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the video signal frequency fap and audio signal frequency fas of the adjacent channel as described above, two traps have been used, one for providing a large amount of attenuation at the video signal frequency fap of the adjacent channel and one for providing a large amount of attenuation at the audio signal frequency fas of the adjacent channel. Each of such traps has been constituted by an LC resonance circuit, a piezoelectric resonator, etc.

Piezoelectric resonators utilizing HS type surface waves such as BGS waves are attracting attentions as piezoelectric resonators suitable for such a purpose. Fig. 2 shows an example of surface wave resonators of the end face reflection type utilizing BGS waves.

An end face reflection type surface wave resonator 1 is configured using a piezoelectric substrate 2 having a rectangular surface. The piezoelectric substrate 2 is made of piezoelectric materials such as lead titanate-lead zirconate type piezoelectric ceramics and piezoelectric single crystal materials including $LiNbO_3$ and $LiTaO_3$. When a piezoelectric ceramic is used, it is polarized in the direction of the arrow P in Fig. 2. A pair of comb-like electrodes 3 and 4 are formed on an upper surface 2a of the piezoelectric substrate 2 to provide an interdigital transducer (hereinafter simply referred to an IDT). The comb-like electrodes 3 and 4 respectively have a plurality

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of electrode fingers 3a through 3c and a plurality of electrode fingers 4a through 4c.

An AC voltage is applied from the comb-like electrodes 3 and 4 to excite BGS waves in the end face reflection type surface wave resonator 1, the BGS waves propagating in the direction of the arrow X in Fig. 2. The BGS waves are reflected between end faces 2b and 2c of the piezoelectric substrate 2.

An effective resonance characteristic is obtained in the end face reflection type surface wave resonator 1 by matching the frequency determined by the IDT and the frequency determined by the distance between the end faces.

However, an end face reflection type surface wave resonator as described above has only one resonance characteristic like LC resonance circuits and piezoelectric resonators of other types. Therefore, in order to achieve desired trapping characteristics at the two frequencies, i.e., the video signal frequency fap of an adjacent channel and audio signal frequency fas of an adjacent channel, it has been necessary to prepare and connect two surface wave resonators.

Surface acoustic wave resonators utilizing Rayleigh waves have been proposed wherein two resonance characteristics have been obtained from a single resonator ~~(for example, refer to International Electronic Technology Bulletin, No. 16, pp. 1-7, 1992).~~ Specifically, among

(for example, refer to "Kokusai-Gihou", that means International Electric Technology Bulletin published in Japan, No.16, pp.1-7, 1992).

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surface wave resonator filters utilizing Rayleigh waves, dual mode resonators utilizing a 0-dimensional longitudinal mode (basic mode) and a 2-dimensional longitudinal mode are well known. In such dual mode resonators, two or more IDT's and reflectors have been necessary to obtain two resonance characteristics. Further, the resonance characteristics of such dual mode resonators are determined by the relation between the reflection coefficient and frequency of the reflectors. Since the frequency range wherein the reflection coefficient is large is narrow, the difference between the two resonance points is as very small as approximately 1 MHz for the range wherein preferable resonance characteristics are obtained. Therefore, it has not been possible to configure a trap filter having the characteristics as shown in Fig. 1 using only such dual mode resonators.

One approach to obtain two resonance characteristics in an end face reflection type surface wave resonator as described above may be to form two IDT's on a piezoelectric substrate to configure two resonant units. However, in an end face reflection type surface wave resonator utilizing HS type surface waves such as BGS waves, the wavelength λ of the IDT's and the distance L between the two opposite end faces on which the surface waves in the piezoelectric substrate are reflected are in a relationship as

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schematically illustrated in Fig. 3 wherein L = (λ/2) X N (multiplied by) (N is an integral number).

Accordingly, there is a difference in the value of the distance L between the two opposite end faces between the resonant unit whose resonance point is at the video signal frequency fap of an adjacent channel and the resonant unit whose resonance point is at the audio signal frequency fas of the adjacent channel. Therefore, it has been considered that it is very difficult to configure a surface wave resonator utilizing HS type surface waves by forming two resonant units of different resonance frequencies on the same substrate.

