

BIPOLAR ANALOG INTEGRATED CIRCUITS

μ PC2745TB, μ PC2746TB

3 V, SUPER MINIMOLD SILICON MMIC WIDEBAND AMPLIFIER FOR MOBILE COMMUNICATIONS

DESCRIPTION

The μ PC2745TB and μ PC2746TB are silicon monolithic integrated circuits designed as buffer amplifier for mobile communications. These low current amplifiers operate on 3.0 V (1.8 V MIN.).

These ICs are manufactured using NEC's 20 GHz fr 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, these IC have excellent performance, uniformity and reliability.

★

FEATURES

- Supply voltage : Recommended $V_{CC} = 2.7$ to 3.3 V
Circuit operation $V_{CC} = 1.8$ to 3.3 V
- Upper limit operating frequency : μ PC2745TB; $f_u = 2.7$ GHz TYP. @ 3 dB bandwidth
 μ PC2746TB; $f_u = 1.5$ GHz TYP. @ 3 dB bandwidth
- High isolation : μ PC2745TB; ISL = 38 dB TYP. @ $f = 500$ MHz
 μ PC2746TB; ISL = 45 dB TYP. @ $f = 500$ MHz
- Power gain : μ PC2745TB; $G_P = 12$ dB TYP. @ $f = 500$ MHz
 μ PC2746TB; $G_P = 19$ dB TYP. @ $f = 500$ MHz
- Saturated output power : μ PC2745TB; $P_{O(sat)} = -1$ dBm TYP. @ $f = 500$ MHz
 μ PC2746TB; $P_{O(sat)} = 0$ dBm TYP. @ $f = 500$ MHz
- High-density surface mounting : 6-pin super minimold package ($2.0 \times 1.25 \times 0.9$ mm)

APPLICATION

- 1.5 GHz to 2.5 GHz communication system (PHS, wireless LAN; etc.): μ PC2745TB
- 800 MHz to 900 MHz cellular telephone (CT2, GSM, etc.) : μ PC2746TB

ORDERING INFORMATION

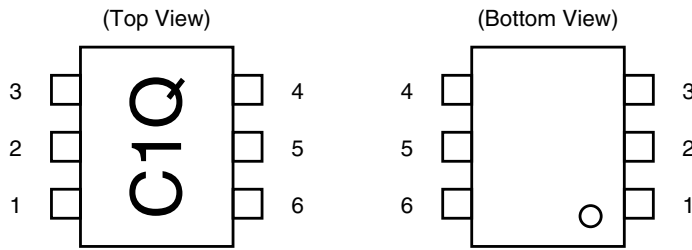
Part Number	Package	Marking	Supplying Form
μ PC2745TB-E3	6-pin super minimold	C1Q	• Embossed tape 8 mm wide
μ PC2746TB-E3		C1R	• 1, 2, 3 pins face the perforation side of the tape • Qty 3 kpcs/reel

Remark To order evaluation samples, please contact your local NEC sales office.
Part number: μ PC2745TB, μ PC2746TB

Caution Electro-static sensitive devices

The information in this document is subject to change without notice. Before using this document, please confirm that this is the latest version.
Not all devices/types available in every country. Please check with local NEC representative for availability and additional information.

PIN CONNECTIONS



Marking is an example of μ PC2745TB

Pin No.	Pin Name
1	INPUT
2	GND
3	GND
4	OUTPUT
5	GND
6	V _{CC}

★ PRODUCT LINE-UP (T_A = +25°C, V_{CC} = 3.0 V, Z_s = Z_L = 50 Ω)

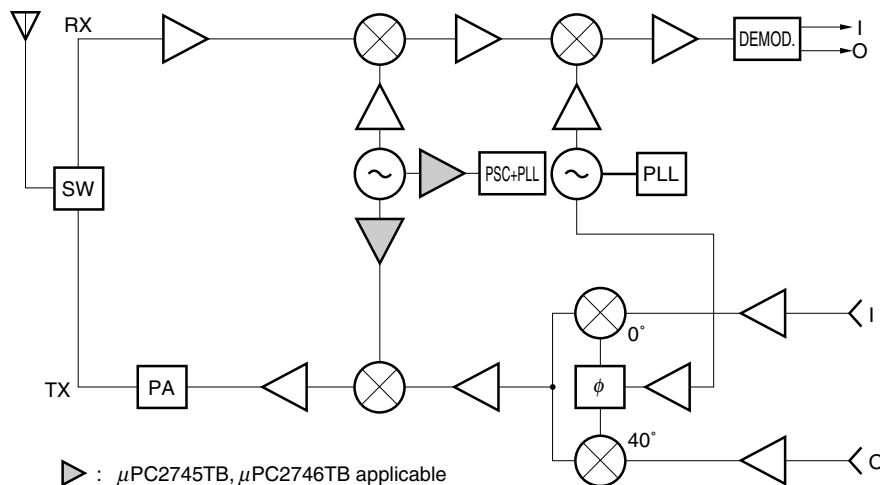
Part No.	f _u (GHz)	P _{O(sat)} (dBm)	G _P (dB)	NF (dB)	I _{CC} (mA)	Package	Making
μ PC2745T	2.7	-1.0	12	6.0	7.5	6-pin minimold	C1Q
μ PC2745TB						6-pin super minimold	
μ PC2746T	1.5	0	19	4.0	7.5	6-pin minimold	C1R
μ PC2746TB						6-pin super minimold	
μ PC2747T	1.8	-7.0	12	3.3	5.0	6-pin minimold	C1S
μ PC2747TB						6-pin super minimold	
μ PC2748T	0.2 to 1.5	-3.5	19	2.8	6.0	6-pin minimold	C1T
μ PC2748TB						6-pin super minimold	
μ PC2749T	2.9	-6.0	16	4.0	6.0	6-pin minimold	C1U
μ PC2749TB						6-pin super minimold	

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

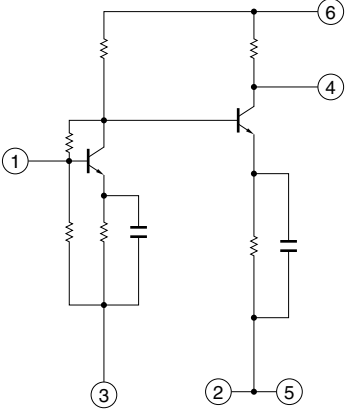
Caution The package size distinguish between minimold and super minimold.

SYSTEM APPLICATION EXAMPLE

DIGITAL CELLULAR SYSTEM BLOCK DIAGRAM



PIN EXPLANATION

Pin No.	Pin Name	Applied Voltage (V)	Pin Voltage (V) ^{Note}	Function and Applications	Internal Equivalent Circuit
1	INPUT	—	0.87 ----- 0.82	Signal input pin. A internal matching circuit, configured with resistors, enables 50 Ω connection over a wide band. this pin must be coupled to signal source with capacitor for DC cut.	
2 3 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. All the ground pins must be connected together with wide ground pattern to decrease impedance difference.	
4	OUTPUT	—	1.95 ----- 2.54	Signal output pin. A internal matching circuit, configured with resistors, enables 50 Ω connection over a wide band. This pin must be coupled to next stage with capacitor for DC cut.	
6	V _{CC}	2.7 to 3.3	—	Power supply pin. This pin should be externally equipped with bypass capacity to minimize ground impedance.	

