DATA SHEET

NEC

# BIPOLAR ANALOG INTEGRATED CIRCUIT

# μPC2709T

## 5 V, MINIMOLD SILICON MMIC
## MEDIUM OUTPUT POWER AMPLIFIER

### DESCRIPTION

The μPC2709T is a silicon monolithic integrated circuit designed as 1st IF amplifier for DBS tuners. This IC is packaged in minimold package.

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

### FEATURES

| | |
|---|---|
| • Supply voltage | : $V_{CC}$ = 4.5 to 5.5 V |
| • Wideband response | : $f_u$ = 2.3 GHz TYP. @3 dB bandwidth |
| • Medium output power | : $P_{O\,(sat)}$ = +11.5 dBm@f = 1 GHz with external inductor |
| • Power gain | : $G_P$ = 23 dB TYP. @f = 1 GHz |
| • Port impedance | : input/output 50 Ω |

### APPLICATIONS

- 1st IF amplifiers in DBS converters
- RF stage buffer in DBS tuners, etc.

### ORDERING INFORMATION

| Part Number | Package | Marking | Supplying Form |
|---|---|---|---|
| μPC2709T-E3 | 6-pin minimold | C1E | Embossed tape 8 mm wide.<br>1, 2, 3 pins face the perforation side of the tape.<br>Qty 3 kpcs/reel. |

**Remark** To order evaluation samples, please contact your local NEC sales office. (Part number for sample order: μPC2709T)

**Caution Electro-static sensitive devices**

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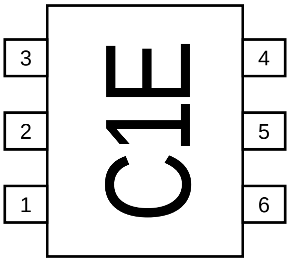
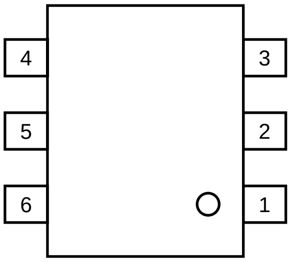
## PIN CONNECTIONS

(Top View)



(Bottom View)



| Pin No. | Pin Name |
|---|---|
| 1 | INPUT |
| 2 | GND |
| 3 | GND |
| 4 | OUTPUT |
| 5 | GND |
| 6 | $V_{CC}$ |

## PRODUCT LINE-UP OF μPC2709 ($T_A$ = +25°C, $V_{CC}$ = $V_{out}$ = 5.0 V, $Z_S$ = $Z_L$ = 50 Ω)

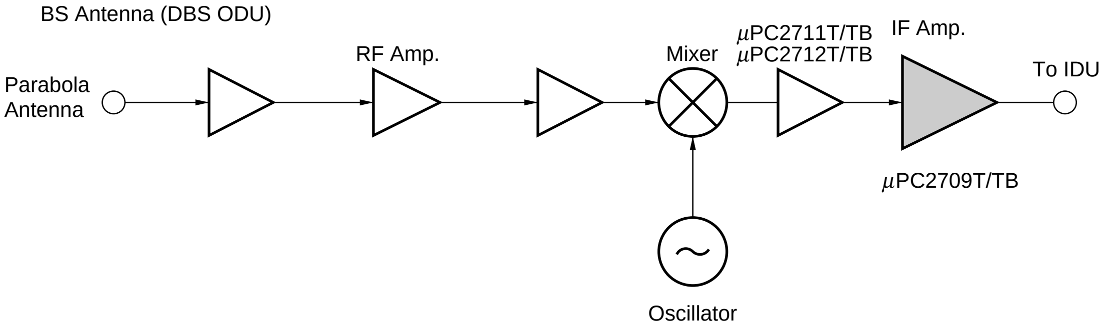
| Part No. | $f_u$ (GHz) | $P_{O\,(sat)}$ (dBm) | $G_P$ (dB) | NF (dB) | $I_{CC}$ (mA) | Package | Marking |
|---|---|---|---|---|---|---|---|
| μPC2709T | 2.3 | +11.5 | 23 | 5 | 25 | 6-pin minimold | C1E |
| μPC2709TB | | | | | | 6-pin super minimold | |

