

Description

This invention relates to a strip line cable. Such a cable typically comprises a strip or belt-like dielectric material and elongate and narrow electrical conductors which are arranged in parallel to one another in sets of pairs facing each other on both sides of the dielectric material.

Transmission lines for microwave and millimeter wave transmission include waveguides, coaxial lines, and strip lines. Being made up of two conductors, the coaxial lines and strip lines are capable of transmitting direct current as well as alternating current. Because of this capability, they are in general used for electric signal transmission. Particularly, the strip line is attracting attention for use as a signal transmission line for computers and other information processing machines because it holds many conductors in a compact size.

It is generally known that the strip line has improved electric signal transmission characteristics when the dielectric material used is one which has a low dielectric constant and dielectric loss, together with a minimum of frequency dependence. In other words, if the dielectric material has a low dielectric constant, it is possible to reduce the size of the strip line, although its characteristic impedance can remain the same, and the rate of signal transmission increases. If the dielectric material has a low dielectric loss, it is possible to reduce the attenuation of signals. Also, if the dielectric material has a low dielectric constant and dielectric loss with a minimum of frequency dependence, the strip line is capable of transmitting pulse signals with a minimum of distortion.

Thus, the dielectric material used for strip lines is required to have a low dielectric constant and dielectric loss with a minimum of frequency dependence. A known example of such a material is a microcellular material of open-cell structure made of a crystalline organic polymer. This material has such an internal structure that a large number of nodes are connected by minute fibrils and a large number of voids are formed among the nodes and minute fibrils. An example is expanded porous PTFE produced according to the method disclosed in U.S. Patent 3,953,566. Other materials used include polyolefins (for example polyethylene, polypropylene, and polystyrene), polyamides, polyesters, and fluoroplastics (polytetrafluoroethylene (PTFE), tetrafluoroethylenehexafluoropropylene copolymer resin (FEP) and tetrafluoroethylene-perfluoroalkylvinyl-ether copolymer resin (PFA), and tetrafluoroethylene-ethylene copolymer (ETFE)) which are made porous by the stretching process, salt leaching process, or solvent evaporation process.

It is known from the application EP-A-0 040 067 to provide a strip line cable comprising a dielectric in tape form and one or more pairs of electrical conductors in which the conductors of the or each pair are disposed parallel to one another on opposite sides of the tape, the dielectric is made of a porous crystalline polymer such

as expanded polytetrafluoroethylene and the cable has outer insulating layers of non-porous material placed over the conductors to fix them to the tape and encapsulate the cable assembly.

In order to further increase the rate of signal transmission, the present inventors carried out extensive studies and conceived the improved structure of strip line according to this invention.

According to the present invention there is provided a strip line cable comprising a plurality of pairs of electrical conductors having a porous strip of dielectric insulation material interposed between the conductors of the pairs, and a covering jacket covering the conductors characterised by, in addition, an insulation layer of a porous plastic dielectric material provided between the conductors and the covering jacket. The porous insulation material is preferably expanded, porous polytetrafluoroethylene. The covering may have a shielding layer provided on the outer periphery thereof. An insulation layer of a non-porous plastic material may be interposed between the strip of dielectric material and the conductors on at least one side of the strip, to improve the transmission characteristics of the cable.

The invention will now be particularly described, by way of example, with reference to the accompanying drawings in which:—

Figure 1 is a schematic view, partly in cross-section, of a conventional strip line cable, and

Figures 2—5 are cross-sectional views of various embodiments of strip line cables according to this invention.

In the conventional strip line cable of Figure 1 a plurality of pairs of conductors 2a, 2a'; 2b, 2b'; 2c, 2c', face each other and a strip of belt-like porous dielectric material 1 is interposed between the pairs of conductors. A covering or jacket 3 holds the parts of the cable together. The covering is formed by integral moulding, fusion bonding, or adhesion of tape or tapes of PTFE, PFA, FEP, ETFE, or polyester.

The strip line of the present invention is characterised in that an insulation layer of a porous plastic material, preferably expanded, porous PTFE, is interposed between at least one conductor and the covering. The plastic material for the insulation layer should preferably be a fluoroplastic which is superior in electrical and thermal properties to other materials.

In the strip line cable in accordance with the invention shown in Figure 2, the porous strip or belt-like dielectric material 1 is expanded, porous PTFE tape having a specific gravity of 0.68 and a thickness of 0.24 mm, produced by known methods. On both sides of this dielectric material 1 are arranged three sets of paired conductors 2a, 2a'; 2b, 2b'; and 2c, 2c', facing each other, parallel to one another at appropriate intervals. Each of the conductors 2a, 2b, 2c is a silver-plated copper wire having a rectangular cross-section, 0.5 mm wide and 0.1 mm thick. Each of the conductors 2a', 2b' and 2c' is a silver-plated copper wire having a rectangular cross-section, 0.8 mm wide

and 0.1 mm thick. Between the silver-plated rectangular copper wires and the covering 3 is interposed in the longitudinal direction an insulation layer 4 which is expanded, porous PTFE tape having a specific gravity of 0.68 and a thickness of 0.127 mm. For the sake of convenience, there is shown three sets of conductors in this embodiment. As many sets of conductors as required may be selected.

