High Isolation X-SP4T (DP8T) SWITCH

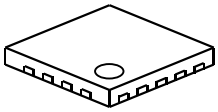
■ GENERAL DESCRIPTION

The NJG1695ME7 is a GaAs X (cross) - SP4T (DP8T) switch MMIC for switching of balanced (differential) mode filters. It features low insertion loss and very high isolation for balanced signal input.

The ESD protection circuits are integrated in the IC to achieve high ESD tolerance.

The ultra-small and ultra-thin EQFN18-E7 package is adopted.

■ PACKAGE OUTLINE



NJG1695ME7

*) The X-SP4T is a paired SP4T switch that features two identical SP4T switches being integrated into one chip. The two SP4T switches are controlled synchronously, and their respective RF lines cross each other on the chip.

■ APPLICATIONS

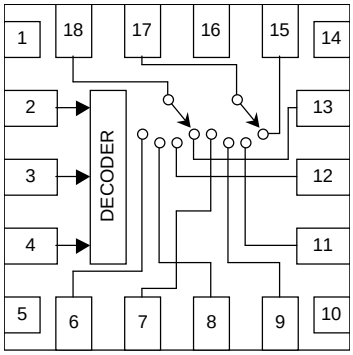
Switching of balanced type filters (Quad band) application
Suitable for 3G and LTE application

■ FEATURES

- Low operation voltage V_{DD}=+1.5~+4.5V
- Low control voltage $V_{CTL(H)}$=+1.35V min.
- High isolation (Balanced mode)
  43dB typ. @f=1.0GHz, P_{IN}=0dBm
  38dB typ. @f=2.0GHz, P_{IN}=0dBm
  35dB typ. @f=2.7GHz, P_{IN}=0dBm
- Low insertion loss
  0.45dB typ. @f=1.0GHz, P_{IN}=0dBm
  0.55dB typ. @f=2.0GHz, P_{IN}=0dBm
  0.80dB typ. @f=2.7GHz, P_{IN}=0dBm
- Small package EQFN18-E7 (Package size: 2.0mm x 2.0mm x 0.397mm typ.)
- RoHS compliant and Halogen Free
- MSL 1

■ PIN CONFIGURATION

(Top View)



1.	GND	10.	GND
2.	VDD	11.	P2B
3.	VCTL2	12.	P2A
4.	VCTL1	13.	P1A
5.	GND	14.	GND
6.	P4A	15.	P1B
7.	P4B	16.	GND(NC)
8.	P3A	17.	PCB
9.	P3B	18.	PCA

■ TRUTH TABLE

"H"=$V_{CTL(H)}$, "L"=$V_{CTL(L)}$

ON PATH	VCTL1	VCTL2
PCA-P1A, PCB-P1B	H	L
PCA-P2A, PCB-P2B	L	L
PCA-P3A, PCB-P3B	L	H
PCA-P4A, PCB-P4B	H	H

NOTE: The information on this datasheet is subject to change without notice.

■ ABSOLUTE MAXIMUM RATINGS

(T_a=+25°C, Z_s=Z_l=50Ω)

PARAMETERS	SYMBOL	CONDITIONS	RATINGS	UNITS
RF Input Power	P_{IN}	V_{DD} =2.7V, V_{CTL}=0V/1.8V ON state port	28	dBm
Supply Voltage	V_{DD}	VDD terminal	5.0	V
Control Voltage	V_{CTL}	VCTL terminal	5.0	V
Power Dissipation	P_D	Four-layer FR4 PCB with through-holes (74.2mmx74.2mm), T_j=150°C	1400	mW
Operating Temperature	T_{opr}		-40~+90	°C
Storage Temperature	T_{stg}		-55~+150	°C

■ ELECTRICAL CHARACTERISTICS

(General conditions: T_a=+25°C, Z_s=Z_l=50Ω, V_{DD}=2.7V, $V_{CTL(L)}$=0V, $V_{CTL(H)}$=1.8V, with application circuit)

PARAMETERS	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Supply Voltage	V_{DD}		1.5	2.7	4.5	V
Operating Current	I_{DD}		-	30	60	μA
Control Voltage (LOW)	$V_{CTL(L)}$		0	0	0.45	V
Control Voltage (HIGH)	$V_{CTL(H)}$		1.35	1.8	4.5	V
Control Current	I_{CTL}		-	5	10	μA

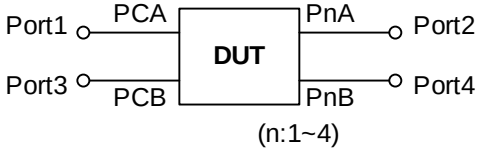
■ ELECTRICAL CHARACTERISTICS

(General conditions: T_a=+25°C, Z_s=Z_l=50Ω, V_{DD}=2.7V, $V_{CTL(L)}$=0V, $V_{CTL(H)}$=1.8V, with application circuit)

PARAMETERS	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Insertion Loss 1	LOSS1	f=1.0GHz, P_{IN}=0dBm	-	0.40	0.60	dB
Insertion Loss 2	LOSS2	f=2.0GHz, P_{IN}=0dBm	-	0.45	0.65	dB
Insertion Loss 3	LOSS3	f=2.7GHz, P_{IN}=0dBm	-	0.80	1.0	dB
Balanced mode isolation 1 (Note1)	B-ISL1	f=1.0GHz, P_{IN}=0dBm PC-P1, P2, P3, P4	40	43	-	dB
Balanced mode Isolation 2 (Note1)	B-ISL2	f=2.0GHz, P_{IN}=0dBm PC-P1, P2, P3, P4	35	38	-	dB
Balanced mode isolation 3 (Note1)	B-ISL3	f=2.7GHz, P_{IN}=0dBm PC-P1, P2, P3, P4	32	35	-	dB
Isolation 1	ISL1	PCA-P1A, P2A, P3A, P4A PCB-P1B, P2B, P3B, P4B f=1.0GHz, P_{IN}=0dBm	26	28	-	dB
Isolation 2	ISL2	PCA-P1A, P2A, P3A, P4A PCB-P1B, P2B, P3B, P4B f=2.0GHz, P_{IN}=0dBm	23	26	-	dB
Isolation 3	ISL3	PCA-P1A, P2A, P3A, P4A PCB-P1B, P2B, P3B, P4B f=2.7GHz, P_{IN}=0dBm	18	20	-	dB
Isolation 4	ISL4	PCA-PCB port f=2.0GHz, P_{IN}=0dBm	17	19	-	dB
Input power at 0.2dB Compression Point	$P_{-0.2dB}$	f=2.0GHz	20	23	-	dBm
VSWR	VSWR	f=2.0GHz, On state port	-	1.2	1.4	-
Switching time	T_{SW}	50% V_{CTL} to 10/90% RF	-	2	5	μs

Note1:
The calculation of “Balanced Mode Isolation” uses the following formula.

