A NEW EASY TO USE ISOLATED POWER PACKAGE

SGS has developed a new package, the ISOWATT218. This package has been designed to be produced with high volume automated equipment. It is easy to mount being fully isolated and reduces overall costs and improves reliability compared with conventional packages.

This note presents some general information on the package, the key parameters concerned with safety standards, and also examines the costs of mounting as well as thermal and electrical characteristics.

The isolation of the collector from the heatsink achieved by molding the package with a high thermal conductivity epoxy resin. The thickness of the resin is closely controlled over the back surface of the internal copper heatspreader.

When mounted directly on to a grounded heatsink the package exceeds the creepage and clearance distances required by UL and V_{DE} safety specifications. Some type of lead forming will be required in order that the creepage distances on the printed circuit board, to which the leads are soldered, are maintained.

Fig. 1 - The ISOWATT218

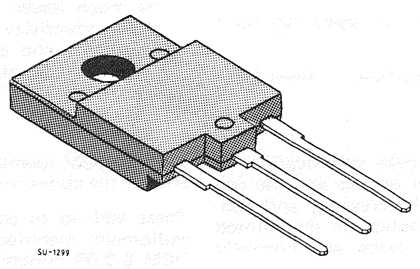
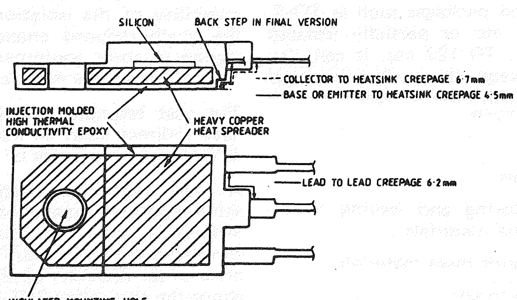


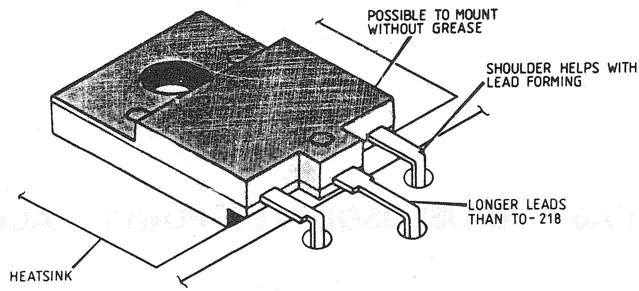
Fig. 2 - Construction of ISOWATT218



- 2.5 deg C/W JUNCTION-CASE THERMAL RESISTANCE GUARANTEED
- INSULATION > 5500v MEASURED , > 4000V GUARANTEED
- FULLY ENCAPSULATED IN RESIN
- INTERCHANGABLE WITH TO-218 AND SOT-93

SU-1305A

Fig. 3 - Mounting of the ISOWATT218 package



The requirements of V_{DE} can be summarised as: Isolation AC line to ground > 2500V AC for 1 minute or:

> 2750V AC for 1 second

Insulation resistance > 2MΩ at 500V DC for 1 minute

Creepage distance over the surface > 4mm (each plane surface > 1mm)

Clearance distance > 3mm

This package will respect these specifications if mounted either with a screw or clip and the collector lead is bent so that the creepage and clearance distances will be respected on the printed circuit board to which the leads will normally be connected.

COST COMPARISONS

The ISOWATT218 package saves the time and cost of mounting non isolated packages such as TO-3, SOT-93/TO-218, TO3P etc or partially isolated devices such as TO-247, TO-127 etc. It can also replace the TO-220 package which when mounted with isolating materials will have a higher thermal resistance than ISCWATT218.

The cost savings are:

1) Direct cost of materials
2) Cost of ordering, storing and issuing to assembly department the materials.
3) The time taken to mount these materials

These costs are estimated to be:

1) Silicon impegnated washer \$ 0.10 (1k resale) isolating bush \$ 0.02 (1k resale)
2) \$ 100/1000 = \$ 0.01 each up to \$ 0.10 each if handled in small batches.
3) Productivity of mounting a conventional plastic power transistor on a heatsink with isolating bush isolating washer and screw is estimated at 200/hour for TO-3 style packages the figure will be much lower, while with the ISOWATT218 the productivity should be increased by 50% . If using a clip or partially isolated device the difference is probably 50/hour. At a total labour cost of \$ 8/hour this saving is \$ 0.04 to \$ 0.08 per unit.