**Remark** Typical performance. Please refer to ELECTRICAL CHARACTERISTICS in detail.

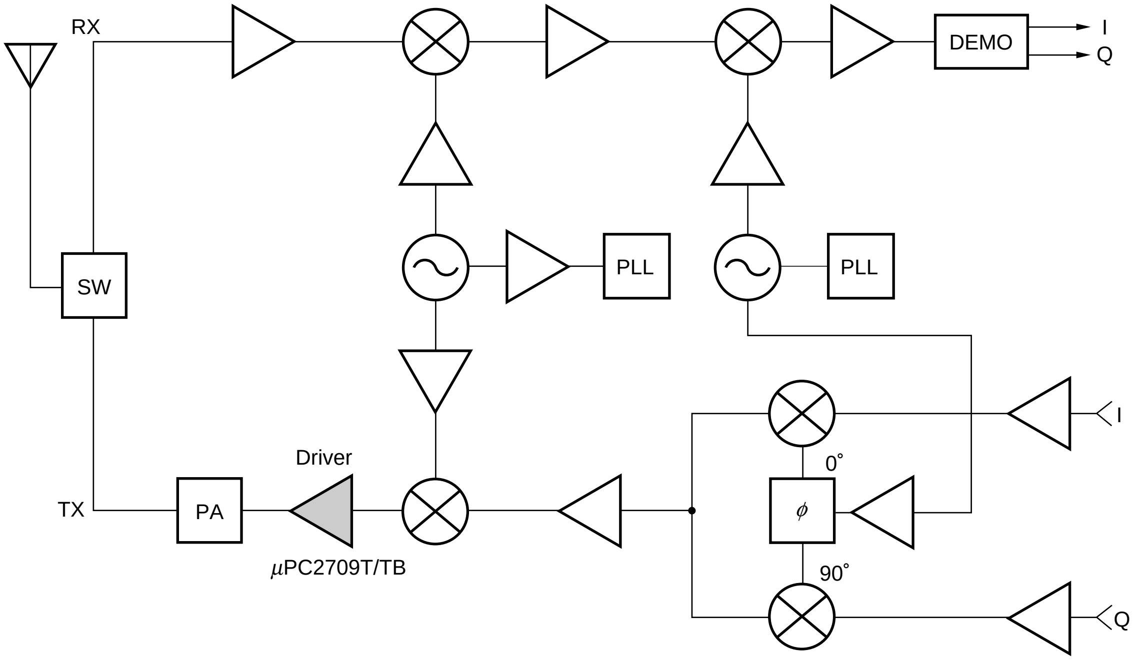
**Caution The package size distinguishes between minimold and super minimold.**

## SYSTEM APPLICATION EXAMPLE

### EXAMPLE OF DBS CONVERTERS

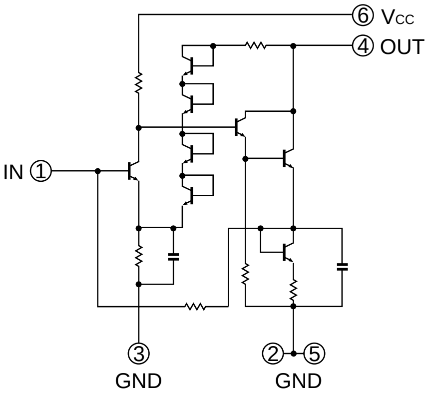


### EXAMPLE OF 900 MHz BAND, 1.5 GHz BAND DIGITAL CELLULAR TELEPHONE



To know the associated products, please refer to each latest data sheet.

## PIN EXPLANATION

| Pin No. | Pin Name | Applied Voltage (V) | Pin Voltage (V)<sup>Note</sup> | Function and Applications | Internal Equivalent Circuit |
|---|---|---|---|---|---|
| 1 | INPUT | – | 1.05 | Signal input pin. A internal matching circuit, configured with resistors, enables 50 Ω connection over a wide band.<br>A multi-feedback circuit is designed to cancel the deviations of $h_{FE}$ and resistance.<br>This pin must be coupled to signal source with capacitor for DC cut. |  |
| 4 | OUTPUT | Voltage as same as $V_{CC}$ through external inductor | – | Signal output pin. The inductor must be attached between $V_{CC}$ and output pins to supply current to the internal output transistors. | |
| 6 | $V_{CC}$ | 4.5 to 5.5 | – | Power supply pin, which biases the internal input transistor.<br>This pin should be externally equipped with bypass capacitor to minimize its impedance. | |
| 2<br>3<br>5 | 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.<br>All the ground pins must be connected together with wide ground pattern to decrease impedance difference. | |

**Note** Pin voltage is measured at $V_{CC}$ = 5.0 V

## ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | Ratings | Unit | Conditions |
|---|---|---|---|---|
| Supply Voltage | $V_{CC}$ | 6 | V | $T_A$ = +25°C, Pin 4 and 6 |
| Total Circuit Current | $I_{CC}$ | 60 | mA | $T_A$ = +25°C |
| Power Dissipation | $P_D$ | 280 | mW | Mounted on double copper clad 50 × 50 × 1.6 mm epoxy glass PWB ($T_A$ = +85°C) |
| Operating Ambient Temperature | $T_A$ | –40 to +85 | °C | |
| Storage Temperature | $T_{stg}$ | –55 to +150 | °C | |
| Input Power | $P_{in}$ | +10 | dBm | $T_A$ = +25°C |