$$\mathrm{B-ISL} = \frac{1}{2}\left(S_{21} - S_{23} - S_{41} + S_{43}\right)$$



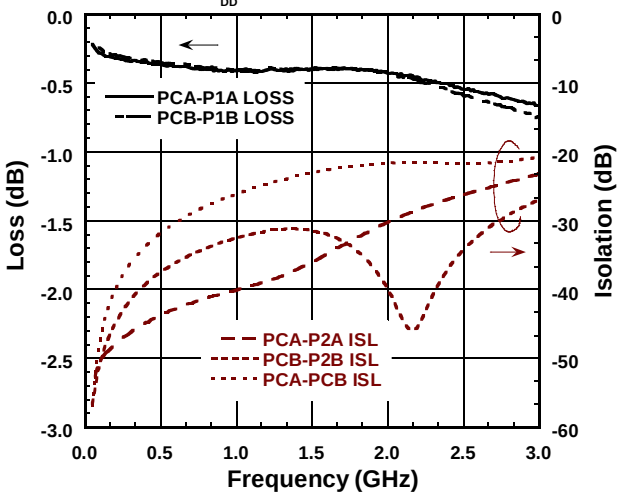
■ TERMINAL INFORMATION

No.	SYMBOL	DESCRIPTION
1, 5, 10, 14	GND	Ground terminal. Please connect to the PCB ground plane.
2	VDD	Positive voltage supply terminal (+1.5~+4.5V). Please place a bypass capacitor between this terminal and GND for best RF performance.
3	VCTL2	Control signal input terminal. This terminal is to be set to High-Level (+1.35V~4.5V) or Low-Level (0~+0.45V).
4	VCTL1	Control signal input terminal. This terminal is to be set to High-Level (+1.35V~4.5V) or Low-Level (0~+0.45V).
6	P4A	The 4th RF port of the 1st switch. This port is connected with PCA port. PCB port is connected with P4B port at the same time. An external capacitor is required to block DC voltage.
7	P4B	The 4th RF port of the 2nd switch. This port is connected with PCB port. PCA port is connected with P4A port at the same time. An external capacitor is required to block DC voltage.
8	P3A	The 3rd RF port of the 1st switch. This port is connected with PCA port. PCB port is connected with P3B port at the same time. An external capacitor is required to block DC voltage.
9	P3B	The 3rd RF port of the 2nd switch. This port is connected with PCB port. PCA port is connected with P3A port at the same time. An external capacitor is required to block DC voltage.
11	P2B	The 2nd RF port of the 2nd switch. This port is connected with PCB port. PCA port is connected with P2A port at the same time. An external capacitor is required to block DC voltage.
12	P2A	The 2nd RF port of the 1st switch. This port is connected with PCA port. PCB port is connected with P2B port at the same time. An external capacitor is required to block DC voltage.
13	P1A	The 1st RF port of the 1st switch. This port is connected with PCA port. PCB port is connected with P1B port at the same time. An external capacitor is required to block DC voltage.
15	P1B	The 1st RF port of the 2nd switch. This port is connected with PCB port. PCA port is connected with P1A port at the same time. An external capacitor is required to block DC voltage.
16	GND(NC)	Not connected terminal. This terminal is not connected with internal circuit. Please connect it to the PCB ground plane.
17	PCB	Common RF port of the 2nd switch. This port is connected to one RF port of the 2nd switch (P1B~P4B). An external capacitor is required to block DC voltage.
18	PCA	Common RF port of the 1st switch. This port is connected to one RF port of the 1st switch (P1A~P4A). An external capacitor is required to block DC voltage.

■ **ELECTRICAL CHARACTERISTICS** (With Application circuit, Loss of external circuit are excluded)

