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PIEZOELECTRIC RESONATOR INCLUDING
OSCILLATION BUFFER MATERIALS

BACKGROUND OF THE INVENTION

5 1. Field of the Invention

The present invention relates to piezoelectric resonators used in various types of high frequency filters, and more specifically to a piezoelectric resonator including oscillation buffer materials arranged to prevent generation
10 of resonance third harmonics.

2. Description of the Related Art

As a conventional example, a piezoelectric resonator as shown in Fig. 4 is known. This piezoelectric resonator 20
15 has oscillating electrodes 22A and 22B ~~on both~~ disposed on opposite major surfaces of a piezoelectric substrate 21. These oscillating electrodes 22A and 22B are formed to extend from opposite ends so that they overlap at the ~~width-directional~~ a central portion of the piezoelectric
20 substrate 21 ~~with~~ so that the piezoelectric substrate 21 is sandwiched therebetween. A high frequency signal applied to the oscillating electrodes 22A and 22B enables the piezoelectric resonator 20 to resonate.

When an electrode ~~with~~ having a shape such as that of a
25 partial excitation electrode ~~capable of optimizing~~ which is



SUMMARY OF THE INVENTION

Accordingly, the The foregoing object advantage is achieved through the provision of a piezoelectric resonator



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Figs. 3A and 3B are graphs showing the resonance

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Fig. 4 is a section view illustrating the structure of an example of a conventional piezoelectric resonator.

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By referring to the attached drawings, ~~one embodiment~~
preferred embodiments of the present invention will be
described below.

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portion 2d, with the oscillating electrode 3B at another end
2f extending over another end face surface 2g of the
piezoelectric substrate 2. In addition, the oscillating
electrodes 3A and 3B overlap each other at the
5 ~~width-directional~~ central portion 2d, with the piezoelectric
substrate 2 sandwiched therebetween.

Subsequently, the structure of the piezoelectric
resonator 1, ~~which is a feature thereof,~~ will be described.
The piezoelectric resonator 1 preferably has oscillation
10 buffer materials 4 respectively ~~formed on~~ disposed at
preferably the opposed ends 2c and 2f of the piezoelectric
electrode 2. The oscillation buffer materials 4, ~~which are~~
preferably comprise insulating resins which do not include
conductive fillers ~~and~~ are formed preferably disposed on
15 the surface 2a of the substrate. The locations at which the
oscillation buffer materials 4 are ~~formed~~ disposed on the
opposed ends 2c and 2f are determined as ~~follows,~~ described
in the following paragraphs.

~~In other words, in~~ In the piezoelectric resonator 1, not
20 only the fundamental resonance wave K_0 but also the resonance
wave K_3 which has a frequency substantially equal to about
three times that of the wave fundamental resonance wave K_0 is
generated. When the resonance electrodes 3A and 3B are
formed so as to optimize the fundamental resonance wave K_0



(See see the conventional example ~~+~~ shown in Figs. 3A and 3B), the S1 mode resonance K_{3S1} and the S2 mode resonance K_{3S2} are generated, as well as the S0 mode resonance K_{3S0} which is the third harmonic resonance K_3 . Conditions of displacement caused by the third harmonic resonances K_{3S0} , K_{3S1} and K_{3S2} having different phases on the piezoelectric substrate 2 are shown in Fig. 1. Although the third harmonic resonances K_{3S0} , K_{3S1} and K_{3S2} cause the maximum displacement in the ~~width-directional~~ central portion 2d of the substrate, the forms in which the displacements are concentrated are respectively different. That is, compared with the S0 mode third harmonic resonance K_{3S0} which causes displacement concentrated in the ~~width-directional~~ central portion of the substrate, the S1 mode third harmonic resonance K_{3S1} and the S2 mode third harmonic resonance K_{3S2} cause displacement to some extent ~~on~~ at the opposed ends 2c and 2f. In Fig. 1, an alternate long and short dashed line represents the S0 mode third harmonic resonance K_{3S0} , an alternate long and two short dashed line represents the S1 mode third harmonic resonance K_{3S1} , and a dashed line represents the condition of displacement caused by the S2 mode third harmonic resonance K_{3S2} . Also, a solid line represents the condition of displacement caused by the fundamental resonance wave K_R .

The oscillation buffer materials 4, which preferably

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have relatively small mass, are ~~formed~~ preferably disposed on the surface 2a at the opposed ends 2c and 2f where displacement occurs due to the S1 mode third harmonic resonance K_{3s1} and the S2 mode third harmonic resonance K_{3s2} .
5 The oscillation buffer materials 4 suppress or prevent the generation of the S1 mode third harmonic resonance K_{3s1} and the S2 mode third harmonic resonance K_{3s2} .

The definite locations ~~in~~ at which the oscillation buffer materials 4 are disposed are ~~as follows~~ described in
10 the following paragraph.

The oscillation buffer materials 4 are preferably disposed at positions spaced apart from reference positions B ~~in the outer substrate width directions~~ by a desired distance D, when the ends of the oscillating electrodes 3A and 3B in
15 the ~~substrate width directional~~ central portion are used as the reference positions B. The desired distance D is preferably set to be substantially equal to one to two times the thickness of the piezoelectric substrate 2.

