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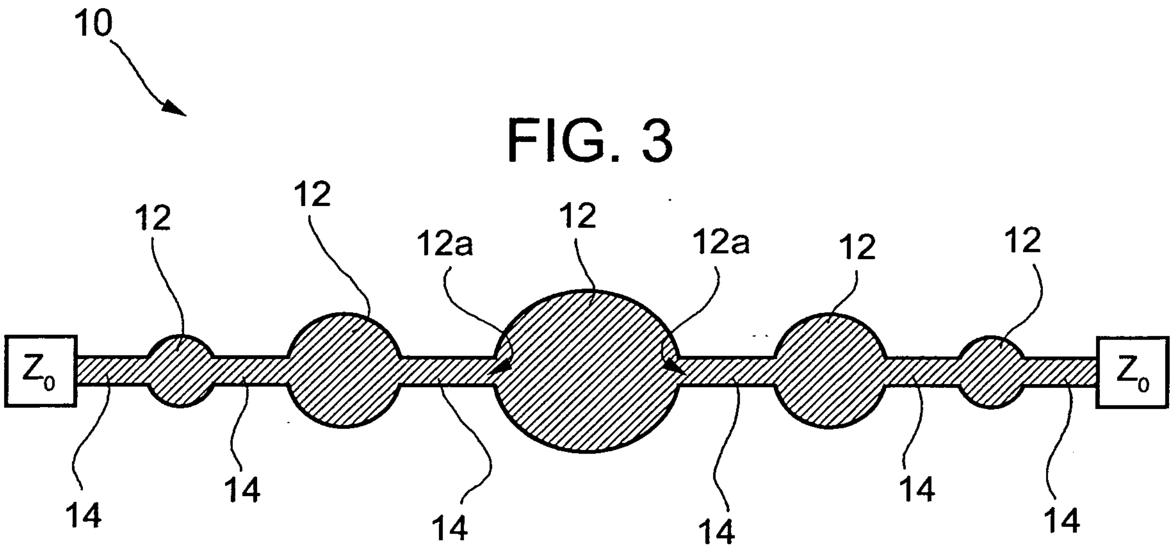
(54) Distributed capacitive component in strip lines, filter, transformer, resonator and divider arrangements

(57) A conductive strip transmission line is disclosed, including at least one capacitive component with distributed parameters which has, in the plane of the strip, a track area (12; 22; 32; 42) delimited by a profile free of angular points, for example an elliptical or circular track area.

Also described are electromagnetic structures and circuit arrangements based on this type of transmission line, such as a low-pass filter (10), a bandpass filter (20), a λ/4 transformer (30), a parallel LC resonator (40), a 90 degree hybrid divider/combiner and a Wilkinson divider, comprising capacitive components of a transmission line with circular track areas.

FIG. 3



EP 1 906 484 A1

Description

[0001] The present invention relates to transmission lines in the form of conductive strips for microwaves, and in particular to microstrip lines for power applications intended for the use of radio frequency and microwave filters and components.

[0002] Specifically, the invention relates to a conductive strip transmission line according to the preamble of Claim 1, and to electromagnetic structures and circuit arrangements based on conductive strip transmission lines.

[0003] There are known electronic devices which operate with high power signals in the microwave field, for example microwave radar transmitters, for which a non-negligible quantity of energy is dispersed in frequency components different from the carrier frequency or from the conventional sideband modulation components. At the output of these devices it is therefore necessary to provide power filters for transmitting the useful carrier frequency while suppressing the spurious emissions.

[0004] The first step in the design of a filter is the definition of the circuit parameters according to the required filter characteristic. Low-pass filters and wideband bandpass filters operating in the frequency range from 100 MHz to 10 GHz, and therefore having distributed parameters, are conveniently made from short portions of transmission lines which approximate to lumped circuit components.

[0005] Figure 1 shows, by way of example, the equivalent T and Π circuits of a portion of TEM mode transmission line, ideally non-dispersive. When the physical length *l* of the portions of line is small and therefore the electrical length is less than n/4 radians, the equivalent reactance (X) and susceptance (B) are given by:

$$\frac{X}{2} \approx Z_0 \frac{\omega l}{2\nu} \qquad B \approx Y_0 \frac{\omega l}{\nu}$$

for the T circuit, and by:

$$X \approx Z_0 \frac{\omega l}{\nu} \qquad \frac{B}{2} \approx Y_0 \frac{\omega l}{2\nu}$$

for the Π circuit, in which Z_0 is the characteristic impedance of the line, ω is the pulsation and ν is the field propagation velocity along the line.

[0006] A short portion of line with a high characteristic impedance, in the approximation in which the length of the portion is much less than the propagation wavelength of the radiation, is the most common implementation of a serial inductance, and a short portion of line with a low characteristic impedance, again in the aforesaid approximation, is the most common implementation of a parallel capacitor, particularly in microwave filters for circuits operating in TEM modes.

[0007] In applications at microwave frequencies, compact microstrip transmission lines are constructed because of the requirements of miniaturization. In a planar microstrip circuit, the inductive effect is provided by a constriction of the track and the capacitive effect is provided by a widening of the track. Thus, the transverse dimensions of the lines are not constant, but vary according to whether the region is inductive or capacitive. A conventional low-pass filter therefore consists of a sequence of portions as shown in Figure 2a, while a conventional bandpass filter is shown in Figure 2b, in which the length and spacing of the stubs determines the frequency behaviour.

