

## LOW DISTORTION DOWN-CONVERTER IC FOR DIGITAL CATV

#### DESCRIPTION

The  $\mu$ PC3220GR 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 fT 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<sub>3</sub> = +1.0 dBm TYP.
- Wide AGC dynamic range GCR<sub>total</sub> = 45.5 dB TYP.
- On chip video amplifier
- Supply voltage : 5 V
- Packaged in 16-pin SSOP suitable for high-density surface mounting

#### APPLICATION

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Digital CATV receivers

#### ORDERING INFORMATION

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

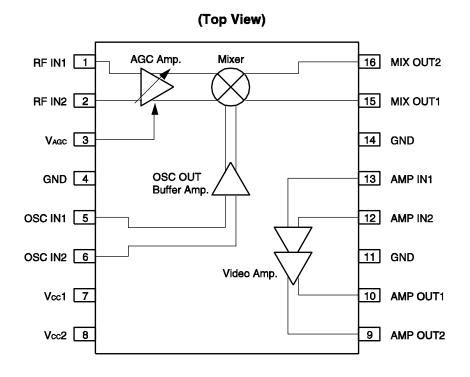
**Note** With regards to terminal solder (the solder contains lead) plated products (conventionally plated), contact your nearby sales office.

**Remark** To order evaluation samples, contact your nearby sales office. Part number for sample order:  $\mu$ PC3220GR-A

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.

## INTERNAL BLOCK DIAGRAM AND PIN CONFIGURATION



## **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		Control
3	Vage	0 to 3.5	Automatic gain control pin. This pins bias govern the AGC output level. Minimum gain at V <sub>AGC</sub> = 0 V Maximum gain at V <sub>AGC</sub> = 3.5 V	AGC Control
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	Vcc1	5.0	Power supply pin of IF down convertor block. Must be connected bypass capacitor to minimize ground impedance.	
8	Vcc2	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	Vcc	$T_A = +25^{\circ}C$	6.0	V
Power Dissipation	PD	T <sub>A</sub> = +85°C <b>Note</b>	433	mW
Operating Ambient Temperature	TA		-40 to +85	°C
Storage Temperature	Tstg		-55 to +150	°C

Note Mounted on double-sided copper-clad  $50\times50\times1.6$  mm epoxy glass PWB

### **RECOMMENDED OPERATING RENGE**

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Supply Voltage	Vcc		4.5	5.0	5.5	V
Operating Ambient Temperature	TA	Vcc = 4.5 to 5.5 V	-40	+25	+85	°C
Gain Control Voltage Range	VAGC		0	I	Vcc	V

## ELECTRICAL CHARACTERISTICS (TA = +25°C, Vcc = 5 V)

Parameter	Symbol	Test Conditions		MIN.	TYP.	MAX.	Unit
DC Characteristics							
Circuit Current 1 (Total Block)	lcc1	No input signal, Vcc1 = Vcc2 =	5 V <b>Note 4</b>	33.0	42.0	53.5	mA
Circuit Current 2 (AGC Amplifier Block + Mixer Block)	Icc2	No input signal, Vcc1 = 5 V	Note 4	15.0	20.0	25.5	mA
Circuit Current 3 (Video Amplifier Block)	Icc3	No input signal, Vcc2 = 5 V	Note 4	18.0	22.0	28.0	mA
AGC Voltage High Level	VAGC (H)	@ Maximum gain	Note 1	3.0	-	Vcc	V
AGC Voltage Low Level	VAGC (L)	@ Minimum gain	Note 1	0	_	0.5	V
RF Characteristics (AGC Amplifier Block + Mixer Block: free	= 84 MHz,	flo = 134 MHz, Plo = -15 dBm,	fif = 50 N	IHz, Zs = 5	0 Ω, ZL = 1	kΩ)	
RF Input Frequency Range	frf	fı⊧ = 50 MHz constant	Note 1	30	-	250	MHz
IF Output Frequency Range	fı⊧	fre = 84 MHz constant	Note 1	0.1	-	150	MHz
Maximum Conversion Gain	ССмах	$V_{AGC}$ = 3.0 V, $P_{in}$ = -50 dBm	Note 1	30.5	33.0	35.5	dB
Minimum Conversion Gain	CGMIN	$V_{AGC}$ = 0.5 V, $P_{in}$ = -20 dBm	Note 1	-18.0	-12.5	-3.5	dB
AGC Dynamic Range	GCRAGC	VAGC = 0.5 to 3.0 V	Note 1	36.0	45.5	-	dB
Noise Figure	NF	DSB, V <sub>AGC</sub> = 3.0 V (@ Maximu	m gain) <b>Note 2</b>	-	7.0	8.5	dB
3rd Order Intermodulaion Distortion	IМз	$\label{eq:Vout} \begin{split} V_{out} &= 0.236 \ V_{P^{*}P} \times 2 \ tone, \\ (single-ended \ output), \\ P_{in} &-30 \ dBm/tone \\ f_{RF1} &= 84 \ MHz, \ f_{RF2} = 85 \ MHz \end{split}$	Note 1	24.0	26.5	_	dBc
RF Characteristics (Video Amplifier Blo	ck: f = 50 M	lHz, Zs = 50 Ω, Z∟ = 1 kΩ)					
Differential Gain	Gdiff	Pin = -55 dBm	Note 3	48.0	50.5	53.5	dB
Maximum Output Voltage 2	Voclip2	P <sub>in</sub> = -25 dBm	Note 3	2.95	3.70	-	V <sub>p-p</sub>