Note Pin voltage is measured at V_{CC} = 3.0 V. Above: μPC2745TB, Below: μPC2746TB

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Conditions	Ratings	Unit
Supply Voltage	V_{CC}	$T_A = +25^{\circ}\text{C}$	4.0	V
Circuit Current	I_{CC}	$T_A = +25^{\circ}\text{C}$	16	mA
★ Power Dissipation	P_D	Mounted on double sided copper clad 50 × 50 × 1.6 mm epoxy glass PWB, $T_A = +85^{\circ}\text{C}$	270	mW
Operating Ambient Temperature	T_A		−40 to +85	$^{\circ}\text{C}$
Storage Temperature	T_{stg}		−55 to +150	$^{\circ}\text{C}$
Input Power	P_{in}	$T_A = +25^{\circ}\text{C}$	0	dBm

RECOMMENDED OPERATING RANGE

Parameter	Symbol	MIN.	TYP.	MAX.	Unit
Supply Voltage	V_{CC}	2.7	3.0	3.3	V

ELECTRICAL CHARACTERISTICS

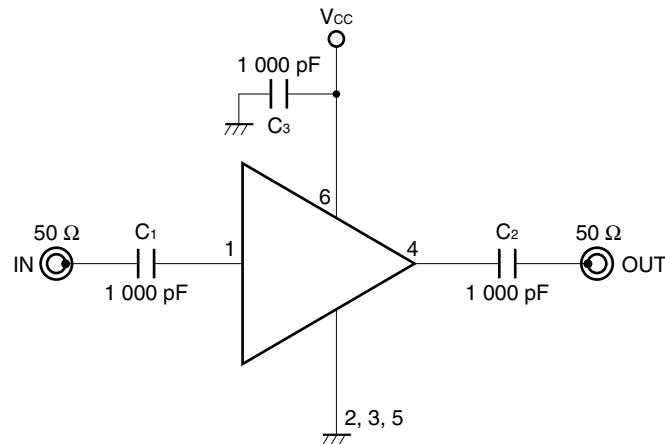
(Unless otherwise specified, $T_A = +25^{\circ}\text{C}$, $V_{CC} = 3.0\text{ V}$, $Z_s = Z_L = 50\ \Omega$)

Parameter	Symbol	Test Conditions	μ PC2745TB			μ PC2746TB			Unit
			MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
Circuit Current	I_{CC}	No signal	5.0	7.5	10.0	5.0	7.5	10.0	mA
Power Gain	G_P	$f = 500\text{ MHz}$	9	12	14	16	19	21	dB
Noise Figure	NF	$f = 500\text{ MHz}$	—	6.0	7.5	—	4.0	5.5	dB
Upper Limit Operating Frequency	f_u	3 dB down below from gain at $f = 0.1\text{ GHz}$	2.3	2.7	—	1.1	1.5	—	GHz
Isolation	ISL	$f = 500\text{ MHz}$	33	38	—	40	45	—	dB
Input Return Loss	RL_{in}	$f = 500\text{ MHz}$	8	11	—	10	13	—	dB
Output Return Loss	RL_{out}	$f = 500\text{ MHz}$	2.5	5.5	—	5.5	8.5	—	dB
Saturated Output Power	$P_{O(sat)}$	$f = 500\text{ MHz}$, $P_{in} = -6\text{ dBm}$	−4.0	−1.0	—	−3.0	0	—	dBm

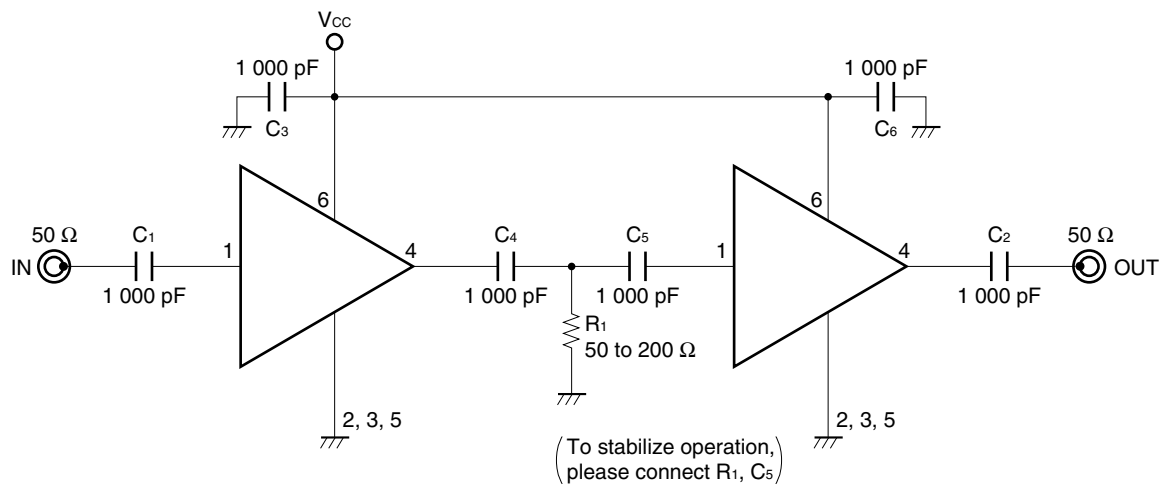
STANDARD CHARACTERISTICS FOR REFERENCE ($T_A = +25^\circ\text{C}$, $V_{CC} = 3.0\text{ V}$, $Z_S = Z_L = 50\ \Omega$)

Parameter	Symbol	Test Conditions	μ PC2745TB	μ PC2746TB	Unit
Circuit Current	I_{CC}	$V_{CC} = 1.8\text{ V}$, No signal	4.5	4.5	mA
Power Gain	G_P	$V_{CC} = 3.0\text{ V}$, $f = 1.0\text{ GHz}$	12.0	18.5	dB
		$V_{CC} = 3.0\text{ V}$, $f = 2.0\text{ GHz}$	11.0	—	
		$V_{CC} = 1.8\text{ V}$, $f = 0.5\text{ GHz}$	7.0	14.0	
Noise Figure	NF	$V_{CC} = 3.0\text{ V}$, $f = 1.0\text{ GHz}$	5.5	4.2	dB
		$V_{CC} = 3.0\text{ V}$, $f = 2.0\text{ GHz}$	5.7	—	
		$V_{CC} = 1.8\text{ V}$, $f = 0.5\text{ GHz}$	8.0	5.0	
Upper Limit Operating Frequency	f_u	$V_{CC} = 1.8\text{ V}$, 3 dB down below from gain at $f = 0.1\text{ GHz}$	1.8	1.1	GHz
Isolation	ISL	$V_{CC} = 3.0\text{ V}$, $f = 1.0\text{ GHz}$	33	38	dB
		$V_{CC} = 3.0\text{ V}$, $f = 2.0\text{ GHz}$	30	—	
		$V_{CC} = 1.8\text{ V}$, $f = 0.5\text{ GHz}$	35	37	
Input Return Loss	RL_{in}	$V_{CC} = 3.0\text{ V}$, $f = 1.0\text{ GHz}$	13.0	10.0	dB
		$V_{CC} = 3.0\text{ V}$, $f = 2.0\text{ GHz}$	14.0	—	
		$V_{CC} = 1.8\text{ V}$, $f = 0.5\text{ GHz}$	6.5	10.0	
Output Return Loss	RL_{out}	$V_{CC} = 3.0\text{ V}$, $f = 1.0\text{ GHz}$	6.5	8.5	dB
		$V_{CC} = 3.0\text{ V}$, $f = 2.0\text{ GHz}$	8.5	—	
		$V_{CC} = 1.8\text{ V}$, $f = 0.5\text{ GHz}$	6.0	9.5	
Saturated Output Power	$P_{O(sat)}$	$V_{CC} = 3.0\text{ V}$, $f = 1.0\text{ GHz}$, $P_{in} = -6\text{ dBm}$	-2.5	-1.0	dBm
		$V_{CC} = 3.0\text{ V}$, $f = 2.0\text{ GHz}$, $P_{in} = -6\text{ dBm}$	-3.5	—	
		$V_{CC} = 1.8\text{ V}$, $f = 0.5\text{ GHz}$, $P_{in} = -10\text{ dBm}$	-11.0	-8.0	
3rd Order Intermodulation Distortion	IM_3	$V_{CC} = 3.0\text{ V}$, $P_{out} = -20\text{ dBm}$, $f_1 = 500\text{ MHz}$, $f_2 = 502\text{ MHz}$	-54	-51	dBc
		$V_{CC} = 3.0\text{ V}$, $P_{out} = -20\text{ dBm}$, $f_1 = 1\ 000\text{ MHz}$, $f_2 = 1\ 002\text{ MHz}$	-50	—	
		$V_{CC} = 1.8\text{ V}$, $P_{out} = -20\text{ dBm}$, $f_1 = 500\text{ MHz}$, $f_2 = 502\text{ MHz}$	-31	-37	

