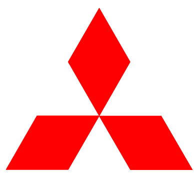


ELECTROSTATIC SENSITIVE DEVICE
OBSERVE HANDLING PRECAUTIONS

MITSUBISHI RF MOSFET MODULE

# RA01L8693MA

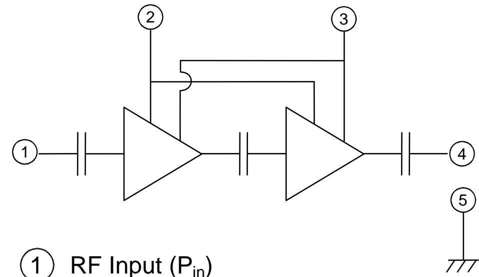
RoHS Compliance , 865-928MHz 1.4W 3.3V, 2 Stage Amp. For RFID READER / WRITER

## DESCRIPTION

The RA01L8693MA is a 1.4-watt RF MOSFET Amplifier Module. The battery can be connected directly to the drain of the enhancement-mode MOSFET transistors.

The output power and drain current increase as the gate voltage increases. With a gate voltage around 0.5V (minimum), output power and drain current increases substantially. The nominal output power becomes available at 1.5V (typical) and 2.0V (maximum). At $V_{GG}$=2.0V, the typical gate current is 1mA.

## BLOCK DIAGRAM




1. RF Input ($P_{in}$)
2. Gate Voltage ($V_{GG}$), Power Control
3. Drain Voltage ($V_{DD}$), Battery
4. RF Output ($P_{out}$)
5. RF Ground

**PACKAGE CODE: H58**

## FEATURES

- Enhancement-Mode MOSFET Transistors ($I_{DD}\cong 0$ @ $V_{DD}$=3.3V, $V_{GG}$=0V)
- $P_{out}$>1.4W, $\eta_T$>38% @ $V_{DD}$=3.3V, $V_{GG}$=2.0V, $P_{in}$=30mW
- Broadband Frequency Range: 865-928MHz
- Low-Power Control Current $I_{GG}$=1mA (typ) at $V_{GG}$=2.0V
- Module Size: 9.1 x 9.2 x 1.8 mm

## RoHS COMPLIANCE

- RA01L8693MA -101 is a RoHS compliance products.
- RoHS compliance is indicate by the letter “G” after the Lot Marking.
- This product include the lead in the Glass of electronic parts and the lead in electronic Ceramic parts.

  How ever ,it is applicable to the following exceptions of RoHS Directions.

  1.Lead in the Glass of a cathode-ray tube, electronic parts, and fluorescent tubes.

  2.Lead in electronic Ceramic parts.

## ORDERING INFORMATION:

| ORDER NUMBER | SUPPLY FORM |
|---|---|
| RA01L8693MA -101 | Antistatic tray,<br>25 modules/tray |

**MAXIMUM RATINGS** ($T_{case}$=+25deg.C. unless otherwise specified)

| SYMBOL | PARAMETER | CONDITIONS | RATING | UNIT |
|---|---|---|---|---|
| $V_{DD}$ | Drain Voltage | $V_{GG}$<2.0V, $Z_G$=$Z_L$=50ohm | 6 | V |
| $V_{GG}$ | Gate Voltage | $V_{DD}$<3.3V, $P_{in}$=0mW, $Z_G$=$Z_L$=50ohm | 3 | V |
| $P_{in}$ | Input Power | f=865-928MHz, $V_{GG}$<2.0V $Z_G$=$Z_L$=50ohm | 50 | mW |
| $P_{out}$ | Output Power | | 3 | W |
| $T_{case(OP)}$ | Operation Case Temperature Range | | -30 to +90 | °C |
| $T_{stg}$ | Storage Temperature Range | | -40 to +110 | °C |

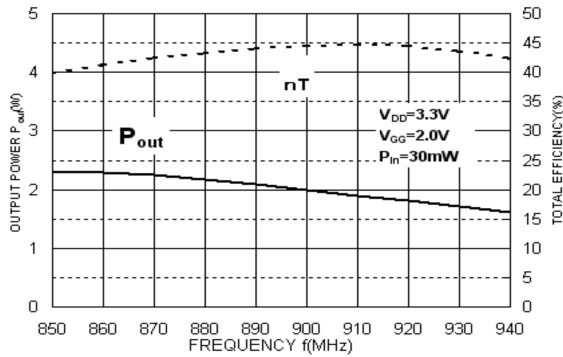
The above parameters are independently guaranteed.

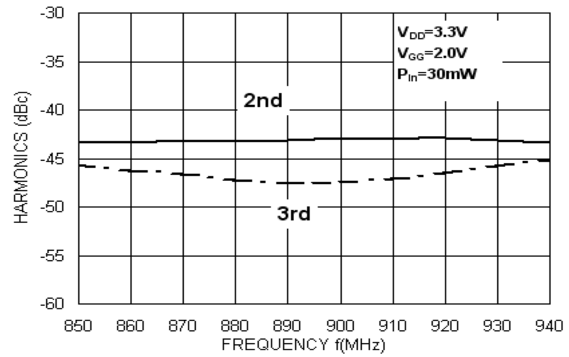
**ELECTRICAL CHARACTERISTICS** ($T_{case}$=+25°C , $Z_G$=$Z_L$=50Ω, unless otherwise specified)

