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(12) # EUROPEAN PATENT SPECIFICATION

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(54) **Transmission line cable.**

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Description

This invention relates to an electric transmission wire including a primary conductor wherein the characteristic impedance along the length of the wire is low, yet the wire is capable of being terminated using standard termination equipment. This invention is particularly useful for solderless wrap connections to printed circuit boards or panels and for twisted wire and single wire interconnections.

Prior to this invention, transmission wire with a low impedance (less than 100 ohms) was not available for use with standard termination equipment. Typically, a primary conductor with a diameter greater than 0.508mm had to be selected in order to achieve a low characteristic impedance. Only a thin wall of insulation could be wrapped around the primary conductor without increasing the characteristic impedance. Since only a thin wall of insulation could be used, there was a poor cut-through resistance of this outer wall of insulation and there were other stripping difficulties.

Because of the low cut-through and abrasion resistance of these thin outer insulation walls, it was often necessary to apply a protective jacket over the wire. This further aggravated the stripping problem as the jacket first had to be removed during termination. During removal, the primary conductor is frequently damaged by the stripping blades. These difficulties have been eliminated, or at least substantially reduced, by the present invention.

GB-A-1151842 discloses a conductor wrapped with a low resistivity tape. The purpose of the tape is to attenuate high frequency currents and no insulating layer is required. The effect of the tape on the characteristic impedance of the cable would be negligible.

According to the present invention there is provided an electric transmission wire comprising a primary conductor with a diameter of less than 20 mils (0.508mm) wrapped with at least one layer of material characterised in that the material of the at least one layer comprises a conductive layer in continuous contact with the primary conductor, said primary conductor and wrapped conductive layer further wrapped with at least one layer of an insulating film such that the overall transmission wire maintains a characteristic impedance below 100 ohms.

Since the layer of conductive material, which can be conductive foil or a conductive foil laminated to a substrate layer, is in contact with the primary conductor, the effective electrical diameter of the primary conductor is increased. An outer layer of insulation may be applied over the foil and primary conductor.

The foil or foil laminate may be applied by either spiral wrapping or by longitudinal wrapping around the primary conductor. This invention provides a desired characteristic impedance along the length of the wire and allows easy removal for standard termination and increased cut-through resistance.

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

Figure 1 is a schematic representation of a cross-section of a single insulated wire according to the invention;

Figure 2 is a schematic representation of a cross-section of a twisted pair of insulated wires according to the invention, and

Figure 3 is a graphical representation depicting the relation between impedance and the ratio D/d where D is the diameter of the insulated wire and d is the actual diameter of the conductor.

In the present invention the effective electrical diameter of a primary conductor of less than 0.508mm diameter is increased by wrapping conductive foil, or conductive foil laminated to a substrate on to the primary conductor, the foil being in contact with the conductor. This may be accomplished by conventional wire wrapping techniques and equipment.

The primary conductor with conductive foil or laminate in contact with it is able to maintain a low characteristic impedance and still be compatible with standard termination equipment and printed circuit boards.

A thicker layer of outer insulation may be applied over the wrapped primary conductor and will not affect the characteristic impedance. This provides increased cut-through resistance. Conventional stripping equipment may be used with the wrapped wire and the thicker layer of outer insulation is easily removed for termination.

The invention also provides benefits for applications in state of the art electronic equipment. The primary conductor with a diameter of less than 0.508mm is compatible with terminal and grid spacings of a printed circuit board having 0.16 cm^2 terminal with grid spacing of 0.254cm.

An inventive embodiment may be used either as a single insulated wire or two insulated wires may be twisted together and be used as a pair of twisted wires.

Referring to the cross-sectional view of a single insulated wire depicted in Figure 1, a conductive metal foil laminate, consisting of a metal foil coating 2 on a laminar support 1, is spirally wrapped around a

primary conductor 3 with the metal foil 2 facing into and in continuous contact with the primary conductor 3 and making electrical contact between the primary conductor 3 and foil 2. The preferred metal foil laminate comprises aluminum foil bonded to polyester or polyimide base film 1 or aluminum foil bonded to a film of expanded polytetrafluoroethylene 1. The primary conductor 3 may have a single wrapping of metal foil or it may have a plurality of wrappings, depending on the desired thickness of the wall, as depicted in Figure 1. Additional insulation 4, if required, is applied over the top of the metal foil laminate wrapping.

