CEL

# 250 MHz QAM IF DOWNCONVERTER

# UPC2798GR

## FEATURES

- **RF/LO FREQUENCY RANGE: 30-250 MHz**
- **ON CHIP VCO**
- **LOW DISTORTION AGC AMPLIFIER:** -9 dBm $IIP_3$ @ MIN Gain
- **ON CHIP VIDEO AMP:** 3.0 Vp-p ($V_{CC}$ = 5 V)
- **SMALL 20 PIN SSOP PACKAGE**
- **AVAILABLE ON TAPE AND REEL**

## DESCRIPTION

NEC's UPC2798GR is a Silicon MMIC Downconverter manufactured with the NESAT™III silicon bipolar process. This product consists of an input AGC amplifier, mixer, local oscillator, and video amplifier. It is housed in a small 20 pin SSOP package. The device is designed for use as an IF downconverter for digital CATV settops and cable modems utilizing QAM modulation.

NEC's stringent quality assurance and test procedures ensure the highest reliability and performance.

## ELECTRICAL CHARACTERISTICS ($T_A$ = 25°C, RF = 45 MHz, $L_O$ = 55 MHz, $P_{LO}$ = -10 dBm, unless otherwise specified)

| PART NUMBER<br>PACKAGE OUTLINE | | | UPC2798GR<br>S20 | | |
|---|---|---|---|---|---|
| **SYMBOLS** | **PARAMETERS AND CONDITIONS** | **UNITS** | **MIN** | **TYP** | **MAX** |
| Total Block ($V_{CC1}$ = 5 V, $V_{CC2}$ = 5 V, $R_L$ = 1 kΩ) | | | | | |
| $I_{CC}$ | Circuit Current (no input signal) | mA | 24.0 | 35.5 | 45.0 |
| $CG_{MAX1}$ | Maximum Conversion Gain, $V_{AGC}$ = 4.0 V, pins G1A - G1B shorted | dB | 68.0 | 74.0 | 76.0 |
| $CG_{MAX2}$ | Maximum Conversion Gain, $V_{AGC}$ = 4.0 V, pins G1A - G1B open | dB | | 58.0 | |
| $CG_{MIN1}$ | Minimum Conversion Gain, $V_{AGC}$ = 1.0 V, pins G1A - G1B shorted | dB | 32.0 | 39.0 | 43.0 |
| $CG_{MIN2}$ | Minimum Conversion Gain, $V_{AGC}$ = 1.0 V, pins G1A - G1B open | dB | | 22.0 | |
| $IIP_3$ | Input Intercept Point, $V_{AGC}$ = 1.0 V, pins G1A - G1B shorted | dBm | | -14.0 | |
| $IIP_3$ | Input Intercept Point, $V_{AGC}$ = 1.0 V, pins G1A - G1B open | dBm | | -8.0 | |
| Total Block ($V_{CC1}$ = 5 V, $V_{CC2}$ = 9 V, $R_L$ = 1 kΩ) | | | | | |
| $I_{CC}$ | Circuit Current (no input signal) | mA | 32.0 | 47.0 | 60.0 |
| $CG_{MAX1}$ | Maximum Conversion Gain, $V_{AGC}$ = 4.0 V, pins G1A - G1B shorted | dB | 72.0 | 78.5 | 81.0 |
| $CG_{MAX2}$ | Maximum Conversion Gain, $V_{AGC}$ = 4.0 V, pins G1A - G1B open | dB | | 59.0 | |
| $CG_{MIN1}$ | Minimum Conversion Gain, $V_{AGC}$ = 1.0 V, pins G1A - G1B shorted | dB | | 43.5 | |
| $CG_{MIN2}$ | Minimum Conversion Gain, $V_{AGC}$ = 1.0 V, pins G1A - G1B open | dB | | 22.5 | |
| $IIP_3$ | Input Intercept Point, $V_{AGC}$ = 1.0 V, pins G1A - G1B open | dBm | | -7.5 | |
| AGC Amplifier and Mixer Block ($V_{CC1}$ = 5 V) | | | | | |
| $I_{CC}$ | Circuit Current (no input signal) | mA | 15.0 | 23.0 | 28.0 |
| $f_{RF}$ | RF Input Frequency Range | MHz | 30 | | 250 |
| $f_{OSC}$ | OSC Frequency Range | MHz | 30 | | 250 |
| $f_{IF}$ | IF Output Frequency Range | MHz | DC | | 150 |
| $CG_{MAX}$ | Maximum Conversion Gain, $V_{AGC}$ = 4.0 V | dB | | 25 | |
| $CG_{MIN}$ | Minimum Conversion Gain, $V_{AGC}$ = 1.0 V | dB | | -7 | |
| GCR | AGC Dynamic Range, $V_{AGC}$ = 1.0 to 4.0 V | dB | 26 | 32 | |
| NF | Noise Figure, SSB, $V_{AGC}$ = 4.0 V (MAX Gain) | dB | | 9 | |
| $V_{AGC\ (H)}$ | AGC Voltage High, at MAX Gain | V | 4.0 | | |
| $V_{AGC\ (L)}$ | AGC Voltage Low, at MIN Gain | V | | | 1.0 |
| AGC $IIP_3$ | AGC Input Intercept Point, at MIN Gain | dBm | | -9 | |

## ELECTRICAL CHARACTERISTICS ($T_A$ = 25°C, RF = 45 MHz, $L_O$ = 55 MHz, $P_{LO}$ = -10 dBm, unless otherwise specified)