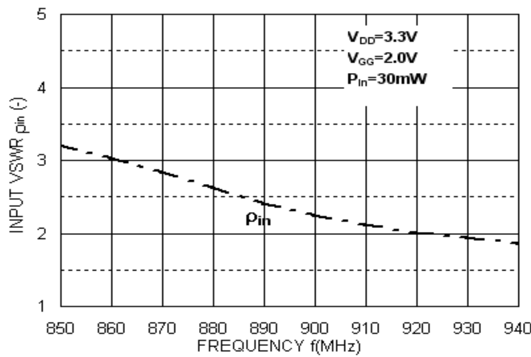
| SYMBOL | PARAMETER | CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| f | Frequency Range | | 865 | | 928 | MHz |
| $P_{out}$ | Output Power | $V_{DD}$=3.3V $V_{GG}$=2.0V $P_{IN}$=30mW | 1.4 | | | W |
| $\eta_T$ | Total Efficiency | | 38 | | | % |
| $2f_o$ | $2^{nd}$ Harmonic | | | | -30 | dBc |
| $\rho_{in}$ | Input VSWR | | | | 4.4:1 | — |
| $P_{out}$ (2) | Output Power | $V_{DD}$=5.0V,$V_{GG}$=2.0V, $P_{IN}$=30mW | 2 | | | W |
| $\eta_T$ (2) | Total Efficiency | $V_{DD}$=5.0V $P_{IN}$=30mW,$P_{OUT}$=2W ($V_{GG}$ control) | | 35 | | % |
| — | Stability | $V_{DD}$=2.5/3.3/6.0V, $V_{GG}$=0.5-2.0V, $P_{IN}$=20-50mW , Po<2.5W Zg=50ohm, Load VSWR=4:1 | No parasitic oscillation | | | — |
| — | Load VSWR Tolerance | $V_{DD}$=6.0V, $P_{IN}$=30mW, $P_{out}$=2W ($V_{GG}$ control), Zg=50ohm, Load VSWR=20:1 | No degradation or destroy | | | — |

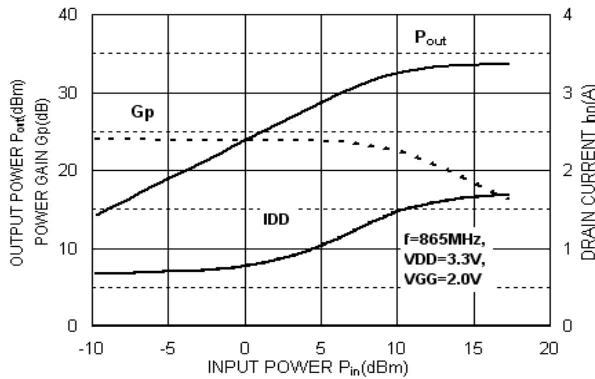
All parameters, conditions, ratings, and limits are subject to change without notice.

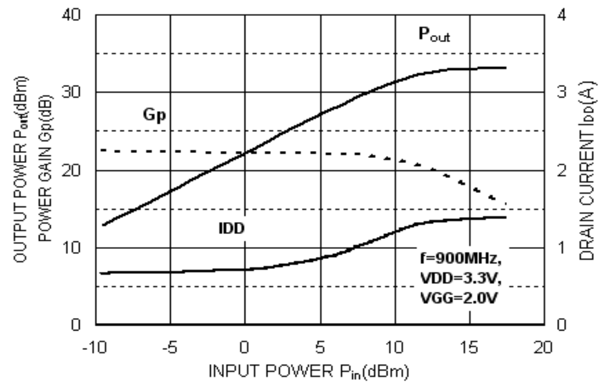
## TYPICAL PERFORMANCE (Vdd=3.3V,$T_{case}$=+25deg.C, $Z_G$=$Z_L$=50Ω, unless otherwise specified)

