To our customers,

Old Company Name in Catalogs and Other Documents

On April 1st, 2010, NEC Electronics Corporation merged with Renesas Technology Corporation, and Renesas Electronics Corporation took over all the business of both companies. Therefore, although the old company name remains in this document, it is a valid Renesas Electronics document. We appreciate your understanding.

Renesas Electronics website: http://www.renesas.com

April 1st, 2010
Renesas Electronics Corporation

Issued by: Renesas Electronics Corporation (http://www.renesas.com)

Send any inquiries to http://www.renesas.com/inquiry.

RENESAS

Notice

1. All information included in this document is current as of the date this document is issued. Such information, however, is subject to change without any prior notice. Before purchasing or using any Renesas Electronics products listed herein, please confirm the latest product information with a Renesas Electronics sales office. Also, please pay regular and careful attention to additional and different information to be disclosed by Renesas Electronics such as that disclosed through our website.
2. Renesas Electronics does not assume any liability for infringement of patents, copyrights, or other intellectual property rights of third parties by or arising from the use of Renesas Electronics products or technical information described in this document. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.
3. You should not alter, modify, copy, or otherwise misappropriate any Renesas Electronics product, whether in whole or in part.
4. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation of these circuits, software, and information in the design of your equipment. Renesas Electronics assumes no responsibility for any losses incurred by you or third parties arising from the use of these circuits, software, or information.
5. When exporting the products or technology described in this document, you should comply with the applicable export control laws and regulations and follow the procedures required by such laws and regulations. You should not use Renesas Electronics products or the technology described in this document for any purpose relating to military applications or use by the military, including but not limited to the development of weapons of mass destruction. Renesas Electronics products and technology may not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations.
6. Renesas Electronics has used reasonable care in preparing the information included in this document, but Renesas Electronics does not warrant that such information is error free. Renesas Electronics assumes no liability whatsoever for any damages incurred by you resulting from errors in or omissions from the information included herein.
7. Renesas Electronics products are classified according to the following three quality grades: "Standard", "High Quality", and "Specific". The recommended applications for each Renesas Electronics product depends on the product's quality grade, as indicated below. You must check the quality grade of each Renesas Electronics product before using it in a particular application. You may not use any Renesas Electronics product for any application categorized as "Specific" without the prior written consent of Renesas Electronics. Further, you may not use any Renesas Electronics product for any application for which it is not intended without the prior written consent of Renesas Electronics. Renesas Electronics shall not be in any way liable for any damages or losses incurred by you or third parties arising from the use of any Renesas Electronics product for an application categorized as "Specific" or for which the product is not intended where you have failed to obtain the prior written consent of Renesas Electronics. The quality grade of each Renesas Electronics product is "Standard" unless otherwise expressly specified in a Renesas Electronics data sheets or data books, etc.

   "Standard": Computers; office equipment; communications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal electronic equipment; and industrial robots.

   "High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control systems; anti-disaster systems; anti-crime systems; safety equipment; and medical equipment not specifically designed for life support.

   "Specific": Aircraft; aerospace equipment; submersible repeaters; nuclear reactor control systems; medical equipment or systems for life support (e.g. artificial life support devices or systems), surgical implantations, or healthcare intervention (e.g. excision, etc.), and any other applications or purposes that pose a direct threat to human life.
8. You should use the Renesas Electronics products described in this document within the range specified by Renesas Electronics, especially with respect to the maximum rating, operating supply voltage range, movement power voltage range, heat radiation characteristics, installation and other product characteristics. Renesas Electronics shall have no liability for malfunctions or damages arising out of the use of Renesas Electronics products beyond such specified ranges.
9. Although Renesas Electronics endeavors to improve the quality and reliability of its products, semiconductor products have specific characteristics such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Further, Renesas Electronics products are not subject to radiation resistance design. Please be sure to implement safety measures to guard them against the possibility of physical injury, and injury or damage caused by fire in the event of the failure of a Renesas Electronics product, such as safety design for hardware and software including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult, please evaluate the safety of the final products or system manufactured by you.
10. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. Please use Renesas Electronics products in compliance with all applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive. Renesas Electronics assumes no liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.
11. This document may not be reproduced or duplicated, in any form, in whole or in part, without prior written consent of Renesas Electronics.
12. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products, or if you have any other inquiries.

(Note 1) "Renesas Electronics" as used in this document means Renesas Electronics Corporation and also includes its majority-owned subsidiaries.

(Note 2) "Renesas Electronics product(s)" means any product developed or manufactured by or for Renesas Electronics.

APPLICATION NOTE

RENESAS

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

Phase-out/Discontinued

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)

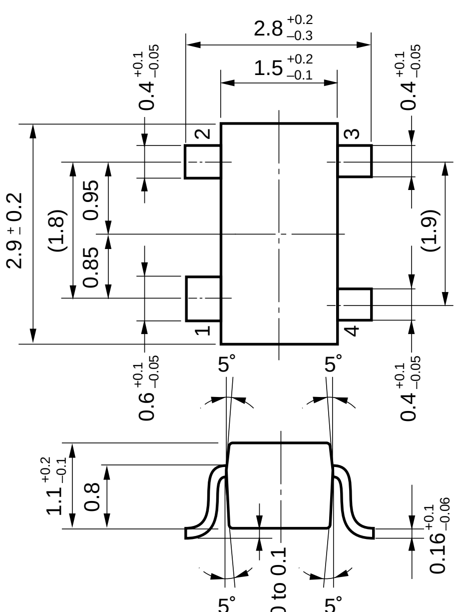
<4> All the models can operate at high frequency and in wide band.

