

[54] MICROWAVE SIGNAL ATTENUATOR

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323/74, 80, 81

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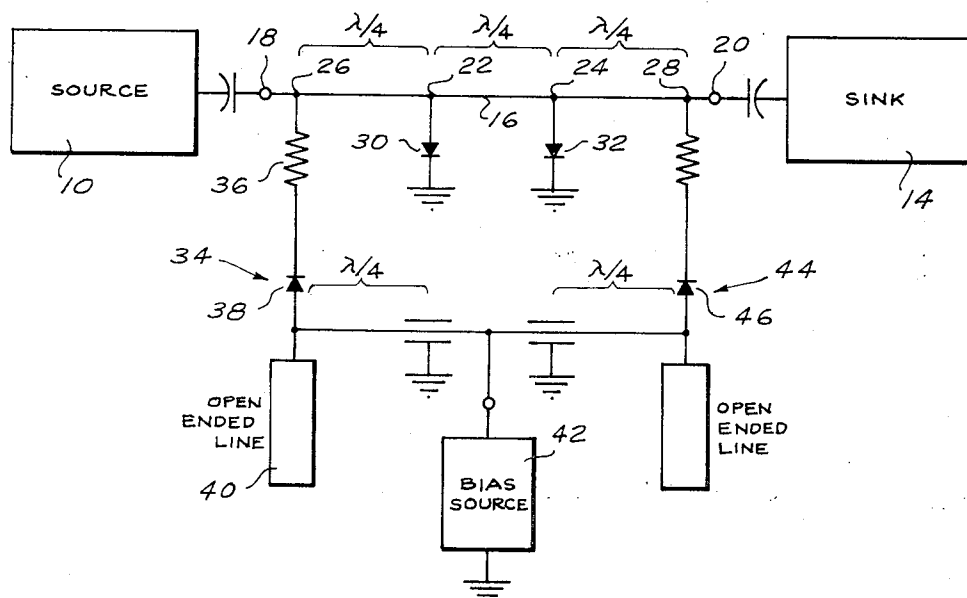
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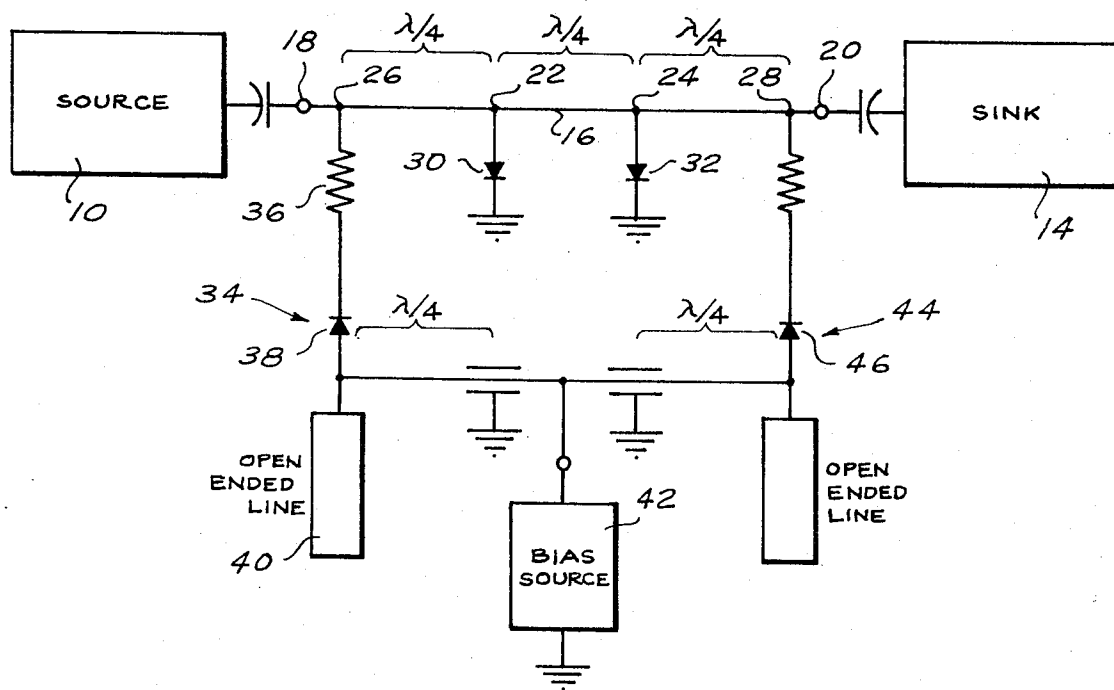
[57] ABSTRACT

A microwave signal attenuator includes at least two diodes shunting to ground points separated by a quarter of a center-frequency wavelength on a transmission line. At a quarter center-frequency wavelength from each diode toward the input and output ports respectively, are connected first and second circuits respectively, comprising an impedance and a diode in series. Bias current is fed via each circuit, the transmission line and the two diodes to ground to controllably vary the resistance of the diodes in accordance with the desired attenuation.

