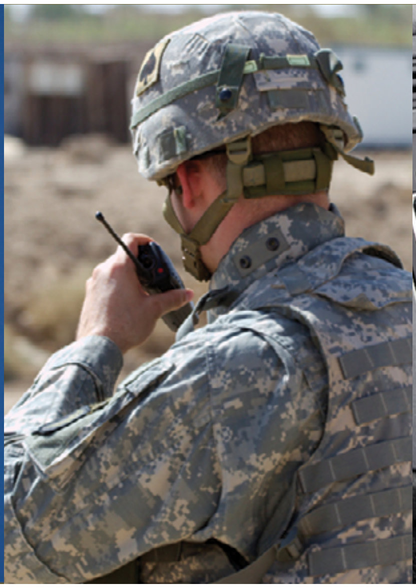
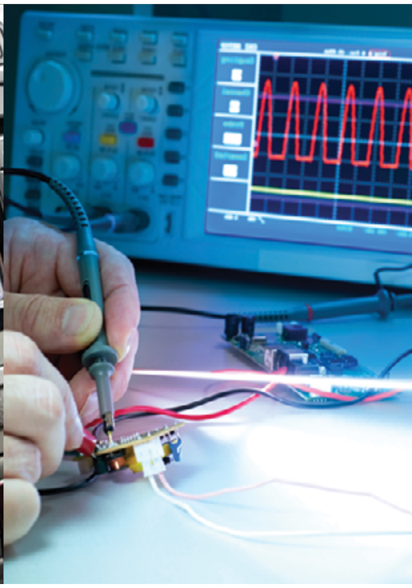
SAW Products





SAW modules

SAW IF, RF, and integrated multi-band filter solutions

Frequency range from 30 MHz to 2.7 GHz

High-Q SAW narrow-band filters

High-volume, cost-efficient manufacturing capabilities

Dispersive and non-dispersive SAW delay lines

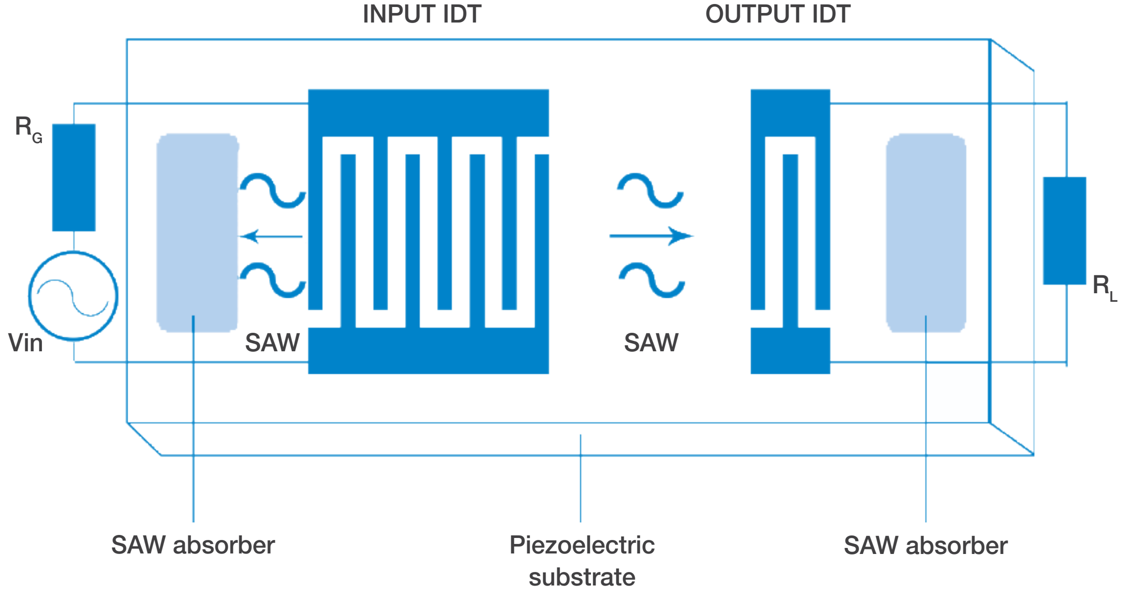
Voltage-controlled SAW oscillators (VCSO)

Microsemi®
Power Matters.™

How Do SAW Filters Work?

Surface acoustic wave (SAW) devices deploy inter-digital transducers (IDTs) to convert electrical signals (MHz range) to mechanical acoustic waves (μm range) and back again to electrical signals. The conversion makes use of piezo- electric properties to generate and detect acoustic waves. These acoustic wavelengths are 100,000 times shorter than electro-magnetic signals of the same frequency. Therefore, highly miniaturized filters can be realized for radio frequency (RF) signal processing.

A wide variety of SAW design techniques are used to find the perfect solution for your individual application. These range from very narrow-band (low loss) designs to very wide-band (low shape factor) designs.



SAW Filter Impedance Matching Networks

The frequency response of inter-digital transducers in a SAW device can be understood as a combination of a static capacitance between IDT “fingers” and a highly frequency-dependent dynamic response related to the electro-acoustic conversion. Depending on the strength of the dynamic part of the response and the employed design approach, some SAW filters require impedance matching networks to compensate their capacitive behavior in order to achieve their optimum frequency response. Intermediate frequency (IF) filters regularly require such reactive matching networks (typically, two-element L/C-networks), while RF filters for front-end applications are typically designed to operate in a pre-defined impedance environment (for instance, 50 Ω, 100 Ω, 200 Ω) without external circuitry.

