

SAW Filter Products

**Innovate
Improve
Grow**

SAW Filters

SAW Resonators

Monolithic Crystal Filters

High-Performance RF Filters

High Volume Low Cost RF-Filters up to 3 GHz

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VECTRON
INTERNATIONAL

A DOVER COMPANY

Types of SAW Devices

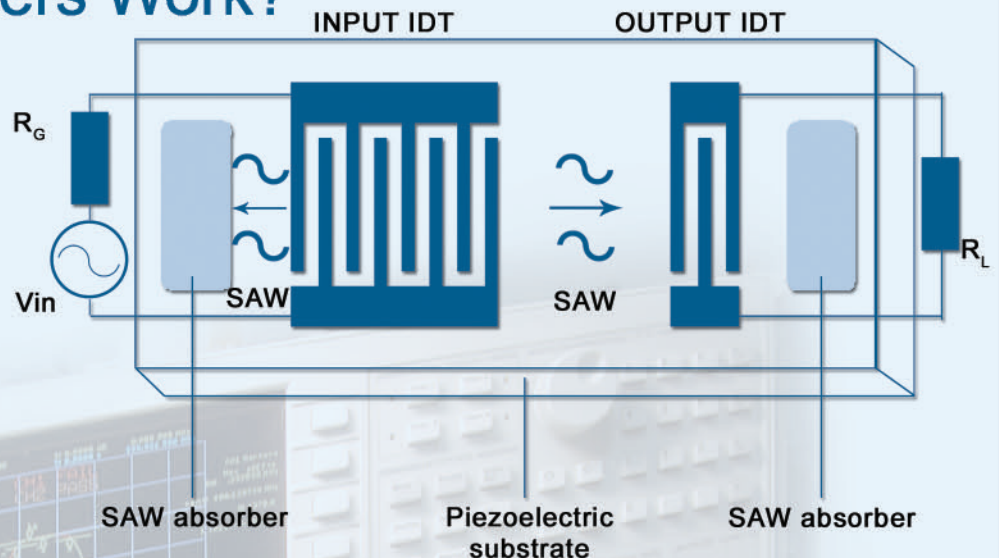
- Precision
- TCRF
- SPUDT
- LCRF
- SFIT
- IEF
- Resonator

Bidirectional, High Loss
Transversely-Coupled Resonator Filter
Single Phase Unidirectional Transducer
Longitudinally-Coupled Resonator Filter
Slanted Finger Interdigital Transducer
Impedance Element Filter
SAW Resonator

How do SAW Filters Work?

Highly polished piezoelectric crystal wafer cuts for SAW filters are non-dispersive in frequency, or for any frequency the acoustic velocity is constant. The piezoelectric property allows for the design of transducers that will convert electromagnetic energy from an electronic circuit to acoustic energy (and vice-versa) in the form of a traveling wave on the surface of the crystal.

The frequency response of a SAW filter is determined by its properties both transduction and reflection and the interaction of the transducers.

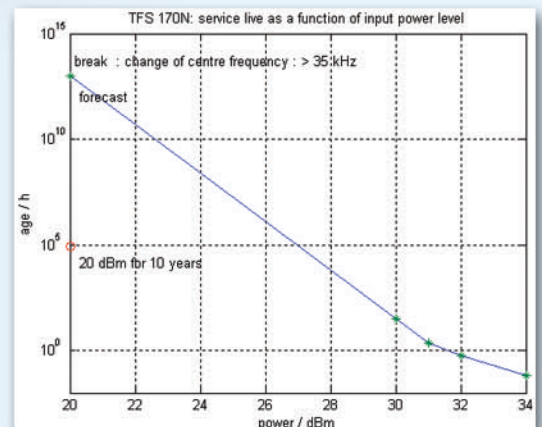


SAW Filter Impedance Matching Networks

- Some SAW filters require matching networks. These include TCRF, SPUDT, SFIT
- Other SAW filters such as the LCRF may or may not require matching
- The IEF type does not generally require matching
- Precision filters that are narrow bandwidth will quite often require matching to flatten the passband. The wider bandwidth filters seldom require matching
- Whether the filter is driven balanced or single ended, has no effect on whether it should be matched or not
- Impedance matching for single-ended driven SAW filters generally require two components on each input and output

