WHITE PAPER

– Crystal Filter (Monolithic Crystal filter: MCF) –

1) Crystal Filter and SAW Filter

Filters are important devices for wireless communication. Without proper design and proper use, unwanted signals from other lines can cause interference, making it difficult for the person speaking to understand. In recent years, frequency bands have become wider in mobile phones, and the use of SAW filters is increasing. On the other hand, commercial wireless communication devices require products with a narrow pass bandwidth, so monolithic crystal filters (hereinafter referred to as MCF), which have sharp attenuation characteristics and good guaranteed attenuation, are used.

・About SAW Filter

Comb-shaped electrodes (IDTs) that can excite surface acoustic waves of a certain frequency are made on the left and right sides of the quartz substrate, and when an electric signal is input to the IDT on the left side, they are converted into acoustic waves (surface acoustic waves), which are transferred to the substrate surface. The signal is transmitted to the IDT on the right side and converted back into an electric signal, allowing only the signal component of a specific frequency to pass.

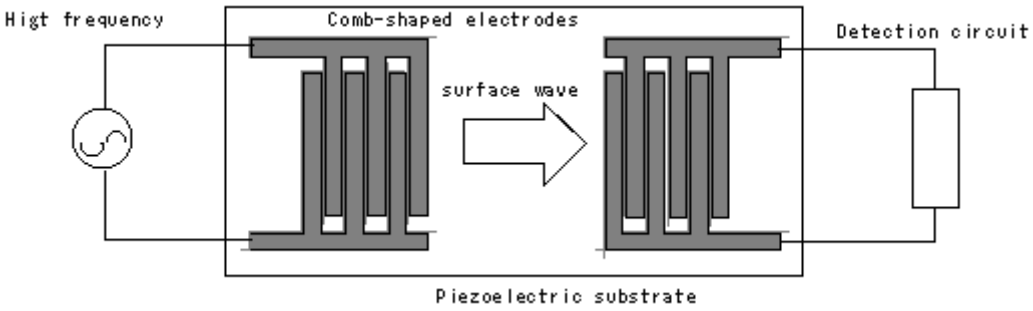


Fig.1: SAW Filter configuration

・About MCF

Multiple MCFs (the number of electrode pairs) can be created by acoustic coupling between electrodes when two or more pairs (often 2 or 3 pairs) are placed close to each other on one AT-cut quartz crystal plate. The same as the above and the characteristic that it resonates with the vibration mode, and the energy confinement theory is applied.

In the case of the dual mode, the symmetric mode frequency and the oblique symmetric mode frequency can be used to form the dual mode filter.

A tandem monolithic crystal filter is a series of multiple monolithic crystal filters connected in series in order to make the attenuation characteristics steep and increase the guaranteed attenuation. Compared to other filters, MCF has excellent characteristics such as stable frequency characteristics against temperature, low energy loss, high cutoff characteristics, and aging characteristics due to the excellent characteristics of the crystal unit. Also, MCF can be designed smaller as the frequency gets higher.