| PART NUMBER<br>PACKAGE OUTLINE | | | UPC2798GR<br>S20 | | |
|---|---|---|---|---|---|
| **SYMBOLS** | **PARAMETERS AND CONDITIONS** | **UNITS** | **MIN** | **TYP** | **MAX** |
| Video Amp Block ($V_{CC2}$ = 5 V, differential, $R_L$ = 1 kΩ) | | | | | |
| $I_{CC}$ | Circuit Current (no input signal) | mA | 9.0 | 12.5 | 17.0 |
| $V_{OUT}$ | Output Voltage | Vp-p | | 3.0 | |
| G1 | Differential Gain 1, pins G1A and G1B shorted, $V_{OUT}$ = 3.0 Vp-p | V/V | | 200 | |
| G2 | Differential Gain 2, pins G1A and G1B open, $V_{OUT}$ = 3.0 Vp-p | V/V | | 26 | |
| Video Amp Block ($V_{CC2}$ = 9 V, differential, $R_L$ = 1 kΩ) | | | | | |
| $I_{CC}$ | Circuit Current (no input signal) | mA | 17.0 | 24.0 | 32.0 |
| $V_{OUT}$ | Output Voltage | Vp-p | | 3.0 | |
| G1 | Differential Gain 1, Pins G1A and G1B shorted | V/V | | 385 | |
| G2 | Differential Gain 2, Pins G1A and G1B open | V/V | | 28.5 | |
| Video Amp Block ($V_{CC2}$ = 5 V, single ended, $R_L$ = 50 Ω) | | | | | |
| $A_{VS1}$ | Single-ended Gain, pins G1A - G1B shorted | dB | | 40.0 | |
| $A_{VS2}$ | Single-ended Gain, pins G1A - G1B open | dB | | 22.5 | |
| $IIP_3$ | Input Intercept Point, pins G1A - G1B open, f1 = 9 MHz, f2 = 11 MHz | dBm | | -11.5 | |
| Video Amp Block ($V_{CC2}$ = 9 V, single ended, $R_L$ = 50 Ω) | | | | | |
| $A_{VS1}$ | Single-ended Gain, pins G1A - G1B shorted | dB | | 45.0 | |
| $A_{VS2}$ | Single-ended Gain, pins G1A - G1B open | dB | | 23.5 | |
| $IIP_3$ | Input Intercept Point, pins G1A - G1B open, f1 = 9 MHz, f2 = 11 MHz | dBm | | -5.0 | |
| Video Amp Block ($V_{CC2}$ = 5 or 9 V, common, $R_L$ = 1 k Ω) | | | | | |
| $BW_{G1}$ | Bandwidth 1, G1 | MHz | | 50 | |
| $BW_{G2}$ | Bandwidth 2, G2 | MHz | | 50 | |
| $R_{IN\ 1}$ | Input Resistance 1, G1 | kΩ | | 3.5 | |
| $R_{IN\ 2}$ | Input Resistance 2, G2 | kΩ | | 9.7 | |
| $C_{IN}$ | Input Capacitance, $C_{IN}$ | pF | | 1.6 | |
| CMRR | Common Mode Rejection Ratio, $V_{CM}$ = 1.0 $V_{p-p}$, $f$ = 100 kHz | dB | | 80 | |
| PSRR | Power Supply Rejection Ratio | dB | | 70 | |
| $\tau_R$ | Rise Time | ns | | 2.6 | |
| $\tau_D$ | Propagation Delay Time | ns | | 4.4 | |

## ABSOLUTE MAXIMUM RATINGS[1] ($T_A$ = 25°C)

| SYMBOLS | PARAMETERS | UNITS | RATINGS |
|---|---|---|---|
| $V_{CC1}$ | Supply Voltage 1 (Mixer Block) | V | 6.0 |
| $V_{CC2}$ | Supply Voltage 2 (Video Amp Block) | V | 6.0 |
| $P_D$ | Power Dissipation, $T_A$ = 85°C[2] | mW | 430 |
| $T_{OP}$ | Operating Temperature | °C | -40 to +85 |
| $T_{STG}$ | Storage Temperature | °C | -55 to +150 |

| SYMBOLS | PARAMETERS | UNITS | RATINGS |
|---|---|---|---|
| $V_{CC1}$ | Supply Voltage 1 (Mixer Block) | V | 6.0 |
| $V_{CC2}$ | Supply Voltage 2 (Video Amp Block) | V | 11.0 |
| $P_D$ | Power Dissipation, $T_A$ = 75°C[2] | mW | 500 |
| $T_{OP}$ | Operating Temperature | °C | -40 to +75 |
| $T_{STG}$ | Storage Temperature | °C | -55 to +150 |

Notes:
1. Operation in excess of any one of these parameters may result in permanent damage.
2. Mounted on a 50 x 50 x 1.6 mm epoxy glass PWB.

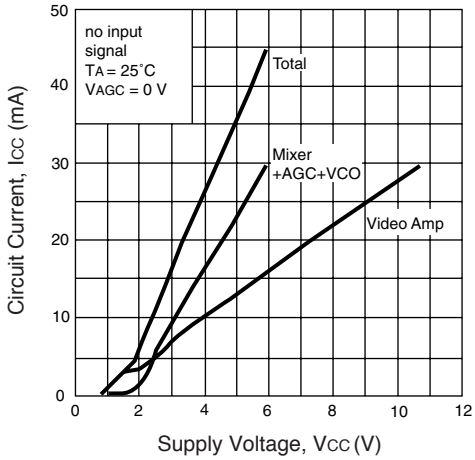
## RECOMMENDED OPERATING CONDITIONS

| SYMBOL | PARAMETER | UNITS | MIN | TYP | MAX |
|---|---|---|---|---|---|
| $V_{CC1}$ | Supply Voltage 1 | V | 4.5 | 5.0 | 5.5 |
| $V_{CC2}$ | Supply Voltage 2 | V | 4.5 | 5.0 | 10.0 |
| $T_{A1}$ | Operating Temp. Range 1* | °C | -40 | +25 | +85 |
| $T_{A2}$ | Operating Temp. Range 2** | °C | -40 | +25 | +75 |

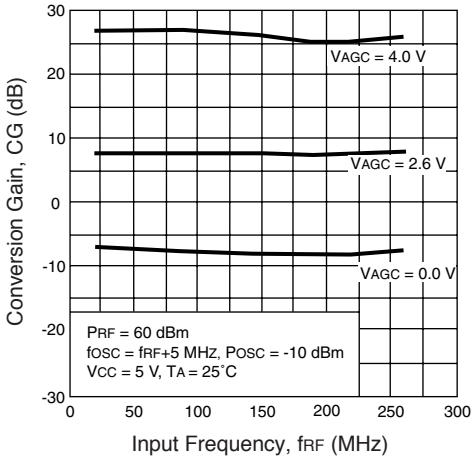
Notes:
* @ $V_{CC1}$ = $V_{CC2}$ = 4.5 to 5.5 V
** @ $V_{CC1}$ = 4.5 to 5.5 V, $V_{CC2}$ = 4.5 to 10.0 V

