

[54] MICROWAVE FILTER

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[58] Field of Search 333/73 W, 73 C, 98 M, 76

[56] References Cited

UNITED STATES PATENTS

2,425,345 8/1947 Ring 333/98 M

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[57]

ABSTRACT

A microwave filter adaptable to suppress the even harmonics of a predetermined fundamental frequency of energy processed in a waveguide. The filter consists of a slanting conductor, for example a wire, connected between the top and bottom walls of a rectangular waveguide such that its ends contact the waveguide at points one half of a guide wavelength apart of the fundamental frequency along the length of the waveguide.

11 Claims, 7 Drawing Figures

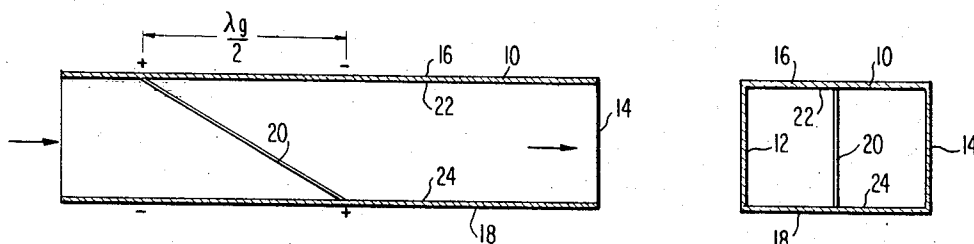


FIG. 1

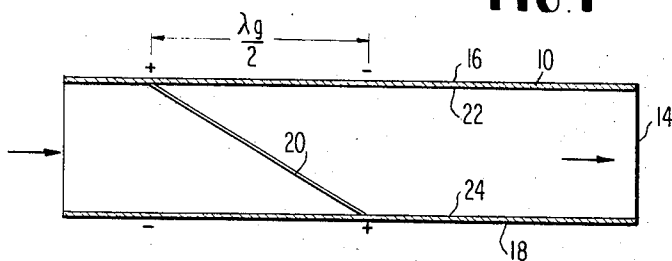


FIG. 2

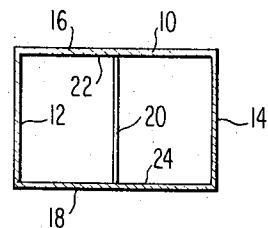


FIG. 3

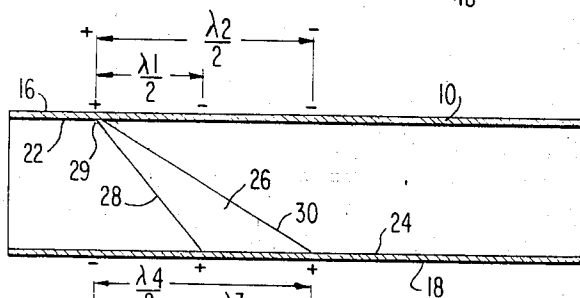


FIG. 4

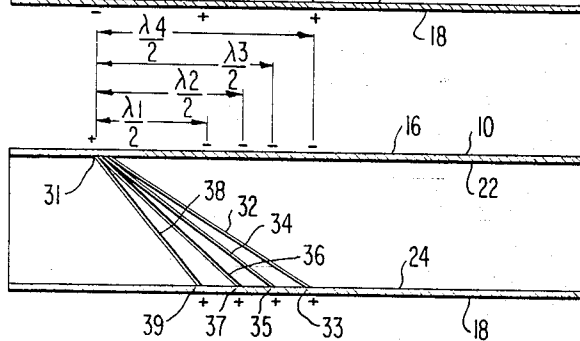


FIG. 5

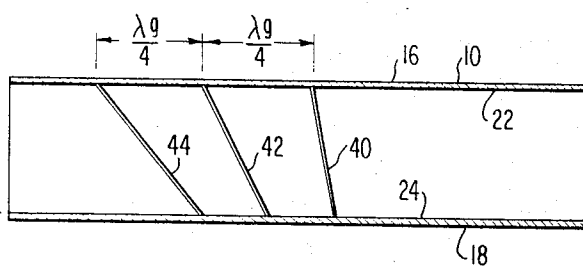


FIG. 6

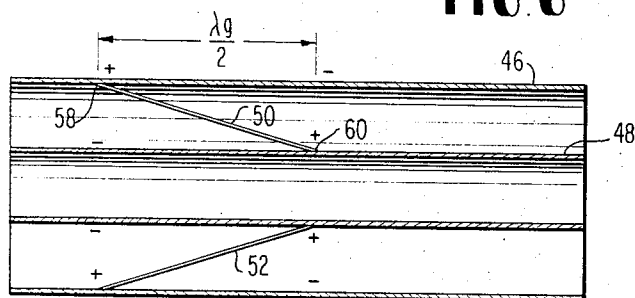
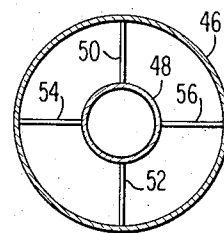


FIG. 7



MICROWAVE FILTER

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to microwave transmission line means and more particularly to microwave filter devices capable of suppressing selective frequencies and more particularly even harmonics of a predetermined fundamental frequency or frequencies.

2. Description of the Prior Art

Microwave filters are well known to those skilled in the art and are widely used in much the same manner as filters in the other types of well known electrical transmission lines. One type of microwave filter comprises the use of resonant chambers in waveguides coupled together to form either wide band or narrow band filters in a manner analogous to the coupling of lumped tuned circuits at lower frequencies. Additionally, dielectric materials have been used to insert series or shunt capacitive elements and resistive card attenuators have also been placed in the waveguide for obtaining a desired filter characteristic.

SUMMARY

Briefly, the subject invention is directed to a microwave filter for suppressing the even harmonic frequencies of one or more fundamental frequencies by means of electrical conductor means, for example at least one wire conductor extending on a slant in a longitudinal plane passing centrally through the waveguide and having the ends of the wire contacting the inner walls or walls of the waveguide at points one half of a guide wavelength apart along the length of the waveguide. The conductor means may, when desirable, be comprised of a set of wires identically positioned between inner and outer conductors of a coaxial waveguide or may even be comprised of a planar conductor element having sloping forward and rear edges of different lengths oriented in the middle of the waveguide in a plane parallel to one of the side walls.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a longitudinal cross sectional view of a first embodiment of the subject invention;