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

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

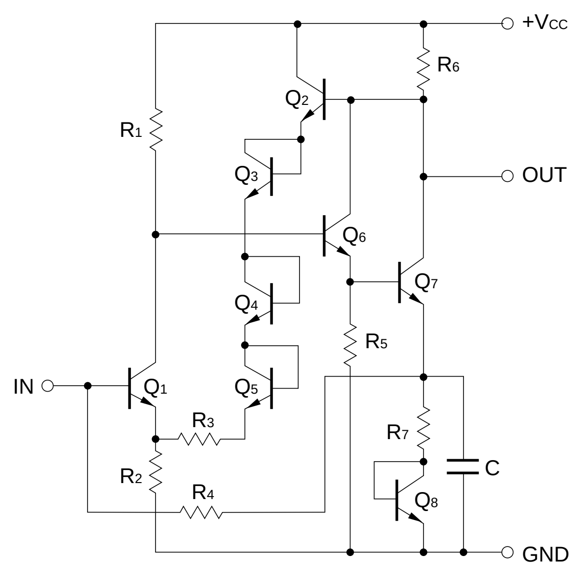
<6> Single power source (V_{CC} = 5 V TYP.)

Figure 1. Package (unit: mm)



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

Figure 2. Internal Equivalent Circuit



Document No. P10964EJ2V0AN00 (2nd edition)
Date Published February 1996 P
Printed in Japan

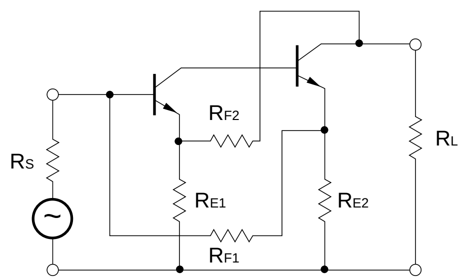
2. CIRCUIT CONFIGURATION

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.

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

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

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

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

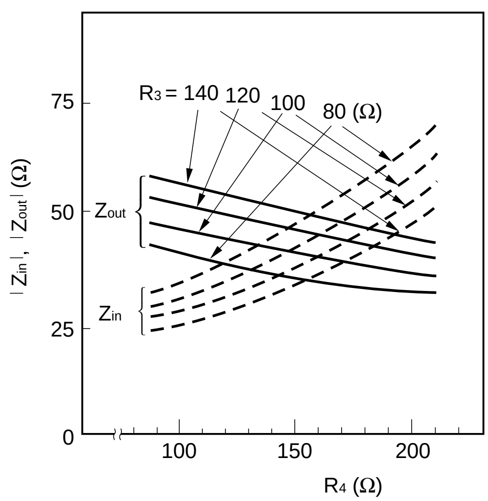
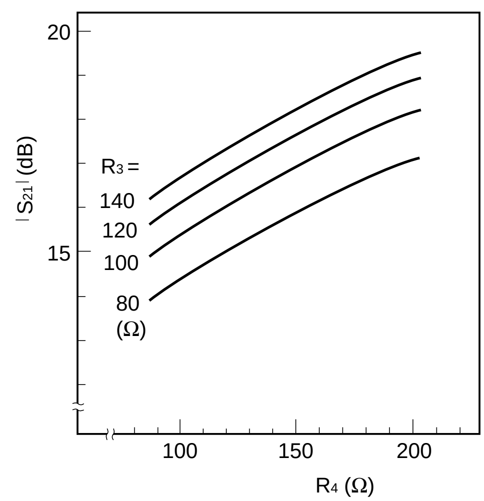


Figure 5. Forward Transmission Gain vs. Negative Feedback Resistor



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).