## TYPICAL CHARACTERISTICS (by measurement circuit 1: AGC Amp and Mixer Block)

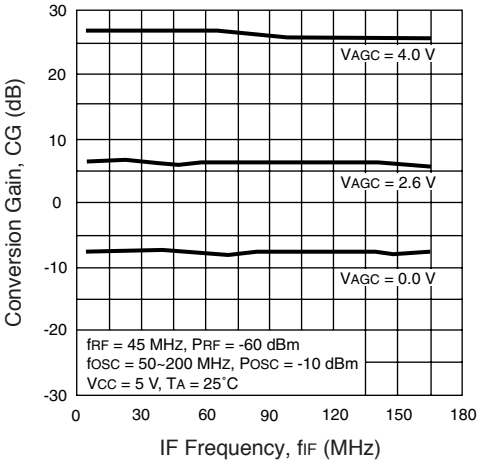
**CIRCUIT CURRENT vs. SUPPLY VOLTAGE**



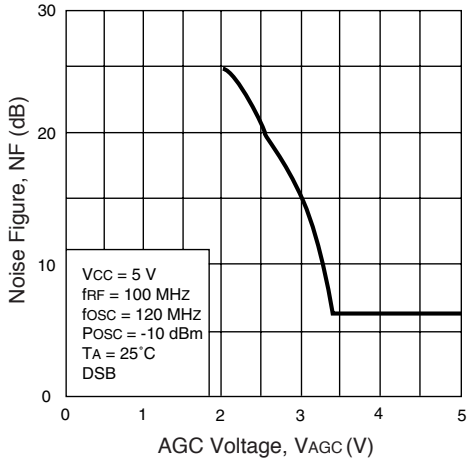

**CONVERSION GAIN vs. INPUT FREQUENCY**



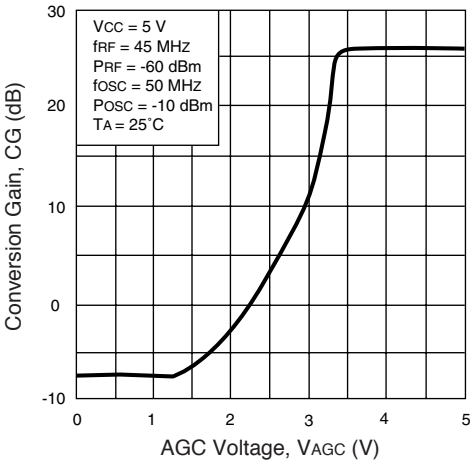

**CONVERSION GAIN vs. IF FREQUENCY**



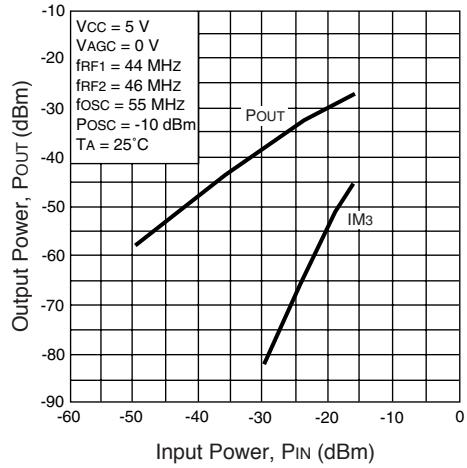

**NOISE FIGURE vs. AGC VOLTAGE**




**CONVERSION GAIN vs. AGC VOLTAGE**

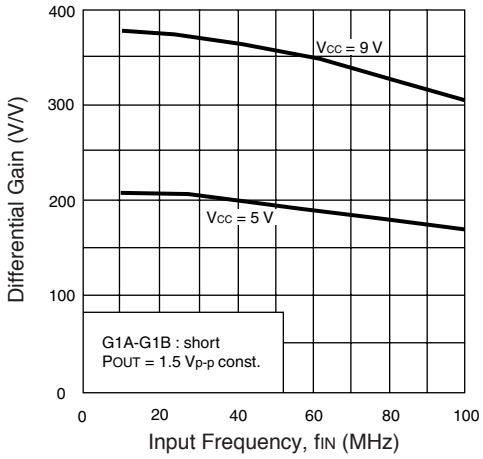



**THIRD ORDER INTERMODULATION LEVEL AND OUTPUT POWER vs. INPUT POWER**

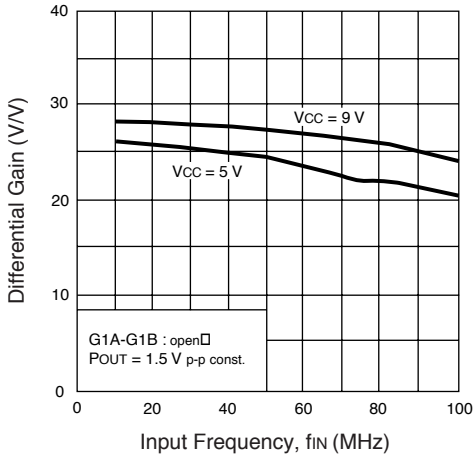


## STANDARD CHARACTERISTICS (by measurement circuit 2: Video Amp, $R_L$ = 1 kΩ, $T_A$ = 25°C)

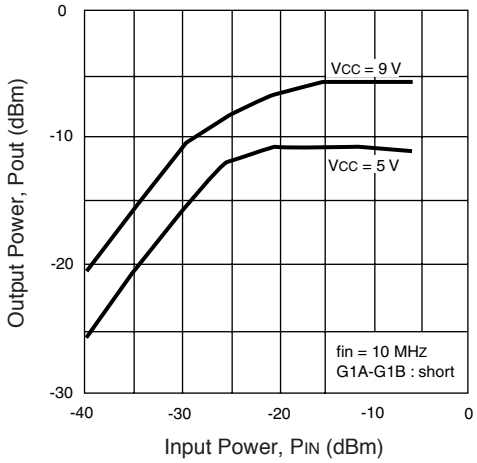
**DIFFERENTIAL GAIN vs. INPUT FREQUENCY**