FIG. 2 is a transverse cross sectional view of the embodiment shown in FIG. 1;

FIG. 3 is a longitudinal cross sectional view of a second embodiment of the subject invention;

FIG. 4 is a longitudinal cross sectional view of a third embodiment of the subject invention;

FIG. 5 is a longitudinal cross sectional view of a fourth embodiment of the subject invention;

FIG. 6 is a longitudinal cross sectional view of a fifth embodiment of the subject invention; and

FIG. 7 is a transverse cross sectional view of the fifth embodiment shown in FIG. 6.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings and more particularly to the embodiment disclosing the inventive concept in its simplest form, reference is made to FIGS. 1 and 2 wherein reference numeral 10 denotes a rectangular waveguide having a pair of relatively narrow side walls 12 and 14 and a pair of upper and lower broadwalls 16 and 18. Whereas many bandpass microwave filters in

current use have the undesirable property of opening up again, i.e. passing energy, at the second and higher even harmonics, the present invention is adapted to suppress the even harmonics of a predetermined fundamental frequency f_0 by the extension of a wire conductor, of as large a diameter as is practically possible, on a slant between the top and bottom broadwalls 16 and 18 and located laterally in a plane running longitudinally through the center of the waveguide 10. The slope of the wire 20 and hence its length is selected such that its ends electrically contact the inner conducting surfaces 22 and 24 of the broadwalls 16 and 18 respectively at points which correspond to one half of a wavelength $\lambda_{g/2}$ of the fundamental frequency f_0 of the electromagnetic energy propagated in the waveguide 10. Under this set of conditions, both ends of the wire conductor 20 will be at the same potential for example, (+) shown in FIG. 1, and hence no current will flow in the wire. With no current flow in the wire conductor 20, there will be no disturbance of the propagating energy of the wavelength λ_g . On the other hand, at those frequencies where the ends of the wire conductor 20 contact the waveguide at distances of an even multiple of one half of a guide wavelength λ_g apart, the two ends of the wire conductor 20 will have a maximum difference of potential, for example (+) and (-) between them, resulting in a maximum current flow for the specific frequency and near total reflection of the propagating energy at that frequency. Thus the single slanting wire conductor 20 will suppress all of the even harmonics of the fundamental frequency f_0 .

