# High Isolation X-SP3T (DP6T) SWITCH

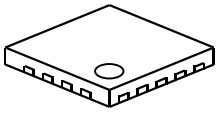
## ■ GENERAL DESCRIPTION

The NJG1683ME7 is a GaAs X (cross) - SP3T (DP6T) switch MMIC for switching of balanced (differential) triple band filters, upper pin compatible for NJG1655ME7. It features low insertion loss and very high isolation for balanced signal input which makes it much suited for balanced filter switching.

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



**NJG1683ME7**

*) The X-SP3T is a paired SP3T switch that features two identical SP3T switches being integrated into one chip. The two SP3T switches are controlled synchronously, and their respective RF lines cross each other on the chip.

## ■ APPLICATIONS

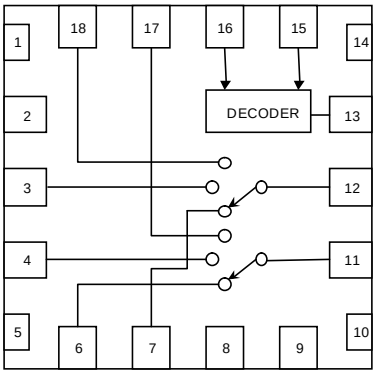
Switching of balanced type filters (Triple band) application
Suitable for 3G and LTE application

## ■ FEATURES

| | | |
|---|---|---|
| ● Low operation voltage | $V_{DD}$=1.5~4.5V | |
| ● Low control voltage | $V_{CTL(H)}$=1.8V typ. | |
| ● High isolation | 55dB typ. | @f=1.0GHz, $P_{IN}$=0dBm |
| (Balanced mode) | 47dB typ. | @f=2.0GHz, $P_{IN}$=0dBm |
| | 45dB typ. | @f=2.7GHz, $P_{IN}$=0dBm |
| ● Low insertion loss | 0.35dB typ. | @f=1.0GHz, $P_{IN}$=0dBm |
| | 0.45dB typ. | @f=2.0GHz, $P_{IN}$=0dBm |
| | 0.60dB 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 | | |
| ● MSL1 | | |

## ■ PIN CONFIGURATION

(Top View)




Pin connection

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

## ■ 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 |

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

## ■ ABSOLUTE MAXIMUM RATINGS

($T_a$=+25°C, $Z_s$=$Z_l$=50Ω)

| PARAMETER | SYMBOL | CONDITIONS | RATINGS | UNITS |
|---|---|---|---|---|
| RF Input Power | $P_{IN}$ | $V_{DD}$ =2.7V, $V_{CTL}$=0V/1.8V | 28 | dBm |
| Supply Voltage | $V_{DD}$ | VDD terminal | 5.0 | V |
| Control Voltage | $V_{CTL}$ | VCTL1, VCTL2 terminal | 5.0 | V |
| Power Dissipation | $P_D$ | Four-layer FR4 PCB with through-hole (101.5x114.5mm), $T_j$=150°C | 1400 | mW |
| Operating Temp. | $T_{opr}$ | | -40~+90 | °C |
| Storage Temp. | $T_{stg}$ | | -55~+150 | °C |

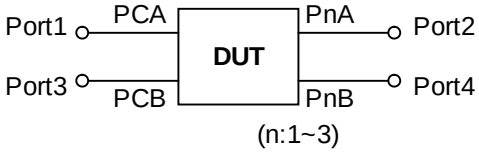
## ■ ELECTRICAL CHARACTERISTICS

(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 | $I_{DD}$ | | - | 20 | 40 | μA |
| Control Voltage (LOW) | $V_{CTL(L)}$ | | 0 | - | 0.45 | V |
| Control Voltage (HIGH) | $V_{CTL(H)}$ | | 1.35 | 1.8 | 4.5 | V |
| Control Current | $I_{CTL}$ | | - | 2 | 8 | μA |
| Insertion Loss 1 | LOSS1 | f=1.0GHz, $P_{IN}$=0dBm | - | 0.35 | 0.55 | dB |
| Insertion Loss 2 | LOSS2 | f=2.0GHz, $P_{IN}$=0dBm | - | 0.45 | 0.70 | dB |
| Insertion Loss 3 | LOSS3 | f=2.7GHz, $P_{IN}$=0dBm | - | 0.60 | 0.85 | dB |
| Balanced mode isolation 1 (Note1) | B-ISL1 | f=1.0GHz, $P_{IN}$=0dBm PC-P1,P2,P3 | 50 | 55 | - | dB |
| Balanced mode isolation 2 (Note1) | B-ISL2 | f=2.0GHz, $P_{IN}$=0dBm PC-P1,P2,P3 | 42 | 47 | - | dB |
| Balanced mode isolation 3 (Note1) | B-ISL3 | f=2.7GHz, $P_{IN}$=0dBm PC-P1,P2,P3 | 40 | 45 | - | dB |
| Isolation 1 | ISL1 | f=1.0GHz, $P_{IN}$=0dBm PCA-P1A,P2A,P3A, PCB-P1B,P2B,P3B | 28 | 31 | - | dB |
| Isolation 2 | ISL2 | f=2.0GHz, $P_{IN}$=0dBm PCA-P1A,P2A,P3A, PCB-P1B,P2B,P3B | 22 | 25 | - | dB |
| Isolation 3 | ISL3 | f=2.7GHz, $P_{IN}$=0dBm PCA-P1A,P2A,P3A, PCB-P1B,P2B,P3B | 18 | 21 | - | dB |
| Isolation 4 | ISL4 | f=2.0GHz, $P_{IN}$=0dBm, PCA-PCB | 15 | 18 | | dB |
| Input Power at 0.2dB Compression Point | $P_{-0.2dB}$ | f=2.0GHz | 19 | 23 | - | dBm |
| VSWR | VSWR | f=2.0GHz, on state | - | 1.2 | 1.5 | |
| Switching Time | Tsw | 50% $V_{CTL}$ to 10%/90% RF | - | 2 | 5 | μs |

Note1:
In application circuit, Calculation of “Balanced Mode Isolation” uses following formula.