Notes 1. By measurement circuit 1

2. By measurement circuit 2

3. By measurement circuit 4

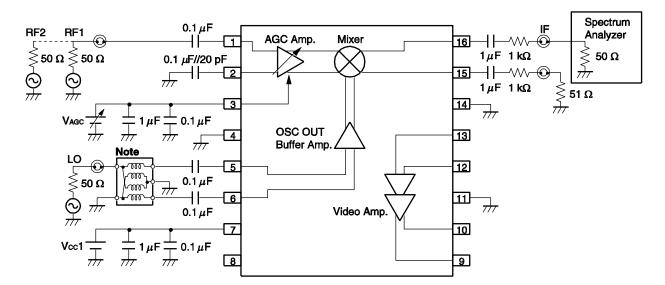
4. By measurement circuit 6

## STANDARD CHARACTERISTICS (T<sub>A</sub> = +25°C, V<sub>cc</sub> = 5 V, Z<sub>s</sub> = 50 $\Omega$ )

Parameter	Symbol	Test Conditions	Reference Value	Unit
AGC Amplifier Block + Mixer Block (fre	= 84 MHz,	flo = 134 MHz, Plo = −15 dBm, fif = 50	MHz, Zs = 50 Ω, Z∟ = 1 kΩ)	
Input 3rd Order Distortion Intercept Point	IIP3	V <sub>AGC</sub> = 0.5 V (@ Minimum gain) f <sub>RF1</sub> = 84 MHz, f <sub>RF2</sub> = 85 MHz <b>Note</b> 4	+1.0	dBm
Maximum Output Voltage1	Voclip1	V <sub>AGC</sub> = 3.0 V, P <sub>in</sub> = -20 dBm <b>Note</b> 1	0.65	V <sub>p-p</sub>
RF IN Impedance	ZRFin	VAGC = 3.0 V, f = 84 MHz Note 2	<b>2</b> 440 – j1100	Ω
OSC IN Impedance	Zoscin	VAGC = 3.0 V, f = 134 MHz Note 2	2 280 – j810	Ω
MIXER OUT Impedance	ZMIXout	VAGC = 3.0 V, f = 50 MHz Note 2	<b>2</b> 30.2 + j2.5	Ω
Video Amplifier Block (f = 50 MHz, Zs =	: 50 Ω, Z∟ =	1 kΩ)		
Frequency Range	fвw	P <sub>in</sub> = -55 dBm, G (f = 10 MHz) -1 dB <b>Note</b> 3	60	MHz
Input Impedance	ZAMPin	f = 50 MHz Note 4	<b>i</b> 330 – j480	Ω
Output Impedance	ZAMPout	f = 50 MHz Note 4	1 21.9 + j22.6	Ω
3rd Order Intermodulaion Distortion	IМз	$\label{eq:Vout} \begin{split} V_{out} &= 0.7 \; V_{P\text{-}P} \times 2 \text{ tone}, \\ f_{in1} &= 49 \; MHz, \; f_{in2} = 50 \; MHz \qquad \text{Note 3} \end{split}$	55.0	dBc
Total Block (fre = 84 MHz, fLo = 134 Mi	Hz, Ριο = -1	5 dBm, fι <sub>F</sub> = 50 MHz, Zs = 50 Ω, ZL = 1	kΩ)	
Maximum Conversion Gain	CGMAX	V <sub>AGC</sub> = 3.0 V, P <sub>in</sub> = -70 dBm Note \$	67.5	dB
Minimum Conversion Gain	CGMIN	V <sub>AGC</sub> = 0.5 V, P <sub>in</sub> = -40 dBm Note \$	<b>5</b> 22.0	dB
Total Dynamic Range	GCR	VAGC = 0.5 to 3.0 V Note \$	<b>5</b> 45.5	dB
Noise Figure	NF	DSB, V <sub>AGC</sub> = 3.0 V (@ Maximum gain) Note 6		dB
Maximum Output Voltage	Voclip	VAGC = 3.0 V (@ Minimum gain)Note \$	<b>5</b> 3.7	V <sub>p-p</sub>
Input 3rd Order Distortion Intercept Point	IIP <sub>3total</sub>	V <sub>AGC</sub> = 0.5 V (@ Minimum gain) f <sub>RF1</sub> = 84 MHz, f <sub>RF2</sub> = 85 MHz <b>Note </b> \$	+1.0	dBm
3rd Order Intermodulaion Distortion	IM3total	$\label{eq:Vout} \begin{split} V_{out} &= 0.7 \ V_{P^{*}P} \times 2 \ tone, \\ P_{in} &-40 \ dBm/tone \\ f_{RF1} &= 84 \ MHz, \ f_{RF2} &= 85 \ MHz  \textbf{Note } \end{split}$	51.0	dBc

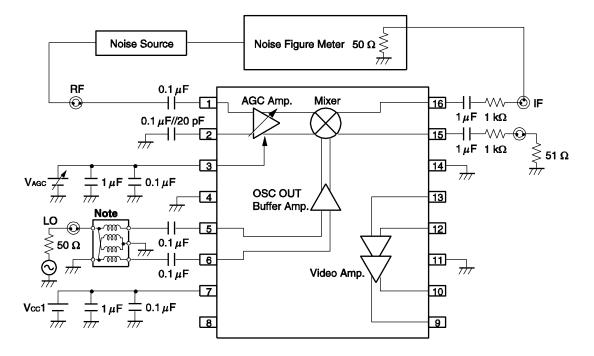
Notes 1. By measurement circuit 1

- 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

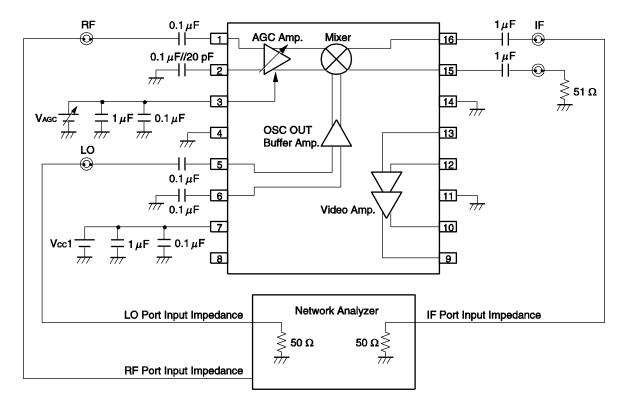


Note Balun Transformer : TOKO 617DB-1010 B4F (Double balanced type)

