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54 Helical filter.

57 The present invention provides an improved helical filter constructed by coupling a plurality of helical oscillators. The oscillators have the same resonant frequency or the same harmonic frequency and have different resonant frequencies or harmonic frequencies, respectively. The oscillators (4, 5) have the same resonant frequency by adjusting the distributed capacities (C_1 , C_2) thereof, respectively, and have different harmonic frequencies by varying the lengths of coils (L_1 , L_2). Furthermore the oscillators (54, 55) have different resonant frequencies by varying the distributed capacities (C_3 , C_4), respectively, and have the same harmonic frequency by using coils (L_5 , L_6) having same length.

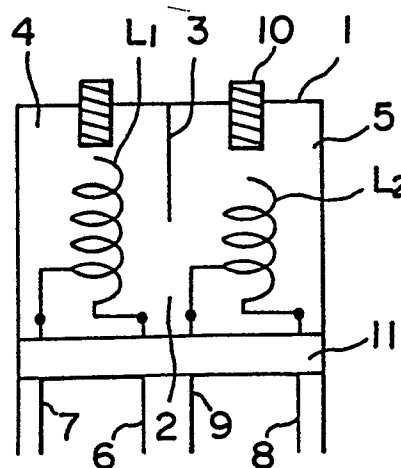


FIG. 1

HELICAL FILTER

The present invention relates to a helical filter which can decrease spurious response by increasing the damping of harmonics with a resonant frequency and conversely can be utilized with a high frequency by utilizing a harmonic.

In general, a helical filter is constructed by electromagnetically connecting a plurality of helical coils each of whose one end is opened while the other end is grounded. More particularly, each helical coil is wound around each bobbin within a metal case and a plurality of such cases with the above-described construction are connected each other by soldering or with an adhesive. Alternatively, helical coils are wound around bobbins disposed on a common base and are covered with case which has a plurality of partition walls for separating adjacent helical coils.

Each helical coil functions as an oscillator and a resonant frequency is adjusted by varying the distributed capacity between the helical coil and its surrounding case. The distributed capacity is varied to shift a dielectric body between the helical coil and the case and a metal screw electrically connected to the case in the vicinity of the coil.

The resonant frequency of all the oscillators is same and the filter is caused to resonate in response to the input signal of the resonant frequency. Furthermore the band of the filter is adjusted in response to the connection between the adjacent oscillators. The state of connection between the adjacent oscillators is varied by varying the sizes of openings of the sides of the cases between the helical coils and the partition walls.

Technical Problem

The helical filters of the types described above are simple in construction and can attain a high Q, but it has a defect that they resonate at high frequencies which are odd multiples of the resonant frequency.

Especially the third harmonic which is most closest to the resonant frequency adversely affects the operation of the helical filter as spurious response.

Furthermore when the helical filter is to resonate with an input signal with a high frequency in the vicinity of 1 GHz, the number of turns of a coil is considerably decreased so that the whole filter characteristics such as a resonant frequency, a degree of damping, a cutoff frequency and so on greatly vary from one helical filter to another. As a result, productivity is degraded and the helical filters cannot be satisfactorily used in practice.

The primary object of the present invention is to simultaneously solve the above problems.

That is, a first object of the present invention is to provide a helical filter which can damp considerably of a signal of harmonic so that spurious response can be substantially eliminated.

A second object of the present invention is to provide a helical filter which can be used at high frequency by conversely utilizing a harmonic.

The inventor noticed the well known fact that a helical filter resonates with odd multiples of the resonant frequency and made extensive studies and experiments based upon the above-mentioned fact.

As a result the inventor found out the fact that a harmonic frequency is varied by varying the length of a coil in an oscillator and even when a distributed capacity is adjusted to maintain the resonant frequency at a predetermined frequency, the harmonic frequency is varied by varying the length of the coil.

Furthermore, the inventor noticed the fact that conversely the harmonic frequency is determined by the length of a coil in an oscillator and even when the distributed capacity is adjusted to vary a resonant frequency, the variation of the resonant frequency hardly occurs.

A possible but not yet proved analysis has not yet been completely carried out, the inventor considers that the reason resides in the fact that a harmonic frequency is influenced by the coupling condition of the oscillators more than by the distributed capacity of the coils.