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



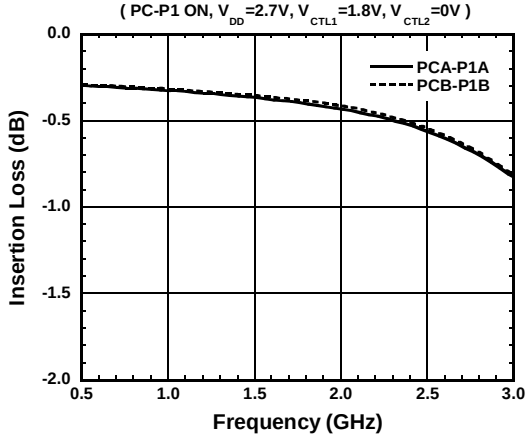
## ■ TERMINAL INFORMATION

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

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

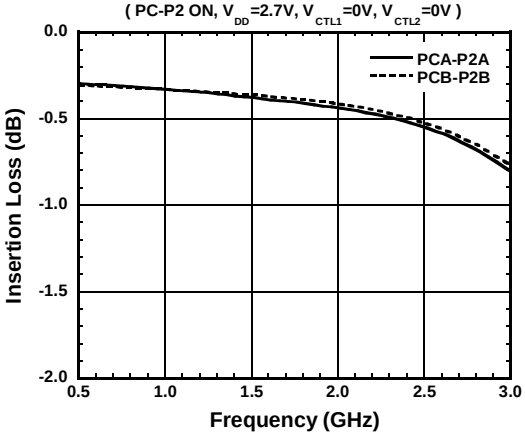
**Insertion Loss vs. Frequency**

( PC-P1 ON, $V_{DD}$=2.7V, $V_{CTL1}$=1.8V, $V_{CTL2}$=0V )



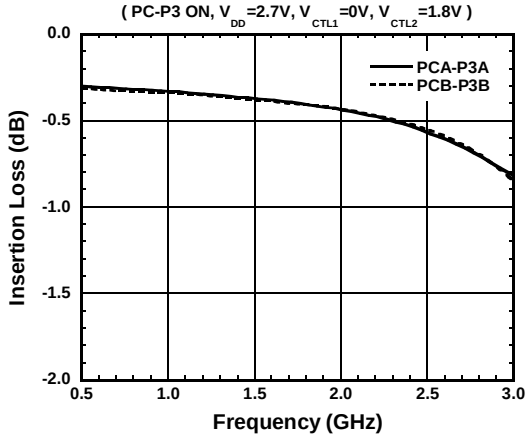

**Insertion Loss vs. Frequency**

( PC-P2 ON, $V_{DD}$=2.7V, $V_{CTL1}$=0V, $V_{CTL2}$=0V )



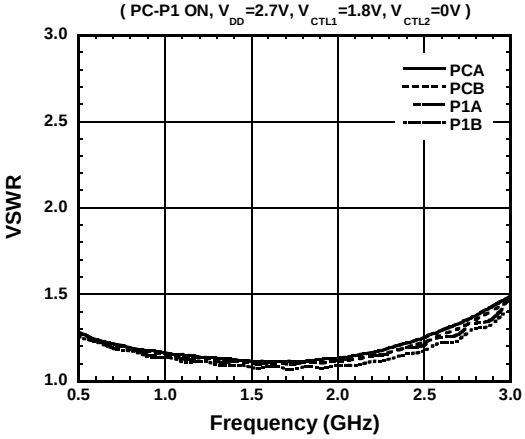

**Insertion Loss vs. Frequency**

( PC-P3 ON, $V_{DD}$=2.7V, $V_{CTL1}$=0V, $V_{CTL2}$=1.8V )



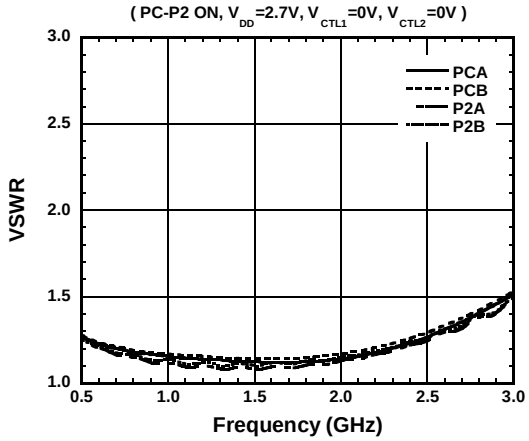

**VSWR vs. Frequency**

( PC-P1 ON, $V_{DD}$=2.7V, $V_{CTL1}$=1.8V, $V_{CTL2}$=0V )



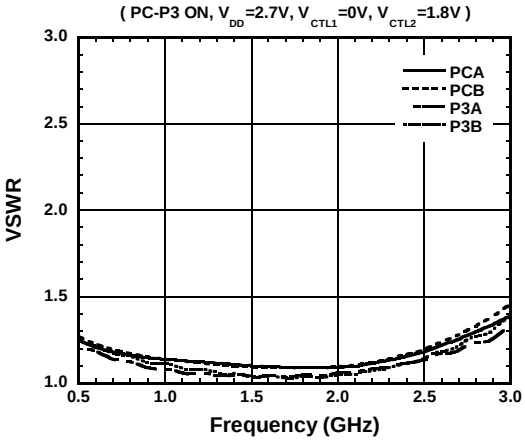

**VSWR vs. Frequency**

( PC-P2 ON, $V_{DD}$=2.7V, $V_{CTL1}$=0V, $V_{CTL2}$=0V )




