TECHNICAL TERMS

The principal terminology used for saw filters is as follows.

Nominal Frequency: This normally refers to the nominal value of the center frequency and is used as the reference frequency of related standards.

Pass Band Width: This is a frequency interval at a value assuring that the relative attenuation is equal to or lower than the specified attenuation.

Ripple: This denotes the largest value of the difference between the maximum and minimum loss when there is an extremely high attenuation in the pass band.

Insertion Loss: This is the difference in attenuation between when a filter is and is not inserted and is classified into minimum loss and constant loss. Minimum loss is the minimum value of insertion loss and constant loss is the insertion loss at the nominal frequency. Each is handled as the reference level of attenuation. Minimum loss is generally used as the reference.

Attenuation Band Width: Frequency width at the value that assures that the relative attenuation is of the same value or higher than the specified attenuation.

Guaranteed Attenuation and Guaranteed Attenuation Band Width
These are the relative attenuation and frequency band guaranteed in the attenuation band.

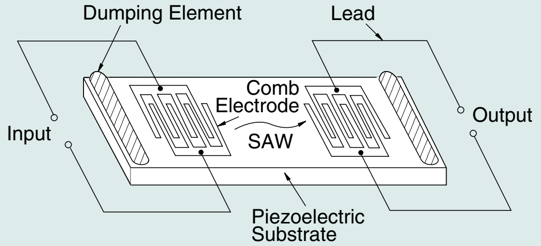
Terminating Impedance: This is the power supply impedance or load impedance as viewed from the filter side and is generally indicated by resistance and parallel capacitance.

Group delay time: Phase variation differentiated by angular frequency

Group delay time ripple: Maximum difference between maximal value and minimal value of the group delay time within the specified pass bandwidth

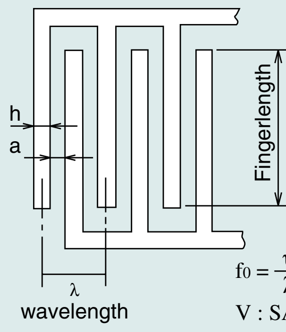
SAW FILTER

A surface acoustic wave (SAW) is a sound wave that propagates along the surface of an elastic body upon which its energy concentrates. Many electronic devices employ them for practical applications.
We design and supply a range of filters, resonators, delay lines and oscillators using SAWs.
Fig. 1 shows the basic construction of a SAW filter. Comb electrodes for exciting and receiving waves are composed of a metallic deposit on a piezoelectric substrate. When an AC voltage is applied at the input terminals of the electrodes, the piezoelectric action causes the portion of the substrate between the adjacent electrodes to be distorted to permit excitation of a SAW with a specific frequency. As illustrated in Fig. 2, the teeth of these electrodes are arranged with a certain pitch. A surface acoustic wave exits with the highest magnitude if its wavelength λ equal to the pitch of the teeth of the electrodes. When the propagation velocity of a wave is υ, the center frequency f_0 is given by
$f_0 = \upsilon/\lambda$
Our SAW filters use too electrode types, one a resonator type and the other a transversal type.



Structure of SAW Filter (Transversal Type)

Fig. 1



$$f_0 = \frac{\upsilon}{\lambda} = \frac{\upsilon}{2\,(a+h)}$$

V : SAW propagation velocity

Comb Electrode (Transversal Type)

Fig. 2

SAW RESONATOR

Fig. 3 shows the basic construction of a SAW resonator. A resonator can be made by increasing the number of teeth of the comb electrodes.
As illustrated in Fig. 4, there are two types of resonator: (a) one-port resonators and (b) two-port resonators. The frequency of these resonators depends upon the pitch between the teeth of their comb electrodes to allow basic waves with a higher frequency range to be oscillated. One-port resonators have high Q factors and are primarily used as oscillators. Two-port resonators are narrow-band filters and serve as higher frequency filters and oscillators.

