APPLICATION NOTE

NEC

GENERAL-PURPOSE HIGH-FREQUENCY WIDEBAND AMPLIFIERS μPC1675G, μPC1676G, μPC1688G

1. GENERAL

The μPC1675G, μPC1676G and μPC1688G are silicon monolithic ICs developed as general-purpose high-frequency wideband amplifiers.

These ICs are based on the μPC1651G packaged in a 4-pin disc mold. The present ICs are each packaged in a 4-pin mini-mold suitable for surface mounting on higher density print board. (the μPC1651G has been discontinued).

The features of these amplifier ICs are:

<1> The 4-pin mini-mold package as shown in Figure 1 substantially reduces the mounting area.

<2> The ICs are supplied on an embossed tape conforming to EIAJ's "Taping Dimensions of Electronic Components (RC-1009)". This embossed tape is 8 mm wide, and suits automatic mounting.

<3> The following three models are available, classified by power gain.

μPC1675G: G_P = 12 dB TYP., NF = 5.5 dB TYP. (@f = 500 MHz)
μPC1676G: G_P = 22 dB TYP., NF = 4.5 dB TYP. (@f = 500 MHz)
μPC1688G: G_P = 21 dB TYP., NF = 4.0 dB TYP. (@f = 500 MHz)

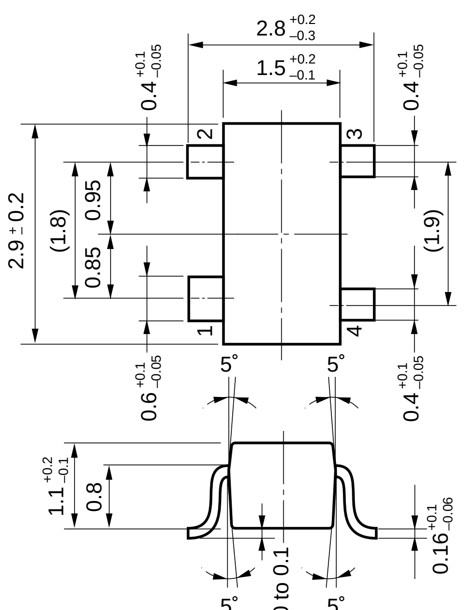
<4> All the models can operate at high frequency and in wide band.

μPC1675G: 1900 MHz TYP.
μPC1676G: 1200 MHz TYP. } frequency point of –3 dB gain from flat gain
μPC1688G: 1100 MHz TYP.

<5> Input/output matched to Z_O = 50 Ω.

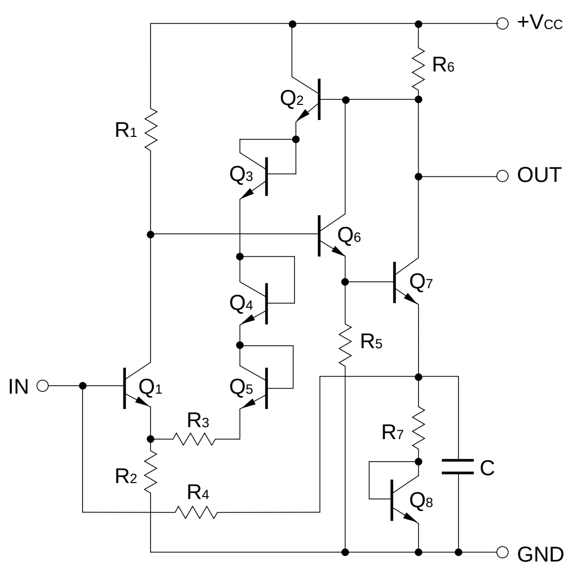
<6> Single power source (V_{CC} = 5 V TYP.)

Figure 1. Package (unit: mm)



Pin connections
1. GND
2. Output
3. V_{CC}
4. Input

Figure 2. Internal Equivalent Circuit



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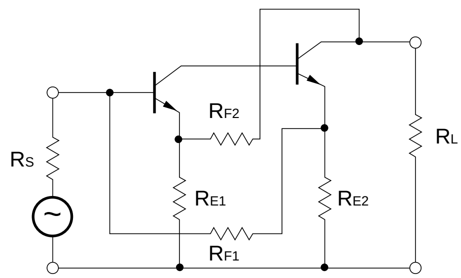
2. CIRCUIT CONFIGURATION

Figure 2 shows the internal equivalent circuit of the μPC1675G/μPC1676G/μPC1688G.

The equivalent circuits of all the models are the same, and gain is set by changing R_2, R_3, R_4, and R_7. Like the μPC1651G, each circuit is designed as multiple negative feedback amplification from the output block to the base and emitter of Q_1. MOS capacitance C is connected to the emitter of Q_7 to peak the frequency characteristics.

The basic circuit is the single-end multiple negative feedback amplification type shown in Figure 3. This circuit configuration has the following features:

Figure 3. Circuit Configuration



<1> Excellent frequency-gain characteristics.

<2> The input/output impedance and gain can be determined by the feedback resistance.

<3> Excellent noise characteristics because the resistance at the emitter of transistor in the input stage is lower than that of the differential circuits.

<4> Excellent impedance matching with external circuits as compared with differential circuits, improving the output efficiency and decreasing the noise.