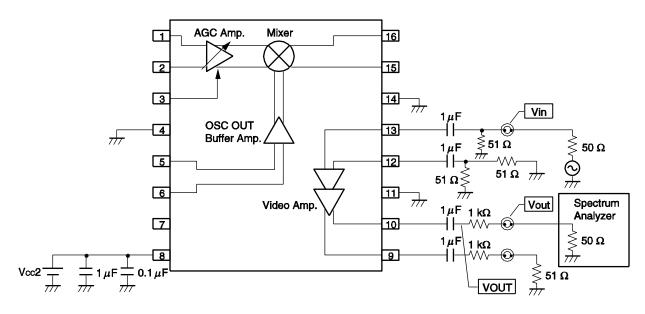
#### **MEASUREMENT CIRCUIT 2**



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

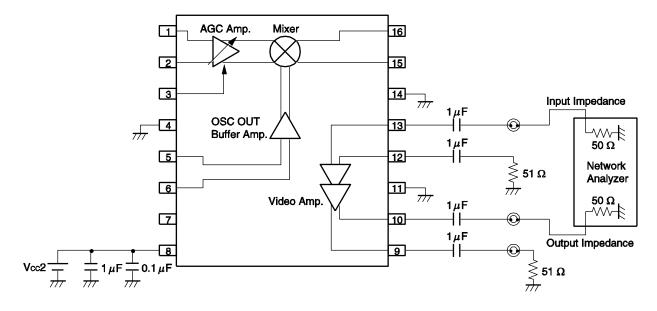


#### **MEASUREMENT CIRCUIT 4**

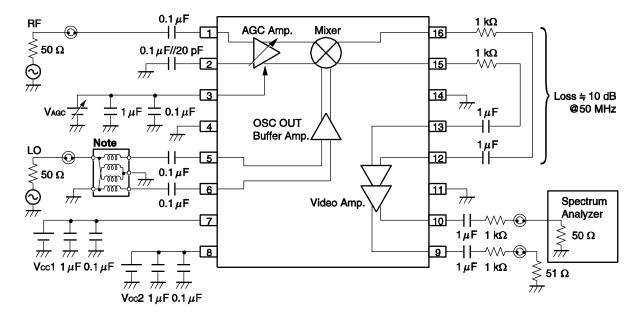


Remarks 1. Voltage Gain (Single Ended) = 20 log (VOUT/Vin) (dB)

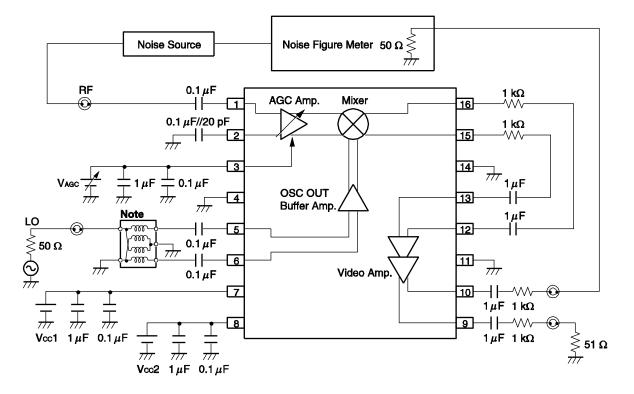
- **2.** Differential Gain (Differential-out) = 20 log ( $2 \times VOUT/Vin$ ) (dB)
- 3. VOUT = Vout (Measured Value)  $\times$  (1 050/50)



#### **MEASUREMENT CIRCUIT 6**

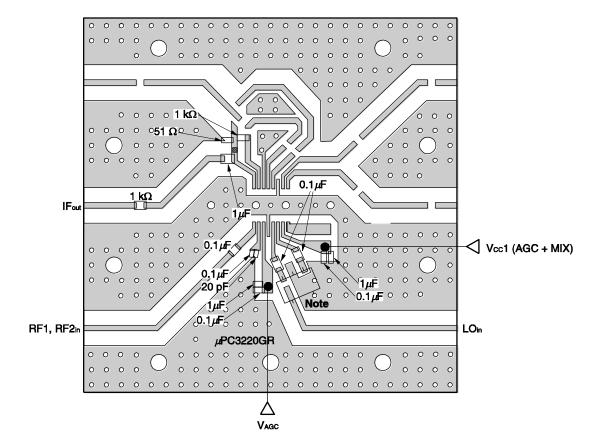


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The application circuits and their parameters are for reference only and are not intended for use in actual design-ins.

