPICAL CHARACTERISTICS (T_A = +25°C , unless otherwise specified)



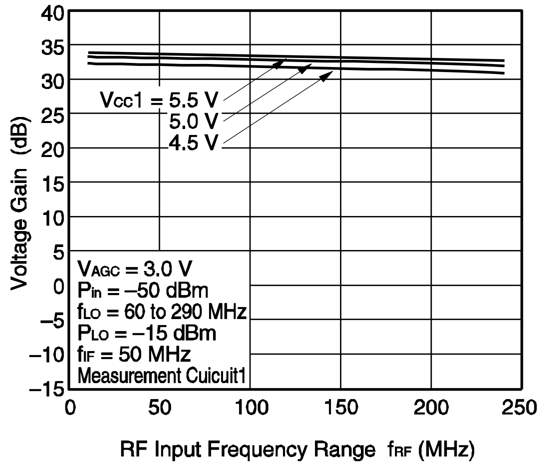




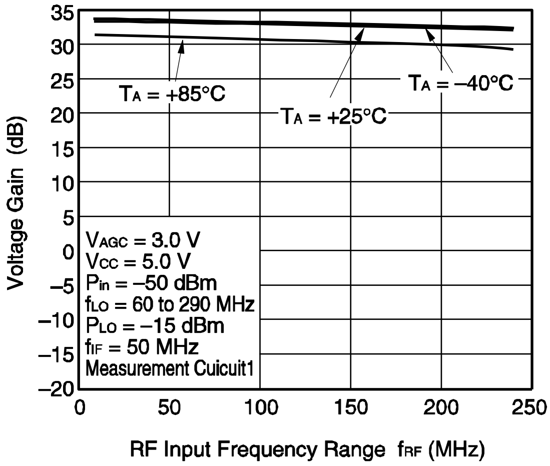
Remark The graphs indicate nominal characteristics.

–AGC Amplifier Block + Mixer Block–

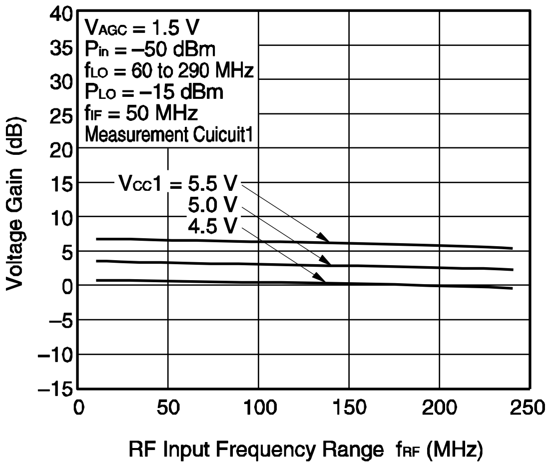
VOLTAGE GAIN vs.
RF INPUT FREQUENCY RANGE



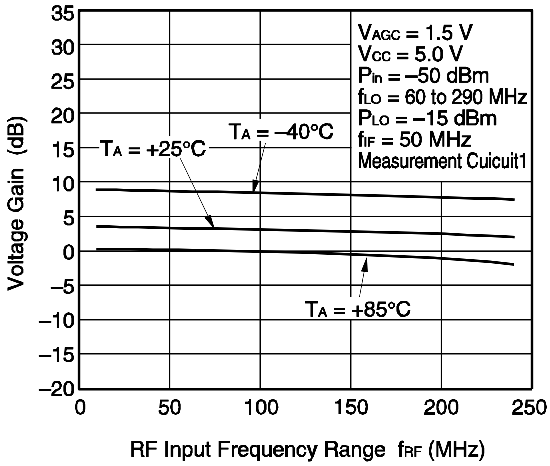
VOLTAGE GAIN vs.
RF INPUT FREQUENCY RANGE



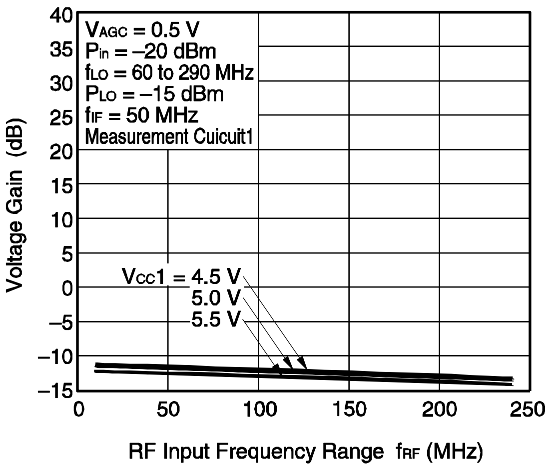
VOLTAGE GAIN vs.
RF INPUT FREQUENCY RANGE



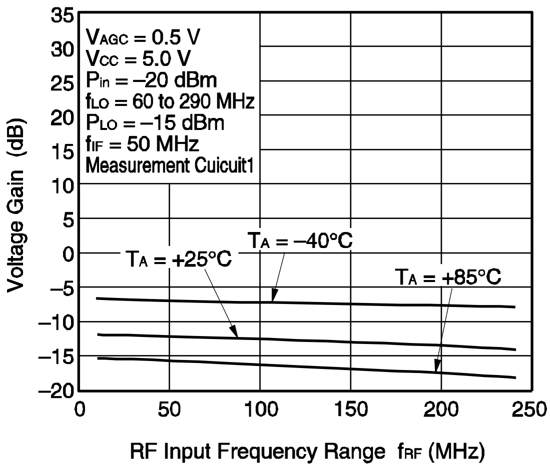
VOLTAGE GAIN vs.
RF INPUT FREQUENCY RANGE



VOLTAGE GAIN vs.
RF INPUT FREQUENCY RANGE

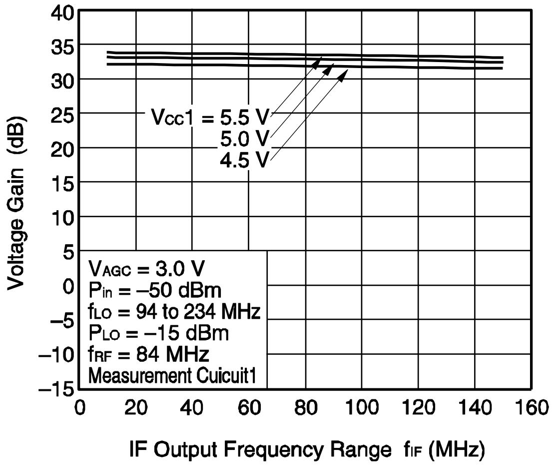


VOLTAGE GAIN vs.
RF INPUT FREQUENCY RANGE

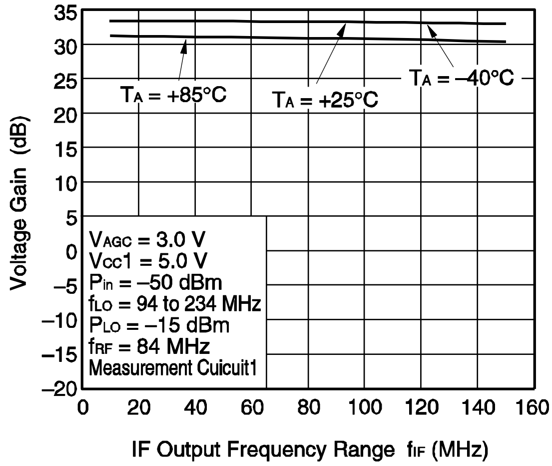


Remark The graphs indicate nominal characteristics.