In large OEM quantities the material costs may be 30% of the above prices.

These add up to cost savings of \$ 0.3 for a small equipment manufacturer, or for a large volume OEM \$ 0.09 minimum! This could be substantially increased depending on labour costs and productivity.

There are other factors to consider such as the reliability of the isolation over the long term and the much reduced chance of failures at isolation testing of some equipment and the very high cost of rectifying these defects.

The cost estimates are direct costs, the user will have indirect costs to add which will increase the differential by a factor of 2 to 3 times.

A more expensive plastic compound is used to achieve good thermal conductivity and the molding process is more complex for the ISOWATT218 compared with SOT-93/TO-218. Consequently the price of an ISOWATT218 device is typically \$ 0.1 above the equivalent SOT-93 device when purchased in high volume, rising to \$ 0.25 for small quantities via distribution.

Even with this adder most users will benefit from a direct cost saving by using the SGS ISOWATT218.

THERMAL RESISTANCE OF SOT-93 (TO-218) AND ISOWATT218

The evaluation of thermal resistance is difficult for the equipment designer as no easy method of measurement is available. This task is made more difficult as power semiconductor suppliers publish thermal resistance for the junction to case which in most practical situations becomes small compared with the total impedance from junction to ambient.

Considering applications where the popular medium power plastic encapsulated devices will be used, with small to medium size heatsinks, the thermal resistance from the package case to the heatsink via any intermediate isolation becomes an important consideration. In the majority of applications of high voltage devices in off line switching power supplies, CRT deflection or motor controls some form of isolation must be employed which can vary from 800V DC up to 2500V AC (3500V DC) depending on the application environment and safety regulations which must be met.

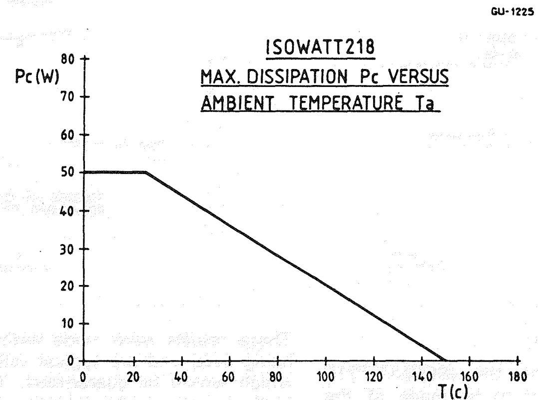
Examining this subject with various power semiconductor suppliers recommendations only adds some confusion which appears to be due to variations in test conditions and mounting torques which are not clearly specified. It should be added that the difficult nature of R_{th} measurements can easily cause a 10% uncertainty in the results.

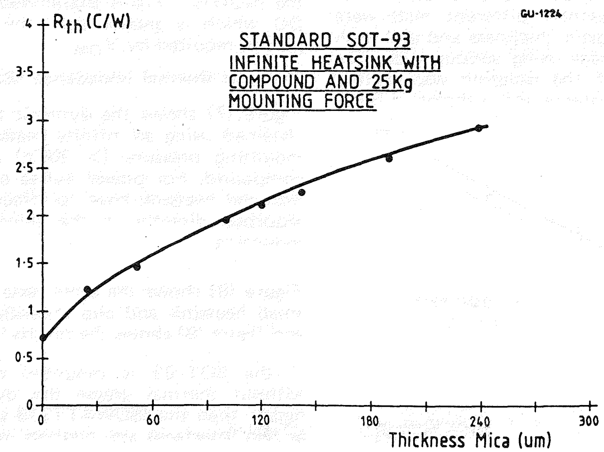
The ISOWATT218 offers many advantages over the conventional SOT-93/TO-218 package when isolation from the heatsink is required however the question is how does its thermal resistance compare in different conditions of mounting? The following notes and evaluations were made to try to offer an understanding of this and some practical advice.