Power Handling Capabilities of SAW

- The power handling capability depends on the design
- Precision SAW filters can handle more power than resonant SAW filters
- Vectron offers certain SAW filters which can handle up to 27 dBm of power
- Some SAWs can handle up to 27dBm of power
- The failure mode is metal migration and then shorting
- Copper doping of 2 to 4% will increase power handling



Advantages of Vectron International

Vectron International is successful in the development of passive electronic components like SAW filters, SAW resonators, and monolithic crystal filters (MCF). Our corporate policy is strictly customer oriented, and our customers choose us because we reliably deliver high-quality components according to the individual customer requirements in terms of performance, costs, and technology modifications.

Due to our flexible design capabilities and cost-optimizing production facilities Vectron has gained a leading role among the suppliers of electronic components for mass market as well as in the high-performance segment.



Reliability on an International Level

Vectron International is a member of Dover Corporation. Dover Corporation is NYSE traded (DOV) and listed on the Fortune 250. Dover Corporation has a broad customer base throughout the world, in over 100 countries with sales close to \$6 billion.

According to the Dover Corporate policy each individual group member operates independently on the sound financial background of a strong international group. Vectron is one of the largest suppliers of Frequency Control Products with worldwide annual sales of over \$200 million and a growth rate that is clearly above average.



IF Filters

There are various different design principles which are suitable for the design of IF SAW filters. However, none of them meets the requirements perfectly.

Precision filter design meets most of the requirements such as low amplitude, group delay and phase ripple in combination with high close-in rejection and outstanding selectivity. The disadvantage of Precision Filters is their high insertion loss.

Low insertion loss and/or miniaturized package size are usually served better by SAW Resonator design principles.

Optimized SPUDT (Single Phase Unidirectional Transducers) filters combine transversal and resonant filter design principles to take advantage of both. By optimizing the transduction and reflection of interdigital transducers, the filter performance can be improved while keeping the chip size (filter size) the same. As a result of internal reflections, the signal length in the time domain is increased.

Vectron SAW designers utilize SFIT (Slanted Finger Interdigital Transducer) filters to provide a low insertion loss with a wide bandwidth. SFIT filters are implemented with parallel connections of a high number of narrow band, low-loss filters. This allows an effective generation of SAW for each frequency in the passband. Vectron has generated a set of sophisticated design tools to achieve low group delay ripple, and suppression of reflections including the triple transit signal.

RF (front end) Filters

The strong influence of insertion loss on system performance requires the application of resonant design principles like LCRF (Longitudinal Coupled Resonator Filter), IEF (Impedance Element Filter) and IEF balanced bridge filters.

Vectron uses its experience in application and a combination of these design principles for the development of low loss filters for front end applications.

IEF constitutes the basic design principle for RF filters with one port resonators used as impedance elements. Resonators are arranged in a ladder configuration. The difference between the acoustic impedance of resonance and anti-resonance is used to achieve a filter performance. The resonators may be designed to have different resonant frequencies.

An LCRF design can be described as a combination of two port resonators. Typically, a parallel connection of 4 two port resonators is used. This allows very low loss by reducing resistive losses and avoiding waveguide effects.

For filters on quartz, a parallel connection is very important to get reasonable termination impedance for stable production having a short matching path to 50 Ohm source or load. The quartz which is used due to its high temperature stability has a low electromechanical coupling coefficient requiring parallel connection.

For wide-band, low-loss filters, Vectron takes advantage of different cuts of higher coupling substrate material (LiNbO₃ / LiTaO₃).



