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(54) **Antenna matching system for motor vehicles**

(57) This invention relates generally to an improved system for connecting an integrated antenna to a car's ground point. The antenna matching system comprises a conductor (B) connected between an antenna element (A) and a first end of a feeder conductor (1) of a coaxial cable (C). A first end of the shielding conductor (2) of the coaxial cable is open, and a second end of the shielding conductor is adapted for its connection to a ground connection point (E) of a vehicle. The length of the conductor is selected to provide an inductive effect which substantially cancels the capacitive component of the antenna at the band of operation. The invention provides a matching system for the antenna of a motor vehicle, that allows to tune the antenna to the designed frequency independently of the selected ground point in the vehicle, so that a greater grade of freedom is obtained to design the antenna matching circuit.

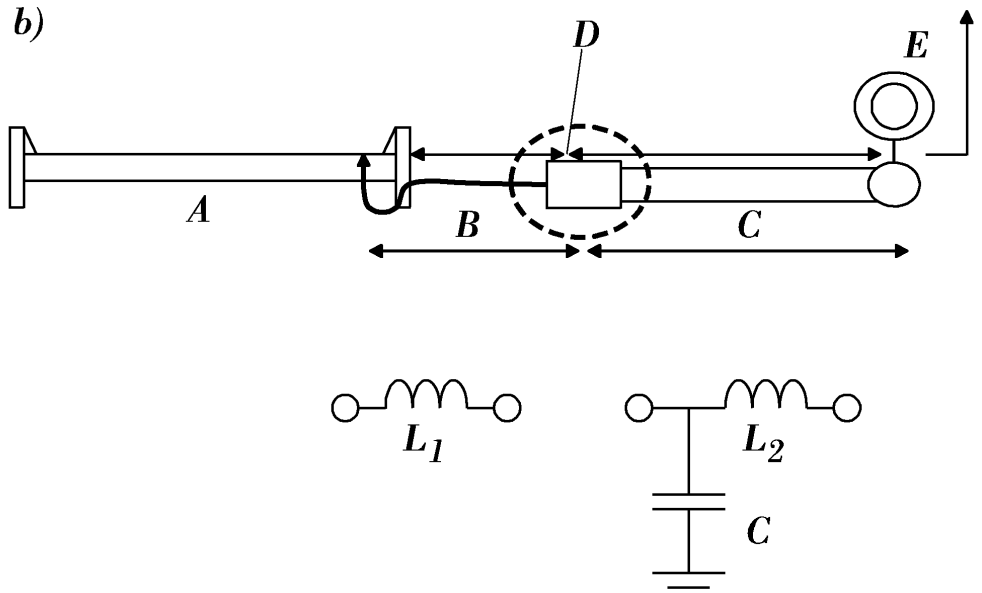

FIG. 1

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Description

OBJECT OF THE INVENTION

[0001] This invention relates generally to an improved system for connecting an integrated antenna to a car's ground point, which provides a maximum profit in terms of the antenna's dimension and efficiency, getting the best performance between antenna's dimension and antenna's gain. The connection system can also be used when the antenna is connected to a high-frequency device such as an amplifier or a diversity module.

[0002] In particular, it is an object of the present invention to provide a matching system for the antenna of a motor vehicle, that allows to tune the antenna at the desired frequency independently of the selected ground point in the vehicle, so that a greater grade of freedom is obtained to design the antenna matching circuit.

BACKGROUND TO THE INVENTION

[0003] Generally, the connection between the integrated antenna and the ground point in the car has a big impact in the antenna's performance. If the wire of connection follows a long distance close to the chassis of the car, the antenna's efficiency is decreased, and therefore the antenna's reception level is also decreased. The antenna's impedance is also modified increasing the mismatch losses between the antenna and the radio receiver.

[0004] Furthermore, if the length and characteristics of this connection it's not well selected, it modifies the frequency of resonance of the antenna which may not be optimized for that reason for the reception at the desired frequency for which the antenna has been designed.

[0005] In spite of this, most of the times the antenna's designer doesn't have enough freedom to select what is the distance between the antenna and the ground point, since the ground point in the vehicle is given by the car manufacturer. For this reason it may be difficult to optimize the reception of the antenna.

[0006] The Fakra connector used in the present invention is know in the prior-art and is described for instance in the European Patent EP-1.345.290.

DESCRIPTION OF THE INVENTION

[0007] The present invention refers to an antenna matching system for motor vehicles which comprises an antenna element, a conductor and a coaxial cable having a feeder conductor within a shielding conductor. Said conductor is connected between the antenna element and a first end of said feeder conductor. A first end of the shielding conductor closer to said first end of the feeder conductor is open, and a second end of the shielding conductor is adapted for its connection to a ground connection point of a vehicle.

[0008] Said shielding conductor has a connection point at a selected distance from said first end, wherein said connection point is adapted for its connection to a ground connection point of a vehicle. In this arrangement, the length of the conductor is selected to provide an inductive effect which substantially cancels the reactance component of the antenna at the band of operation.

[0009] With the suitable length of the wire or conductor, the inductive effect added at the antenna's impedance could be adjusted to minimize the reactance at the band of operation. This length is adjusted to obtain a null reactance at the center frequency of the band of operation.

[0010] As the coaxial it is not shielded, due to the distance between the feeder conductor and the shielding conductor of the coaxial cable a capacitive ground effect is generated, so that said capacitive ground effect substantially cancels the inductance component of the antenna's reactance at the band of operation, and the original bandwidth of the antenna is increased without mismatching the antenna. Then, in order to obtain the appropriate value for this capacitance, a particular coaxial cable has to be selected.