Figure 2 shows a cross-sectional view of a twisted pair of insulated wires in which a conductive metal foil laminate, consisting of metal foil 12 on a laminar support 10, is spirally wrapped around each primary conductor 13 with the metal foil 12 facing the wires and in continuous contact with primary conductors 13 making electrical contact between the primary conductors 13 and the foil 12. Additional insulation 14, if required, is applied over the top of the metal foil laminate wrapping.

Figure 2 also shows the initial diameter of the primary conductor 13 as being d_1. As the conductive metal foil is wrapped around each conductor, the effective electrical diameter is increased and is measured as d_{eff}. Without the conductive wrapping, the primary conductor actual diameter d_1 is also its effective electrical diameter. Additional insulation 14 may be applied over the top of the metal foil laminate wrapping. The total diameter of the conductor 13, wrapped conductive foil 12, support 10 and outer insulation covering 14 is measured as D. The characteristic impedance Z is logarithmically related to the diameter of the insulated wire by the ratio D/d. Where the invention is used, the diameter of the primary conductor (d) is substituted by d_{eff}. Thus, by using the invention, the characteristic impedance is reduced because the effective electrical diameter of the primary conductor is increased.

In a preferred embodiment, the additional insulation 14 may be a polyester film or polyimide based film insulation. This additional insulation may be applied by extrusion or by additional wrapping to a desired outside diameter. Cut-through resistance is increased by the addition of this insulation.

EXAMPLE 1

Existing solderless wrap on a primary conductor, and a primary conductor wrapped according to the present invention, for a single 50 ohm insulated wire are contrasted. A final outer diameter of wire of 0.498mm is desired as this is the optimum size for automatic wire stripping equipment.

Using conventional technology, a single 28(l) AWG (American Wire Gauge) primary conductor with an actual diameter of 0.32mm, relative dielectric constant E = 3.1 and a characteristic impedance of 50 ohms, was covered by an outer layer of polyester film insulation. Here, the final diameter of 0.358mm was attained without increasing the characteristic impedance. A D/d ratio of 1.12 was calculated by referring to Figure 3.

Using the present invention, a single 28(l) AWG primary conductor of actual diameter 0.32mm was wrapped with three layers of aluminum foil laminated tape whereby the foil was in constant physical contact with the primary conductor. An outer layer of polyester film insulation was applied over the primary conductor foil combination. The final diameter of this embodiment was 19.6 mils 0.498mm.

By wrapping the foil around the primary conductor, the diameter of the primary conductor of 0.32mm was increased to an effective electrical diameter of 0.445mm.. The characteristic impedance was maintained at 50 ohms and the resulting wire had a calculated D/d ratio of 1.13.

The following chart summarizes results of the calculated outer wall thickness and cut-through radius of curvature for both conventional solderless wrap on a primary conductor and the present invention.

CHART 1

Comparison of 28(1) AWG Primary Conductors Using Existing Technology And The Present Invention for 50 ohms Impedance

	Z0 ohms	d mm	d_{eff} mm	D/d	D/d_{eff}	D mm	Outer Wall mm	Cut-through Radius of Curvature mm
Conventional Technology	50	0.32	-	1.12	-	0.358	0.019	0.179
Foil-Wrapped	50	0.32	0.445	-	1.13	0.498	0.027	0.249

Wall = (D-d)/2

Cut-through radius of curvature = D/2

An insulated wire with an outer wall thickness of 0.019mm does not fit standard automated stripping machines. The standard wire cutting equipment is not able to cut into, grab and pull off the outer wrapping without injury to the primary conductor. Further, a radius of curvature of 0.179mm does not meet conventional wire cut-through requirements.