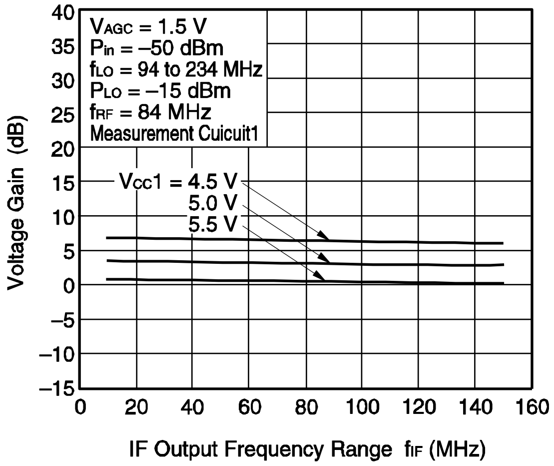
VOLTAGE GAIN vs.
IF OUTPUT FREQUENCY RANGE



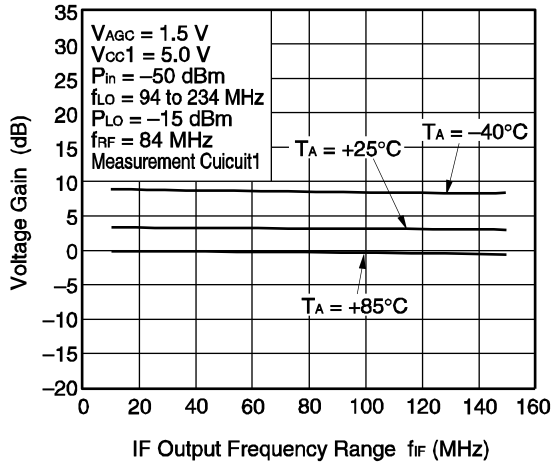
VOLTAGE GAIN vs.
IF OUTPUT FREQUENCY RANGE



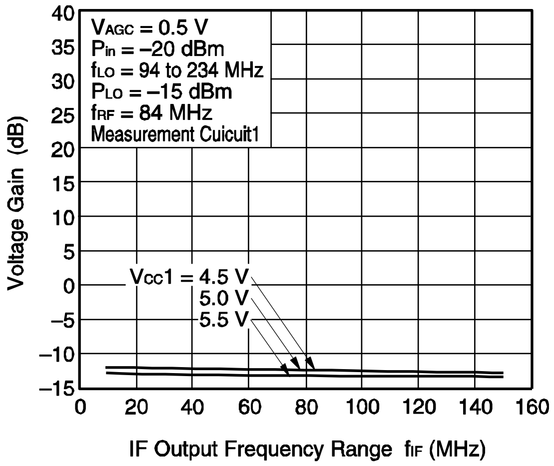
VOLTAGE GAIN vs.
IF OUTPUT FREQUENCY RANGE



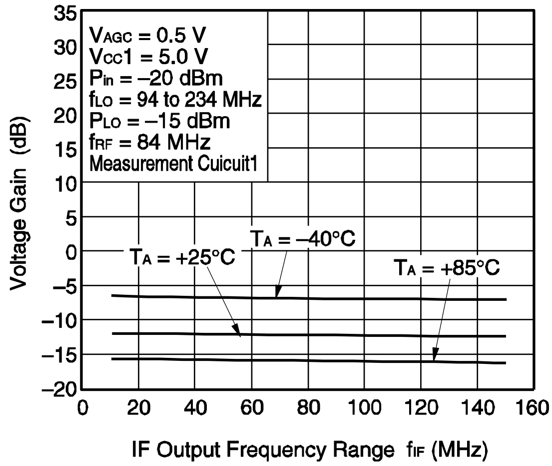
VOLTAGE GAIN vs.
IF OUTPUT FREQUENCY RANGE



VOLTAGE GAIN vs.
IF OUTPUT FREQUENCY RANGE

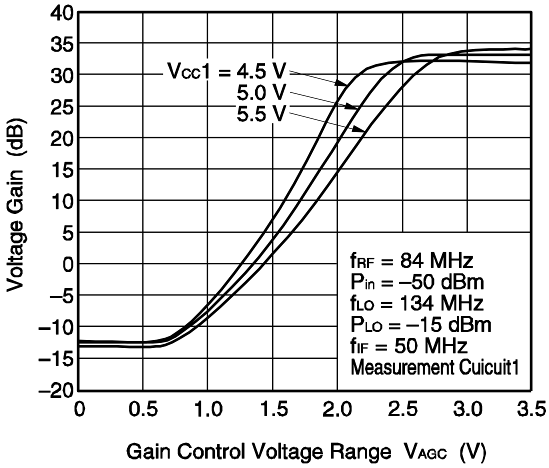


VOLTAGE GAIN vs.
IF OUTPUT FREQUENCY RANGE

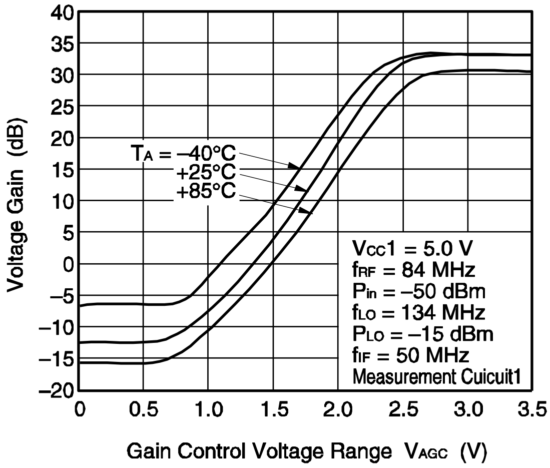


Remark The graphs indicate nominal characteristics.

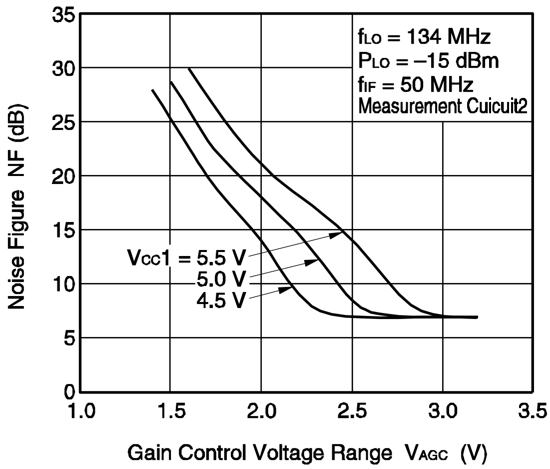
VOLTAGE GAIN vs.
GAIN CONTROL VOLTAGE RANGE



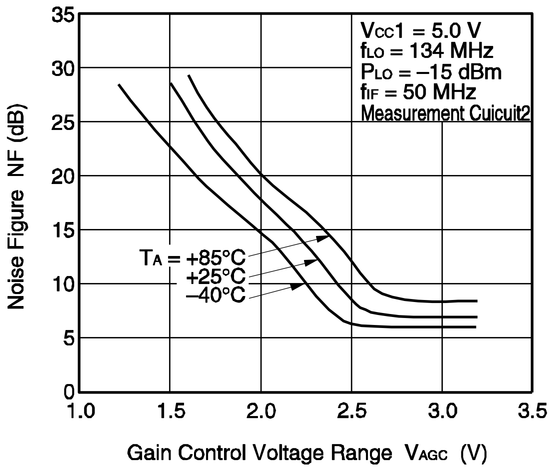
VOLTAGE GAIN vs.
GAIN CONTROL VOLTAGE RANGE



NOISE FIGURE vs.
GAIN CONTROL VOLTAGE RANGE

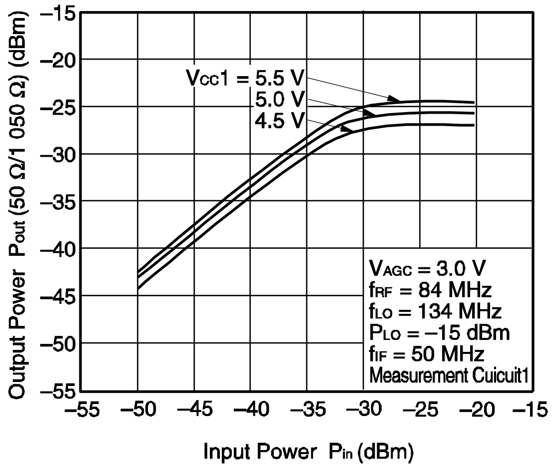


NOISE FIGURE vs.
GAIN CONTROL VOLTAGE RANGE

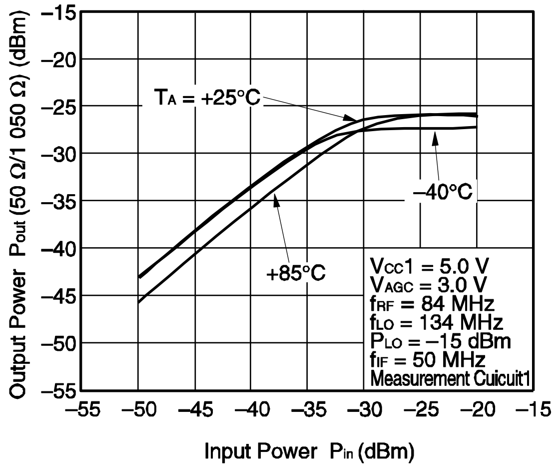


Remark The graphs indicate nominal characteristics.