[0008] These filter circuits are easily manufactured and inexpensive.

[0009] Microstrip transmission lines have intrinsic limitations in respect of the maximum transmissible power level.

[0010] The capability of a microstrip line to sustain high-power signals, such as pulsed signals of brief duration (of the order of a few tens of microseconds) with a low mean power level but peaks of high pulse power, depends on its configuration, and in particular is limited by the phenomenon of impact ionization and consequent breakdown, in air or in the dielectric.

[0011] The breakdown phenomenon occurs when the electrical field in the proximity of the edges of the line is greater than the limit field supported by the dielectric in which the discharge takes place. The discharge in this case is known as a "no-electrode" discharge, since many of the free electrons undergo numerous cycles of oscillation (and collisions) before reaching an electrode.

[0012] The minimum intensity of the breakdown field is found at a field radio frequency equal to the collision frequency of the gas forming the atmosphere of the medium in which the line is located. The maximum transfer of energy between the electromagnetic field and the gas subject to breakdown is produced in this condition.

[0013] The critical pressure at which the discharge occurs can be calculated approximately by means of the equation

$$p \cdot \lambda \cong 47.4[Pa \cdot m]$$

[0014] The probability of discharge also depends on the electrical field intensity (due to geometrical factors) and increases with a decrease in the pressure of the aforesaid gas. The discharge (corona effect) can also occur when the pressure is greater than the critical pressure for electrical field values given by the equation:

$$E = \mathrm{K} \cdot p$$

where E is the root mean square value of the electrical field expressed in volts/cm, *p* is the pressure of the gas expressed in mmHg and K is a constant dependent on the gas (approximately 40 for air).

[0015] The electrical field value for which a breakdown occurs in air and at a pressure of 760 mmHg (or 1 atm) is approximately 3 kV/mm, this value decreasing at low pressures, in accordance with the preceding equation.

[0016] Typically, for a dielectric material used as a substrate for a conductive strip transmission line, the electrical breakdown field strength is greater by an order of magnitude than that of air, for example 30 kV/mm for FR4 material and 15 kV/mm for alumina. The rigidity values of the dielectric materials are such that the discharge phenomena take place predominantly in the air surrounding the microstrip.

[0017] Similar values of field strength can occur because of surface irregularities in the microstrip lines, but can also be found in ordinary transmission lines carrying signals with peak power levels of 1 kW. In particular, the edges and angles of a planar track configuration promote the initiation of the breakdown, considerably limiting the power which can be supported by the line.

[0018] Microstrip power circuits including filters for the elimination of the spurious components at the undesired frequencies have geometries which promote the development of the breakdown phenomenon (see Figures 2a and 2b) and are difficult to use for carrying power in excess of a peak value of 1 kW.

[0019] The object of the present invention is to avoid the drawbacks of the known art by providing a conductive strip circuit configuration which limits the development of the breakdown phenomenon as much as possible.

[0020] According to the present invention, this object is achieved by means of a conductive strip transmission line having the characteristics claimed in Claim 1.

[0021] Specific embodiments of the invention are defined in the dependent claims.

[0022] The invention also proposes electromagnetic structures and circuit arrangements such as a low-pass filter, a bandpass filter, a $\lambda/4$ transformer and a parallel LC resonator, comprising transmission lines according to the invention.

[0023] The present invention is based on the principle of replacing the rectangular shapes of the capacitive components of a conventional conductive strip transmission line, such as a microstrip line, with geometries free of angular points, in other words track areas with a polygonal profile with rounded angles, or with a wholly curved profile.

[0024] Geometrically, these track areas can be formed by any two-dimensional domain having a diameter of less than $\lambda_g/4$, where λ_g denotes the radiation propagation wavelength in the transmission line in question for which the area shows capacitive and non-resonant behaviour. Otherwise, track areas with a diameter in the range from $\lambda_g/4$ to λ_g would act as resonators.

[0025] Preferably, in order to minimize the electrical field concentrations around it, and to simplify the design, the conductive track area of the capacitive component is a regular geometrical figure, for example a circular or elliptical configuration (generally referred to as areas whose profile is a closed conic section), for which it is possible to determine - at least approximately - an analytical formula for the characteristic impedance as a function of the geometrical parameters of the figure.

[0026] The innovative layout reduces the probability of impact ionization and thus limits the consequent breakdown phenomenon in the dielectric. In particular, the strength of the electrical field which would otherwise be present in the angular points of microstrip lines is reduced by a factor of approximately 2.

[0027] Conveniently, the capacitive component according to the invention can be connected to one or more track portions of an electromagnetic structure or circuit arrangement by portions of its profile separated by a predetermined angle, for example diametrically opposed portions.

[0028] The proposed circuit configurations are a low-pass filter including at least one LC cell with distributed parameters, a bandpass filter including at least one LC resonant cell with distributed parameters, a $\lambda/4$ transformer, a parallel LC resonator, a 90 degree hybrid divider/combiner and a Wilkinson divider, all comprising capacitive components with a conductive track area in the form of a pad with a profile free of angular points.

[0029] Advantageously, the proposed geometries improve the power carrying capacity of a microstrip circuit, for example one comprising low-pass filters for eliminating the spurious frequency components, reducing the electrical field strength around the line, and thus increasing the maximum transmissible power at which the breakdown phenomenon occurs. It has been found experimentally that the transmission lines proposed by the invention can support power levels at least twice those supported by conventional lines, up to a peak of approximately 3 kW.