As the first approximation, the input/output impedances R_i and R_o, and gain S_{21} of the circuit in Figure 3 can be generally determined by the following equation.

$$R_i = \frac{(R_{F2} + R_{E2})\, R_{E1} \cdot R}{R_{E1} \cdot R + R_{E2}\,(R_{F1} + R_{E1} + R)} \quad \cdots\cdots\cdots\cdots \ (1)$$

$$R_o = \frac{(R_{F1} + R_{E1})\, R_{E2} \cdot R}{R_{E1}\,(R_{E2} + R_{F2} + R) + R_{E2} \cdot R} \quad \cdots\cdots\cdots\cdots \ (2)$$

$$S_{21} = \frac{R_{F1} + R_{E1}}{R_{E1}} \quad \cdots\cdots\cdots\cdots \ (3) \ \ (\text{where } R_S = R_L = R)$$

By following modification on Figure 3, multiple negative feedback amplifier is realized as monolithic IC shown in Figure 2.

<1> To increase the feedback loop gain, the final stage Q_6 and Q_7 are connected in a Darlington configuration. Q_6 is connected to R_5 to optimize the bias current.

<2> As for feedback to the emitter of Q_1 from the collectors of Q_6 and Q_7, the impedance and voltage are adjusted by the emitter-follower configuration of Q_2 and the diodes of Q_3 through Q_5.

<3> Q_8 diode rises up Q_7 emitter potential to supply bias current to Q_1 base through feedback path.

Simulation results of input/output impedance and gain vs. R_3 , R_4 feedback resistance are shown below (the result of this simulation is slightly different from the calculation using equation 1 through 3 because the circuit configuration is more complicated than Figure 3. R_3 is equivalent to R_{F2} in Figure 3, and R_4 is equivalent to R_{F1}).

Figure 4. Input/Output Impedance vs. Feedback Resistor

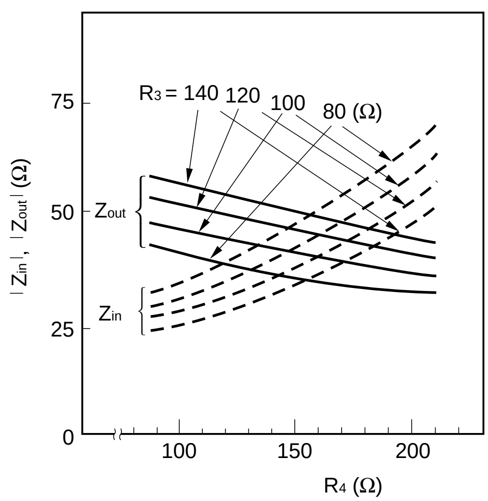
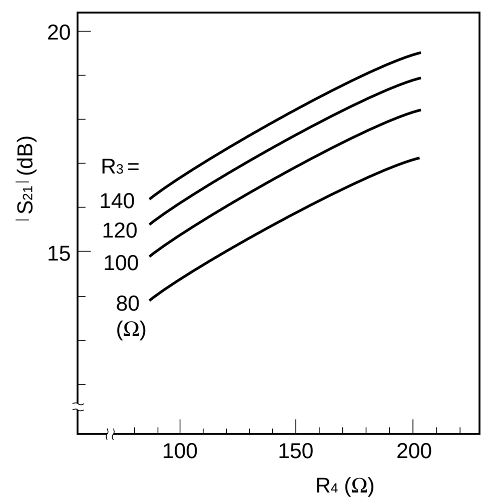


Figure 5. Forward Transmission Gain vs. Negative Feedback Resistor



As shown in Figures 4 and 5, the input/output impedance and gain can be easily controlled by feedback resistors R_3 and R_4.

Respectively, the input/output impedance is set to 50 Ω for wideband operation, and R_3 and R_4 to 120 Ω and 200 Ω to obtain a sufficient gain.

3. CHARACTERISTICS

This chapter compares the measured characteristics of μPC1675G and μPC1676G as representative IC. The absolute maximum ratings and electrical characteristics are shown in Table 1 and 2. (Test circuit is shown in Figure 20.)

Table 1. Absolute Maximum Ratings (T_A = +25 ˚C)

Parameter	Symbol	Rating	Unit
Supply voltage	V_{CC}	6	V
Total dissipation	P_T	200	mW
Operating temperature range	T_{opt}	–40 to +85	˚C
Storage temperature range	T_{stg}	–55 to +150	˚C

Table 2. Electrical Characteristics (V_{CC} = 5 V, T_A = +25 ˚C)

Parameter	Symbol	Condition	Specifications						Unit
			μPC1675G			μPC1676G			
			MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
Supply current	I_{CC}	Without signal	12	17	22	14	19	24	mA
Power gain	G_P	f = 500 MHz	10	12	14	19	22	24	dB
Noise factor	NF	f = 500 MHz	–	5.5	7.0	–	4.5	6.0	dB
Upper-limit operating frequency	f_u	–3 dB from gain flat	1600	1900	–	1000	1200	–	MHz
Isolation	ISL	f = 500 MHz	21	25	–	24	28	–	dB
Input return loss	RL_{in}	f = 500 MHz	9	12	–	9	12	–	dB
Output return loss	RL_{out}	f = 500 MHz	8	11	–	6	9	–	dB
Output power	P_O	f = 500 MHz, P_{in} = 0 dBm	2	4	–	3	5	–	dBm

Figures 6 through 11 and Figures 12 through 17 show the characteristic curves including the voltage characteristics and temperature characteristics of the μPC1675G and μPC1676G. Figure 18 shows the impedance characteristics (Smith chart).