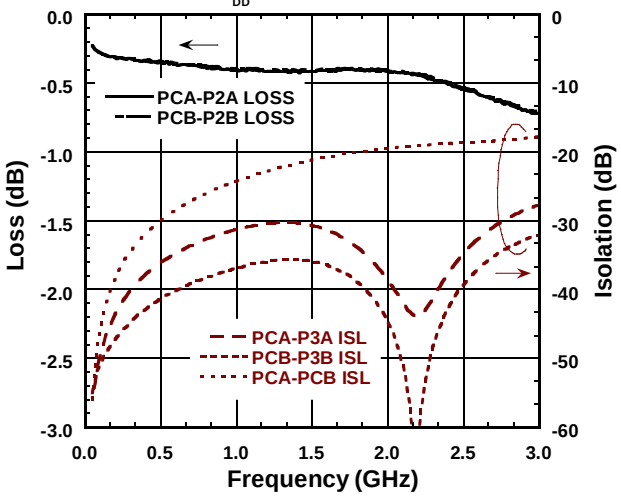
Insertion Loss vs. Frequency

PC-P1 ON, V_{DD}=2.7V, VCTL1=1.8V, VCTL2=0V



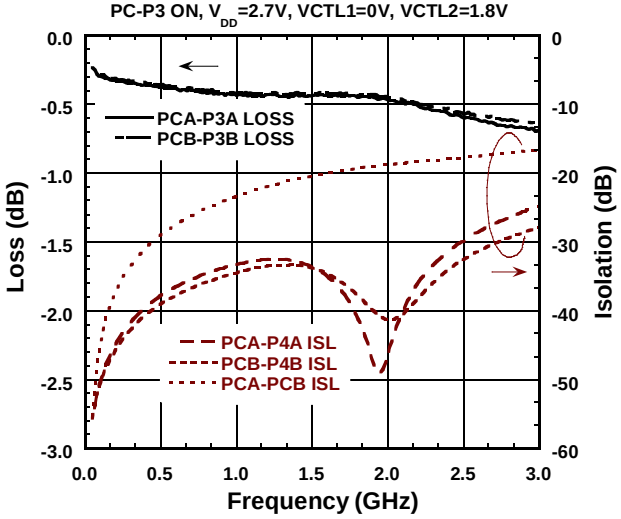
Insertion Loss vs. Frequency

PC-P2 ON, V_{DD}=2.7V, VCTL1=0V, VCTL2=0V



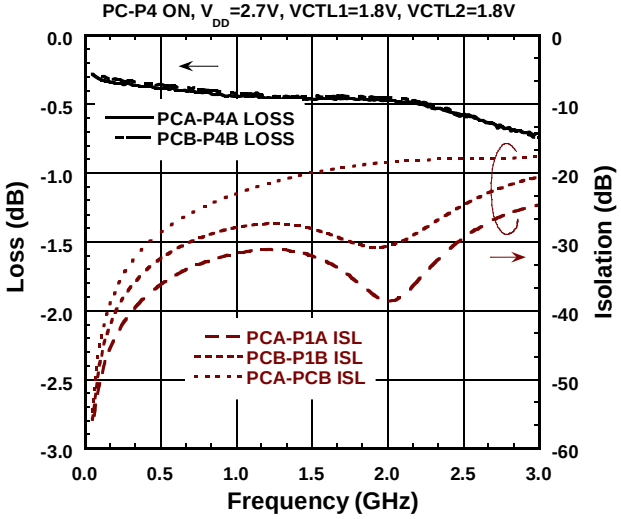
Insertion Loss vs. Frequency

PC-P3 ON, V_{DD}=2.7V, VCTL1=0V, VCTL2=1.8V



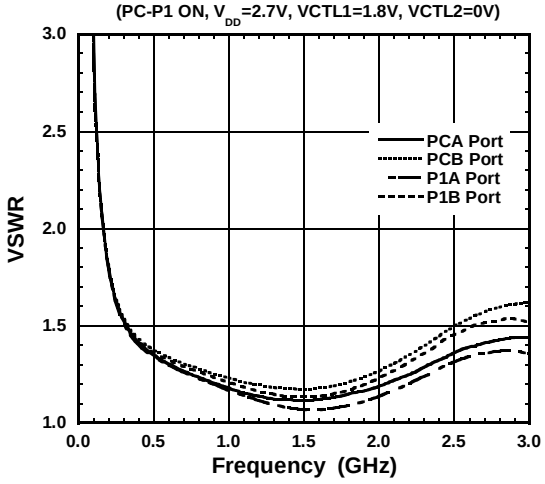
Insertion Loss vs. Frequency

PC-P4 ON, V_{DD}=2.7V, VCTL1=1.8V, VCTL2=1.8V



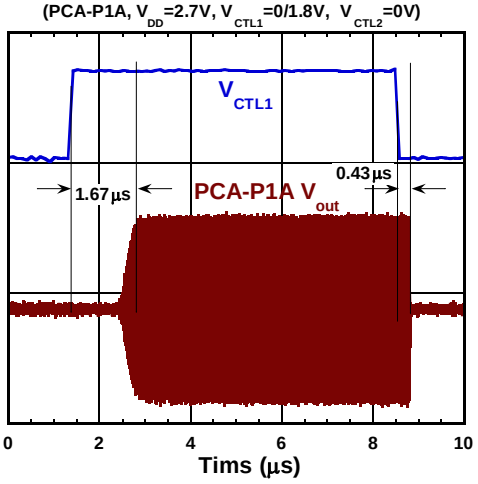
VSWR vs. Frequency

(PC-P1 ON, V_{DD}=2.7V, VCTL1=1.8V, VCTL2=0V)



Switching Time

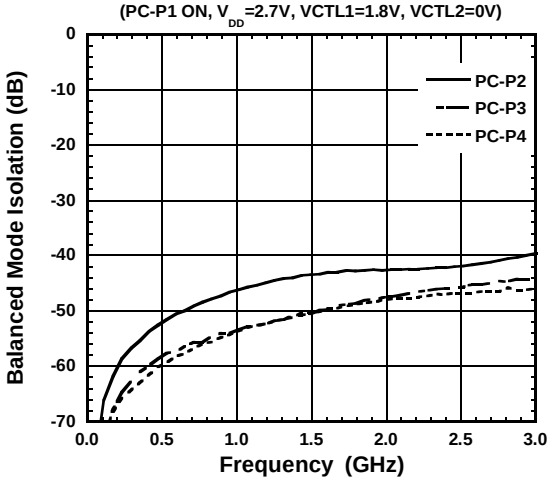
(PCA-P1A, V_{DD}=2.7V, V_{CTL1}=0/1.8V, V_{CTL2}=0V)



■ **ELECTRICAL CHARACTERISTICS** (With Application circuit, Loss of external circuit are excluded)

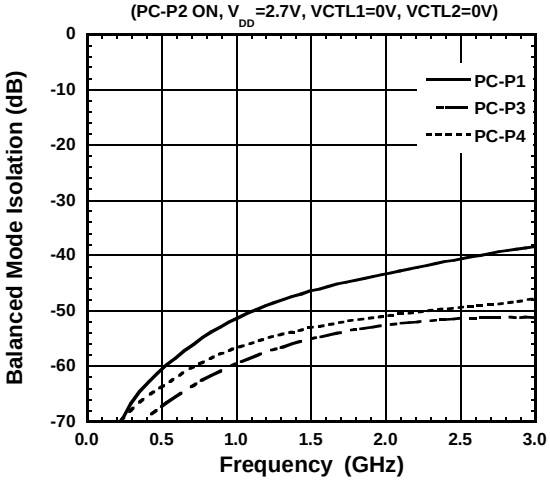
Balanced Mode Isolation vs. Frequency

(PC-P1 ON, V_{DD}=2.7V, VCTL1=1.8V, VCTL2=0V)



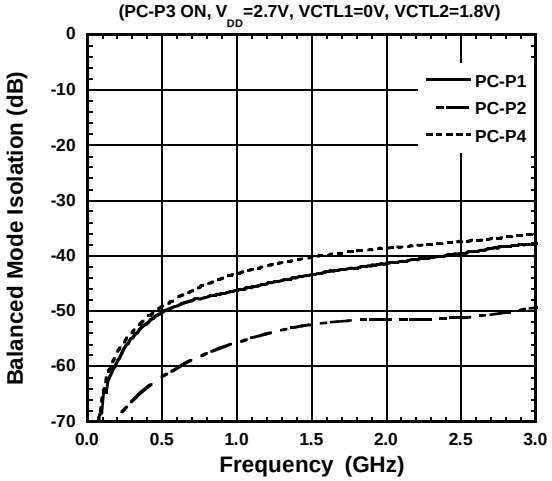
Balanced Mode Isolation vs. Frequency

(PC-P2 ON, V_{DD}=2.7V, VCTL1=0V, VCTL2=0V)



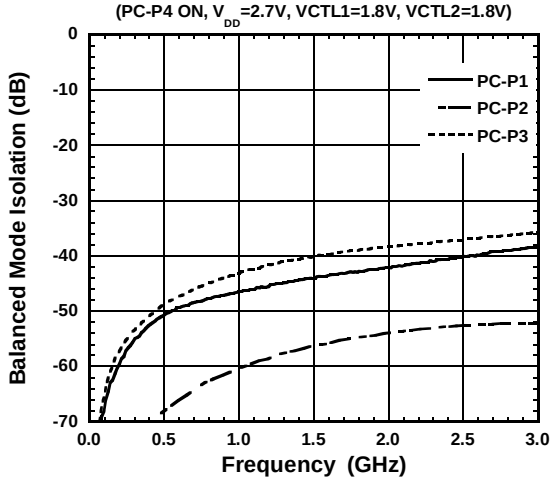
Balanced Mode Isolation vs. Frequency

(PC-P3 ON, V_{DD}=2.7V, VCTL1=0V, VCTL2=1.8V)