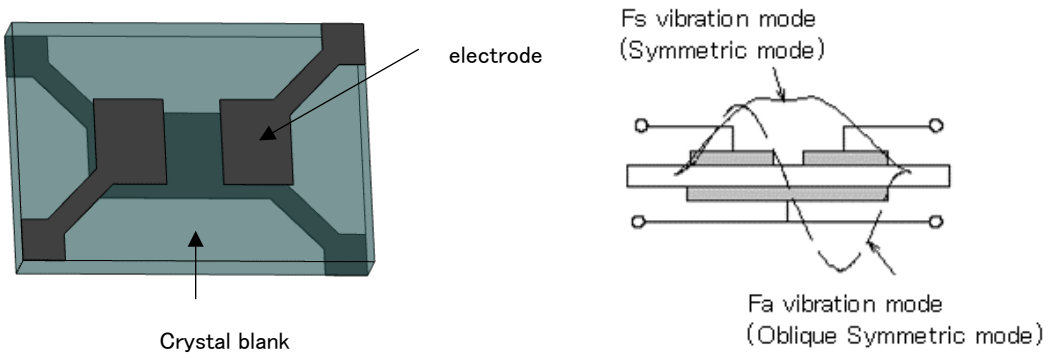
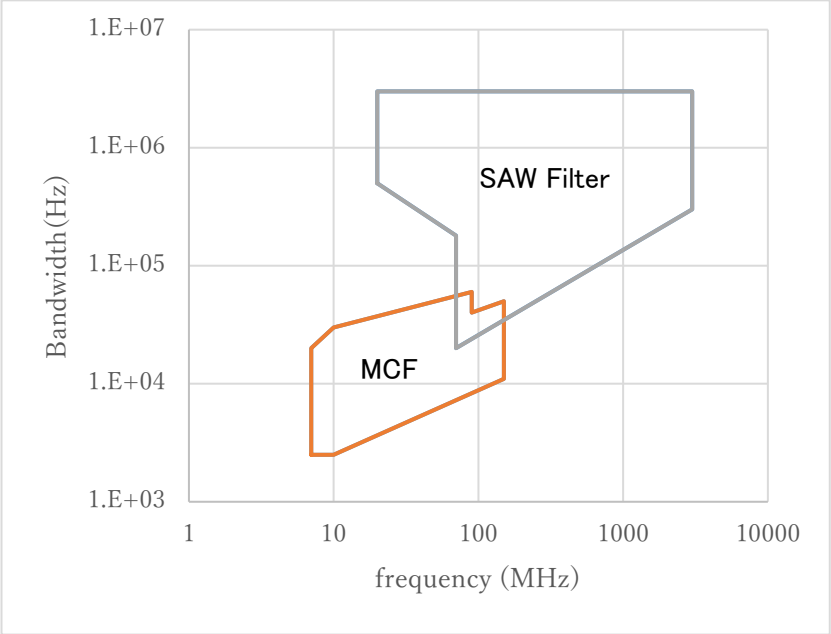


Fig.2: MCF configuration and Vibration mode outline

・Relationship between frequency and pass bandwidth of MCF and SAW Filter

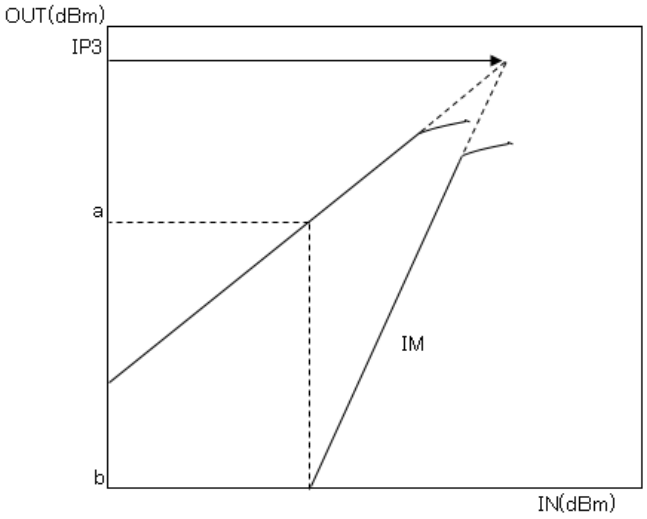
The horizontal axis shows the nominal frequency and the vertical axis shows the pass band width, indicating that the manufacturable range of MCF is low frequency/narrow band compared to SAW filter.



2) About Intermodulation (IM)

We will explain about intermodulation, which is an important characteristic of filters.