TEST CIRCUIT



EXAMPLE OF APPLICATION CIRCUIT



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

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

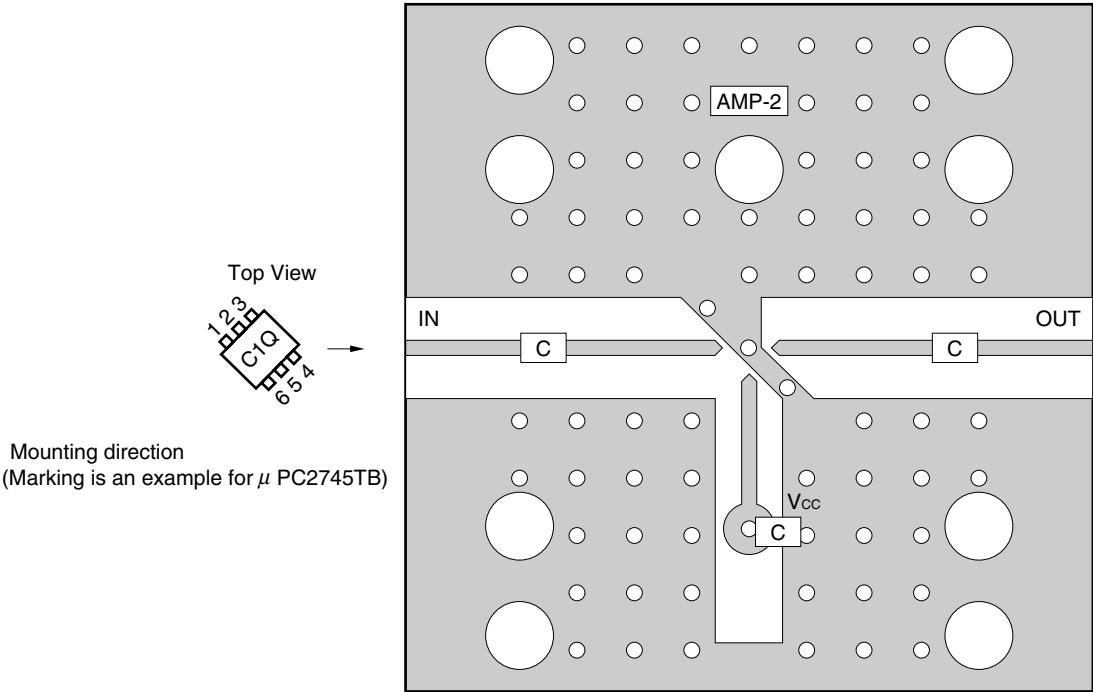
Capacitors of 1 000 pF are recommendable as the bypass capacitor for the V_{CC} pin and the coupling capacitors for the input and output pins.

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, $C = 1/(2\pi Rf_c)$.

ILLUSTRATION OF THE TEST CIRCUIT ASSEMBLED ON EVALUATION BOARD



COMPONENT LIST

	Value
C	1 000 pF

Notes

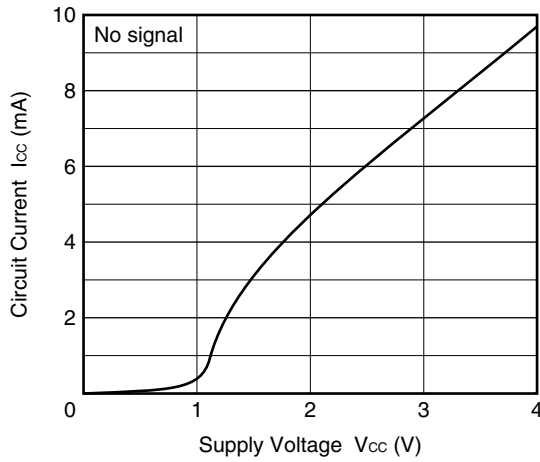
1. 30 × 30 × 0.4 mm double sided copper clad polyimide board.
2. Back side: GND pattern
3. Solder plated on pattern
4. ⊕ ⊕ ⊕ : Through holes

For more information on the use of this IC, refer to the following application note: **USAGE AND APPLICATIONS OF 6-PIN MINI-MOLD, 6-PIN SUPER MINI-MOLD SILICON HIGH-FREQUENCY WIDEBAND AMPLIFIER MMIC (P11976E).**

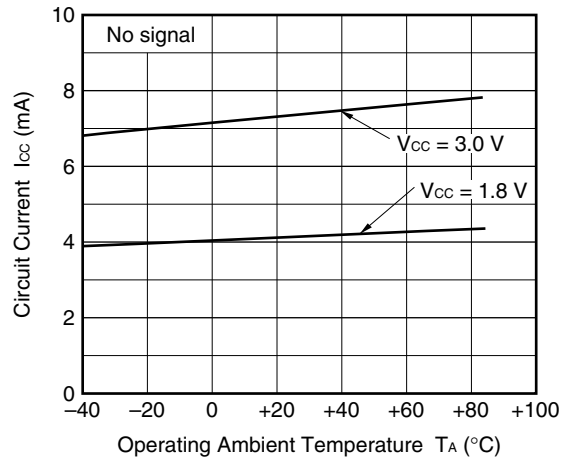
TYPICAL CHARACTERISTICS (Unless otherwise specified, $T_A = +25^\circ\text{C}$)