Telecommunications

- Flat passband
- Medium to low insertion loss
- Low amplitude, phase and group delay ripple
- Sharp filter characteristics and excellent close-in rejection



Frequency MHz	Bandwidth MHz	Insertion Loss dB	Package mm
70	0.25-40	20-25	DIP 14&18
140	0.05-7	5-25	13x6
57-348	0.2-20	3.5-15	13x6
410-475	5	2.5	5x5 / 3.8x3.8
482-922	24	3	3x3
851-2657	38-66	1.5-2.5	3x3 / 2x2.5

The wide range of IF and RF SAW filters take advantage of a large selection of quartz, lithium niobate and lithium tantalate substrate material cuts. This allows for optimal performance of narrow band, medium band and wide band filters.

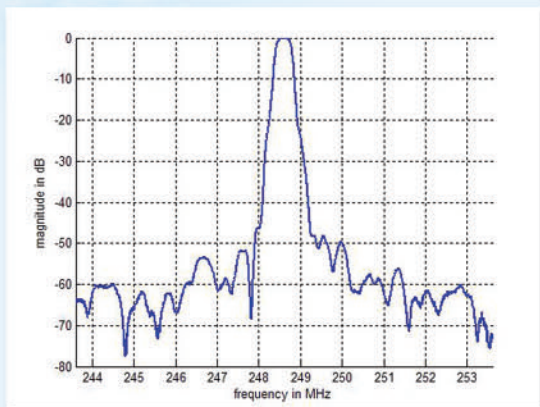
Many different SAW design principles are available for customized solutions.

Vectron has several production lines that enable us to address low volume, medium volume and high volume markets. Multilayer ceramic based, surface-mount and metal-can pinned packages are supported.

Vectron provides filter sets and cascaded filter pairs as well. Customized solutions may include an internal matching of the filter to 50 Ohms.

Filters for oven applications are available.

Vectron leads the market for GSM base station filters.



WiMAX Applications

- Low insertion loss and sharp transition from pass band to stop band
- IF filters with several bandwidths from 3.15 to 16.5 MHz
- Low insertion loss and high input power handling capabilities for RF filters
- Low cost



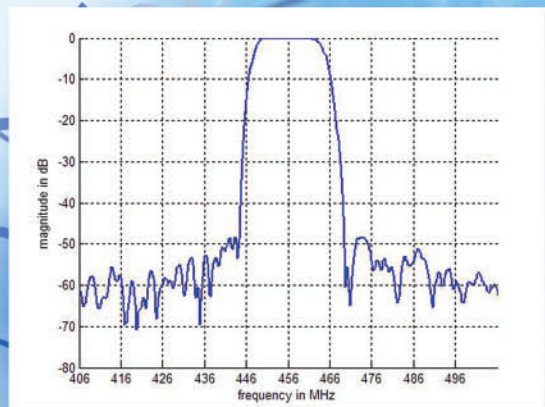
**Selection of typical SAW filters for this application:*

Type	Frequency MHz	Bandwidth MHz	Insertion Loss dB	Package mm
TFS44M	44	14.00	14.0	11x5
TFS360K	360	30.00	6.5	5x5
TFS380K	380	4.12	12.0	5x5
TFS456E	456	3.15	9.0	7x5
TFS456G	456	3.40	8.8	7x5
TFS456H	456	6.80	9.0	7x5
TFS456F	456	12.60	9.0	3.8x3.8
TFS456K	456	13.20	9.0	3.8x3.8
TFS456N	456	16.50	12.0	5x5
TFS464D	464	3.00	9.8	7x5
TFS468C	468	4.50	11.0	7x5
TFS468D	468	9.00	11.0	7x5
TFS468E	468	3.16	11.0	7x5
TFS468F	468	6.30	10.5	7x5
TFS2535A	2535	66.00	2.0	2.5x2
TFS2657A	2657	66.00	2.5	2.5x2

Vectron offers RF filters and IF filters to several regions of the world.

Concerning IF filters, Vectron supports standards for Europe, the USA, and Asia which has resulted in the development of low-loss filters with a bandwidth of 3.15 up to 16.5 MHz.