[0011] Moreover, the length of this coaxial has an inductive effect, useful to compensate (to cancel) the capacitive component of the antenna's reactance. By adding the two effects simultaneously it's possible to generate a loop around the desired 50 Ohms in the Smith Chart, therefore, increasing the bandwidth.

[0012] This new form of connection allows to tune the antenna to the designed frequency, independently of the selected ground point in the vehicle. With the present invention a bigger grade of freedom is possible to design the antenna.

DESCRIPTION OF THE DRAWINGS

[0013] To complete the description and in order to provide for a better understanding of the invention, a set of drawings is provided. Said drawings form an integral part of the description and illustrate a preferred embodiment of the invention, which should not be interpreted as restricting the scope of the invention, but just as an example of how the invention can be embodied. The drawings comprise the following figures:

Figure 1.- figure (a) is an schematic representation of a prior-art connection between the antenna (A) and the ground point of a vehicle (E), by means of a simple wire (B). Figure (b) is an schematic representation of a connection between the antenna and the ground point of a vehicle according to the present invention.

Figure 2.- figure (a) is a detailed schematic representation of the matching system of the invention. Figure (b) is a representation of the coaxial cable alone.

Figure 3.- represents the electric model corresponding to the simple wire and the coaxial wire of the matching system.

Figure 4.- shows a perspective schematic view of a connection of an antenna to the ground point of a vehicle according to the present invention.

Figure 5.- figure (a) is a Smith Chart showing the antenna's impedance in the band of operation. Figure (b) is a Smith Chart showing the effect of the new form of connection in the antenna's performance.

Figure 6.- figure (a) is a graph showing the relation of the frequency and the VSWR in a situation where the resonant frequency of the antenna is out of the band of operation. Figure (b) is a similar graph when the antenna is matched in the band but the bandwidth is very narrow. Figure (c) shows the effect the matching system of the invention where the antenna is matched in the band of operation and a broader bandwidth.

Figure 7.- figure (a) is a Smith Chart showing the antenna's impedance. Figure (b) is a Smith Chart showing the effect of the new form of connection in the antenna's performance.

Figure 8.- is a practical embodiment of the matching system using a Fakra connector.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0014] The antenna assembly of the invention has been represented in figure 1(b), wherein it can be observed that the system comprises an integrated antenna (A), a wire or conductor (B), a not-shielded coaxial cable (C) and a ground connection (E).

[0015] The antenna (A) can be printed on a robust electrical substrate or dielectric support to ensure the correct position and viability of the antenna within a component of the vehicle. Alternatively the antenna can be printed directly on the glass of the window of a motor vehicle. The integrated antenna is optimized to receive the signals at the correct band, and it is designed to have good efficiency and the adequate impedance to match the antenna to 50 Ohms or the impedance of the band operation at the desired frequency.

[0016] A simple wire or conductor (B) is connected between the integrated antenna (A) and an end of the feeder conductor (1) of a coaxial cable (C) by means of a coaxial connector (D). The length (length 1) of the conductor (B) is selected to match the antenna to the correct frequency band operation. As an electrical model this conductor (B) can be represented as an inductor (L1) at the input of the antenna, as represented schematically in figure 1(b). The conductor (B) increase the antenna's efficiency, opposite than if an inductor is connected directly at the antenna's input, because in this situation the antenna's efficiency doesn't change.

[0017] In terms of the electrical functionality this stage has an inductive effect at the antenna's input. This inductive effect could be selected adequately to improve the antenna's resonant frequency and bandwidth, therefore, the antenna's gain. However, if the distance of this simple wire (B) it isn't adequately selected then the antenna it isn't optimized at the band operation with the adequately impedance, antenna's efficiency and antenna's gain.

[0018] The antenna system further comprises a not-shielded coaxial wire (C). Examples of coaxials useful for this function are: RG-58, RG-316. They could be designed for 50 , 75 Ohms or the specific impedance of the band operation indistinctly. The shielding conductor is a tubular-shaped conductor and the feeder conductor is axially housed within the shielding conductor, both having similar length. The feeder conductor is spaced-apart a certain distance from the shielding conductor be means of a dielectric sleeve (3).

[0019] The electrical model of the coaxial cable (C) is a combination between an inductor (L2) and a capacitor (C) connected to ground as shown in figure 1(b). The inductor effect is generated by the conductor (B) and the capacitor is generated by the coupled effect between the feeder conductor (1) and the shielding conductor (2) of the coaxial connected to ground. It could be said that the coaxial cable (C) is a practical LC designed to optimize the antenna's impedance, therefore its VSWR and gain.

[0020] The shielding conductor (2) is connected to ground at a second end by means of a ground connection (E), which is the point where the connection to the car's ground is done. To make this connection a metallic ring it's useful, and it's a correct way to ensure the perfect electrical connection between the ground part of the coaxial and the metallic car's structure. After this ground connection, a shielded coaxial is connected which provides the connection between the antenna and the radio's input.

[0021] The feeder conductor (1) of the coaxial cable (C) is connected to the conductor (B) by means of a not-shielded coaxial connection (D), which is the point where the wire take a connection with a RF coaxial cable to the ground in the car.

[0022] Preferably a Fakra coaxial connector is used to connect the conductor (B) to the coaxial (C).. Therefore, a not shielded connection has been done because there is a track were the ground of the coaxial isn't directly connected to the car. The advantage of this solution is that you get the reference of the car's ground in this point but you don't have a physical connection with it. In this way you get another conductor which is acting as a parasite element to the feeding line without shielding the second track of the connection's route. This situation it's useful in the way of getting a LC model between the antenna and the car's ground. This LC achieves to optimize the antenna's bandwidth and return losses to improve

the quality of the reception at the antenna's output.
In another preferred embodiment, the conductor (B) is implemented by the same feeder conductor (1) which extends out of the shielding conductor. Obviously, in this embodiment the coaxial connection (D) is not necessary.