It is an object of the present invention to provide an end face reflection type surface wave resonator utilizing HS type surface waves wherein at least two resonant units of different resonance frequencies are formed into a single element.

SUMMARY OF THE INVENTION

According to a first aspect of the present invention, there is provided an end face reflection type surface wave resonator wherein horizontal shear wave type surface waves are reflected by two opposite end faces of a piezoelectric substrate, comprising a piezoelectric substrate having ~~the~~

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~~piezoelectric substrate having~~ two opposite end faces and first and second IDT's formed on the piezoelectric substrate. A first resonant unit is constituted by the portion wherein the first IDT is formed, and a second resonant unit is constituted by the portion wherein the second IDT is formed with a resonance frequency f_2 different from the resonance frequency f_1 of the first resonant unit. A distance L is made equal or close to $(\lambda_1/2) \times N_1$ (N_1 is an integral number) and N_2 (N_2 is an integral number) is chosen to make $(\lambda_2/2) \times N_2$ close to the distance L where L represents the distance between the two opposite end faces; λ_1 represents the wavelength of a surface wave excited by the first resonant unit; and λ_2 represents the wavelength of a surface wave excited by the second resonant unit.

Specifically, the end face reflection type surface wave resonator according to the first aspect of the present invention includes first and second resonant units having different resonance frequencies provided by forming first and second IDT's on a piezoelectric substrate having two end faces opposite to each other. Each of the resonant units excites HS type surface waves like the end face reflection type surface wave resonator 1 utilizing BGS waves as described above and the HS type surface waves are reflected by the two opposite end faces of the piezoelectric substrate.

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In addition to BGS waves, the term "HS type surface waves" implies general surface waves including Love waves which have components of displacement in the direction perpendicular to the direction in which the surface waves propagate.

According to the first aspect of the invention, in an end face reflection type surface wave resonator having the above-described first and second resonant units, the distance L between the two opposite end faces and the wavelengths λ_1 and λ_2 of surface waves excited respectively by the first and second resonant units are chosen to satisfy the relationships as described above. Specifically, the distance L is made equal or close to $(\lambda_1/2) \times N_1$ and the value of N_2 is chosen to make $(\lambda_2/2) \times N_2$ closer to the distance L. In a surface wave resonator according to the present invention, the first resonant unit provides a desired resonance characteristic because the distance L is decided as described above. On the other hand, the value N_2 for the second resonant unit is decided after the resonance characteristic of the first resonant unit is established in the range as described above.

Although the distance L is made equal or close to $(\lambda_1/2) \times N_1$, it is preferably in the range of $(\lambda_1/2) \times N_2 \pm (\lambda_1/20)$. It is known that an end face reflection type surface wave resonator provides an acceptable resonance

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characteristic where the error of the distance L between the two opposite end faces is in the range of $\pm \lambda_1/20$. Therefore, the range defined above as "equal or close to "$(\lambda_1/20) \times N_1$", i.e., the allowable range for the distance L to obtain a desired resonance characteristic from the first resonant unit, is the range of $(\lambda_1/2) \times N_2 \pm (\lambda_1/20)$ as described above.

On the other hand, it is not necessary that the distance L equals $(\lambda_2/2) \times N_2$ for the second resonant unit. It is commonly considered that, in an end face reflection type surface wave resonator, the distance L must be equal to (the wavelength of a surface wave excited $\times$ (multiply) 1/2 $\times$ (multiply) an integral number). The reason is that a deviation of the distance L from such a value results in a ripple in the region of lower frequencies. In some applications, however, such a ripple at some low frequency does not create any problem. For example, a ripple in the region of frequencies lower than the resonance point of the second resonant unit may not be a problem when the resonance frequency f_1 of the first resonant unit is higher than the resonance frequency f_2 of the second resonant unit. In such a case, a deviation of the distance L from the optimum value will not be a serious problem for the second resonant unit. Therefore, although N_2 for the second resonant unit is chosen to make $(\lambda_2/2) \times N_2$ closer to the distance L, it is not essential

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that the distance L equals $(\lambda_2/2) \times N_2$. Further, the distance L may be out of the range expressed by $(\lambda_1/2) \times N_2 \pm (\lambda_1/20)$.