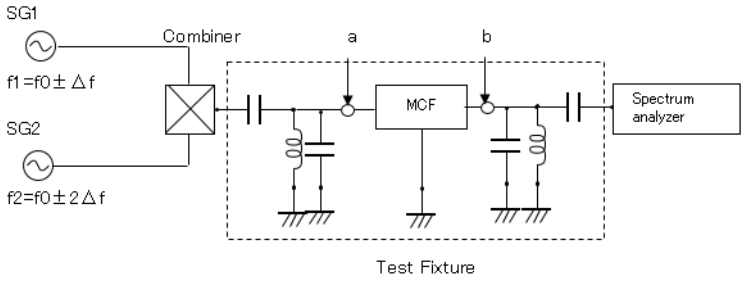
In devices that receive radio waves, such as mobile phones, televisions, and radios, not only the desired radio waves but also other powerful radio waves arrive at the same time. At this time, if the circuit has nonlinearity (the output is not proportional to the input), a harmful phenomenon called intermodulation occurs. In the linear case, the output wave from the circuit is represented by a linear function of the input wave. In the non-linear case, a higher-order term occurs, and an odd-order term among them causes intermodulation. The next (even-order) term is called harmonics.

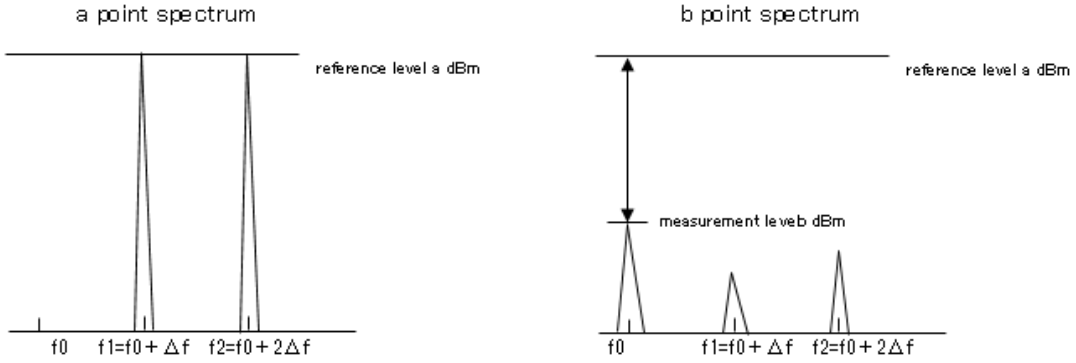


Intermodulation vs. Third-order intercept point

The point where the straight lines of the main signal output level and intermodulation output level intersect is called third-order intercept point (IP3). In reality, it saturates at a certain level, so the lines do not intersect with each other, and the point is that the straight line region will not be saturated as it is and will intersect if the level goes up.

Intermodulation measuring method





IM = a-b (dB)

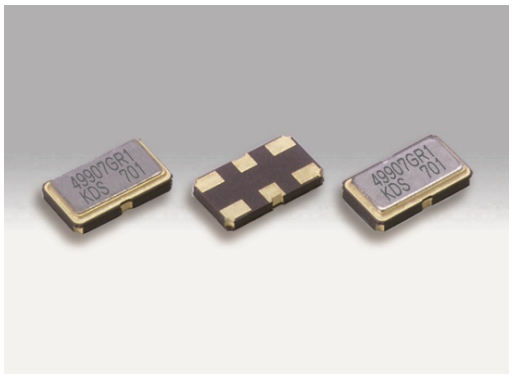
IP3 = a+$^{1}/_{2}$(a-b) (dBm)

Our MCF has improved intermodulation characteristics through crystal design, electrode structure, and manufacturing process. Please contact us as we will respond to each customer's request individually.

3) MCF history of our company

In 1994, we started the production of 7.0 × 5.0 × 1.3 mm DSF753S 2pole product as a full-scale MCF surface mount product. At that time, 4-pole products were mainly tandem connection with 2-pole characteristics, but the tandem connection had the disadvantage that the board occupying area was large and the cost was high. The demand for miniaturization of communication equipment has increased, and the demand for miniaturization of MCF has also increased. In 1996, we have developed DSF753SB that realized 4 poles in one package (7.0 × 5.0 × 1.3 mm package, built-in single crystal blank plate with 2 sets of electrodes), which was the first in the industry. To improve spurious performance, we have also developed a DSF753SD product that contains two crystal elements in one package. Furthermore, in 2017, in order to respond the demand of smaller handheld type radio, we have developed the 6.0x3.5mm size 4-pole DSF633SDF that achieves the size reduction while maintaining the same performance as the DSF753SD. At present, the majority of the market is 4 pole products of 7.0 x 5.0 mm size, but there was a problem that the flexibility of layout decreased as the communication equipment became smaller. The DSF633SDF reduces the mounting area by 40% compared to the conventional product, and it has improved the flexibility of layout design. Due to the improved frequency adjustment process, the DSF633SDF has better intermodulation characteristics than its predecessor. Improved intermodulation characteristics, resulting the third-order intercept point of the communication and enhance communication against noise and interference.

