

A DIELECTRIC WAVEGUIDE

This invention relates to a dielectric waveguide for the transmission of electromagnetic waves. More particularly, the invention relates to a dielectric waveguide having higher order mode suppression filters.

Electromagnetic fields are characterised by the presence of an electric field vector E orthogonal to a magnetic field vector H . The oscillation of these components produce a resultant wave which travels in free space at the velocity of light and is transverse to both of these vectors. The power magnitude and direction of this wave is obtained from the Poynting vector given by:

$$P = E \times H \text{ (Watts /m}^2\text{)}$$

Electromagnetic waves may exist in both unbounded media (free space) and bounded media (such as coaxial cables and waveguides). This invention is concerned with the behaviour of electromagnetic energy in a bounded medium and, in particular, in a dielectric waveguide.

For propagation of electromagnetic energy to take place in a bounded medium, it is necessary that Maxwell's

equations are satisfied when the appropriate boundary conditions are employed.

In a conventional metal waveguide, these conditions are that the tangential component of the electric field, E_t , is zero at the metal boundary and also that the normal component of the magnetic flux density, B_n , is zero.

The behaviour of such a waveguide structure is well understood. Under excitation from external frequency sources, characteristic field distributions or modes will be set-up. These modes can be controlled by variation of frequency, waveguide shape and/or size. For regular shapes, such as rectangles, squares or circles, the well-defined boundary conditions mean that operation over a specific frequency band using a specific mode is guaranteed. This is the case with most rectangular waveguide systems operating in a pure TE_{10} mode. This is known as the dominant mode in that it is the first mode to be encountered as the frequency is increased. The TE_{mn} type nomenclature designates the number of half sinusoidal field variations along the x and y axes, respectively.

Another family of modes in standard rectangular

waveguides are the TM_{mn} modes, which are treated in the same way. They are differentiated by the fact that TE_{mn} modes have no E_z component, while TM_{mn} modes have no H_z component.

The dielectric waveguide disclosed in U.S. Patent 4,463,329 does not have such well-defined boundary conditions. In such a dielectric waveguide, fields will exist in the polytetrafluoroethylene (PTFE) cladding medium. Their magnitude will decay exponentially as a function of distance away from the core medium. This phenomenon also means that, unlike conventional waveguides, numerous modes may, to some degree, be supported in the waveguide depending upon the difference in dielectric constant between the mediums, the frequency of operation and the physical dimensions involved. The presence of these so-called "higher order" modes is undesirable in that they extract energy away from the dominant mode, causing excess loss. They cause, in certain cases, severe amplitude ripple and they contribute to poor phase stability under conditions of flexure.

A launching horn employed in conjunction with a waveguide taper performs a complex transformation from conventional waveguide to the dielectric waveguide.

Techniques such as the finite element method may be used to make this transformation as efficient as possible. However, the presence of any impedance discontinuity will result in the excitation of higher order modes.

According to the present invention there is provided a dielectric waveguide for the transmission of electromagnetic waves comprising a core of PTFE, one or more layers of PTFE cladding overwrapped around said core, mode suppression filters of an electromagnetically lossy material ^{embedded in} ~~associated with~~ said waveguide, and an electromagnetic shielding layer covering said cladding.

The mode suppression filters may be affixed to a launcher. The mode suppression filters are preferably mica cards. The core may be extruded, unsintered PTFE; extruded, sintered PTFE; expanded, unsintered, porous PTFE; or expanded, sintered, porous PTFE. The core may contain a filler. The or each cladding layer may be extruded, unsintered PTFE; extruded, sintered PTFE; expanded, unsintered, porous PTFE; or expanded, sintered, porous PTFE. The cladding layer may contain a filler. The ^electromagnetic shielding layer covering the cladding preferably is aluminized tape, and most preferably is aluminized Kapton (Registered Trade Mark) polyimide tape. The dielectric waveguide may be further overwrapped with a tape of carbon-filled PTFE.

A dielectric waveguide embodying the invention and incorporating mode suppression filters will now be described, by way of example, with reference to the accompanying drawings in which:-

Fig. 1 is a side elevation of the waveguide, with parts of the waveguide cut away for illustration purposes, and also showing one launcher;

Fig. 2 is an elevational view, partly in cross section, of the launcher taken along line 2-2 of Fig. 1;

Fig. 3 is a perspective view, partly in cross section, of the waveguide and mode suppression filters; and

Figs. 4, 5 and 6 are perspective views of modified waveguide core and mode suppression filters with the cladding and outer layers omitted for clarity of illustration.

The dielectric waveguide for the transmission of electromagnetic waves comprises a core of polytetrafluoroethylene (PTFE), one or more layers of PTFE cladding overwrapped around the core, the core and/or cladding having mode suppression filters of an

electromagnetically lossy material embedded therein, and an electromagnetic shielding layer covering the cladding. The mode suppression filters are preferably mica cards.