A trap circuit for a video intermediate frequency stage of a television receiver or a video tape recorder may be cited as an example of applications wherein no problem is caused by a ripple in the region of frequencies lower than the resonance frequency f_2 of the second resonant unit which is lower than the resonance frequency f_1 of the first resonant unit as described above. In other words, when the first resonance frequency f_1 is the audio signal frequency fas of an adjacent channel and the second resonance frequency f_2 is the video signal frequency fap of the adjacent channel, there is no problem even if a ripple occurs as described above in the region of frequencies lower than the adjacent channel video signal frequency.

Accordingly, an end face reflection type surface wave resonator according to the present invention is preferably used as a resonator serving as a trap circuit in a video intermediate frequency stage as described above.

The first and second resonant units may be separated from each other by at least one groove formed on the piezoelectric substrate. In this case, one of the two end faces of each of the first and second resonant units is constituted by an inner wall of the groove.

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According to a second aspect of the present invention, there is provided an end face reflection type surface wave resonator utilizing HS type surface waves comprising a piezoelectric substrate having at least one groove formed on at least one surface thereof, first and second IDT's which are formed on the piezoelectric substrate with the at least one groove interposed therebetween and which serve as first and second resonant units, respectively, an inner wall of the groove serving as at least one of the two opposite end faces for reflecting surface waves of each of the first and second resonant units.

Specifically, in a surface resonator according to the second aspect of the invention, at least one groove is formed on at least one surface of the piezoelectric substrate, and the first and second resonant units are configured, separated by the at least one groove. In this case, at least one of the two opposite end faces for reflecting surface waves of each of the first and second resonant units is constituted by an inner wall of the groove.

Since the first and second resonant units are configured using a single piezoelectric substrate, this second aspect of the invention makes it possible to provide an end face reflection type surface wave resonator having a plurality of resonance characteristics using a single element like in the

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first aspect of the invention. Thus, the first and second aspects of the invention are similar in that they both solve the problem mentioned above.

In the context of the surface wave resonator according to the second aspect of the invention, the term "HS type surfaces waves" again implies general surface waves ~~including~~ such as BGS waves and Love waves which have components of displacement in the direction perpendicular to the direction in which the surface waves propagate.

In a surface wave resonator according to the first aspect of the present invention, the first and second resonant units of the end face reflection type utilizing HS type surface waves are provided using a piezoelectric substrate having two end faces opposite to each other. This makes it possible to provide an end face reflection type surface wave resonator having a plurality of resonance characteristics using a single element.

According to the first aspect of the invention, since the distance L as explained above is chosen to be equal or close to $(\lambda_1/2) \times N_1$, the first resonant unit exhibits a desired resonance characteristic. On the other hand, N_2 for the second resonant unit is chosen so that $(\lambda_2/2) \times N_2$ is close to the distance L. As a result, when $(\lambda_2/2) \times N_2$ is not equal to the distance L or when the distance L is out of the range of $(\lambda_2/2) \times N_2 \pm (\lambda_2/20)$, a ripple occurs in the

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region of frequencies lower than the second resonance frequency f_2. However, even with such a ripple, a trap circuit having a plurality of traps can be provided using a surface wave resonator according to the first aspect of the invention for applications wherein no problem is caused by a ripple in the region of frequencies lower than the resonance frequency f_2 of the second resonant unit.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 illustrates the relationship between the attenuation and frequency characteristic of a video intermediate frequency stage of a television receiver.

Fig. 2 is a perspective view illustrating a conventional surface wave resonator utilizing BGS waves.

Fig. 3 is a sectional view of an end face reflection type surface wave resonator.

Fig. 4 illustrates the relationship between the impedance and frequency characteristic of an end face reflection type surface wave resonator with the distance between the two opposite end faces off the optimum value.

Fig. 5 illustrates the relationship between the impedance and frequency characteristic of an end face reflection type surface wave resonator with the distance between the two opposite end faces in a preferable range.

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Fig. 6 is a plan view illustrating an end face reflection type surface wave resonator according to a first embodiment of the present invention.