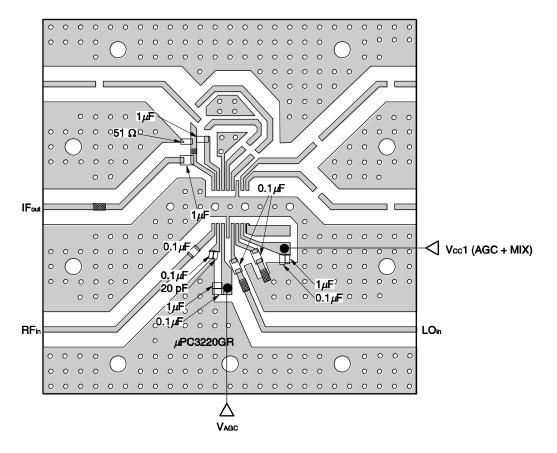


■ ILLUSTRATION OF THE MEASUREMENT CIRCUIT1, 2 ASSEMBLED ON EVALUATION BOARD

Note Balun Transformer

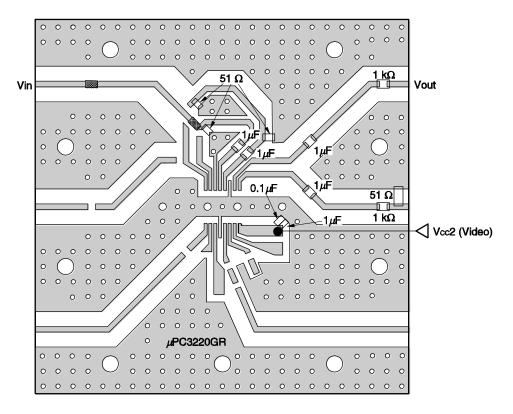
- 1. Back side: GND pattern
- 2. Solder plated on pattern
- 3.  $\circ$  O : Through hole
- 4. Emeresents cutout

#### **ILLUSTRATION OF THE MEASUREMENT CIRCUIT3 ASSEMBLED ON EVALUATION BOARD**



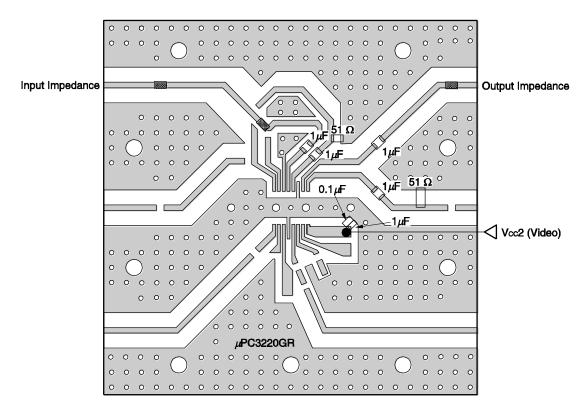
- 1. Back side: GND pattern
- 2. Solder plated on pattern
- 3. oO: Through hole
- 4. Epresents cutout
- 5. Epresents short-circuit strip

#### **ILLUSTRATION OF THE MEASUREMENT CIRCUIT4 ASSEMBLED ON EVALUATION BOARD**



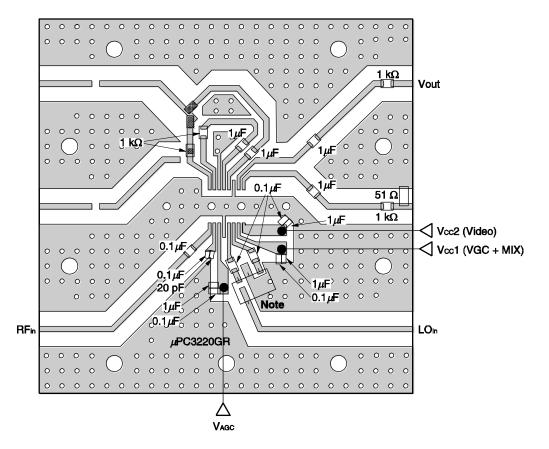
- 1. Back side: GND pattern
- 2. Solder plated on pattern
- 3. oO: Through hole
- 4. Expresents short-circuit strip

#### **ILLUSTRATION OF THE MEASUREMENT CIRCUIT5 ASSEMBLED ON EVALUATION BOARD**



- 1. Back side: GND pattern
- 2. Solder plated on pattern
- 3. o O: Through hole
- 4. Expresents short-circuit strip

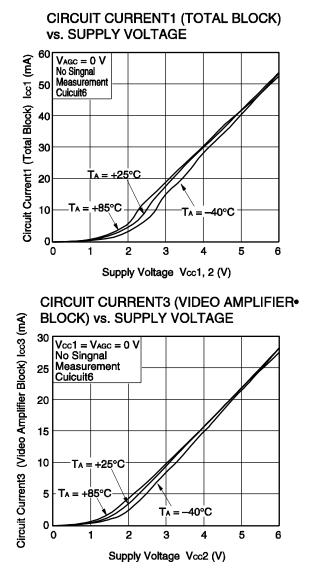
■ ILLUSTRATION OF THE MEASUREMENT CIRCUIT6, 7 ASSEMBLED ON EVALUATION BOARD



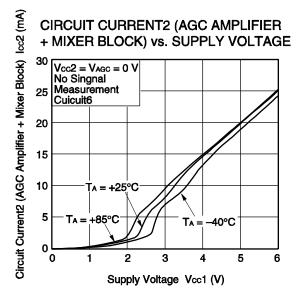
Note Balun Transformer

- 1. Back side: GND pattern
- 2. Solder plated on pattern
- 3.  $\circ$  O : Through hole
- 4. Zerresents cutout
- 5. Expresents short-circuit strip