DSF633SDF 4POLE



Characteristic

・Seam-sealed product of the same 3-layer ceramic package as the DSF753SD

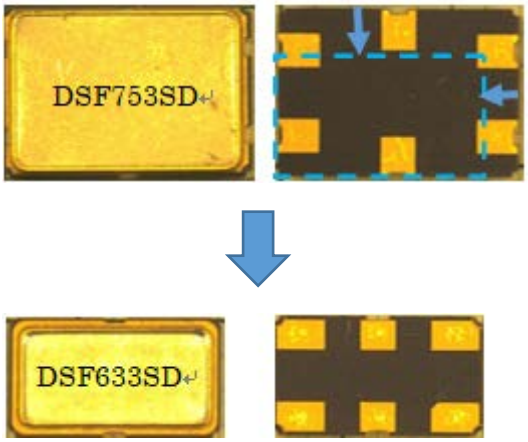
・Small size, low height (6.0mm x 3.5mm x 1.1mm)

・High accuracy and high reliability

・High-density mounting is possible

・Suitable for small devices such as handy devices such as commercial wireless and amateur wireless

・Frequency range: 37 MHz to 130 MHz, pass band width: 1.5 to 15 kHz



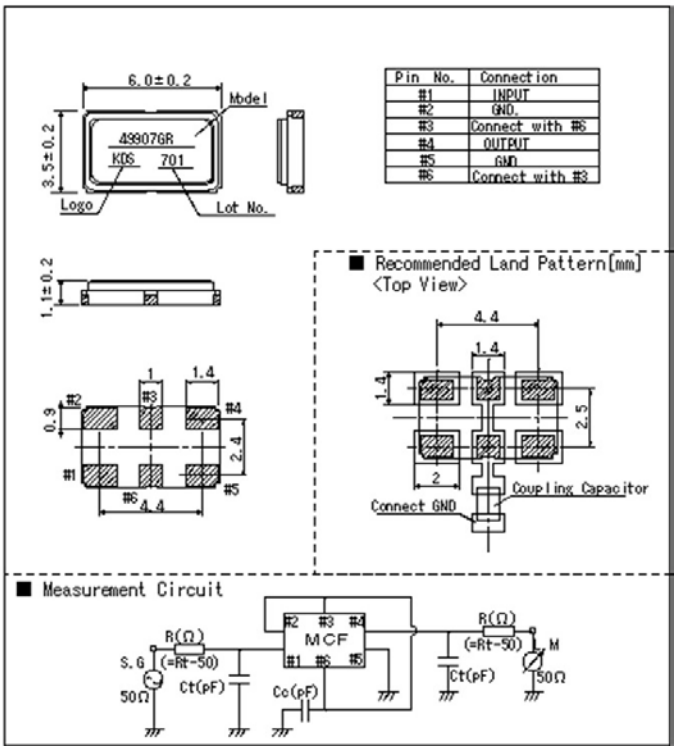
・Mounting area is reduced by 40% compared to 7.0 x 5.0 mm size product!

・Improved flexibility in layout design!