Fig. 7 illustrates the relationship between the impedance and frequency characteristic of a second resonant unit of the surface wave resonator shown in Fig. 6.

Fig. 8 illustrates the relationship between the impedance and frequency characteristics of a first resonant unit of the surface wave resonator shown in Fig. 6.

Fig. 9 is a perspective view of an end face reflection type surface wave resonator according to a second embodiment of the present invention.

Fig. 10 is a perspective view illustrating a modification of the surface wave resonator of the embodiment shown in Fig. 9.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The present invention will now be clarified by the following description which will proceed with reference to the accompanying drawings.

Fig. 4 and Fig. 5 illustrate the relationship between the impedance and frequency characteristic of the end face reflection type surface wave resonator shown in Fig. 2. Fig. 4 shows a characteristic exhibited when the distance L

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between the two opposite end faces is (λ/10) greater than the optimum value (λ/2) X N of the distance L, and Fig. 5 shows a characteristic exhibited when the distance L between the two opposite end faces is (λ/20) greater than the optimum value (λ/2) X N of the distance L.

As apparent from Fig. 4, when the distance L deviates from the optimum value by (λ/10), i.e., when the distance L between the two opposite end faces is not sufficiently accurate, such a deviation causes a ripple in the area of frequencies lower than the resonance point fr, as indicated by the arrow A.

On the other hand, as apparent from Fig. 5, when the distance L between the two opposite end faces deviates from the optimum value by (λ/20), no ripple occurs in the area of frequencies lower than the resonance point fr. Now, it will be understood that the distance L between the two opposite end faces of the end face reflection type surface wave resonator shown in Fig. 2 must be in the range of (λ/2) X N $\pm$ (λ/20).

Assume that resonators are configured in a video intermediate frequency stage of a television receiver and that one of the resonators resonates with the video signal frequency fap (31.9 MHz) of an adjacent channel and the other resonates with the audio signal frequency fas (40.4 MHz) of the adjacent channel.

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If the resonator resonating at 31.9 MHz is configured using a substrate through which sound travels at a velocity of 2400 m/sec., the resonator provides a wavelength of 75.2 μm. The resonator for the audio signal frequency fas (40.4 MHz) of the adjacent channel will provide a wavelength λ of 59.4 μm if a substrate is used through which sound travels at a velocity of 2400 m/sec.

Therefore, when the above-described two resonators are formed on the single piezoelectric substrate, the distances L between the two opposite end faces of those resonators must be made as close to each other as possible taking the difference between the wavelengths of those resonators in to account. In the above-described example, the resonator for the video signal frequency fap of the adjacent channel will have a distance Lap of 300.8 μm if four pairs of electrode fingers are provided, and the resonator for the audio signal frequency fas of the adjacent channel will have a distance Las of 297 μm if five pairs of electrode fingers are provided. The difference between the lengths Lap and Las is 3.8 μm which value is about one-sixteenth of the wavelength 59.4 μm.

Thus, in the above-described configuration wherein a sufficient resonant characteristic is pursued for each resonator by simply adjusting the numbers of the electrode pairs of those resonators, one of the resonators can not

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satisfy the equation $L = (\lambda/2) \times N \pm (\lambda/20)$. In addition, when the numbers of electrode pairs are on the order of 4 or 5 as described above, only weak excitation of surface waves will be achieved, and the values of capacitance and impedance available will not meet the above described purpose. This makes it impossible to design resonators with flexibility to provide the capacitance and impedance optimized for the purpose.

In the frequency characteristic of a video intermediate frequency stage as shown in Fig. 1, there is no ripple in between the color signal frequency f_c and the video signal frequency f_p (i.e., between 34.47 MHz and 38.9 MHz), although such a ripple occurs in the position indicated by the arrow A in Fig. 4. This suggests that the ripple indicated by the arrow A in Fig. 4 does not create a problem for a video intermediate frequency stage of a television receiver.

It will be understood that an end face reflection type surface wave resonance unit can be used as a trap for the video signal frequency of an adjacent channel even if the distance L between the two opposite end faces thereof is out of the range of the optimum value $\pm \lambda/20$.