[0023] The end of the shielding conductor closer to the conductor (B) is open, and the second end of the shielding conductor is connected to a ground connection (E). At this end a conventional shielded coaxial cable is used to connect the antenna matching system to a radio's input.

[0024] The antenna matching system of the invention improve the antenna's bandwidth and efficiency. Additionally, an important saving of cost in SMD electronic components is obtained, because the components of a matching network are implemented by the conductor (B) and the non-shielded coaxial (C).

[0025] On the other hand this solution it's useful to optimize the antenna's reception when the antenna is connected to an active system as an amplifier or a diversity module. In the way that this sort of connection can avoid the highest inductive effect between the radiant element and the ground point of connection.

[0026] The electric model obtained with the conductor (B) is series with the not-shielded coaxial (C), is shown in figure 3.

[0027] As showed in figure 6(a) when the antenna it's directly connected by a simple wire to the ground's connection as in the prior-art tecniques (figure 1(a)), the antenna's impedance it's out of the band of operation, therefore the antenna is not optimized for the band of operation. In the arrangement of figure 1(a) the wire placed between the antenna and the ground point, adds and additional reactance component with inductive effect to the antenna's impedance. Therefore, the resonant frequency of the antenna is out of the band of operation, as shown in figure 7(a).

[0028] On the contrary when the antenna is not connected by the unshielded coaxial (figure 6(b), the antenna's impedance is in the band of operation, therefore the antenna is optimized for the band of operation and its bandwidth is broader.

[0029] In Smith Chart representation of figure 5(a), it's possible to observe the inductive effect. The antenna's impedance in the band of operation has a positive reactance.
With the connection arrangement of the invention (with the non-shielded connectivity), it's possible to compensate this inductive effect with the properly length of the wire. If the length of this wire is reduced, then the reactance component of the antenna could also be adjusted to be near of null at the band of operation.

[0030] With the properly length of the wire the inductive effect added at the antenna's impedance could be adjusted to minimize the reactance at the band of operation. This length is adjusted to obtain a null reactance at the center frequency of the band of operation. This process has been illustrated in figure 7(a).

[0031] In the new situation (with the properly length of the wire), the antenna is resonant in the desired band again. This effect is shown in figure 6(b) where it can be observed that the antenna is matched but it has a narrow bandwidth.

[0032] In order to increase the bandwidth without mismatching the antenna the second part of a non-shielded coaxial is added. As the coaxial it is not shielded, between the conductor and the ground of the coaxial a capacitance is generated, as illustrated schematically in figure 2(b). This capacitance compensates (cancel), the inductance component of the antenna's reactance. To obtain the properly value for this capacitance an appropriate coaxial has to be selected.

[0033] Moreover, the length of this coaxial has an inductive effect, useful to compensate (cancel) the capacitive component of the antenna's reactance. Adding the two effects simultaneously it's possible to generate a loop around the desired 50 Ohms in the Smith Chart, therefore, increasing the bandwidth. These effects have been represented in figure 7(b), and the results of improved bandwidth can be observed in figure 6(a).

[0034] The antenna is designed to cover the most important broadcast services:

> Broadcast station radio reception in the AM (LW: 150 kHz - 279 kHz and MW: 530 kHz - 1710 kHz) Japan and European FM band (78 MHz - 108 MHz).

[0035] But it's also possible to cover another wireless service as:

> GSM900, GSM1800, GPS, DAB, DTB, PCS1900, KPCS, CDMA, WCDMA, TDMA, UMTS, TACS, ETACS, SDARS, WiFi, WiMAX, UWB, Bluetooth, ZigBee.

Claims

1. An antenna matching system for motor vehicles comprising an antenna element, a conductor and a coaxial cable having a feeder conductor within a shielding conductor,
wherein said conductor is connected between the antenna element and a first end of said feeder conductor, and
wherein a first end of the shielding conductor closer to said first end of the feeder conductor is open,
said shielding conductor having a connection point at a selected distance from said first end, said connection point adapted for its connection to a ground connection point of a vehicle,
and wherein the length of the conductor is selected to provide an inductive effect which substantially cancels the capacitive component of the antenna at the band of operation.

2. An antenna matching system according to claim 1 wherein the feeder conductor is spaced apart from said shielding conductor, the distance between the feeder conductor and the shielding conductor is selected to provide a capacitive ground effect, said capacitive ground effect substantially cancels the inductance component of the antenna's reactance at the band of operation, so that the original bandwidth of the antenna is increased.

3. An antenna matching system according to claim 1 wherein said conductor is an unshielded part of the feeder conductor.

4. An antenna matching system according to any of the preceding claims, wherein the second end of the shielding conductor is connected to an electric terminal for its electric connection to the vehicle.

5. An antenna matching system according to any of the preceding claims wherein the antenna element is adapted for the reception of at least one communication service selected from the group: AM, MW, FM GSM900, GSM1800, GPS, DAB, DTB, PCS1900, KPCS, CDMA, WCDMA, TDMA, UMTS, TACS, ETACS, SDARS, WiFi, WiMAX, UWB, Bluetooth, ZigBee.

6. An antenna matching system according to claim 1 wherein the conductor is connected to the coaxial cable by means of a Fakra connector.