Figure 6. G_P, NF vs. f Characteristics of μPC1675G

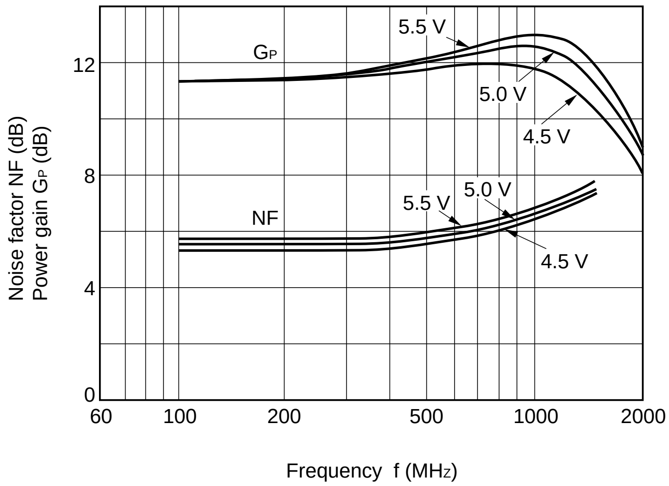


Figure 7. Isolation vs. f Characteristics of μPC1675G

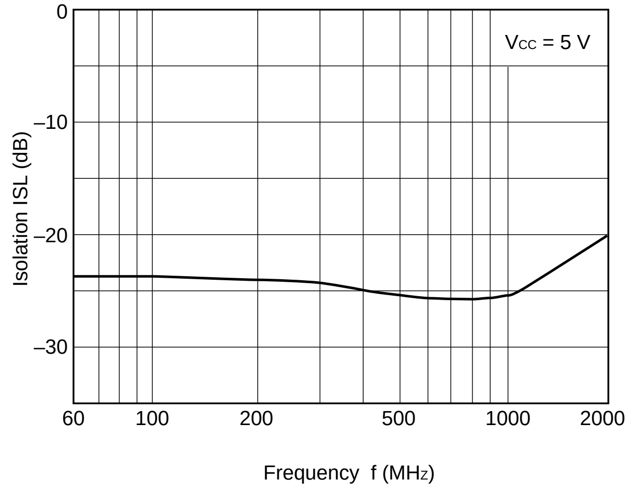


Figure 8. Return Loss vs. f Characteristics of μPC1675G

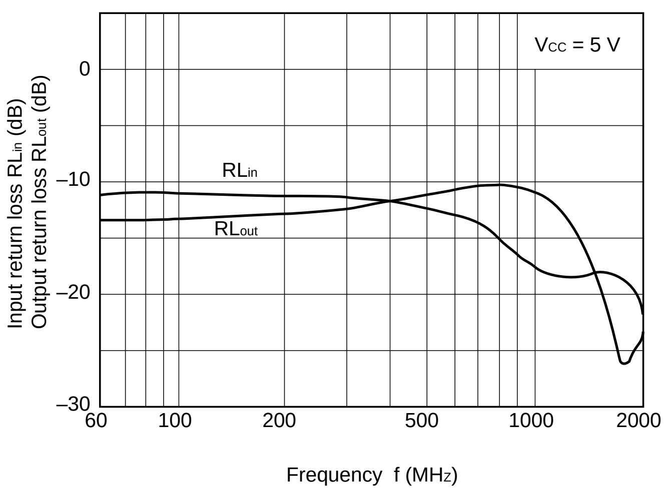


Figure 9. Input/Output Characteristics of μPC1675G

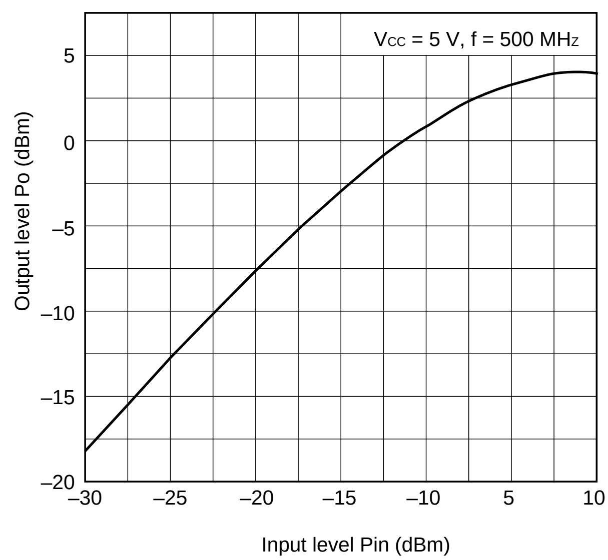


Figure 10. IM3 Characteristics of μPC1675G

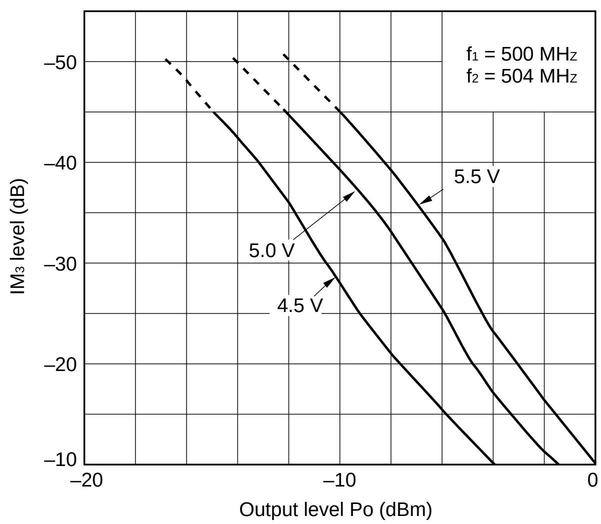


Figure 11. GP vs. Temperature Characteristics of μPC1675G

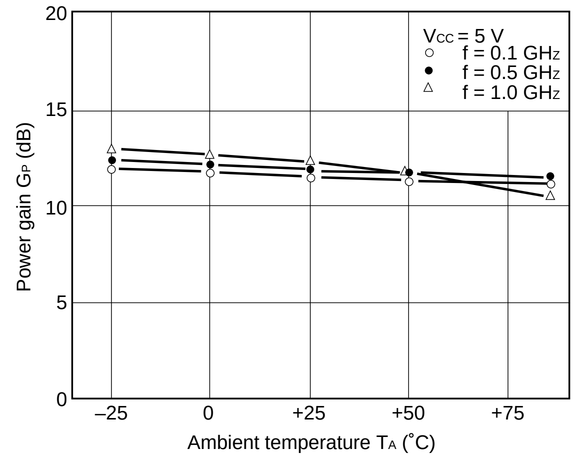