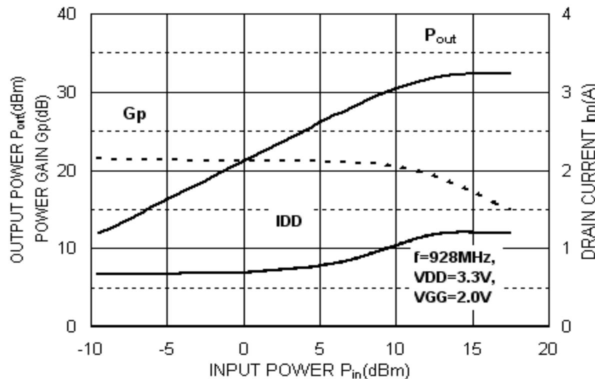


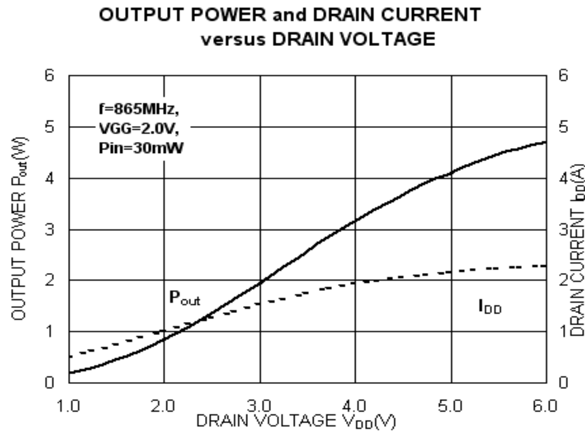



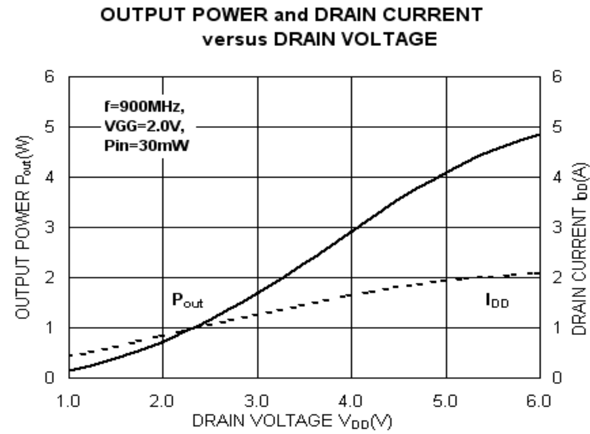



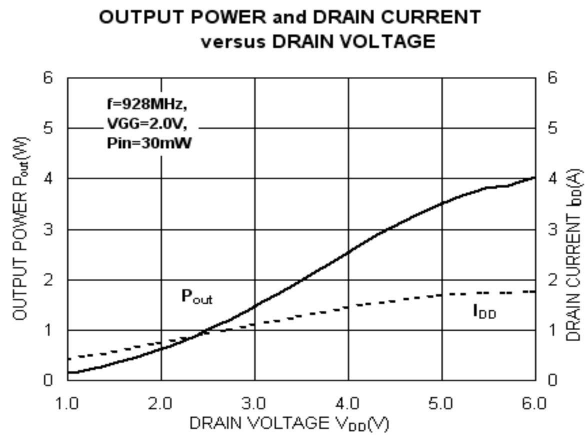



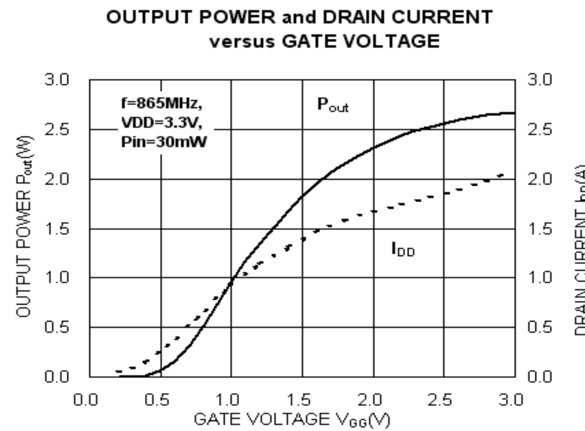



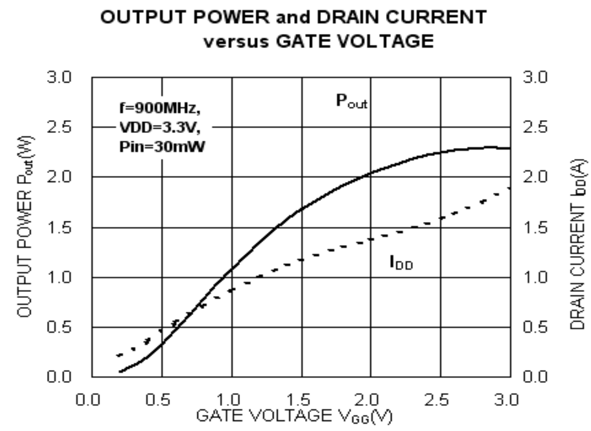
**TYPICAL PERFORMANCE** ($T_{case}$=+25deg.C, $Z_G$=$Z_L$=50Ω, unless otherwise specified)