Balanced Mode Isolation vs. Frequency

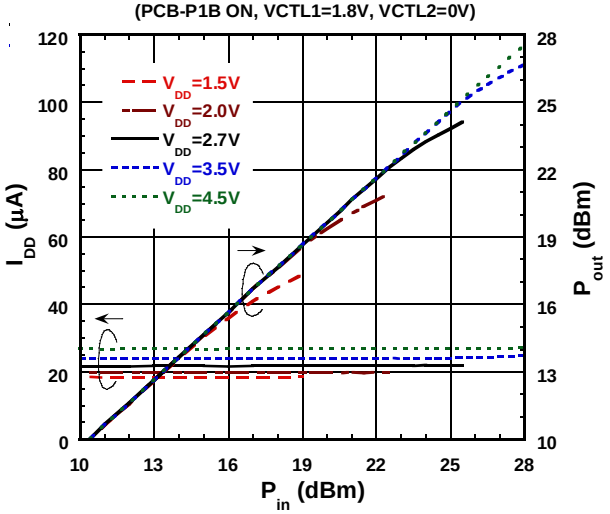
(PC-P4 ON, V_{DD}=2.7V, VCTL1=1.8V, VCTL2=1.8V)



■ **ELECTRICAL CHARACTERISTICS** (With Application circuit, Loss of external circuit are excluded)

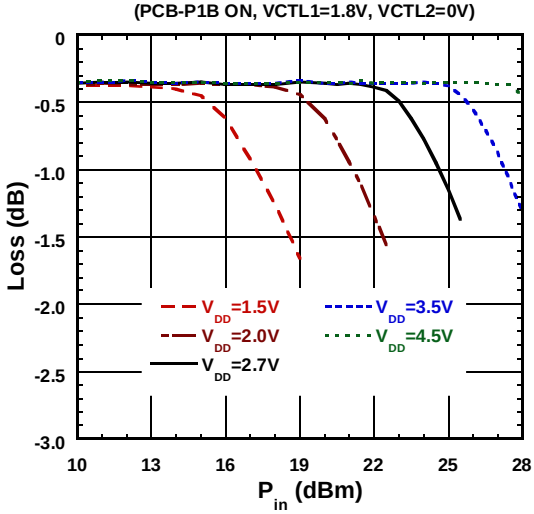
P_{out} & I_{DD} vs. P_{in} at 1.0GHz

(PCB-P1B ON, VCTL1=1.8V, VCTL2=0V)



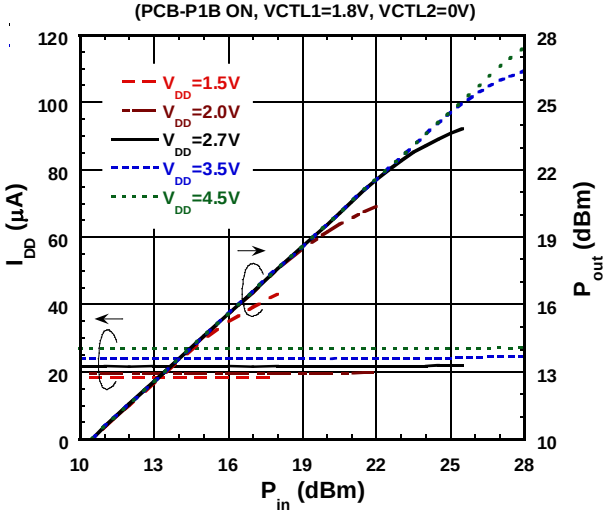
Loss vs. P_{in} at 1.0GHz

(PCB-P1B ON, VCTL1=1.8V, VCTL2=0V)



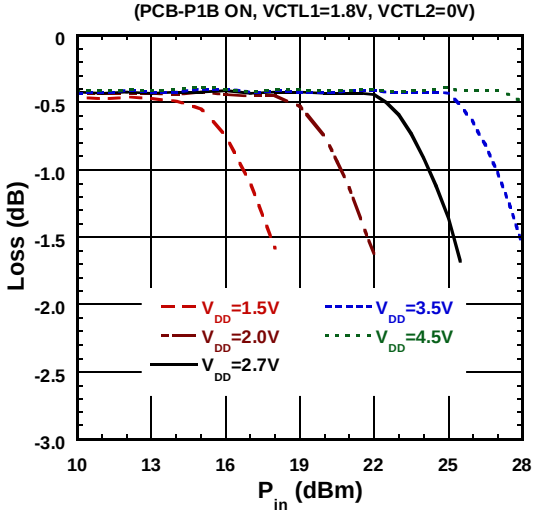
P_{out} & I_{DD} vs. P_{in} at 2.0GHz

(PCB-P1B ON, VCTL1=1.8V, VCTL2=0V)



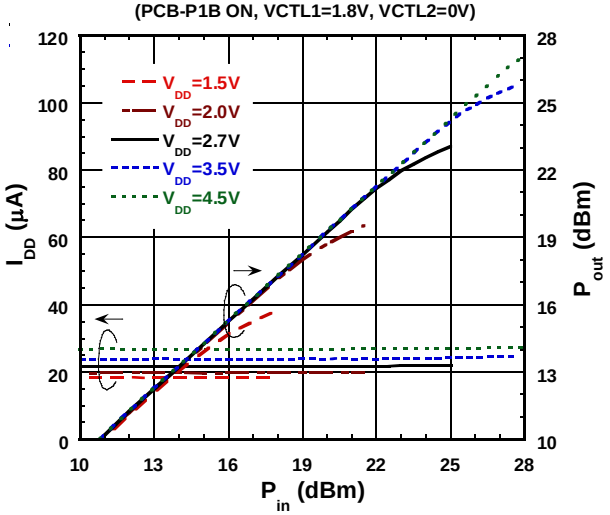
Loss vs. P_{in} at 2.0GHz

(PCB-P1B ON, VCTL1=1.8V, VCTL2=0V)



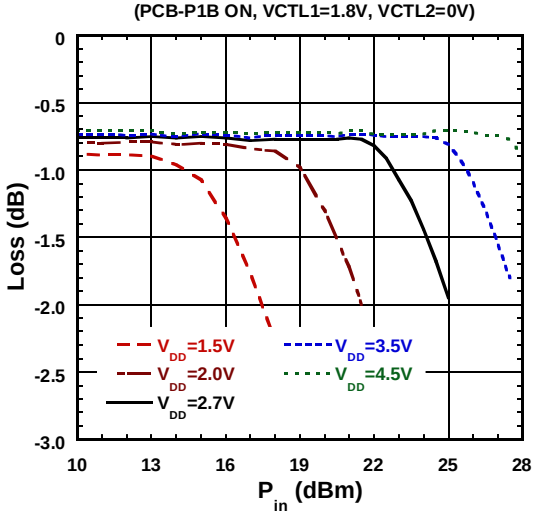
P_{out} & I_{DD} vs. P_{in} at 2.7GHz

(PCB-P1B ON, VCTL1=1.8V, VCTL2=0V)