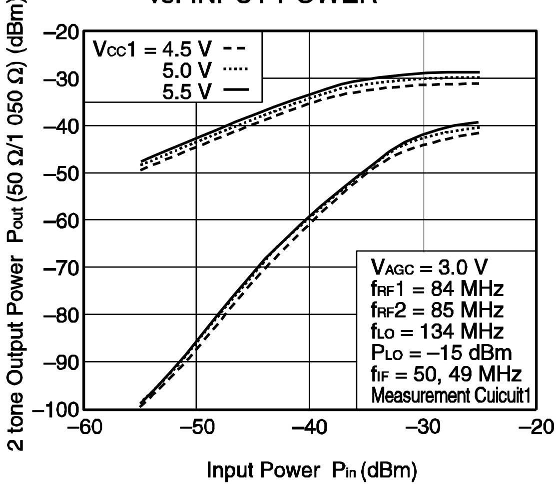
OUTPUT POWER vs. INPUT POWER



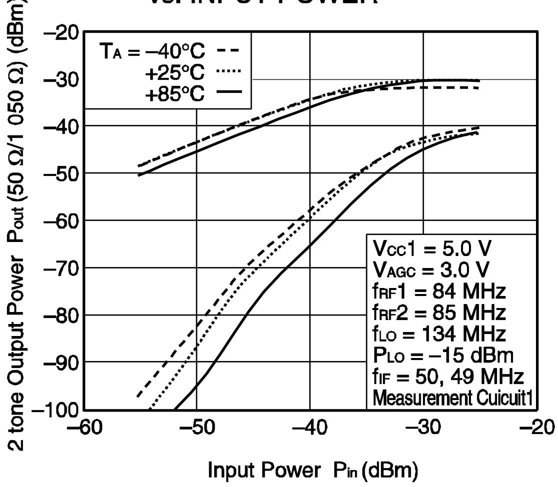
OUTPUT POWER vs. INPUT POWER



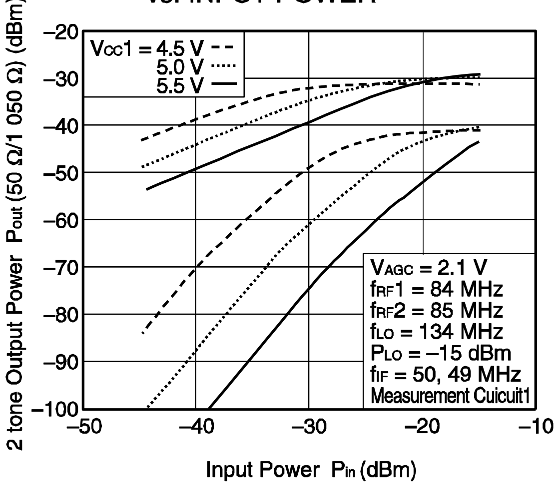
2 TONE OUTPUT POWER vs. INPUT POWER



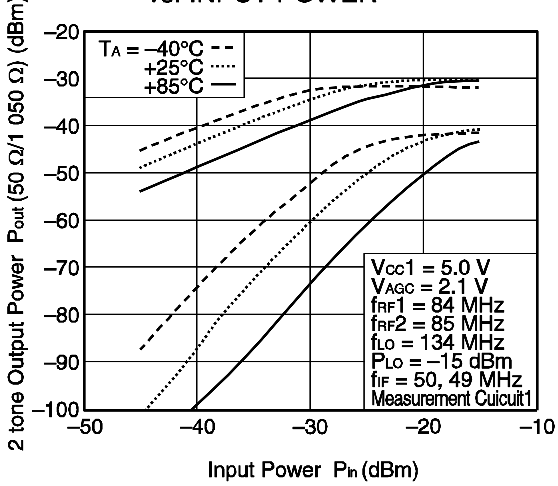
2 TONE OUTPUT POWER vs. INPUT POWER



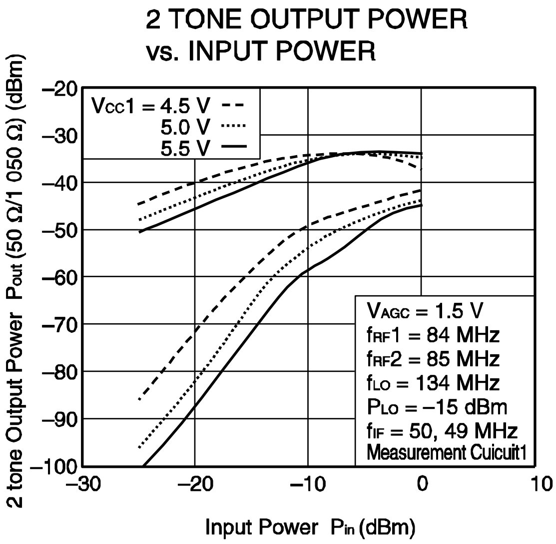
2 TONE OUTPUT POWER vs. INPUT POWER

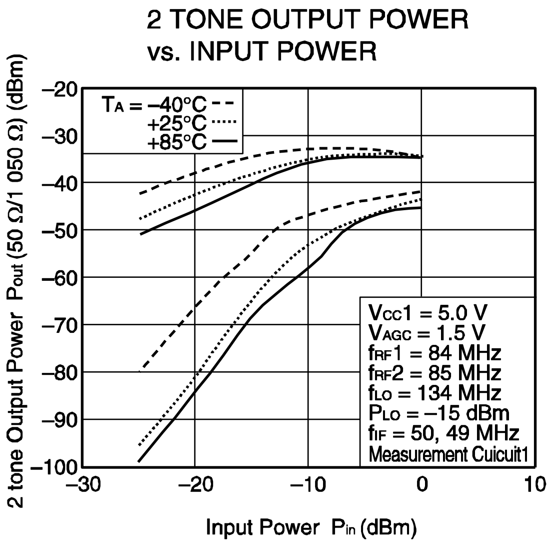


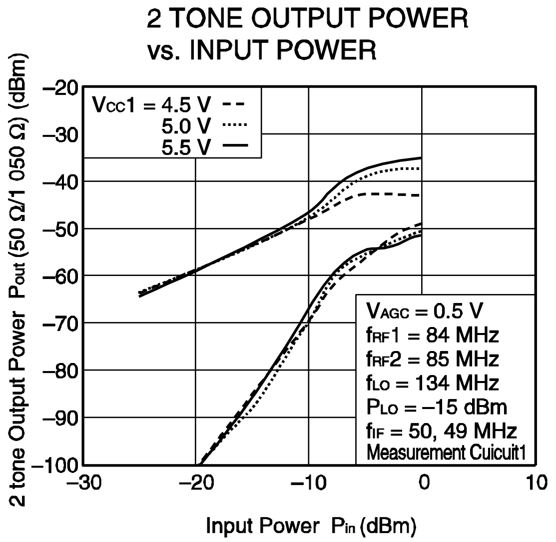
2 TONE OUTPUT POWER vs. INPUT POWER

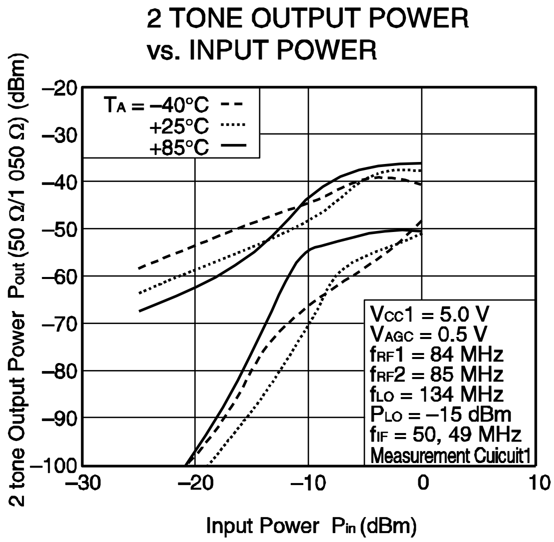


Remark The graphs indicate nominal characteristics.