In contrast, the present invention provides a primary conductor with an increased electrical diameter and increased outer wall diameter and cut-through radius of curvature so that standard automated stripping

machines could be used.

EXAMPLE 2

A comparison similar to that described in Example 1 was also made with a 28(l) AWG primary conductor with an actual diameter of 0.32mm, relative dielectric constant E = 3.1 and a characteristic impedance of 55 ohms. Here the D/d ratio was found to be 1.15 by referring to Figure 3.

Test data was accumulated and calculations made were similar to those as described in Example 1. Test results are summarised in Chart 2 shown below.

CHART 2

Comparison of 28(1) AWG Primary Conductors using Existing Technology And The Present Invention for Wire With A Characteristic Impedance of 55 ohms

	Z0 ohms	d mm	deff mm	D/d	D/deff	D mm	Outer Wall mm	Cut-through Radius of Curvature mm
Conventional Technology	55	0.32	-	1.15	-	0.368	0.024	0.184
Foil-Wrapped	55	0.32	0.445	-	1.15	0.51	0.031	0.257

Wall = (D-d)/2

Cut-through radius of curvature = D/2

Here again, one skilled in the art can see that the inventive entity allows the impedance to remain at 55 ohms but the outer wall and cut-through radius are increased (by 39%) and can be used with existing wire stripping equipment.

EXAMPLE 3

Existing solderless wrap of primary conductors and the present invention for a 75 ohm twisted pair of insulated wires are compared. An outside diameter of 0.495mm is desired as this is the optimum size for the automatic wire-stripping machines.

Using conventional technology, a pair of 30(l) AWG primary conductors with initial diameters of 0.257mm, relative dielectric constant of 3.12, a characteristic impedance of 75 ohms is extrapolated from Figure 3 to have a D/d ratio of 1.36.

Similarly, a pair of 30(l) AWG primary conductors are individually wrapped with aluminum foil laminated tape so that the foil is in constant physical contact with each primary conductor. Here, the outer diameter D is 0.495mm, the effective electrical diameter d_{eff} is 0.366mm, and the ratio of D/d_{eff} is found to be 1.31.

The following chart summarizes physical characteristics of a 30(l) AWG twisted pair using existing art and a twisted pair as constructed by the present invention.

CHART 3

75 ohm Twisted Pair 30(1) AWG

	Z0 ohms	d mm	d_{eff} mm	D/d	D/d_{eff}	D mm	Outer Wall mm	Cut-through Radius of Curvature mm
Conventional Technology	75	0.257	-	1.36	-	0.345	0.046	0.173
Foil-Wrapped	75	0.257	0.366	-	1.31	0.495	0.066	0.248

Wall = (D-d) / 2

Cut-through radius of curvature = D / 2

In this example, we achieve the desired combination of a 30(l) AWG twisted pair of wires with an outer diameter of 0.495mm and maintain the desired impedance of 75ohms. If one were simply to insulate the 30-(l) AWG with polyester film insulation to make an outer diameter of 0.495mm, the characteristic impedance would be 100 ohms.

Also for a 75 ohm twisted pair 30(l) AWG, the wall thickness has been increased to add cut-through resistance without increasing the characteristic impedance in this invention. Further, the cut-through radius

of curvature is increased by 43% and is easily compatible with existing stripping equipment.

Claims

1. An electric transmission wire comprising a primary conductor (3) with a diameter of less than 0.508mm wrapped with at least one layer (2) characterised in that the material of the at least one layer comprises a conductive layer in continuous contact with the primary conductor, said primary conductor and wrapped conductive layer further wrapped with at least one layer of an insulating film (4) such that the overall transmission wire maintains a characteristic impedance below 100 ohms.

2. An electric transmission wire according to claim 1 characterised in that it is twisted together with a second primary conductor with a diameter of less than 0.508mm wrapped with a said conductive layer in continuous contact therewith and further wrapped with at least one layer of an insulating film.

3. An electric transmission wire according to claim 1 characterised in that said wire maintains a characteristic impedance less than 75 ohms.