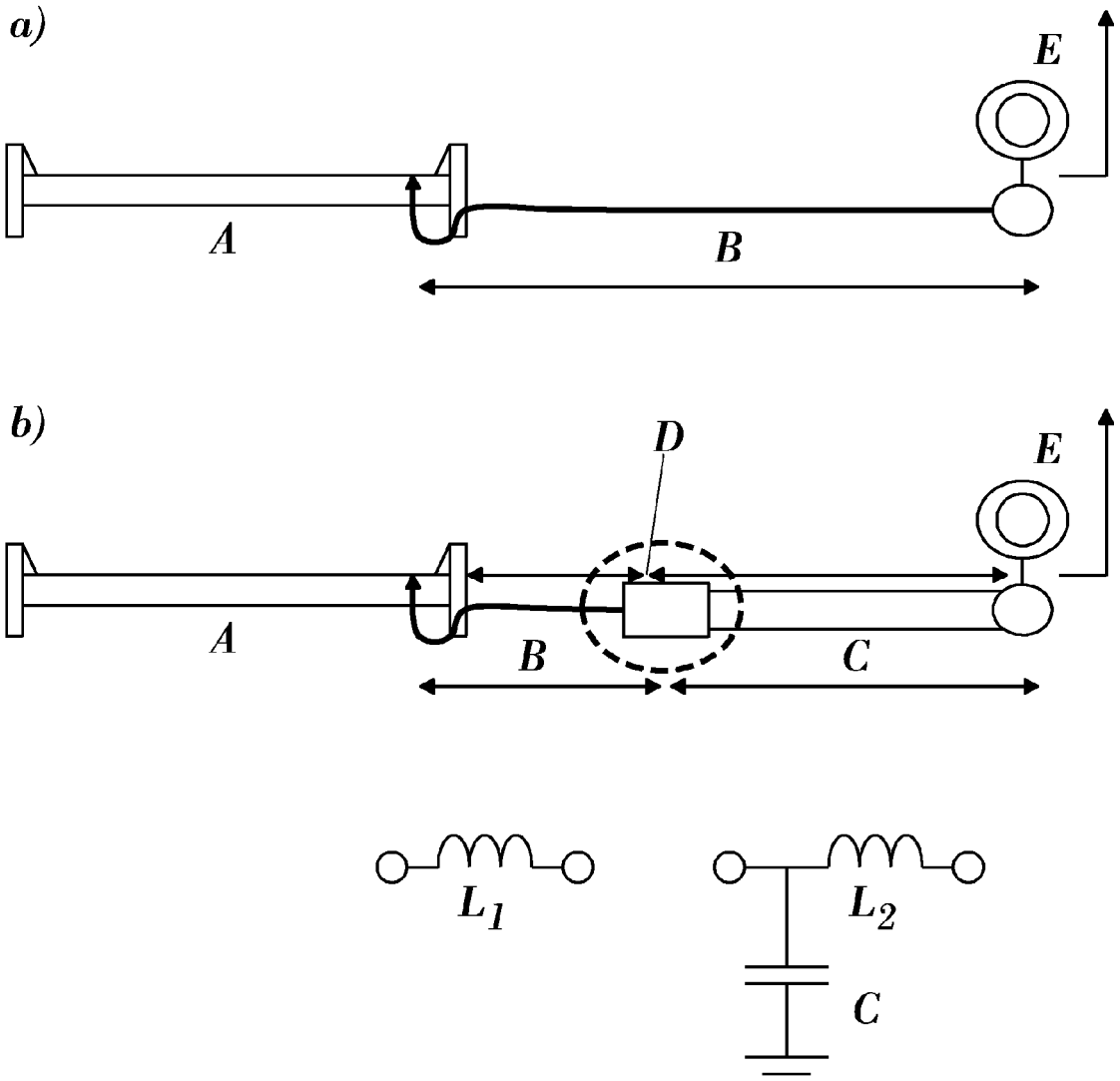


FIG. 1

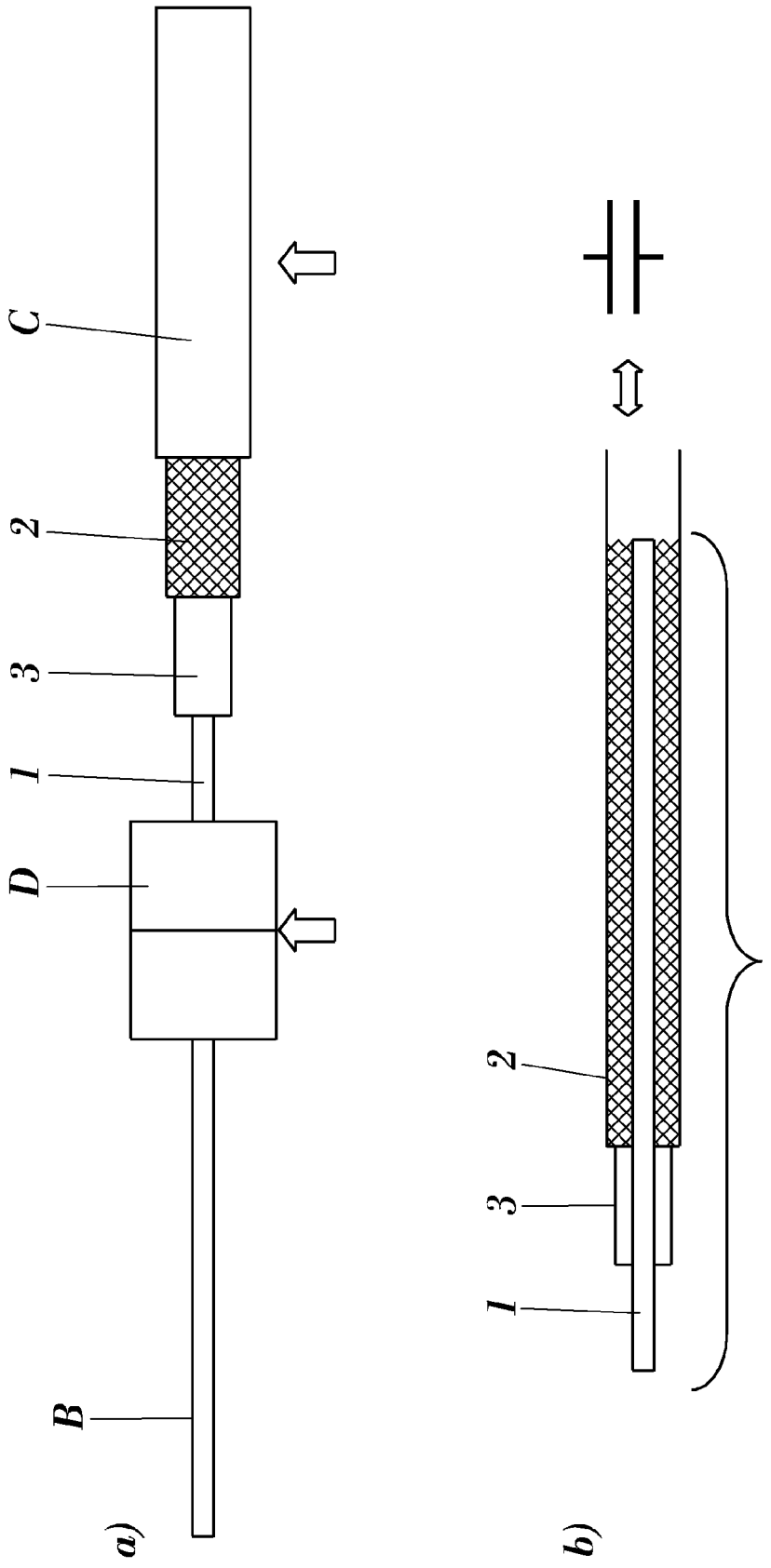


FIG. 2