[0030] Further characteristics and advantages of the invention will be disclosed more fully in the following detailed description, provided by way of example and without restrictive intent, with reference to the attached drawings, in which:

Figure 1 shows the equivalent T and Π circuits of a portion of TEM mode transmission line;
Figures 2a and 2b show the conventional embodiments of a low-pass filter and a bandpass filter respectively, in a planar microstrip circuit;
Figure 3 shows an embodiment of a low-pass filter in a planar microstrip circuit according to the invention;
Figure 4 shows an embodiment of a bandpass filter in a planar microstrip circuit according to the invention;
Figure 5 shows an embodiment of a λ/4 transformer comprising capacitive components according to the invention;
Figure 6 shows an embodiment of an LC resonator comprising capacitive components according to the invention;
Figures 7a and 7b show an embodiment of a wide-band 90 degrees hybrid divider/combiner comprising capacitive components according to the invention, and the corresponding equivalent circuit; and
Figures 8a and 8b show an embodiment of a Wilkinson divider comprising capacitive components according to the invention, and the corresponding equivalent circuit.

[0031] Figures 2a and 2b show, respectively, a low-pass filter and a conventional bandpass filter in a planar microstrip circuit, constructed from short portions of transmission lines which can be represented by the equivalent T and Π circuits of Figure 1, which have already been discussed in the introductory part of this description and are therefore not described further.

[0032] Figure 3 shows an embodiment of a low-pass filter 10 according to the invention in a planar microstrip circuit, operating at frequencies of the order of GHz, including a plurality of LC cells with distributed parameters, each cell comprising, in combination, an inductive component including a straight track portion, and a capacitive component with a circular configuration, in series with the inductive portion.

[0033] The circular track area 12 of the capacitive components is connected to the straight inductive track portions 14 for the input and output of the propagation mode guided by the line, through two diametrically opposed profile portions 12a.

[0034] It is also possible to connect the circular track area of the capacitive components to the straight portions by means of profile portions separated by an angle in the range from 45 to 180 degrees, and preferably in the range from 90 to 180 degrees, thus producing a circuit substantially in the form of a broken line, for example in order to reduce the longitudinal dimensions of the circuit.

[0035] In the circular configuration, the characteristic impedance of the capacitive component, in the form of a portion of transmission line, can be calculated from the approximate analytical formulae

$$\frac{377}{\frac{\pi}{2}\cdot\frac{R}{h}\cdot\sqrt{3\varepsilon_{r,SUB}}} \qquad \varepsilon_{r,SUB} \leq 2$$

and

$$\frac{377}{\frac{\pi}{2}\cdot\frac{R}{h}\cdot\sqrt{\frac{3}{2}\left(\varepsilon_{r,SUB}+1\right)}} \qquad \varepsilon_{r,SUB} > 2$$

where R is the radius of the circular track area, h is the thickness of the dielectric material, and $\varepsilon_{r,SUB}$ is the dielectric constant of the substrate.

[0036] An analytical formula for the approximate evaluation of the upper power limit which can be transmitted in such a structure is as follows:

$$\frac{P}{(2h)^2}\left[\frac{KW}{inc^2}\right] \approx 25 \cdot \frac{R}{h} \cdot \sqrt{\frac{3}{2}\left(\varepsilon_{r,SUB}+1\right)} \cdot \frac{\frac{t}{2h}}{0.01}$$

where P is the peak power measured in kW, R is the radius of the circular track area, h is the thickness of the dielectric material, t is the thickness of the conductive strip, and $\varepsilon_{r,SUB}$ is the dielectric constant of the substrate.

[0037] Such a low-pass filter configuration can also be produced by using capacitive components with an elliptical track area (not shown), connected to the inductive straight track portions by means of two diametrically opposed profile portions located at the vertices of the elliptical profile curve of the area.

[0038] Exactly the same principles are applicable to the production of bandpass filter configurations (Figure 4) with identical geometrical configurations of the capacitive components.

[0039] A bandpass filter 20 in a planar microstrip circuit includes a plurality of series LC resonant cells with distributed parameters comprising a main straight track portion 21, from which stubs, each including a capacitive component, branch off. The track area 22 of the capacitive component is connected to the end of a straight track portion 24 belonging to the stub via a profile portion 22a.

[0040] In general, a conductive strip transmission line, in which the capacitive component with distributed parameters are represented by pads having the aforementioned shapes, can conveniently be used in applications which require printed capacitors or resonator circuits with low characteristic impedance.

[0041] Figure 5 shows an embodiment of a λ/4 transformer 30 in a planar microstrip circuit, which includes a pair of capacitive components of circular configuration, whose track areas 32 are interconnected by means of a lumped inductive component 34.

[0042] This produces a compact configuration, preferable in the case in which the metric value of λ/4 (with reference to the central operating frequency) is high for providing a conventional track portion, requiring excessive occupation of space in the resulting circuit.

[0043] Figure 6 shows an embodiment of a parallel LC resonator 40 in a planar microstrip circuit, which includes a capacitive component with a track area 42 of circular configuration, connected via first diametrically opposed profile portions 42a to a pair of inductive straight track portions 44 connected to a ground plane GND. The resonator configuration can be connected to portions of a main track 46 for the propagation of a mode, at second profile portions 42b of the track area 42 of the capacitive component, intermediate between the first portions 42a.