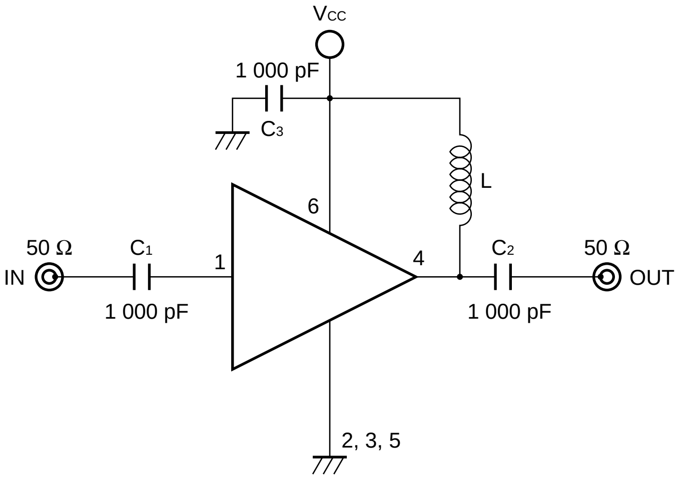
## RECOMMENDED OPERATING CONDITIONS

| Parameter | Symbol | MIN. | TYP. | MAX. | Unit | Notice |
|---|---|---|---|---|---|---|
| Supply Voltage | $V_{CC}$ | 4.5 | 5.0 | 5.5 | V | The same voltage should be applied to pin 4 and 6. |
| Operating Ambient Temperature | $T_A$ | –40 | +25 | +85 | °C | |

## ELECTRICAL CHARACTERISTICS ($T_A$ = +25°C, $V_{CC}$ = $V_{out}$ = 5.0 V, $Z_S$ = $Z_L$ = 50 Ω)

| Parameter | Symbol | Test Conditions | MIN. | TYP. | MAX. | Unit |
|---|---|---|---|---|---|---|
| Circuit Current | $I_{CC}$ | No Signal | 19 | 25 | 32 | mA |
| Power Gain | $G_P$ | f = 1 GHz | 21.0 | 23.0 | 26.5 | dB |
| Maximum Output Level | $P_{O\,(sat)}$ | f = 1 GHz, $P_{in}$ = 0 dBm | +9.0 | +11.5 | – | dBm |
| Noise Figure | NF | f = 1 GHz | – | 5.0 | 6.5 | dB |
| Upper Limit Operating Frequency | $f_u$ | 3 dB down below flat gain at f = 0.1 GHz | 2.0 | 2.3 | – | GHz |
| Isolation | ISL | f = 1 GHz | 26 | 31 | – | dB |
| Input Return Loss | $RL_{in}$ | f = 1 GHz | 7 | 10 | – | dB |
| Output Return Loss | $RL_{out}$ | f = 1 GHz | 7 | 10 | – | dB |
| Gain Flatness | $\Delta G_P$ | f = 0.1 to 1.8 GHz | – | ±1.0 | – | dB |

## TEST CIRCUIT



### COMPONENTS OF TEST CIRCUIT FOR MEASURING ELECTRICAL CHARACTERISTICS

| | Type | Value |
|---|---|---|
| $C_3$ | Capacitor | 1 000 pF |
| L | Bias Tee | 1 000 nH |
| $C_1$ to $C_2$ | Bias Tee | 1 000 pF |

### EXAMPLE OF ACTURAL APPLICATION COMPONENTS

| | Type | Value | Operating Frequency |
|---|---|---|---|
| C1 to C3 | Chip Capacitor | 1 000 pF | 100 MHz or higher |
| L | Chip Inductor | 300 nH | 10 MHz or higher |
| | | 100 nH | 100 MHz or higher |
| | | 10 nH | 1.0 GHz or higher |

### INDUCTOR FOR THE OUTPUT PIN

The internal output transistor of this IC consumes 20 mA, to output medium power. To supply current for output transistor, connect an inductor between the $V_{CC}$ pin (pin 6) and output pin (pin 4). Select large value inductance, as listed above.

The inductor has both DC and AC effects. In terms of DC, the inductor biases the output transistor with minimum voltage drop to output enable high level. In terms of AC, the inductor make output-port impedance higher to get enough gain. In this case, large inductance and Q is suitable.