**VSWR vs. Frequency**

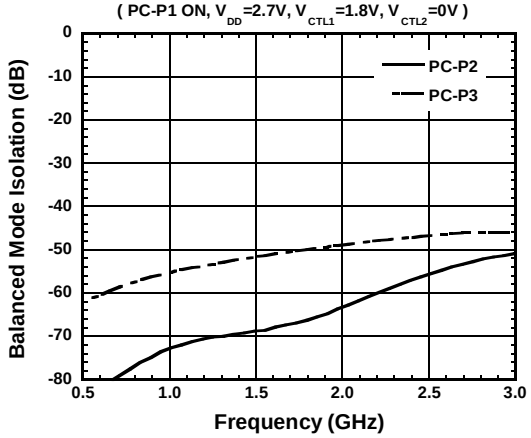
( PC-P3 ON, $V_{DD}$=2.7V, $V_{CTL1}$=0V, $V_{CTL2}$=1.8V )



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

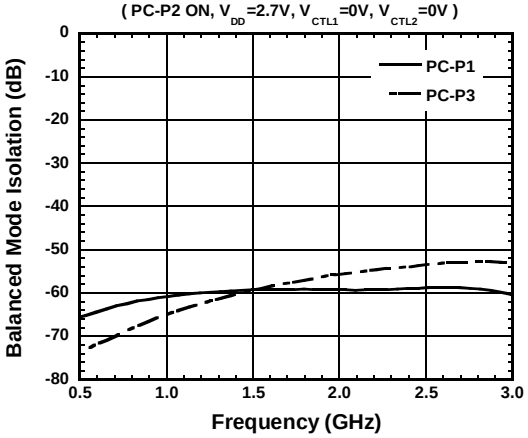
**Balanced Mode Isolation vs. Frequency**

( PC-P1 ON, $V_{DD}$=2.7V, $V_{CTL1}$=1.8V, $V_{CTL2}$=0V )



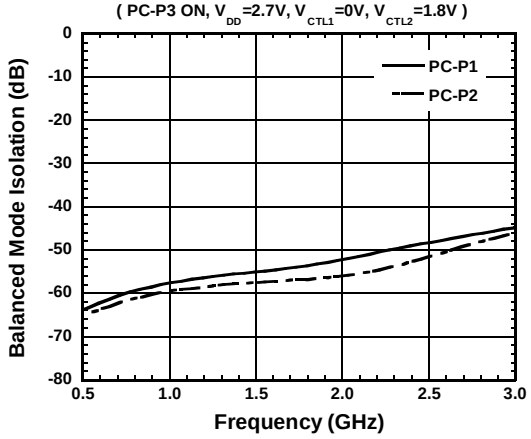

**Balanced Mode Isolation vs. Frequency**

( PC-P2 ON, $V_{DD}$=2.7V, $V_{CTL1}$=0V, $V_{CTL2}$=0V )



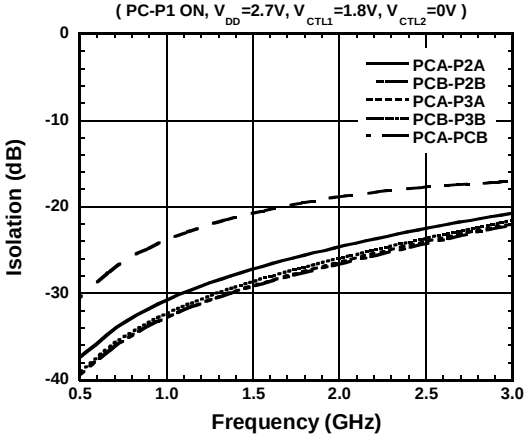

**Balanced Mode Isolation vs. Frequency**

( PC-P3 ON, $V_{DD}$=2.7V, $V_{CTL1}$=0V, $V_{CTL2}$=1.8V )



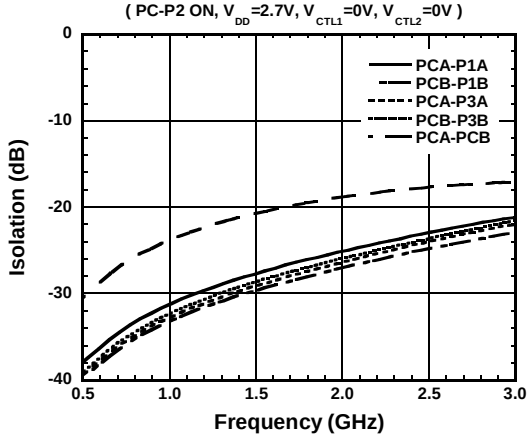

**Isolation vs. Frequency**

( PC-P1 ON, $V_{DD}$=2.7V, $V_{CTL1}$=1.8V, $V_{CTL2}$=0V )



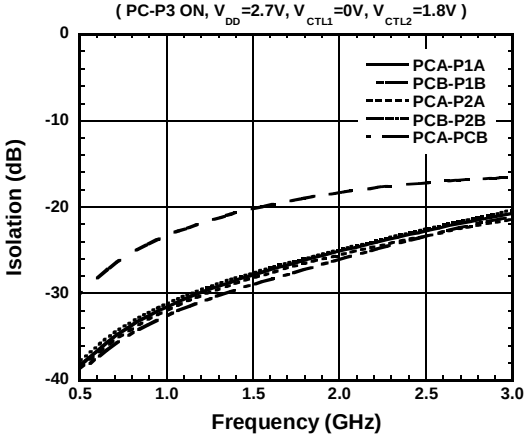

**Isolation vs. Frequency**

( PC-P2 ON, $V_{DD}$=2.7V, $V_{CTL1}$=0V, $V_{CTL2}$=0V )