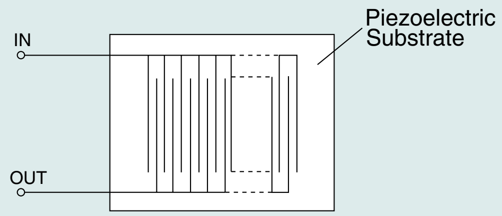
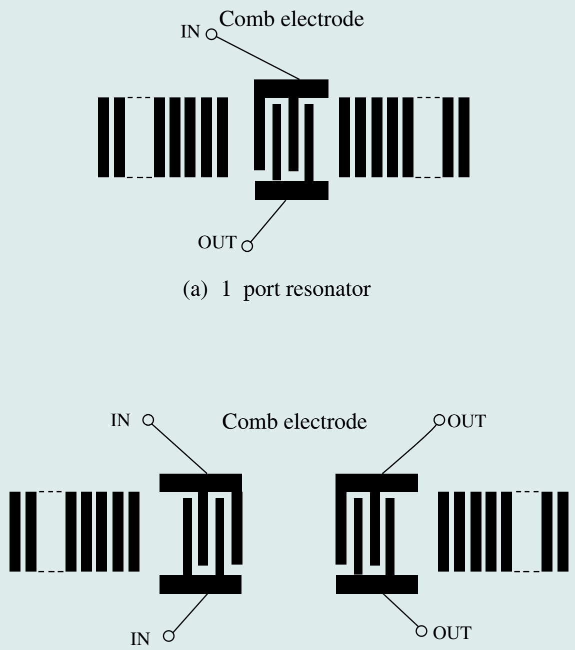


Fig. 3



(a) 1 port resonator

(b) 2 port resonator

Fig. 4

Piezoelectric wafer

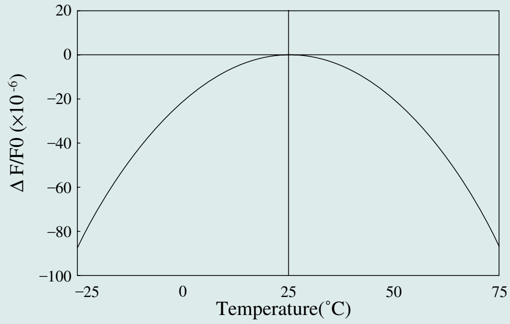
NDK uses the piezoelectric materials shown on the right. The 128° Y-X lithium niobate ($LiNbO_3$) wafer is ideally suited for wide-band low-insertion-loss filters due to great electromechanical coupling coefficient despite great temperature coefficient, and due to little possibility to generate bulk wave spurious.
Although ST-cut crystal wafers are inferior in that the coupling coefficient is small, the frequency vs. temperature characteristics are expressed in terms of quadratic curve having zero temperature coefficient around room temperature and therefore, they are ideally suited for communications equipment requiring stability.

The X-112° Y lithium tantalum ($LiTaO_3$) falls between $LiNbO_3$ and crystal wafers in terms of electromechanical coefficient and temperature coefficient.

Material	Cut Angle	Prepagation Speed (m/s)	Coupling Coefficient (k^2)	Temperature Coefficient ($\times 10^{-6}$/°C)
$LiNbO_3$	128° Y-X	3980	0.055	–75
$LiTaO_3$	X-112° Y	3290	0.0064	–20
Crystal	ST	3158	0.0016	–0.036 (2nd)

Frequency vs. temperature characteristics

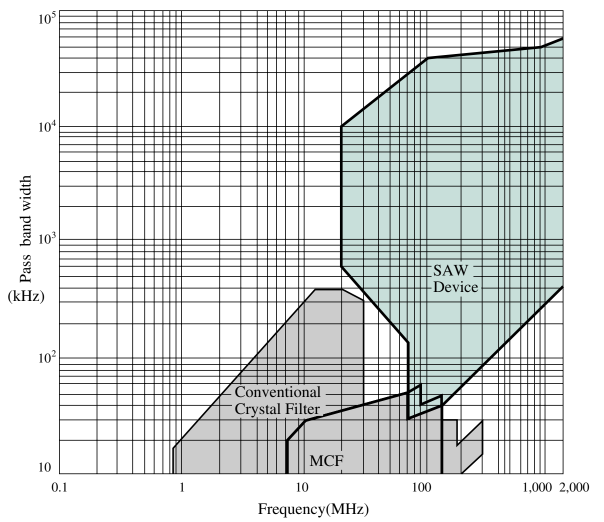
Different piezoelectric materials have different frequency vs. temperature characteristics. The figure on the right shows the frequency vs. temperature characteristics.