Figure 12. GP, NF vs. f Characteristics of μPC1676G

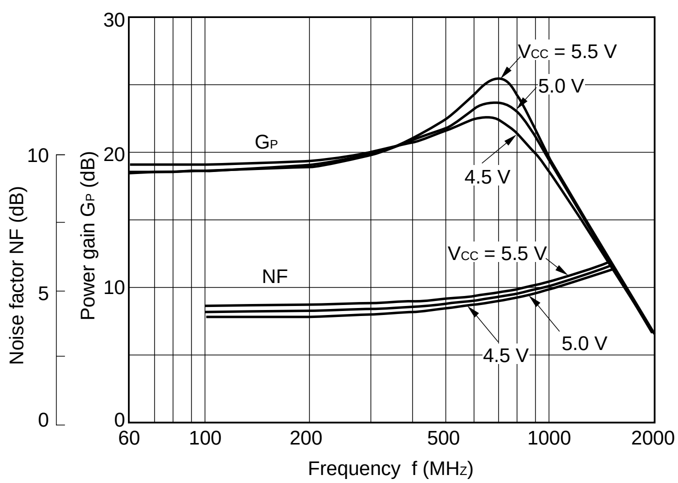


Figure 13. Isolation vs. f Characteristics of μPC1676G

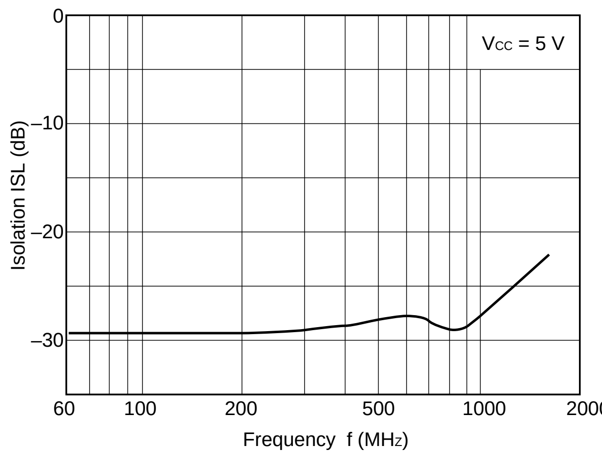


Figure 14. Return Loss vs. f Characteristics of µPC1676G

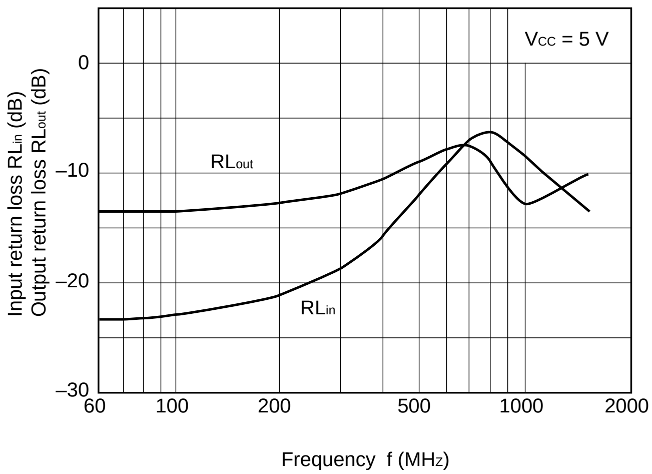


Figure 15. Input/Output Characteristics of µPC1676G

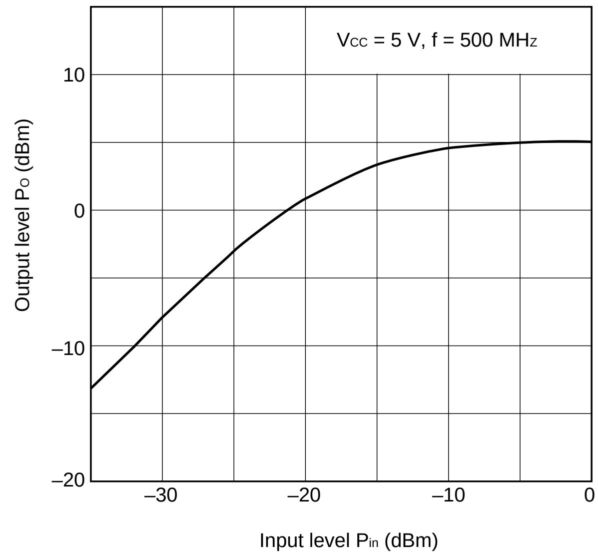


Figure 16. IM3 Characteristics of µPC1676G

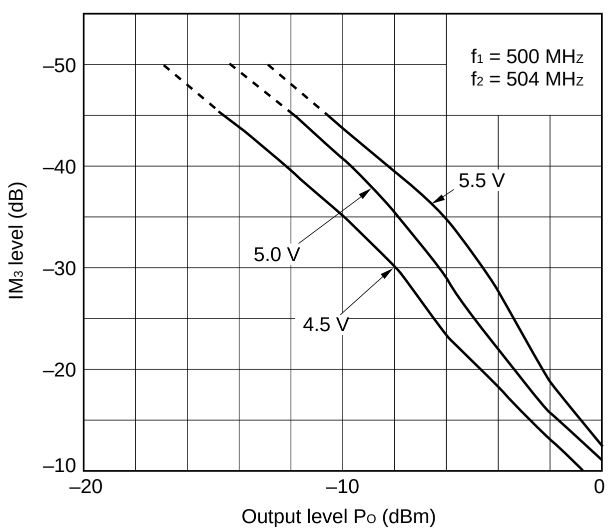


Figure 17. GP Temperature Characteristics of µPC1676G

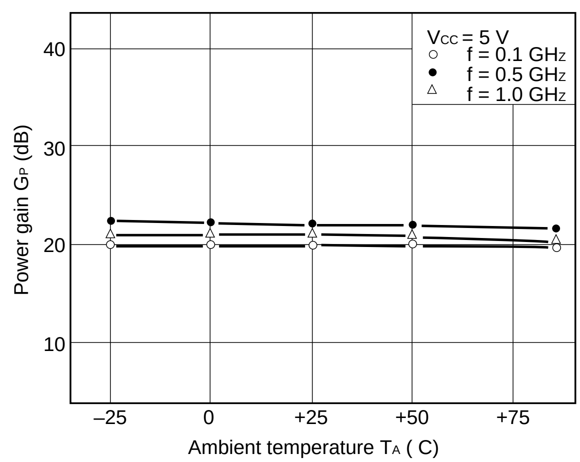