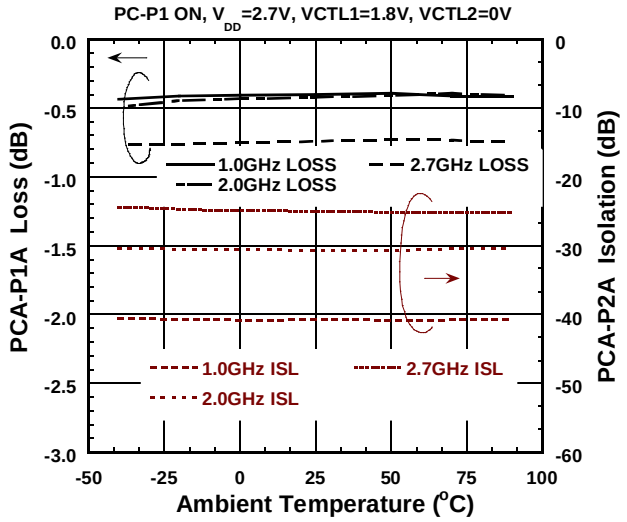
Loss vs. P_{in} at 2.7GHz

(PCB-P1B ON, VCTL1=1.8V, VCTL2=0V)

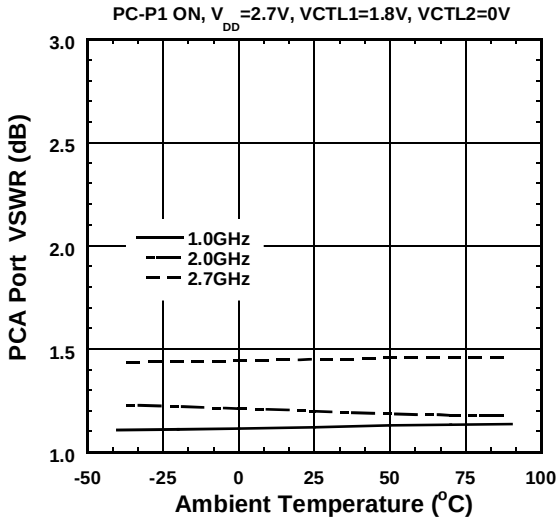


■ **ELECTRICAL CHARACTERISTICS** (With Application circuit, Loss of external circuit are excluded)