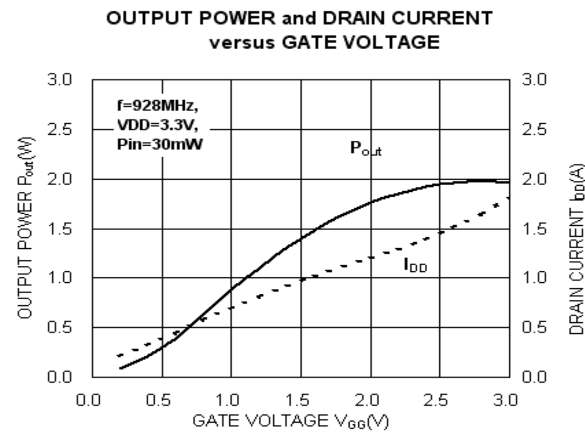


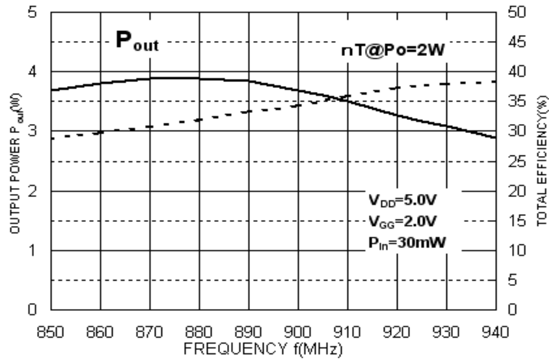



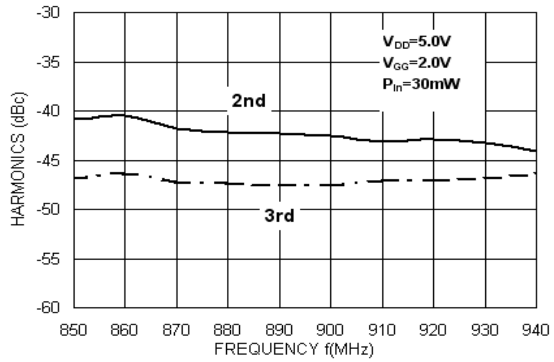



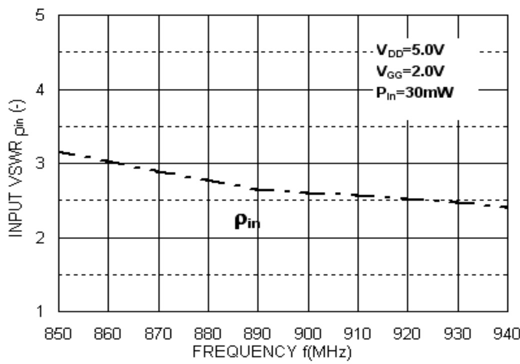



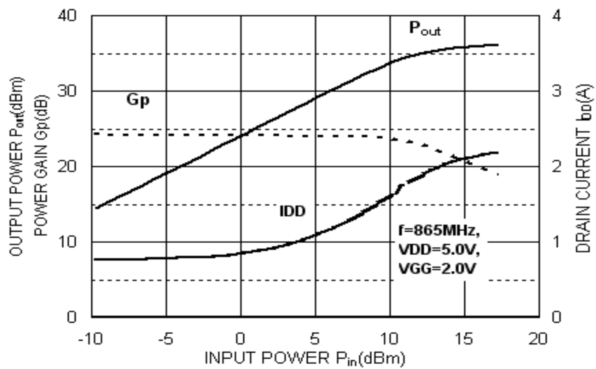



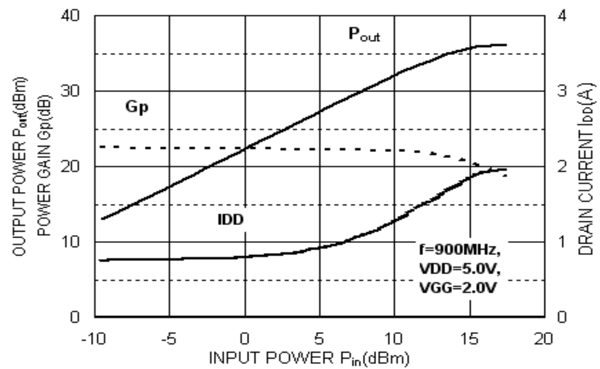
**TYPICAL PERFORMANCE** (Vdd=5.0V,$T_{case}$=+25deg.C, $Z_G$=$Z_L$=50Ω, unless otherwise specified)