Phase-out/Discontinued

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

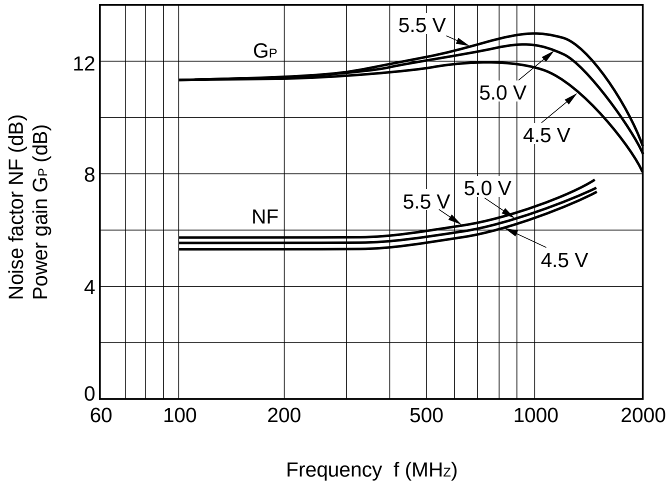


Figure 7. Isolation vs. f Characteristics of μPC1675G

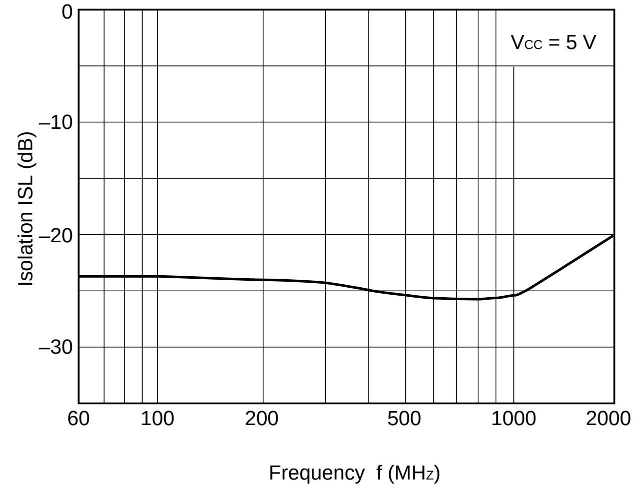


Figure 8. Return Loss vs. f Characteristics of μPC1675G

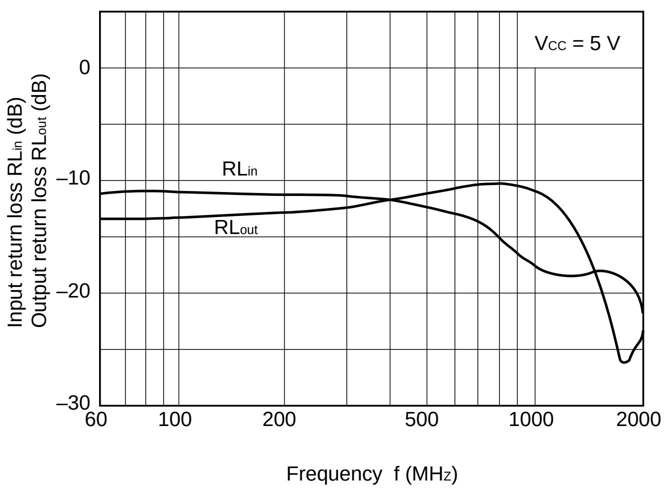


Figure 9. Input/Output Characteristics of μPC1675G

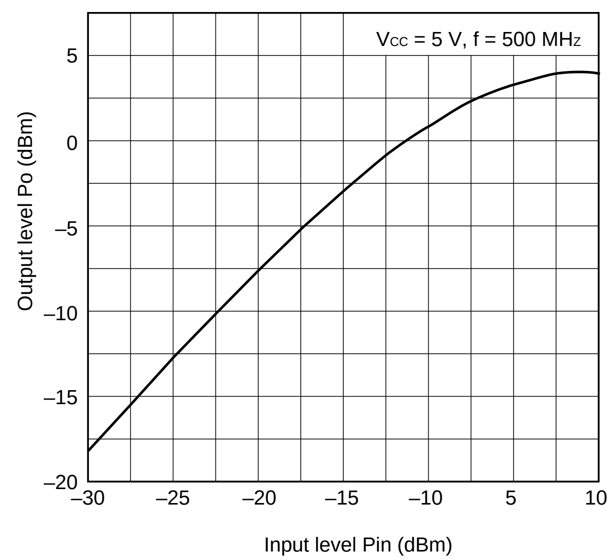


Figure 10. IM_3 Characteristics of μPC1675G