Figure 18 (a). S_{11} vs. f Characteristics of μPC1675G

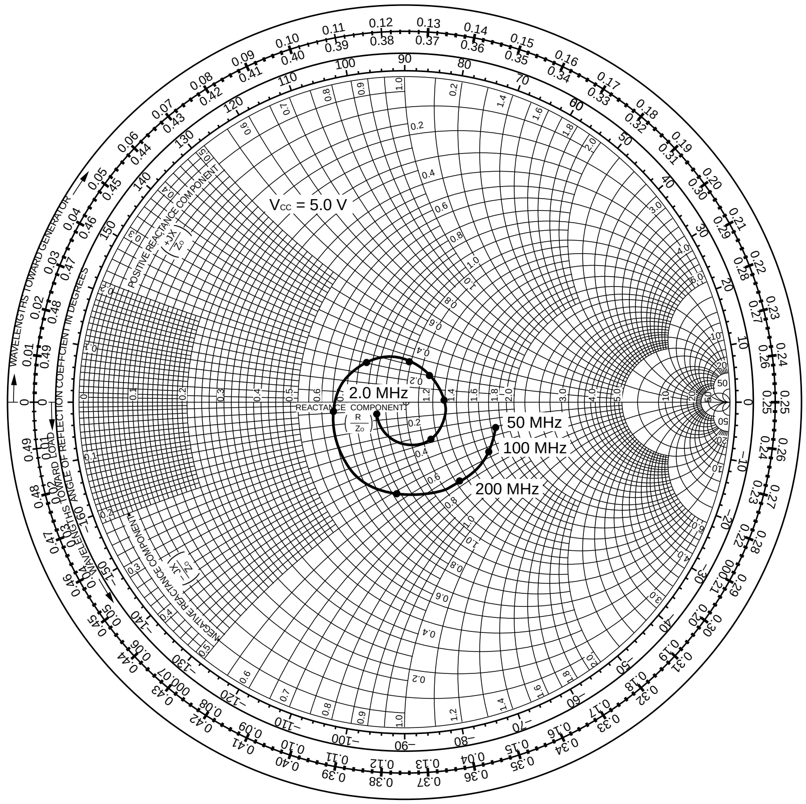


Figure 18 (b). S_{22} vs. f Characteristics of μPC1675G

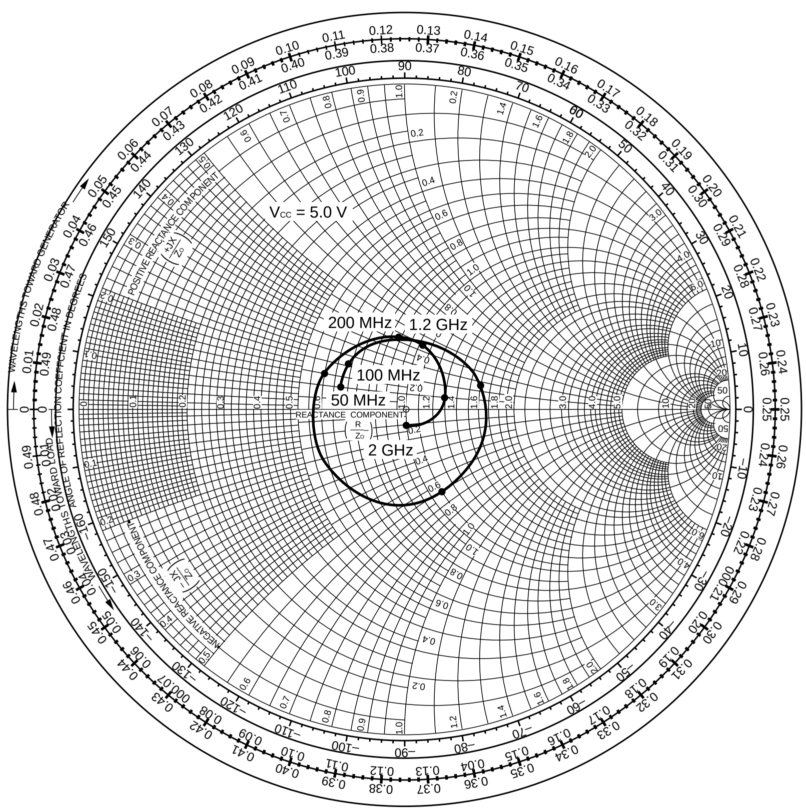


Figure 18 (c). S11 vs. f Characteristics of μPC1676G

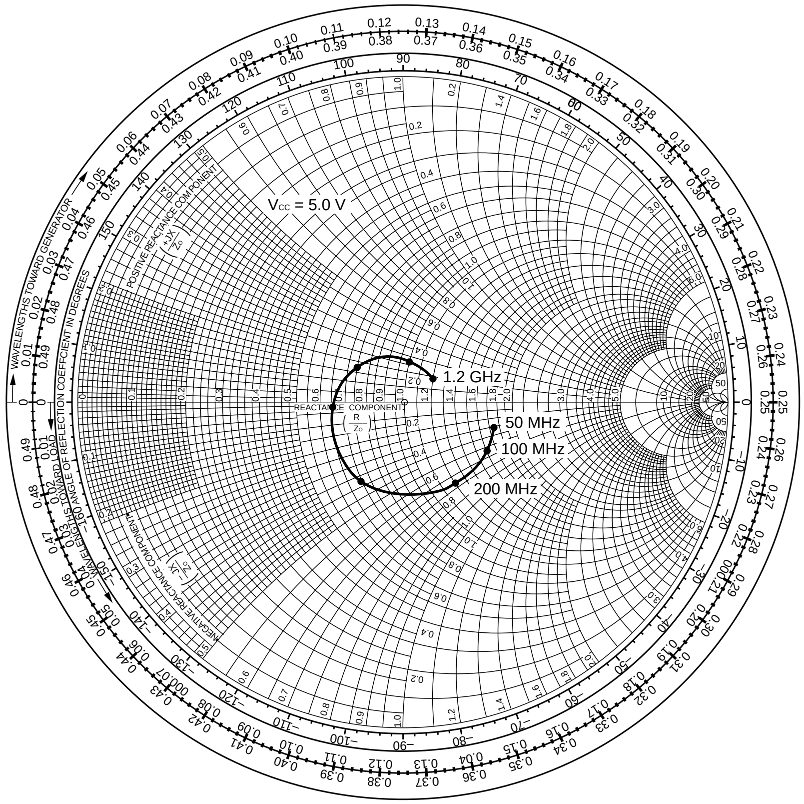
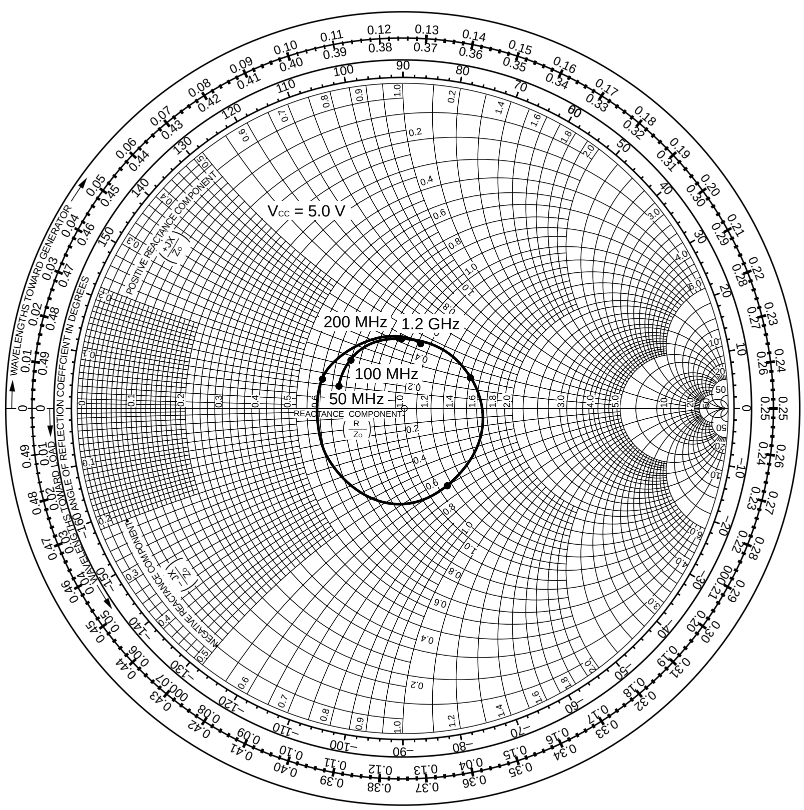


Figure 18 (d). S22 vs. f Characteristics of μPC1676G



4. PRINTED PATTERN MOUNTING EXAMPLE

The μPC1675G/μPC1676G/μPC1688G are wideband amplifiers of simple construction with only four pins: input, output, power, and GND.

Because the upper-limit operating frequency is as high as 1900 MHz TYP. in the case of μPC1675G and 1200 MHz TYP. with the μPC1676G, the frequency characteristics substantially vary depending on the conditions of the print pattern (especially at high frequencies).

Figure 19 shows these variations in the characteristics of the μPC1675G. Print boards A, B, and C in this figure are:

Board A : Double-sided copper clad epoxy glass board with GND on the back and front surfaces connected, and a GND line inserted between input and output to provide an isolation effect.
Figure 20 shows an example pattern.