**Isolation vs. Frequency**

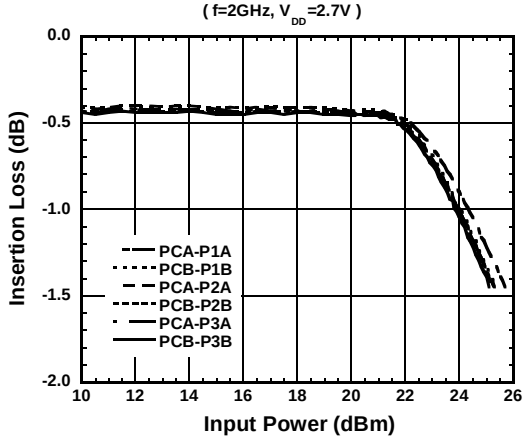
( PC-P3 ON, $V_{DD}$=2.7V, $V_{CTL1}$=0V, $V_{CTL2}$=1.8V )



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

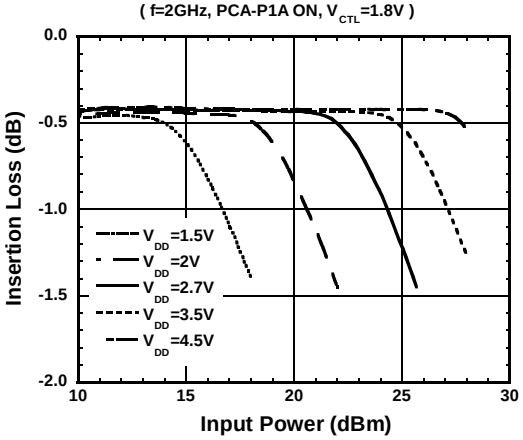
**Insertion Loss vs. Input Power**

( f=2GHz, $V_{DD}$=2.7V )



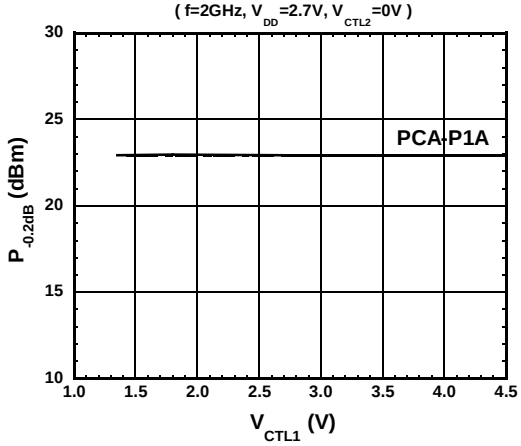

**Insertion Loss vs. Input Power**

( f=2GHz, PCA-P1A ON, $V_{CTL}$=1.8V )



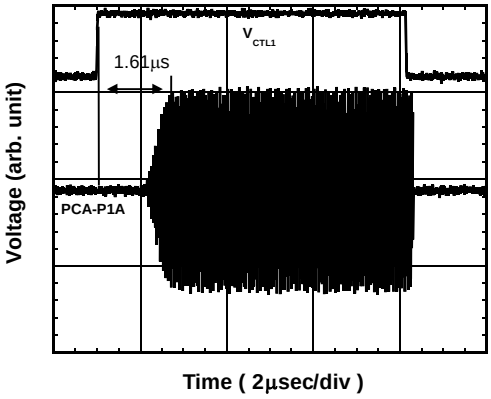

**$P_{-0.2dB}$ vs. $V_{CTL}$**

( f=2GHz, $V_{DD}$=2.7V, $V_{CTL2}$=0V )



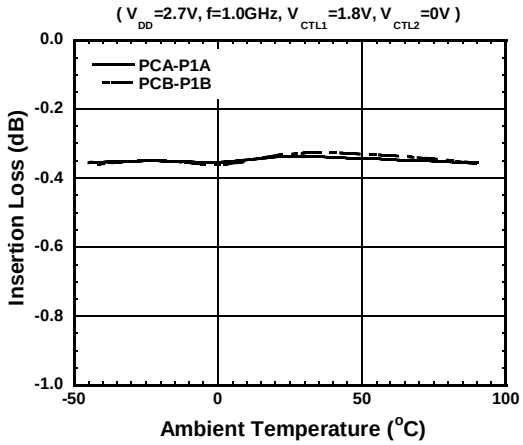

**Switching Time**

( $V_{DD}$=2.7V, $V_{CTL2}$=0V )

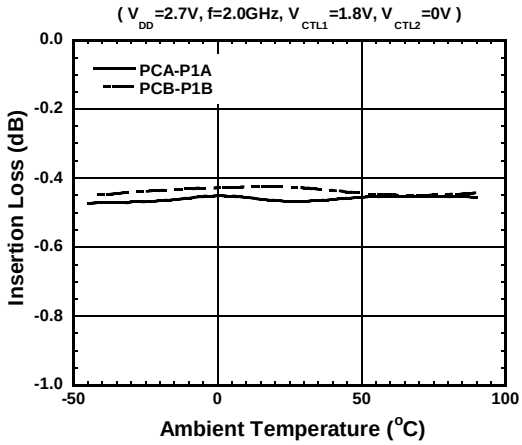


■ **ELECTRICAL CHARACTERISTICS** (With Application circuit, Loss of external circuit are excluded)

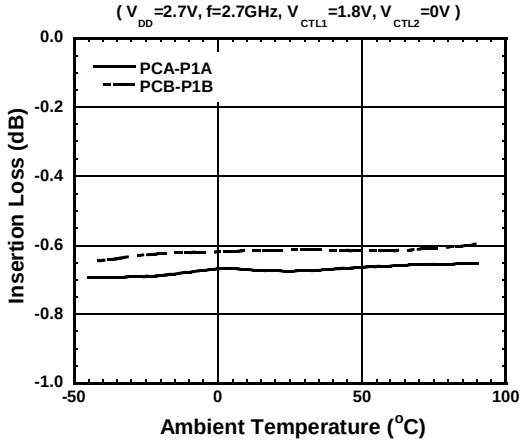
**Insertion Loss vs. Ambient Temperature**