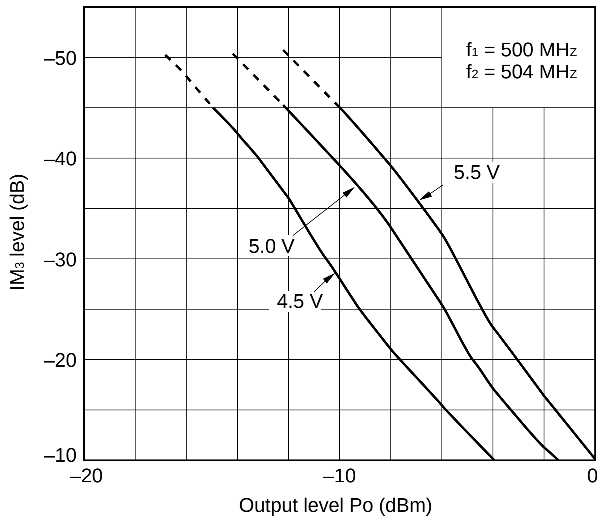


Figure 11. G_P vs. Temperature Characteristics of μPC1675G

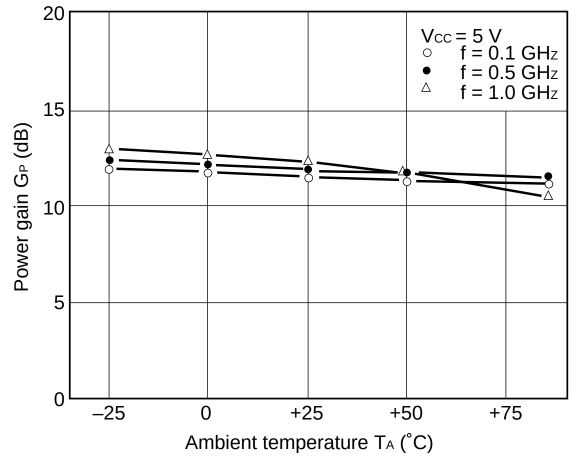


Figure 12. G_P, NF vs. f Characteristics of μPC1676G

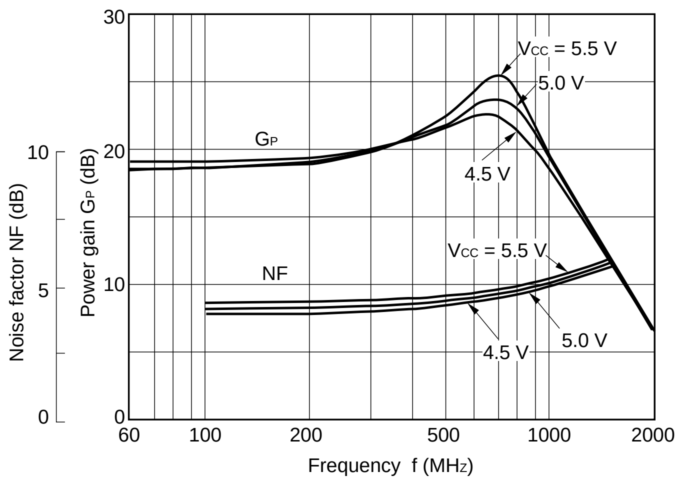


Figure 13. Isolation vs. f Characteristics of μPC1676G

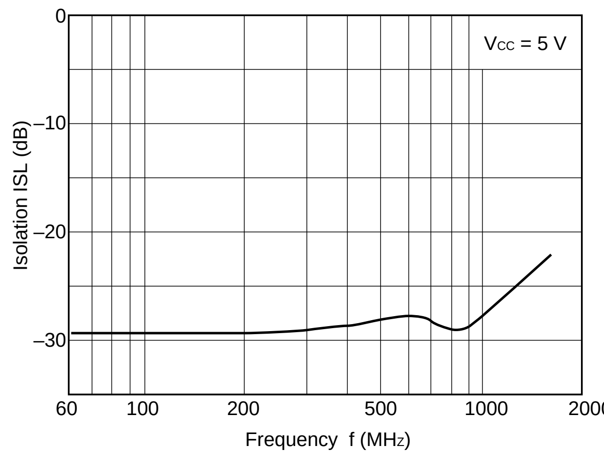


Figure 14. Return Loss vs. f Characteristics of μPC1676G

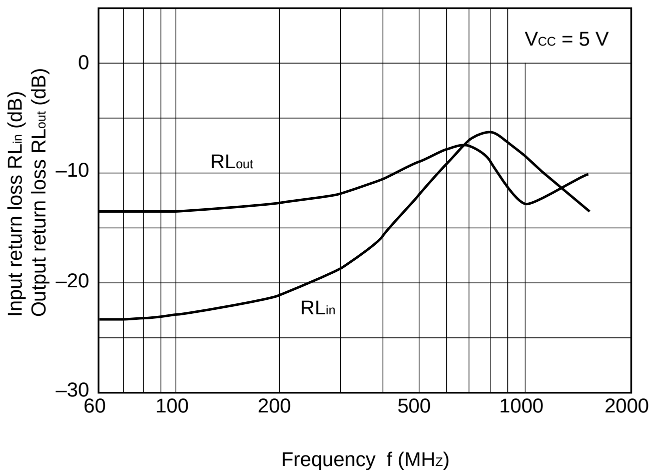