Supporting the different chipset designs available on the market, Vectron offers different IF center frequencies.



Navigation (GPS / GIS)

- Low insertion loss
- Very low group delay and phase-ripple
- Single-ended to balanced operation
- Customized front end filters



Selection of typical SAW filters for this application:

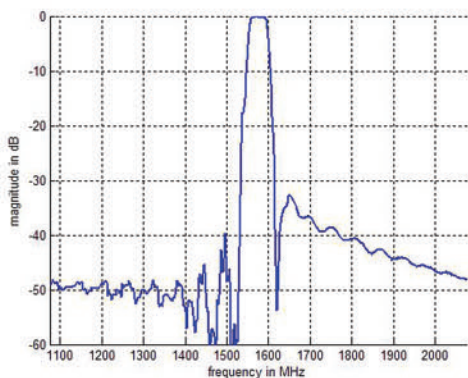
Type	Frequency MHz	Bandwidth MHz	Insertion Loss dB	Package mm
TFS140Y	140.16	20	15.0	13x6
TFS1227	1227.60	20	3.0	3x3
TFS1237	1237.00	40	2.0	3x3
TFS1575	1575.42	2.4	1.5	3x3
TFS1575A	1575.42	2.4	1.5	2.5x2
TFS1575G	1575.42	2.0	3.5	3x3
TFS1590	1590.00	48.0	2.2	3x3

Vectron has developed a family of RF filters for navigation applications. Even for one frequency and one chipset, several filters are available to offer the customer the best compromise between group delay and phase ripple, insertion loss, close-in rejection and package size. Solutions for single-ended to single-ended, and single-ended to balanced operations are supported.

IF filters for GPS are available as well.

Vectron has substantial experience with RF and IF SAW filters. This allows us to handle all requests for GPS RF and IF filters.

Highly automated and flexible production lines are utilized for high and medium volume products to address market needs for low cost solutions.



Automotive Applications

- High reliability
- Low insertion loss
- Wide operating temperature range
- Low cost



Selection of typical SAW filters for this application:

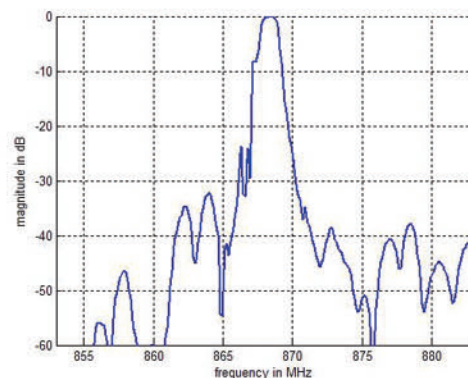
Type	Frequency MHz	Bandwidth MHz	Insertion Loss dB	Package mm
TFS315A	315.02	0.40	1.5	5x5
TFS315D	315.00	0.60	1.9	3.8x3.8
TFS315G	315.00	0.30	1.6	3.8x3.8
TFS433K	433.42	0.15	4.0	7x5
TFS433V	433.92	0.32	3.8	3.8x3.8
TFS433S	433.92	1.71	2.6	5x5
TFS868A	868.92	0.40	4.3	5x5
TFS868K	868.30	0.50	2.4	3.8x3.8
TFS868H	868.30	0.40	3.8	3.8x3.8
TFS869F	869.00	2.00	1.8	3x3
TFS915F	915.00	0.80	3.2	3.8x3.8
TFS915M	915.00	12.50	3.0	3.8x3.8

The requirement for low insertion loss requires the application of resonant design principles like LCRF (Longitudinal Coupled Resonator Filter), IEF (Impedance Element Filter) and balanced bridge filter.

Vectron uses its experience in applications and a combination of design principles for the development of low-loss filters for automotive applications.

To support the booming market of automotive applications, VI Teltow was certified according to TS16949 in 2004.

All design principles needed to address this market with its special requirements are available.