### CAPACITORS FOR THE $V_{CC}$, INPUT AND OUTPUT PINS

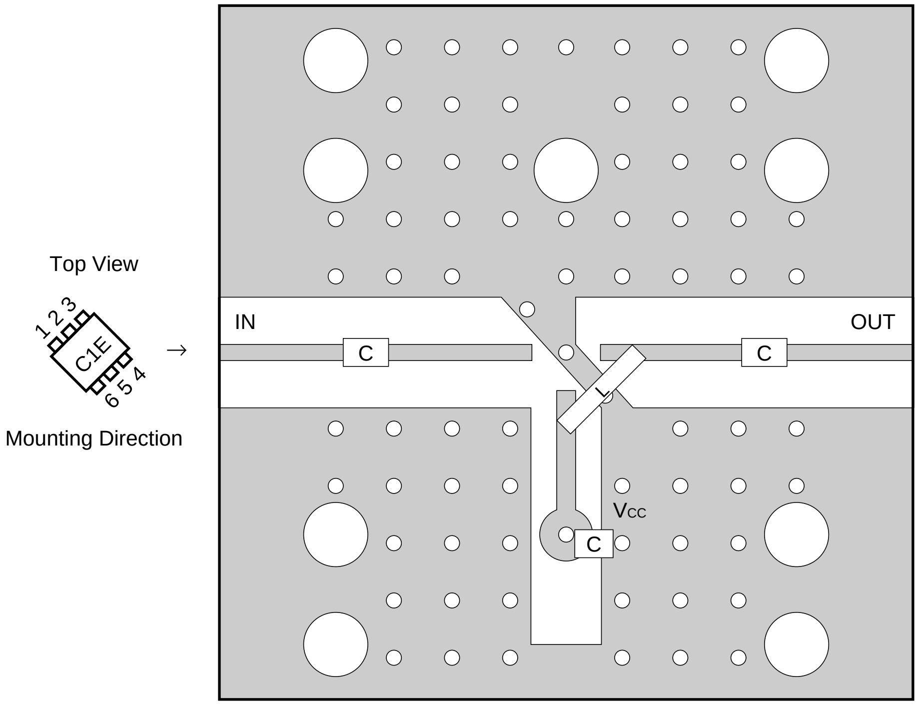
Capacitors of 1 000 pF are recommendable as the bypass capacitor for the $V_{CC}$ pin and the coupling capacitors for the input and output pins.

The bypass capacitor connected to the $V_{CC}$ pin is used to minimize ground impedance of $V_{CC}$ pin. So, stable bias can be supplied against $V_{CC}$ fluctuation.

The coupling capacitors, connected to the input and output pins, are used to cut the DC and minimize RF serial impedance. Their capacitance are therefore selected as lower impedance against a 50 Ω load. The capacitors thus perform as high pass filters, suppressing low frequencies to DC.

To obtain a flat gain from 100 MHz upwards, 1 000 pF capacitors are used in the test circuit. In the case of under 10 MHz operation, increase the value of coupling capacitor such as 10 000 pF. Because the coupling capacitors are determined by equation, $C = 1/(2\ \pi Rfc)$.

## ILLUSTRATION OF APPLICATION CIRCUIT ASSEMBLED ON EVALUATION BOARD



## COMPONENT LIST

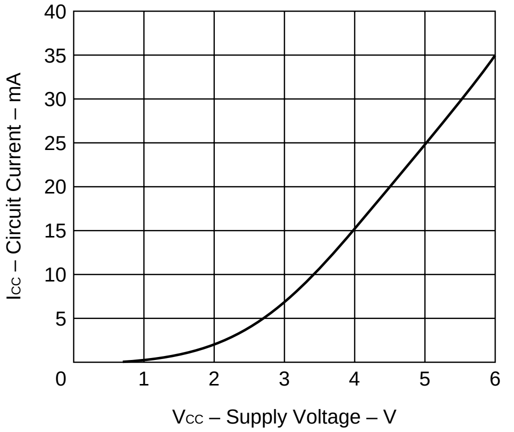
| | Value |
|---|---|
| C | 1 000 pF |
| L | 300 nH |