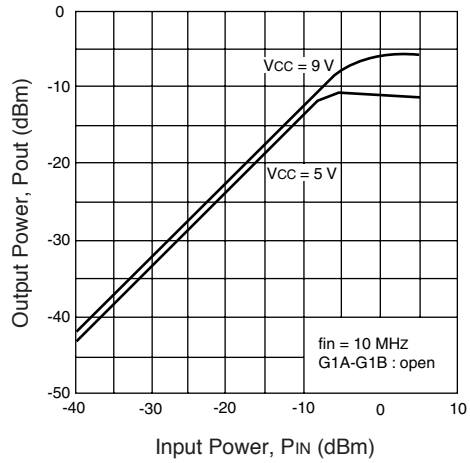

**DIFFERENTIAL GAIN vs. INPUT FREQUENCY**



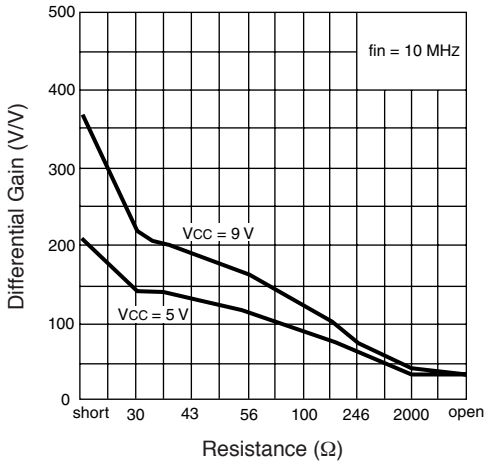

**OUTPUT POWER vs. INPUT POWER (VIDEO AMP)**




**OUTPUT POWER vs. INPUT POWER (VIDEO AMP)**

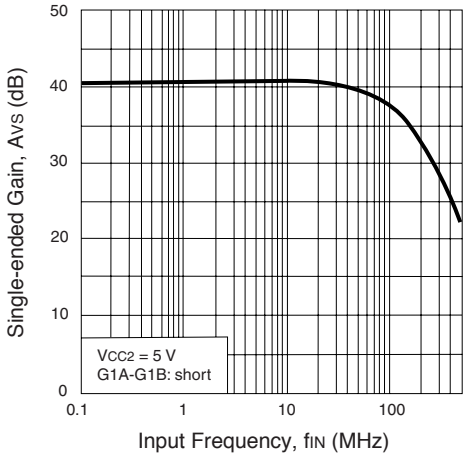



**DIFFERENTIAL GAIN vs. RESISTANCE**

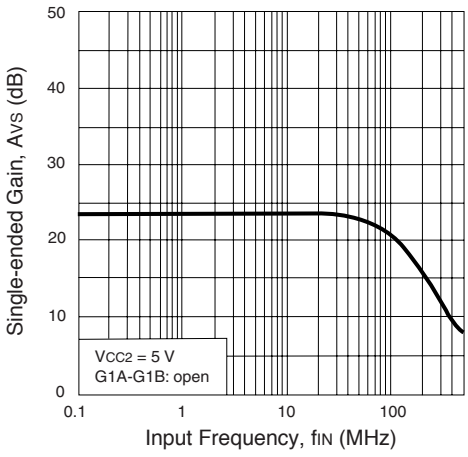


## STANDARD CHARACTERISTICS (by measurement circuit 3: Video Amp, $R_L$ = 50 Ω, $T_A$ = 25°C)

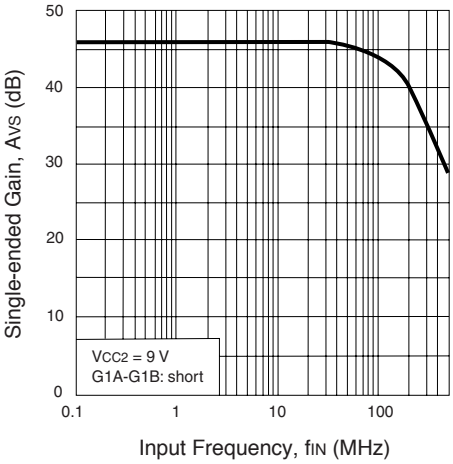
**GAIN vs. INPUT FREQUENCY**



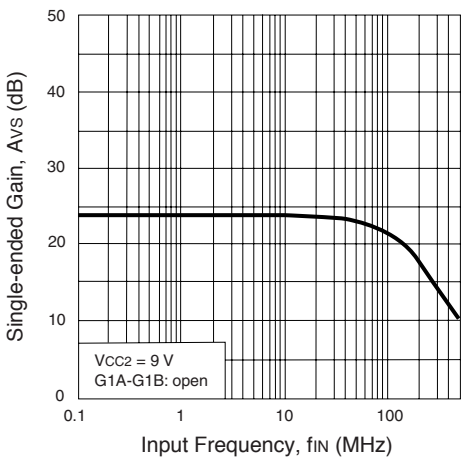

**GAIN vs. INPUT FREQUENCY**



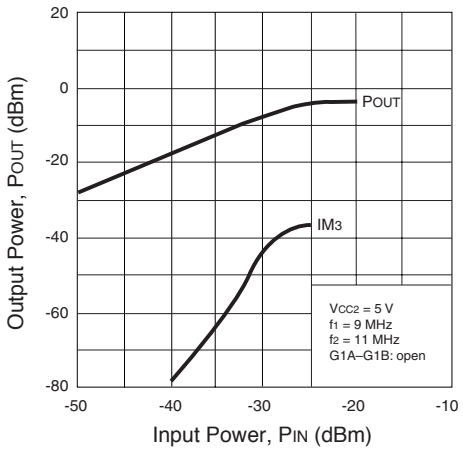

**GAIN vs. INPUT FREQUENCY**



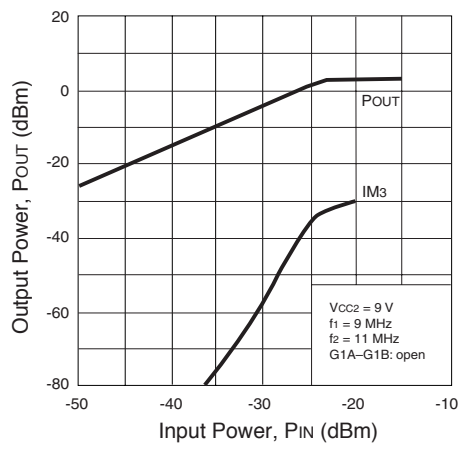

**GAIN vs. INPUT FREQUENCY**




**THIRD ORDER INTERMODULATION LEVEL AND OUTPUT POWER vs. INPUT POWER**

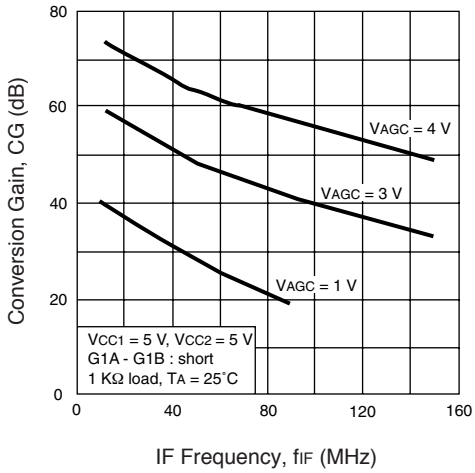



**THIRD ORDER INTERMODULATION LEVEL AND OUTPUT POWER vs. INPUT POWER**

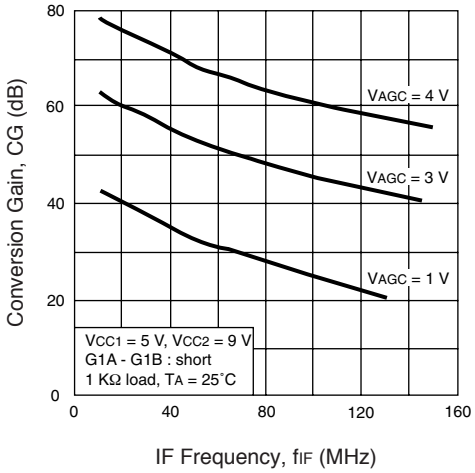


## TYPICAL CHARACTERISTICS (by measurement circuit 4: Total Block, $f_{RF}$ = 45 MHz, $P_{RF}$ = -60 dBm, Posc = -10 dBm)