7 Claims, 1 Drawing Figure



MICROWAVE SIGNAL ATTENUATOR 12



MICROWAVE SIGNAL ATTENUATOR 12

MICROWAVE SIGNAL ATTENUATOR

This invention pertains to microwave signal attenuators and more particularly to absorptive shunt attenuators.

Microwave signal attenuators are used to control the amplitude of a microwave signal transmitted between, say, a source and a sink. The simplest of such attenuators is merely a PIN diode connected between the microwave signal conductor (a transmission line, stripline or microstrip line) and ground. In addition to feeding the microwave signal down the conductor, a direct current is also fed down the conductor. When this current passes through the diode, the shunt resistance of the diode becomes smaller and some of the microwave energy is shunt to ground and does not reach the output port connected to the sink. Such attenuators are simple but because of the discontinuity introduced in the microwave path by the diode, much of the energy is undesirably reflected back toward the input port connected to the source.

In order to provide a shunt attenuator which is highly absorptive, i.e., the reflective components from the diodes do not return to the source, a pair of 90° hybrids are connected in tandem with shunt diodes placed at the pair of tandem connections. One port of each hybrid is terminated with a resistive load, while the remaining port of one hybrid is the input port of the attenuator and the remaining port of the other hybrid, the output port. While such attenuators are truly absorptive, and can handle large amounts of power, they are relatively large and have a limited bandwidth.

In order to solve the size and bandwidth problems there have come into existence attenuators using series-shunt combinations of diodes in the transmission line. However, such attenuators have limited power handling capabilities because some of the diodes are in series with the microwave signal conductor of the transmission line. In addition, there is added complexity because complicated diode biasing schemes are required.

It is, accordingly, an object of the invention to provide an improved microwave signal attenuator.

It is another object of the invention to provide such an attenuator which is about as large as the series-shunt attenuators but is easier to manufacture than those attenuators and can handle considerably more power.

It is a further object of the invention to provide an improved microwave signal attenuator which requires a simple biasing scheme and which does not apply bias via the main portion of the transmission line.

Briefly, the invention contemplates a microwave signal conductor, such as a transmission line, with an input port and an output port. Between the two ports there are four points along the line spaced from each other at odd multiples of quarter center-frequency wavelengths. (By center-frequency wavelength is meant the wavelength for the microwave signal at its center or normal operating frequency.) Connected to the two inner points are shunt diodes for shunting microwave energy to ground or other suitable reference potentials. Connected to the two outer points are series circuits comprising an impedance and diode, the impedance having a resistive component at the center-frequency wavelength substantially equal to the characteristic impedance of the microwave signal conductor. A bias source is connected to the diodes in the se-

ries circuits so that current flows through these circuits and the other two diodes to vary the shunt resistance of the diodes to control the amount of microwave energy flowing down the conductor to ground.

Other objects, the features and advantages of the invention will be apparent from the following detailed description of the invention when read with the accompanying drawing whose sole FIGURE shows a microwave system utilizing the invention.

In the sole FIGURE, a microwave signal source 10 is connected via a microwave signal attenuator 12 to a microwave signal sink or utilization device 14.

The attenuator 12 comprises a length of transmission line 16 having one end as an output port 20. D.C. blocking capacitors can respectively connect the ports 18 and 20 to the source 10 and sink 14. Positioned along the line 16 are inner points 22 and 24 and outer points 26 and 28. All points are separated from each other by an odd multiple of quarter center-frequency wavelengths. For the sake of compactness the ideal separation is one-quarter center-frequency wavelength. In addition, while only two inner points are shown, there can be more than two such points. Connected between each inner point and ground is a PIN diode to provide the shunting function. Thus, diode 30 is connected to point 22 and diode 32 to point 24.