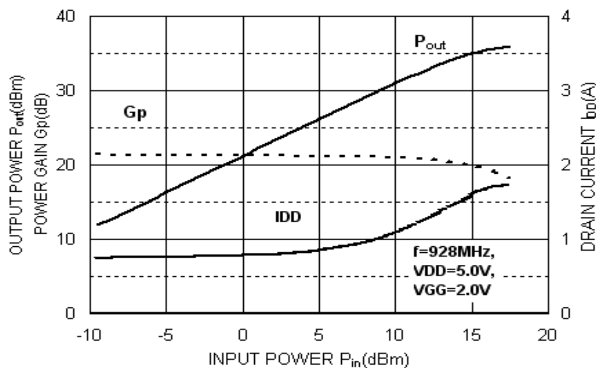


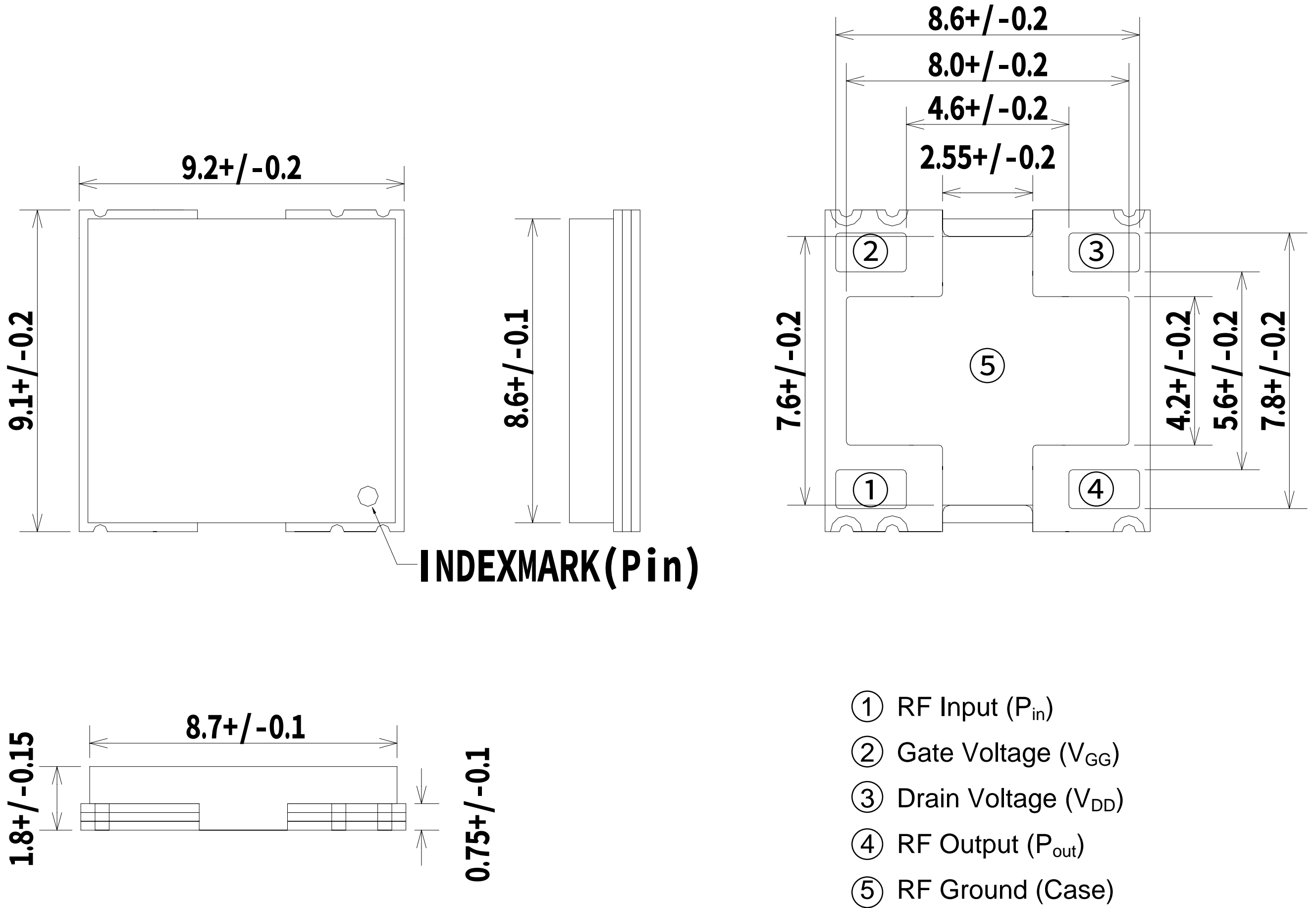



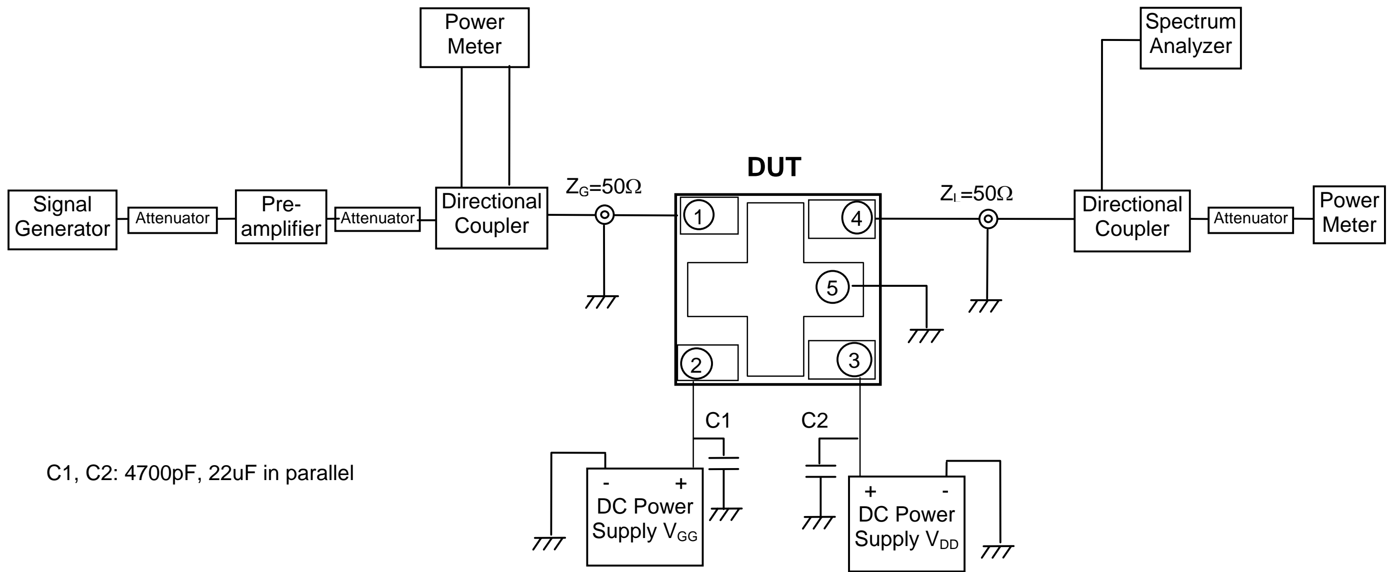



**OUTLINE DRAWING** (mm)

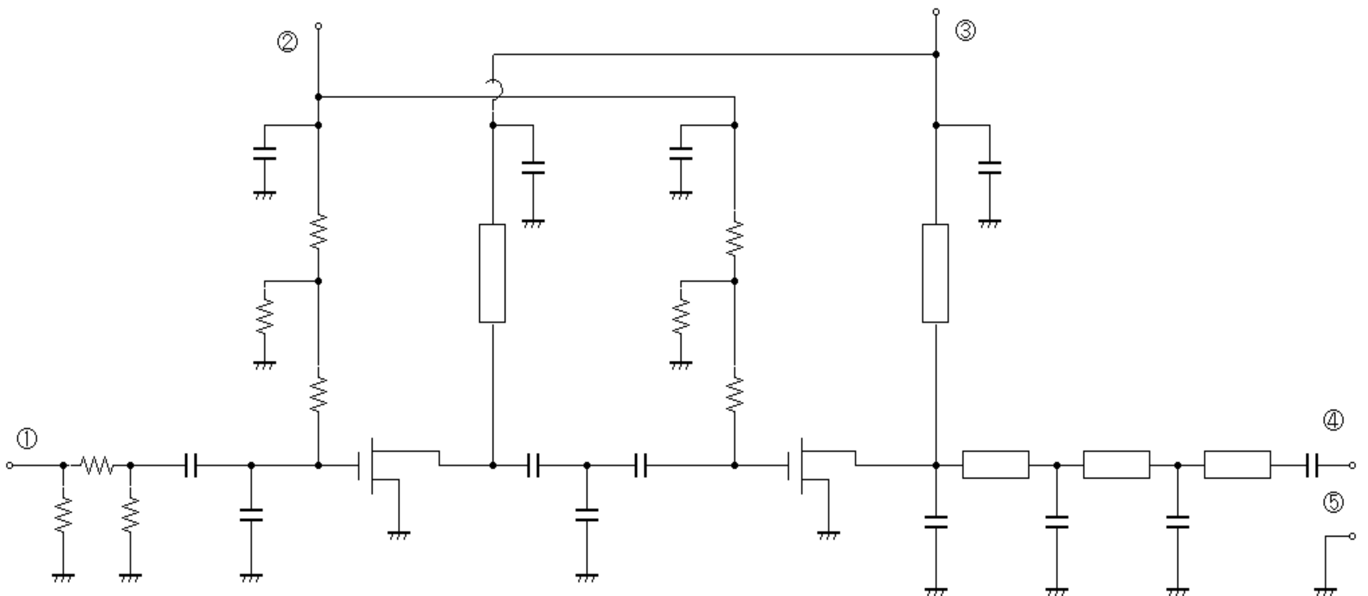


## TEST BLOCK DIAGRAM




① RF Input ($P_{in}$)
② Gate Voltage ($V_{GG}$)
③ Drain Voltage ($V_{DD}$)
④ RF Output ($P_{out}$)
⑤ RF Ground

## EQUIVALENT CIRCUIT



**PRECAUTIONS, RECOMMENDATIONS, and APPLICATION INFORMATION:**

**Construction:**

This module consists of an alumina substrate. For mechanical protection, a metal cap is attached (witch makes the improvement of RF radiation easy). The MOSFET transistor chips are die bonded onto the substrate, wire bonded to the substrate, and coated with resin. Lines on the substrate (eventually inductors), chip capacitors, and resistors form the bias and matching circuits. The DC and RF connection is provided at the backside of substrate.
Following conditions must be avoided:
a) Bending forces on the alumina substrate (for example, by fast thermal changes)
b) Defluxing solvents reacting with the resin coating on the MOSFET chips (for example, Trichloroethylene)
c) Frequent on/off switching that causes thermal expansion of the resin
d) ESD, surge, over voltage in combination with load VSWR, and oscillation

**ESD:**

This MOSFET module is sensitive to ESD voltages down to 1000V. Appropriate ESD precautions are required.