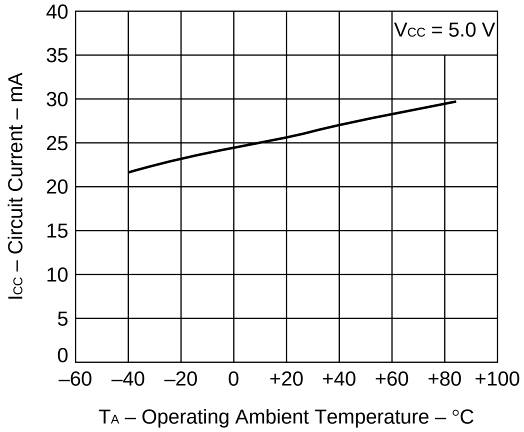
**Notes**

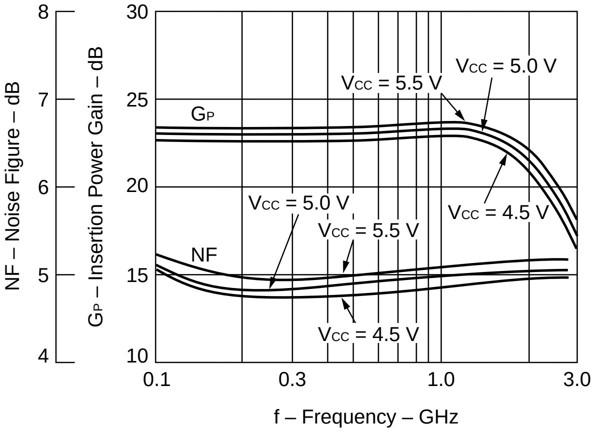
1. 30 × 30 × 0.4 mm double sided copper clad polyimide board.
2. Back side: GND pattern
3. Solder plated on pattern
4. ○ ◯ : Through holes

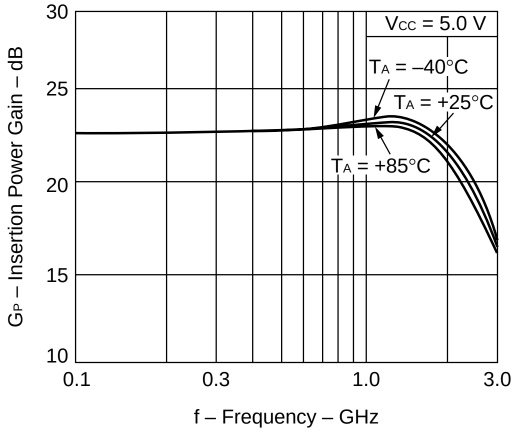
For more information on the use of this IC, refer to the following application note: USAGE AND APPLICATION OF SILICON MEDIUM-POWER HIGH-FREQUENCY AMPLIFIER MMIC (P12152E).

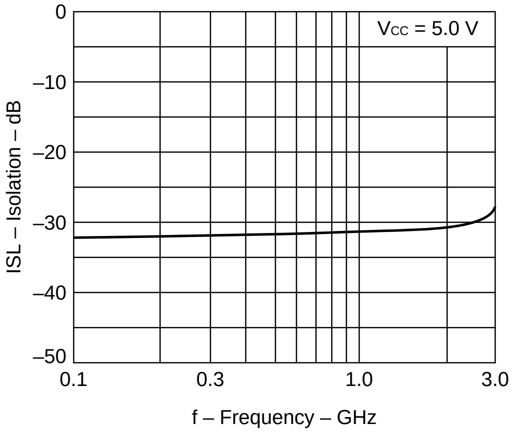
## TYPICAL CHARACTERISTICS ($T_A$ = +25°C unless otherwise specified)