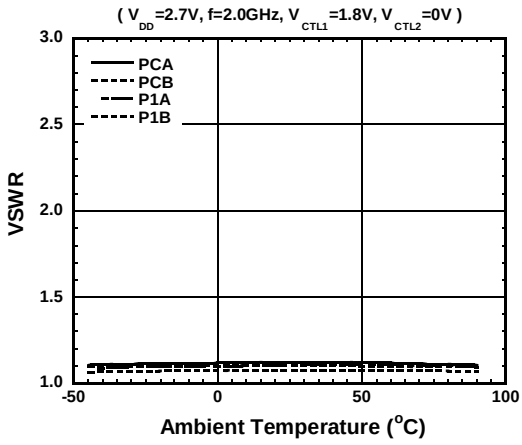

**Insertion Loss vs. Ambient Temperature**



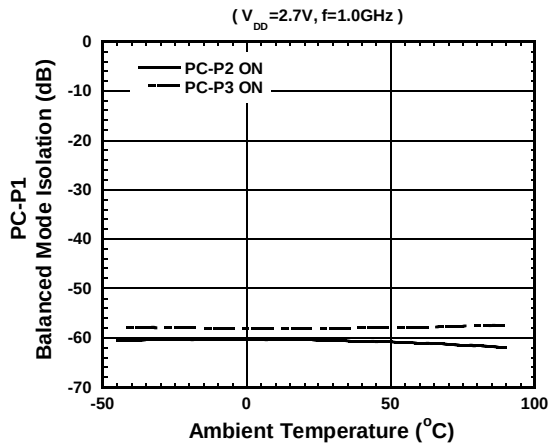

**Insertion Loss vs. Ambient Temperature**



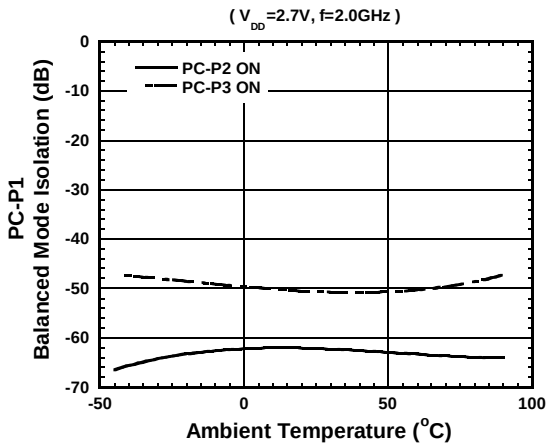

**VSWR vs. Ambient Temperature**




**Balanced Mode Isolation vs. Ambient Temperature**



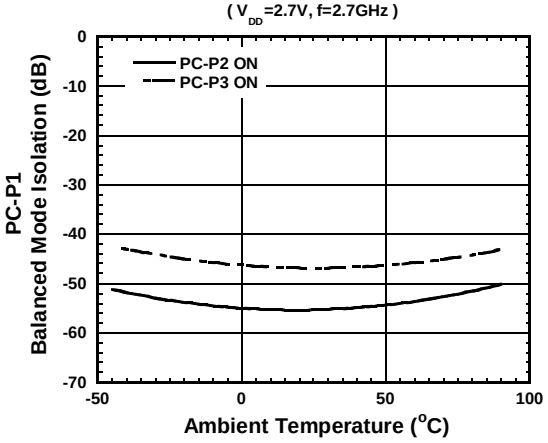

**Balanced Mode Isolation vs. Ambient Temperature**



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

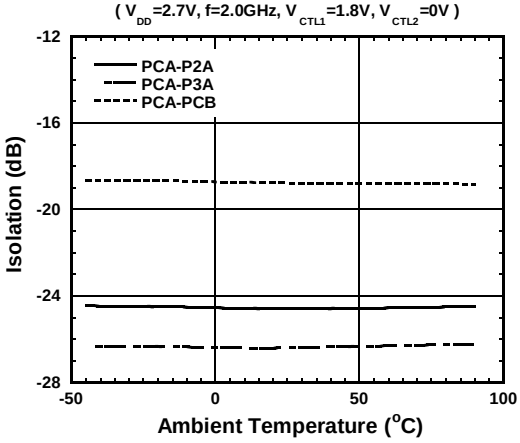
**Balanced Mode Isolation vs. Ambient Temperature**

( $V_{DD}$=2.7V, f=2.7GHz )



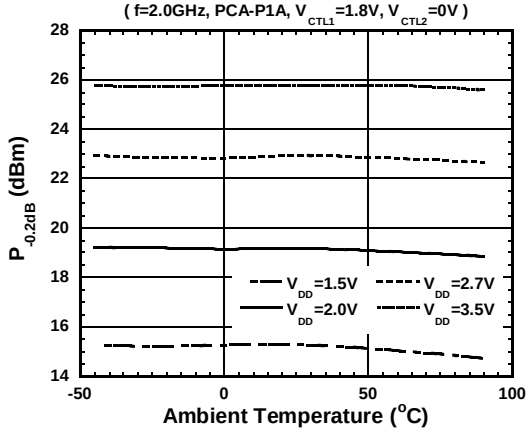

**Isolation vs. Ambient Temperature**

( $V_{DD}$=2.7V, f=2.0GHz, $V_{CTL1}$=1.8V, $V_{CTL2}$=0V )