Medical Applications

- Products for medical bands at 403 MHz and 611 MHz
- Low insertion loss
- High reliability
- Single-ended to balanced
- Small-sized packages
- Customized solutions

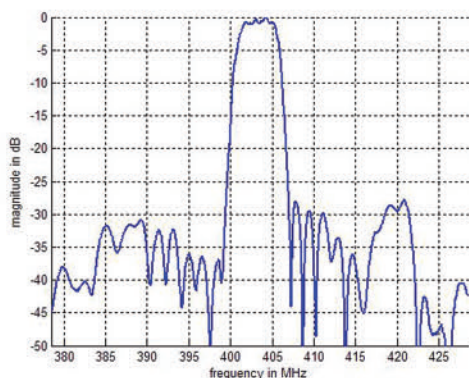


Selection of typical SAW filters for this application:

Type	Frequency MHz	Bandwidth MHz	Insertion Loss dB	Package mm
TFS141	141.70	2.20	15.0	13x6
TFS144	144.15	2.20	15.0	13x6
TFS403	403.50	3.00	4.6	5x5
TFS403B	403.50	3.00	1.8	3.8x3.8
TFS611	611.00	6.00	5.6	5x5
TFS611A	611.00	6.00	4.3	3.8x3.8

Most of Vectron's SAW filters for medical applications are based on the optimized SPUDT design principle. This provides the best compromise between close-in rejection and low insertion loss for small-sized packaged devices. The advantage is given by the design principle and the substrate materials applicable for it. If the insertion loss is more important than close-in rejection, Vectron uses design techniques based on resonant structures. Considering the bandwidth for medical applications, Vectron uses substrate materials with higher temperature coefficients. This reduces the close-in rejection, which may be guaranteed in the operating temperature range.

Vectron is using its experience in the development and production of GSM base station filters, where it leads the market to support the upcoming need for medical applications. All design principles that are needed to address this market with its special requirements are available. Several cuts of LiTaO₃ and quartz are used to find the best solution for the customer. The market of filters for medical applications is one of customized products.



Space and Military

- Full set of SAW design principles for customized products
- Low volumes supported
- Internal matching ability
- Introduction of additional production steps for high reliability



Selection of typical SAW filters for this application:

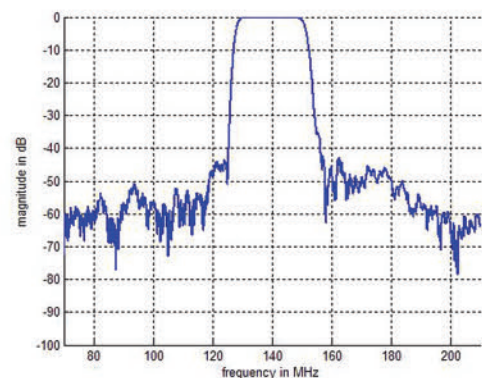
Type	Frequency MHz	Bandwidth MHz	Insertion Loss dB	Package mm
TFS35A	35.42	1.70	17.0	13x6
TFS70AG	70.00	4.00	18.5	35x20
TFS70AH	70.00	4.00	18.5	35x20
TFS140E	140.455	0.05	54.0	11x5
TFS188A	188.00	0.60	4.8	11x5
TFS457	457.50	24.00	2.7	5x5
TFS590	590.00	0.40	6.0	7x5
TFS1220	1220.00	0.20	4.0	3.8x3.8

The Space and Military family of SAW Products offer high reliability under specific environmental conditions. However, each solution is unique.

Vectron has developed technology for impedance matching the SAW chip internally. Thus, we can support customer requests for solutions without matching. This has been applied for the TFS70AG and TFS70AH, where high termination impedances are internally matched to 50 Ohms.

Our VI Teltow plants are TS16949 and ISO 14000 certified. Additional production and testing steps are used on a case by case basis to ensure high reliability. The focus is on the definition of requirements together with the customer and reported to the customer with quality tools like PPAP and APQP.

Together with different preventive techniques like FMEA we ensure that the ordered parts are of the best quality and on time when they reach the customer.



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