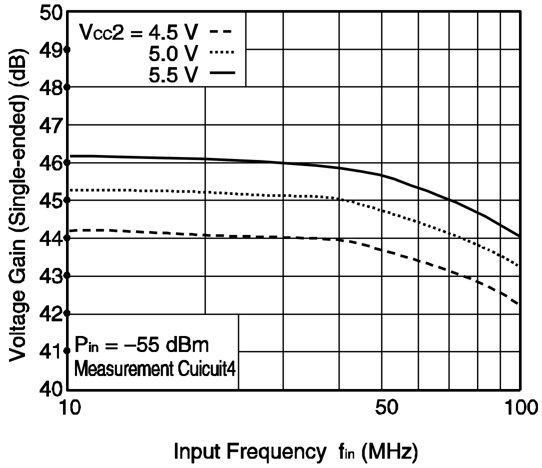




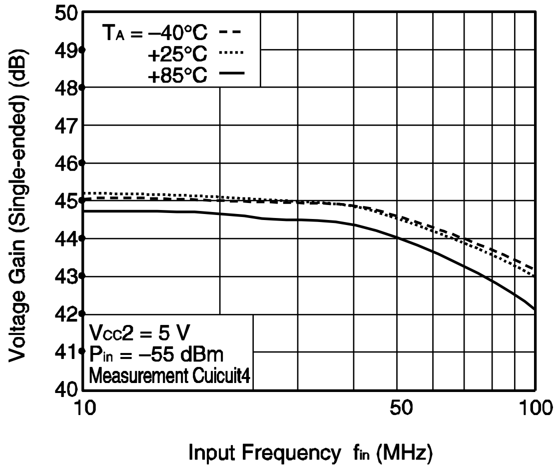
Remark The graphs indicate nominal characteristics.

–Video Amplifier Block–

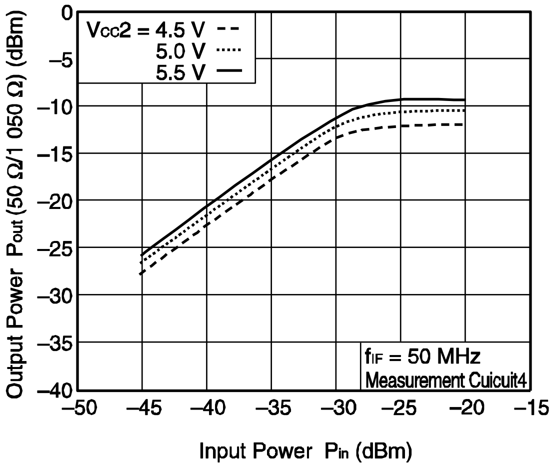
VOLTAGE GAIN (SINGLE-ENDED) vs. INPUT FREQUENCY



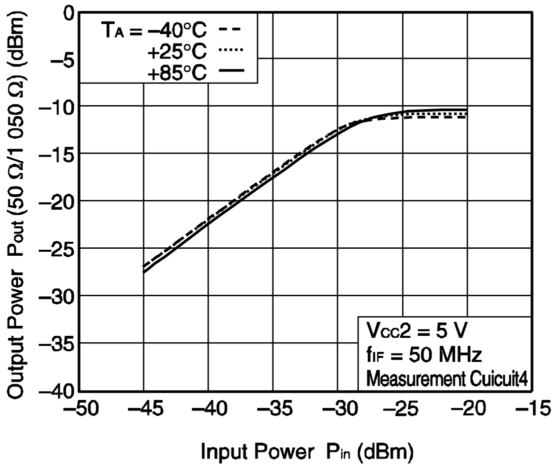
VOLTAGE GAIN (SINGLE-ENDED) vs. INPUT FREQUENCY



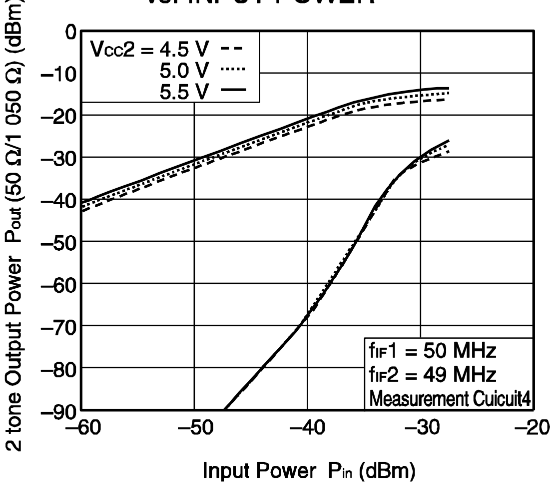
OUTPUT POWER vs. INPUT POWER



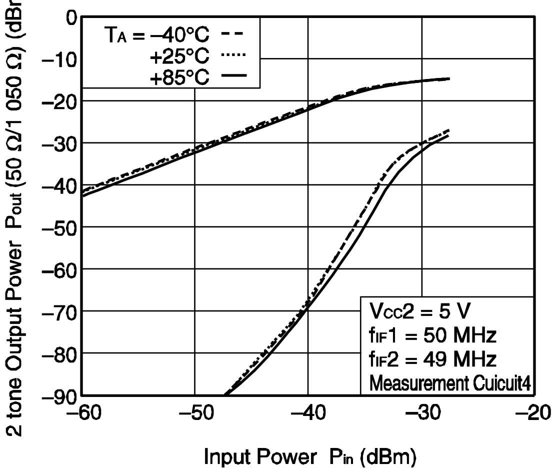
OUTPUT POWER vs. INPUT POWER



2 TONE OUTPUT POWER vs. INPUT POWER



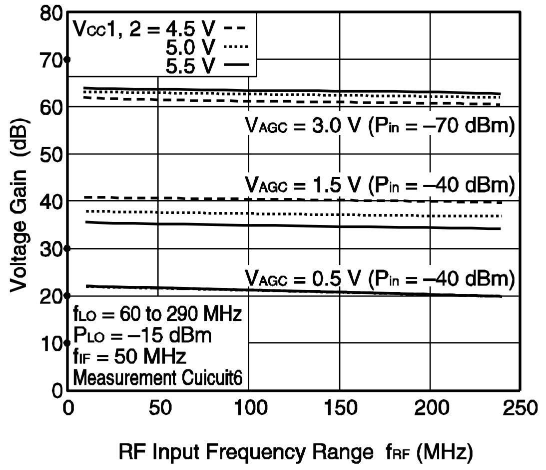
2 TONE OUTPUT POWER vs. INPUT POWER



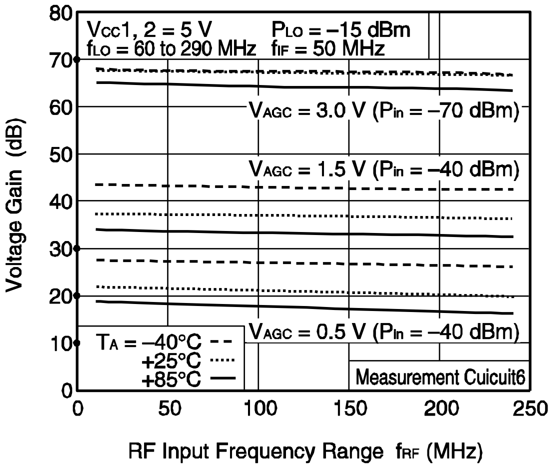
Remark The graphs indicate nominal characteristics.