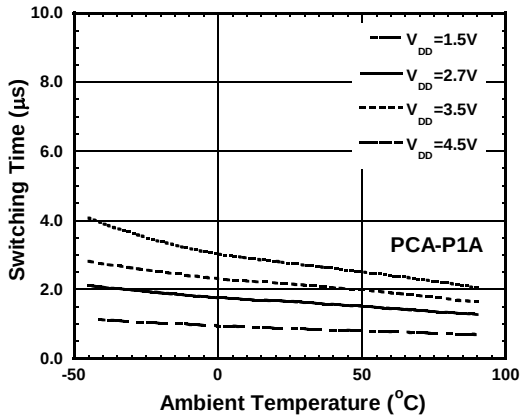

**$P_{-0.2dB}$ vs. Ambient Temperature**

( f=2.0GHz, PCA-P1A, $V_{CTL1}$=1.8V, $V_{CTL2}$=0V )



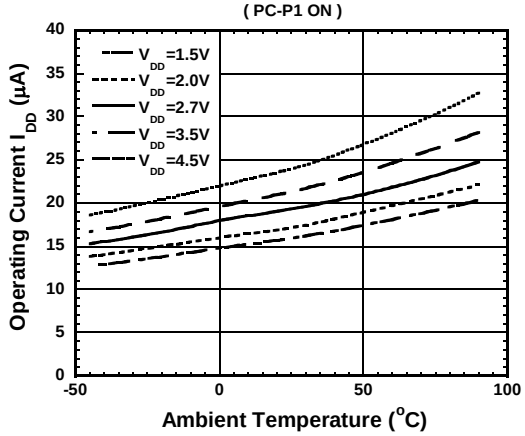

**Switching Time vs. Ambient Temperature**

( f=2.0GHz, PC-P1 ON )

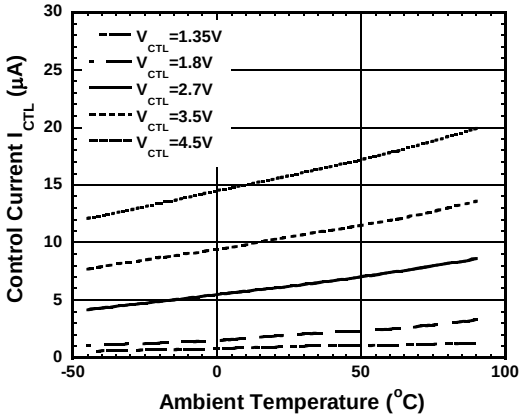



**$I_{DD}$ vs. Ambient Temperature**

( PC-P1 ON )

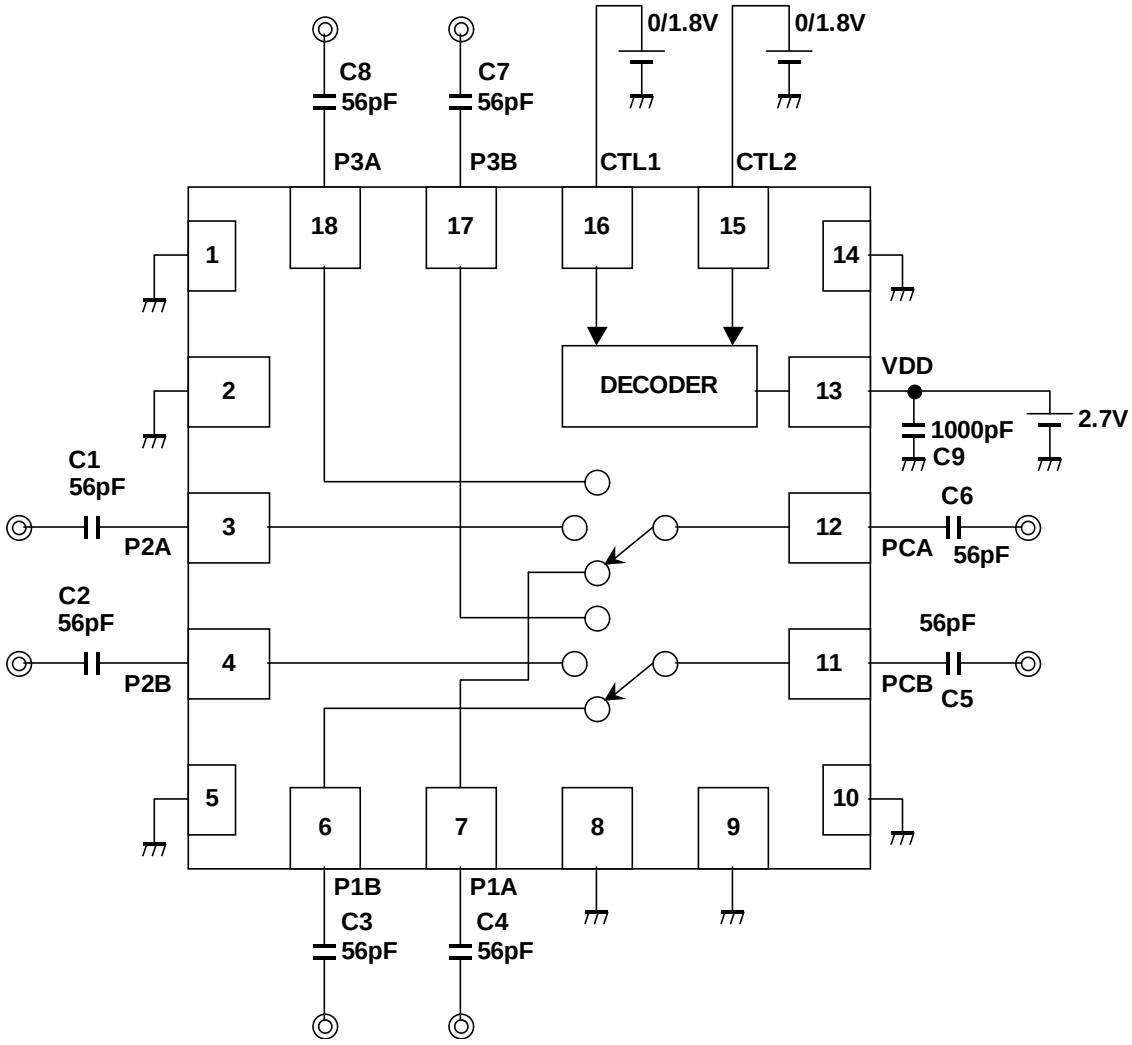



**$I_{CTL}$ vs. Ambient Temperature**



## ■ APPLICATION CIRCUIT

(TOP VIEW)