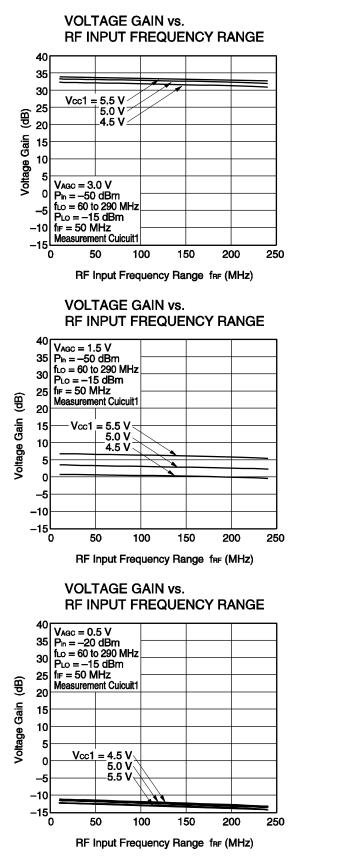
## TYPICAL CHARACTERISTICS (TA = $+25^{\circ}C$ , unless otherwise specified)



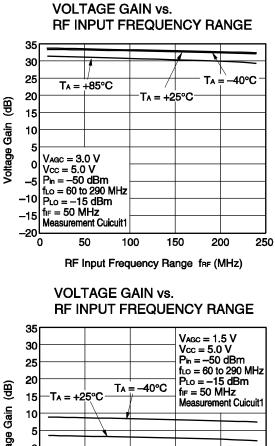
Remark The graphs indicate nominal characteristics.

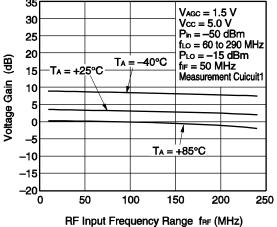


-AGC Amplifier Block + Mixer Block-

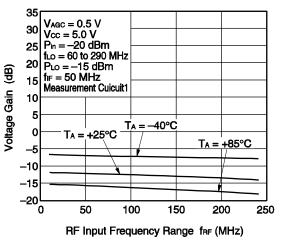


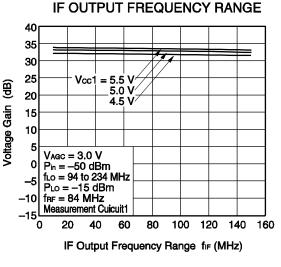
**Remark** The graphs indicate nominal characteristics.





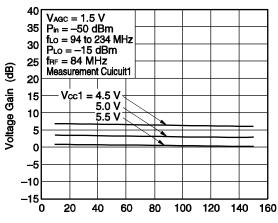
VOLTAGE GAIN vs. **RF INPUT FREQUENCY RANGE** 





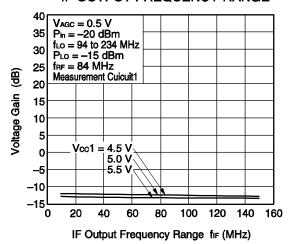
# VOLTAGE GAIN vs.

VOLTAGE GAIN vs. IF OUTPUT FREQUENCY RANGE

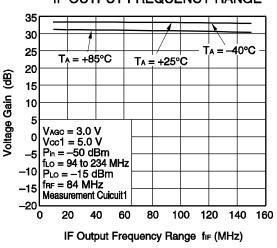


IF Output Frequency Range fir (MHz)

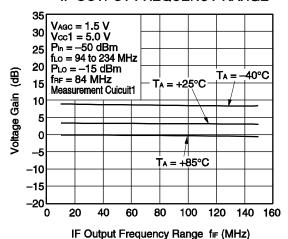
VOLTAGE GAIN vs. IF OUTPUT FREQUENCY RANGE



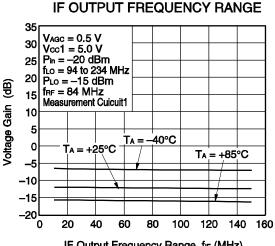
VOLTAGE GAIN vs. IF OUTPUT FREQUENCY RANGE



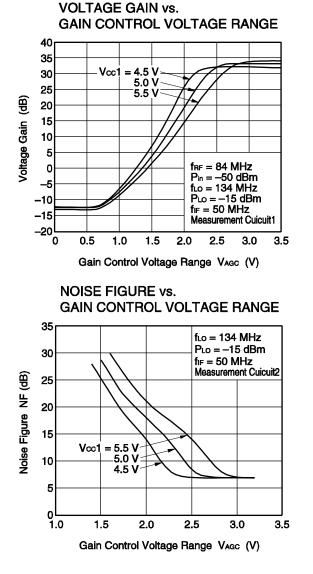
VOLTAGE GAIN vs. IF OUTPUT FREQUENCY RANGE



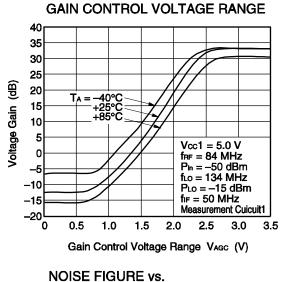
VOLTAGE GAIN vs.



IF Output Frequency Range fir (MHz)

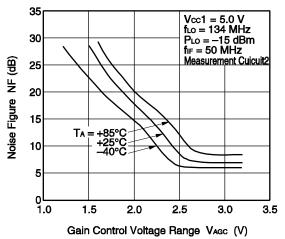


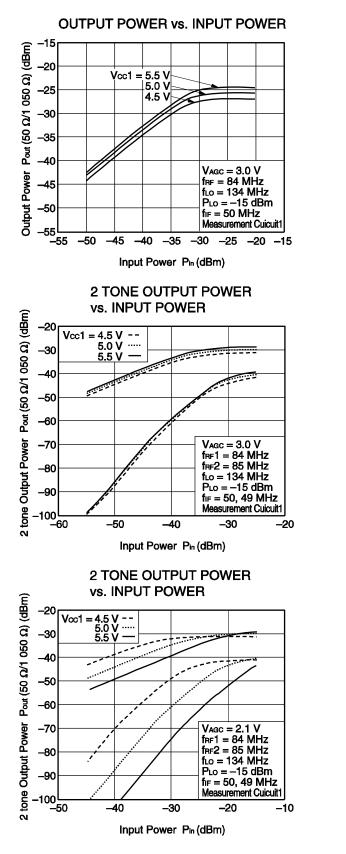
Remark The graphs indicate nominal characteristics.