■Standard Specification

Model	D44813GR	D49903GR	D58010GR	D73312GR
Nominal Frequency	44.850MHz	49.950MHz	58.050MHz	73.350MHz
Pass Bandwidth	±6.50kHz min./3dB	±1.75kHz min./3dB	±5.0kHz min./3dB	±6.0kHz min./3dB
Stop Bandwidth	±12.5kHz max./18dB	±6.25kHz max./20dB	±12.5kHz max./25dB	±25kHz max./40dB
Ripple	1.0dB max.	1.0dB max.	1.0dB max.	1.0dB max.
Insertion Loss	4.0dB max.	6.0dB max.	5.0dB max.	5.0dB max.
Guaranteed Attenuation	80dB min.	80dB min.	80dB min.	80dB min.
Terminating Impedance	380Ω//5pF Cc=17pF	150Ω//11pF Cc=33pF	450Ω//4.5pF Cc=9.5pF	380Ω//5pF Cc=11pF
Operating Temperature	-20～＋70℃	-20～＋70℃	-20～＋70℃	-20～＋70℃

■Dimensions[mm]



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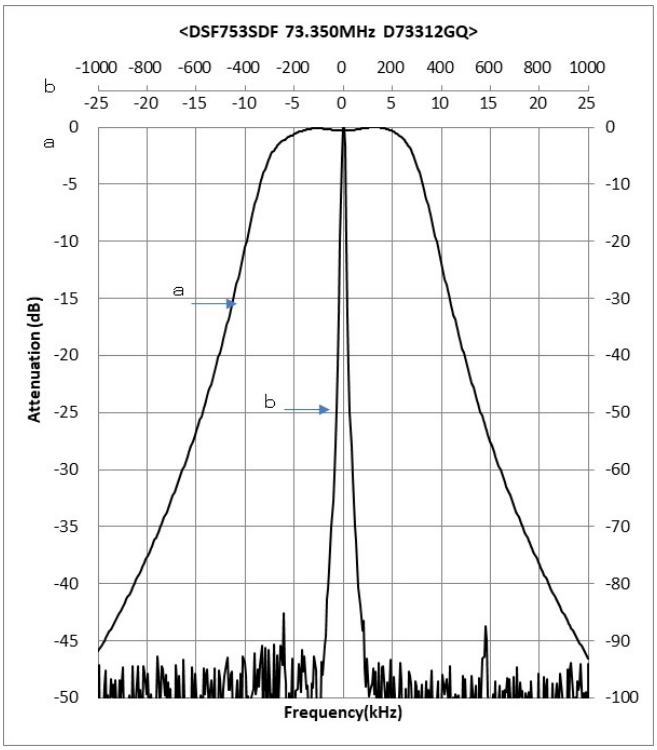
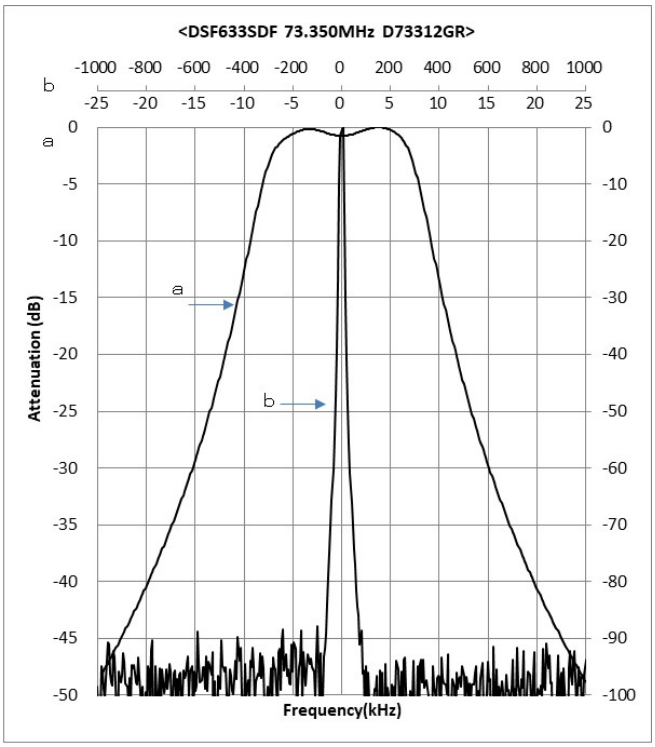
■Characteristic Chart





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