Temperature Characteristics of SAW Devices
(Piezo-Electric materials: Crystal)

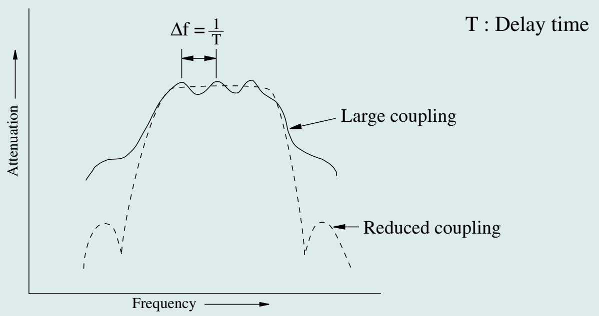
Production Ability Range

Fig. 5



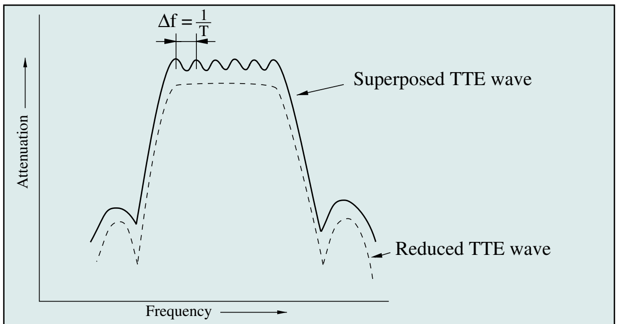
APPLICATION NOTE

1. Use the SAW product within its maximum ratings.
2. Never apply a voltage higher than the maximum input rating, as a higher voltage will accelerate deterioration of the product's characteristics.
3. The shield grounding conditions should be determined so that electrical coupling between input and output may be minimized before using the SAW device. Otherwise, the coupling between input and output will cause ripples in the amplitude and group delay characteristics.
   Note that the ripple frequency is $\Delta f = 1/T$
4. The SAW's TTE waves that have been multiply reflected between the input and output sections are superimposed over the main signal wave to produce ripples in the amplitude and group delay characteristics. These ripples may be reduced by mismatching the I/O terminating conditions. The SAW device should be operated at the specified terminating conditions.
   Note that the ripple frequency is $\Delta f = 1/T$
5. Be careful not to apply force to the pin terminals.
6. The specified ambient temperature conditions when storing and transporting the SAW device must be less than 85 ˚C.
7. Be careful not to apply a power voltage to the SAW product when soldering it.
8. Avoid ultrasonic cleaning for the SAW device both as an independent unit and after it has been mounted on a PC board. The choice of a cleaning agent should also be taken into consideration when cleaning the SAW product.
9. Mounting of surface mount type SAW Devices.
   9-1 Severe temperature change;
   Under severe temperature change conditions, solder portion may crack due to different temperature coefficients between print wire board material and surface mount type SAW Device ceramic package.
   If such case is expected, please contact us for temperature conditions etc. beforehand.
   9-2 Shock from automatic mounting;
   If the automatic mounting process applies too much mechanical shock to SAW Devices, electrical characteristics may deteriorate. Please note.
   9-3 (Stress caused by bending the PC board) If the PC board is bent after a SAW Device is soldered to it, the mechanical stress may cause the soldered part to come off or the SAW Device package to crack.



Filter characteristics depend on the electrical coupling between the input and output sections.

Fig. 6



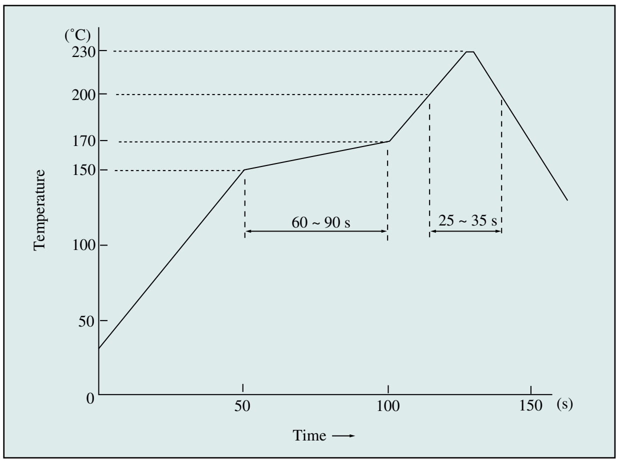
Filter characteristics affected by a TTE wave

Fig. 7

10. Reflow Soldering

The chart below is the standard temp. profile of reflow soldering for SAW device.

Temperature profile



- **Soldering**

To avoid product damage during soldering, condition, please follow reflow conditions.

- Pre-heat temperature : +0→150°C 30 seconds min
- Pre-heat : +150~170°C 60~90 seconds
- Heat : 200°C min 25~35 seconds
- Peak temperature : 225°C min, 235°C max