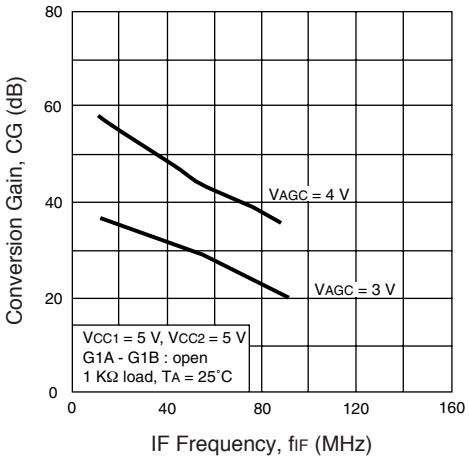
**CONVERSION GAIN vs. IF FREQUENCY**



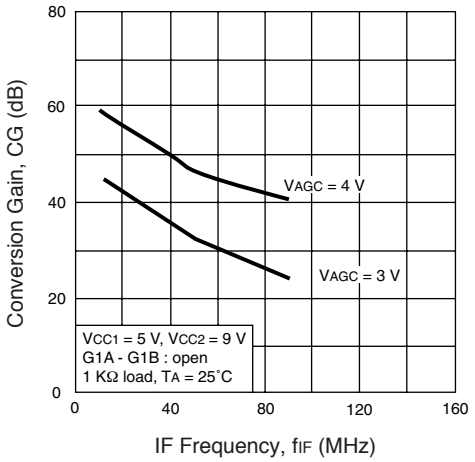

**CONVERSION GAIN vs. IF FREQUENCY**




**CONVERSION GAIN vs. IF FREQUENCY**

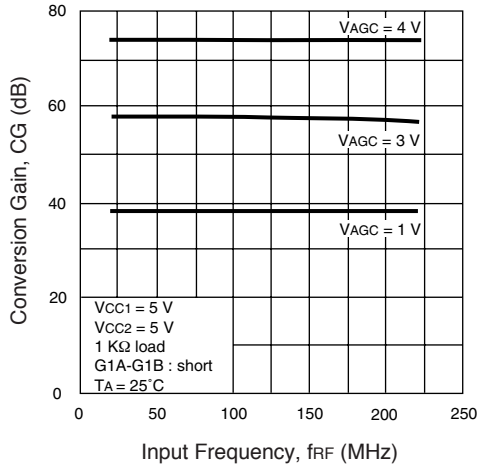



**CONVERSION GAIN vs. IF FREQUENCY**

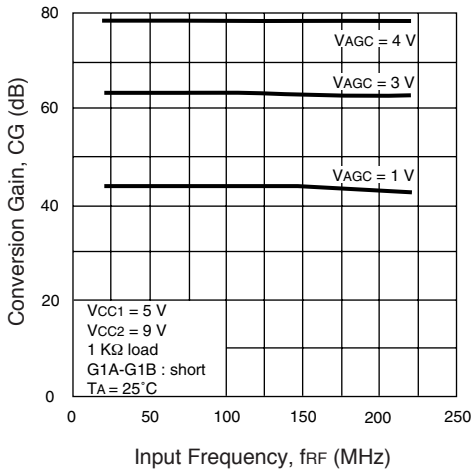


## TYPICAL CHARACTERISTICS (by measurement circuit 4: Total Block, $P_{RF}$ = -60 dBm, $f_{OSC} = f_{RF} + 10$ MHz, $P_{OSC}$ = -10 dBm)