— μ PC2745TB —

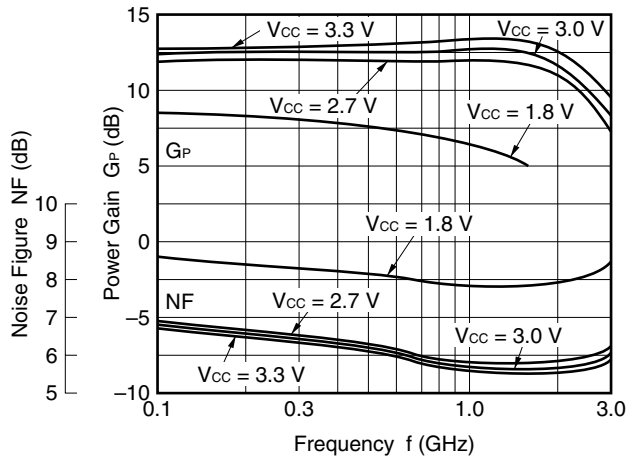
CIRCUIT CURRENT vs. SUPPLY VOLTAGE



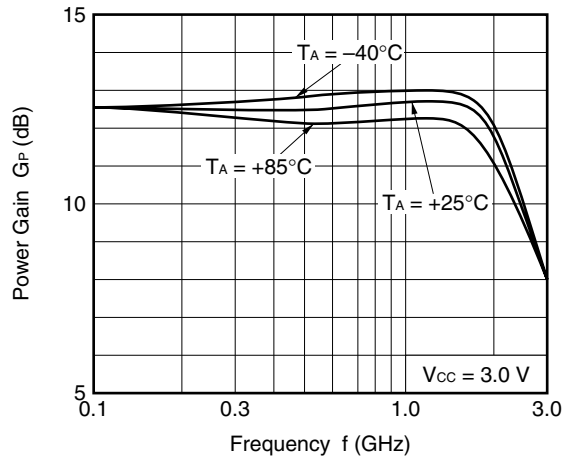
CIRCUIT CURRENT vs. OPERATING AMBIENT TEMPERATURE



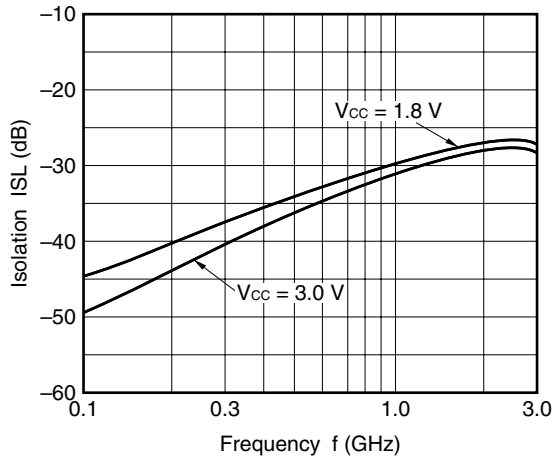
NOISE FIGURE, POWER GAIN vs. FREQUENCY



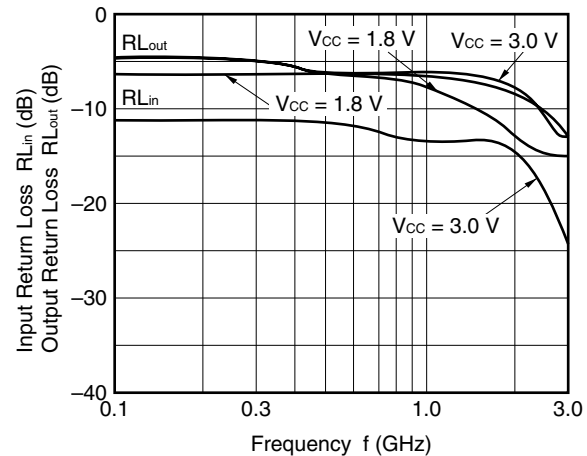
POWER GAIN vs. FREQUENCY



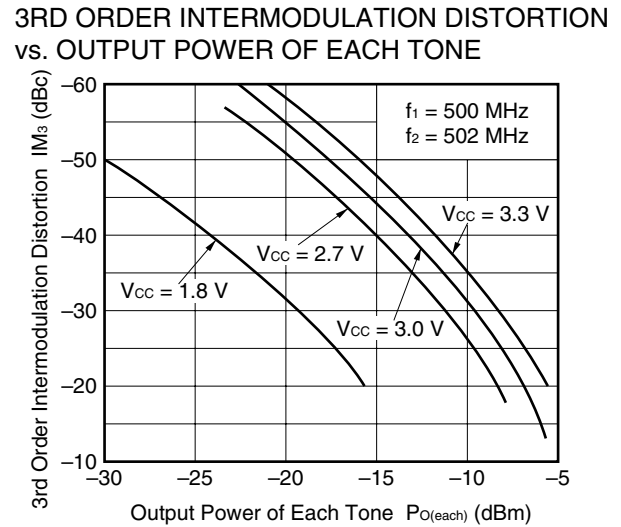
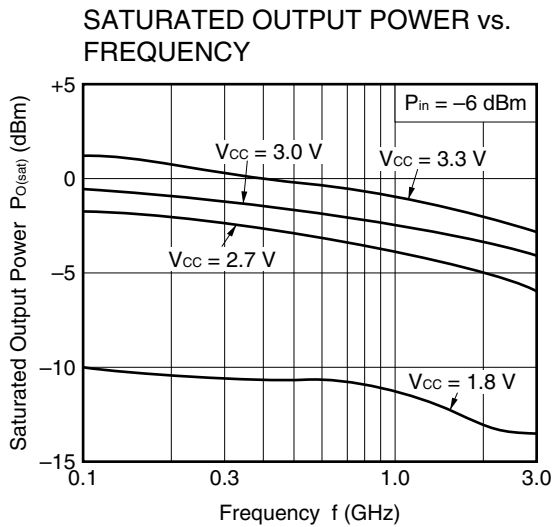
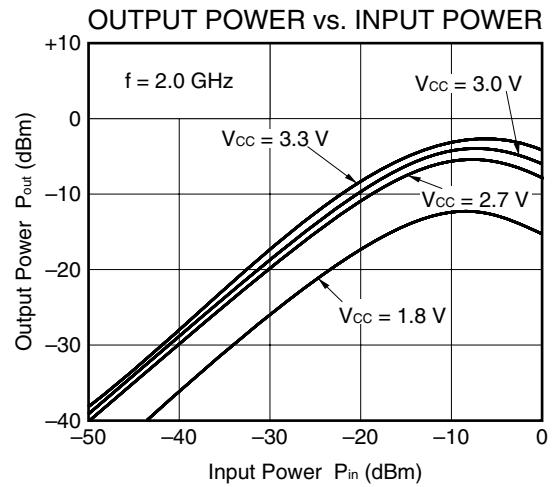
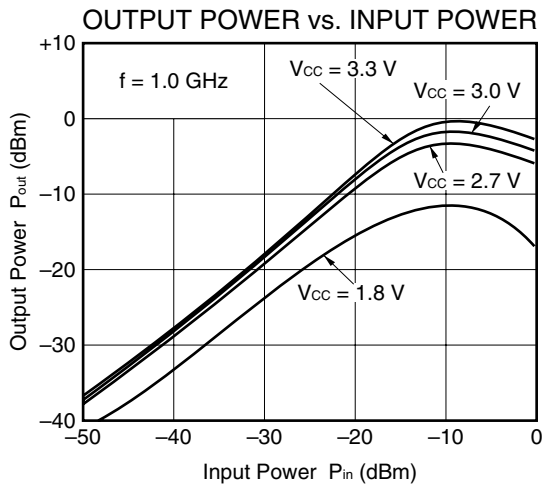
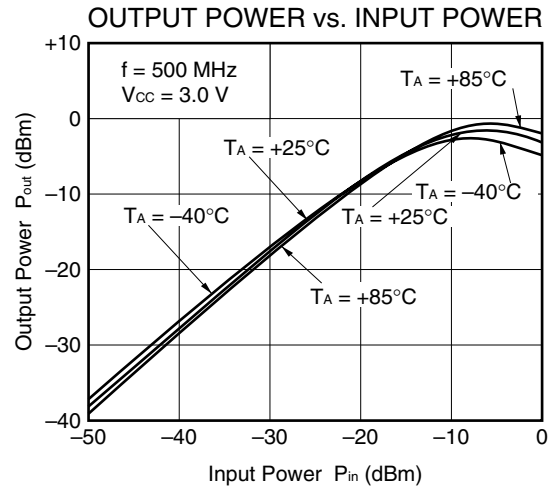
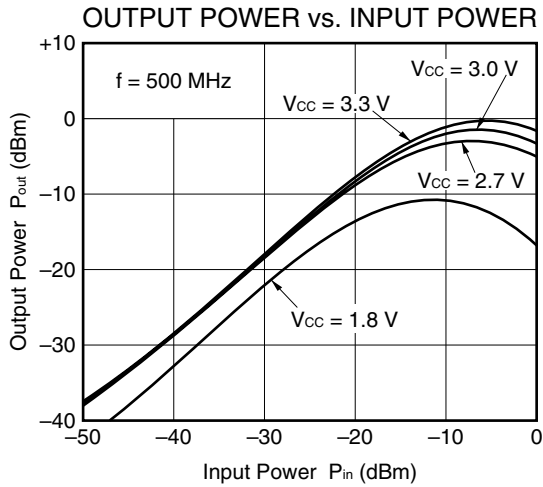
ISOLATION vs. FREQUENCY