From such a point of view, the inventor has found that the optimum resonators can be configured for the trap circuit as described above to be used for, for example, a

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video intermediate frequency by selecting the number M_1 of the pairs of electrode fingers for a first resonant unit such that the distance L between the two opposite end faces thereof results in the desired resonance characteristic and by selecting the number M_2 of the pairs of electrode fingers of a second resonant unit such that the distances L between the two opposite end faces of those resonators becomes as close to each other as possible regardless of the optimum value and allowable range for the distance.

A description will now be made with reference to Figs. 6 though 8 on the configuration and operation of an end face reflection type surface wave resonator of an embodiment according to a first aspect of the present invention.

Fig. 6 is a plan view of an end face reflection type surface wave resonator according to a first embodiment of the present invention.

An end face reflection type surface wave resonator 11 is uniformly polarized in the direction in which electrode fingers to be described later extend and is configured using a piezoelectric substrate 12 having a rectangular surface. The piezoelectric substrate 12 is made of a piezoelectric ceramic such as a lead titanate-lead zirconate type piezoelectric ceramic and a piezoelectric single crystal material such as $LiTaO_3$ and $LiNbO_3$.

A first IDT 14 and a second IDT 13 are formed on the

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upper surface of the piezoelectric substrate 12. The first IDT 14 and the second IDT 13 are provided by forming electrodes as described below.

Bus bars 15 through 17 are formed in parallel with side faces 12c and 12d connecting two opposite end faces 12a and 12b of the piezoelectric substrate 12. The bus bars 15 and 17 are formed along the side faces 12c and 12d, respectively. The bus bar 16 is formed in the middle of the piezoelectric substrate 12 in parallel with the side faces 12c and 12d.

A plurality of electrode fingers 18a through 18e are formed so that they extend from the bus bar 15 toward the bus bar 16 but do not reach the bus bar 16. Similarly, a plurality of electrode fingers 19a through 19d are formed so that they extend from the bus bar 16 toward the bus bar 15 but do not reach the bus bar 15. The IDT 13 is constituted by a comb-like electrode formed by the bus bar 15 and plurality of electrode fingers 18a through 18e and a comb-like electrode formed by the bus bar 16 and plurality of electrode fingers 19a and 19d.

A plurality of electrode fingers 20a through 20e are formed so that they extend from the bus bar 16 toward the bus bar 17. Similarly, a plurality of electrode fingers 21a through 21f are formed so that they extend from the bus bar 17 toward the bus bar 16 but do not reach the bus bar 16.

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The IDT 14 is constituted by a comb-like electrode formed by the bus bar 16 and plurality of electrode fingers 20a through 20e and a comb-like electrode formed by the bus bar 17 and plurality of electrode fingers 21a and 21f.

The above-described electrode fingers have a width which is about one-fourth the wavelength of a surface wave excited by the IDT's except the electrode fingers 18a, 18e, 21a, and 21f formed along the end faces 12a and 12b. Each of the intervals of those electrode fingers is also one-fourth the wavelength of a surface wave excited by the IDT's 13 and 14. ~~except the~~ The electrode fingers 18a, 18e, 21a, and 21f formed along the end faces 12a and 12b ~~for which the interval~~ have a width which is about one-eighth the wavelength excited by the IDT's 13 and 14.

The IDT's 13 and 14 having the above-described configurations can be obtained by forming an aluminum film on the upper surface of the piezoelectric substrate 12 using thin film forming methods such as deposition, plating, and sputtering and by patterning the film using photolithography or the like. Alternatively, the IDT's 13 and 14 may be formed by screen-printing a conductive material to provide the surface configuration as shown in Fig. 6.

In the surface wave resonator 11 according to the present embodiment, a second resonant unit is constituted by the area in which the IDT 13 is formed and a first resonant

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unit is constituted by the area in which the IDT 14 is formed. The second resonant unit is a resonator serving as a trap for the video signal frequency of an adjacent channel, and the first resonant unit is a resonator serving as a trap for the audio signal frequency of the adjacent channel. Electrical connection for the operation of those units may be established by connecting the bus bar 16 to a reference potential and by electrically connecting the bus bars 15 and 17 to signal lines. Thus, the surface wave resonator 11 according to the present embodiment can be used as a single electrical component having three terminals.