Connected to each outer point is a series circuit. Typical series circuit 34 connected to point 26 comprises resistor 36, PIN diode 38 and reactive termination element 40. Resistor 36 is chosen to have a resistance substantially equal to the characteristic impedance of line 16 while reactive termination element 40 is chosen to have a reactance which is equal in magnitude to the reactance of the length of line between points 22 and 26 but to have the opposite reactance function. A suitable reactance terminal element can be a length of open-ended transmission line one-quarter of a center-frequency wavelength long with the same characteristic impedance as line 16.

Connected to the junction of diode 38 and reactive termination element 40, via a high impedance connection which can be a quarter wavelength of line, is a bias source 42 in the form of an amplitude controlled D.C. current generator. By D.C. is meant a frequency much lower than the frequency of the microwave signals. When the diodes are all polarized in the same direction, as shown, current can flow from bias source 42, via diodes 38 and 30 to ground. Thus, when diodes 30 and 32 have the same shunt resistance (R_s)/current (I) characteristic it should be apparent that the resistances of these diodes are always equal to each other for any controlled current flow. Furthermore, since the resistance of resistor 36 equals the characteristic impedance of the line 16 between the points 22 and 26 then for the center frequency, the impedance seen at a point 26 looking toward point 22 equals the impedance of circuit 34 and any reflections because of diodes 30 are absorbed. Furthermore, because of the complementary action of reactive termination element 40 on the reactive component of the line 16 between points 22 and 26 increased operating bandwidth is obtained for the attenuator.

It should be noted that the series circuit 44 connected to point 28 is identical in all respects to circuit 34 and operates in the same manner and therefore, will not be discussed except to emphasize that the same bias source 42 also controls the resistance of the diode 46

in that circuit and the shunting diode 32 with these diodes polarized in the same direction as diodes 38 and 22. Thus, a single bias source can be used for all attenuation control.

There has thus been shown an improved microwave signal attenuator. While there may be apparent to those skilled in the art, many modifications and variations satisfying many or all of the objects of the invention, such modifications and variations come within the spirit and scope of the invention as defined by the appended claims.

What is claimed is:

1. A microwave signal attenuator for attenuating signals having a given center-frequency comprising a microwave signal conductor with a given characteristic impedance and having an input port at one end and a signal output port at the other end, at least first and second diodes, said first diode connecting a first point on said microwave signal conductor to ground, said second diode connecting a second point on said microwave signal conductor to ground, said first and second points being separated by an odd number of quarter center-frequency wavelengths, a first circuit including an impedance having a resistive component with a value at said center-frequency substantially equal to said characteristic impedance and a third diode connected in series, one end of said first circuit being connected to a third point on said microwave signal conductor which is between said input port and said first point and displaced from said first point by an odd number of quarter center-frequency wavelengths, a second circuit including an impedance having a resistive component with a value at said center-frequency substantially equal to said characteristic impedance and a fourth diode connected in series, one end of said second circuit being connected to a fourth point on said microwave signal conductor which is between said output port and said second point and displaced from said second point by an odd number of quarter center-frequency wavelengths, and bias means for applying a current to said first circuit so that the same current flows through said third and first diodes, and for applying a current to said second circuit so that the same

current flows through said fourth and second diodes.

2. The microwave signal attenuator of claim 1 wherein said first circuit comprises a first resistor, said third diode and a first reactive impedance connected in series and said second circuit comprises a second resistor, said fourth diode and a second reactive impedance connected in series, said resistors having values equal to the characteristic impedance of said microwave signal conductor.

3. The microwave signal attenuator of claim 2 wherein said first and second reactive impedances have values such that they are equal in magnitude and opposite in reactance function to the impedance between said third-and-first points and said fourth-and-second points, respectively.

4. The microwave signal attenuator of claim 3 wherein each of said first and second impedances is an open-ended transmission line having a characteristic impedance substantially equal to the characteristic impedance of said microwave signal and a length equal to an odd number of quarter center wavelengths.

5. The microwave signal attenuator of claim 3 wherein an end of each of said first and second resistors is connected to said third and fourth points, respectively, and said bias means is connected to the junction of said third diode and said first impedance and the junction of said fourth diode and said second impedance.

6. The microwave signal attenuator of claim 3 wherein all of said diodes have substantially the same shunt resistance-current characteristic and are polarized in the same direction to pass current from said bias means to ground whereby equal currents flow through all of said diodes so that all of said diodes have the same resistance at the center frequency.

7. The microwave signal attenuator of claim 6 wherein an end of each of said first and second resistors is connected to said third and fourth points, respectively, and said bias means is connected to the junction of said third diode and said first impedance and the junction of said fourth diode and said second impedance.

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