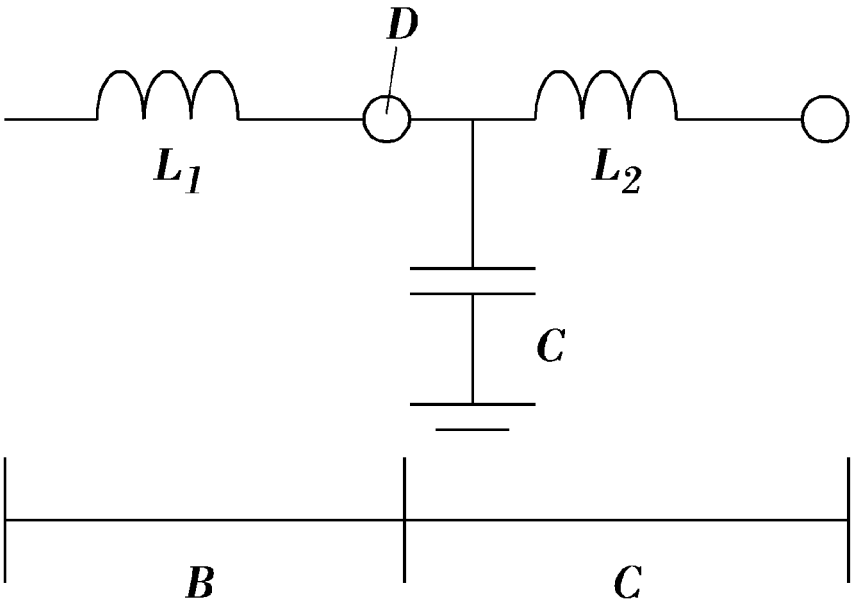


FIG. 3

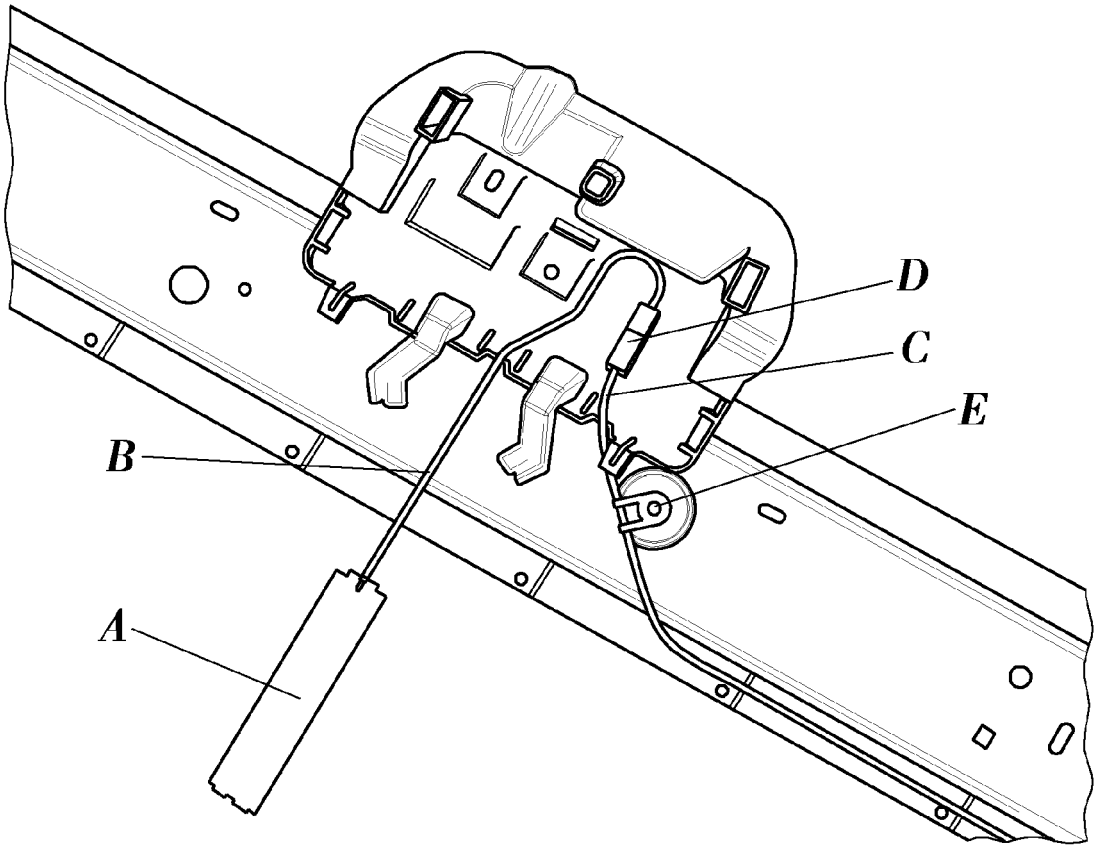
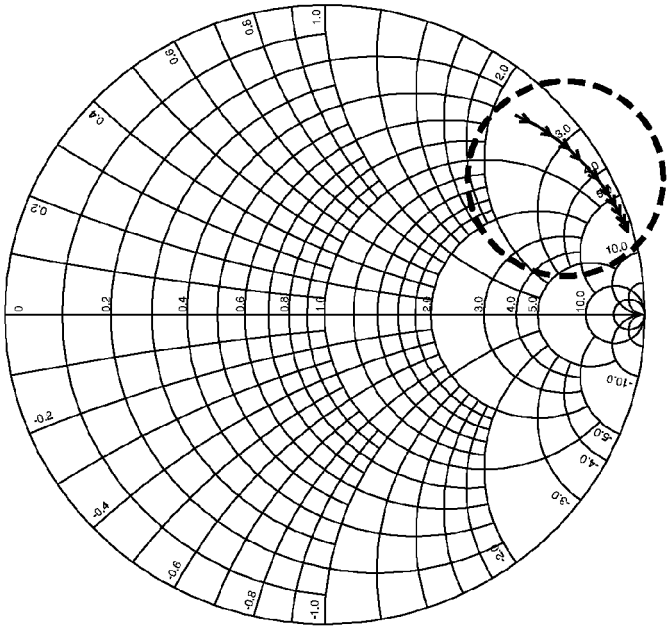