4. An electric transmission wire according to claim 1 characterised in that the or each wrapped conductive layer is aluminum laminated to polyester film.

5. An electric transmission wire according to claim 1 characterised in that the or each wrapped conductive layer is aluminum laminated to an expanded PTFE film.

6. An electric transmission wire according to claim 1 characterised in that the or each wrapped conductive layer is aluminum laminated to a polyimide film.

7. An electric transmission wire according to claim 1 characterised in that the or each wrapped conductive layer is wrapped spirally around said primary conductor.

8. An electric transmission wire according to claim 1 characterised in that the or each wrapped conductive layer is wrapped longitudinally around said primary conductor.

Revendications

1. Fil de transmission électrique comprenant un conducteur primaire (3) ayant un diamètre inférieur à 0,508 mm enveloppé d'au moins une couche (2), caractérisé en ce que la matière de ladite couche au moins comprend une couche conductrice qui est en contact continu avec le conducteur primaire, le conducteur primaire et la couche conductrice enveloppée étant en outre enveloppés d'au moins une couche d'un film isolant (4) afin que le fil de transmission dans son ensemble garde une impédance caractéristique inférieure à 100 Ω.

2. Fil de transmission électrique selon la revendication 1, caractérisé en ce qu'il est retordu avec un second conducteur primaire ayant un diamètre inférieur à 0,508 mm enveloppé d'une couche conductrice en contact continu avec lui et enveloppé en outre d'au moins une couche d'un film isolant.

3. Fil de transmission électrique selon la revendication 1, caractérisé en ce que le fil garde une impédance caractéristique inférieure à 75 Ω.

4. Fil de transmission électrique selon la revendication 1, caractérisé en ce que la couche ou chaque couche conductrice enveloppée est formée d'un stratifié d'aluminium sur un film de polyester.

5. Fil de transmission électrique selon la revendication 1, caractérisé en ce que la couche ou chaque couche conductrice enveloppée est formée d'un stratifié d'aluminium sur un film de PTFE expansé.

6. Fil de transmission électrique selon la revendication 1, caractérisé en ce que la couche ou chaque couche conductrice enveloppée est un stratifié d'aluminium sur un film de polyimide.

7. Fil de transmission électrique selon la revendication 1, caractérisé en ce que la couche ou chaque

couche conductrice enveloppée est enroulée en spirale autour du conducteur primaire.

8. Fil de transmission électrique selon la revendication 1, caractérisé en ce que la couche ou chaque couche conductrice enveloppée est enroulée longitudinalement autour du conducteur primaire.

Patentansprüche

1. Elektrische Übertragungsleitung, umfassend einen Primärleiter (3) mit einem Durchmesser von weniger als 0,508 mm, umwickelt mit mindestens einer Schicht (2), dadurch gekennzeichnet, daß das Material der mindestens einen Schicht eine leitende Schicht aufweist, die in durchgehender Berührung mit dem Primärleiter steht, der Primärleiter und die gewickelte leitende Schicht weiterhin von mindestens einer Schicht aus einem isolierenden Film (4) derart umwickelt sind, daß die gesamte Übertragungsleitung einen Wellenwiderstand von weniger als 100 Ohm behält.

2. Elektrische Übertragunsleitung nach Anspruch 1, dadurch gekennzeichnet, daß sie zusammen mit einem zweiten Primärleiter verdrillt ist, der einen Durchmesser von weniger als 0,508 mm aufweist, umwickelt mit einer damit in durchgehendem Kontakt stehendem leitenden Schicht und weiterhin umwickelt mit mindestens einer Schicht aus einem isolierenden Film.

3. Elektrische Übertragungsleitung nach Anspruch 1, dadurch gekennzeichnet, daß die Leitung einen Wellenwiderstand von weniger als 75 Ohm aufweist.

4. Elektrische Übertragungsleitung nach Anspruch 1, dadurch gekennzeichnet, daß die oder jede umwickelte leitende Schicht ein mit Aluminium beschichteter Polyesterfilm ist.