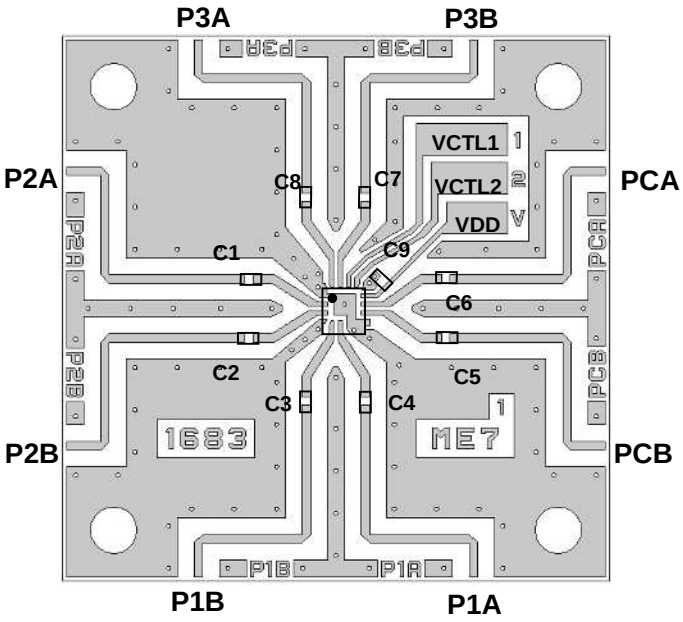



## ■ PARTS LIST

| PART ID | Value | Notes |
|---|---|---|
| C1~C8 | 56pF | MURATA (GRM15) |
| C9 | 1000pF | |

## ■ TEST PCB LAYOUT

(TOP VIEW)

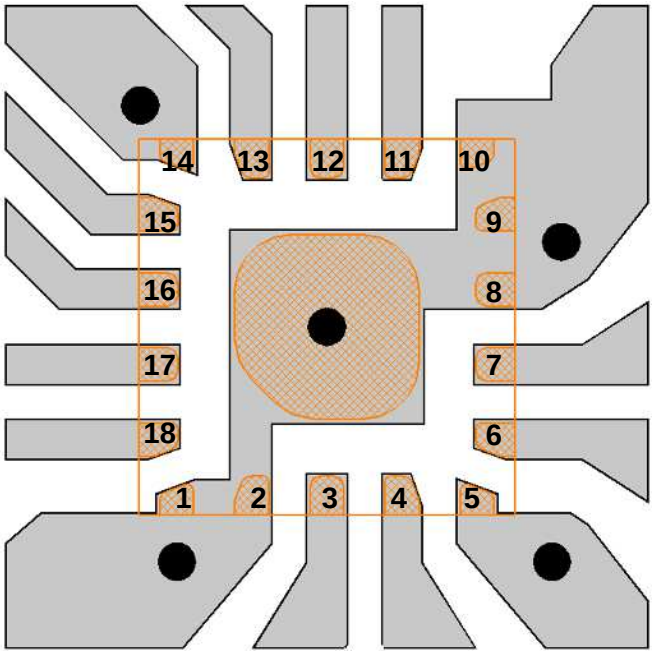



| | |
|---|---|
| PCB: | FR-4, t=0.2mm |
| Capacitor Size: | 1005 |
| Strip Line Width: | 0.4mm |
| PCB Size: | 26 x 26mm |

Losses of PCB, capacitors and connectors

| Frequency (GHz) | Loss (dB) |
|---|---|
| 1.0 | 0.33 |
| 2.0 | 0.57 |
| 2.7 | 0.71 |

**<PCB LAYOUT GUIDELINE>**




PCB Pattern

Through-hole (radius: 0.10mm)

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 1, 2, 8, 9 and 10 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~C8).
(However, in case there is no possibility that DC current flows, the DC blocking capacitors are unnecessary, e.g. 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 (C9) 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.

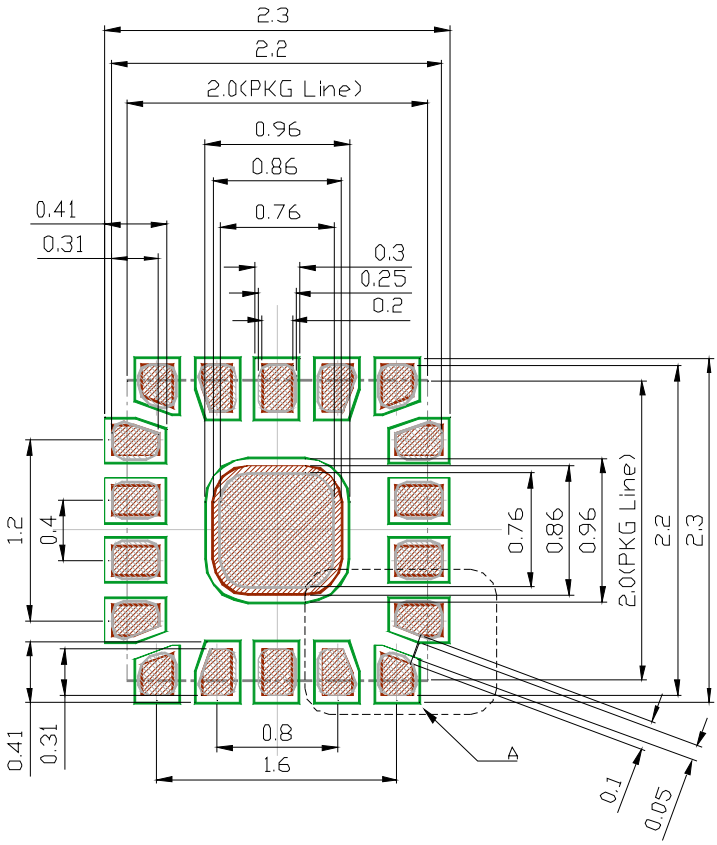
## ■ RECOMMENDED FOOTPRINT PATTERN (EQFN18-E7 PACKAGE REFERENCE)