Figure 15. Input/Output Characteristics of μPC1676G

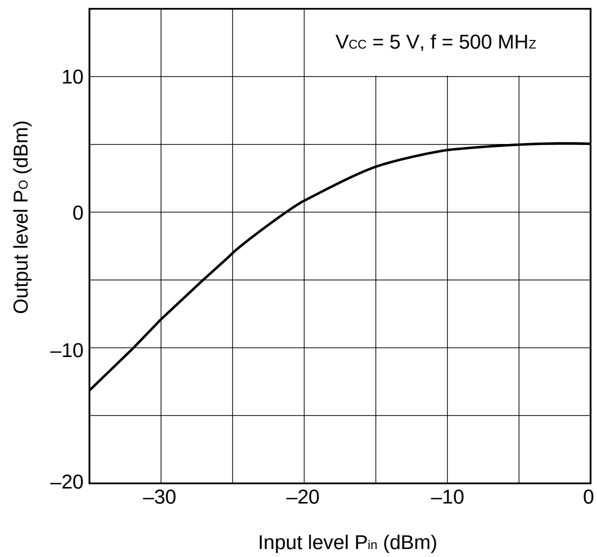


Figure 16. IM3 Characteristics of μPC1676G

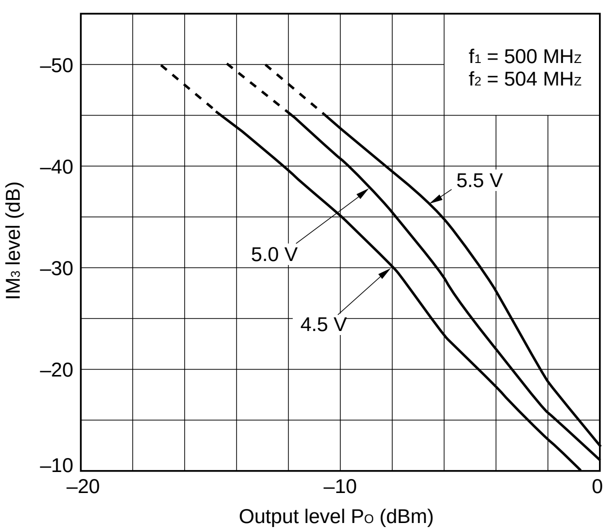
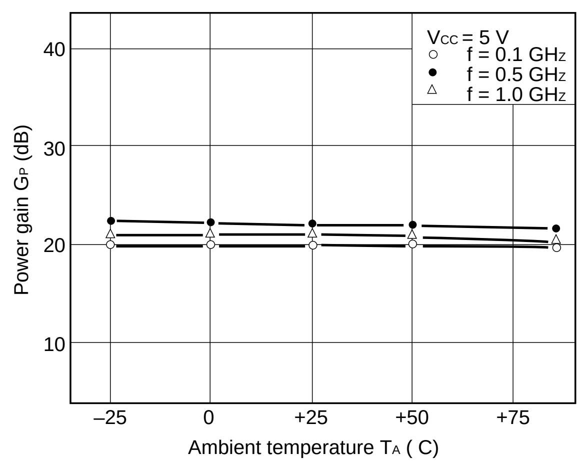


Figure 17. GP Temperature Characteristics of μPC1676G



Phase-out/Discontinued

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

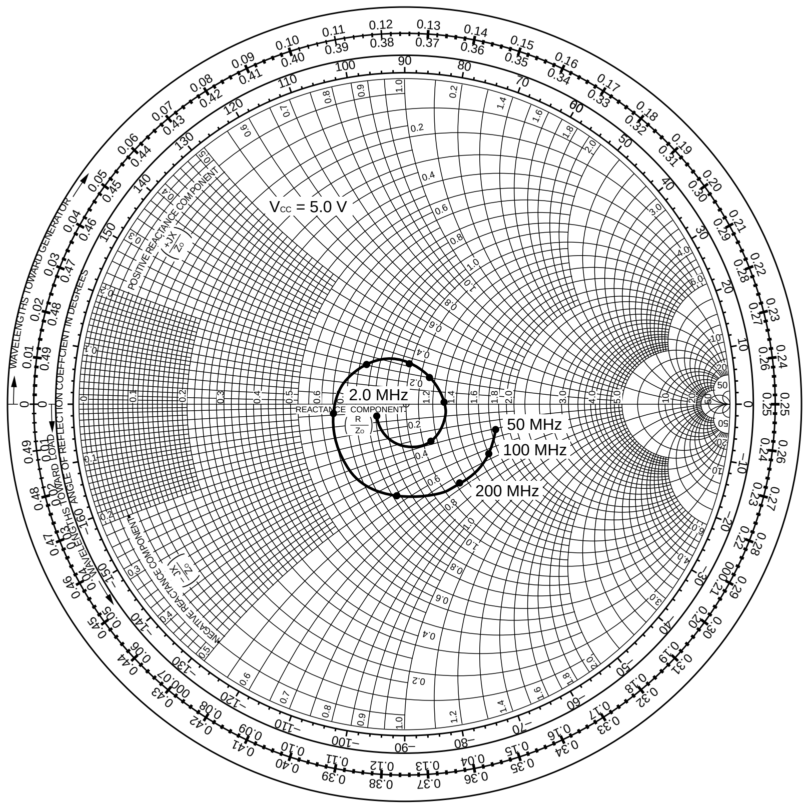
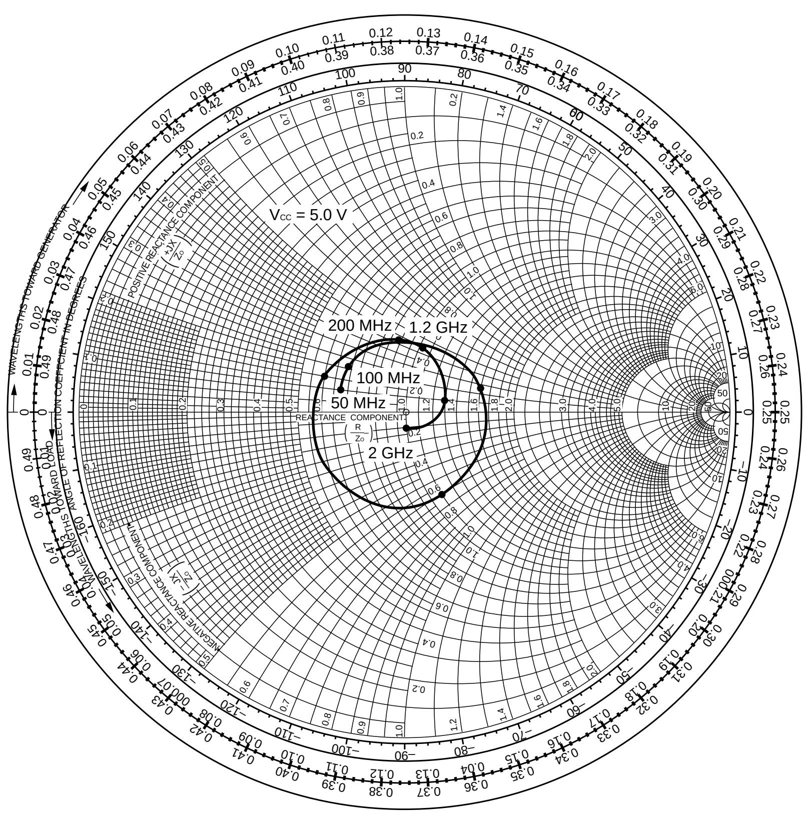


