Application note: Microstrip Isolators & Circulators

1. Overview Summary
1.1 Microstrip Isolator and Circulator mounting instructions are given in detail in the following application note
1.2 Make a cut in the circuit board / substrate so the Microstrip pads and the mating circuitry should be in the same plane (ie hog out the correct depth so the top of the unit pads is exactly the same height as the adjacent circuitry), note minimize gaps
1.3 Assemble the unit secure using screws or epoxy
1.4 Interconnect using soldered tab or by bonding
1.5 MSS (substrate only units) 6 to 23GHz only can be mounted on Non Magnetic material ie Aluminum, units below 6GHz and above 24GHz need a ferrous / magnetic mount to give correct magnetic field to ensure over temperature spec performance) (if mounted on aluminum they will only meet spec 10-35°C> This mounting can be direct on to the customers steel / Kovar housing or on to a steel backing plate (MSSM Model)

2. General Notes
2.1 Use in hermetic/sealed enclosures only.
2.2 Material Hexagonal Ferrite
2.3 Temperature range –40 to 70C (3-40GHz), -10° to 80°C (66-77GHz) 0-50C (90-98GHz), with about +6 C of temperature gradient to the back side of your isolator
2.4 Extended Temperature range Microstrip isolators and circulators are typically specified -40ºC +70ºC They work at higher and lower temperatures at a slightly degraded spec At -45°C or 80 °C, add 0.1 dB to Insertion Loss, and subtract 1.0 dB from Isolation At -50°C or 90C °C, add 0.3 dB to Insertion Loss, and subtract 4.0 dB from Isolation At -55°C or 100C °C, add 0.4 dB to Insertion Loss, and subtract 5.0 dB from Isolation Higher temperature parts with better specs are available
2.5 CAUTION: Microstrip Isolators and Circulators. *contain low melting point, Indium fine tuning elements and unit should be mounted using an Indium based solder **or** clear epoxy, as a secondary operation, in strict compliance with the following:* a**. All Microstrip Isolators and Circulators have pure indium tuning elements** that can be damaged by sustained temperatures over 130°C, (Indium melting point is 156°C). So under no circumstances should unit ever exceed 130°C for a few seconds b. **Recommended Interconnection is by non ultrasonic wedge bonding**, • Heat the unit to a maximum of 100°C for <3 minutes • Maximum wedge temperature during the bonding process 350°C for 25ms e. **Cavity Effect:** Minimum distance between the housing/module cover: 1.0 - 1.5mm above the magnet without any change in performances. and about 0.7mm with minimum changes.
2.6 Max Temperature On Standard units: If Curing adhesive: do not exceed 120 °C for up to 10 min. or 130 °C for up to 5 seconds. Do not heat above 130° C.
2.7 Storage Temperature -40 to 85C, Sustained periods over 85C will decrease reliability
2.8 Thermal shock spec. 5°C/min. over the full temperature range.
2.9 Circuit plating: 0.5 micron (micro meter) Chrome, 2.0 micron Copper, 2.0 micron Gold (28GHz), 4.0 micron Copper, 2.0 micron Gold (MSS family). Suitable for all kinds of gold wire and tin lead solder bonds Note: micron (micrometer, 1×10^{-6} of meter or µ meter)
2.10 Environmental testing. **Shock:** Built to withstand the harsh Aerospace environment of shock and vibration. The units have low mass and are very robust. We also make devices for military aircraft and spacecraft Devices have been tested under the following environmental conditions: - operational temperature: -60 to +85degrees C - sinusoidal vibration: 1-2000 Hz at amplitude 20g - single shock: 150g at pulse duration 0.1-2.0 ms - multiple shocks: 10g at duration 1.0-2.0 ms - linear acceleration: 20g - absence of resonant frequencies at 1-4000 Hz
2.11 Magnet: Weight typically 0.2Grams it is attached with epoxy, Magnet is rare Earth type typically Samarium Cobalt, Considering low mass, we have good experience with shock and vibration No Coefficient of Thermal Expansion problems within the storage temperature range

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2.12 Cleaning processes for the materials prior to bonding: Alcohol quick wipe with minute quantity is recommended
Water cleaning is not recommended, if used, ensure device is completely dry after cleaning
Note Acetone should NOT be used: Indium tuning elements are used to optimize performance, these are protected by a special microwave frequency conformal coating that can be dissolved by the acetone

2.13 2.14 Thermal resistance: Must be <10-4 m2K/W Between isolator and "heat sink" surface

Surface flatness/finish for the carrier: 0.02mm

3 Handling: Handle with care, the ferrite is very fragile, use only non-magnetic tools.
Observe anti static rules to protect circuits it may be connected to. **NOTE:** There may be fragile, coated miniature **tuning elements** on the isolator surface, DO NOT TOUCH with anything! particularly important >60GHz
4.1 Mounting: Microstrip Tabs and the mating circuitry should be in the same plane (same height)
Minimize any change of height/step on the joint.