INPUT RETURN LOSS, OUTPUT RETURN LOSS vs. FREQUENCY



— μ PC2745TB —

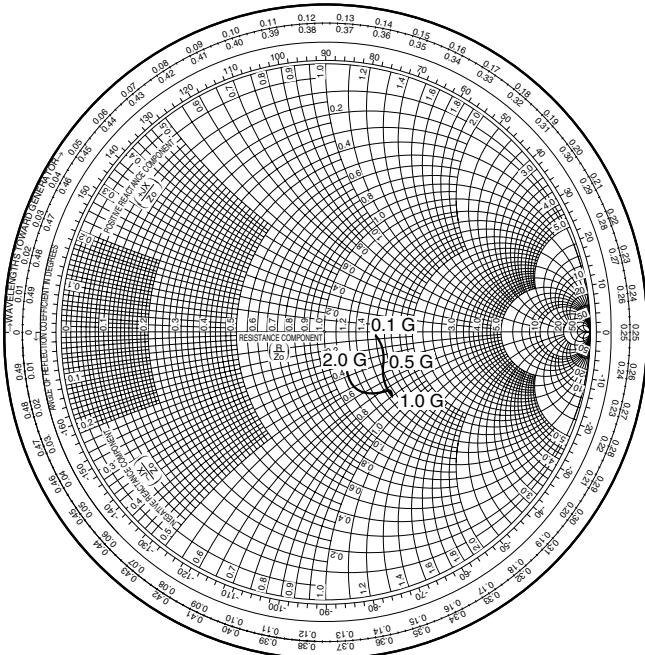


Remark The graphs indicate nominal characteristics.

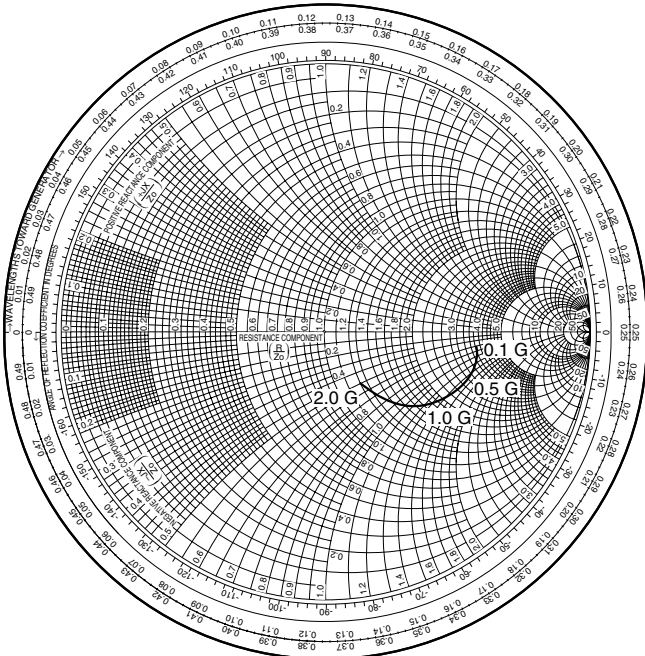
S-PARAMETERS (T_A = +25°C, V_{CC} = 3.0 V)

— μ PC2745TB —

S₁₁-FREQUENCY



S₂₂-FREQUENCY



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

μPC2745TB

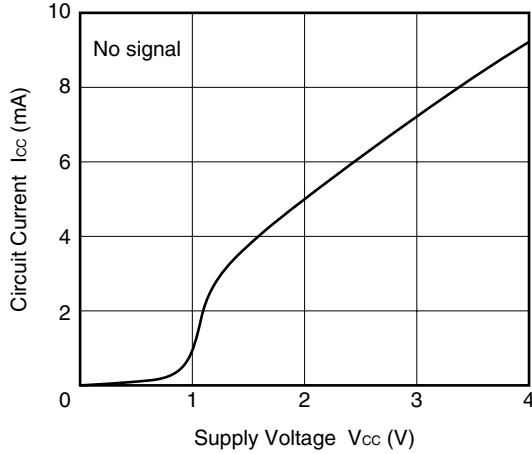
V_{CC} = 3.0 V, I_{CC} = 8.4 mA

FREQUENCY MHz	S ₁₁		S ₂₁		S ₁₂		S ₂₂		K
	MAG.	ANG.	MAG.	ANG.	MAG.	ANG.	MAG.	ANG.	
100.0000	0.318	-3.9	4.055	-17.2	0.003	62.9	0.593	-6.6	20.94
200.0000	0.325	-5.9	4.030	-35.5	0.006	54.2	0.584	-12.1	11.68
300.0000	0.346	-7.2	3.985	-52.5	0.009	42.0	0.579	-16.5	8.29
400.0000	0.341	-8.9	3.916	-70.7	0.012	29.4	0.562	-20.6	6.26
500.0000	0.339	-10.8	3.842	-87.3	0.013	11.8	0.546	-23.0	6.29
600.0000	0.326	-13.9	3.775	-104.7	0.015	1.6	0.527	-26.2	5.50
700.0000	0.311	-20.8	3.668	-121.5	0.017	-11.9	0.515	-29.9	5.46
800.0000	0.312	-25.8	3.594	-138.1	0.018	-24.2	0.511	-32.4	5.36
900.0000	0.325	-31.9	3.525	-154.2	0.020	-38.4	0.512	-34.8	4.91
1000.0000	0.356	-32.8	3.497	-170.3	0.019	-45.9	0.523	-35.8	4.93
1100.0000	0.382	-32.7	3.503	173.7	0.020	-54.3	0.525	-36.3	4.56
1200.0000	0.416	-31.2	3.542	156.7	0.022	-70.5	0.530	-36.8	4.14
1300.0000	0.416	-30.9	3.569	139.1	0.023	-78.4	0.518	-37.5	3.92
1400.0000	0.415	-30.8	3.520	121.4	0.025	-88.4	0.509	-38.8	3.53
1500.0000	0.393	-30.3	3.501	103.7	0.025	-102.9	0.492	-40.5	3.68
1600.0000	0.386	-31.3	3.429	86.8	0.025	-114.1	0.481	-42.5	3.78
1700.0000	0.373	-30.5	3.355	69.7	0.026	-125.7	0.474	-43.8	3.68
1800.0000	0.369	-31.6	3.303	52.7	0.028	-130.3	0.468	-44.8	3.50
1900.0000	0.366	-29.6	3.229	35.8	0.028	-142.5	0.457	-44.8	3.63
2000.0000	0.353	-30.0	3.179	18.8	0.030	-152.4	0.440	-45.0	3.62
2100.0000	0.344	-28.6	3.081	1.5	0.031	-164.9	0.416	-45.0	3.85
2200.0000	0.313	-29.5	2.999	-15.4	0.031	-177.1	0.389	-45.4	4.23
2300.0000	0.293	-31.6	2.911	-32.5	0.033	171.1	0.365	-46.4	4.23
2400.0000	0.267	-35.1	2.802	-49.4	0.034	160.8	0.346	-47.4	4.40
2500.0000	0.262	-39.9	2.695	-66.0	0.036	148.3	0.331	-48.2	4.45
2600.0000	0.253	-40.3	2.598	-82.3	0.036	134.8	0.321	-48.3	4.54
2700.0000	0.253	-40.9	2.496	-98.6	0.034	121.4	0.311	-47.6	5.08
2800.0000	0.248	-35.5	2.400	-114.6	0.036	106.5	0.299	-46.7	5.01
2900.0000	0.237	-30.2	2.306	-130.2	0.032	92.8	0.279	-46.3	5.88
3000.0000	0.230	-20.6	2.209	-146.4	0.031	83.6	0.254	-46.2	6.49