Figure 18 (b). S_{22} vs. f Characteristics of μPC1675G



Phase-out/Discontinued

Figure 18 (c). S_{11} vs. f Characteristics of μPC1676G

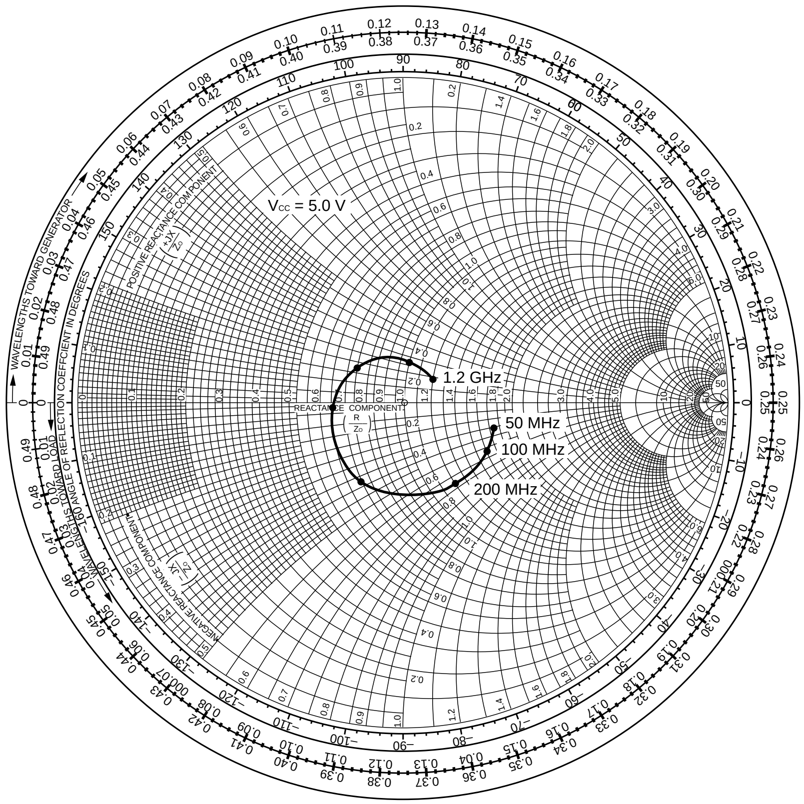
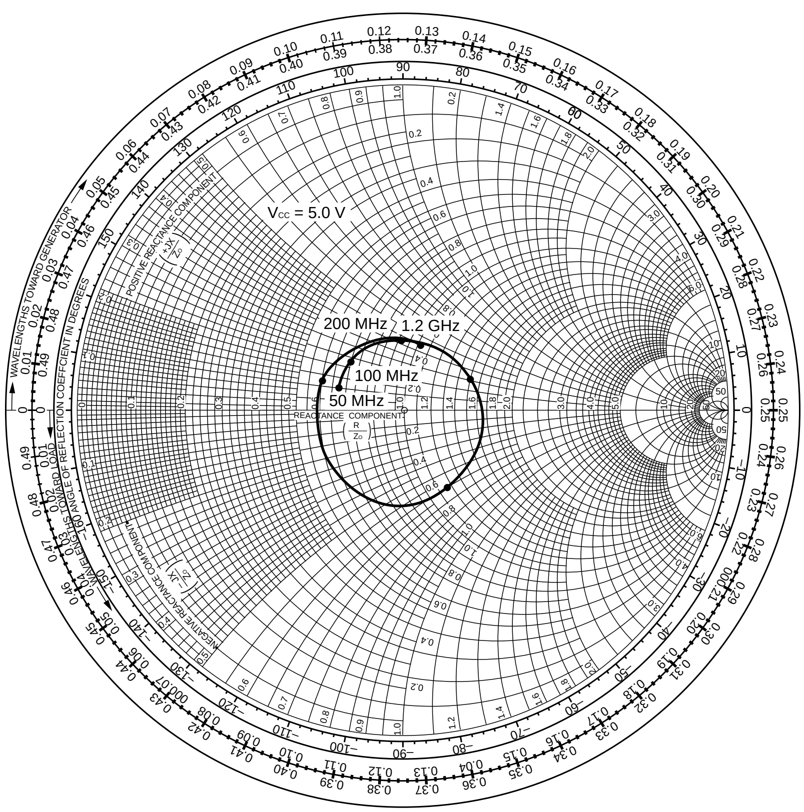


Figure 18 (d). S_{22} vs. f Characteristics of μPC1676G



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)