Where there is a requirement for suppressing the even harmonics of a plurality of fundamental frequencies, one may resort to the configurations such as shown in FIGS. 3, 4 and 5. In the configuration shown in FIG. 3, the wire conductor 20 shown in FIGS. 1 and 2 has been replaced by a relatively narrow sheet like metal conductor 26 providing an edge view such as shown in FIG. 2, but having a profile in the form of a triangular wedge having a relatively shorter side dimension 28 than the other longer dimension 30. The side dimensions converge at substantially the same contact point 29 on the conducting surface 22 of the upper wall 16 while the opposite ends thereof contact the inner surface 24 of the lower broadwall 18 at separate points. It can be seen that the length of the edge 28 is adapted to act as a suppressor of even harmonics for the frequency $f_1 = 1/\lambda_1$ while the length of the edge 30 is adapted to act as an even harmonic filter for the frequency $f_2 = 1/\lambda_2$. The intermediate body portion is accordingly adapted to provide the same even harmonic suppressant function for all the frequencies between f_1 and f_2 .

Whereas the configuration shown in FIG. 3 comprises a continuous or band suppression type harmonic filter, the configuration in FIG. 4 is adapted to act as a notch suppression filter and constitutes an arrangement which is intermediate the limits prescribed by the configurations shown in FIGS. 1 and 2 and instead of a single wire conductor 20 or a continuous wedge shaped sheet conductor 26, the filter is comprised of a plurality of wire conductors 32, 34, 36 and 38 of selectively different lengths, having a substantially common contact point 31 on the surface 22 of the upper broadwall 16 and separated contact points 33, 35, 37 and 39 on the inner conducting surface 24 of the lower broadwall 18. Such a configuration is adapted to provide

even harmonic suppression of the respective frequencies $f_1 = 1/\lambda_1$, $f_2 = 1/\lambda_2$, $f_3 = 1/\lambda_3$, and $f_4 = 1/\lambda_4$.

FIG. 5 is a variation of the configuration shown in FIG. 4, in that a plurality of wire conductors 40, 42, 44 are arranged in planar fashion in the center of the waveguide such as shown in FIG. 2; however, they do not share a common contact point in the inner conducting surface 22 of the upper broadwall 10 but rather are selectively spaced at a quarter wavelength $\lambda_{g/4}$ of a selected frequency f_g . The respective wire conductors 40, 42 and 44 because of their different length, have a different slant and contact the inner surface 24 of the lower broadwall 18 at different spacings other than a quarter wavelength spacing and therefore are adapted to suppress the even harmonics of f_1 , f_2 and f_3 . In the embodiment shown in FIG. 5, while operating in the same manner as the configuration shown in FIG. 4, for the number of wire conductors utilized, it additionally acts to cancel any mismatching occurring at the predetermined frequency f_g .

Where for example the inventive concept is desired to be utilized in connection with circular waveguide, the same criteria would obtain depending upon the planar orientation of the one or more conductors in the waveguide, since for example if the conductors are parallel to the E or electric field vector of the propagated energy, the conductors will act as previously described; however, if the planar orientation is perpendicular to the E field vector, it is not seen. Since the H or magnetic field vector is orthogonal to the E field vector, its effect is just the opposite to that of the electric field; however, it is still the difference of potential existing at the respective ends of the wire conductors caused by the electric E field which results in the reflection or suppression of the even harmonics.

Where an even harmonic filter for coaxial waveguide structure such as shown in FIGS. 6 and 7 is used and wherein reference numeral 46 denotes the outer circular waveguide while reference numeral 48 denotes the inner concentric waveguide, the filter for even harmonics of a fundamental frequency corresponding to $f_g = 1/\lambda_g$ comprises a plurality of wire conductors 50, 52, 54 and 56 of equal length and disposed in quadrature while having contact on the inner conducting surface 58 of waveguide 46 and the outer conducting surface 60 of the waveguide 48 at the same position along the structural length of the configuration (FIG. 6) such that coincidence of potentials will result from all four conductors.