FIG. 4

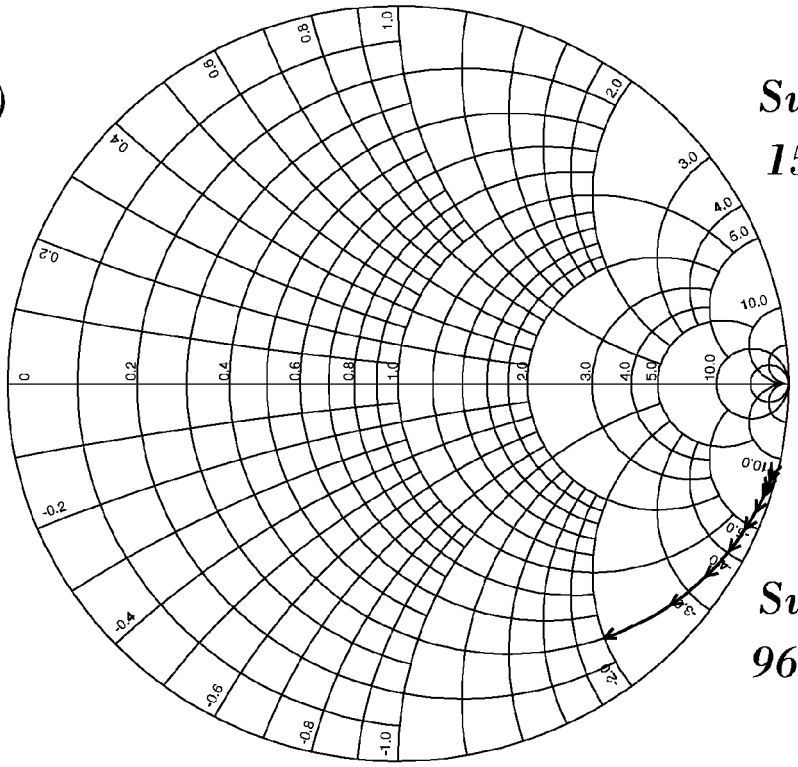
a)



Swp Max
150MHz

Swp Min
96.05MHz

b)