The composition of the higher order modes which are created and supported in the dielectric waveguide assembly have field distributions which are unique from the desired, fundamental mode of propagation. Subsequently, it is possible to filter out these unwanted modes by consideration and placement in the waveguide of resistive cards such as mica. Placement of the mica cards should be such that there is little or no interruption of the desired mode.

Because the desired mode is vertically polarized, it has no component in the same plane as the filters. However, the presence of TE_{mn} and TM_{mn} modes, where $n \neq 0$, would mean that the filtering action would start to take place on these modes, thus leading to their attenuation. Depending upon the desired effect, these cards can be oriented as desired. They may be of arbitrary shape, but are preferably of the shapes shown in the drawings described below. These shapes ensure that there is a smooth transition into the launcher rather than an abrupt discontinuity, which would mean

that the incident energy would be reflected rather than absorbed.

The filters may be inserted into the cladding by slitting the cladding and fitting them in place. Alternatively, they may be embedded in the core by forming a slot and inserting them or simply forcing them into the core material. Another method is to cast or secure them in the launching horn.

In the drawings, Fig. 1 shows a dielectric waveguide 10, according to the invention, having a core 12 with a tapered end 13, a cladding 14 surrounding the core 12, an electromagnetic shielding layer 16 surrounding the cladding, and an external absorber 18 surrounding the layer 16. When a launcher 20 with conventional flange 21, is connected to the dielectric waveguide 10, electromagnetic energy enters the launcher 20. An impedance transformation is carried out in the taper 13 of the core 12 of waveguide 10 such that the energy is coupled efficiently into the core 12 of dielectric waveguide 10. Once captured by the core 12, propagation takes place through the core 12 which is surrounded by the cladding 14. The core 12 is polytetrafluoroethylene and the cladding 14 is polytetrafluoroethylene, preferably expanded, porous polytetrafluoroethylene tape

overwrapped over core 12. The cladding layer 16 may be of polytetrafluoroethylene extruded over core 12. Propagation uses the core/cladding interface to harness the energy. Mode suppression filters 15 may be secured to the wall of launcher 20. The filters 15 are of an electromagnetically lossy material, and preferably are mica cards.

To prevent cross-coupling or interference from external sources, the electromagnetic shield 16 is provided as well as the external absorber 18. The shield is preferably aluminized Kapton (Registered Trade Mark) polyimide tape, and the absorber is preferably carbon-filled PTFE tape.

Within the opening 17 of launcher 20, shown in Fig. 2, the mode suppression filters 15 are secured to the launching horn 20 such that, upon insertion of the waveguide 10 into the horn 20, the filters 15 may or may not penetrate and become embedded within the cladding 14.

In the embodiment of Fig. 3, rectangular mica cards 15 are inserted into slits in the cladding 14 and are oriented in the horizontal plane as shown adjacent the core 12.

Fig. 4 shows a core 12 with mode suppression filters 15 located adjacent thereto. The cladding and outer coverings are omitted for clarity of illustration.

Fig. 5 shows an alternative embodiment of core 12 having triangular shaped mode suppression filters 15A positioned adjacent thereto.

Fig. 6 shows a further alternative embodiment of core 12 having triangular shaped mode suppression filters 15B positioned adjacent thereto in an inverted configuration from that of Fig. 5. The cladding and outer coverings are omitted from Figs. 5 and 6 for clarity of illustration.



CLAIMS

1. A dielectric waveguide for the transmission of electromagnetic waves comprising a core of PTFE, one or more layers of PTFE cladding overwrapped around said core, mode suppression filters of an electromagnetically lossy material ^{embedded in} ~~associated with~~ said waveguide, and an electromagnetic shielding layer covering said cladding.
2. A dielectric waveguide according to claim 1, wherein said mode suppression filters are embedded in said cladding.
3. A dielectric waveguide according to claim 1, wherein said mode suppression filters are embedded in said core.
4. A dielectric waveguide according to any preceding claim, wherein said mode suppression filters are mica cards.
5. A dielectric waveguide according to claim 1, wherein said core is extruded, unsintered PTFE; extruded sintered PTFE; expanded, unsintered, porous PTFE, or expanded sintered PTFE.



6. A dielectric waveguide according to claim 1, wherein said core and/or said cladding contains a filler.

7. A dielectric waveguide according to claim 1, wherein the or each said cladding layer is extruded, unsintered PTFE; extruded sintered PTFE; expanded unsintered porous PTFE or expanded sintered porous PTFE.

8. A dielectric waveguide according to claim 1, wherein said shielding layer is aluminized tape.

9. A dielectric waveguide according to claim 8, overwrapped with a tape of carbon-filled PTFE.

10. A dielectric waveguide according to claim 1, and when used in association with a launching horn, wherein said mode suppression filters are secured to said launching horn.

11. A dielectric waveguide substantially as herein described with reference to the accompanying drawings.