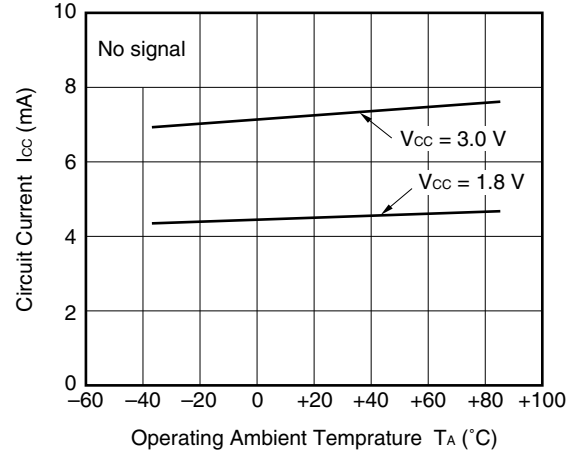
TYPICAL CHARACTERISTICS (Unless otherwise specified, $T_A = +25^\circ\text{C}$)

— μ PC2746TB —

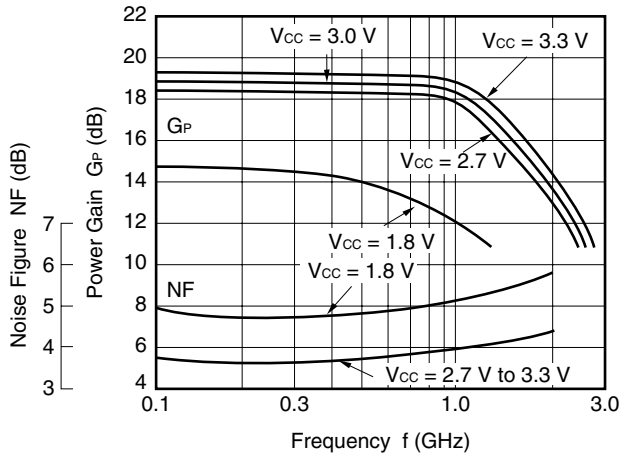
CIRCUIT CURRENT vs. SUPPLY VOLTAGE



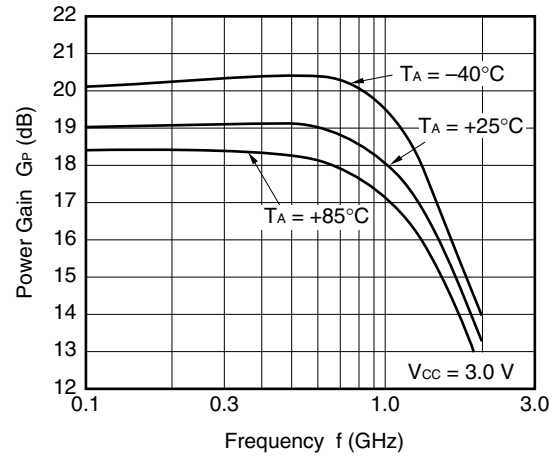
CIRCUIT CURRENT vs. OPERATING AMBIENT TEMPERATURE