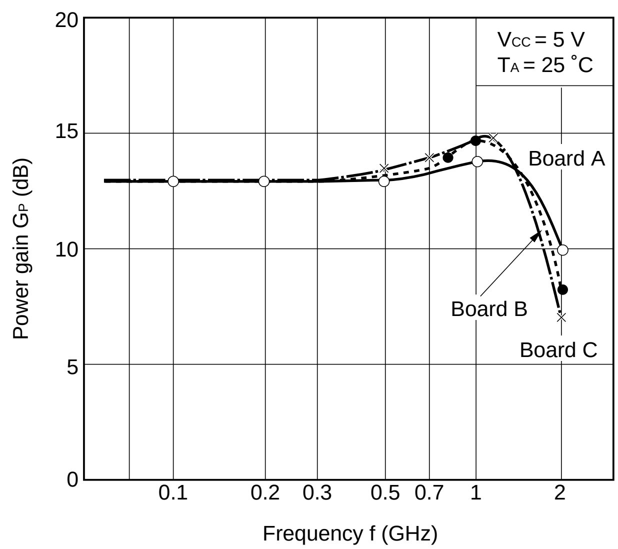


Figure 20 (a). Pattern Example (Top View)

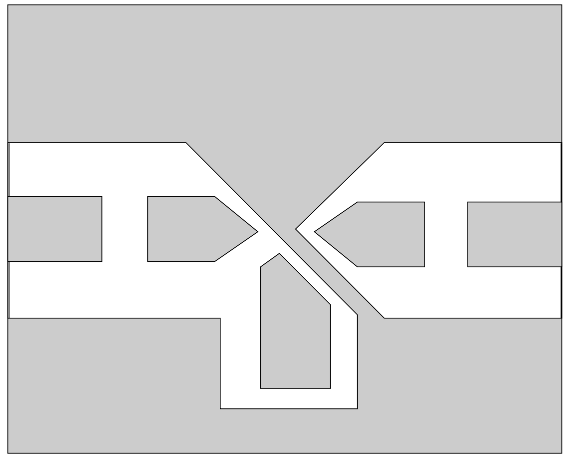


Figure 20 (b). Mounting Example (Top View)

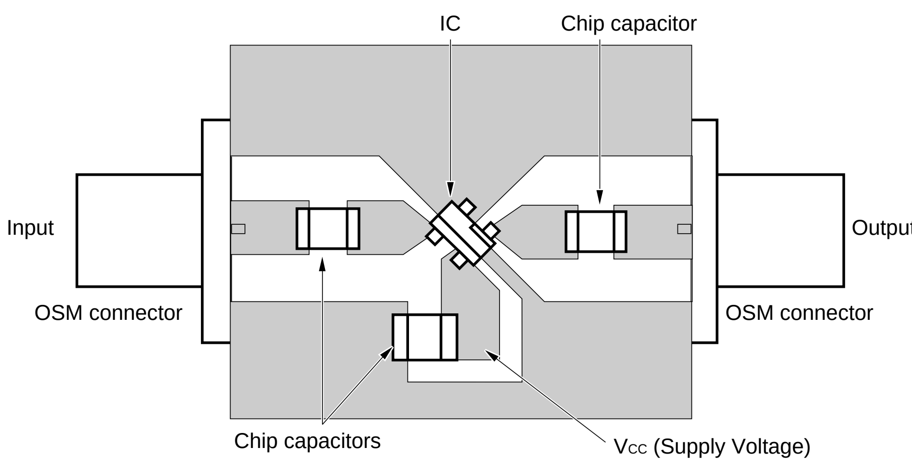
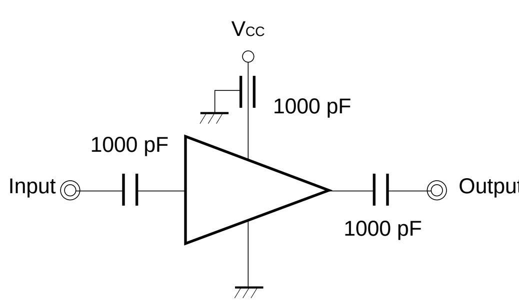


Figure 20 (c). Operation Circuit



5. APPLICATION EXAMPLE

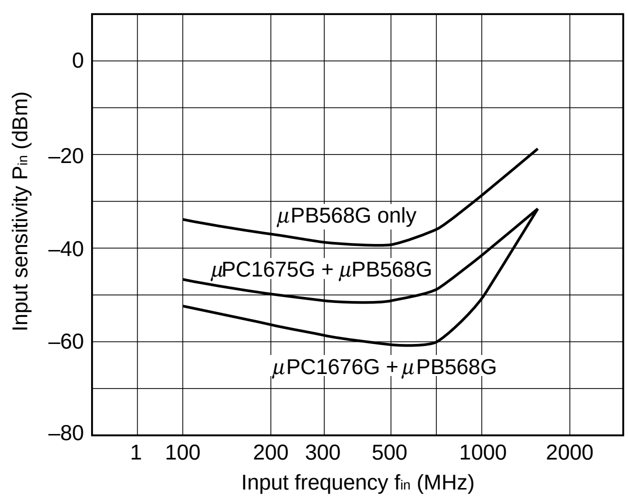
(1) Buffer amplifier for prescaler

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).

