NEW HIGH PERFORMANCE 3.5 MM, LOW COST, UTILITY COAXIAL CONNECTOR WITH MODE FREE OPERATION THROUGH 34 GHz

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ABSTRACT

A utility 3.5 millimeter connector was designed to cover frequencies above 18 GHz in coaxial transmission lines. The superior cost/performance characteristics of this new connector are presented in this paper.

INTRODUCTION

A new low cost/high performance 3.5 millimeter "utility" connector was developed (Figure 1) to compliment the precision 3.5 millimeter hermaphroditic, but quite expensive connector now being standardized by IEC. The precision connector was originally recommended as a proposed product standard by the Joint Industry Research Committee for the Standardization of Miniature Precision Coaxial Connectors (JIRC/SMPCC) sponsored by the U.S. Department of Commerce between 1966–1972. Although this connector is of high performance precision, its price tag makes it prohibitive to use widely as a utility connector.

Electrical–Mechanical Characteristics

Many mechanical properties were considered in the design of this connector (Figure 2). An objective was to build on experience gained from the use of other RF connectors. An example, the mating surface of the outer conductor on the male connector has a wall thickness of .020 inches. This relatively thick wall will withstand high contact force insuring good connector repeatability, long life, and low leakage.

The center conductors are not supported at their interface, but rather .250 inches back from the interface. The four slot female center conductor is formed to contact the male center conductor at the interface, even under the worst diameter tolerance conditions. This construction also assures proper contact all around the male pin even under the worst concentricity tolerance limits. The benefit of these features is a connector that is free of resonances and reflections due to improper center conductor contact.

The recessed bead has other advantages. The impedance of the transmission line at the connector is controlled by only two parameters — that is, the diameters of the center and outer conductors. A sufficiently large spacing between the beads of the connector mated pair was chosen to allow resonance free operation to 34 GHz. Any higher order modes that may be generated at the transmission lines support (bead) will die out rapidly, and not cause a resonance problem (ref. No. 1). With air as the interface dielectric there are none of the plastic filled connector problems, such as, 1) an air gap length that is hard to control and can change with temperature 2) a line impedance that also depends on the plastic's dielectric constant and dimensions. The additional benefits to the user are that the line impedance can be established by two simple physical measurements and that the performance of any mated pair of these connectors will be very similar.

The material used for center and outer conductors is gold plated BeCu. This material is used to assure the highest contact pressure and electrical conductivity and is a non ferro-magnetic material. Long wear, low loss and low leakage as well as less succeptibility to damage are the results of using this tough material.

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The connector assembly consists of the center conductor, outer conductor and bead. It is designed to be used with a 3.5 mm transmission line terminator (Figure 3). Devices designed with the terminator makes selection of any combination of available connectors possible. Properly selected connector combinations tend to reduce system cost and improve performance by eliminating the need of adapters. Other advantages of this type construction include the ability to minimize the short length of high impedance line formed at the center conductor interface and also allows pretesting of the bead assembly. These advantages are available to keep the connector SWR low. As an added convenience for users interested in phase measurements, the interface plane is the same for center and outer conductors, and the distance to the bead is the same for both male and female connectors. Impedance measurements made on a device are then independent of the sex of the connector.

Interface with Other Connectors

Even though this connector is a true 3.5 mm airline type which operates to 34 GHz, it will also mate non-destructively with SMA series connectors. Within the frequency band of the SMA connector, the SWR performance of this 3.5 mm utility connector/SMA interface is similar to the interface SWR of a mated pair of SMA connectors. In addition, connections to .141 diameter semi-rigid coaxial cable can be made with existing connectors.

Performance

As discussed above, the connector was designed to provide excellent repeatability, long life and low leakage. Since the diameter tolerances of the center and outer conductor are closely held, the major sources of SWR are the bead and the short section of high impedance transmission line formed by the gap between the full diameters of the male and female pins at the connector interface. Figure 4 shows measured data of the magnitude of these SWR sources in the 18 to 34 GHz frequency range.

Measurement Techniques Applied

A special computer controlled network analyzer was built to extend its measurement capability to 26.5 GHz in order to allow evaluation of the transmission and reflection characteristics of this new connector. A special slotted line was also constructed to measure the bead reflections up to 34 GHz using "Sanderson's" technique (ref. No. 2). Furthermore, tuned waveguide reflectometers with waveguide-coax adapters were utilized to verify measurement results taken by the above mentioned techniques.

Insertion loss and repeatability measurement are taken with the automatic network analyzer to 26.5 GHz and above 26.5 GHz with detectors and ratiomeasuring equipment.

Leakage measurement is done according to the IEEE Connector Standard (ref. No. 3) using a specially built triaxial cavity.

CONCLUSION

This connector has distinct advantages in performance and price as described above. Furthermore, it is directly compatible with the most widely used SMA connector. Its terminator dimensions are shown in Figure 3.