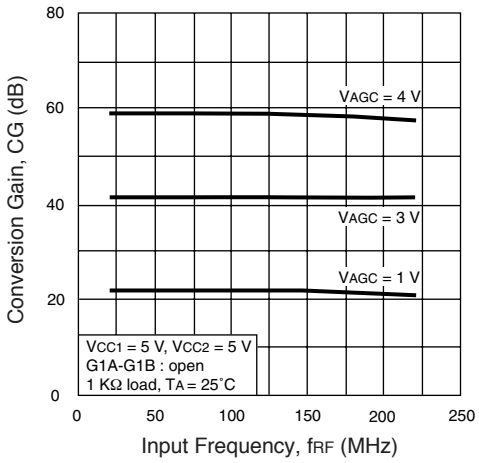
**CONVERSION GAIN vs. INPUT FREQUENCY**



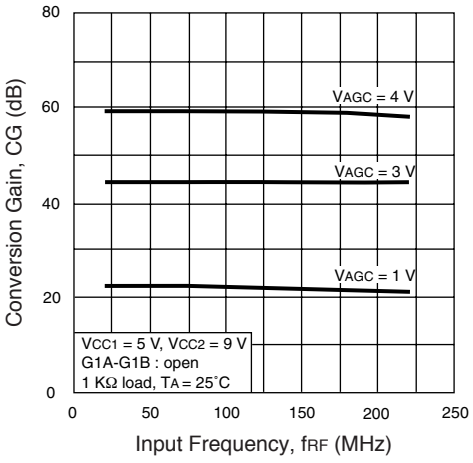

**CONVERSION GAIN vs. INPUT FREQUENCY**




**CONVERSION GAIN vs. INPUT FREQUENCY**

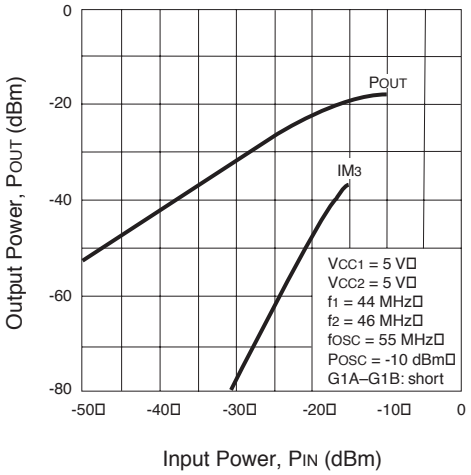



**CONVERSION GAIN vs. INPUT FREQUENCY**

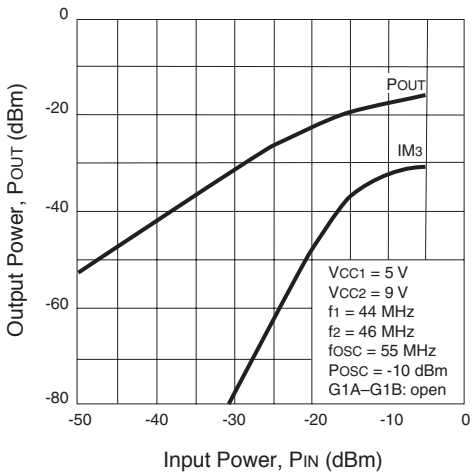


## STANDARD CHARACTERISTICS (by measurement circuit 4: Total Block)

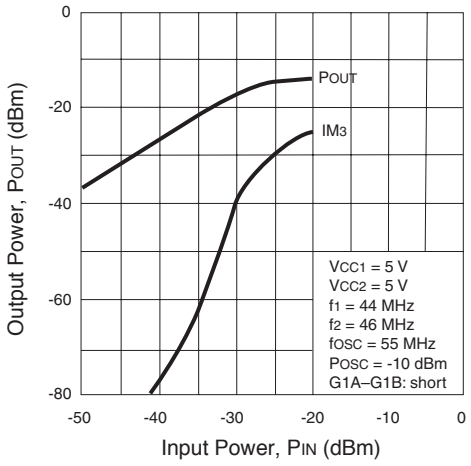
**THIRD ORDER INTERMODULATION LEVEL AND OUTPUT POWER vs. INPUT POWER**




**THIRD ORDER INTERMODULATION LEVEL AND OUTPUT POWER vs. INPUT POWER**

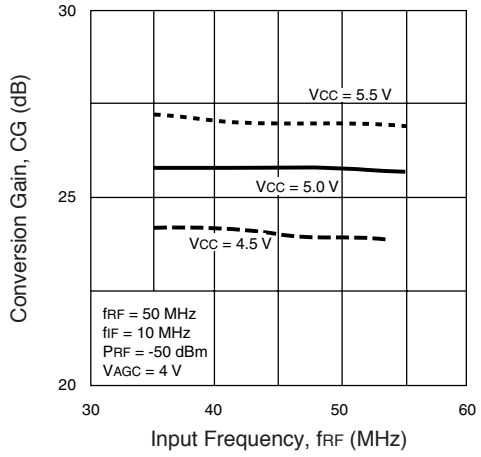



**THIRD ORDER INTERMODULATION LEVEL AND OUTPUT POWER vs. INPUT POWER**

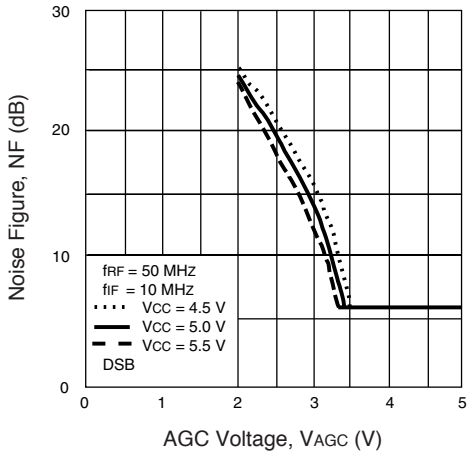


## STANDARD CHARACTERISTICS (by application circuit example : MIXER block)

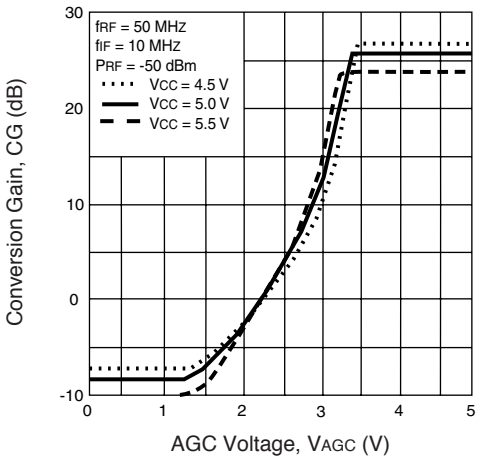
**CONVERSION GAIN vs. INPUT FREQUENCY**



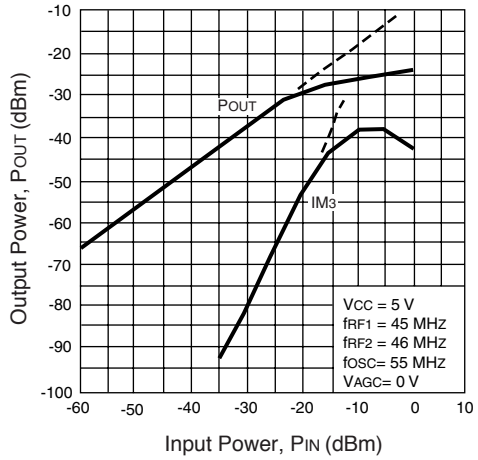

**NOISE FIGURE vs. AGC VOLTAGE**



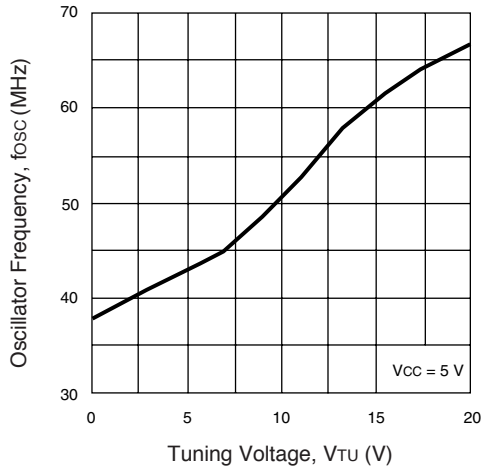

**CONVERSION GAIN vs. AGC VOLTAGE**



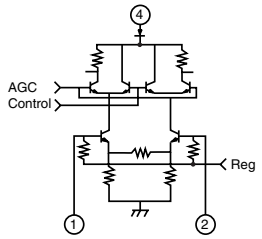
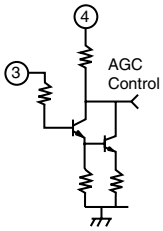
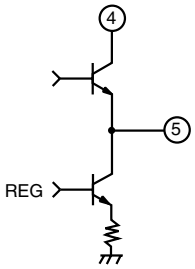
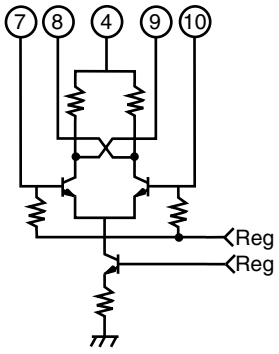

**THIRD ORDER INTERMODULATION LEVEL AND OUTPUT POWER vs. INPUT POWER**



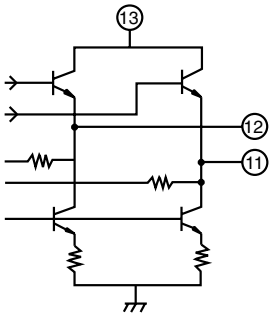
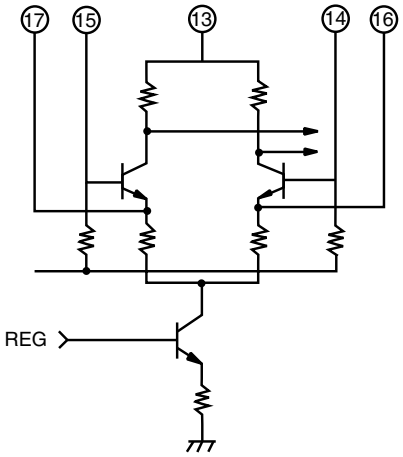
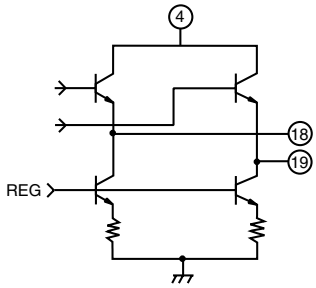