–Total Block–

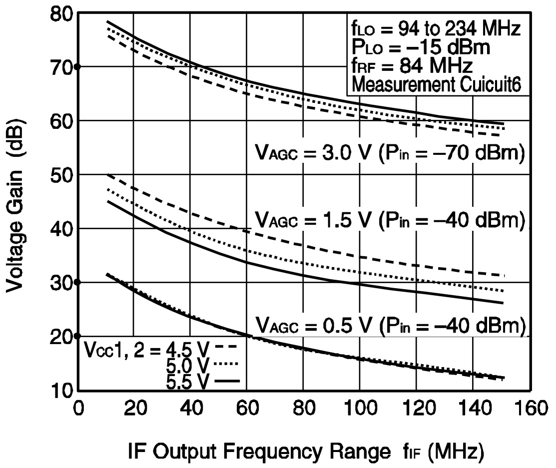
VOLTAGE GAIN
vs. RF INPUT FREQUENCY RANGE



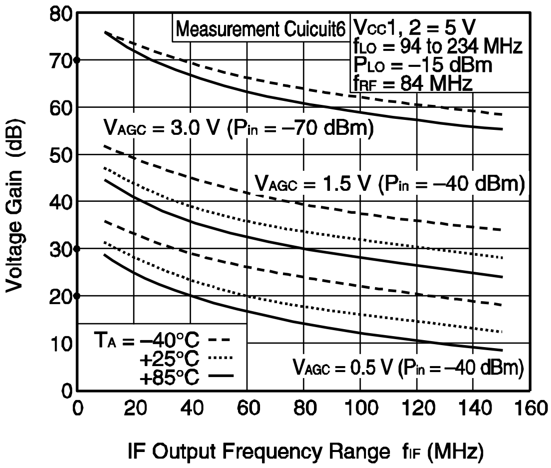
VOLTAGE GAIN
vs. RF INPUT FREQUENCY RANGE



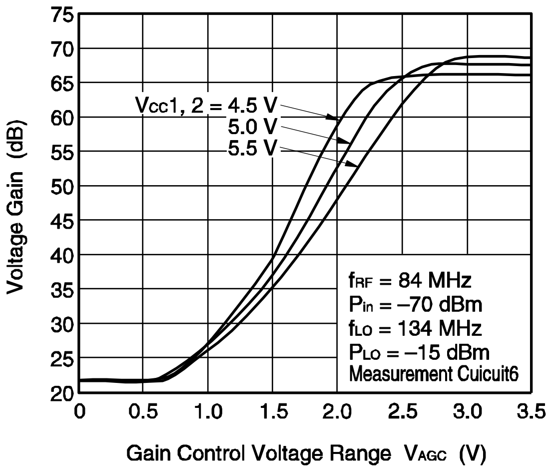
VOLTAGE GAIN
vs. IF OUTPUT FREQUENCY RANGE



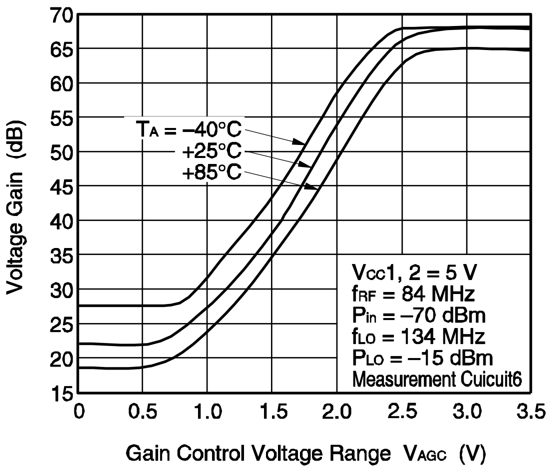
VOLTAGE GAIN
vs. IF OUTPUT FREQUENCY RANGE



VOLTAGE GAIN
vs. GAIN CONTROL VOLTAGE RANGE

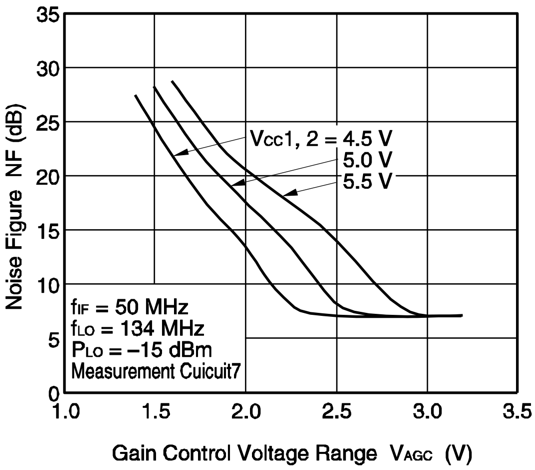


VOLTAGE GAIN
vs. GAIN CONTROL VOLTAGE RANGE

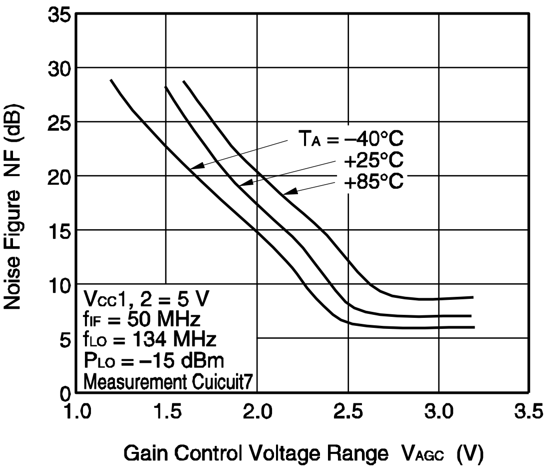


Remark The graphs indicate nominal characteristics.

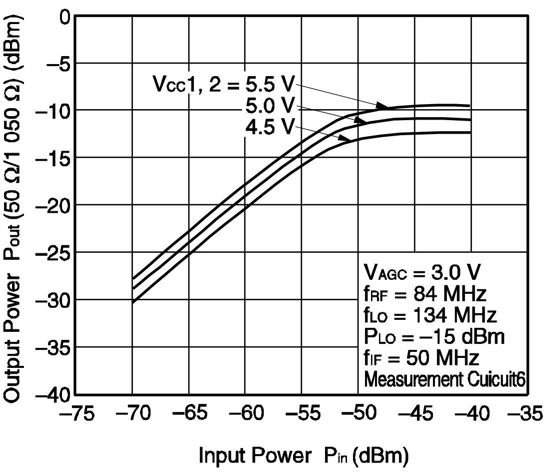
NOISE FIGURE vs.
GAIN CONTROL VOLTAGE RANGE



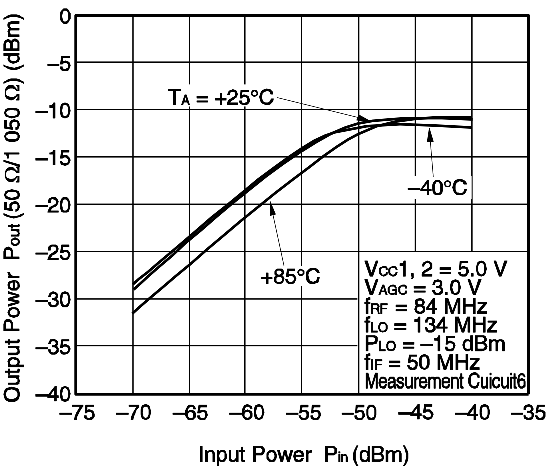
NOISE FIGURE vs.
GAIN CONTROL VOLTAGE RANGE