The present invention was made based upon the above-described newly found out facts and is characterized in that a resonant frequency or a harmonic frequency of each oscillator is made equal while the other is made different in a helical filter comprising a plurality of interconnected helical oscillators.

FIG. 1 is a view used to explain a first preferred embodiment of a helical filter in accordance with the present invention;

FIG. 2 shows a diagram of an equivalent circuit thereof;

FIG. 3 illustrates the resonance characteristic of each oscillator;

FIG. 4 illustrates the characteristic of the filter;

FIG. 5 is a sectional view of a second preferred embodiment of a helical filter in accordance with the present invention;

FIG. 6 is a sectional view of a third embodiment of the present invention;

FIG. 7 is a view used to explain a fourth

preferred embodiment of a helical filter in accordance with the present invention;

FIG. 8 is a diagram illustrating an equivalent circuit thereof; and

FIG. 9 illustrates the characteristic thereof.

First Embodiment, FIGS. 1-4

As described above, FIG. 1 is a view used to explain a first preferred embodiment of the present invention; FIG. 2, a diagram illustrating an equivalent circuit thereof; FIG. 3 illustrates resonance characteristics of respective oscillators; and FIG. 4 shows a characteristic of the first embodiment.

Referring first to FIGS. 1 and 2, helical coils L_1 and L_2 have different length, respectively, and housed within a metal case 1. A partition wall 3 between the helical coils L_1 and L_2 has an opening 2. The distributed capacity C_1 exists between the helical coil L_1 and the case 1 while the distributed capacity C_2 exists between the helical coil L_2 and the case 1. Thus a helical oscillator 4 is constructed by the coil L_1 and the distributed capacity C_1 equivalently connected in parallel while an oscillator 5 is constructed with the coil L_2 and the distributed capacity C_2 .

As best shown in FIG. 1, one end of the coil L_1 is opened while the other end thereof is connected to a grounded terminal 6 with a tap being connected to an input terminal 7. In like manner, one end of the coil L_2 is opened while the other end thereof is connected to a grounded terminal 8 with a tap being connected to an output terminal 9. As shown in FIG. 2, the coupling between the coils L_1 and L_2 produces an equivalent capacity C_k which represents the coupling condition between the oscillators 4 and 5.

As best shown in FIG. 3, by the adjustment of the distributed capacities C_1 and C_2 , the resonant frequencies of the oscillators 4 and 5 are selected in the vicinity of 250 MHz. This adjustment is carried out by screws 10 made of a metal and connected to the case 1 and movable vertically at the upper ends of the coils L_1 and L_2 . The harmonics of the oscillators 4 and 5 which are three times as high as the resonant frequency exist in the vicinity of 850 MHz and 650 MHz. In FIG. 3, the characteristic of the oscillator 4 is represented by the solid line while that of the oscillator 5, by the dotted line, but the oscillators 4 and 5 have the same characteristic in the vicinity of the resonant frequency so that the characteristic is represented by the solid line.

Component parts such as bobbins around which are wound the coils L_1 and L_2 , nuts in threadable engagement with the screws 10 and other parts which do not constitute the present

invention are not shown in FIG. 1. The grounded terminal 6, the input terminal 7, the grounded terminal 8 and the output terminal 9 are extended from a common base 11, but it is of course apparent to those who are skilled in the art that such pin type terminals are replaced by flat connectors which can be directly connected to an electrical conductive pattern of a circuit substrate (not shown).

The filter characteristic in response to an input signal of the helical filter with the above-mentioned construction is shown in FIG. 4.

Two small peaks appear in the vicinity of 750 MHz which is three times as high as the resonant frequency 250 MHz, but they are damped by the order of 50 dB as compared with the resonant frequency so that they may be substantially neglected. The same is true for the harmonic frequencies higher than five times as high as the resonant frequency. The reasons is that the harmonic frequencies of two oscillators are made different from each other by changing the coils L_1 and L_2 in length as described above. It is seen that the resonant frequency exists in the vicinity of 250 MHz in the form of a simple peak, indicating that the coincidence in resonant frequency between the two oscillators. The damping of the signal is of the order of 2 dB which is very small.