**OSCILLATOR FREQUENCY vs. TUNING VOLTAGE**



## PIN FUNCTIONS

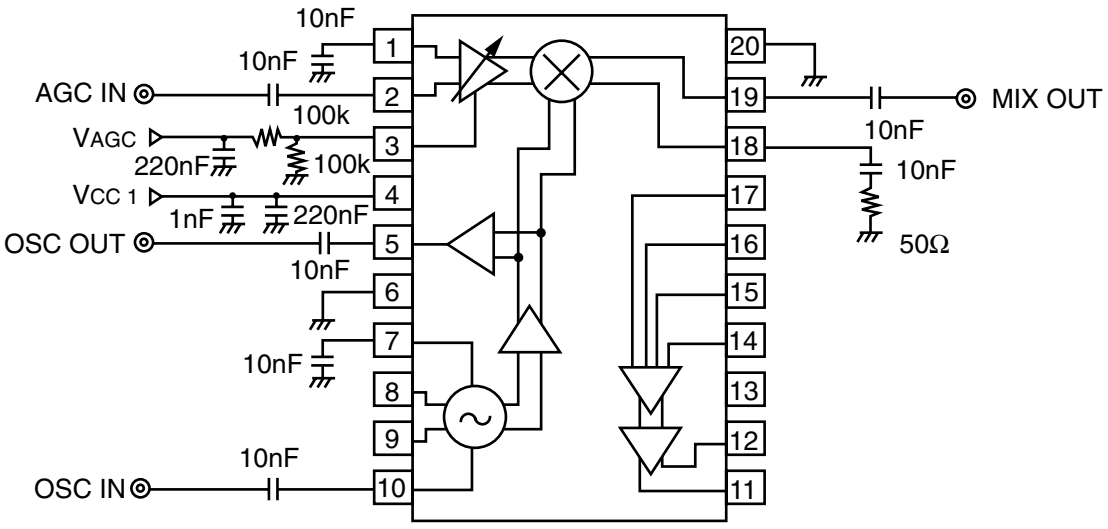
| Pin No. | Pin Name | Pin Voltage Typ. (V) | Function and Explanation | Equivalent Circuit |
|---|---|---|---|---|
| 1 | AGC IN1 | 1.5 | RF input pins. Pins 1 and 2 are each base inputs to a differential amplifier. In the case of a single-ended input, bypass the unused pin to ground through a capacitor. |  |
| 2 | AGC IN2 | 1.5 | | |
| 3 | $V_{AGC}$ | 0~5 | Gain control pin of the mixer input amplifier. $V_{AGC}$ up = gain up. It is recommended to use a 100k Ω voltage divider at this pin. |  |
| 4 | $V_{CC}1$ | 5.0 | Supply voltage pin for the downconverter block. This pin should be connected with a bypass capacitor (e.g., 1000 pF) to minimize ground impedance. | |
| 5 | OSC OUT | 4.0 | Output pin for the internal oscillator. This pin may be connected to the input of a PLL synthesizer. |  |
| 6 | GND | 0.0 | Ground pin. This pin must be connected to system ground. Form ground pattern as wide as possible to minimize ground impedance. | |
| 7 | OSC B2 | 2.4 | Input pins for the internal oscillator. The internal oscillator consists of a balanced amplifier. |  |
| 8 | OSC C1 | 4.6 | | |
| 9 | OSC C2 | 4.6 | | |
| 10 | OSC B1 | 2.4 | | |

## PIN FUNCTIONS

| Pin No. | Pin Name | Pin Voltage Typ. (V) ( ) is value at Vcc = 9V | Function and Explanation | Equivalent Circuit |
|---|---|---|---|---|
| 11 | OUT2 | 2.5 (4.7) | Output pins for the video amplifier. With $R_L$ = 1k Ω, the differential output voltage is 3 Vp-p. OUT1 and INA are in phase. OUT2 and INB are in phase. In the case of a single-ended output, bypass the unused pin to ground through a capacitor. |  |
| 12 | OUT1 | 2.5 (4.7) | | |
| 13 | Vcc2 | 5~9 | Supply voltage pin for the video amplifier block. This pin should be connected with a bypass capacitor (e.g., 1000 pF) to minimize ground impedance. | |
| 14 | INB | 2.5 (4.1) | Input pins for the video amplifier. These pins have high impedance. In the case of a single-ended input, bypass the unused pin to ground through a capacitor. |  |
| 15 | INA | 2.5 (4.1) | | |
| 16 | G1B | 1.7 (3.3) | Gain control pins for the video amplifier. The gain may be adjusted by varying the value of the resistor between pins 16 and 17. Maximum gain = short; Minimum gain = open. | |
| 17 | G1A | 1.7 (3.3) | | |
| 18 | MIX OUT1 | 3.7 | Output pins for the downconverter. These are emitter follower outputs which feature low impedance. In the case of a single-ended output, bypass the unused pin to ground through a capacitor. |  |
| 19 | MIX OUT2 | 3.7 | | |
| 20 | GND | 0.0 | Ground pin. This pin must be connected to system ground. Form ground pattern as wide as possible to minimize ground impedance. | |