**Thermal Design of the Heat Sink:**

At $P_{out}$=1.4W, $V_{DD}$=3.3V and $P_{in}$=30mW each stage transistor operating conditions are:

| Stage | $P_{in}$ (W) | $P_{out}$ (W) | $R_{th(ch-case)}$ (°C/W) | $I_{DD}$ @ $\eta_T$=38% (A) | $V_{DD}$ (V) |
|---|---|---|---|---|---|
| 1st | 0.03 | 0.3 | 57.2 | 0.115 | 3.3 |
| 2nd | 0.3 | 1.4 | 7.6 | 1.00 | |

The channel temperatures of each stage transistor $T_{ch} = T_{case} + (V_{DD} \times I_{DD} - P_{out} + P_{in}) \times R_{th(ch-case)}$ are:

$T_{ch1} = T_{case} + (3.3V \times 0.115A - 0.3W + 0.03W) \times 57.2°C/W = T_{case} + 6.3\ °C$
$T_{ch2} = T_{case} + (3.3V \times 1.0A - 1.4W + 0.3W) \times 7.6°C/W = T_{case} + 16.7\ °C$

For long-term reliability, it is best to keep the module case temperature ($T_{case}$) below 70°C. For an ambient temperature $T_{air}$=45°C and $P_{out}$=1.4W, the required thermal resistance $R_{th\ (case-air)} = ( T_{case} - T_{air}) / ( (P_{out} / \eta_T ) - P_{out} + P_{in} )$ of the heat sink, including the contact resistance, is:
$R_{th(case-air)} = (70°C - 45°C) / (1.4W/38\% - 1.4W + 0.03W) = 10.8°C/W$

When mounting the module with the thermal resistance of 10.8°C/W, the channel temperature of each stage transistor is:

$T_{ch1} = T_{air} + 31.3\ °C$
$T_{ch2} = T_{air} + 41.7\ °C$

The 175°C maximum rating for the channel temperature ensures application under derated conditions.