R_{th} junction to case:

For devices in the conventional SOT-93 package with power ratings of 90W to 125W the thermal resistance is from 1 to 1.4°C/W, the ISOWATT218 has a maximum power dissipation rated as only 50W (2.5°C/W) with the same die as the 125W conventional device. With the 90W types the corresponding R_{th} in ISOWATT218 will be 2.9°C/W (43W).

Fig. 4





R_{th} case to heatsink:

The very best which can be achieved with direct mounting i.e. no isolation is 0.3°C/W if a thermal grease is used. However if no compound is used then this figure will range from 0.8 to 1.5 depending on the mounting method and pressure or torque applied. All this assumes that the heatsink surface is flat.

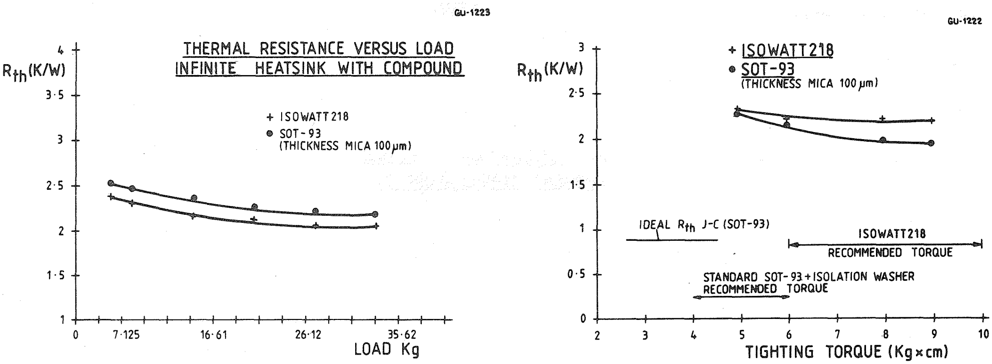
When an isolation layer is used the thermal resistance will depend on the desired insulation properties and may vary by about 1°C/W from a low voltage isolation to a high voltage case.

In the conventional packages thermal compound will be applied on both sides of the isolation layer for best heat transfer. Mounting with a screw the thermal impedance may vary by about 0.3°C/W for torque variation from 4 to 6 Kg. cm. Higher torque up to 10 Kg. cm could reduce the figure by 0.2 °C/W but is not recommended with isolating washers due to the risk of damaging them. If a clip is used over the centre of the package a force of 4Kg will give similar results to screw mounting with 4 Kg. cm while increasing the load to 20Kg will reduce the R_{th} by about 0.2°C/W, but such a load is impractical for spring clips which can be easily assembled.

For the ISOWATT218 mounted with thermal compound and using a screw the effect of torque on R_{th} is less noticable than for the conventional package as there is only one layer of compound to compress. As there is no fragile isolation layer the package may be mounted with torques of 6 to 10 Kg. cm without any risk of damage and consistent R_{th} will be achieved.

The following diagram (5) illustrates these results. The measurements were made with a device of 125W rating in the conventional package. Therefore the ideal R_{th} is about 0.8°C/W. The same die was used in the ISOWATT218 package.

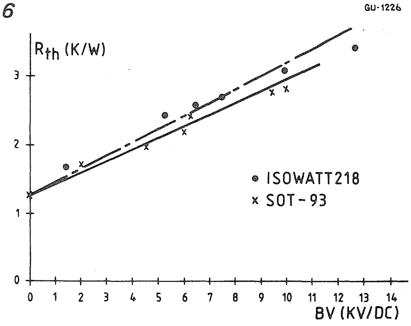
Fig. 5



Isolation voltage breakdown:

The development phase of the ISOWATT218 package required a decision to be made of the thickness of the plastic layer to be employed for the isolation. Consequently different tests were made with various plastic thickness and also with the conventional package using various mica. The breakdown voltage of the isolation was plotted against the thermal resistance and is shown in fig. 6.