## MEASUREMENT CIRCUIT 1

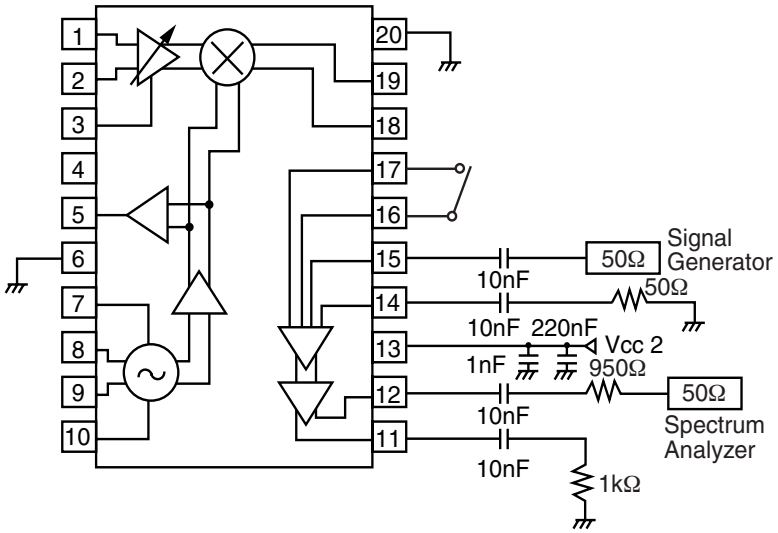
### AGC & MIXER BLOCK




## MEASUREMENT CIRCUIT 2

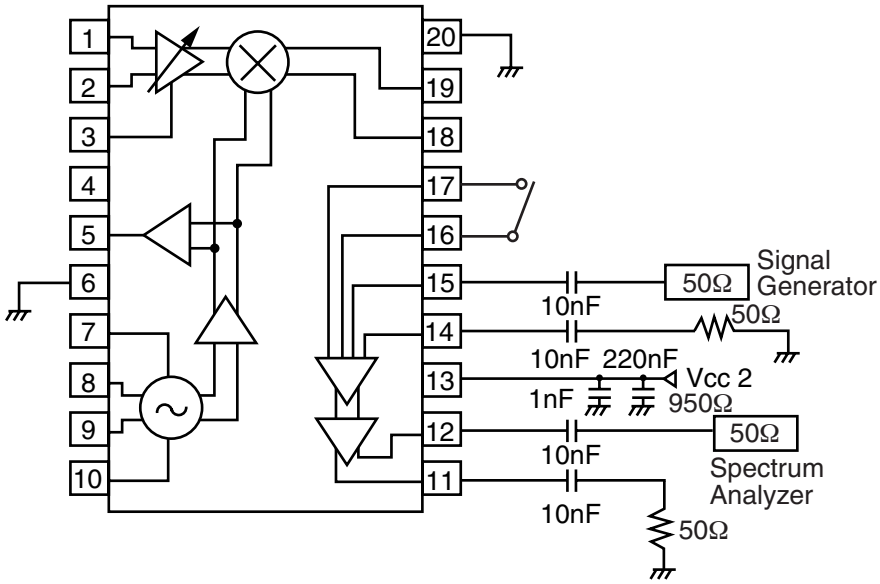
### VIDEO AMP BLOCK

**RL = 1kΩ**



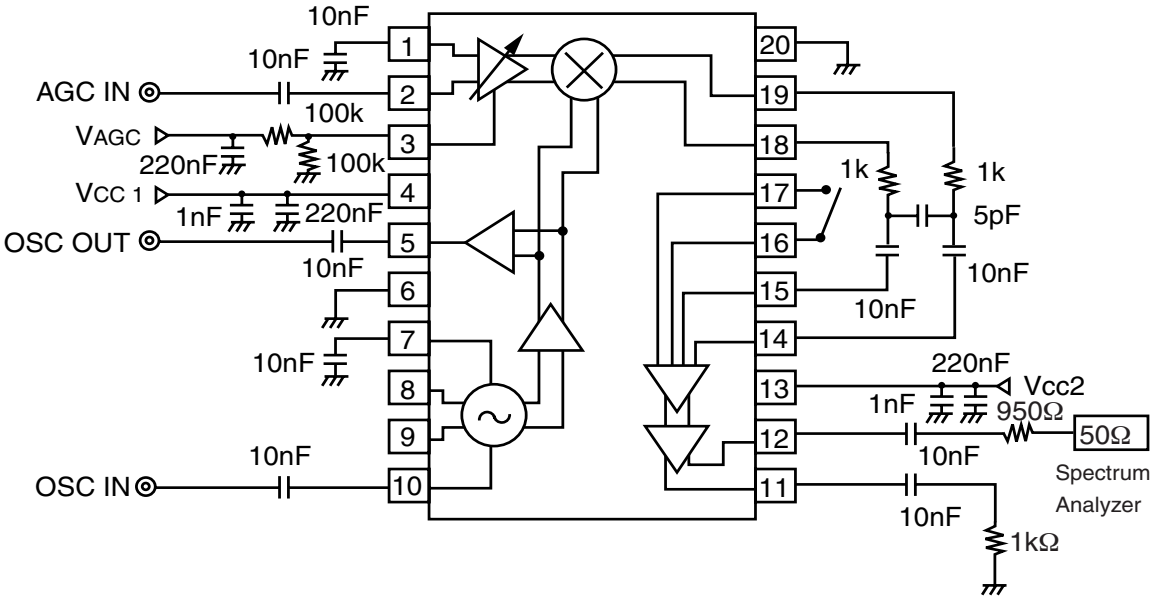
## MEASUREMENT CIRCUIT 3

**VIDEO AMP BLOCK**
**RL = 50Ω**

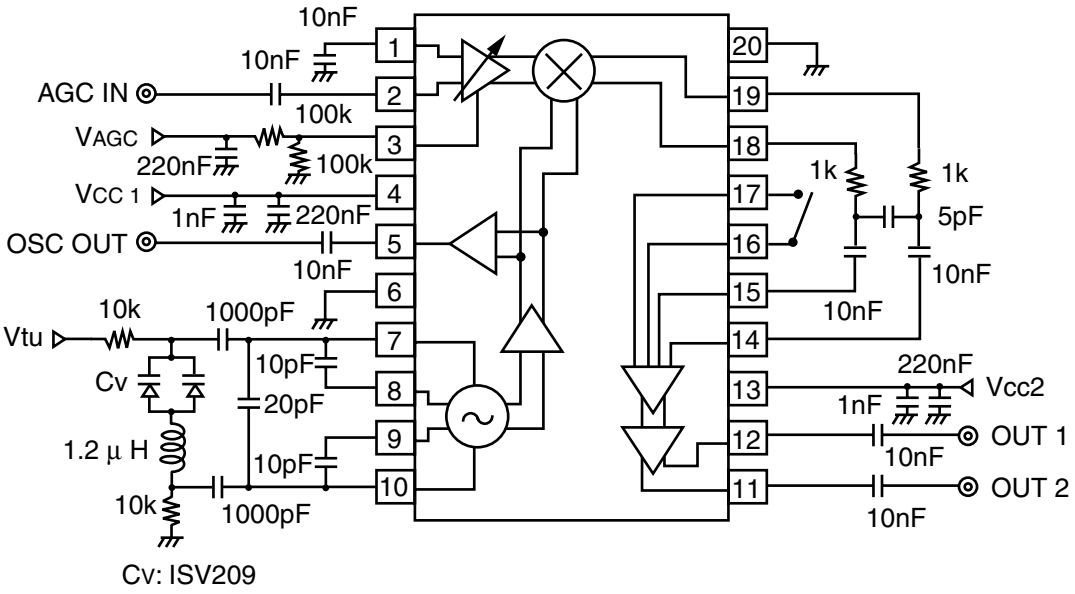



## MEASUREMENT CIRCUIT 4

**TOTAL BLOCK**

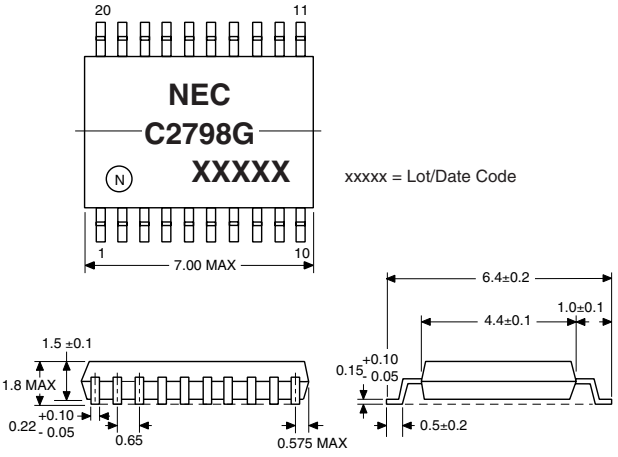


## APPLICATION CIRCUIT EXAMPLE



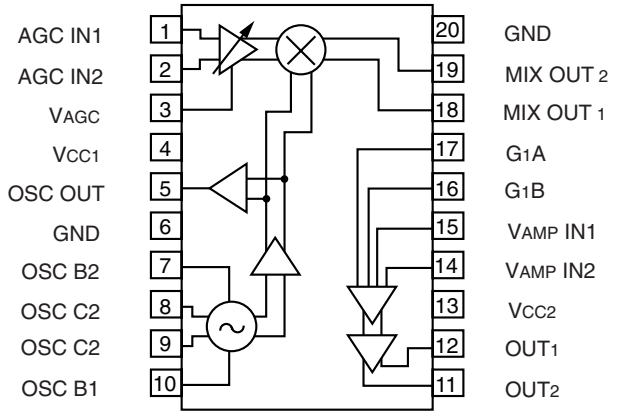

## OUTLINE DIMENSIONS (Units in mm)

**PACKAGE OUTLINE SSOP 20**




All dimensions are typical unless specified otherwise.

## INTERNAL BLOCK DIAGRAM




## ORDERING INFORMATION

| PART NUMBER | QUANTITY |
|---|---|
| UPC2798GR-E1-A | 2500/Reel |

Notes: Embossed tape, 12 mm wide.

Life Support Applications

These NEC products are not intended for use in life support devices, appliances, or systems where the malfunction of these products can reasonably be expected to result in personal injury. The customers of CEL using or selling these products for use in such applications do so at their own risk and agree to fully indemnify CEL for all damages resulting from such improper use or sale.

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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 | |
|---|---|---|---|
| Lead (Pb) | < 1000 PPM | -A | -AZ |
| | | 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.