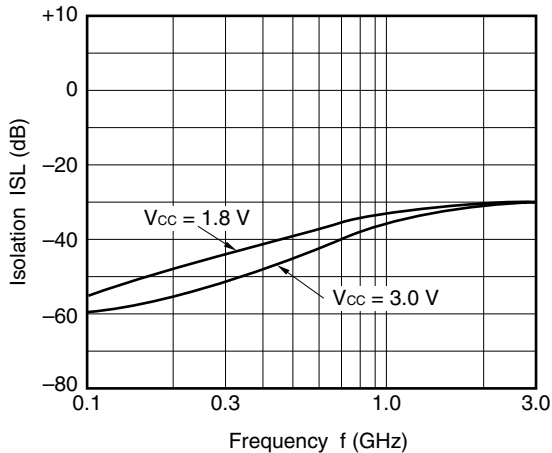
NOISE FIGURE, POWER GAIN vs. FREQUENCY



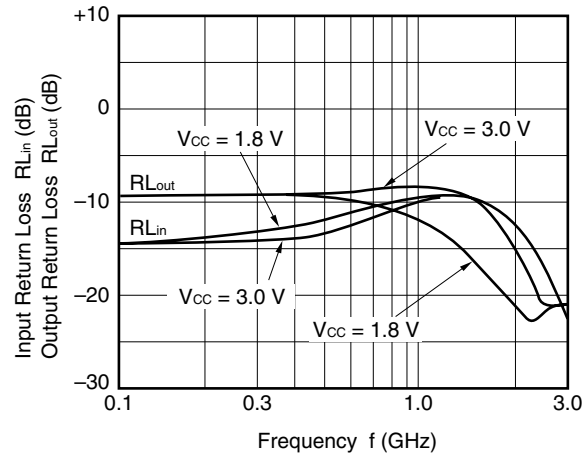
POWER GAIN vs. FREQUENCY



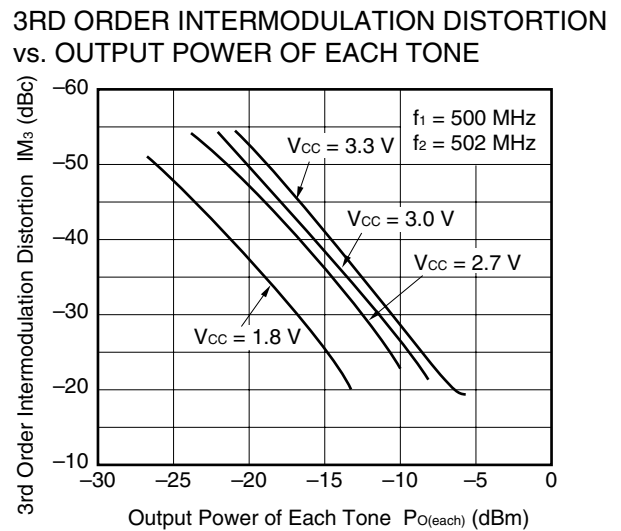
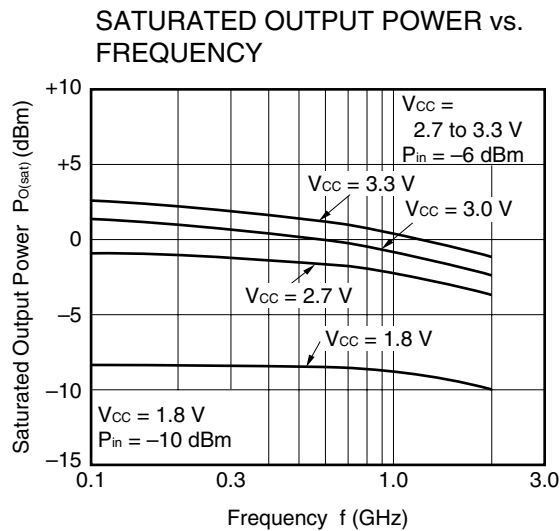
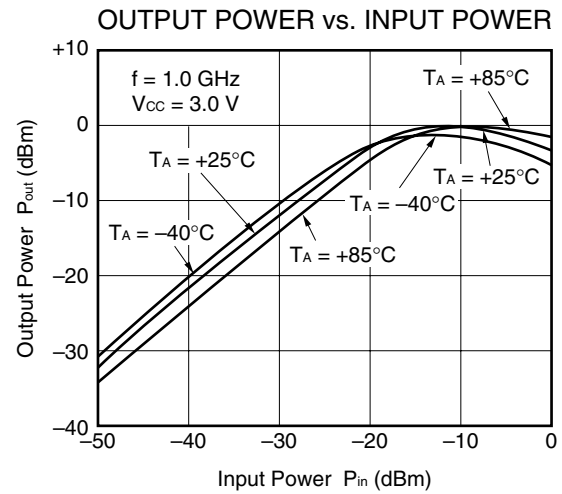
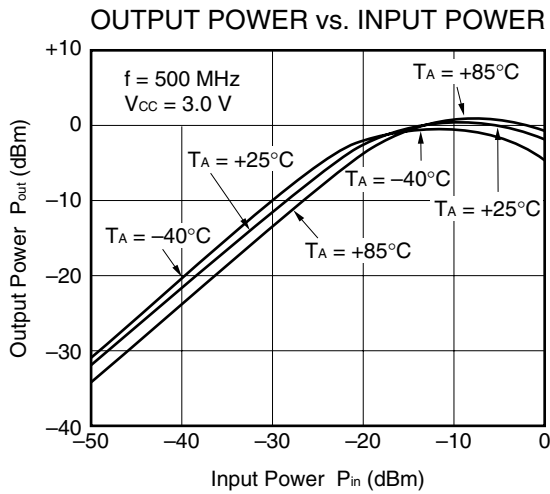
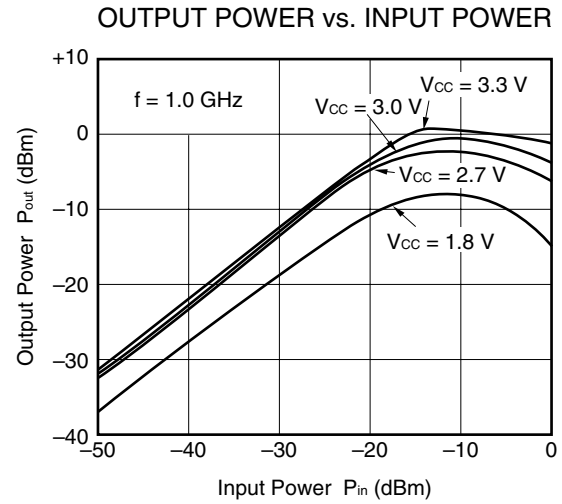
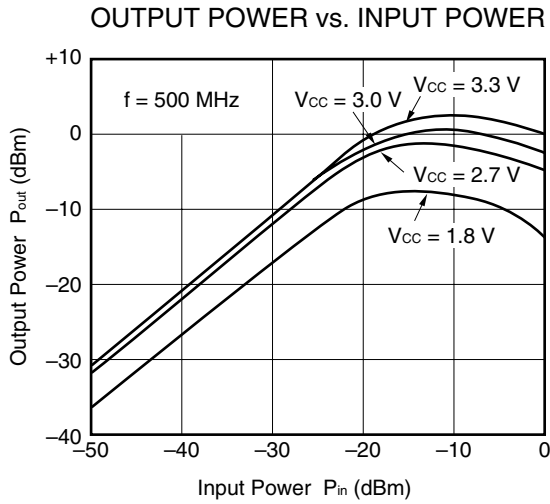
ISOLATION vs. FREQUENCY



INPUT RETURN LOSS, OUTPUT RETURN LOSS vs. FREQUENCY



— μ PC2746TB —

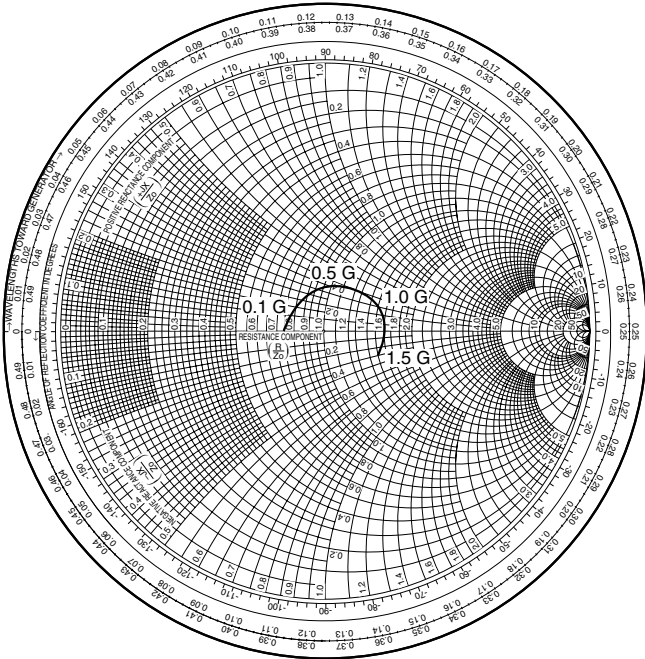


Remark The graphs indicate nominal characteristics.

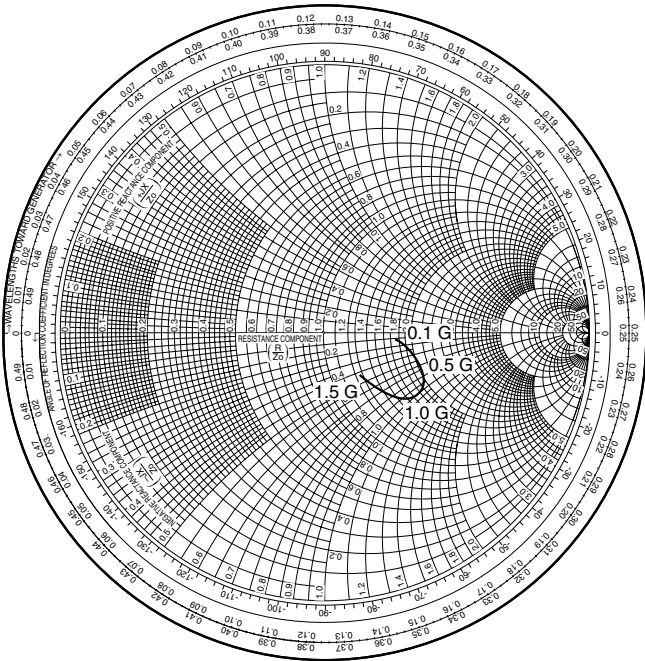
S-PARAMETERS (T_A = +25°C, V_{CC} = 3.0 V)