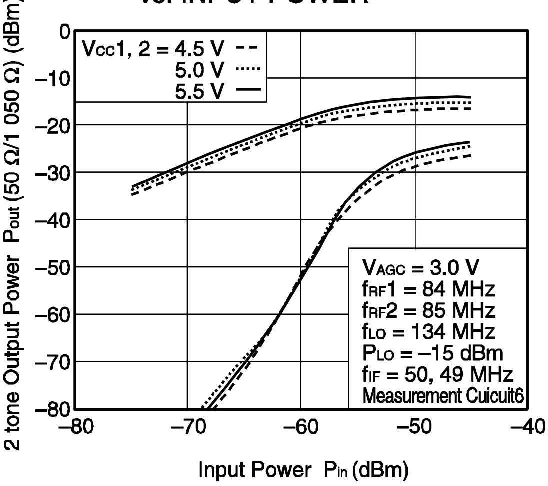
OUTPUT POWER vs. INPUT POWER



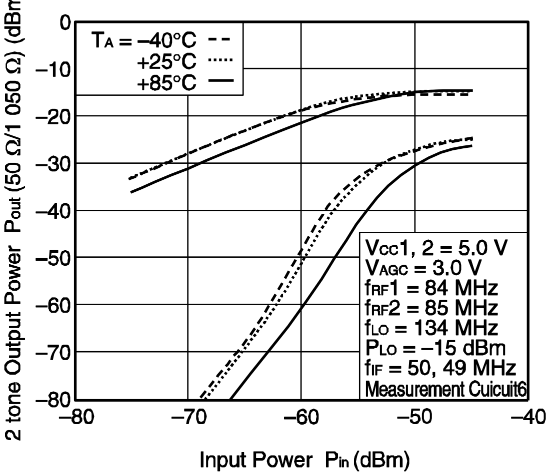
OUTPUT POWER vs. INPUT POWER



2 TONE OUTPUT POWER
vs. INPUT POWER

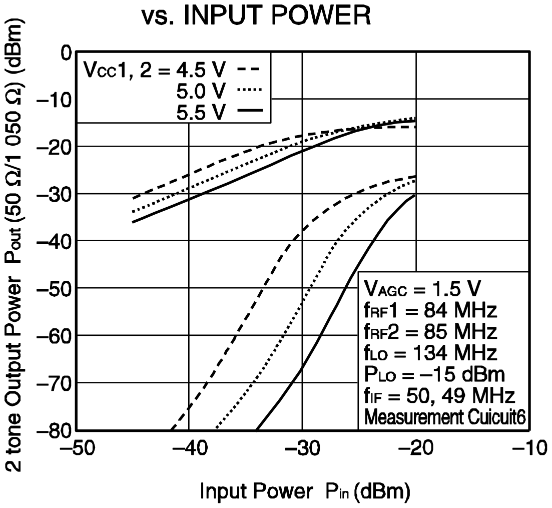


2 TONE OUTPUT POWER
vs. INPUT POWER

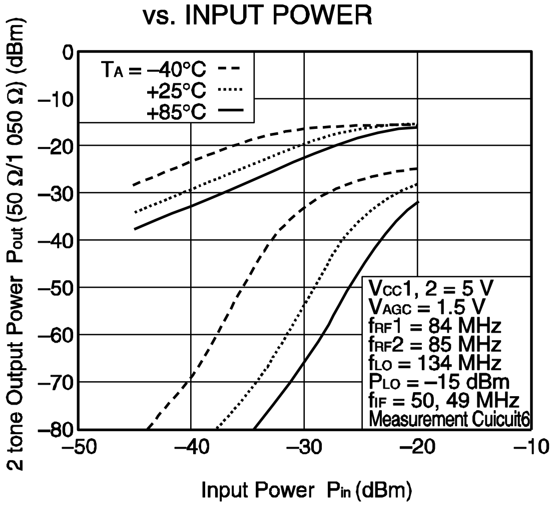


Remark The graphs indicate nominal characteristics.

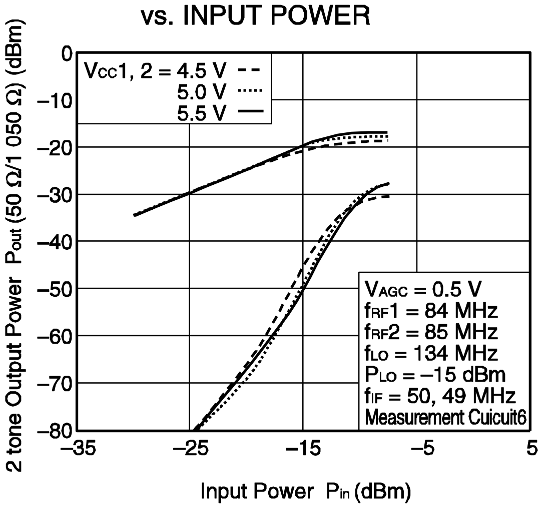
2 TONE OUTPUT POWER vs. INPUT POWER



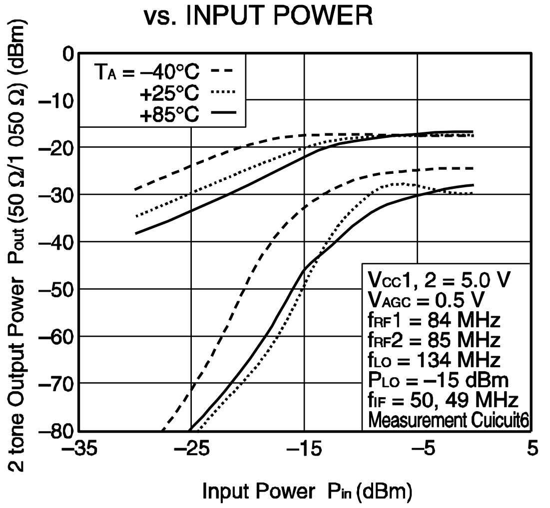
2 TONE OUTPUT POWER vs. INPUT POWER



2 TONE OUTPUT POWER vs. INPUT POWER

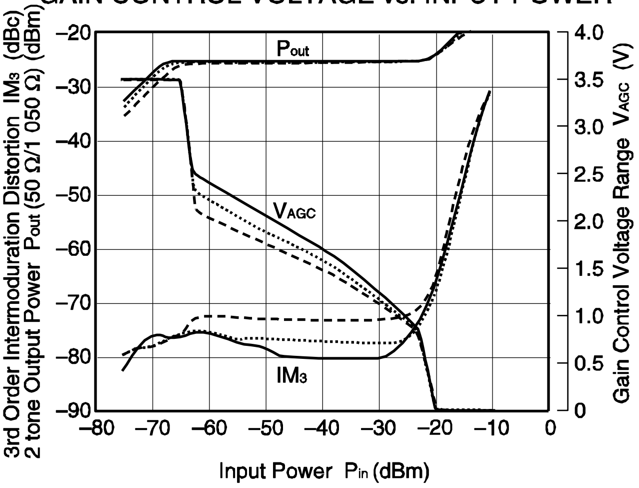


2 TONE OUTPUT POWER vs. INPUT POWER



Remark The graphs indicate nominal characteristics.