[0044] In an alternative embodiment, the resonator can be produced by connecting the track area 42 of the capacitive component to only one inductive straight track portion 44, the resonator configured in this way being connectable to a main track portion 46 for propagating the mode at a profile portion 42b of the track area 42 diametrically opposed to the profile portion 42a through which the aforesaid track area is connected to the inductive track portion 44.

[0045] Figure 7a shows an embodiment of a wide-band 90 degree hybrid divider/combiner circuit 50 made in microstrip planar technology, which includes capacitive components with track areas of circular configuration, connected to inductive track portions and to lumped inductive components.

[0046] Specifically, with reference also to the equivalent circuit in Figure 7b, the 90 degree divider/combiner circuit has a pair of input ports IN1 and IN2, the second of which is closed on to a matched impedance in the divider configuration illustrated here, and a pair of output ports OUT1 and OUT2. Between the input ports and the output ports, the circuit has a pair of meshes with distributed parameters, including track portions which approximate to lumped components.

[0047] The meshes include a pair of branches for direct connection between an input port and an output port (the horizontal branches in the arrangement shown in the figure), and transverse branches between the direct connection branches (vertical in the arrangement shown in the figure). Each of the direct connection branches comprises a pair of terminal circular track areas 52', forming capacitive components with distributed parameters, connected, to an input port and to an output port of the circuit, respectively, and an intermediate circular track area 52'' connected to the terminal track areas via λ/4 inductive track portions 54' (with reference to the central operating frequency) consisting of a sequence of straight segments arranged in a tortuous path. The transverse branches which connect the terminal track areas 52' consist of an air-cored conducting wire 54'' forming a lumped inductive component, while the transverse branch which connects the intermediate track areas 52'' is another λ/4 inductive track portion 54' consisting of a sequence of straight segments arranged in a tortuous path.

[0048] Each of the terminal track areas 52' is connected to the adjoining input/output port and to the track portions 54' of the corresponding connecting branch at profile portions. The intermediate track areas 52" have diametrically opposed profile portions for connection to the track portions 54' of the direct connecting branch, and a profile portion for connection to the transverse track portion 54' which is intermediate between the preceding portions, in other words separated from them by an angle of 90 degrees.

[0049] Capacitive components with distributed parameters and a smaller capacitance correspond to circular track areas with a smaller diameter.

[0050] In the embodiment shown by way of example, relating to a divider circuit operating at a frequency of 1 GHz and with a pass band of 1 GHz (i.e. between 500 MHz and 1.5 GHz), the track areas 52' have a diameter of 5 mm each, the track areas 52" have a diameter of 7.5 mm each, and the whole circuit has overall dimensions of 4 x 3 cm, excluding the connectors.

[0051] Conveniently, due to the fact that the capacitive components with distributed parameters are made from track areas (or transmission line portions) 52', 52" in the form of circular areas rather than square or rectangular areas, the aforesaid circuit has a reduced number of angles of the planar track configuration, which would concentrate the electrical field and promote the initiation of breakdown, as compared with the prior art. Square or rectangular track areas with a capacitive effect and with dimensions suitable for the use of the aforesaid circuit would have their shapes circumscribed on the circular area actually constructed, and would also result in a higher consumption of conductive material. Secondly, because of the provision of transverse branches with lumped inductive components, such as air-cored windings, the illustrated circuit can overcome the construction problems which would require the provision at this position of a $\lambda/4$ track portion with distributed parameters and with the necessary impedance, which would require a very narrow track, of the order of hundredths of a millimetre, which cannot be produced by present-day technological processes.

[0052] Another example of a circuit embodiment based on the transmission lines proposed by the invention is the Wilkinson divider configuration shown in Figure 8a, the equivalent circuit of which being shown in Figure 8b.

[0053] The Wilkinson divider circuit, indicated by the numeral 60 in the figure, comprises two $\lambda/4$ lines formed by capacitive components of circular configuration whose track areas 62', 62" are interconnected via corresponding inductive components 64, which can be made with distributed parameters as printed track portions (as shown in the figure, for example) or as lumped elements, as air-cored windings. The two $\lambda/4$ lines have a common first track area 62' of greater surface area, and the second track areas with a smaller surface area 62'' are interconnected by a lumped resistor 65. The track area 62' of greater surface area is formed by the collapse of two track areas similar to the track areas 62", and has a surface area approximately twice as large as the surface area of the track area 62''.

[0054] Conveniently, the embodiment with circular transmission line portions not only supports a higher power transmission level, as mentioned above for the other configurations described, but also provides further advantages from the electromagnetic and architectural point of view.

[0055] Firstly, it enables the contacts of the resistor to be incorporated in the track areas 62", so that these contacts no longer form a discontinuity in the line and a disturbance of the electromagnetic characteristics of the circuit. Secondly, it makes it possible to escape from the rigidity of the form factor of the circuit as a whole, which would be imposed by the use of conventional transmission lines. This is because the circular track areas 62' and 62" can be formed on the substrate at any angle, and are not necessarily positioned at the vertices of an equilateral triangle, thus allowing better management of the available space on the substrate, particularly in the case of complex arrangements in which the circuits surrounding the divider impose strict layout constraints.