Board B : Board A without GND line between input and output.

Board C : Board B without GND on back side.

As shown in figure 19, a print board equivalent to A is necessary because of peaking in the vicinity of f = 1 GHz and an increase in the frequency characteristics. The GND line between input and output has an especially important effect. Board A is used to measure characteristics in Chapter 3.

Figure 19. Mounting Characteristics Example of μPC1675G (G_P = 13 dB)

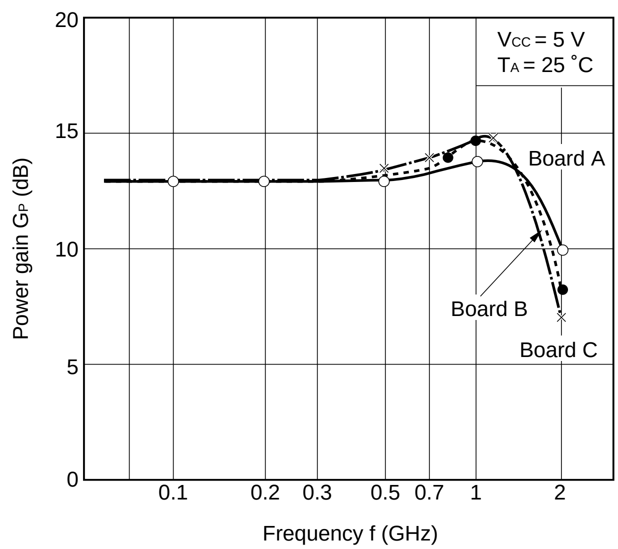


Figure 20 (a). Pattern Example (Top View)

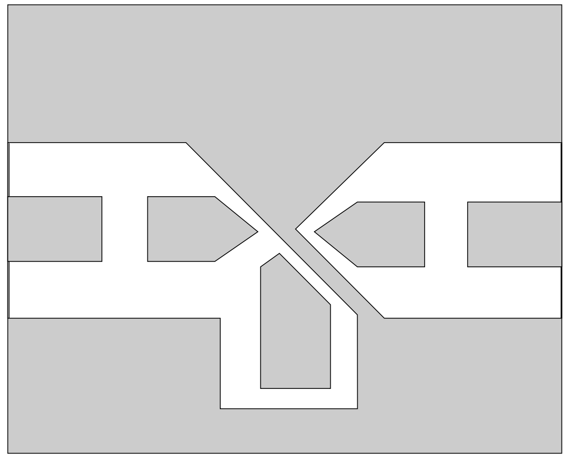


Figure 20 (b). Mounting Example (Top View)

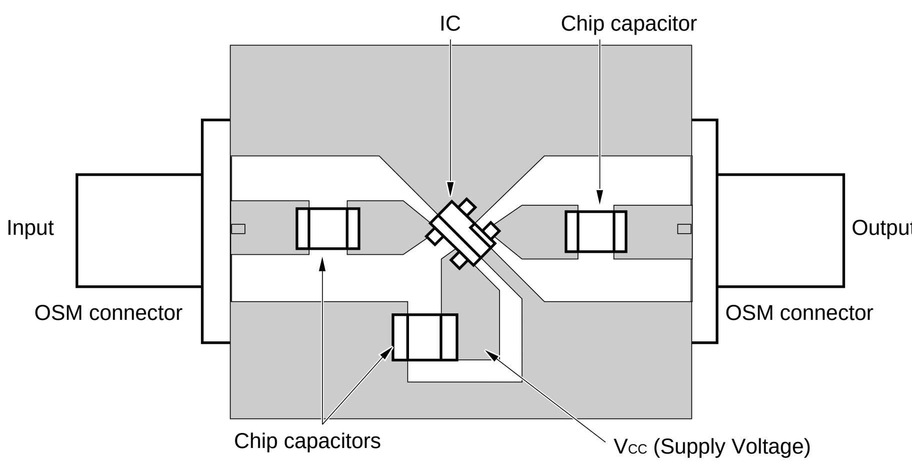
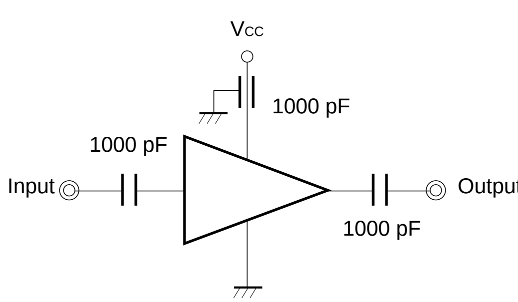


Figure 20 (c). Operation Circuit



5. APPLICATION EXAMPLE

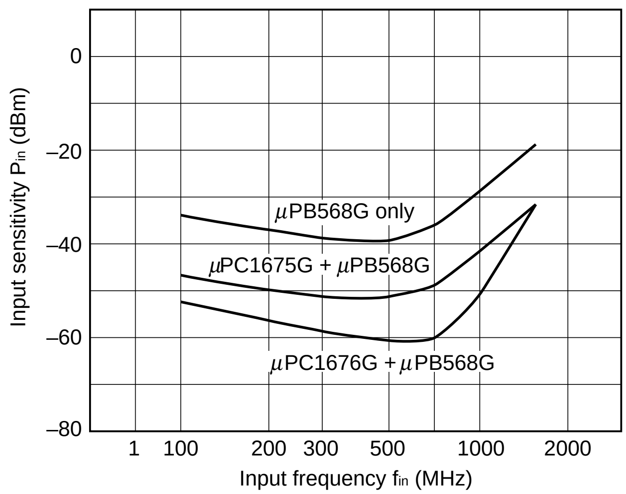
(1) Buffer amplifier for prescaler

The input sensitivity of 1-GHz-class prescalers used in UHF and VHF TV tuners has recently increased. Even so, a buffer amplifier is connected in the stage preceding these prescalers. The purpose of this is to decrease coupling with the local oscillation stage and to improve isolation after the oscillation stage and prescaler.