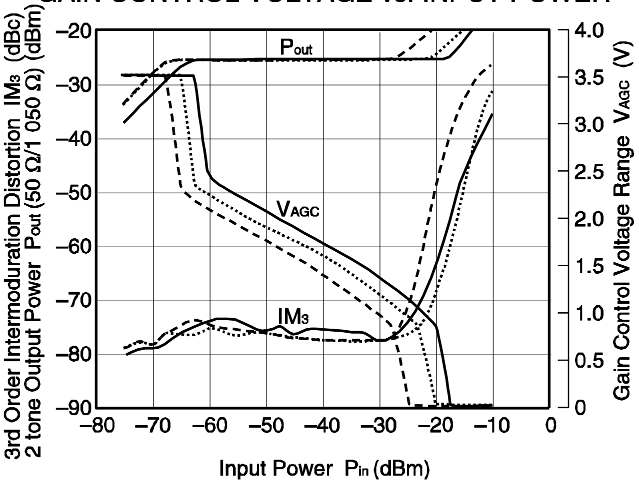
IM3, 2 TONE OUTPUT POWER,
GAIN CONTROL VOLTAGE vs. INPUT POWER



$V_{CC}1, 2 = 4.5$ V	- -
5.0 V	·····
5.5 V	——

Conditions
$f_{RF}1 = 84$ MHz
$f_{RF}2 = 85$ MHz
$f_{LO} = 134$ MHz
$P_{LO} = -15$ dBm
$f_{IF} = 50, 49$ MHz
@$V_{out} = 0.7\ V_{p-p}$/tone
Measurement Cuicuit6

IM3, 2 TONE OUTPUT POWER,
GAIN CONTROL VOLTAGE vs. INPUT POWER



$T_A = -40$°C	- -
+25°C	·····
+85°C	——

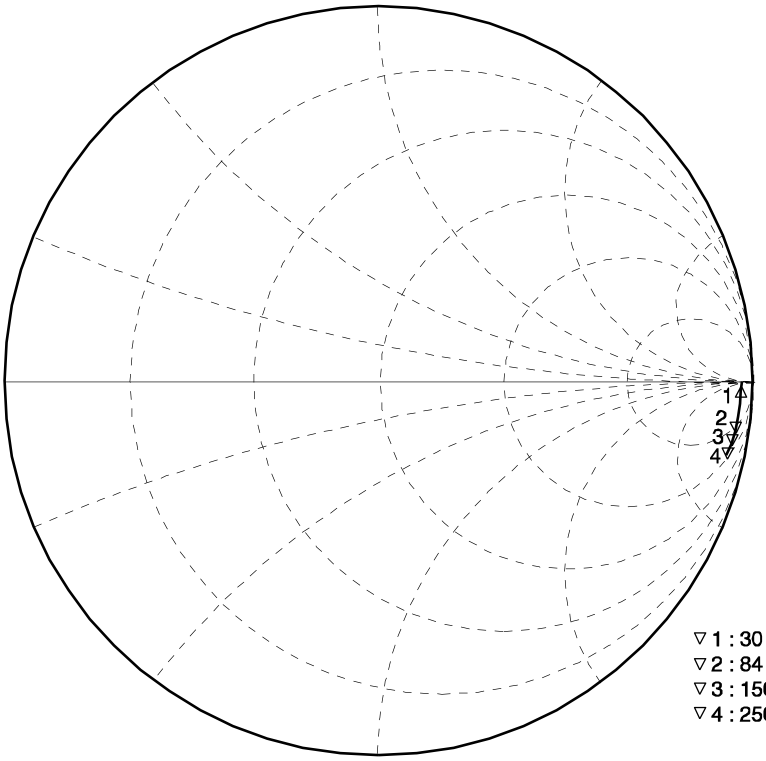
Conditions
$f_{RF}1 = 84$ MHz
$f_{RF}2 = 85$ MHz
$f_{LO} = 134$ MHz
$P_{LO} = -15$ dBm
$f_{IF} = 50, 49$ MHz
@$V_{out} = 0.7\ V_{p-p}$/tone
Measurement Cuicuit6

Remark The graphs indicate nominal characteristics.

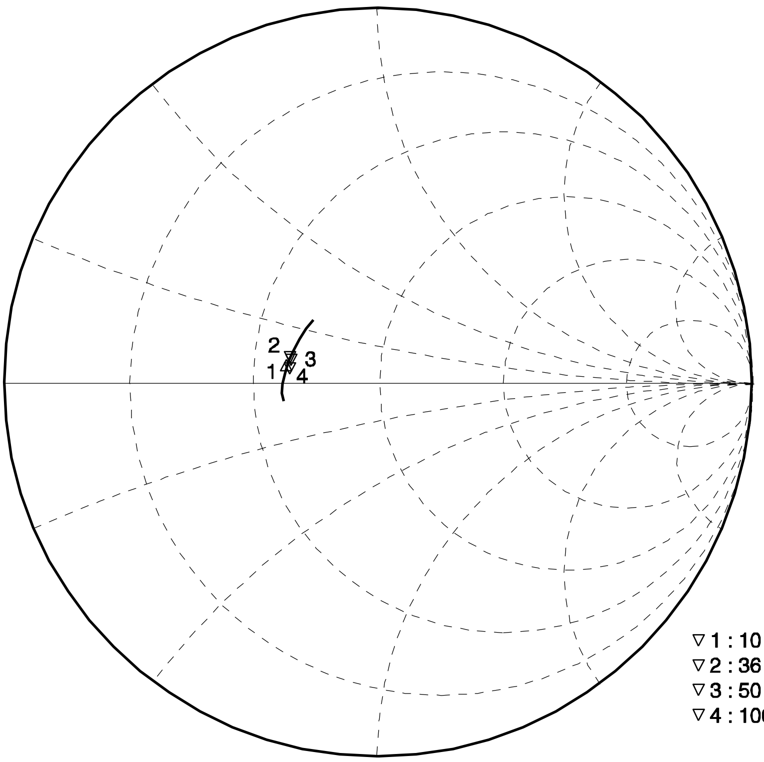
S-PARAMETERS

–AGC Amplifier Block + Mixer Block– ($V_{CC}1$ = 5.0 V, V_{AGC} = 3.0 V, by measurement circuit 3)