When three helical oscillators are interconnected each other, it is preferable that the frequencies of three helical oscillators are made different from each other in the vicinity of high harmonic frequencies so that three peaks appear and consequently the signal is damped.

Furthermore as in the first preferred embodiment, it is possible to vary the distributed capacity by displacing the screw connected to the case, but it is also possible to vary the distributed capacity by covering a helical coil L_3 with a dielectric screw 21 made of such as Teflon made into threadable engagement with a case 20 such that the screw 21 is vertically moved, as shown in FIG. 5.

In the first preferred embodiment described above, it is not necessary that each helical coil is wound around a bobbin exactly in the form of a helix.

Referring next to FIG. 6 illustrating a third preferred embodiment of the present invention, a helical coil L_4 is wound from the uppermost winding groove 31 to the lowermost winding groove 31 for a plurality of times. The lower end of the helical coil L_4 is connected to a grounded terminal while the upper end thereof is opened. With such helical coil L_4 , an oscillator can be constructed.

In addition, a helical coil can be wound in such a way that its turns are spaced apart from each other, but it is also possible that a helical coil is wound with the adjacent turns being made into

intimate contact with other. Furthermore a helical coil can be formed by connecting conductor patterns through insulating films by utilizing the laminated inductor technique.

However according to the experiments conducted by the inventor, it was found out that when modified helical coils of the type described above are used to construct a filter, it is difficult to separate the resonant frequency from a harmonic frequency as compared with the case of using the coils L_1 , L_2 and L_3 . It follows therefore that it is preferable that a helical coil exactly in the form of a helix with its turns being spaced apart from each other by a predetermined distance is used.

Fourth Embodiment, FIGS. 7-9

Next referring to FIGS. 7-9, a fourth embodiment of a helical filter in accordance with the present invention in which all oscillators have the same harmonic frequency, but have different resonant frequencies, respectively, will be described. As described above, FIG. 7 is a view used to explain the fourth embodiment; FIG. 8 is a diagram of an equivalent circuit thereof; and FIG. 9 illustrates the characteristic thereof.

Referring first to FIGS. 7 and 8, helical coils L_5 and L_6 have the same length and are covered with a metal case 51 with a partition wall 53 with an opening 52 being disposed between the coils L_5 and L_6 . The distributed capacity C_3 exists between the helical coil L_5 and the case 1 while the distributed capacity C_4 , between the helical coil L_6 and the case 1. Thus a helical oscillator 54 is constructed with a coil L_5 and the distributed capacity C_3 equivalently connected in parallel with the coil L_5 while another oscillator 55, with the coil L_6 and the distributed capacity C_4 .

One end of the coil L_5 is opened while the other end thereof is connected to a grounded terminal 56 with a tap being connected to an input terminal 57. In like manner, one end of the helical coil L_6 is opened while the other end thereof is connected to a grounded terminal 58 with a tap being connected to an output terminal 59. An equivalent capacity C_{kl} is obtained by the coupling between the coils L_5 and L_6 and represents the coupling condition between the oscillators 54 and 55.

The resonant frequencies of the oscillators 54 and 55 are selected at frequencies in the vicinity of 250 MHz, but they are slightly different from each other by varying the distributed capacities C_3 and C_4 . In the oscillator 55, it is provided a metal screw 60 which is always in contact with a case 51 and vertically moves the upper side of the coil L_5 , thereby adjusting the distributed capacity C_4 . How-

ever, another oscillator 54 is not provided with such screw and the resonant frequency of the oscillator 55 is higher than that of the oscillator 54. A harmonic frequency three times as high as the resonant frequency of each oscillator exists in the vicinity of 750 MHz.

In FIG. 7, bobbins around which are wound the coils L_5 and L_6 , a nut for engagement with the screw 60 and other parts which do not constitute the present invention are not shown. The grounded terminal 56, the input terminal 57, the grounded terminal 58 and the output terminal 59 are extended from a common base 61.

The helical filter with the above-mentioned construction has a filter characteristic in response to an input signal as shown in FIG. 9.