An example of the locations in which the oscillation
20 buffer materials 4 are ~~disposed are as follows~~ preferably disposed is described in the following paragraphs.

A piezoelectric resonator having a piezoelectric substrate 2, which is made of PZT (lead zirconate titanate), preferably about 5.4 mm long, about 0.3 mm thick and





The materials used for the oscillation buffers 4 and their thickness t preferably satisfy the equation $F = C/2t$, where C represents the speed of sound naturally determined by the oscillation buffer material 4; and F represents the frequency of the third harmonic oscillation, which is approximately equal to about three times the resonance frequency of the piezoelectric resonator 1.

Determination of the oscillation buffer material 4 depends upon several factors. ~~the following.~~

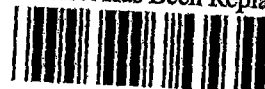
By adjusting the resonance frequency of the oscillation buffer material 4 so it substantially agrees with the frequency of the third harmonic oscillation which is to be attenuated, the third harmonic oscillation can be efficiently reduced. In addition, the characteristic oscillation frequency f of the oscillation buffer material 4 formed on the piezoelectric substrate 2 can be ~~found~~ determined using the equation $f = C/2t$, where C represents the speed C of sound naturally determined by the oscillation buffer material 4 and the shape (in particular, the thickness t , preferably in the thickness-slide-oscillation-mode of the piezoelectric resonator 1) of the oscillation buffer material on the piezoelectric substrate 2. Thus, by adjusting the natural oscillation frequency f of the oscillation buffer material 4, ~~found~~ which is determined using the equation $f = C/2t$, so it





piezoelectric resonator of the preferred embodiments of the present invention, it can be seen that the resonance third harmonic K_3 is controlled ~~so it~~ such that the resonance third harmonic is not generated ~~without~~ and the characteristics of the fundamental resonance wave K_1 ~~being~~ are not deteriorated or affected. This is due to the fact that the S1 and S2 mode resonance third harmonics which displace the substrate ends 2c and 2f are controlled and thus, degenerated due to the oscillation buffer materials 4 ~~formed~~ located at the ends 2c and 2f.

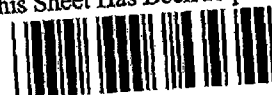
The reason why only the generation of the resonance third harmonic K_3 is selectively suppressed despite the arrangement in which the oscillation buffer materials 4 are ~~formed~~ disposed at the substrate ends 2c and 2f where displacement also occurs due to the fundamental resonance wave K_1 is because, by adjusting the natural oscillation frequency f of the oscillation buffer material 4 so it substantially agrees with the frequency F of the third harmonic oscillation which is substantially equal to about three times the resonance frequency of the piezoelectric resonator 1, the third harmonic oscillation can be efficiently reduced. Another reason is that the fundamental resonance wave K_1 is not affected by the oscillation buffer material 4 because it has greater excitation frequency than



As described above, by providing the oscillation buffer materials 4 which have relatively small specific gravity in the piezoelectric resonator 1, the generation of the resonance third harmonic K_3 can be suppressed without the fundamental resonance wave K_0 being affected.

While the invention has been particularly shown and described with reference to preferred embodiments thereof, it will be understood by those skilled in the art that the foregoing and other changes in form and details may be made therein without departing from the spirit and scope of the invention.

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5 disposed on one of said opposite major surfaces of a
piezoelectric substrate; wherein

the piezoelectric substrate is adapted to suppress
a third harmonic oscillation having a frequency substantially
equal to about three times a resonance frequency of said
10 piezoelectric substrate.

6. A piezoelectric resonator according to claim 5,
wherein the piezoelectric substrate is arranged such that the
third harmonic oscillation is suppressed without suppressing
a fundamental resonance wave of said piezoelectric substrate.

7. A piezoelectric resonator according to claim 5,
further comprising an oscillation buffer material disposed on
a portion of at least one of said opposite major surfaces of
said piezoelectric substrate for suppressing said third
5 harmonic oscillation, said portion of said at least one of
said opposite major surfaces of said piezoelectric substrate
is displaced by a third harmonic oscillation having a
frequency substantially equal to about three times a
resonance frequency of said piezoelectric substrate.

8. A piezoelectric resonator according to claim 7,
wherein said oscillation buffer material comprises insulating





resin.

9. A piezoelectric resonator according to claim 7,
wherein a composition and a thickness of said oscillation
buffer material are determined so as to satisfy the equation:

$$F = C/2t$$

5 where t represents a thickness of said oscillation buffer
material; C represents a speed of sound naturally determined
by the composition of said oscillation buffer material; and F
represents a frequency of the third harmonic oscillation
which is substantially equal to three times said resonance
10 frequency.

11. A piezoelectric resonator according to claim 8,
wherein the oscillation buffer material is disposed on each
of said opposite major surfaces of said piezoelectric
substrate.