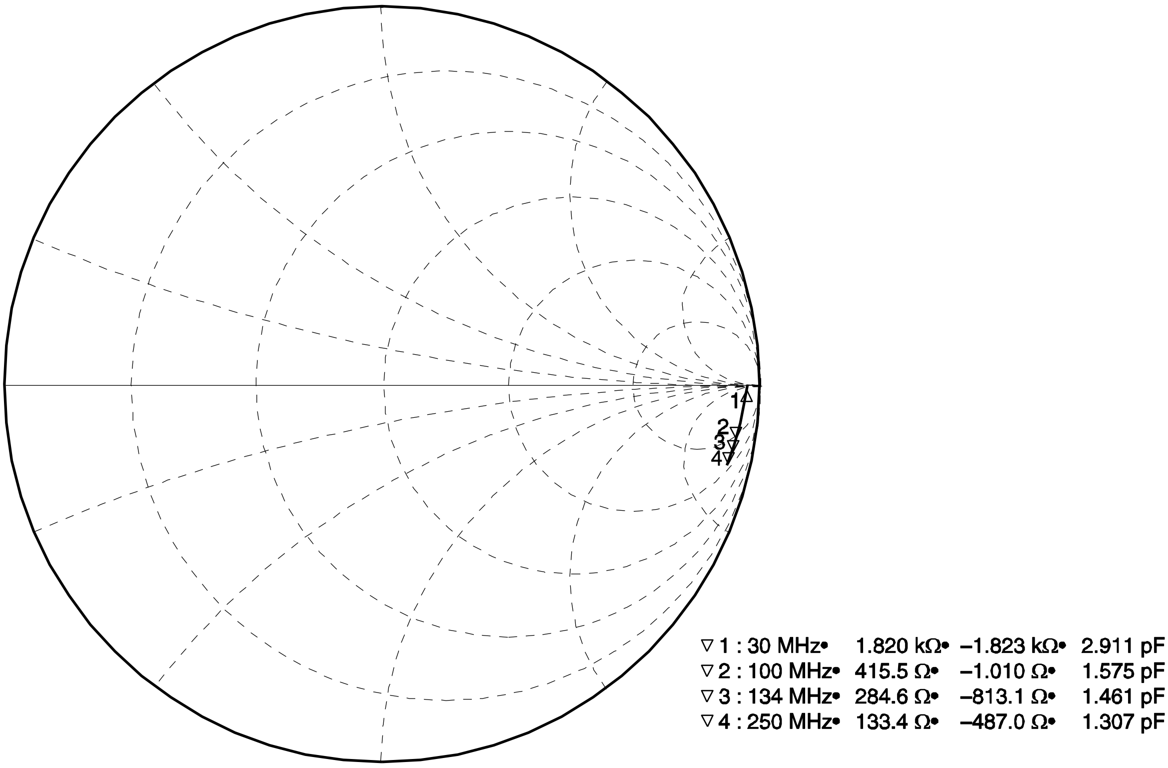
MIXER RF Input Impedance



MIXER IF Output Impedance

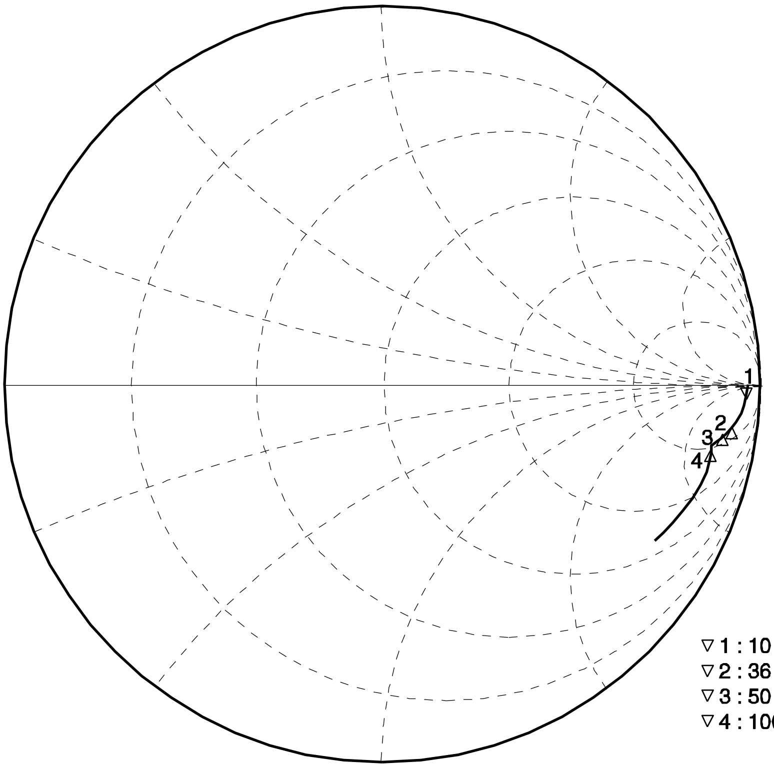


MIXER OSC Input Impedance



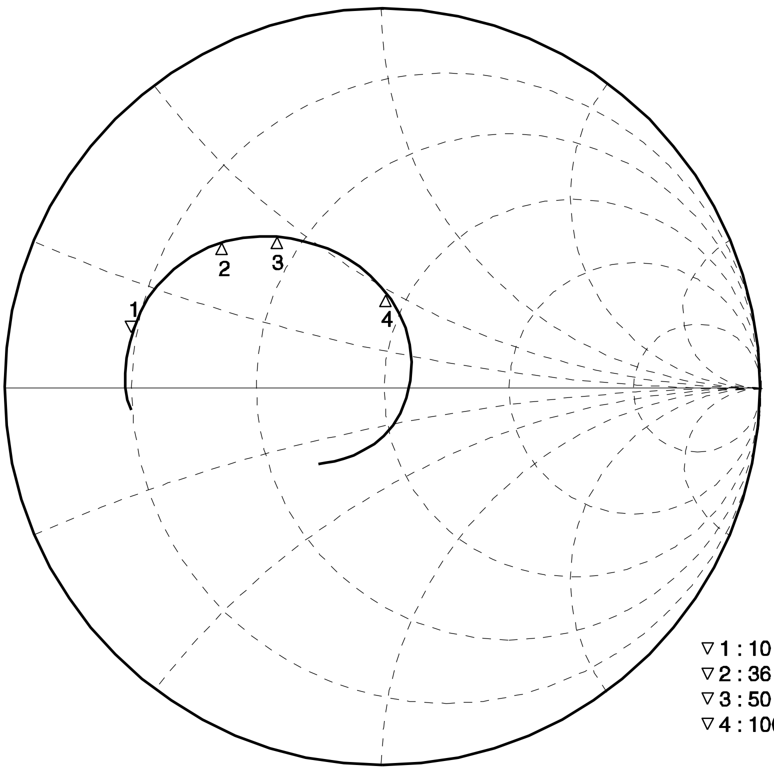
–Video Amplifier Block– (VCC2 = 5.0 V, by measurement circuit 5)

Video Amplifier Input Impedance



▽ 1 : 10 MHz•	1.187 kΩ•	–1.177 kΩ•	13.54 pF
▽ 2 : 36 MHz•	389.8 Ω•	–588.3 Ω•	7.516 pF
▽ 3 : 50 MHz•	333.4 Ω•	–481.1 Ω•	6.617 pF
▽ 4 : 100 MHz•	245.5 Ω•	–369.7 Ω•	4.304 pF

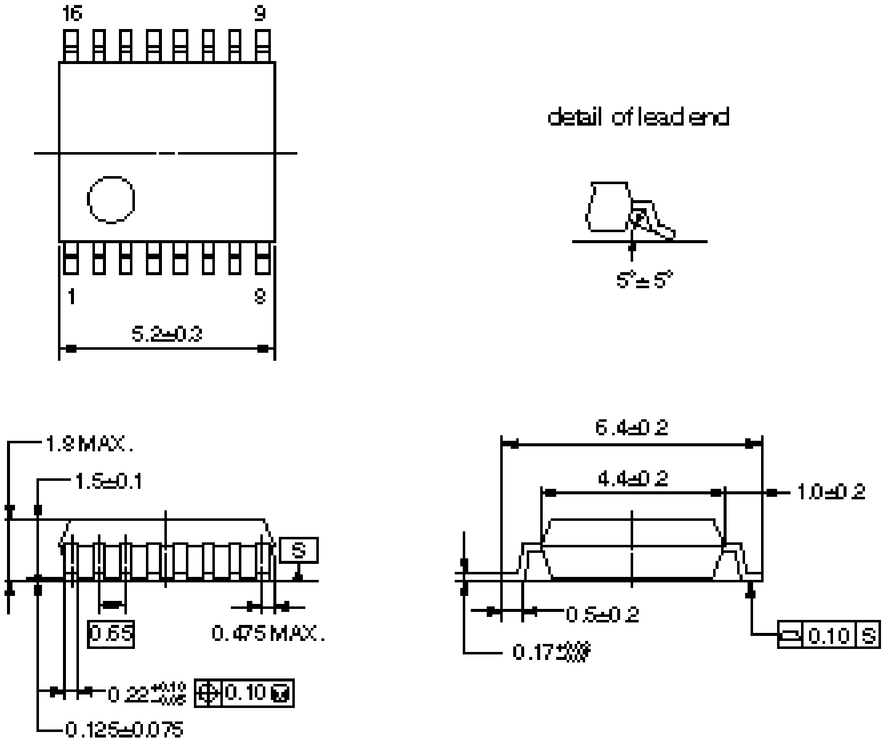
Video Amplifier Output Impedance



▽ 1 : 10 MHz•	10.04 Ω•	5.225 Ω•	83.16 nH
▽ 2 : 36 MHz•	15.86 Ω•	17.70 Ω•	78.25 nH
▽ 3 : 50 MHz•	21.54 Ω•	22.61 Ω•	71.96 nH
▽ 4 : 100 MHz•	45.48 Ω•	23.89 Ω•	38.02 nH

PACKAGE DIMENSIONS

16-PIN PLASTIC SSOP (5.72 mm (225)) (UNIT: mm)



NOTES ON CORRECT USE

(1) Observe precautions for handling because of electro-static sensitive devices.

(2) Form a ground pattern as widely 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 V_{CC} line.

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

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