[0056] Clearly, provided that the principle of the invention is retained, the forms of embodiment and the details of production can be varied considerably from what has been described and illustrated purely by way of example and without restrictive intent, without departure from the scope of protection of the present invention as defined by the attached claims.

Claims

1. Conductive strip transmission line for propagating a TEM or quasi-TEM mode, comprising a track of conductive material and a ground plane from which the said track is separated by at least one layer of dielectric material of predetermined thickness, **characterized in that** it includes at least one capacitive component with distributed parameters which has, in the plane of the strip, a track area (12; 22; 32; 42) delimited by a profile free of angular points, the said area having a diameter of less than one quarter of the propagation wavelength of the aforesaid mode.

2. Transmission line according to Claim 1, in which the profile of the track area is a curved line comprising straight segments connected by curved segments.

3. Transmission line according to Claim 1, in which the profile of the track area is a closed conic section.

4. Transmission line according to Claim 3, in which the said capacitive component has an elliptical track area.

5. Transmission line according to Claim 3, in which the said capacitive component has a circular track area (12; 22; 32; 42).

6. Transmission line according to Claim 5, in which the characteristic impedance of the capacitive component can be calculated as

$$\frac{377}{\frac{\pi}{2}\cdot\frac{R}{h}\cdot\sqrt{3\varepsilon_{r,SUB}}} \qquad \varepsilon_{r,SUB} \leq 2$$

$$\frac{377}{\frac{\pi}{2}\cdot\frac{R}{h}\cdot\sqrt{\frac{3}{2}\left(\varepsilon_{r,SUB}+1\right)}} \qquad \varepsilon_{r,SUB} > 2$$

where R is the radius of the said circular area, h is the thickness of the dielectric material, and $\varepsilon_{r,SUB}$ is the dielectric constant of the substrate.

7. Transmission line according to Claim 4 or 5, in which at least one portion of the profile of the track area (12; 22; 32; 42) can be connected to a track portion (14; 24; 46) for the input/output of the aforesaid propagation mode.

8. Transmission line according to Claim 7, comprising two diametrically opposed profile portions (12a; 42b) which can be connected to track portions (14; 24; 46) for the input and output, respectively, of the aforesaid propagation mode.

9. Transmission line according to Claim 7, comprising two profile portions which can be connected to track portions for the input and output, respectively, of the aforesaid propagation mode, separated by an angle in the range from 45 to 180 degrees.

10. A low-pass filter arrangement (10) for a conductive strip transmission line, including at least one LC cell with distributed parameters, **characterized in that** the said cell comprises, in combination, an inductive component including a straight track portion (14) and a capacitive component having a track area (12) delimited by a profile free of angular points, in series with the said inductive straight track portion (14).

11. A bandpass filter arrangement (20) for a conductive strip transmission line, including at least one LC resonant cell with distributed parameters, **characterized in that** it comprises a main straight track portion (21) from which at least one stub, including a capacitive component having a track area (22) delimited by a profile free of angular points, branches off.

12. Arrangement (20) according to Claim 11, in which the track area (22) of the said capacitive component is positioned at the end of a straight track portion (24) of the said stub.

13. A λ/4 transformer arrangement (30) for a conductive strip transmission line, comprising a pair of capacitive components having a track area (32) delimited by a profile having no angular points, interconnected by a lumped inductive component (34).

14. A parallel LC resonator arrangement (40) for a conductive strip transmission line, comprising a capacitive component having a track area (42) delimited by a profile free of angular points, connected at the position of at least a first profile portion (42a) to at least one corresponding inductive straight track portion (44) connected to a ground plane (GND), the said arrangement (40) being connectable to at least one track portion (46) for the input/output of a propagation mode at a second profile portion (42b) of the track area (42) of the capacitive component, intermediate between the said first portions (42a).

15. Parallel LC resonator arrangement (40) according to Claim 14, in which the said second profile portion (42b) of the track area (42) of the capacitive component is diametrically opposed to the said first portion (42a).

16. Parallel LC resonator arrangement (40) according to Claim 14, in which the said track area (42) of the capacitive component is connected, at a pair of diametrically opposed first profile portions (42a), to a pair of inductive straight track portions (44), the said arrangement (40) being connectable to at least one track portion (46) for the input/output of a propagation mode at a second profile portion (42b) of the track area (42) of the capacitive component, intermediate between the said first portions (42a).

17. A 90 degree hybrid divider/combiner arrangement (50) for a planar conductive strip circuit, including a pair of meshes whose branches comprise portions of transmission line with a total length of λ/4 at the central frequency, adapted to provide distributed parameter impedances with a predetermined value, **characterized in that** the said portions of transmission line with a length of λ/4 include capacitive components having track areas (52', 52") delimited by a profile free of angular points.

18. A wilkinson divider arrangement (60) for a planar conductive strip circuit, comprising a pair of portions of transmission line with a total length of λ/4 at the central frequency, adapted to provide distributed parameter impedances of a predetermined value, having a first end in common and second ends connected by a lumped resistive impedance device (65), **characterized in that** the said transmission line portions with a length of λ/4 include capacitive components having track areas (62', 62'') delimited by a profile having free of angular points.

