

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 means for higher order mode suppression.

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 produces a resultant wave which travels in free space at the velocity of light and is transverse to both field 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 cable or waveguide). This invention relates to 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.

A dielectric waveguide is disclosed in U.S. Patent 4,463,329. This waveguide 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 impedance 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 having a dominant mode and higher order modes, said dielectric waveguide comprising:

- (a) a core of PTFE;
- (b) at least one layer of PTFE cladding wrapped around said core;
- (c) a higher order mode suppression layer of an electromagnetically lossy material covering said cladding, said higher order mode suppression layer providing suppression of modes other than the dominant mode;
- (d) an electromagnetic shielding layer covering said mode suppression layer; and
- (e) a carbon-filled PTFE tape covering said electromagnetic shielding layer.

The mode suppression layer is preferably a tape of carbon-filled PTFE. 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. Such a cladding layer may contain a filler.

The electromagnetic shielding layer covering the mode suppression layer is preferably aluminized Kapton (Trade Mark) polyimide tape.

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

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

Figure 2 is a cross-sectional view of the dielectric waveguide taken along the line 2-2 of Figure 1.

The dielectric waveguide for the transmission of electromagnetic waves and to be described below in more detail comprises a core of polytetrafluoroethylene (PTFE), one or more layers of PTFE cladding overwrapped around the core, a mode suppression layer of an electromagnetically lossy material covering the cladding and an electromagnetic shielding layer covering the mode suppression layer. The mode suppression layer is preferably a tape of carbon-filled PTFE. Another electromagnetically lossy material layer ^{is} ~~may be~~ placed around the shield to absorb any extraneous energy.

The operation of the waveguide to be described is based

on the premise that, unlike the required guided mode in a dielectric waveguide, the higher order modes exist to a far greater extent in the cladding. This being the case, a mode suppression layer is placed around the cladding to absorb the unwanted modes as they impinge on the cladding/free space interface. In so doing, care must be taken not to truncate the electric field distribution of the required guided mode, as it too decays exponentially into the cladding. This is controlled by the amount of cladding used. The so-called mode suppression layer may be of carbon-filled PTFE. A shielding layer ^{is} ~~may be~~ placed around the mode suppression layer and another electromagnetically lossy material layer ^{is} ~~may be~~ placed around the shield to absorb any extraneous energy.

Figure 1 shows a dielectric waveguide according to the invention, with parts of the dielectric waveguide cut away for illustration purposes. When launcher 20 with conventional flange 21 is connected to dielectric waveguide 10, within seat 12' indicated by the dashed lines, 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 cladding 14. The core 12 is polytetrafluoroethylene and the cladding 14 is polytetrafluoroethylene, preferably expanded, porous polytetrafluoroethylene tape overwrapped over core 12. Propagation uses the core/cladding interface to harness the energy. Mode suppression layer 15 covers the cladding 14. Layer 15 is a layer of an electromagnetically lossy material. Preferably, the mode suppression layer 15 is carbon-filled PTFE tape overwrapped about the cladding 4.

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

Figure 2 is a cross-sectional view of dielectric waveguide 10 taken along line 2-2 of Figure 1 showing rectangular core 12 overwrapped with tape 14 covered by mode suppression layer 15 and showing shield layer 16 and absorber layer 18.



CLAIMS

1. A dielectric waveguide for the transmission of electromagnetic waves having a dominant mode and higher order modes, said dielectric waveguide comprising:
 - (a) a core of PTFE;
 - (b) at least one layer of PTFE cladding wrapped around said core;
 - (c) a higher order mode suppression layer of an electromagnetically lossy material covering said cladding, said higher order mode suppression layer providing suppression of modes other than the dominant mode;
 - (d) an electromagnetic shielding layer covering said mode suppression layer; and
 - (e) a carbon-filled PTFE tape covering said electromagnetic shielding layer.
2. A dielectric waveguide according to claim 1 wherein said mode suppression layer is a tape of carbon-filled PTFE.
3. A dielectric waveguide according to claim 1 or claim



2, wherein said core is extruded, sintered or unsintered, PTFE.

4. A dielectric waveguide according to claim 1 or claim 2, wherein said core is expanded, sintered or unsintered, porous PTFE.

5. A dielectric waveguide according to any preceding claim, wherein said core contains a filler.

6. A dielectric waveguide according to any preceding claim, wherein the or each said cladding layer is extruded, sintered or unsintered, PTFE.

7. A dielectric waveguide according to any one of claims 1 to 5, wherein the or each said cladding layer is expanded, sintered or unsintered, porous PTFE.

8. A dielectric waveguide according to any preceding claim, wherein the or each said cladding layer contains a filler.

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