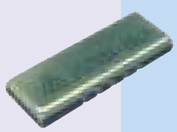


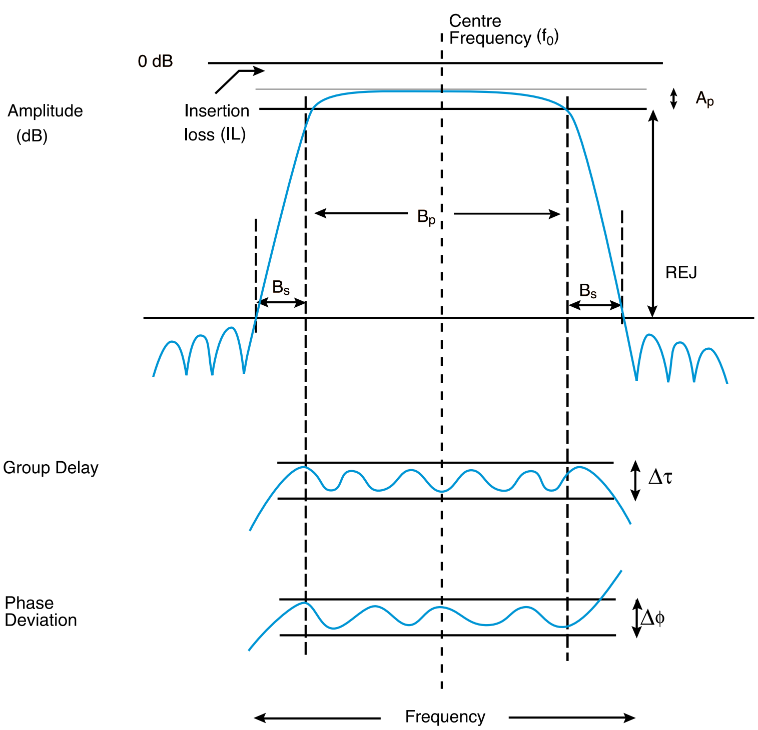
How to Specify a Custom SAW filter

Specifying a SAW Filter

Because of the special qualities of SAW devices, it is not helpful to think in terms of standard responses such as Butterworth or Chebyshev. Instead, it is better to specify the basic requirements directly. It has to be remembered that there are many types of SAW filters, so a particular requirement will often be met by only one or two types*. On the other hand, the existence of many types gives attractive options to the designers.

SAW filters are capable of very substantial versatility, and if this is required we recommend that you discuss requirements with COM DEV. However, for many cases the basic requirement is simply to pass a signal occupying a specified frequency band, and reject signals outside this band. In the passband the signal is to be passed with minimal distortion, which implies that the filter response must have an amplitude which is as flat as possible, and its phase must be almost linear with respect to frequency. It has to be remembered that there must be "room" between the passband and the stop bands on either side, otherwise the response is not realizable. These spaces are called the skirts, or transition bandwidth. Insertion loss is important because it affects the amount of gain needed elsewhere in the system, and sometimes relates to the system noise figure. The main parameters which need to be specified are:

- Centre frequency (f_0)
- Width of passband (B_p)
- Amplitude Variation over the above bandwidth (A_p)
- Phase Variation over the above band width ($\Delta\phi$)
- Transition Bandwidth (B_s)
- Stop-band rejection (REJ)
- Insertion loss (IL)



* *See COM DEV SAW Products Application Note 102*

Particular points to note are:

- The *Fractional Bandwidth* is $B_p \div f_0$. This ratio has a strong bearing on the substrate material to be used (see Table 1), and hence the temperature coefficient. The first consideration for the SAW designer is to select a suitable material and device type (Table 2 is a partial list).
- The *Shape Factor* is the bandwidth at the stopband edges divided by the width of the passband, i.e. $(B_p + 2 \cdot B_s) \div B_p$. The minimum possible value for this depends on the filter type. Transversal filters can have shape factor as low as 1.1. The actual filter size is largely determined by B_s. The minimum value for B_s is approximately 200 kHz.
- In the passband, it is necessary to specify the allowed Amplitude and Phase Variation, and these must be specified relative to stated bandwidths. Usually, the same band can be used for both parameters. The band must be specified because the results will depend on it.

The Phase Variation can be specified in different ways. One way is to specify the allowed Group Delay Variation, $\Delta\tau$, over a specified band. Another way is to specify the allowed Phase Variation, $\Delta\phi$, over a specified band. Alternatively, sometimes the rms Phase Deviation is quoted. For a SAW filter the Phase Variation is usually the most relevant measure of performance.

Phase or delay distortion are usually specified only for the region in or near the passband. Distortion in the skirts or stop bands is usually meaningless because the filter response is at a low level in these places.

A typical specification might be as follows:

Passband edges:	95, 105 MHz
Passband Amplitude Variation	< 1 dB
Lower stop band frequency range	50–90 MHz
Rejection in lower stopband	> 40 dB
Upper stop band frequency range	110–200 MHz
Rejection in upper stop band	> 40 dB
Phase Variation*	< 1.5 deg
Band for Phase Variation	96–104 MHz
Delay Variation*	< 0.5 µs
Band for Delay Variation	94.5–105.5 MHz
Insertion Loss	< 10 dB
Package type	SMT
Temperature range (operational)	-40 to 80 ºC
Temperature range (storage)	-50 to 100 ºC

** Usually, Phase or Delay Variation are specified, but not both.*

Further Notes

■ Temperature Effects
Temperature changes cause the response to shift up or down with frequency, and these effects need to be considered when the device is specified. It is usually necessary to design the filter to have skirt widths less than those of the original specification to allow for this. If a small shape factor is required it is important to verify this because the reduction in skirt width may make the filter very difficult, or even impossible, to design.

■ It is often better to specify Phase Variation rather than Delay Variation. The reason is that SAW devices, particularly transversal filters, can have quite substantial delay. For example, if the shape factor is to be reduced, this will involve an increase in the spacing between transducer centers. This causes the phase to vary more rapidly, giving larger delay fluctuations because the delay is the differential of the phase. Hence, the delay error has increased even though he response is similar in other respects—the distortion of an applied signal is usually not increased.

■ The preceding description covers only the most basic requirements. SAW technology is capable of much more complex and demanding responses. There is also a considerable range of device types, and many types not mentioned here could be considered for a particular application. The customer should feel free to discuss special requirements with COM DEV SAW engineers.

Table 1. Common substrate materials

Material	SAW velocity, m/s	k^2	Max. bandwidth	TCD (ppm/deg C)
Quartz, 34° Y-X	3152	0.13 %	4 %	0
$LiNbO_3$, 128° Y-X	3978	5.4 %	20 %	75
$LiTaO_3$, X-112° Y	3302	0.84 %	8 %	18
$LiTaO_3$, 42° Y-X	4214	5.0 %	20 %	32

Table 2. Performance capabilities of SAW Bandpass Filters (partial list)

Type	material	Centre freq. MHz (approx)	Loss db	bandwidth MHz	stopband suppression	amplitude ripple	shape factor
Transversal	any	30–1500	15–30	< 20 %	< 60 dB	0.1 dB	1.1:1
SPUDT	Quartz	30–1000	5–10	< 2 %	< 45 dB	0.5 dB	2:1
TCR	Quartz	50–400	1–2	< 0.2 %	< 40 dB	1 dB	3:1
LCR	$LiTaO_3$	20–2000	> 2	< 3 %	< 40 dB	1 dB	3:1
IEF	$LiTaO_3$ or $LiNbO_3$	800–3000	1–3	2–5 %	< 40 dB	2 dB	2:1

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