Fig. 6



These results were made with thermal compound being used and are typical values - not the values which would be guaranteed. The final choice was made for a typical breakdown of 5 to 6KV DC and the ISOWATT218 is guaranteed to withstand 4KV DC which is greater than the 2750V AC for 1 second required by V_{DE}.

Dynamic thermal impedance (Z_{th}):

Figure (7) shows the dynamic thermal impedance obtained using an infinite heatsink with very high mounting pressure (> 20Kg) and using thermal compound. For power pulses of < 0.1s the isolation and heatsink have no effect and the energy is absorbed directly in the silicon and its copper mounting.

Figure (8) shows the same tests carried out with a small heatsink and clip mounting with 5Kg force and figure (9) shows the results in free air.

If the SOT-93 is mounted with isolation but without thermal grease the overall R_{th} will be higher than the ISOWATT218 without compound as two interfaces are involved instead of only one.

Independent results state an R_{th} of 2.2 to 3°C/W for the case to heatsink of SOT-93, without compound and a mica adequate only for 1500 or 2000V peak isolation, depending on mounting pressure or torque. Adding the R_{th} of the device will result in lower overall results only if the isolation accepted is inferior and the mounting is carefully controlled.

Fig. 7

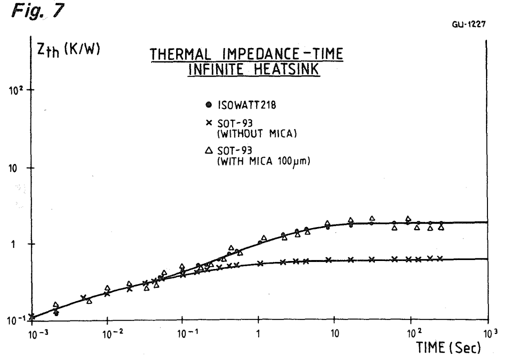


Fig. 8

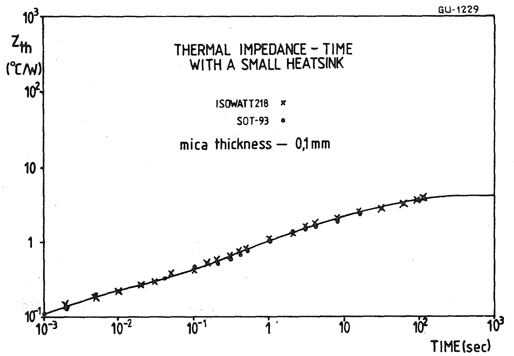
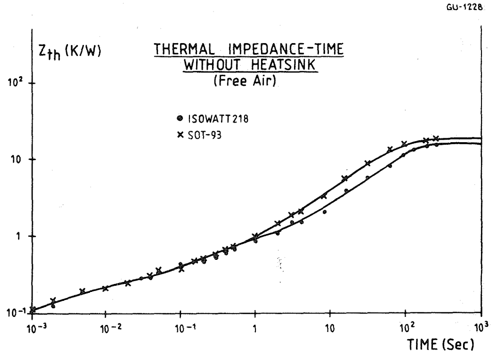


Fig. 9



CAPACITANCE FROM DEVICE COLLECTOR TO HEATSINK

In high frequency switching applications it may be important to consider the electrical capacitance which can affect RFI performance of the equipment.

A theoretical analysis of the capacitance of the ISOWATT218 which was verified by direct measurement shows the value to be typically 17pF.

CONCLUSIONS:

These tests have shown that the ISOWATT218 when mounted on a heatsink with thermal compound has an R_{th} very close to that of a conventional SOT-93/TO-218 mounted with compound and an isolation washer. When mounted with a screw the torque used is not so critical as the conventional package. Certainly even a worst case interpretation of the data indicates that any increase is negligible compared with the overall R_{th} from junction to ambient which with moderate heatsinks will be greater than 15°C/W. Any small increase is more than compensated by the convenience of the ISOWATT218 package.

From an overall cost point of view the ISOWATT218 represents a saving compared with conventional packages. The construction makes it much easier for the equipment to respect the safety standard of UL or V_{DE} which may be required.