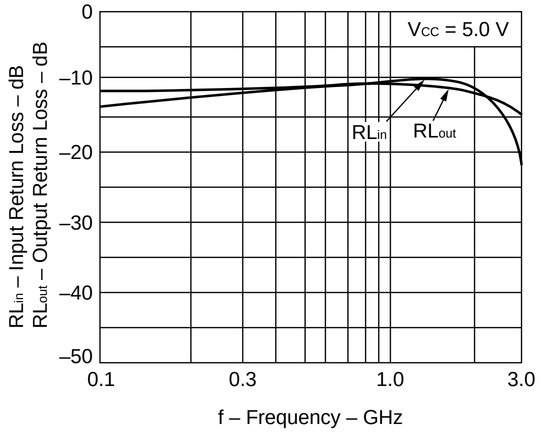

CIRCUIT CURRENT vs. SUPPLY VOLTAGE


CIRCUIT CURRENT vs. OPERATING AMBIENT TEMPERATURE

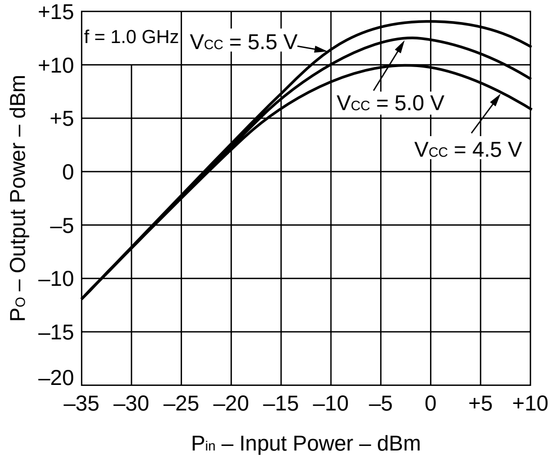

NOISE FIGURE AND INSERTION POWER GAIN vs. FREQUENCY


INSERTION POWER GAIN vs. FREQUENCY

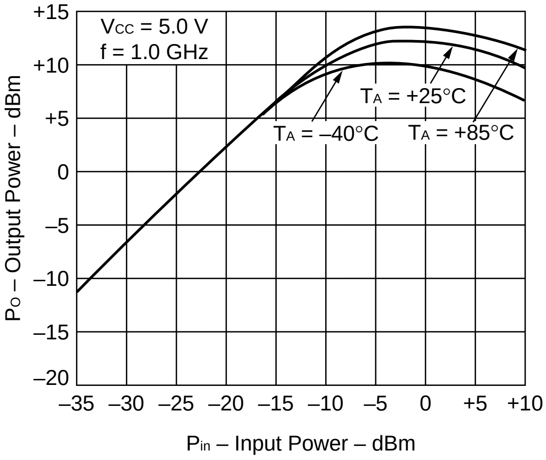

ISOLATION vs. FREQUENCY


INPUT RETURN LOSS, OUTPUT RETURN LOSS vs. FREQUENCY

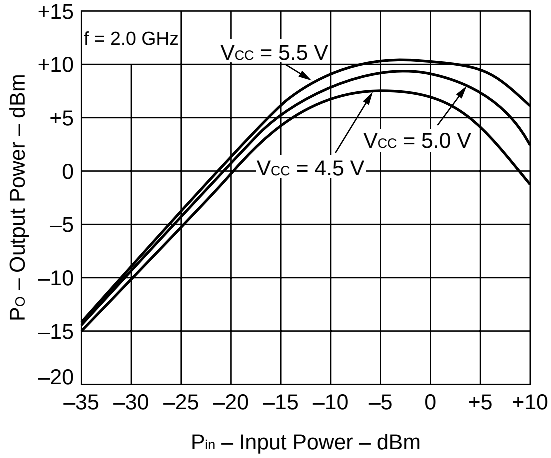
**OUTPUT POWER vs. INPUT POWER**



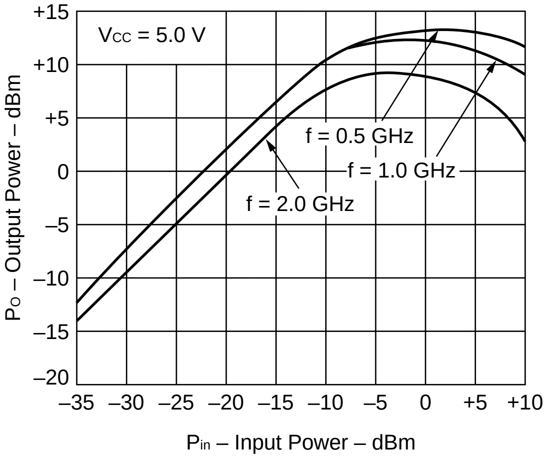
**OUTPUT POWER vs. INPUT POWER**



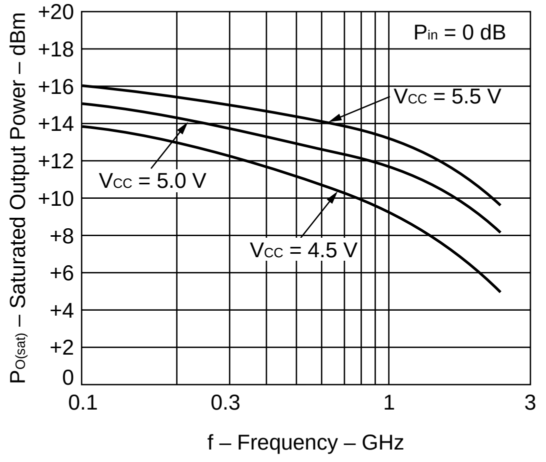
**OUTPUT POWER vs. INPUT POWER**



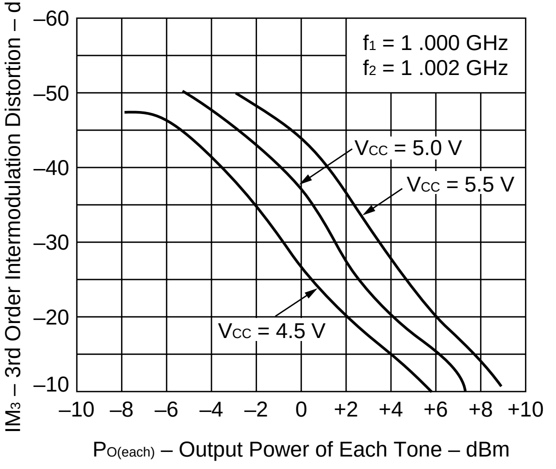
**OUTPUT POWER vs. INPUT POWER**



**SATURATED OUTPUT POWER vs. FREQUENCY**

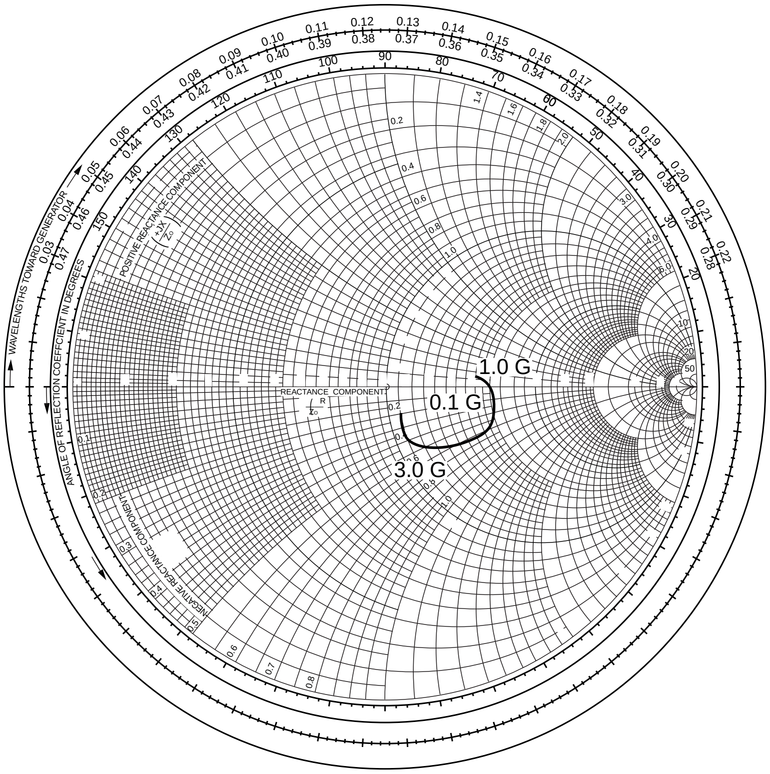


**THIRD ORDER INTERMODULATION DISTORTION vs. OUTPUT POWER OF EACH TONE**

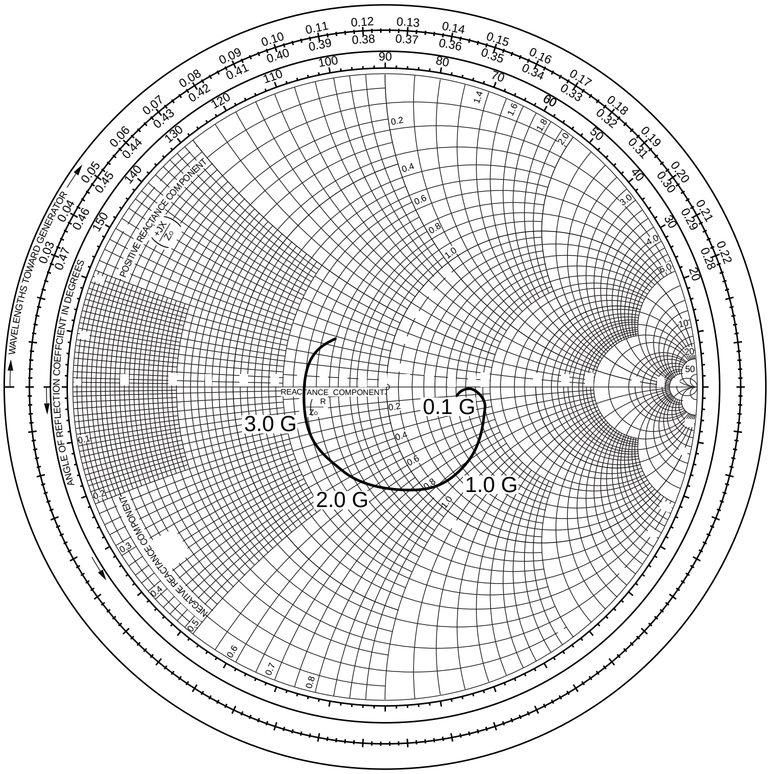


## S-PARAMETER (VCC = Vout = 5.0 V)

### S11-FREQUENCY



### S22-FREQUENCY



## TYPICAL S-PARAMETER VALUES ($T_A$ = +25°C)

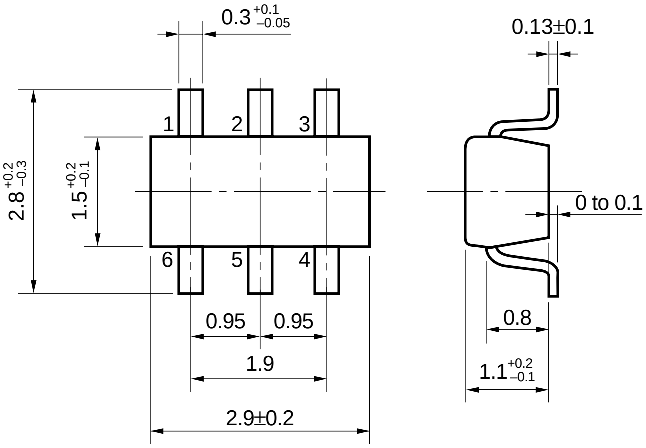
μPC2709T

$V_{CC} = V_{out}$ = 5.0 V, $I_{CC}$ = 30 mA

| Frequency | S11 | | S21 | | S12 | | S22 | | K |
|---|---|---|---|---|---|---|---|---|---|
| MHz | MAG | ANG | MAG | ANG | MAG | ANG | MAG | ANG | |
| 100.0000 | .258 | –4.1 | 12.706 | –3.7 | .022 | 7.5 | .234 | –4.6 | 1.66 |