The assembly of the expanded, porous PTFE tape 1 and the conductors arranged on both sides thereof is covered entirely with a covering which is a laminate composed of an unsintered, unstretched and unexpanded PTFE layer 3 (0.127 mm thick) and an unsintered expanded, porous PTFE layer 4 (0.127 mm thick and 0.68 in specific gravity). The former layer is placed outside. The assembly thus produced is passed through calendar rolls (not shown) and then through a heating bath for 30 minutes, so that the unsintered PTFE layers (one expanded and the other unstretched) are sintered. Thus there is obtained an integral, fusion bonded body composed of the external covering 3, the insulation layer 4, and the expanded, porous PTFE dielectric tape 1. The expanded, porous PTFE tape may be incompletely or partially sintered, and the cable is still useful.

The strip line cable as described above can have the following dimensions and properties. The porous PTFE tape 1 is 0.17 mm thick. The distance between adjacent conductors is 1.27 mm. The characteristic impedance is 50 ohms. The propagation delay time is 3.7 ns/m, which is comparable to 3.9 ns/m in the case of a conventional strip line cable (as shown in Figure 1) in which the individual conductors are directly covered with the covering 3 made of solid, nonporous insulation material. In addition, the strip line is superior to conventional ones in faithful pulse transmission characteristics and decreased crosstalk between adjacent conductors and between adjacent layers.

In the case of the embodiment shown in Figure 2, compression is accomplished by using a pressure roll system having projecting parts which press only the part held between adjacent conductors. Pressing with such a roll forms grooves 3a in the outer covering, and, as a result, the dielectric material 1 and the insulation layer 4 are compressed as indicated by reference numerals 1' and 4'. The configuration in this embodiment is effective in decreasing crosstalk between lines or between layers for the reasons mentioned below. The compressed parts 1' and 4' decrease in porosity and increase in dielectric constant as compared with the other parts of the dielectric material 1 and insulation layer 4 which remain uncompressed. Each conductor (2a, 2a'; 2b, 2b'; and 2c, 2c') is surrounded by the compressed parts 1' and 4' (having an increased dielectric constant) and the outer covering 3 (having originally a high dielectric constant). This surrounding material absorbs electromagnetic waves, reducing their diffusion. In addition, the

grooves formed as mentioned above prevent the strip line from being deformed by force applied in the thickness direction and prevent the conductors from moving in the transverse or widthwise direction.

Figures 3, 4 and 5 show other embodiments of the present invention. In the embodiment shown in Figure 3, each conductor (2a, 2a'; 2b, 2b'; and 2c, 2c') is first covered entirely with an insulation layer 4 made of a porous plastic material. The covered conductors are arranged on both sides of the porous strip or belt-like dielectric material 1, and the outer covering 3, made of a nonporous plastic material, is placed on the encased conductors. In the embodiment shown in Figure 4, the insulation layer 4 of porous plastic material is arranged on one side of each conductor (2a, 2a'; 2b, 2b'; and 2c, 2c') opposite to the porous strip or belt-like dielectric material 1. In both embodiments as shown in Figure 3 and Figure 4, it is permissible to arrange the insulation layer 4 on only one of the paired signal conductors (e.g. 2a, 2b and 2c). It will be easily understood that the embodiments of these structures also produce improved transmission characteristics.

In the embodiment shown in Figure 5, a thin insulation layer 5, which is a nonporous plastic tape such as unstretched PTFE tape, is provided between the porous or belt-like dielectric material 1 and the paired conductors (2a, 2a'; 2b, 2b'; and 2c, 2c'). This insulation layer increases the dielectric strength of the strip line with a minimum effect on propagation delay time. This insulation layer 5 may be formed on only one side of the belt-like dielectric material 1.

In any one of the above-mentioned embodiments, the porous strip or belt-like dielectric material 1 and/or the insulation layer 4 of porous plastic material may be made of the porous plastics film having a large number of through holes which is produced according to the process disclosed in Japanese Patent Laid-Open No. 176132/1982 "Sheetlike Resin Material". The conductors used in the strip line of this device are not limited to those mentioned above. They may be solid wires having a round cross-section or twisted or multiple lines, and they may be copper wire, silver-plated wire, copper-clad steel wire, or gold-plated stainless steel wire, for example.

By means of the embodiments described above, electro-magnetic waves in the dielectric material surrounding the signal wires can be absorbed, and propagation delay time reduced.

