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Prepared : K. Kajiwara T.Okawa

Confirmed : T. Okawa

(Taking charge of Silicon RF by
MIYOSHI Electronics)

SUBJECT: PRECAUTIONS AND RECOMMENDATIONS FOR MITSUBISHI ELECTRIC SILICON RF POWER SEMICONDUCTORS

GENERAL:

MITSUBISHI ELECTRIC Silicon RF Power Semiconductors designed for mobile and portable radio applications have high reliability and good performance, as they are designed and manufactured under strict quality control.

However, the reliability of semiconductor devices are remarkably affected by usage conditions such as circuit constructions, mounting method, environments, etc., should be noted before use.

1. PRECAUTIONS TO BE TAKEN IN APPLICATION OF SILICON RF POWER SEMI- CONDUCTOR

MITSUBISHI ELECTRIC Silicon RF Power Semiconductors are designed for Mobile Communication terminals. They are not designed for Base Station applications.

MITSUBISHI ELECTRIC cannot take any liability for failures resulting from Base Stations operation time or conditions exceeding those normally found in Mobile Communication terminals.

In the case of using this devices for Base Stations or similar applications which have same operating conditions described above, the following conditions may result in failures.

- 1) Low supply voltage at first stage in combination with nominal input power.
(for Bip Devices)

Low supply voltage in combination with nominal input power changes the DC Base Bias of class AB operated transistors to negative values. In long term this leads to transistor DC forward current gain (hFE) degradation finally resulting in low device gain or output power.

- 2) Frequent on/off switching. (for Bip and MOSFET Devices)

On/off switching causes thermal expansion of the resin covering chips and wire bonds. In frequent and long term Base Station usage this mechanical stress causes the wire bonds to break resulting in reduced or no output power.

Other problems can occur when applying our RF devices for highly demanding Base Station applications.

Even under recommended operating conditions, Mitsubishi Electric can not take any liability for failures resulting from Base station operation time or conditions exceeding those normally found in Mobile Communication terminals.

2. MAXIMUM RATINGS

Maximum ratings of the RF Power Devices are defined by the “Absolute Maximum Ratings” shown in each specification sheet.

Maximum ratings should not be exceeded in any circumstances, even momentarily. And each maximum rating is guaranteed independently.

If a device is operated in excess of the absolute maximum ratings, the device may immediately be degraded or destroyed.

3. NORMAL OPERATING VOLTAGE

Normal operating voltage for Mitsubishi RF Power Modules is shown in electrical characteristics-conditions of output power or total efficiency.

For example, 12.5V for mobile radio, 9.6V, 7.2V for portable radio. For Bi-polar transistor module, base bias lead or lead which is connected to both base and collector, supply voltage should be regulated and + 0.2V maximum to the nominal operating voltage is recommended.

4. THERMAL DESIGN

In order to keep high reliability of the equipment, it is better to keep the device temperature low. The case temperature of the module is recommended to keep lower than 90 deg. C under all conditions, and to keep lower than 60 deg. C under standard conditions.

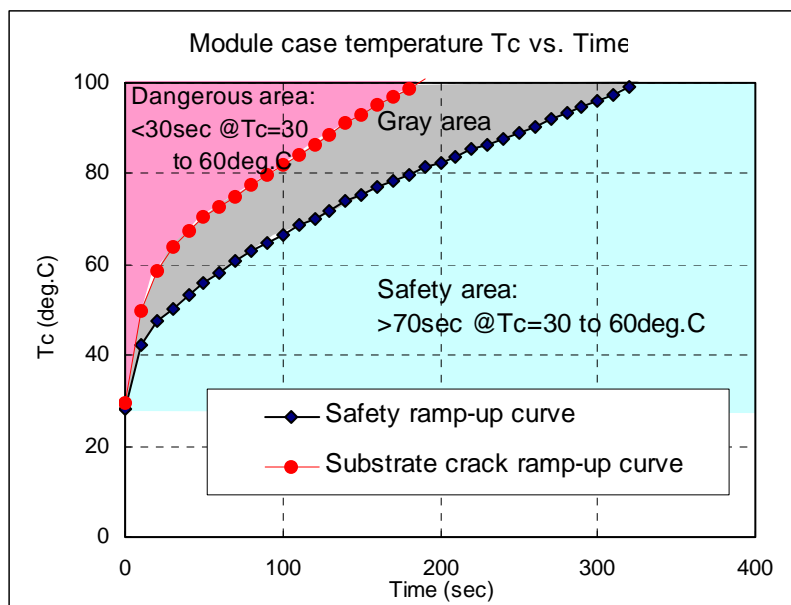
For discrete transistor, keep the operating junction temperature of Transistors $T_{j(op)}$ less than specified temperature.