5. Elektrische Übertragungsleitung nach Anspruch 1, dadurch gekennzeichnet, daß die oder jede gewickelte leitende Schicht ein mit Aluminium beschichteter Film aus expandiertem PTFE ist.

6. Elektrische Übertragungsleitung nach Anspruch 1, dadurch gekennzeichnet, daß die oder jede gewickelte leitende Schicht ein mit Aluminium beschichteter Polyimidfilm ist.

7. Elektrische Übertragungsleitung nach Anspruch 1, dadurch gekennzeichnet, daß die oder jede gewickelte leitende Schicht spiralförmig um den Primärleiter herumgewickelt ist.

8. Elektrische Übertragungsleitung nach Anspruch 1, dadurch gekennzeichnet, daß die oder jede gewickelte leitende Schicht in Längsrichtung um den Primärleiter herumgewickelt ist.

FIG. 1

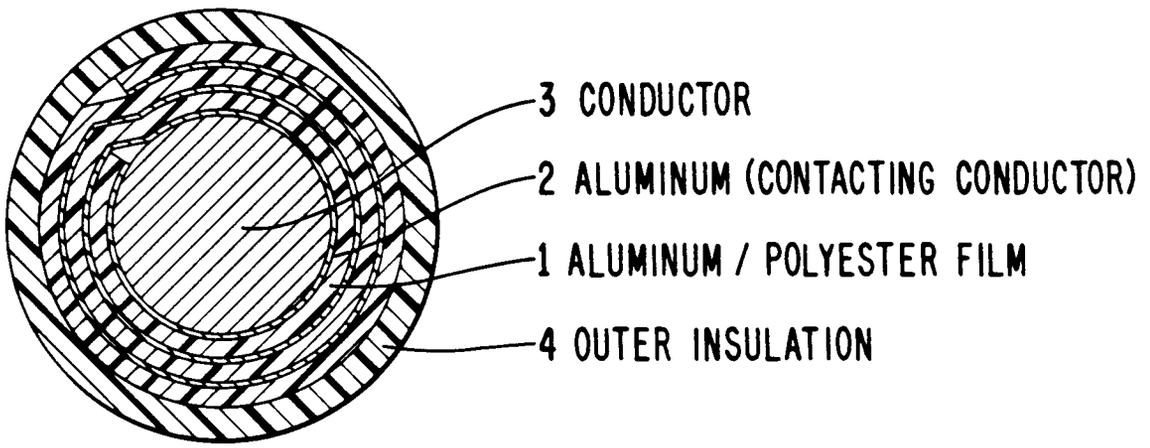

3 CONDUCTOR
2 ALUMINUM (CONTACTING CONDUCTOR)
1 ALUMINUM / POLYESTER FILM
4 OUTER INSULATION

FIG. 2

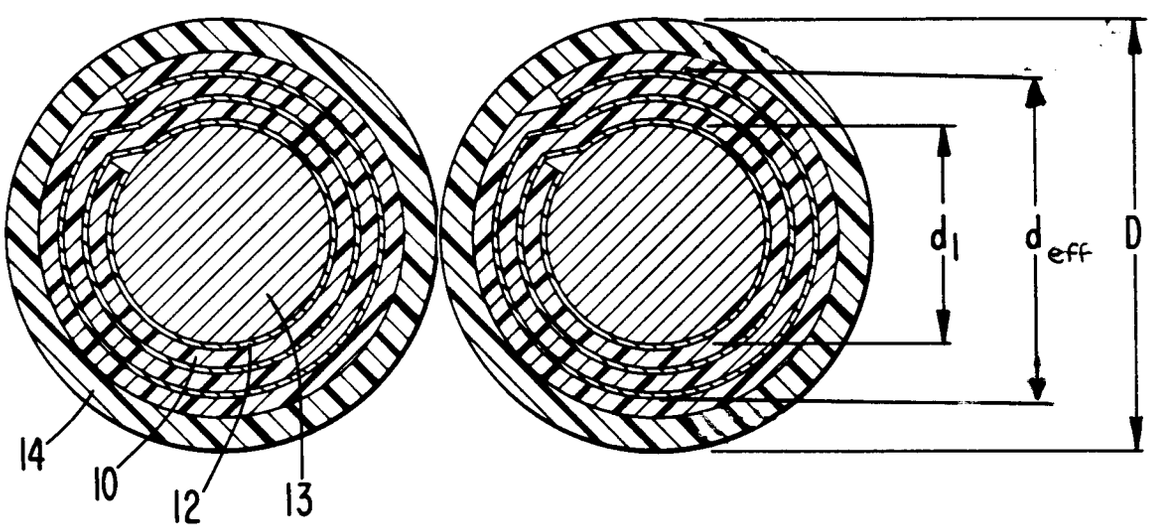
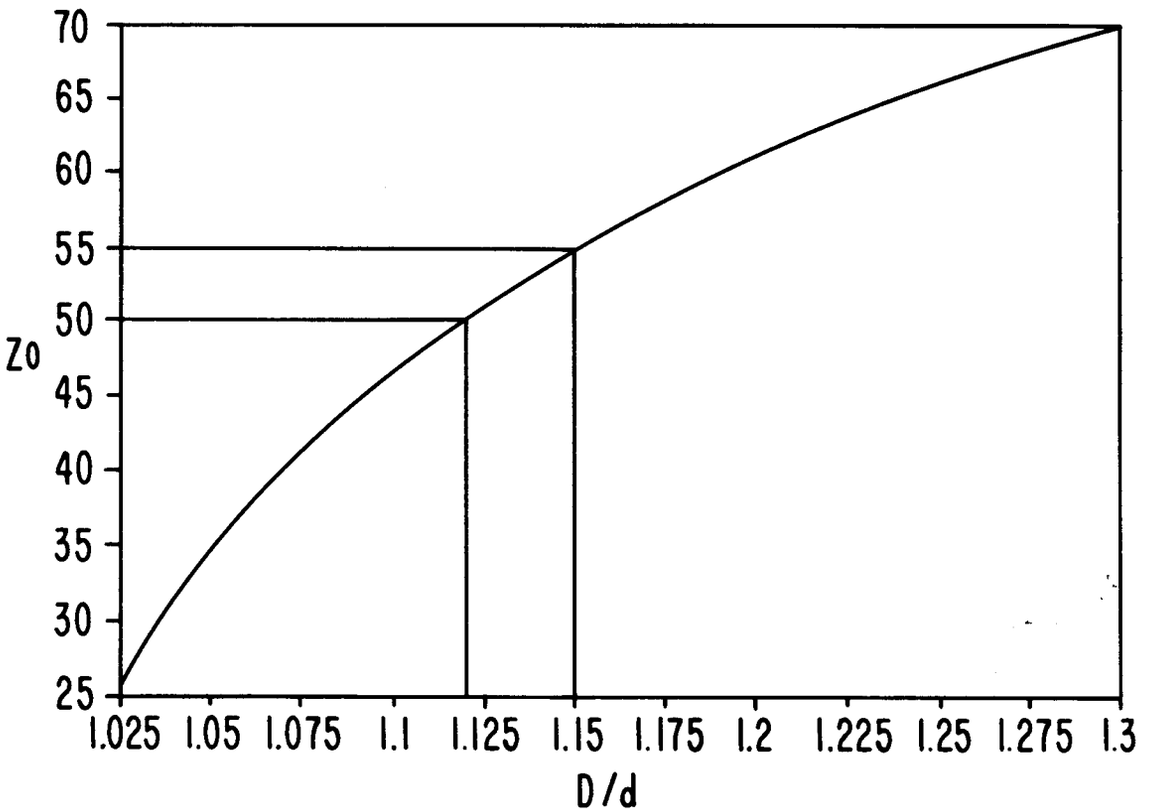

d1
deff
D
14
10
12
13

FIG. 3


70
65
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55
50
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25
Zo
1.025
1.05
1.075
1.1
1.125
1.15
1.175
1.2
1.225
1.25
1.275
1.3
D/d