

MICROWAVE CONNECTOR

The present invention relates to a microwave connector for use in providing a microwave connection between two environments separated by a barrier, the connector also functioning as a seal should the connecting systems be breached. The invention will be described with particular reference to an embodiment thereof in which the microwave connector is of subminiature 'A' type (SMA type) configuration, it being understood that this is in no way intended to limit the scope of the said invention.

The invention originates from a requirement for a microwave connector to operate within a submarine mast environment. Modern submarine mast design dictates the placement of electronic equipment in an electronics pod at the mast head connected by microwave transmission lines to processing equipment in the hull. This arrangement creates the requirement for a connector capable of providing a microwave connection through a pressure boundary without compromising the nature of that boundary, the boundaries concerned being the submarine hull and the mast junction of the electronics pod. Hence in normal use the connector is required to function in the conventional manner while preventing the penetration of water, pressurised or otherwise, through

the boundaries should the mast head or connecting cable systems be breached.

In the past microwave connections through boundaries have been facilitated by the use of small lengths of semi-rigid coaxial cable that protrude either side of the interface. In this construction female SMA "bullets" are soldered to the centre conductor, one at each end of the semi-rigid coaxial cable, before the cable is housed in a metal sheath. This solder joint forms part of the pressure sealing and is a weak link giving rise to reliability problems during installation and normal service. This problem is further compounded by the need to have two such solder joints within each construction.

The present invention does not rely on this kind of joint to provide the pressure sealing characteristics of the connector. Moreover, connectors embodying the invention provide enhanced Voltage Standing Wave Ratio (VSWR) performance up to 40GHz while the design of the connector as a disaster seal enables it to withstand a pressure differential of up to 1000 PSI ($6.89 \times 10^6 \text{ Nm}^{-2}$). A further advantage of such connectors is that it is possible to pre-test the sealing characteristics of each connector before attaching microwave

transmission lines or before installation in a particular barrier so that differing bulkhead requirements may be accommodated.

Although the present invention originated from a consideration of the problems of microwave transmission in submarine mast environments, connectors embodying the invention are equally suited to other applications wherein a microwave connection is required between two environments, possibly of differing chemical composition or under different physical conditions, and separated by a barrier or bulkhead.

According to the present invention there is provided a microwave connector for use in providing a microwave connection between two environments separated by a barrier, the connector also capable of functioning as a seal should the connecting cable systems be breached, the connector comprising a connector body having a central opening extending throughout its length, a central contact located within said central opening and connecting means also located therein to provide a suitable connection for the transmission of microwaves between a transmission line on one side of said barrier and said central contact, and having an insulating sleeve within which said central contact is located

the relative sizing of said central opening, said central contact and said insulating sleeve ensuring a pressure sealing interference fit within said central opening between said central contact, said insulating sleeve and said connector body.

According to another aspect of the present invention there is provided a method of manufacturing a microwave connector for use in providing a microwave connection between two environments separated by a barrier, the connector also capable of functioning as a seal should the connecting cable systems be breached, the method comprising the steps:

- providing a connector body having a central opening extending throughout its length;

- providing an elongate insulating sleeve;

- sliding the insulating sleeve into said central opening;

- providing an elongate contact;

- pressing the contact into the sleeve to radially expand the sleeve to form a pressure sealing interference fit within said central opening between said contact, said insulating sleeve and said connector body; and

- providing connection means for location in a end of said central opening to provide a suitable connection for the transmission of microwaves between a transmission line on one side of said barrier and said contact.

A microwave connector embodying the invention will now be particularly described, by way of example, with reference to the accompanying single Figure of the drawing which is a cross-sectional view of the microwave connector.

The microwave connector is shown in the Figure to comprise a connector body 10, situated within an opening 12 in a barrier 14, and held in place by a retaining nut 16, the barrier 14 serving to separate the two environments 18 and 20. The connector body 10 terminates in a standard SMA connector 22 and has a central opening therein which extends throughout the length of the connector body, the diameter of the central opening being such that it slidably receives insulating sleeve 24. Insulating sleeve 24 abuts rear insulator 26 also located within the central opening but in a region of increased internal diameter. The insulating sleeve 24 and the rear insulator 26 are both preferably of polytetrafluoroethylene (PTFE) or a material with similar mechanical and dielectric properties. The mechanical properties of PTFE, together

with its low dielectric loss, combine to provide the connector with enhanced pressure sealing properties while maintaining a mode-free operation characteristic at microwave frequencies of up to 40 GHz.