Ceramic substrate in the module may crack by excessive stress such as foreign object between Fin and chassis or expansion by thermal force.

For foreign object between Fin and chassis, recommendation is written in next item 5.

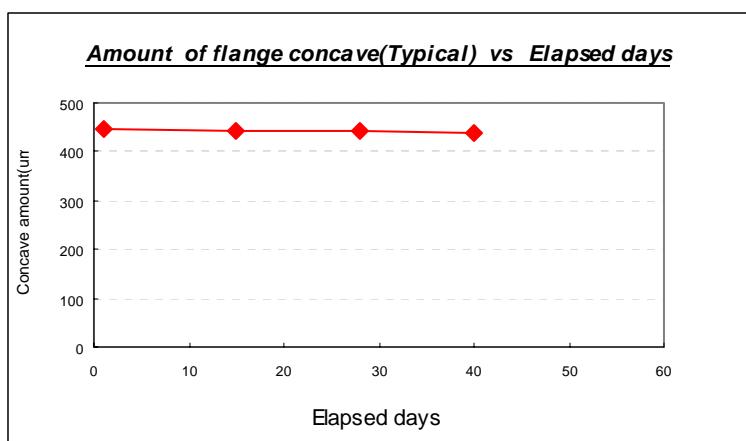
Concerning expansion by thermal force, MITSUBISHI recommend to design the ramp-up speed of module case temperature as below.

Customer needs to design the heat sink size and control the output power of the module in order to keep safety ramp-up curve.



5. MOUNTING AND HANDLING

5-1 When the module is mounted onto a heat sink of equipment, thermal compound to get heat sinking should be applied between the module’s fin and the heat sink. Following thermal compound is recommended. “G746 Shinetsu Chemical Industry Co., Ltd.” In addition, the copper flange on an aluminum heat sink will result in a bimetallic system which can create a bending problem. While the assembling process, which assembles copper flange and aluminum substrate, approximately 400um concave of flange will be resulted at H2S outline. Following graph shows typical performance of Concave amount of H2S outline vs. elapsed days. Elapsed days means the day of placed by itself at room temperature.



Accordingly, good thermal compound must be used to fill all gaps between the mounting surface. There will be no mechanical problem with excess compound as long as there is a path for the excess compound to escape as the module is tightened down with the mounting screws.

5-2 When mounting a device to the circuit, do not apply excessive stress to the leads or the fin. In particular, if there are foreign objects between the module and heat sink, or if there are some burrs or rising on the surface of the heat sink it may happen that the substrate of the module will crack or break due to excessive stress from screwing the modules onto the heat sink. Therefore, the surface of these heat sink in contact with the module must be as flat as possible (less than 50um). When screwing a module onto the heat sink, screw torque is recommended as the following Table 1.

Table 1 : Screw and Torque

Screw	Torque (kgf-cm)
M2	1.2 (0.9 - 1.5)
M2.6	2.4 (1.8 – 3)
M3	5 (4 – 6)
M4	11 (9 – 14)

Tightening sequence must be proceed as following method.

Mounting the modules should be given careful instruction and their procedures monitored at regular intervals. Since the flanges are punched from a roll of material, there can sometimes be a small “roll – up” at the end of the mounting flange. If the mounting hardware were tightened completely at one end first, it is easy to see that the other end could be “lifted” off the mounting surface well in excess of the allowable flange bending tolerance. This should be avoided by first lightly alternately snubbing down the mounting hardware “finger-tight.” Next, the hardware can be torqued to its final specification again in at least to sequential steps.

5-3 For Soldering, the major precautions are as follows :

1) Flux ;

Roles of flux are to remove oxidized layer on the object, and prevent from oxidation during heating or lowering surface tension on the objects. Rosin flux, which is less corrosive, and highly insulated, is recommended.

2) Soldering temperature ;

This module is designed for manual soldering.

In the case of Sn-Pb eutectic solder ;

The temperature of the lead soldering should be lower than 260 deg C with shorter than 10 seconds ,or lower than 350 deg C with shorter than 3 seconds.

In the case of Lead-Free solder ;

The temperature of the lead soldering should be lower than 350 deg C and shorter than 3 seconds.

3) Cleaning after soldering ;

The recommended solvent for cleaning the residual flux is the Ethyl Alcohol. Don't use Trichloroethylene type solvents.