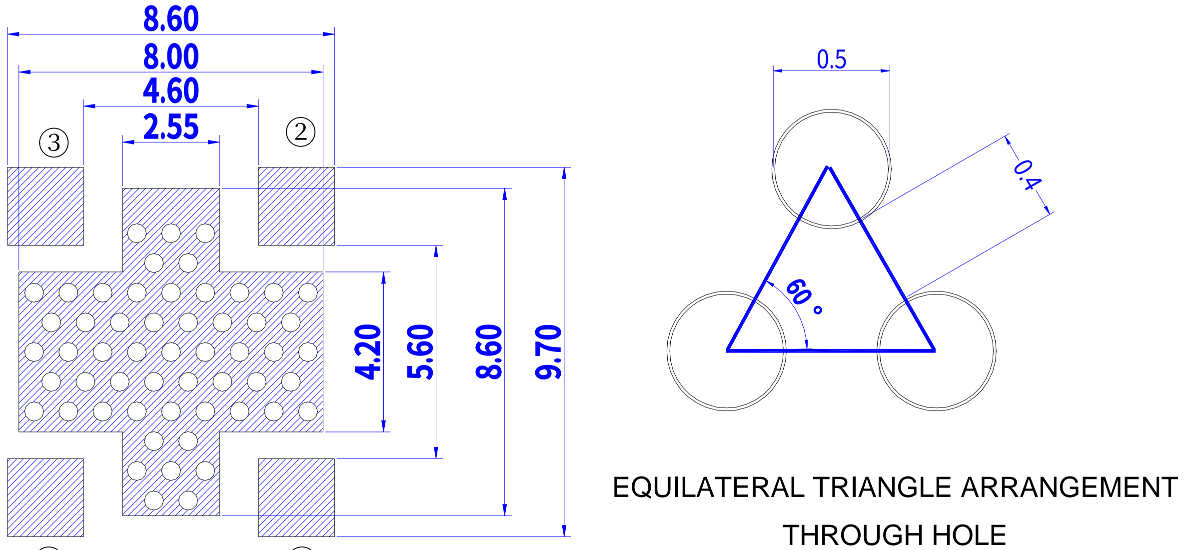
**Output Power Control:**
The recommended method to control the output power is by the input power (Pin).

**Oscillation:**
To test RF characteristics, this module is put on a fixture with two bias decoupling capacitors each on gate and drain, a 4.700 pF chip capacitor, located close to the module, and a 22 µF (or more) electrolytic capacitor.
When an amplifier circuit around this module shows oscillation, the following may be checked:
a) Do the bias decoupling capacitors have a low inductance pass to the case of the module?
b) Is the load impedance $Z_L$=50Ω
c) Is the source impedance $Z_G$=50Ω

**Frequent on/off switching:**
In base stations, frequent on/off switching can cause thermal expansion of the resin that coats the transistor chips and can result in reduced or no output power. The bond wires in the resin will break after long-term thermally induced mechanical stress.

**Quality:**
Mitsubishi Electric is not liable for failures resulting from base station operation time or operating conditions exceeding those of RFID reader / writer.
This module technology results from more than 20 years of experience, field proven in tens of millions of mobile radios. Currently, most returned modules show failures such as ESD, substrate crack, and transistor burnout, which are caused by improper handling or exceeding recommended operating conditions. Few degradation failures are found.

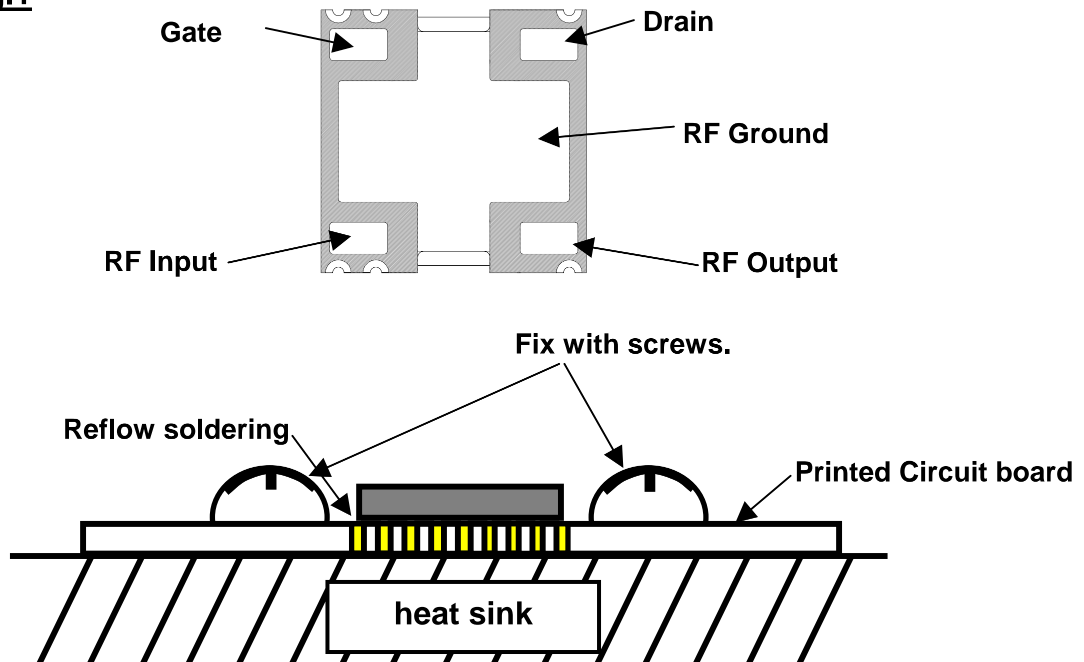
**P.C.B Land Pattern Recommendation**




**Mounting method**

Mitsubishi recommends device mounting like Fig.1. In order to heat radiation, we recommend to fix the PCB and heat sink by screw. This PCB has through holes that filled up with resin to restrain the solder flow under the RF Ground. The interval of through holes is 0.4mm and these holes are arranged in the shape of equilateral triangles.