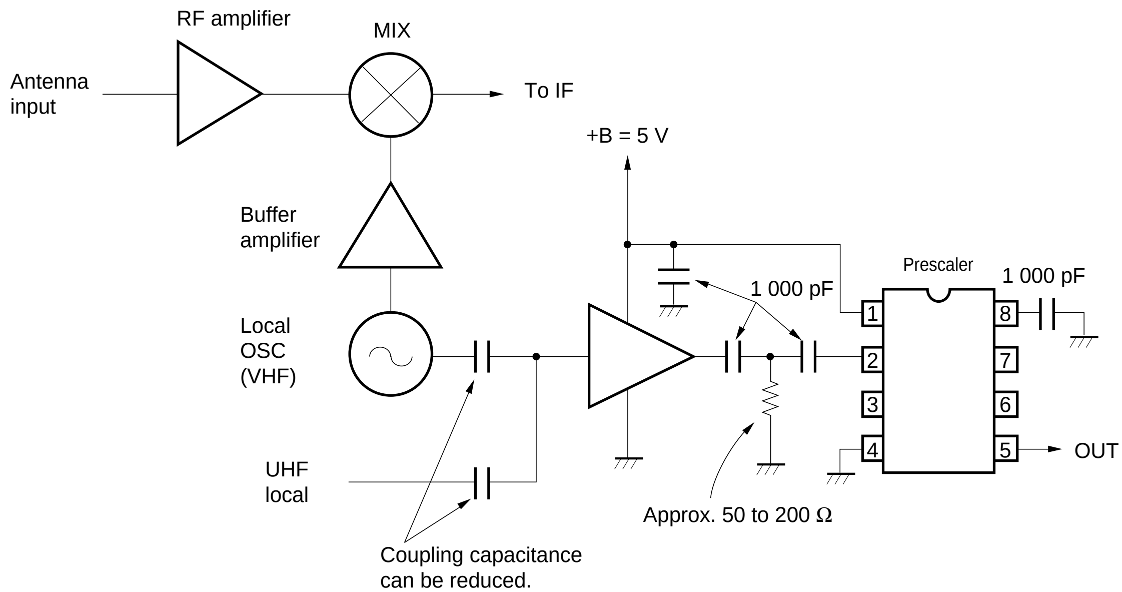
As another local oscillation peripheral, the amplifier IC can also be used as a buffer amplifier to the MIX stage to prevent oscillation drift when a high input is applied to the antenna (Figure 22).

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.

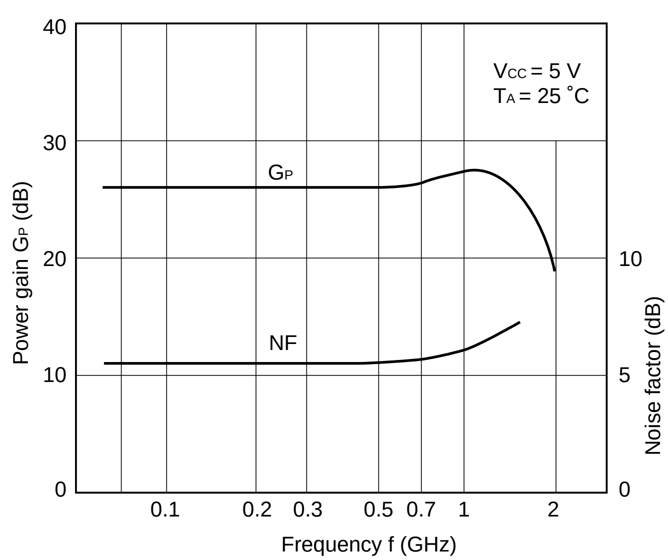
Therefore, the amplifier ICs can be used as a cascade amplifier.

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 ≒ 10 dBm, use the μPC1675G + μPC1658G.

Figure 23. Cascade Amplifier Characteristics of Two μPC1675Gs



[MEMO]

Phase-out/Discontinued

NEC

Facsimile Message

From:

Name

Company

Tel. FAX

Address

Although NEC has taken all possible steps to ensure that the documentation supplied to our customers is complete, bug free and up-to-date, we readily accept that errors may occur. Despite all the care and precautions we've taken, you may encounter problems in the documentation. Please complete this form whenever you'd like to report errors or suggest improvements to us.

Thank you for your kind support.

North America
NEC Electronics Inc.
Corporate Communications Dept.
Fax: +1-800-729-9288

Hong Kong, Philippines, Oceania
NEC Electronics Hong Kong Ltd.
Fax: +852-2886-9022/9044

Asian Nations except Philippines
NEC Electronics Singapore Pte. Ltd.
Fax: +65-250-3583

Europe
NEC Electronics (Europe) GmbH
Technical Documentation Dept.
Fax: +49-211-6503-274

Korea
NEC Electronics Hong Kong Ltd.
Seoul Branch
Fax: +82-2-551-0451

Japan
NEC Corporation
Semiconductor Solution Engineering Division
Technical Information Support Dept.
Fax: +81-44-548-7900

South America
NEC do Brasil S.A.
Fax: +55-11-889-1689

Taiwan
NEC Electronics Taiwan Ltd.
Fax: +886-2-719-5951

I would like to report the following error/make the following suggestion:

Document title: ____________________

Document number: ____________________ Page number: ____________________

If possible, please fax the referenced page or drawing.

Document Rating	Excellent	Good	Acceptable	Poor
Clarity	❏	❏	❏	❏
Technical Accuracy	❏	❏	❏	❏
Organization	❏	❏	❏	❏

NEC

Phase-out/Discontinued