4.2 Connection with 50 ohm Microstrip of adjacent circuits: minimize any gap between the isolator and adjacent customer circuitry/substrate. , Use good, low inductance bonding techniques

4.3 Microstrip Isolators & Circulators in Cavities in non magnetic material, with non magnetic cover
Some simple rules need to be followed to avoid specification degradation resulting from "Modeing" radiation in the cavity.

1. Distance from the top of the magnet to cavity roof/cover >1 mm. at 18GHz
2. If interconnection has any problems such as a step in height it will lead to radiation causing IL and VSWR problems

4.5 Mounting : Distance between units No additional magnetic shielding is required if the distance between two devices is kept to a minimum of 2.54 mm with face to face, back to back, or face to back The minimum distance between two microstrip devices shoulder to shoulder is "0"mm

5.1 **Connection tabs:** Tabs should be narrower (about 10% less) than the Microstrip line, (typically 0.08-0.12mm wide). (eg 13.82 mils (0,35mm wide at 13GHz), The tabs should not exceed 0.4 mm total length and in no case protrude 0.2mm over the device end. Tabs must be flat against substrate, and must not lean over the edge. Tabs thickness should be 20-25 micrometers, (0.6 mils / 0.006")
We recommend using annealed gold tabs. {width of the tabs shouldn't exceed width of the input/output line of Microstrip device,

5.2 Interconnection All thin film isolator circuits are gold on copper, suitable for soldering (very easy with regular tin-lead solder), (silver solder preferred), or gold thermo-compression bonding

5.3 Bonding: Suitable for all kinds of gold wire/ribbon and tin lead solder bonds. Don't use excessive heat, force or ultrasonic, when bonding as the ferrite is very fragile.

5.4 Parallel gap impulse welding. We recommend parallel gap impulse welding for connection of our standard thin film Microstrip devices with PCB.
Welding Pulse amplitude and connection force depends on ferrite thickness, We use following limitation:
1 mm ferrite thickness: pulse amplitude 0.8 v , connection force 100gram
0.635 mm ferrite thickness: pulse amplitude 0.5 v , connection force 80 gram
0.38 mm ferrite thickness: pulse amplitude 0.4 v , connection force 60 gram
0.25 mm ferrite thickness: pulse amplitude 0.25 v , connection force 45 gram
{set to pulse duration 20usec max},

5.5 Soldering: Hand: Use temperature controlled soldering iorn set to 120-130°C for 2-3 seconds.

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6 MSS Substrate units

6.1 Integration: We can supply as a single substrate for customer to add components to, on request. (in production volume)

6.2 Mounting substrate type Microstrip devices (MSS) metal base

Substrate type microstrip devices should be mounted on metal base with the minimum thickness of 1mm.
If non-magnetic mounting (-NM) is specified, mount only on non-ferromagnetic material, ie Aluminum
If magnetic (-M) (default) mounting is specified, mount only on ferromagnetic material ie steel or Kovar
Mounting Surface should be smooth with surface roughness <0.4 micron.

6.3 Mounting substrate type Microstrip devices (MSS) method

Non conductive epoxy is standard,
Solder in units (with no added tuning tabs) can be specified for high volume units (>1000)

6.4 Soldering. Any solder material that does not contain Lead or Tin could be used for mounting of standard substrate type Microstrip devices on the metal base.Indium paste preffered Temperature of the metal base should not exceed +130°C for 5 seconds.

6.5 Adhesive: Non conductive epoxy is recommended, the Glue (epoxy) should be a high quality extended temperature type and have a dielectric constant less than 4.0 and glue thickness <3-8 micron. Excessive insertion loss will result if the glue is too thick., suggest:
Loctite 42050 Super Bonder Instant Adhesive, or 3M Scotch weld Epoxy Adhesive DP-420 off white
If conductive epoxy is used, great care must be taken to ensure non is extruded on the sides at any input or output. (excess will degrade VSWR) or at the load side were excess will degrade isolation

6.6 Max Temperature: If Curing adhesive: do not exceed 120 °C for up to 10 min. or 130 °C for up to 5 seconds. Do not heat above 130° C.