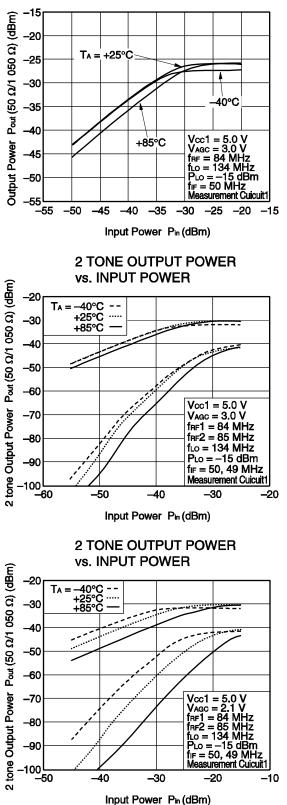
VOLTAGE GAIN vs.

GAIN CONTROL VOLTAGE RANGE

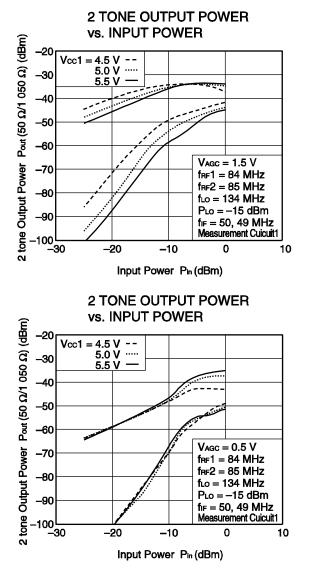




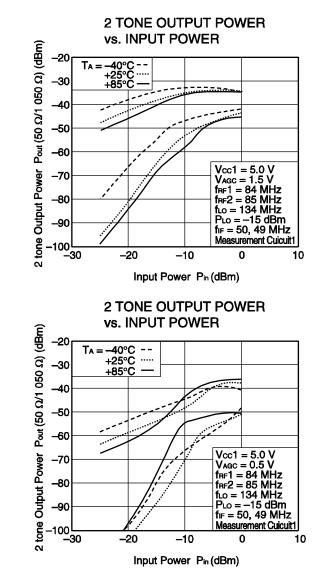
## **OUTPUT POWER vs. INPUT POWER**



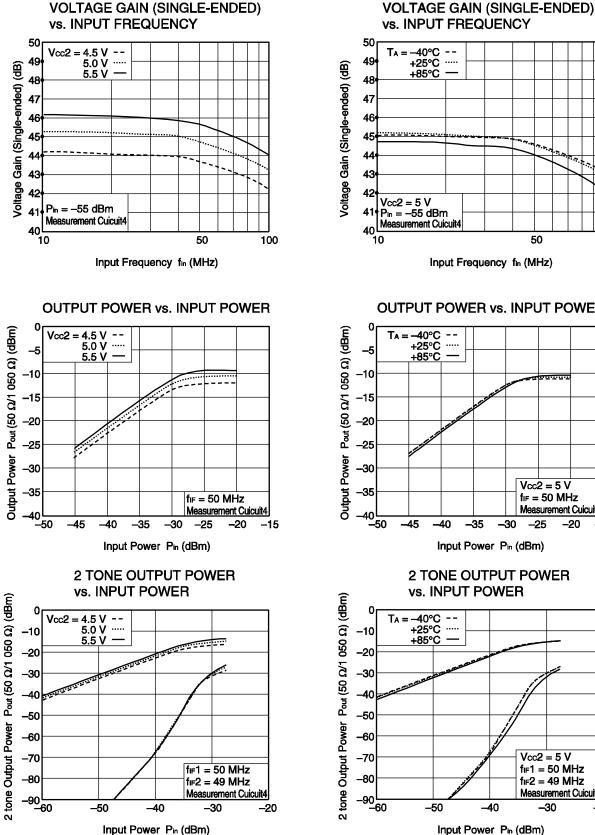
Remark The graphs indicate nominal characteristics.



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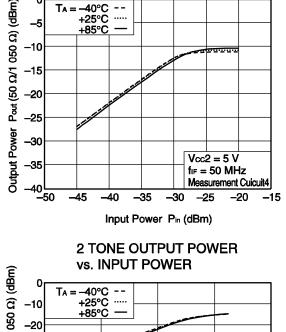
vs. INPUT FREQUENCY

Input Frequency fin (MHz)

50

100

**OUTPUT POWER vs. INPUT POWER** 



Remark The graphs indicate nominal characteristics.