FIG. 1

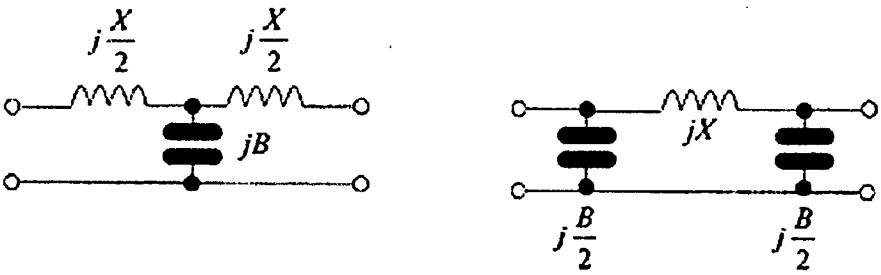


FIG. 2a

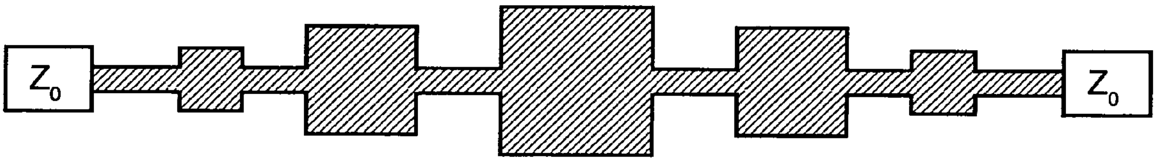


FIG. 2b

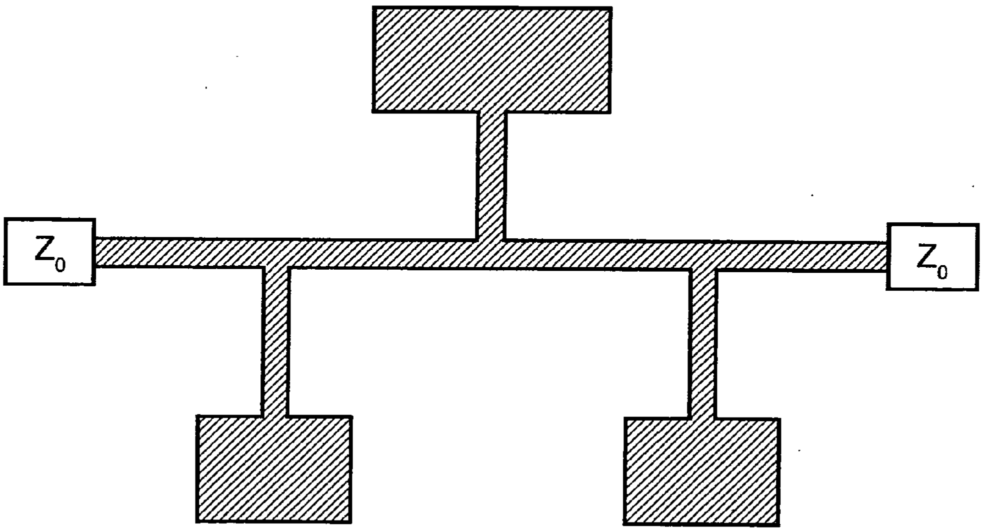


FIG. 3

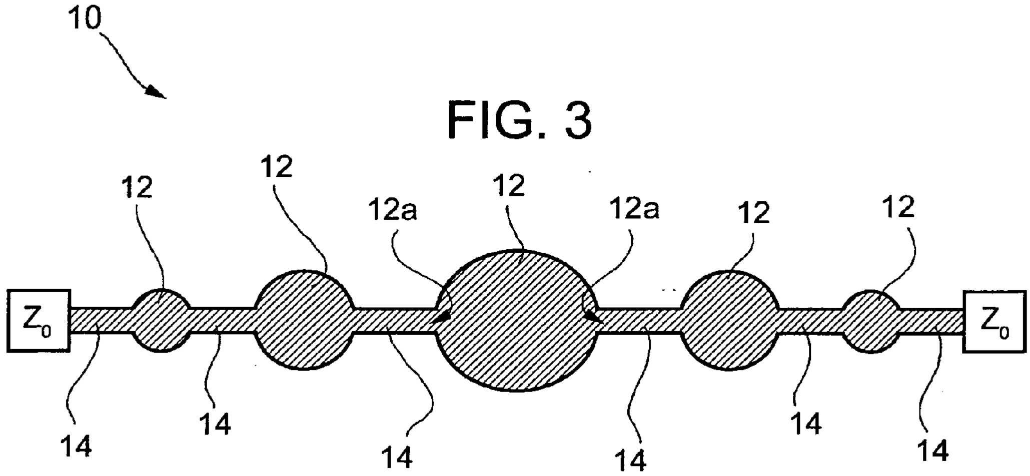


FIG. 4

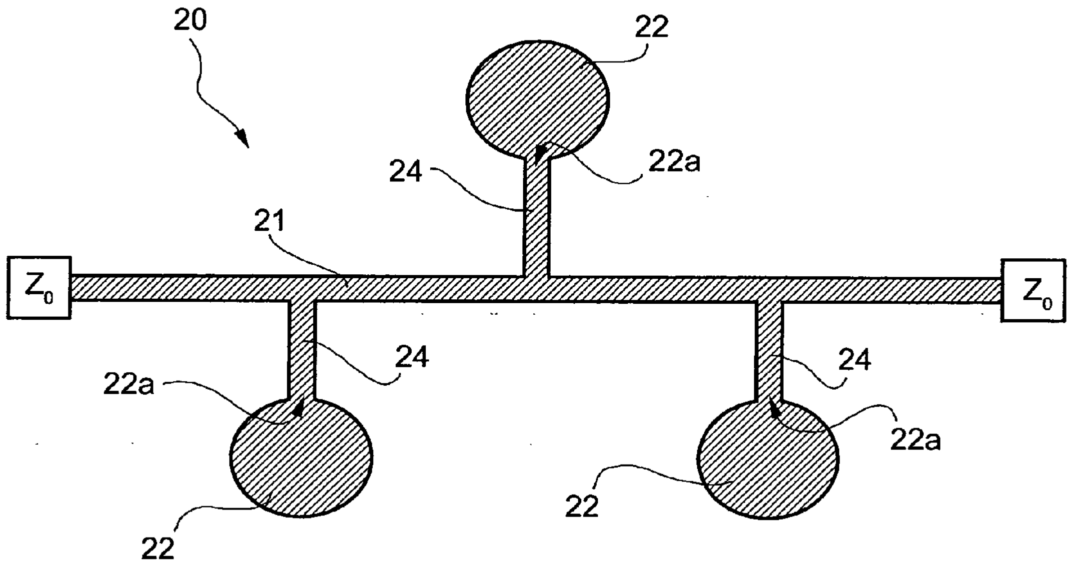


FIG. 5

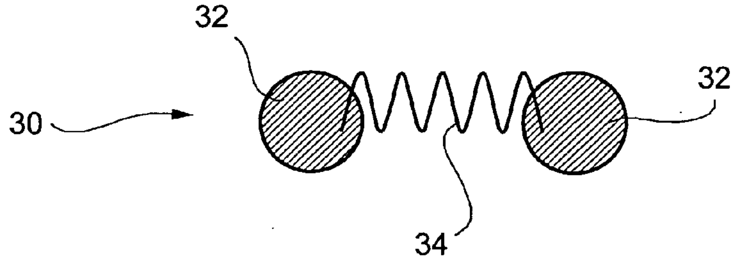


FIG. 6

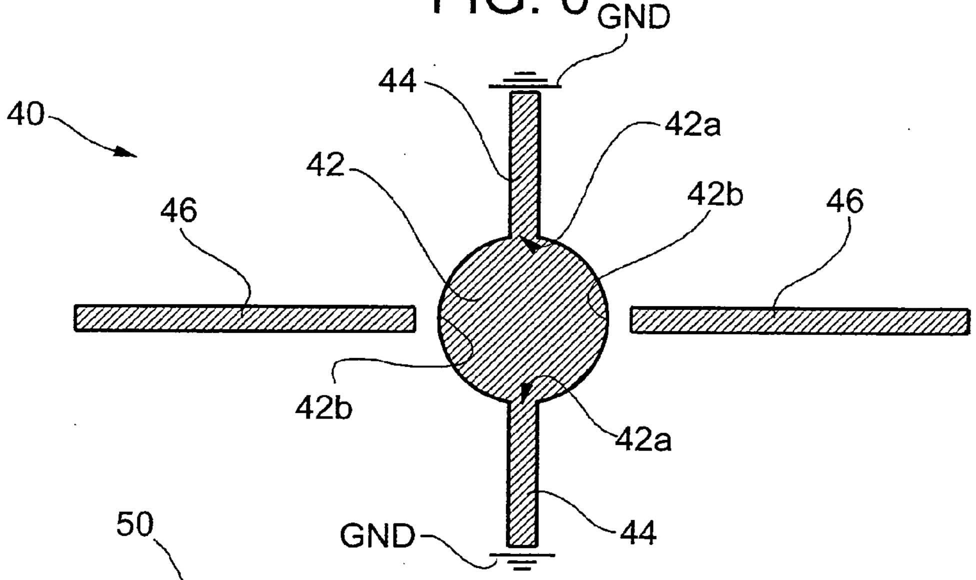


FIG. 7a

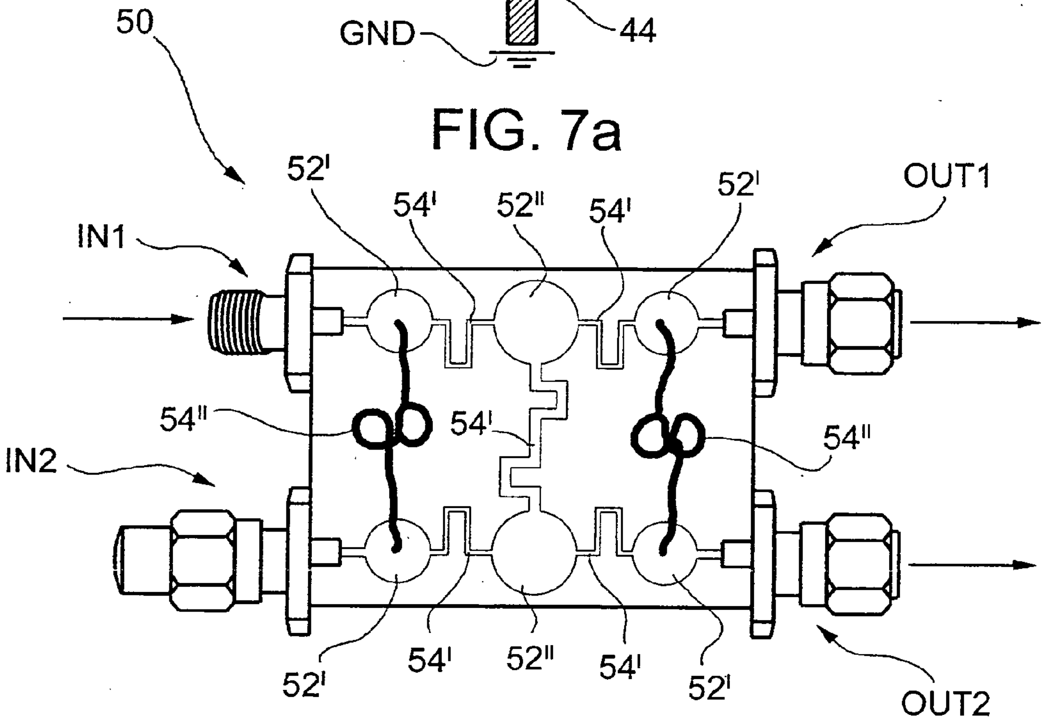


FIG. 7b

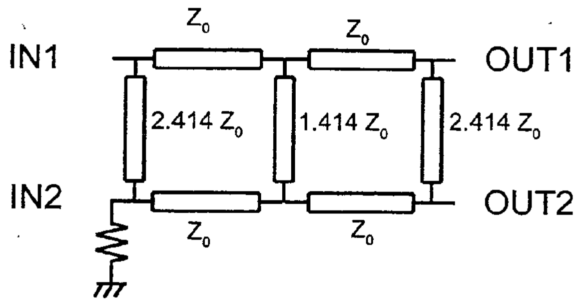


FIG. 8a

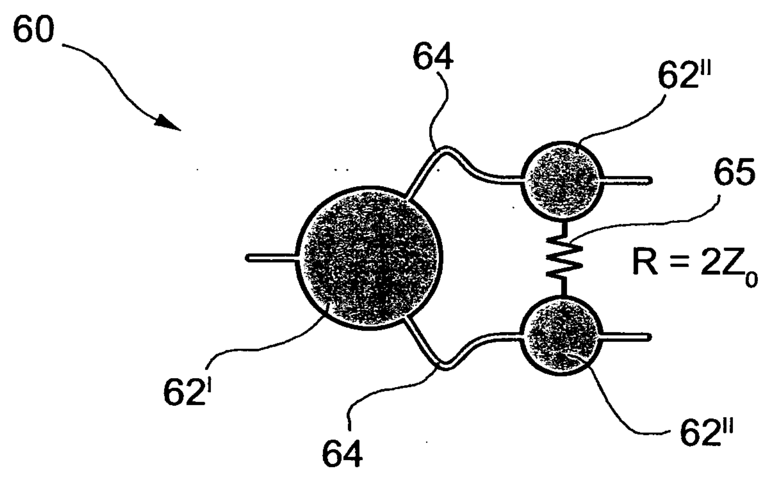
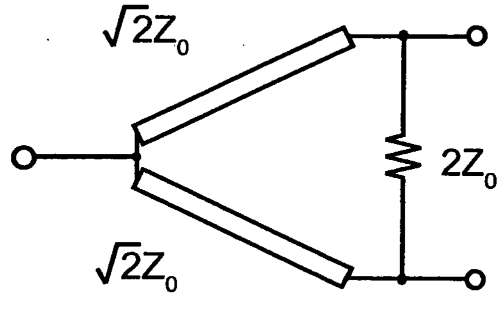


FIG. 8b



European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 06 42 5668

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 3 769 617 A1 (WEST L) 30 October 1973 (1973-10-30) * column 4, line 55 - column 5, line 5; figure 7 * -----	1-3,5-9	INV. H01P1/203 H01P3/08 H01P5/18
A	EP 0 660 438 A2 (MATSUSHITA ELECTRIC IND CO LTD [JP]) 28 June 1995 (1995-06-28) * abstract; figures 2-7,11,14 * * column 4, lines 28-38 * * column 5, lines 13-28 * * column 11, lines 35-53 * * column 17, lines 17-28 * -----	1-9	