In the surface wave resonator 11 according to this embodiment, the distance L between the two opposite end faces 12a and 12b is 287 μm, and the sound velocity in the piezoelectric substrate 12 is 2400 m/sec. The numbers M_1 and M_2 of the electrode fingers of the first and second resonant units are five and four, respectively. Therefore, the adjacent channel video signal frequency (31.9 MHz) and the adjacent channel audio frequency (40.4 MHz) have wavelengths $\lambda ap = \lambda_2 = 75.2$ μm and $\lambda as = \lambda_1 = 59.4$ μm, respectively in the resonators.

Thus, the resonance characteristic of the first resonant unit serving as a trap for the adjacent channel audio signal frequency satisfies $L = (\lambda_1/2) \times N_1$. So it is apparent that no undesirable spurious response occurs in the

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region of frequencies lower than the resonance point, as shown in Fig. 8.

On the other hand, for the resonance characteristic of the second resonant unit serving as a trap for the adjacent channel video signal frequency, since the length $(\lambda_2/2) \times N_2$ thereof deviates from the above distance L by 3.8 μm, a spurious response occurs in the region of frequencies lower than the resonance point as indicated by the arrow A.

However, such a spurious response in the region of frequencies lower than the adjacent channel video signal frequency does not adversely effect the characteristics of the video intermediate frequency stage. Therefore, the surface wave resonator 11 according to the present embodiment can be used as preferable elements serving as two traps of a video intermediate frequency stage of a television receiver. In other words, two traps can be provided using a single element. This provides an advantage over conventional LC resonance circuits and ~~conventional~~ conventional trap circuits utilizing piezoelectric resonators in that circuit configuration can be significantly simplified with a reduction in manufacturing cost.

Fig. 9 is a perspective view illustrating a surface wave resonator according to another embodiment of the present invention. The surface wave resonator 31 shown in Fig. 9 is an embodiment according to a second aspect of the

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invention and is similar to the first embodiment in that it is an element serving as a trap circuit in a video intermediate frequency stage of a television receiver.

The surface wave resonator 31 is configured using a piezoelectric substrate 32 having a rectangular surface. The piezoelectric substrate 32 is made of a piezoelectric ceramic such as a lead titanate-lead zirconate type piezoelectric ceramic and a piezoelectric single crystal material such as $LiTaO_3$ and $LiNbO_3$.

A groove 33 is formed on the upper surface of the piezoelectric substrate 32 in parallel with end faces 32a and 32b facing each other. A first IDT 34 and a second IDT 35 are formed on both sides of the groove 33 to configure first and second resonant units, respectively.

The IDT 34 has comb-like electrodes 36 and 37 which are arranged so that the electrode fingers thereof are ~~interleaved~~ interdigitated. Electrode fingers ~~36c~~ 36b, 37a, and 37b are formed to have a width which is one-fourth the wavelength λ of a surface wave excited by the first resonant unit and are spaced by $\lambda/4$ from each other. The width of electrode fingers 36a and 36c on both ends is $\lambda/8$.

The second IDT 35 similarly has a pair of comb-like electrodes 38 and 39 which are arranged so that the electrode fingers thereof are ~~interleaved~~ interdigitated. Electrode fingers 38a, 38b, 39b, and 39c are formed to have a width

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which is one-fourth the wavelength λ of a surface wave excited by the second resonant unit and are spaced by $\lambda/4$ from each other. The width of electrode fingers 39a and 38c on both ends of the second resonant unit is one-eighth the wavelength of a surface wave excited therein.

In the surface wave resonator 31 according to the present embodiment, the first and second resonant units are separated by the groove 33. Therefore, a surface wave excited by the first resonant unit is reflected by the end face 32a and one inner wall 33a of the groove 33. Similarly, a surface wave excited by the second resonant unit is reflected by the other inner wall 33b of the groove 33 and the end face 32b. In other words, each of the inner walls 33a and 33b of the groove 33 serves as one of the end faces of the respective end face reflection type surface wave resonant units.

In the surface wave resonator 31 according to the present embodiment, two resonant units are provided using the single piezoelectric substrate 32 as described above by forming the groove 33 to use the inner walls thereof as end faces on which surface waves from the resonant units are reflected.