There exist two peaks in the vicinity of the resonant frequency 250 MHz so that it is noted that two different resonant frequencies exist. The reason is that the resonant frequencies of the two oscillators 54 and 55 are made different from each other by varying the distributed capacity in the manner described above. The degree of damping in response to an input signal is of the order 20 dB. The harmonic frequency three times as high as the resonant frequency exists in the vicinity of the 750 MHz and defines a single peak. As a result, it is understood that the harmonic frequencies of the two oscillators are coincident with each other. The degree of damping in harmonic frequency is less and of the order of 2 dB. As a result, this harmonic frequency can be used as a resonant frequency.

As described above, in the helical filter in accordance with the present invention, the harmonic frequency of the resonant frequency is determined by the length of the coil in each oscillator. Furthermore, the resonant frequency is hardly affected by the harmonic frequencies and is adjusted by the adjustment of the distributed capacity. When the harmonic frequencies of the oscillators are made different from each other, the signal is considerably damped so that the adverse effect of spurious response on the signal at the resonant signal can be eliminated.

Furthermore the oscillators may have the same harmonic frequencies, but different resonant frequencies so that the helical filter is so constructed as to resonate at a harmonic frequency. The resonant frequency is not different from the conventional one so that the number of turns of a helical coil is not necessary to extremely decrease as in the case of increasing the resonant frequency, so that the variation in filter characteristics can be avoided. Therefore the frequency which is used is not limited to a low resonant frequency, but can be increased to a high frequency.

Claims

1. A helical filter of the type coupling a plurality of helical oscillators (4, 5, 54, 55) characterized in that said oscillators have the same resonant frequency or harmonic frequency and have different resonant frequencies or harmonic frequencies, respectively.

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2. A helical filter of the type coupling a plurality of helical oscillators (4, 5, 54, 55) characterized in that said oscillators have the same resonant frequency by adjusting the distributed capacity (C_1 , C_2 , C_3 , C_4) of each oscillator and have different harmonic frequencies by varying the lengths of coils (L_1 , L_2 , L_5 , L_6).

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3. A helical filter as set forth in Claim 2, wherein the harmonic frequency is about three times as high as the resonant frequency.

4. A helical filter of the type coupling a plurality of helical oscillators, characterized in that coils (L_1 , L_2 , L_5 , L_6) have substantially the same length so that the harmonic frequencies of said oscillators (4, 5, 54, 55) become same each other and the resonant frequencies of said oscillators are different from each other by varying the distributed capacities (C_1 , C_2 , C_3 , C_4).

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5. A helical filter as set forth in Claim 4, wherein the harmonic frequencies are about three times as high as said resonant frequencies, respectively.

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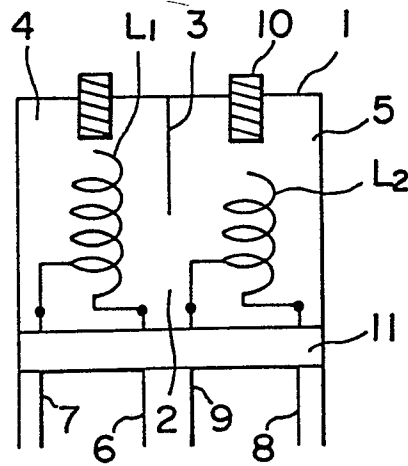