-20

Vcc2 = 5 V

-40

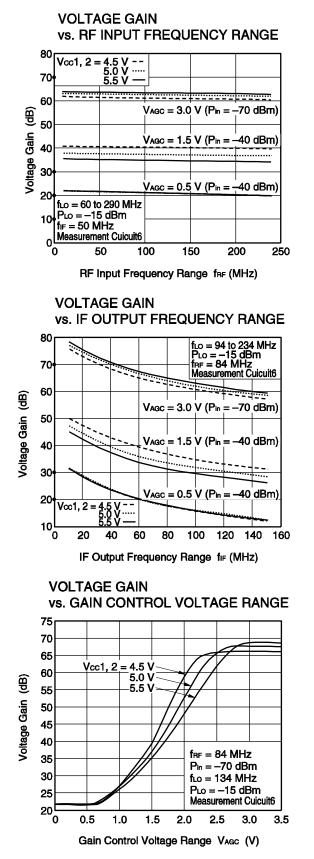
fı⊧1 = 50 MHz

fı⊧2 = 49 MHz

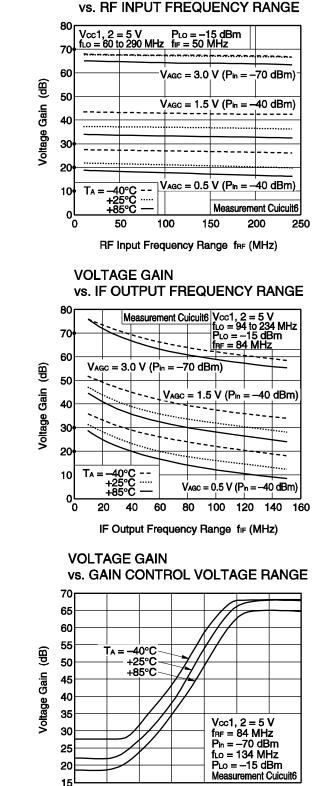
-30

Measurement Cuicuit4

## -Total Block-



Remark The graphs indicate nominal characteristics.



2.0

Gain Control Voltage Range VAGC (V)

2.5

3.0

3.5

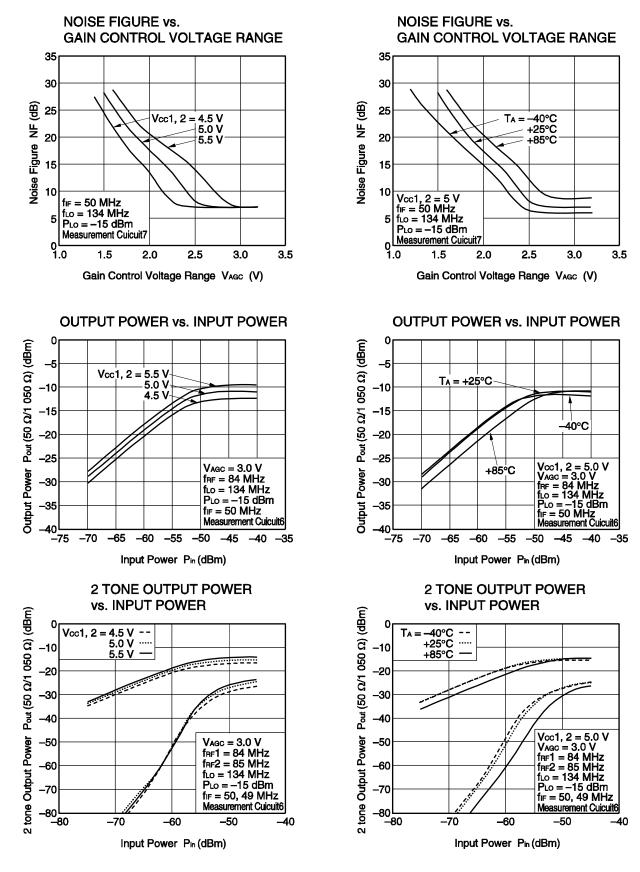
1.5

**VOLTAGE GAIN** 

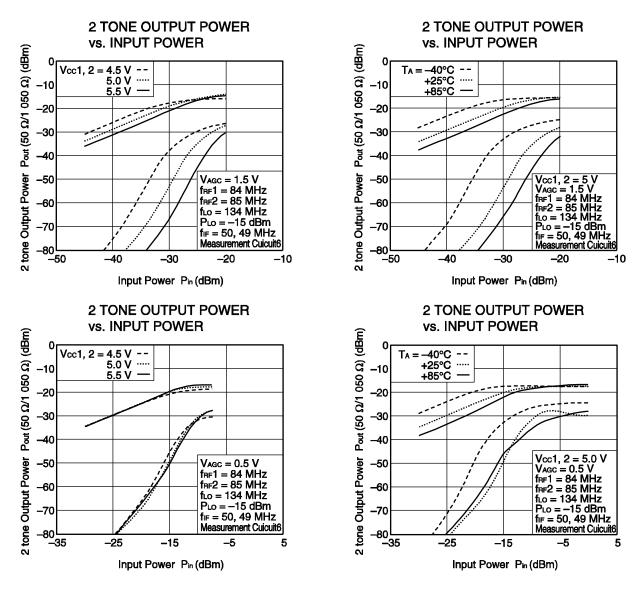
0

0.5

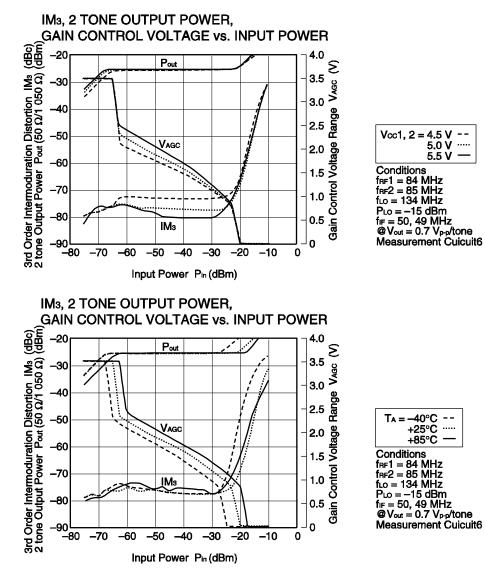
1.0



Remark The graphs indicate nominal characteristics.