Thus, the present embodiment also makes it possible to provide a surface wave resonator of the end face reflection type having two different resonance characteristics using a

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single element.

It is therefore possible to provide traps for the video signal frequency and audio signal frequency of an adjacent channel for a video intermediate frequency stage of a television receiver by freely selecting the numbers of the electrode fingers of the IDT's 34 and 35 and the distance between the two opposite end faces of each resonant unit.

In operation, the comb-like electrodes 37 and 39 may be interconnected to package the surface wave resonator 31 of the present embodiment into a component having three terminals.

Fig. 10 is a perspective view showing a modification of the surface wave resonator according to the embodiment shown in Fig. 9. A surface wave resonator 41 according to this alternative embodiment has two grooves 42 and 43 formed between first and second resonant units on both ends thereof. As a result, a part 44 of the substrate remains between the grooves 42 and 43.

Since the resonator 41 is otherwise similar to the surface wave resonator 31 shown in Fig. 9, such like parts are indicated by like reference numbers and will not be described.

In the surface wave resonator according to the second aspect of the invention, the first and second resonant units may be separated from each other by forming a plurality of

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grooves therebetween as in the surface wave resonator shown in Fig. 10.

Although not shown, according to the second aspect of the invention, one or more additional grooves may be formed between the adjacent resonant units on the side of the piezoelectric substrate opposite to that on which the IDT's are formed.

Various modifications to the present invention will become apparent to those skilled in the art from the foregoing description and accompanying drawings. Accordingly, the present invention is to be limited solely by the scope of the following claims.

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CLAIMS

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What is claimed is:

1. An end face reflection type surface wave resonator wherein horizontal shear wave type surface waves are reflected by two opposite end faces of a piezoelectric substrate, comprising:

a piezoelectric substrate having said piezoelectric substrate; and

first and second interdigital transducers formed on said piezoelectric substrate, wherein;

a first resonant unit is constituted by the portion wherein said first interdigital transducer is formed, and a second resonant unit is constituted by the portion wherein said second interdigital transducer is formed with a resonance frequency f_2 different from the resonance frequency f_1 of said first resonant unit;

a distance L is made equal or close to $(\lambda_1/2) \times N_1$ (N_1 is an integral number) and N_2 (N_2 is an integral number) is chosen to make $(\lambda_2/2) \times N_2$ close to L, with L representing the distance between said two opposite end faces, λ_1 representing the wavelength of a surface wave excited by said first resonant unit, and λ_2 representing the wavelength of a surface wave excited by said second resonant unit.

2. The surface wave resonator according to Claim 1, wherein said distance L is in a range expressed by $(\lambda_1/2) \times$

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$N_1 \pm (\lambda_1/20)$.

3. The surface wave resonator according to Claim 1 or Claim 2, wherein said distance L is out of the range expressed by $(\lambda_2/2) \times N_2 \pm (\lambda_2/20)$.

4. The surface wave resonator according to any one of Claims 1 to 3, wherein the resonance frequency f_1 of said first resonant unit is higher than the resonance frequency f_2 of said second resonant unit.

5. The surface wave resonator according to any one of Claims 1 to 4 which is a resonator that constitutes a trap circuit of a video intermediate frequency stage of a television receiver and wherein said first resonance frequency f_1 is the audio signal frequency of an adjacent channel and said second resonance frequency f_2 is the video signal frequency of the adjacent channel.

6. The surface wave resonator according to any one of Claims 1 to 5, wherein said first and second resonant units are separated by at least one groove formed on said piezoelectric substrate, one of the two end faces of each of said first and second resonant units being constituted by an inner wall of said groove.

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7 8. An end face reflection type surface wave resonator utilizing horizontal shear wave type surface waves comprising:

a piezoelectric substrate having at least one groove formed on at least one of the surfaces thereof; and

first and second interdigital transducers which are formed on said piezoelectric substrate, separated by said at least one groove, and which constitute first and second resonant units, respectively, at least one of the two end faces of each of said first and second resonant units for reflecting surface waves being constituted by an inner wall of said groove.

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