FIG. 1

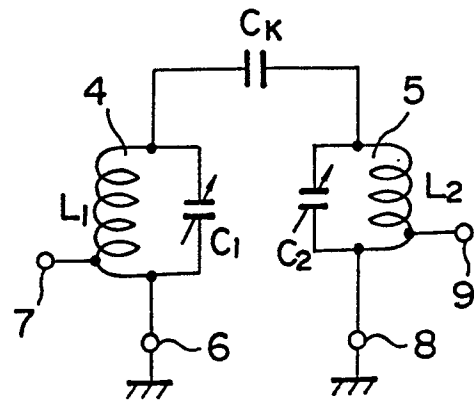


FIG. 2

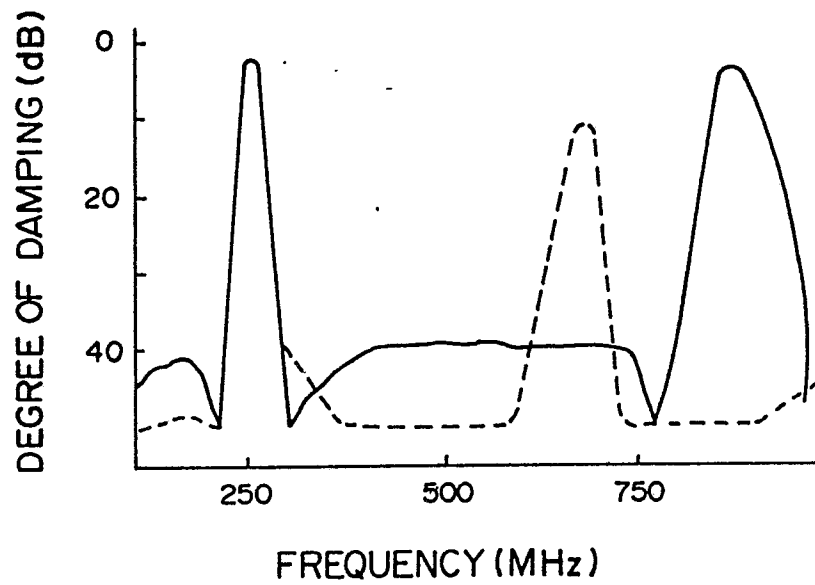


FIG. 3

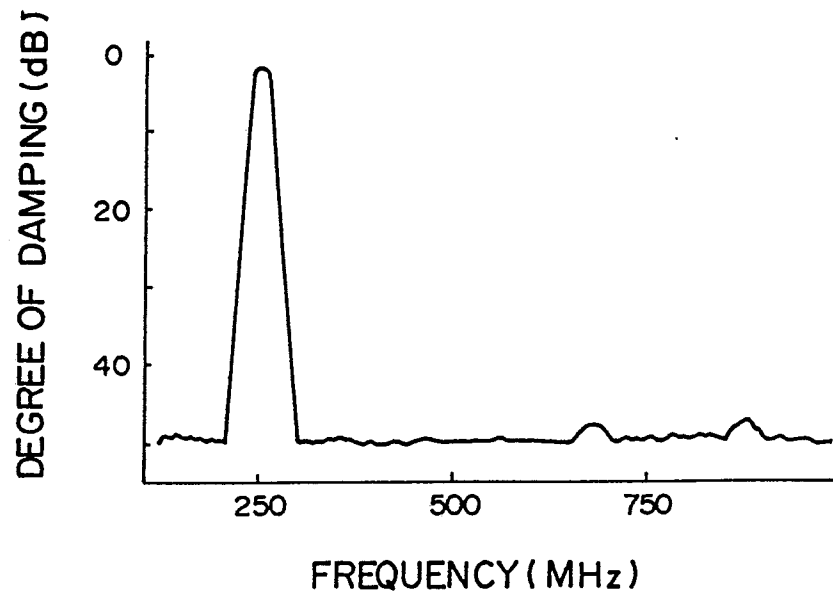


FIG. 4

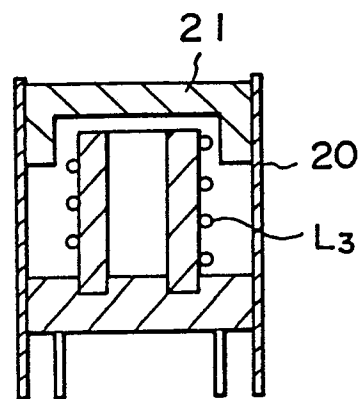


FIG. 5

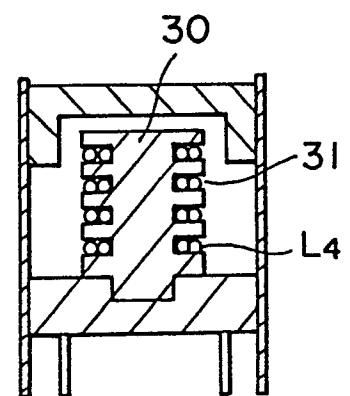


FIG. 6