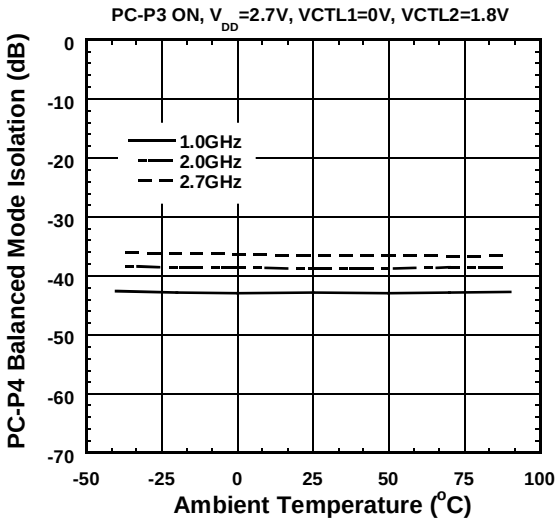
Insertion Loss vs. Temperature



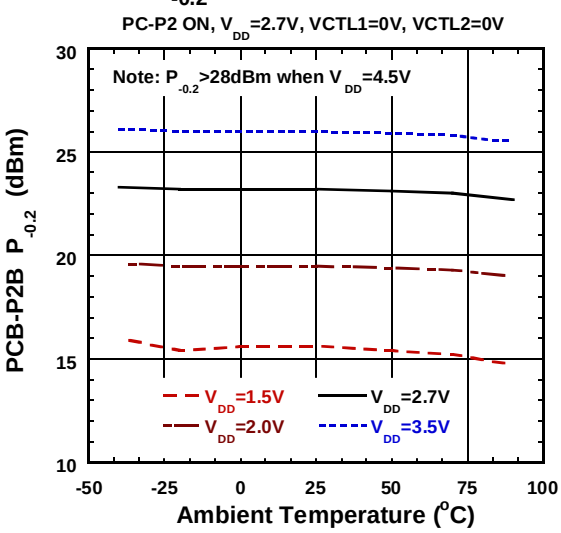
VSWR vs. Temperature



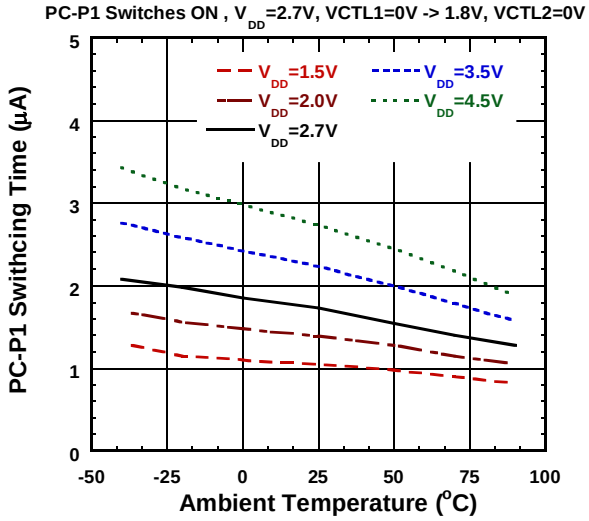
Balanced Mode Isolation vs. Temperature



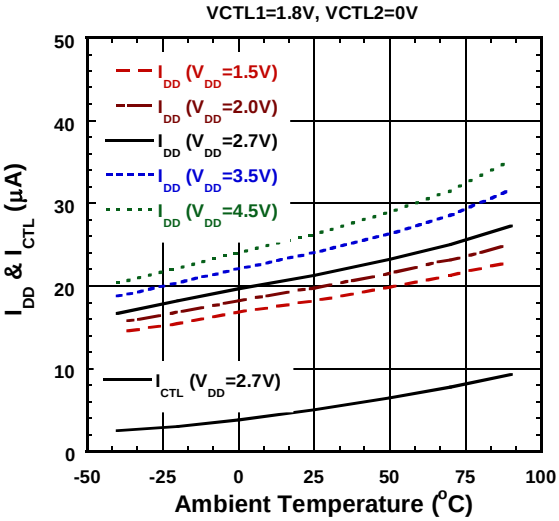
$P_{-0.2}$ vs. Temperature



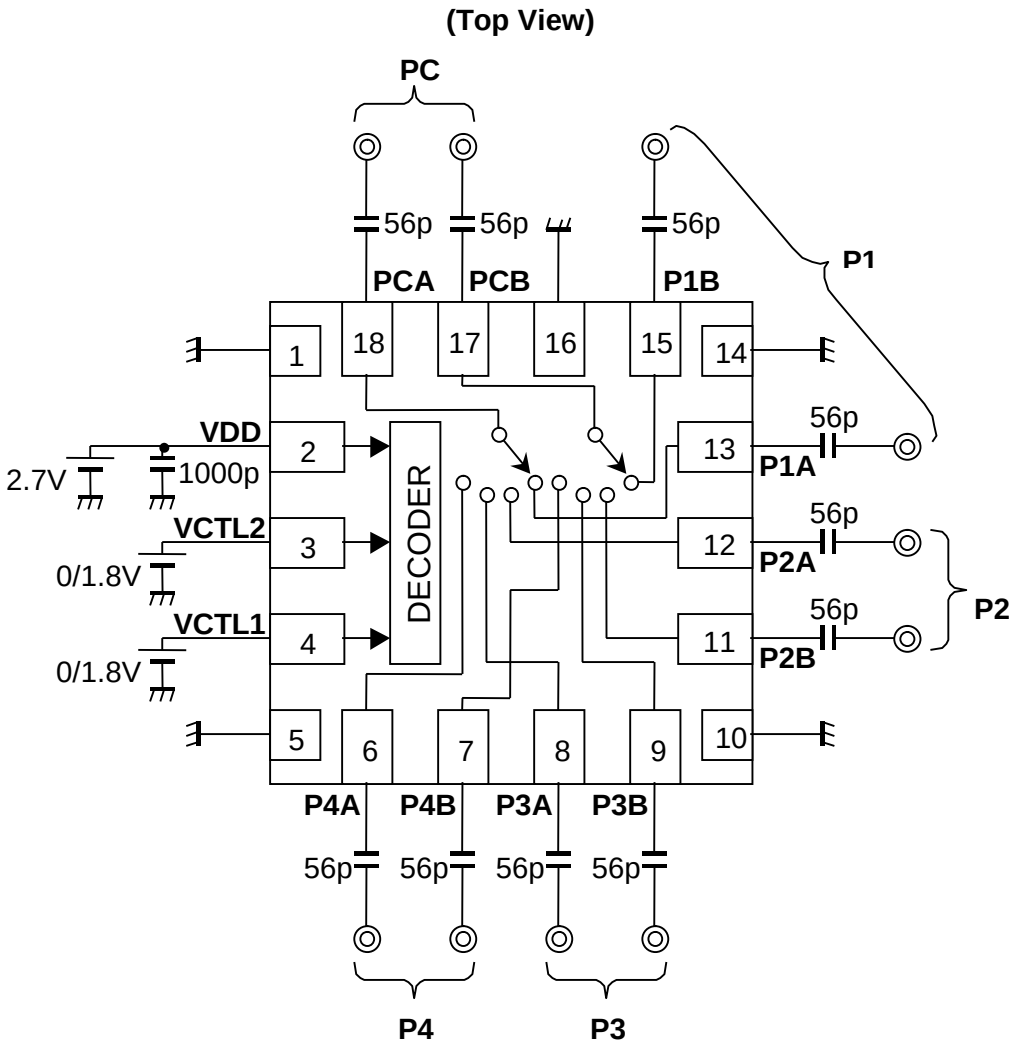
Switching Time vs. Temperature



I_{DD} & I_{CTL} vs. Temperature



■ APPLICATION CIRCUIT

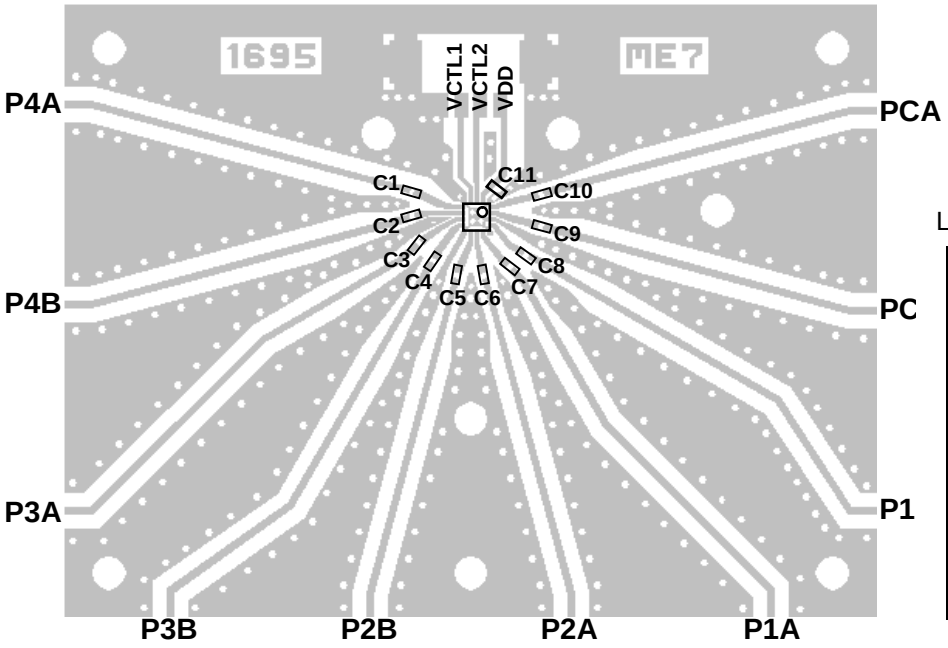


■ PARTS LIST

Part ID	Value	Notes
C1~C10	56pF	MURATA (GRM03)
C11	1000pF	MURATA (GRM15)

■ TEST PCB LAYOUT

(TOP VIEW)

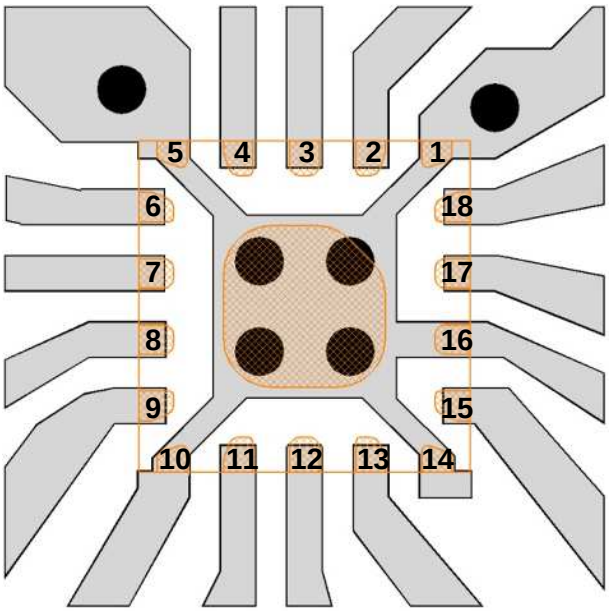


PCB:	FR-4, t=0.2mm
Capacitor Size:	0603, 1005
Strip Line Width:	0.4mm
PCB Size:	53 x 40mm

Losses of PCB, capacitors and connectors

Paths	Frequency (GHz)	Loss (dB)
PCA-P1A, PCB-P1B, PCA-P3A, PCB-P3B	1.0	0.50
	2.0	0.84
	2.7	1.10
PCA-P2A, PCB-P2B, PCA-P4A, PCB-P4B	1.0	0.46
	2.0	0.77
	2.7	0.97

<PCB LAYOUT GUIDELINE>



PCB Pattern

Through-hole (radius: 0.15mm)

Pin

Note2:

The ground plane and the through-holes under Tab, as shown in the picture, are not necessities. There is no problem in deleting them in the practical PCB design, though in such case beware that the GND terminals (pin 10 and 14 as for this particular design shown in the picture) still need through-holes being located in their vicinities.