**Fig.1**

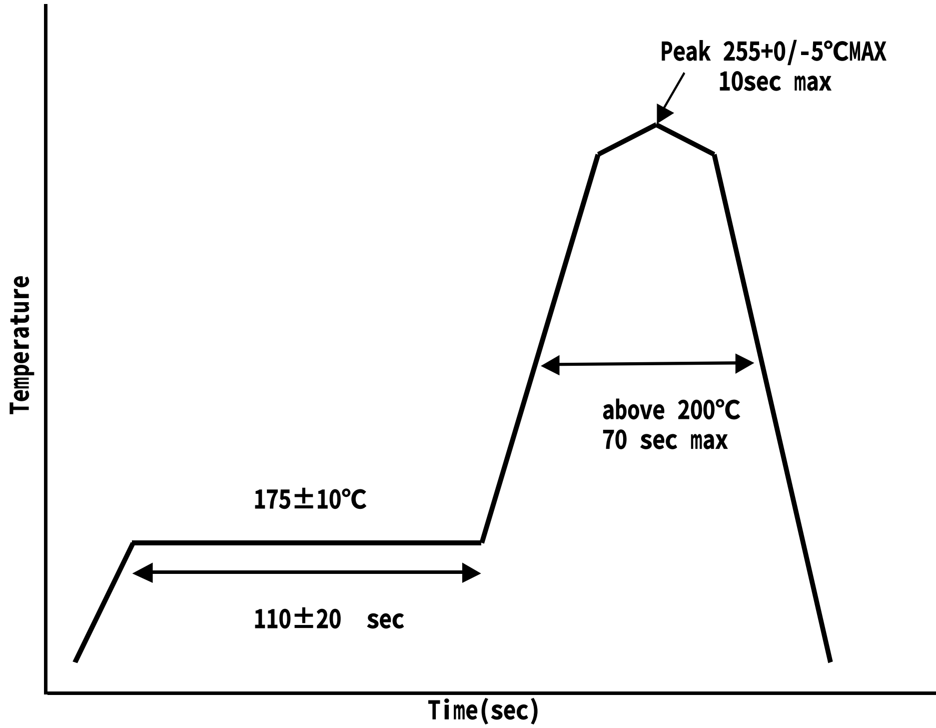



# Note: Mitsubishi Heat Sink size=30 * 60 * 10 Unit: mm

**Reflow soldering**

Regarding to reflow soldering, Mitsubishi recommend the heat profile of Fig.2. Reflow soldering is able to do till 3 times.

**Fig.2**



## Precautions for the use of MITSUBISHI silicon RF power amplifier devices

1. The specifications of mention are not guarantee values in this data sheet. Please confirm additional details regarding operation of these products from the formal specification sheet. For copies of the formal specification sheets, please contact one of our sales offices.
2. RA series products (RF power amplifier modules) and RD series products (RF power transistors) are designed for consumer mobile communication terminals and were not specifically designed for use in other applications. In particular, while these products are highly reliable for their designed purpose, they are not manufactured under a quality assurance testing protocol that is sufficient to guarantee the level of reliability typically deemed necessary for critical communications elements. Examples of critical communications elements would include transmitters for base station applications and fixed station applications that operate with long term continuous transmission and a higher on-off frequency during transmitting, especially for systems that may have a high impact to society.
3. RA series and RD series products use MOSFET semiconductor technology. They are sensitive to ESD voltage therefore appropriate ESD precautions are required.
4. In the case of use in below than recommended frequency, there is possibility to occur that the device is deteriorated or destroyed due to the RF-swing exceed the breakdown voltage.
5. In order to maximize reliability of the equipment, it is better to keep the devices temperature low. It is recommended to utilize a sufficient sized heat-sink in conjunction with other cooling methods as needed (fan, etc.) to keep the case temperature for RA series products lower than 60deg/C under standard conditions, and less than 90deg/C under extreme conditions.
6. RA series products are designed to operate into a nominal load impedance of 50 ohms. Under the condition of operating into a severe high load VSWR approaching an open or short, an over load condition could occur. In the worst case there is risk for burn out of the transistors and burning of other parts including the substrate in the module.
7. The formal specification includes a guarantee against parasitic oscillation under a specified maximum load mismatch condition. The inspection for parasitic oscillation is performed on a sample basis on our manufacturing line. It is recommended that verification of no parasitic oscillation be performed at the completed equipment level also.
8. For specific precautions regarding assembly of these products into the equipment, please refer to the supplementary items in the specification sheet.
9. Warranty for the product is void if the products protective cap (lid) is removed or if the product is modified in any way from it's original form.
10. For additional "Safety first" in your circuit design and notes regarding the materials, please refer the last page of this data sheet.
11. Please refer to the additional precautions in the formal specification sheet.

**warning !**

Do not use the device at the exceeded the maximum rating condition. In case of plastic molded devices, the exceeded maximum rating condition may cause blowout, smoldering or catch fire of the molding resin due to extreme short current flow between the drain and the source of the device. These results causes in fire or injury.

## Keep safety first in your circuit designs !

Mitsubishi Electric Corporation puts the maximum effort into making semiconductor products better and more reliable, but there is always the possibility that trouble may occur with them. Trouble with semiconductors may lead to personal injury, fire or property damage. Remember to give due consideration to safety when making your circuit designs, with appropriate measures such as (i) placement of substitutive, auxiliary circuits, (ii) use of non-flammable material or (iii) prevention against any malfunction or mishap.

## Notes regarding these

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