Central contact 28 is rod-shaped and has a diameter that is standard within SMA connector technology and a tip portion 30, of reduced diameter, which forms the central contact within SMA connector 22. The internal diameter of insulating sleeve 24 is toleranced such that an interference fit exists between the central contact and the sleeve. The central contact 28 is pressed, via a support guide, into the central opening of insulating sleeve 24 until the tip portion 30 protrudes from the sleeve forming part of SMA connector 22. This operation radially expands the insulating sleeve causing a dimensional interference between the sleeve and the connector body 10 thus providing the pressure sealing characteristics of the connector. A twofold advantage of the connector described is that these sealing characteristics are not reliant on solder joints or adhesive and may be fully tested before attachment to any existing microwave transmission lines or before installation in a particular barrier so that any bulkhead requirement may be accommodated.

The microwave transmission line to be connected through the boundary is shown in the Figure as coaxial cable 32 the central conductor 34 of which is soldered to contact bucket 36. Contact bucket 36 is received within insulator 26 and is attached to central contact 28 by means of screw threads. Both contact bucket 36 and central contact 28 are preferably of the same material, such as gold plated brass or more preferably, a gold plated beryllium-copper alloy. Coaxial cable 32 is held by an SMA hat 38 and SMA retaining nut 40. This retaining means obviates the need to over-tighten the contact bucket 36 on to central contact 28 causing the central conductor 34 of the coaxial cable to twist, the retaining means also immobilizing coaxial cable 32 thus enhancing the reliability of the solder joint between the central conductor 34 and the contact bucket.

A further microwave transmission line (not shown) may be attached to SMA connector 22, if provided with suitable connecting means for mating therewith, thus completing the microwave connection between environments 18 and 20 without loss of transmission characteristics and without compromising the nature of the boundary.

The connector will now be further described by reference to particular dimensions, it being understood that any

dimensions so given are exemplary and are not intended to limit the scope of the invention in any way.

The central opening within the connector body 10, between SMA connector 22 and rear insulator 26, is preferably of constant diameter and further preferably has a diameter of about 4.06mm (0.160 inch). Central contact 28 has an overall length of approximately 59.74mm (2.352 inches) of which about 2.16mm (0.085 inch) is taken up by the tip portion 30, and about 4.75mm (0.187 inch) by the threaded portion at the opposing end. The decreased diameter of the tip portion is approximately 0.91mm (0.036 inch), while the diameter of the remainder of the central contact is approximately 1.27mm (0.050 inch). The above dimensions dictate much of the size and shape of insulating sleeve 24. In order to achieve a slide fit within the central opening of the connector body the outer diameter of the sleeve is also approximately 4.06mm (0.160 inch). The internal diameter of sleeve 24 is made approximately 1.17mm (0.046 inch) so that about a 0.10mm (0.004 inch) interference exists within said internal diameter. It has been shown that an interference fit of the kind described above gives rise to a connector capable of withstanding a pressure differential of up to $6.89 \times 10^6 \text{ Nm}^{-2}$ (1000 PSI) at ambient temperature. It is

expected that this pressure differential can be maintained over a temperature range from -40°C to $+70^{\circ}\text{C}$.

Contact bucket 36 has an overall length of about 11.33mm (0.446 inch). The section of smaller external diameter has a length of about 5.49mm (0.216 inch) and an external diameter of approximately 2.18mm (0.086 inch), this section receiving the threaded portion of central contact 28 and being received by rear insulator 26. The rear insulator has a length of approximately 6.27mm (0.247 inch) and an external diameter of about 6.96mm (0.274 inch) and is located abutting the insulating sleeve within a region of the connector body in which the central opening therethrough has a diameter of approximately 6.99mm (0.275 inch). Central contact 28 passes through a central opening within rear insulator 26 of approximate diameter 1.30mm (0.051 inch) before being received in a threaded opening, about 5.08mm (0.200 inch) in length, within the contact bucket, the contact bucket also being received in a central opening within the rear insulator but of approximate diameter 2.21mm (0.087 inch). The contact bucket and central contact are attached by means of the screw threads which are preferably of 12 B.A. type.