— μ PC2746TB —

S₁₁-FREQUENCY



S₂₂-FREQUENCY

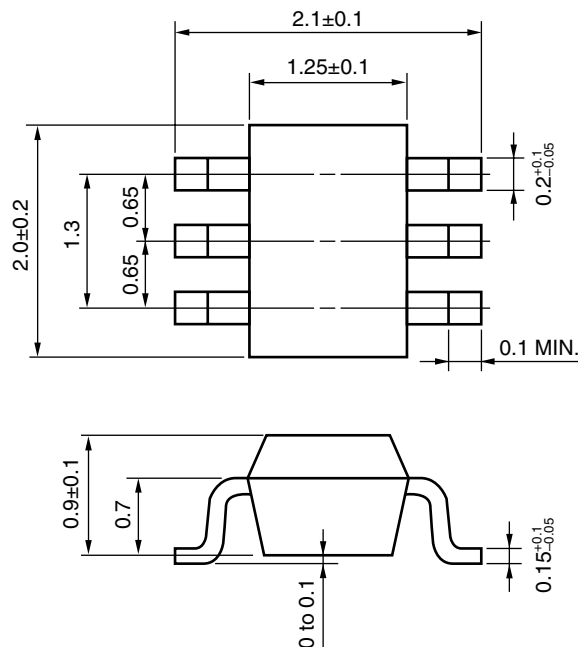


TYPICAL S-PARAMETER VALUES ($T_A = +25^\circ\text{C}$) μ PC2746TB $V_{CC} = 3.0\text{ V}$, $I_{CC} = 7.7\text{ mA}$

FREQUENCY MHz	S ₁₁		S ₂₁		S ₁₂		S ₂₂		K
	MAG.	ANG.	MAG.	ANG.	MAG.	ANG.	MAG.	ANG.	
100.0000	0.146	165.0	6.443	-19.4	0.001	77.0	0.403	-5.3	108.63
200.0000	0.130	141.7	6.594	-38.7	0.003	51.8	0.406	-8.6	20.56
300.0000	0.117	117.9	6.623	-58.1	0.004	47.7	0.418	-11.0	16.33
400.0000	0.128	100.8	6.522	-77.5	0.005	51.1	0.417	-14.0	12.34
500.0000	0.139	90.8	6.613	-96.9	0.008	33.1	0.424	-16.2	8.14
600.0000	0.145	83.1	6.481	-116.1	0.009	21.7	0.422	-19.4	7.22
700.0000	0.135	77.0	6.424	-135.1	0.010	14.7	0.426	-23.8	6.52
800.0000	0.131	67.4	6.353	-153.6	0.011	-0.4	0.433	-27.7	5.63
900.0000	0.119	49.3	6.234	-172.1	0.014	-10.5	0.442	-32.1	4.80
1000.0000	0.142	30.4	6.137	169.6	0.015	-24.2	0.455	-34.7	4.44
1100.0000	0.170	18.0	5.992	151.1	0.016	-28.7	0.455	-37.5	4.02
1200.0000	0.219	10.6	5.972	133.3	0.019	-48.0	0.453	-39.7	3.49
1300.0000	0.245	7.4	5.867	115.1	0.019	-63.4	0.433	-42.7	3.40
1400.0000	0.268	3.1	5.679	97.0	0.022	-72.2	0.409	-45.5	3.16
1500.0000	0.270	1.5	5.582	79.1	0.021	-86.9	0.375	-48.3	3.38
1600.0000	0.268	-3.9	5.380	61.8	0.022	-99.6	0.349	-49.9	3.36
1700.0000	0.258	-7.8	5.122	44.5	0.024	-110.7	0.318	-50.0	3.42
1800.0000	0.251	-14.3	4.880	27.9	0.024	-122.9	0.294	-49.2	3.67
1900.0000	0.249	-16.7	4.634	11.7	0.025	-135.3	0.268	-45.4	3.73
2000.0000	0.240	-20.5	4.475	-4.4	0.026	-146.0	0.248	-40.5	3.91

★ PACKAGE DIMENSIONS

6-PIN SUPER MINIMOLD (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 the V_{CC} pin.
- (4) The DC cut capacitor must be attached to input pin and output 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 Time: 30 seconds or less (at 210°C) Count: 3, Exposure limit: None ^{Note}	IR35-00-3
VPS	Package peak temperature: 215°C or below Time: 40 seconds or less (at 200°C) Count: 3, Exposure limit: None ^{Note}	VP15-00-3
Wave Soldering	Soldering bath temperature: 260°C or below Time: 10 seconds or less Count: 1, Exposure limit: None ^{Note}	WS60-00-1
Partial Heating	Pin temperature: 300°C or below Time: 3 seconds or less (per side of device) Exposure limit: None ^{Note}	—

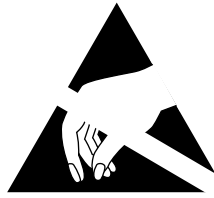
Note After opening the dry pack, keep it in a place below 25°C and 65% RH for the allowable storage period.

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

NESAT (NEC Silicon Advanced Technology) is a trademark of NEC Corporation.

- **The information in this document is current as of February, 2001. The information is subject to change without notice. For actual design-in, refer to the latest publications of NEC's data sheets or data books, etc., for the most up-to-date specifications of NEC semiconductor products. Not all products and/or types are available in every country. Please check with an NEC sales representative for availability and additional information.**
- No part of this document may be copied or reproduced in any form or by any means without prior written consent of NEC. NEC assumes no responsibility for any errors that may appear in this document.
- NEC 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 NEC semiconductor products listed in this document or any other liability arising from the use of such products. No license, express, implied or otherwise, is granted under any patents, copyrights or other intellectual property rights of NEC or others.
- Descriptions of circuits, software and other related information in this document are provided for illustrative purposes in semiconductor product operation and application examples. The incorporation of these circuits, software and information in the design of customer's equipment shall be done under the full responsibility of customer. NEC assumes no responsibility for any losses incurred by customers or third parties arising from the use of these circuits, software and information.
- While NEC endeavours to enhance the quality, reliability and safety of NEC semiconductor products, customers agree and acknowledge that the possibility of defects thereof cannot be eliminated entirely. To minimize risks of damage to property or injury (including death) to persons arising from defects in NEC semiconductor products, customers must incorporate sufficient safety measures in their design, such as redundancy, fire-containment, and anti-failure features.
- NEC semiconductor products are classified into the following three quality grades:
 "Standard", "Special" and "Specific". The "Specific" quality grade applies only to semiconductor products developed based on a customer-designated "quality assurance program" for a specific application. The recommended applications of a semiconductor product depend on its quality grade, as indicated below. Customers must check the quality grade of each semiconductor product before using it in a particular application.
 "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
 "Special": 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, life support systems and medical equipment for life support, etc.
 The quality grade of NEC semiconductor products is "Standard" unless otherwise expressly specified in NEC's data sheets or data books, etc. If customers wish to use NEC semiconductor products in applications not intended by NEC, they must contact an NEC sales representative in advance to determine NEC's willingness to support a given application.
 (Note)
 (1) "NEC" as used in this statement means NEC Corporation and also includes its majority-owned subsidiaries.
 (2) "NEC semiconductor products" means any semiconductor product developed or manufactured by or for NEC (as defined above).