In the preferred embodiments the strip or belt-like material made of porous crystalline polymeric material is covered by a material having a higher dielectric constant than said dielectric material. This structure causes the electric field to concentrate within the covering and prevents the electric field of each conductor from radiating outside. This reduces the interlayer crosstalk and interline crosstalk which may take place when the strip lines are placed on top of each other. In addition to the above-mentioned advantages, the strip line cable of this invention may have another advantage.

tage, if the resin covering can be easily removed by cutting the knife, namely that it is easy to handle for terminal formation.

If necessary, the strip line may be entirely covered with a shielding layer 6 made, e.g. of metal or conductive fluoroplastic as shown in Figure 3. In the case in which the shielding layer is so close to the conductors that the transmission characteristic may be adversely affected, it will be necessary to make the covering thicker or to interpose a layer of porous crystalline polymeric material, e.g. expanded, porous PTFE, between at least one side of the covering and the shielding layer. In the latter case, it is easy to remove the shielding layer from the main body.

The shape and combination of the conductors are not limited to the embodiments mentioned above. The positions of conductors 2b and 2b' may be exchanged. In the case where rectangular conductors are used, the conductors 2a, 2b and 2c for signal transmission may be thinner than the grounding conductors 2a', 2b', and 2c', so that interlayer crosstalk is reduced.

In the case where the strip line is used in the form of a flat cable, the terminals may be separated from one another or the paired lines at intermediate locations may be separated from one another so as to reduce crosstalk and improve flexibility.

Claims

1. A strip line cable comprising a plurality of pairs of electrical conductors having a porous strip of dielectric insulation material (1) interposed between the conductors (2a, 2a'; 2b, 2b'; 2c, 2c') of said pairs, and a covering jacket (3) covering said conductors characterised by, in addition, an insulation layer (4) of a porous plastic dielectric material provided between said conductors (2a, 2a'; 2b, 2b'; 2c, 2c') and said covering jacket (3).

2. A cable according to claim 1 wherein both the strip of insulation material (1) interposed between the conductors of said pairs and the insulation layer (4) provided between said conductors and said covering jacket are expanded, porous polytetrafluoroethylene.

3. A cable according to claim 1 or claim 2 wherein said covering has a shielding layer (6) on the outer periphery thereof.

4. A cable according to any preceding claim wherein an insulation layer (5) of a nonporous plastic material is interposed between said strip of dielectric material (1) and said conductors on at least one side of said strip.

Patentansprüche

1. Streifenleitungskabel, umfassend mehrere Paare elektrischer Leiter mit einem porösen Streifen aus dielektrischem Isolierstoff (1) zwischen den Leitern (2a, 2a'; 2b, 2b'; 2c, 2c') der Paare, und einen abdeckenden Mantel (3), der die Leiter abdeckt, gekennzeichnet durch zusätzlich eine isolierende Schicht (4) auf einem porösen dielektrischen Kunststoff, die zwischen den Leitern (2a, 2a'; 2b, 2b'; 2c, 2c') und dem abdeckenden Mantel (3) vorgesehen ist.

2. Kabel nach Anspruch 1, bei dem sowohl der Streifen aus Isolierstoff (1) zwischen den Leitern der Paare als auch die Isolierschicht (4) zwischen den Leitern und dem abdeckenden Mantel expandiertes, poröses Polytetrafluoroethylen sind.

3. Kabel nach Anspruch 1 oder 2, bei dem die Abdeckung eine Abschirmschicht (6) auf ihrer äußeren Peripherie besitzt.

4. Kabel nach einem der vorhergehenden Ansprüche, bei dem zwischen dem Streifen aus dielektrischem Material (1) und den Leitern auf mindestens einer Seite des Streifens eine Isolierschicht (5) aus einem nicht-porösen Kunststoff angeordnet ist.

Revendications

1. Câble à ligne plate comprenant plusieurs paires de conducteurs électriques, ayant une bande poreuse d'un matériau diélectrique (1) d'isolement disposée entre les conducteurs (2a, 2a'; 2b, 2b'; 2c, 2c') des paires, et une gaine de revêtement (3) qui recouvre les conducteurs, caractérisé par une couche d'isolement (4) d'une matière plastique diélectrique poreuse supplémentaire, disposée entre les conducteurs (2a, 2a'; 2b, 2b'; 2c, 2c') et la gaine de revêtement (3).

2. Câble selon la revendication 1, caractérisé en ce que la bande de matière d'isolement (1) disposée entre les conducteurs des paires et la couche d'isolement (4) disposée entre les conducteurs et la gaine de revêtement sont toutes deux formées de polytétrafluoroéthylène poreux expansé.

3. Câble selon la revendication 1 ou 2, dans lequel le revêtement a une couche de blindage (6) à sa périphérie externe.

4. Câble selon l'une quelconque des revendications précédentes, dans lequel une couche d'isolement (5) d'une matière plastique non poreuse est disposée entre la bande de matière diélectrique (1) et les conducteurs d'un côté au moins de la bande.

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