The authors would like to extend their appreciation to those who contributed in the development of these connectors: Ronald Pratt, Jerry Burgess, Donald Chambers, Pasquale Petti, and special thanks to Lawrence B. Renihan who did the original design.

REFERENCE

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(2) A.E. Sanderson: *An Accurate Substitution Method of Measuring the VSWR of Coaxial Connectors.* Microwave Journal, vol. 5, no. 1, January 1962, pp. 69—73.

(3) IEEE Standard no. 287: *Precision Coaxial Connectors.*

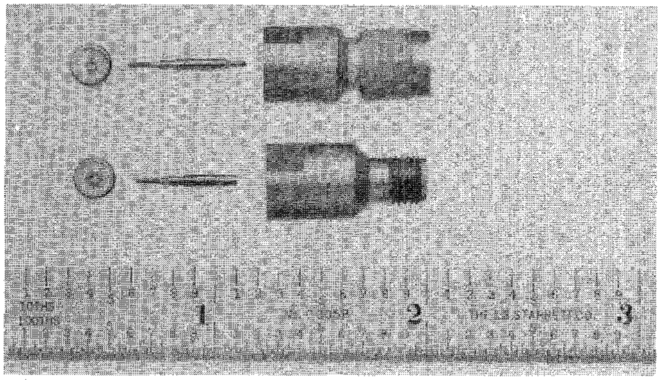

Figure 1. Photograph of the male and female 3.5mm utility connectors; outer, inner conductors and bead-insulators.

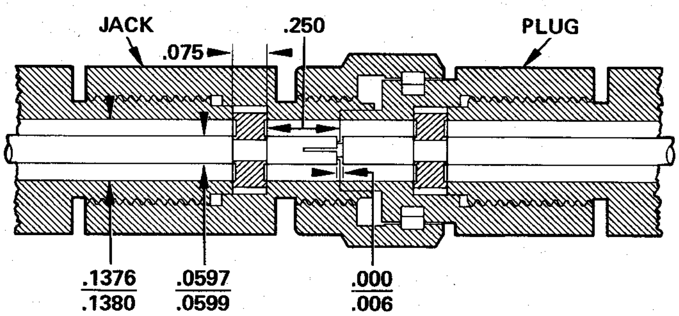

Figure 2 shows a cross section of the connectors mated and as assembled onto center and outer conductors.

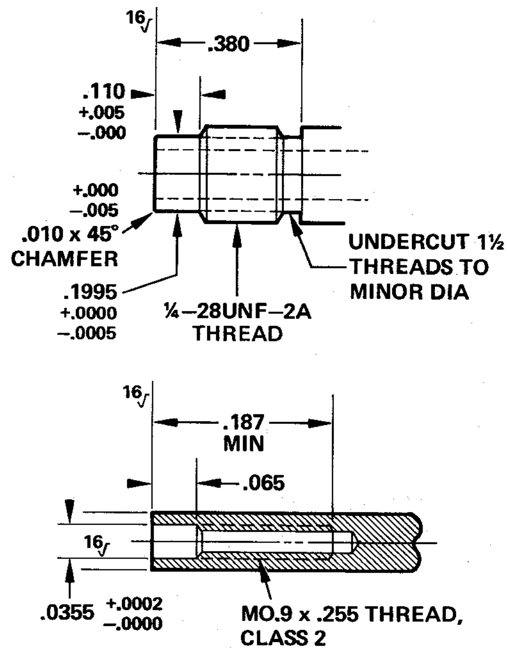

Figure 3 shows the outer conductor and center conductor machining detail required to accept either the male or female connector.

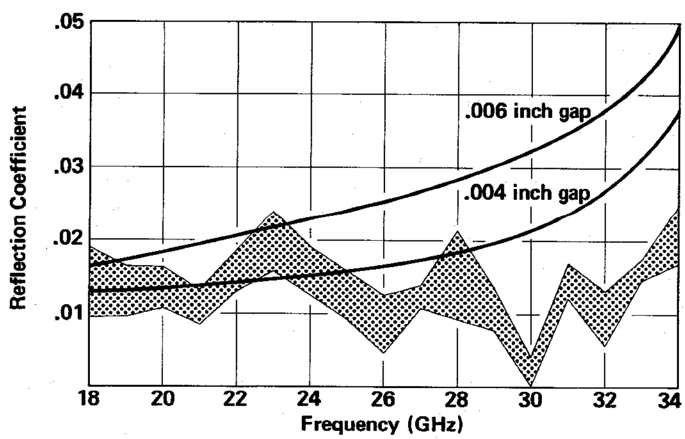

Figure 4 shows reflection coefficient as a function of frequency for several samples of single beads with a gap of .002 to .003 inches between the full diameters of the male and female center conductors (dotted area). The two other curves represent the reflection due to gap only, for .004 and .006 inch gap.