Swp Max
150MHz

Swp Min
96.05MHz

FIG. 5

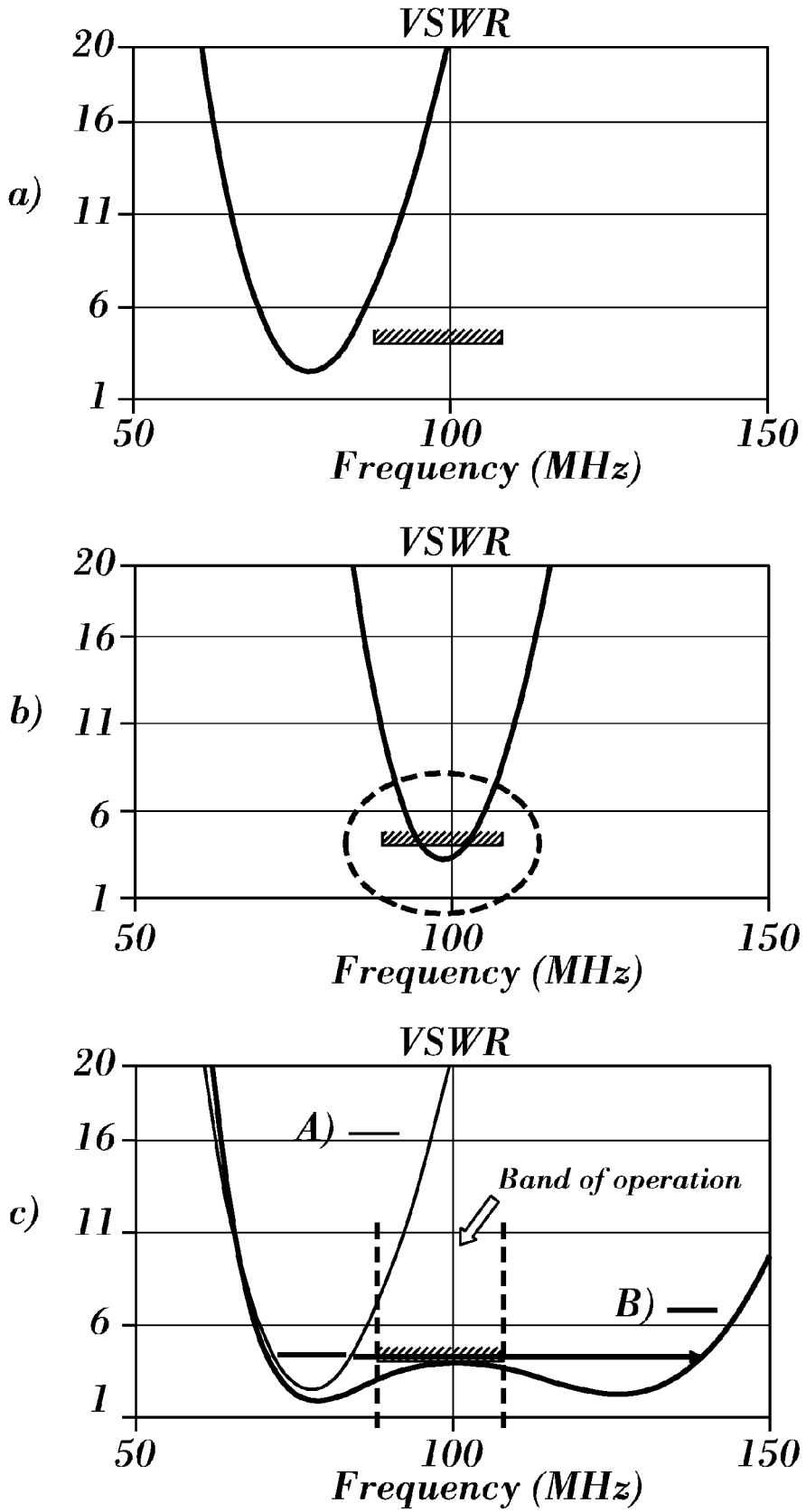
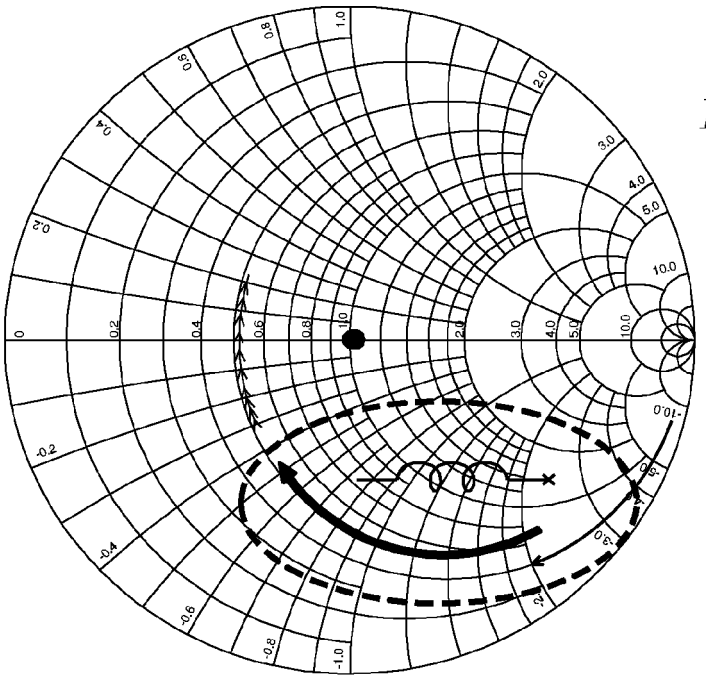

a)
VSWR
20
16
11
6
1
50
100
150
Frequency (MHz)
b)
VSWR
20
16
11
6
1
50
100
150
Frequency (MHz)
c)
VSWR
20
16
11
6
1
A)
Band of operation
B)
50
100
150
Frequency (MHz)