: Land

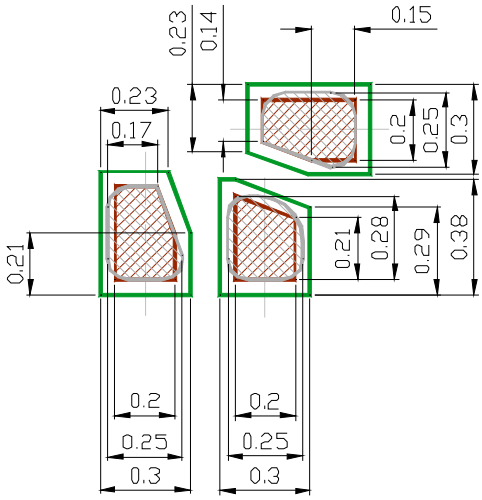
: Mask (Open area) *Metal mask thickness: 100um

: Resist (Open area)

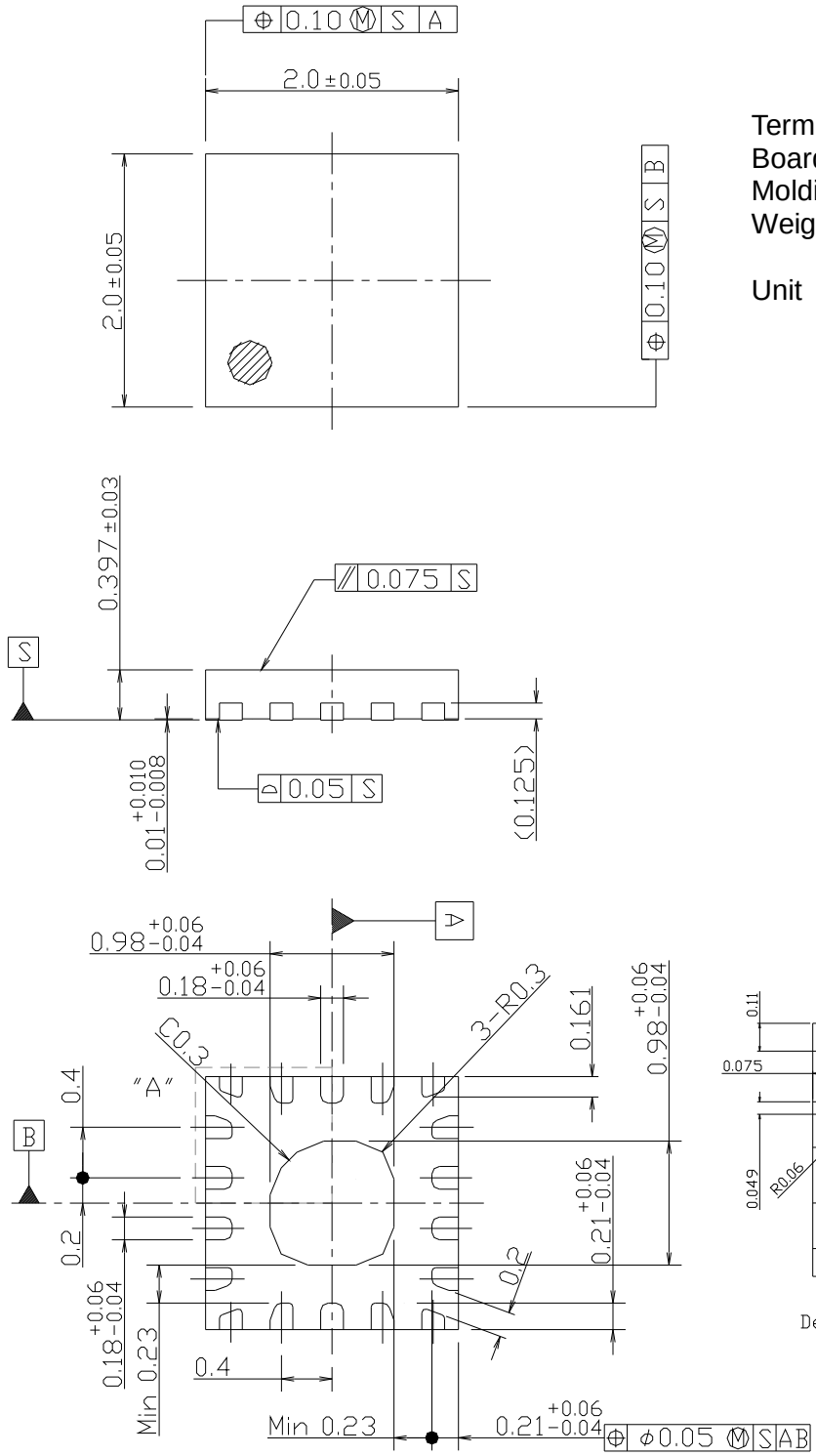
PKG : 2.0mm x 2.0mm
Pin pitch : 0.4mm




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.

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    - Power Generator Control Equipment (nuclear, steam, hydraulic, etc.)
    - Life Maintenance Medical Equipment
    - Fire Alarms / Intruder Detectors
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    - Various Safety Devices
    - Traffic control system
    - Combustion equipment

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    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.

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