PRECAUTIONS

[1] The DC current at RF ports must be equal to zero, which can be achieved with DC blocking capacitors (C1~C10).
(However, in case there is no possibility that DC current flows, the DC blocking capacitors are unnecessary, i.e. the RF signals are fed by SAW filters that block DC current by nature, etc.)

[2] To reduce stripline influence on RF characteristics, please locate the bypass capacitor (C11) close to VDD terminal.

[3] For good isolation, the GND terminals must be connected to the PCB ground plane of substrate, and the through-holes connecting the backside ground plane should be placed near by the pin connection.

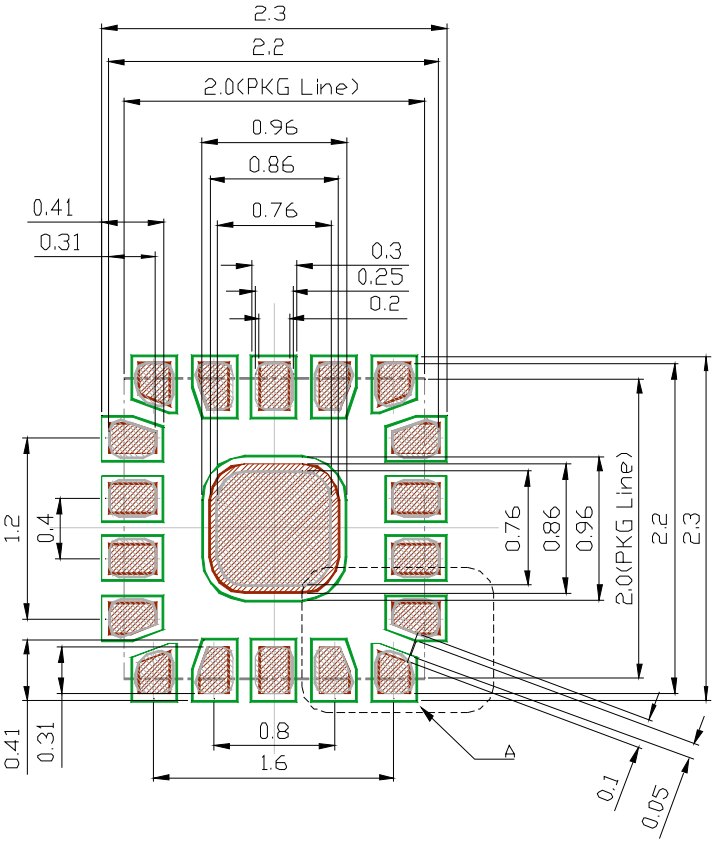
■ RECOMMENDED FOOTPRINT PATTERN (EQFN18-E7 PACKAGE REFERENCE)

: Land

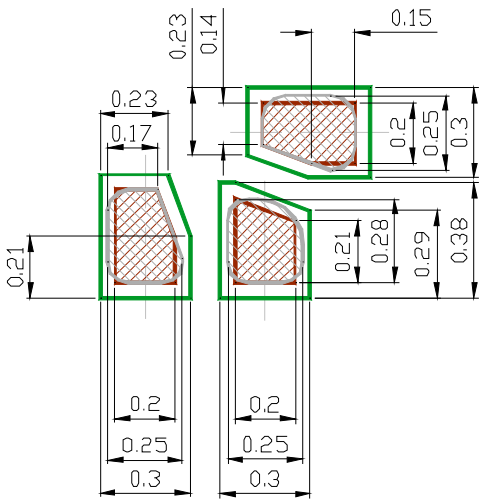
: Mask (Open area) *Metal mask thickness: 100um

: Resist (Open area)