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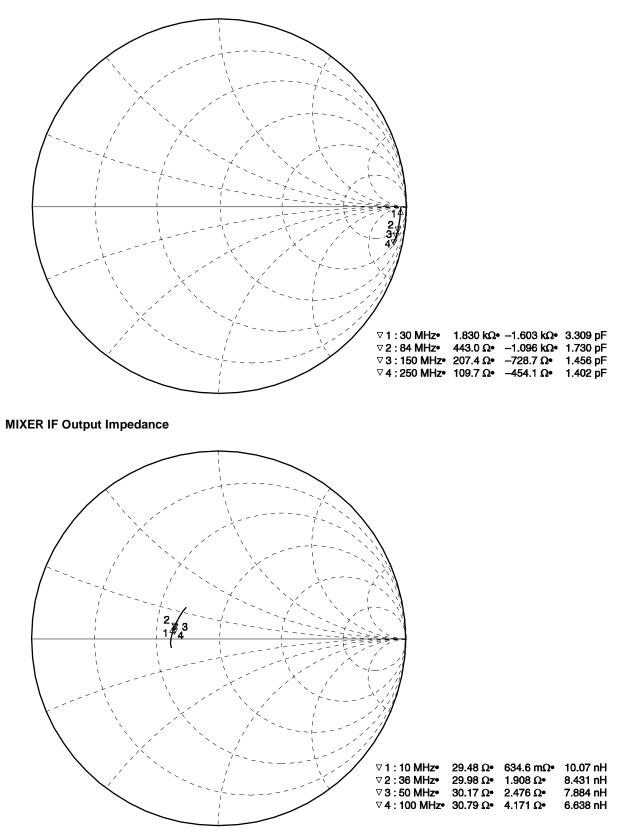


Remark The graphs indicate nominal characteristics.

## S-PARAMETERS

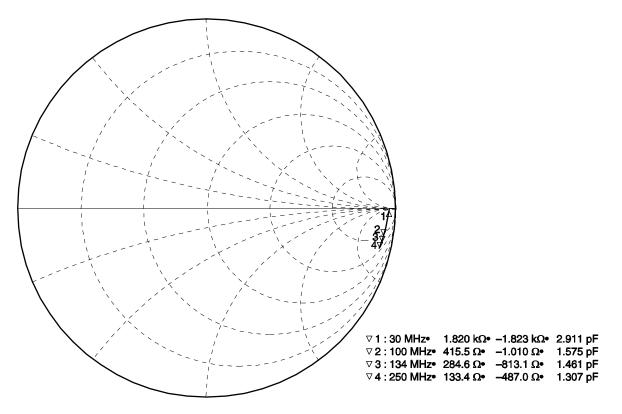
-AGC Amplifier Block + Mixer Block- (Vcc1 = 5.0 V, VAGc = 3.0 V, by measurement circuit 3)

MIXER RF Input Impedance



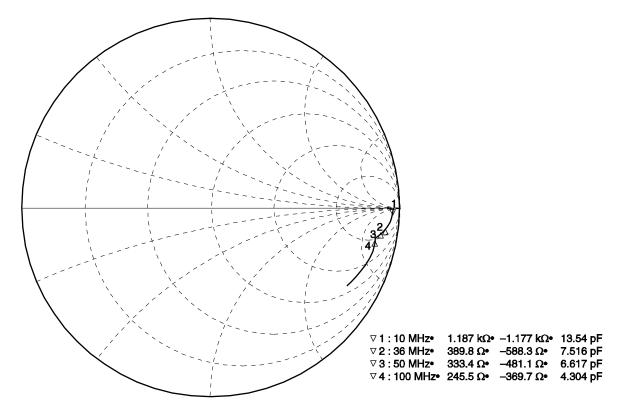
Data Sheet PU10165EJ05V0DS

#### **MIXER OSC Input Impedance**

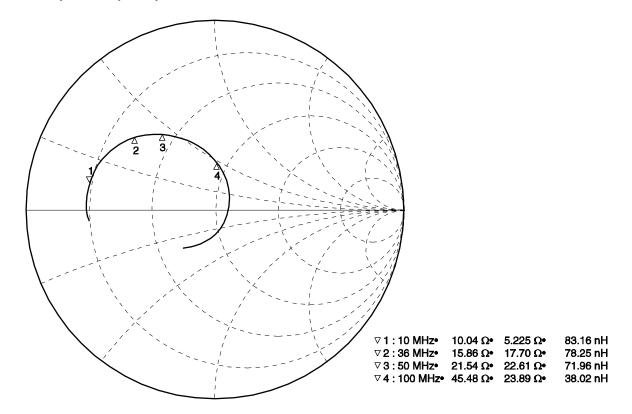


-Video Amplifier Block- (Vcc2 = 5.0 V, by measurement circuit 5)





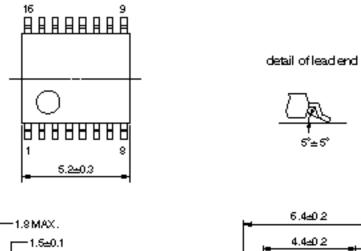
Video Amplifier Output Impedance

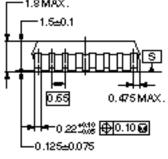


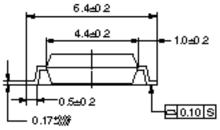
Data Sheet PU10165EJ05V0DS

## 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 Vcc 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			

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