The section of contact bucket 36 of larger external diameter is about 5.84mm (0.230 inch) in length and has an external diameter of approximately 3.05mm (0.120 inch). Within this section is a central opening of approximate diameter 2.18mm (0.086 inch) within which coaxial cable 32 is attached to the contact bucket by means of a solder joint.

Although the present invention has been described with reference to a particular embodiment, it will be clear to those skilled in the art that the invention is in no way limited to coaxial connectors of SMA type configuration but is equally applicable to other types of microwave connector.



CLAIMS

1. A microwave connector for use in providing a microwave connection between two environments separated by a barrier, the connector also capable of functioning as a seal should the connecting cable systems be breached, the connector comprising a connector body having a central opening extending throughout its length, a central contact located within said central opening and connection means also located therein to provide a suitable connection for the transmission of microwaves between a transmission line on one side of said barrier and said central contact, and having an insulating sleeve within which said central contact is located, the relative sizing of said central opening, said central contact and said insulating sleeve ensuring a pressure sealing interference fit within said central opening between said central contact, said insulating sleeve and said connector body.

2. A microwave connector according to claim 1 wherein said insulating sleeve is of resilient material and, in an undeformed condition, is a sliding fit in said central opening and said central contact is sized to radially expand said insulating sleeve to provide said pressure sealing interference fit.



3. A microwave connector according to claim 1 or 2 wherein said insulating sleeve and said central connector are elongate and said pressure sealing interference fit extends over a substantial length thereof.
4. A microwave connector according to claim 1, 2 or 3 wherein said connecting means comprises a contact bucket attached to said central contact by means of screw threads and connected to said transmission line by means of solder.
5. A microwave connector according to claim 4 wherein said central contact and said contact bucket are of gold plated brass.
6. A microwave connector according to claim 4 wherein said central contact and said contact bucket are of a gold plated beryllium-copper alloy.
7. A microwave connector according to any preceding claim wherein said insulating sleeve is of polytetrafluoroethylene (PTFE) or a material with similar mechanical and dielectric properties.
8. A microwave connector according to any preceding claim wherein said connector body and said central contact terminate in a standard SMA type connector.



9. A microwave connector according to any preceding claim wherein said interference fit is approximately a 0.010mm (0.004 inch) interference fit within said central opening between said central contact, said insulating sleeve and said connector body.
10. A microwave connector according to any preceding claim wherein said central opening within said connector body has a diameter of approximately 4.06mm (0.160 inch) substantially throughout the length of the portion containing the insulating sleeve; and wherein said central contact has a diameter of about 1.27mm (0.050 inch) substantially throughout its length.
11. A microwave connector according to any preceding claim wherein said transmission line on one side of said barrier is held by SMA retaining means.
12. A microwave connector according to any preceding claim wherein said transmission line on one side of said barrier is a coaxial cable.
13. A method of manufacturing a microwave connector for use in providing a microwave connection between two environments separated by a barrier and which connector is also capable of functioning as a seal should the connecting cable systems be breached, the method



comprising the steps:

providing a connector body having a central opening extending throughout its length;

providing an elongate insulating sleeve;

sliding the insulating sleeve into said central opening;

providing an elongate contact;

pressing the contact into the sleeve to radially expand the sleeve to form a pressure sealing interference fit within said central opening between said contact, said insulating sleeve and said connector body; and

providing connection means for location in a end of said central opening to provide a suitable connection for the transmission of microwaves between a transmission line on one side of said barrier and said contact.

14. The method of claim 13 wherein said contact is pressed into said insulating sleeve via a support guide.

15. A microwave connector substantially as herein described with reference to the accompanying drawing.