FIG. 6

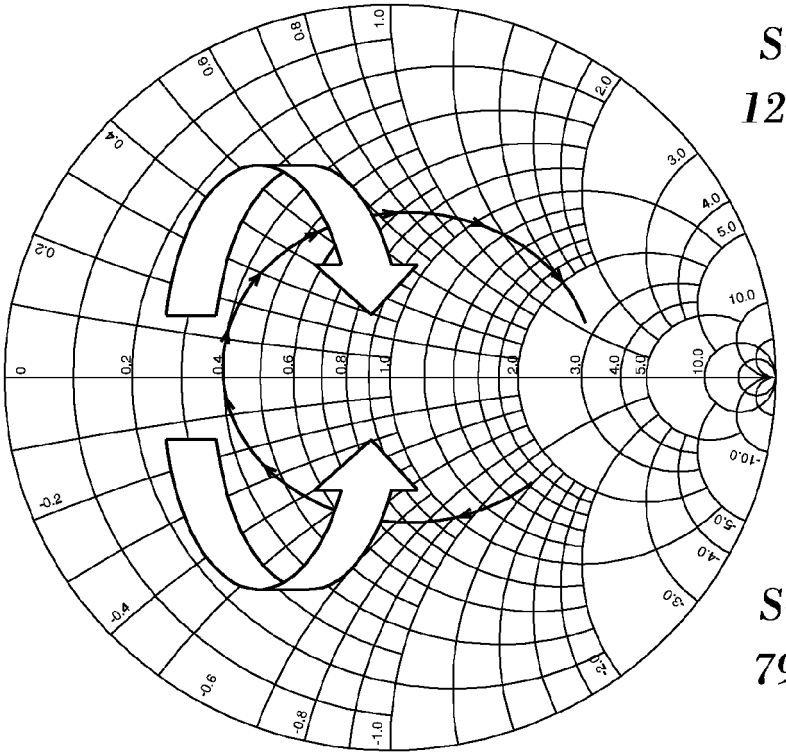
a)



Swp Max
129.05MHz

Swp Min
79.6MHz

b)



Swp Max
129.05MHz

Swp Min
79.6MHz

FIG. 7

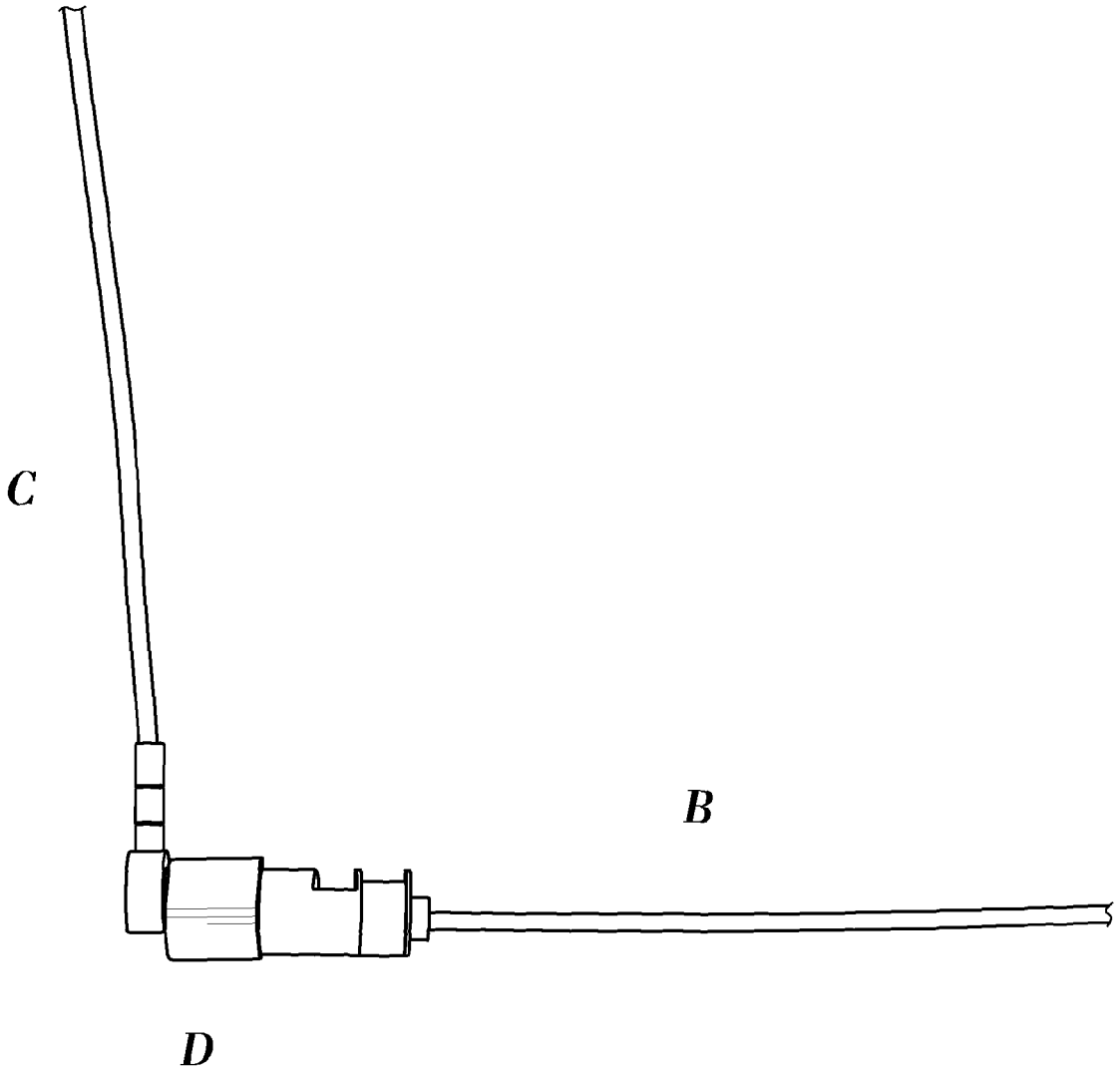


FIG. 8

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EUROPEAN SEARCH REPORT

Application Number
EP 07 11 3394

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	25 October 2007	van Norel, Jan

CATEGORY OF CITED DOCUMENTS

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