While the present invention has been shown and described with a certain degree of particularity with respect to what is considered to be the preferred embodiments of the subject invention, it will be appreciated that other modifications may be resorted to without departing from the spirit and scope of the invention. For example, in addition to having any number of conductors of various slopes employed in a co-planar configuration, the conductors may have different diameters resulting in further bandpass shaping.

Accordingly, I claim as my invention:

1. A microwave filter for the even harmonic frequencies of at least one predetermined fundamental frequency propagated in a waveguide, comprising in combination:

waveguide transmission line means; and

electrical conductor means centrally located in said waveguide transmission line means, extending lon-

gitudinally on a slant between opposing conductive surface portions of said waveguide transmission line means and having the ends respectively electrically contacting said opposing conductive surface portions at points along the length of the waveguide transmission line means spaced substantially one half wavelength apart of said at least one predetermined fundamental frequency.

2. The microwave filter as defined by claim 1 wherein said electrical conductor means comprises a wire conductor.

3. The microwave filter as defined by claim 1 wherein said electrical conductor means comprises at least one wire conductor having a circular cross section of predetermined diameter.

4. The microwave filter as defined by claim 1 wherein said electrical conductor means comprises a plurality of wire conductors of unequal length arranged in a common plane.

5. A microwave filter as defined by claim 1 wherein said waveguide transmission line means comprises a rectangular waveguide having opposing narrow and broad conducting walls, and

said electrical conductor means comprises a wire conductor electrically contacting opposing broadwalls and extending in the central longitudinal plane of said rectangular waveguide.

6. The microwave filter as defined by claim 1 wherein said waveguide transmission line means comprises a rectangular waveguide having opposing narrow and broad conducting walls, and

wherein said electrical conductor means comprises a sheet of metallic conductor of substantially constant thickness and having one edge dimension greater than the other edge dimension, said edge dimensions terminating in and contacting the opposing broadwalls of said rectangular waveguide and lying in a substantially central longitudinal plane of said waveguide.

7. The filter as defined by claim 6 wherein said sheet of metallic conductor comprises a wedge shaped element having side edge dimensions of predetermined unequal lengths.

8. The microwave filter as defined by claim 1 wherein said waveguide transmission line means comprises a rectangular waveguide having opposing narrow and broadwalls, and

wherein said electrical conductor means comprises a plurality of wire conductors of having predetermined unequal lengths and having one corresponding end contacting substantially the same surface portion of one of said broadwalls and the other corresponding end contacting the opposite broad conducting wall, and wherein the plurality of wire conductors lie in a common plane running substantially along the central longitudinal axis of said waveguide.

9. The microwave filter as defined by claim 1 wherein said waveguide transmission line means comprises a rectangular waveguide having opposing narrow and broad walls, and

wherein said electrical conductor means comprises a plurality of wire conductor means of predetermined unequal lengths electrically contacting opposing broadwall conductive portions, lying in a common plane extending substantially along the central longitudinal axis of said waveguide and

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wherein said plurality of electrical conductors have the same corresponding ends contacting the same broadwall at spaced intervals of substantially a quarter wavelength of a predetermined frequency.

10. The microwave filter as defined by claim 1 wherein said waveguide transmission line means comprises coaxial waveguide having inner and outer circular waveguides, and

wherein said electrical conductor means comprises a plurality of wire conductors of substantially equal lengths extending from the inner conducting surface of said outer waveguide to the outer conduct-

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ing surface of said inner waveguide, said wire conductors being separated from one another but positioned at substantially the same location along the lengthwise dimension of said waveguide.

5 11. The microwave filter as defined by claim 10 wherein said plurality of wire conductors comprises four conductors of substantially equal lengths and wherein two conductors lie in a first central longitudinal plane running through said waveguide and the other two conductors lie in a second central longitudinal plane substantially orthogonal with the first recited plane.

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