| 200.0000 | .261 | –2.9 | 12.793 | –12.2 | .024 | 3.1 | .240 | –6.9 | 1.52 |
| 400.0000 | .271 | –4.6 | 13.023 | –27.0 | .025 | 6.5 | .260 | –13.5 | 1.32 |
| 600.0000 | .275 | –8.1 | 13.305 | –41.3 | .026 | 10.5 | .288 | –22.1 | 1.29 |
| 800.0000 | .278 | –12.7 | 13.595 | –57.4 | .026 | 11.0 | .312 | –33.5 | 1.27 |
| 1000.0000 | .279 | –15.2 | 13.816 | –72.3 | .027 | 15.6 | .324 | –43.4 | 1.20 |
| 1200.0000 | .276 | –20.7 | 13.992 | –90.3 | .027 | 17.7 | .332 | –59.0 | 1.19 |
| 1400.0000 | .263 | –25.6 | 13.750 | –109.3 | .027 | 19.2 | .326 | –75.1 | 1.22 |
| 1600.0000 | .246 | –28.6 | 13.195 | –128.3 | .028 | 20.6 | .302 | –90.6 | 1.27 |
| 1800.0000 | .237 | –31.7 | 12.254 | –147.5 | .030 | 27.9 | .254 | –106.8 | 1.33 |
| 2000.0000 | .222 | –33.6 | 10.976 | –166.1 | .031 | 33.2 | .198 | –120.8 | 1.47 |
| 2200.0000 | .194 | –33.1 | 9.664 | 177.5 | .033 | 35.8 | .143 | –132.5 | 1.61 |
| 2400.0000 | .176 | –26.8 | 8.392 | 162.0 | .034 | 38.5 | .089 | –144.4 | 1.81 |
| 2500.0000 | .173 | –23.2 | 7.771 | 154.8 | .035 | 39.2 | .065 | –150.6 | 1.90 |

## PACKAGE DIMENSIONS

### 6 pin minimold (Unit: mm)



## 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 $V_{CC}$ line.
(4) The inductor must be attached between $V_{CC}$ and output pins. The inductance value should be determined in accordance with desired frequency.