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~~The present search report has been drawn up for all claims~~

2

Place of search	Date of completion of the search	Examiner
Munich	28 February 2007	Jäschke, Holger

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
....
& : member of the same patent family, corresponding document

European Patent Office

Application Number

EP 06 42 5668

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing more than ten claims.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☒ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

see annex

European Patent Office

LACK OF UNITY OF INVENTION SHEET B

Application Number
EP 06 42 5668

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-9

   Strip transmission line over a ground plane comprising capacitive component with a track area delimited by a profile free of angular points, the area having a diameter of less than one quarter wavelength.

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2. claims: 10-12

   A filter arrangement including at least one LC cell with distributed parameters, the cell comprises a straight track portion and a capacitive component having a track area delimited by a profile free of angular points.

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3. claim: 13

   A transformer arrangement comprising a pair of capacitive components having a track area delimited by a profile having no angular points and a lumped inductive component.

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4. claims: 14-16

   A resonator arrangement comprising a capacitive component having a track area delimited by a profile free of angular points, connected via an inductive straight track portion to a ground plane.

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5. claims: 17,18

   A divider/combiner arrangement comprising portions of lambda/4 transmission line providing distributed parameter impedances including capacitive components having track areas delimited by a profile free of angular points.

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 06 42 5668

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

28-02-2007

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82