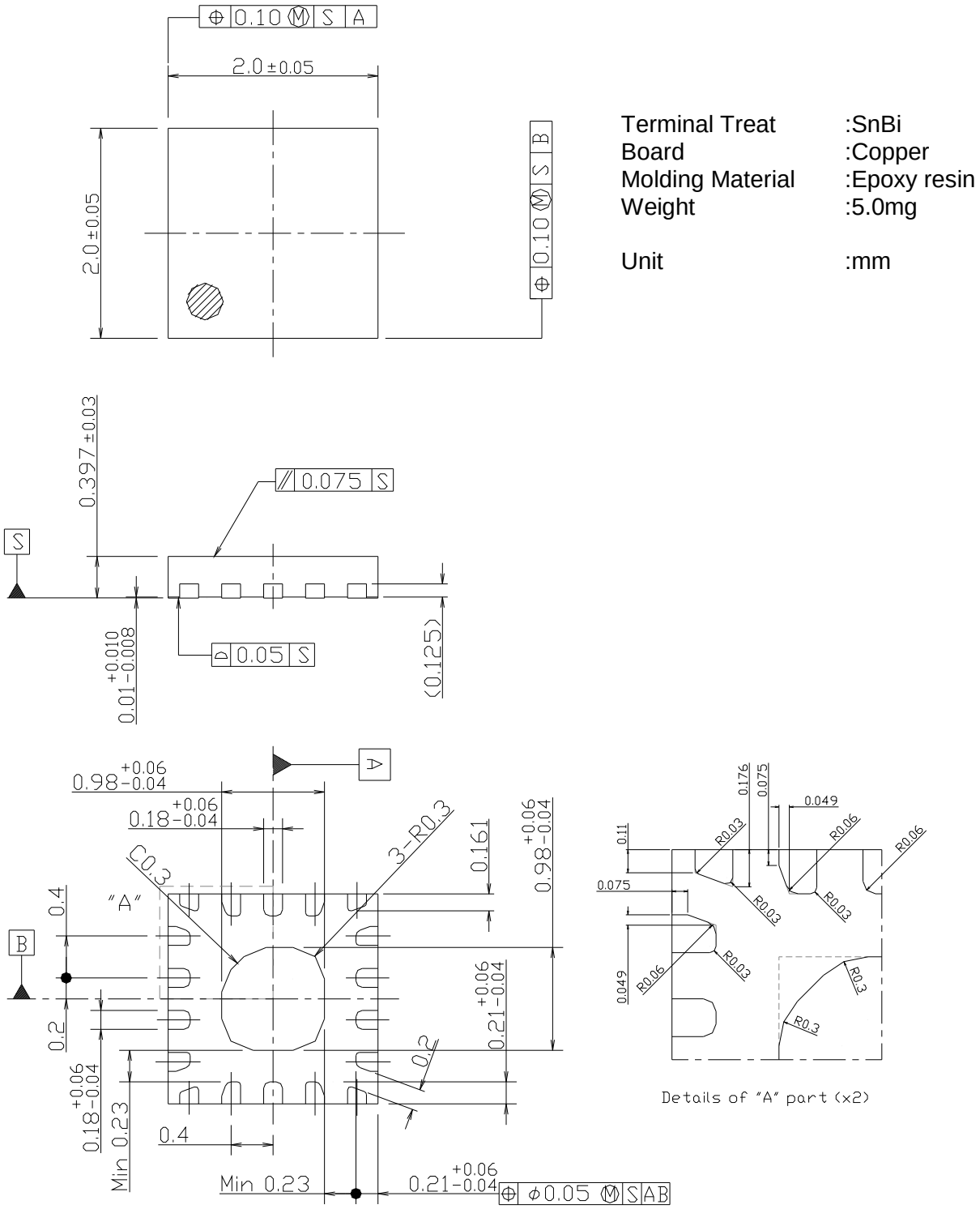
PKG : 2.0mm x 2.0mm



Detail A



■ PACKAGE OUTLINE (EQFN18-E7)



Terminal Treat	:SnBi
Board	:Copper
Molding Material	:Epoxy resin
Weight	:5.0mg
Unit	:mm

Cautions on using this product

This product contains Gallium-Arsenide (GaAs) which is a harmful material.

- Do NOT eat or put into mouth.
- Do NOT dispose in fire or break up this product.
- Do NOT chemically make gas or powder with this product.
- To waste this product, please obey the relating law of your country.

This product may be damaged with electric static discharge (ESD) or spike voltage. Please handle with care to avoid these damages.

1. The products and the product specifications described in this document are subject to change or discontinuation of production without notice for reasons such as improvement. Therefore, before deciding to use the products, please refer to our sales representatives for the latest information thereon.
2. The materials in this document may not be copied or otherwise reproduced in whole or in part without the prior written consent of us.
3. This product and any technical information relating thereto are subject to complementary export controls (so-called KNOW controls) under the Foreign Exchange and Foreign Trade Law, and related politics ministerial ordinance of the law. (Note that the complementary export controls are inapplicable to any application-specific products, except rockets and pilotless aircraft, that are insusceptible to design or program changes.) Accordingly, when exporting or carrying abroad this product, follow the Foreign Exchange and Foreign Trade Control Law and its related regulations with respect to the complementary export controls.
4. The technical information described in this document shows typical characteristics and example application circuits for the products. The release of such information is not to be construed as a warranty of or a grant of license under our or any third party's intellectual property rights or any other rights.
5. The products listed in this document are intended and designed for use as general electronic components in standard applications (office equipment, telecommunication equipment, measuring instruments, consumer electronic products, amusement equipment etc.). Those customers intending to use a product in an application requiring extreme quality and reliability, for example, in a highly specific application where the failure or misoperation of the product could result in human injury or death should first contact us.
    - Aerospace Equipment
    - Equipment Used in the Deep Sea
    - Power Generator Control Equipment (nuclear, steam, hydraulic, etc.)
    - Life Maintenance Medical Equipment
    - Fire Alarms / Intruder Detectors
    - Vehicle Control Equipment (automotive, airplane, railroad, ship, etc.)
    - Various Safety Devices
    - Traffic control system
    - Combustion equipment

    In case your company desires to use this product for any applications other than general electronic equipment mentioned above, make sure to contact our company in advance. Note that the important requirements mentioned in this section are not applicable to cases where operation requirements such as application conditions are confirmed by our company in writing after consultation with your company.
6. We are making our continuous effort to improve the quality and reliability of our products, but semiconductor products are likely to fail with certain probability. In order to prevent any injury to persons or damages to property resulting from such failure, customers should be careful enough to incorporate safety measures in their design, such as redundancy feature, fire containment feature and fail-safe feature. We do not assume any liability or responsibility for any loss or damage arising from misuse or inappropriate use of the products.
7. The products have been designed and tested to function within controlled environmental conditions. Do not use products under conditions that deviate from methods or applications specified in this datasheet. Failure to employ the products in the proper applications can lead to deterioration, destruction or failure of the products. We shall not be responsible for any bodily injury, fires or accident, property damage or any consequential damages resulting from misuse or misapplication of the products.
8. Quality Warranty
    8-1. Quality Warranty Period
    In the case of a product purchased through an authorized distributor or directly from us, the warranty period for this product shall be one (1) year after delivery to your company. For defective products that occurred during this period, we will take the quality warranty measures described in section 8-2. However, if there is an agreement on the warranty period in the basic transaction agreement, quality assurance agreement, delivery specifications, etc., it shall be followed.
    8-2. Quality Warranty Remedies
    When it has been proved defective due to manufacturing factors as a result of defect analysis by us, we will either deliver a substitute for the defective product or refund the purchase price of the defective product.
    Note that such delivery or refund is sole and exclusive remedies to your company for the defective product.
    8-3. Remedies after Quality Warranty Period
    With respect to any defect of this product found after the quality warranty period, the defect will be analyzed by us. On the basis of the defect analysis results, the scope and amounts of damage shall be determined by mutual agreement of both parties. Then we will deal with upper limit in Section 8-2. This provision is not intended to limit any legal rights of your company.
9. Anti-radiation design is not implemented in the products described in this document.
10. The X-ray exposure can influence functions and characteristics of the products. Confirm the product functions and characteristics in the evaluation stage.
11. WLCSP products should be used in light shielded environments. The light exposure can influence functions and characteristics of the products under operation or storage.
12. Warning for handling Gallium and Arsenic (GaAs) products (Applying to GaAs MMIC, Photo Reflector). These products use Gallium (Ga) and Arsenic (As) which are specified as poisonous chemicals by law. For the prevention of a hazard, do not burn, destroy, or process chemically to make them as gas or power. When the product is disposed of, please follow the related regulation and do not mix this with general industrial waste or household waste.
13. Please contact our sales representatives should you have any questions or comments concerning the products or the technical information.

NISSHINBO

Nisshinbo Micro Devices Inc.

Official website
https://www.nisshinbo-microdevices.co.jp/en/

Purchase information
https://www.nisshinbo-microdevices.co.jp/en/buy/