(5) The DC cut capacitor must be attached to input pin.

## RECOMMENDED SOLDERING CONDITIONS

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

| Soldering Method | Soldering Conditions | Recommended Condition Symbol |
|---|---|---|
| Infrared Reflow | Package peak temperature: 235°C or below<br>Time: 30 seconds or less (at 210°C)<br>Count: 3, Exposure limit[Note]: None | IR35-00-3 |
| VPS | Package peak temperature: 215°C or below<br>Time: 40 seconds or less (at 200°C)<br>Count: 3, Exposure limit[Note]: None | VP15-00-3 |
| Wave Soldering | Soldering bath temperature: 260°C or below<br>Time: 10 seconds or less<br>Count: 1, Exposure limit[Note]: None | WS60-00-1 |
| Partial Heating | Pin temperature: 300°C<br>Time: 3 seconds or less (per side of device)<br>Exposure limit[Note]: None | ——— |

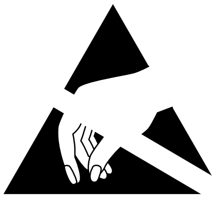
**Note** After opening the dry pack, keep it in a place below 25°C and 65% RH for the allowable storage period.

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

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

**[MEMO]**

**[MEMO]**



**ATTENTION**

OBSERVE PRECAUTIONS
FOR HANDLING
ELECTROSTATIC
SENSITIVE
DEVICES

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

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