6.7 Detailed Installation instruction for MSS and MSSM Isolators and Circulators.

a. **Preferred attachment for the MSS and MSSM models** is by using a thin smear of clear non conductive epoxy, with temperature of polymerization close to 80°C, it is important to leave area around microstrip junctions clear to facilitate grounding. We do not recommend conductive epoxies as it is too easy to contaminate the isolator surface and detune/damage the unit.

b. **Alternate attachment for MSS and MSSM model** is by soldering, (Soldering is a more complicated process, but Insertion loss at frequencies over 12 GHz can be a little better than with epoxy)

- *Note the substrates come soldered to a metal back plate. Mounting can only be with low melting point indium solder*
- Fitting is by using a Indium paste solder (we suggest Lead free: 50% Indium / 50% Tin Alloy) with 125°C liquidus.
- Use a controlled solder reflow cycle of up to 125°C for 5 seconds maximum, with slow up and down ramps. (do not use a hot plate due to the inability to control-it will likely melt the Indium and even desolder the ferrite substrates)

c. **Recommended Interconnection is by non ultrasonic wedge bonding**,

- Heat the unit to a maximum of 100°C for <3 minutes
- Maximum wedge temperature during the bonding process 350°C for 25ms

d. **Cavity Effect:** Minimum distance between the housing/module cover: 1.0 - 1.5mm above the magnet without any change in performances. and about 0.7mm with minimum changes.

e. **MSSM unit may be mounted on any metal base (Ferrous or Non Ferrous / ie: Steel or Aluminum**

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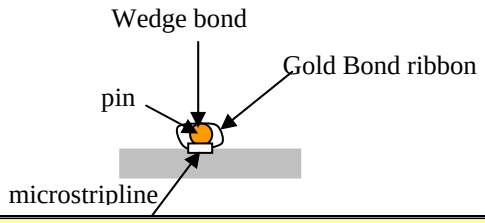
6.7 Connecting Microstrip Line to Pin Connector

Description: The isolator input will be used with 0.025" thick Alumina (thin film) with 0.010" wide microstripline. Output will be to a 0.012 diameter connector pin glass feedthru.



6.8 Units passed all shock and vibration test.

We have exhaustively tested the Microstrip Drop in's.

The units have low mass and are very robust.

-Vibration in frequency range 1-5000Hz with acceleration 400m/sec2 (40g)
- repeated shocks with acceleration 1500m/sec2 (150g) and duration 1-5msec
- single shock with acceleration 15000m/sec2 (1500g) and duration 0.1-2msec
- linear centrifugal acceleration 5000m/sec2
- acoustic noise 50-10000Hz at sound pressure level up to 170dB
- absence of resonance in frequency range 1-100Hz

7.0 54-65GHz MSS Parts

1 CAUTION ! The devices are very fragile-substrate thickness is 0.12mm.
Do not place the devices into an external magnetic fields stronger than 1kOe as in such case they would be demagnetized.

2. **The devices should be installed on a steel /Kovar surface. This surface should be smooth (surface roughness should not excess 0.4 micrometers) and it should be plated silver or gold.**
3. **The devices have to be glued to the steel basis by nonconductive glue with low insertion loss within operating frequency range and dielectric constant not more than 4.0, and glue thickness 3-8 micrometers.**
4. **Be careful when bonding-the devices are very fragile.**
5. **NOTE! Be careful with the long Microstrip branch of the isolator. typically a miniature tuning element is placed there. This tuning element is covered with varnish. Do not touch it!**
6. **Connection with 50-Ohm Microstrip of adjacent circuits:**
   a. **Width of device's output Microstrips is 0.12 mm. Customer's microcircuits should be tightly (without gaps) placed near the device.**
   b. **The connection jumpers should be not wider than 0.12 mm and not narrower than 0.09 mm. The length of jumper over the device should not exceed 0.2 mm, total length of the jumper should not exceed 0.4 mm. The jumpers must be tightly pressed to Microstrips and in no case to lean over the Microstrip' s edges.**
   c. **Recommended connection jumpers**
      i. **-Gold foil of thickness not more than 20 micrometers; it is inadmissible to make micro welding of the jumper for two times,**
      ii. **-Silver –indium foil of thickness 20/25 micrometers; the foil is adhering to Microstrip after careful cleaning of the surface to be connected. This type of Jumper makes possible multiple connections and disconnections.**

NOTE! Connection is very critical for the device's operation. In the case of poor connection some improvement of matching can be made by means of placing of tuning elements on only user's own Microstrips of adjacent circuits.

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