5-4 When the module is screwed after soldering the leads to the circuit board, excessive stress is applied to the leads. Therefore, please solder the leads to the circuit board after screwing the modules onto the, heat sink.

5-5 If the module falls onto a hard surface, it will be damaged by mechanical shock and can no longer be used.

5-6 To obtain good stability and electrical performances, it is necessary to take precautions concerning the earth potential of the module. As the fin is the ground terminal, the fin should be connected to the ground of the set completely in RF condition.

5-7 Long lead connection to the external circuit board will cause performance degradation due to the impedance mismatch. So, the connection of the lead to the circuit board should be as short as possible.

6. VOLTAGE SUPPLY

If the modules have two or more leads for same DC supply voltage, and these leads are not well isolated, parasitic oscillation occasionally may occurred. Therefore, the all

DC supply leads should be combined by RFC (Radio Frequency Choke) and/ or bypass capacitor (10uF and 4700pF in parallel). Also the lead which is supplied different voltage from other lead (Ex. Lead for power control) should be isolated by bypass capacitor.

7. HANDLING PRECAUTIONS FOR ELECTROSTATIC DISCHARGE (ESD)

MOS FET devices have lower surge endurance compared with silicon bipolar devices. And there is a possibility of burn out when static electricity or surge is added to devices. Please take specific care described below. This is particularly important for SiRF MOS devices RA and RD series.

7-1 Workplace Environments

- 1) When humidity falls below 40% to 50%, human bodies and other insulated substances can easily become charged with Static Electricity due to contact and friction with other substances. Please maintain the relative humidity as about 60% or more in the workplace environment. If necessary, use Humidifier is recommended.
- 2) All equipments, jigs and tools in the workplace must be grounded to Earth.
- 3) Place a conductive mat ($10^{11}\Omega$ or less) over the floor of the workplace, or take other appropriate measure in order to protect against static electricity. And a conductive mat must be grounded to earth.
- 4) Cover the workbench surface also with a conductive mat ($10^{11}\Omega$ or less) and ground it to earth.
- 5) Avoid insulating materials that are likely to build up static charge. Such materials should be replaces with conductive materials as much as possible.
- 6) Make sure that work chairs must also be provided with anti-static textile cover and are grounded to the conductive mat on the floor through a metal chain or similar measures.
- 7) When in processes, packages may retain electrostatic charges, use an ionizer to neutralize ions.
- 8) Do not touch terminals of the device directly.
- 9) For temporally storage and transport, use appropriate containers (boxes, bags and jigs) made of anti-static materials or materials which can dissipate electrostatic charge.
- 10) The cart surface that comes into contact with device packaging is made of materials that conduct electrostatic charges and grounded to the conductive floor mat through metal chain.
- 11) Check the effect of anti-static measures by taking periodic measurements of electrostatic potential.

7-2 Operating Environments

- 1) The operator must wear anti-static clothes and conductive footwear that has a resistance in the range of $10^5\Omega$ to $10^8\Omega$. Test the conductivity of an operator 's static electricity level once a day or so by using a checker.
- 2) Operators must use a wrist strap or ankle strap which is grounded to earth via a resister of about between $0.25M\Omega$ and $1M\Omega$.
- 3) Use a soldering iron (powered by a low voltage of 6V to 24V) designed for use with semiconductors. The chip of the soldering iron must be grounded to earth

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- 4) . If the tweezers you use are possibly to touch the device terminals, use anti-static tweezers and in particular avoid metallic tweezers. If the device touches low resistance materials, rapid discharge can occur, and then the device can be degraded or destroyed.
- 5) Do not place the devices or their containers near by the strong sources of electric field such as CRT display and radio transmitters.

7-3 Post-Mounting Environments

- 1) Even after the device has been mounted on a printed circuit board (PCB), keep left from electrostatic charges should be taken into account.
- 2) When storing or shipping printed circuit boards with semiconductor devices mounted on them, store them in conductive containers, bags or racks. Avoid placing them in just plastic boxes, vinyl bags or polystyrene containers that are prone to static electricity build up.
- 3) When packing more than one printed circuit board in a box, use spacers so that PCBs do not come into contact with each other or rattle around in the container.
- 4) Use a conductive materials or cotton sheet even when covering them for the purpose of protecting from dust.
- 5) In processes of testing, inspection and installing sub-assembled PCB with semiconductor devices, operators should take the same body grounding as when handling the semiconductor devices themselves.

8. WARNING

Many devices use the Beryllium oxide substrate. Handle with care at the disposal.
In selection guide by function, devices used BeO is indicated.

9. 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.