Figure 21 shows the sensitivity characteristics when NEC's μPB568G 1-GHz prescaler is used, and Figure 22 shows a circuit example. As the load on the μPC1675G/1676G, a 51-Ω resistor is connected to GND. Values of 50 to 200 Ω are suitable for this resistor. Because the saturation output of the μPC1675G/1676G can be kept to 4 to 5 dBm, overload input to the prescaler can also be prevented (usually, a prescaler does not divide the frequency when an input higher than 8 to 10 dBm is applied).

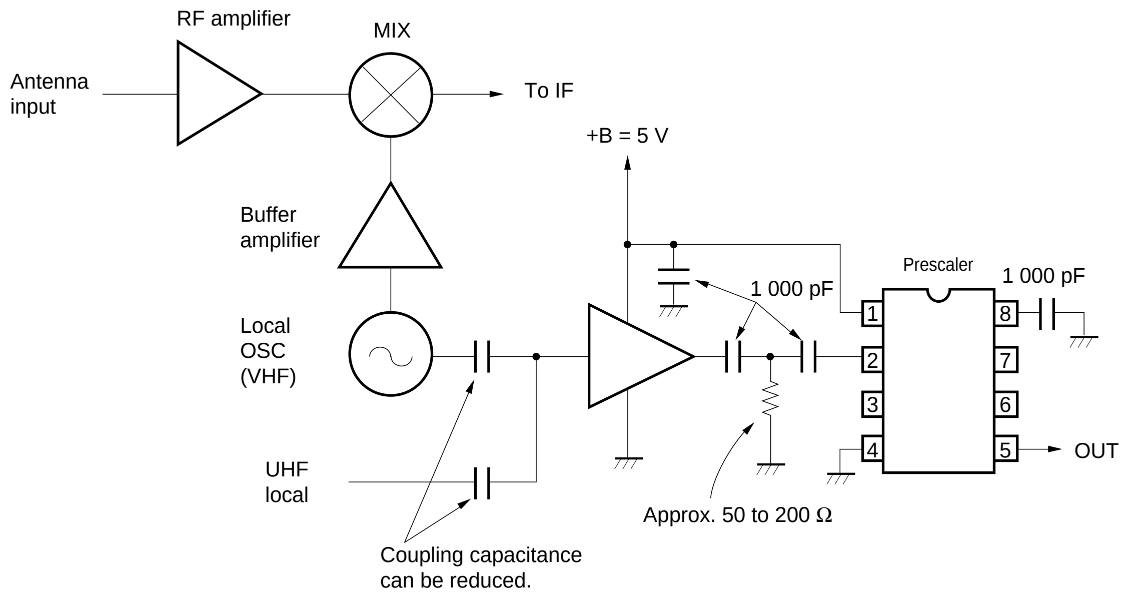
As another local oscillation peripheral, the amplifier IC can also be used as a buffer amplifier to the MIX stage to prevent oscillation drift when a high input is applied to the antenna (Figure 22).

Figure 21. Input Sensitivity Characteristics of μPC1675G/1676G + Prescaler μPB568G



Note μPB568G has been discontinued.

Figure 22. Prescaler Buffer Amplifier



(2) Cascade amplifier

The input/output impedance of the μPC1675G/1676G/1688G is matched to 50 Ω so that multiple amplifier ICs can be connected.

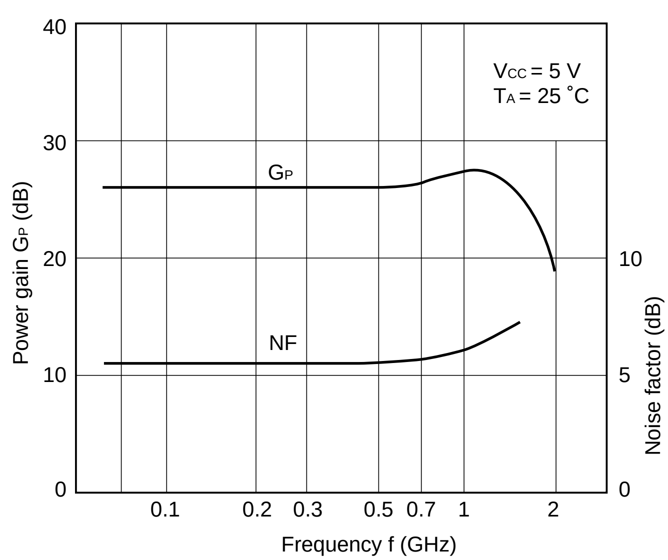
Therefore, the amplifier ICs can be used as a cascade amplifier.

Figure 23 shows an example of the characteristics of two μPC1675Gs connected in cascade. For the print pattern, a double-sided copper clad epoxy glass board is used as described in Chapter 4, and the input and output are isolated by the GND line.

The μPC1676G is a high-gain type IC. However, because of peaking at f = 700 MHz, the targeted characteristics must be considered of the combination.

As a combination to produce output $P_O \fallingdotseq 10$ dBm, use the μPC1675G + μPC1658G.

Figure 23. Cascade Amplifier Characteristics of Two μPC1675Gs



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