Microsemi can provide SAW filters with integrated “balun” (conversion balanced to single-ended) functionality and solutions for different terminating impedances at input and output ports (for instance, 50 Ω to 200 Ω). In addition to these common impedance levels, special solutions are available to match customized and complex terminating impedances or high-impedance level open-collector circuits.

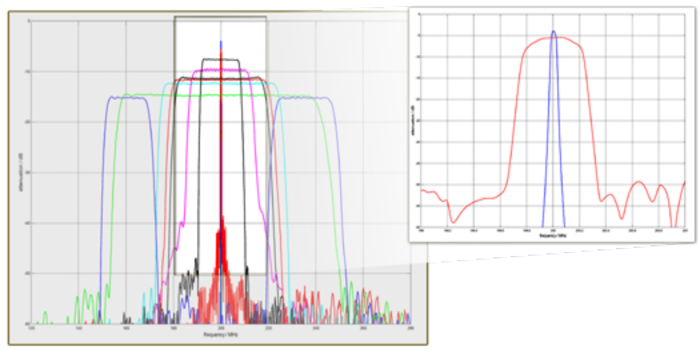
IF Filters

To achieve high-performance heterodyne RF transceiver systems, highly selective filters for the intermediate frequency (IF) stage are mandatory. For such filters, system designers focus on highly linear amplitude and phase response within the desired filter pass band, as well as the steepest possible roll-off to achieve maximum adjacent channel suppression. Microsemi uses a large variety of different SAW filter design approaches to fulfill these requirements for all kinds of applications, in line with moderate insertion loss to limit amplification requirements and power consumption in the IF stage.

Extensive use of resonant and recursive design approaches, known in the digital world as infinite impulse response (IIR) filters, ensure maximum performance in combination with minimum size, whereas design approaches equivalent to finite impulse response (FIR) filters allow for realization of filter shape factors (ratio of stop-band and pass-band width) very close to the theoretical limit (that is, even below 1.05).

Microsemi's SAW IF filters are found in all kinds of high-performance RF systems, from communications to aerospace and defense systems, in medical and industrial electronics, and countless other applications.

Hundreds of readily developed IF filter solutions in frequency ranges between 30 MHz and 1 GHz, covering fractional bandwidth ranges between 0.01% and >50%, are available off the shelf. Selected examples at a center frequency of 200 MHz are shown in the following images.



RF Filters

The strong influence of a front-end filter's insertion loss on the transceiver system's performance requires the application of low-loss filter design principles, utilizing various kinds of electrically or acoustically coupled high-Q SAW resonators.

Microsemi uses numerous design techniques to realize the required solutions. While filter solutions consisting of a network of one-port SAW resonators offer advantages in terms of minimum insertion los and RF power handling capabilities, filter principles using acoustically coupled resonators are chosen for high out-of-band rejection and for applications requiring integrated impedance transformation (for instance, 50 Ω to 200 Ω) or "balun" (single-ended to balanced) functionality. Combinations of both approaches ensure optimum design-to-application.

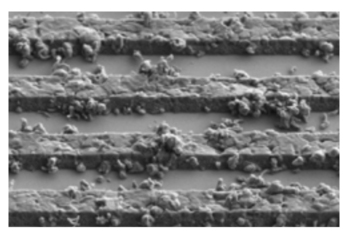
Besides a comprehensive, constantly growing portfolio of RF front-end filters for communication applications (that is, most 3GPP frequency bands), Microsemi also offers highly temperature-stable filters for narrow-band RF filtering applications, covering fractional bandwidth ranges of less than 0.1%. Such devices are widely used in professional communications applications, military radio systems, and test and measurement applications, in functionality both as filtering devices and high-Q frequency-determining components for high-frequency oscillators.

Power Handling Capabilities

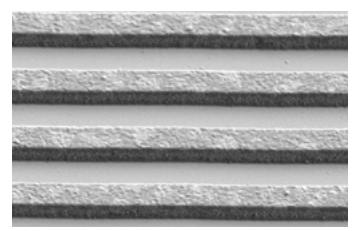
Increased signal power level is a key approach when good signal–to–noise ratio in RF transmission systems or outstanding noise floor in oscillator signals is required. While small size is one of the key advantages of SAW filters compared to competing technologies, the combination of high power levels and small size results in high power densities, and therefore risk of premature failure for highly miniaturized solutions.

A SAW device's power handling capability depends on numerous factors, such as the employed design approach, the device's center frequency, the exposure signal's frequency and modulation scheme, and its duty cycle or the ambient temperature.

Microsemi's innovative high-power technology significantly reduces degradation effects of micro-acoustic stress caused by high RF signal power, allowing realizations of SAW filters with substantially improved power handling capabilities and superior lifetime and helps system designers achieve their performance goals.



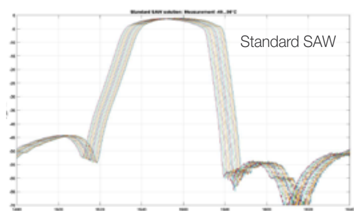
Standard SAW IDT after extended high power exposure

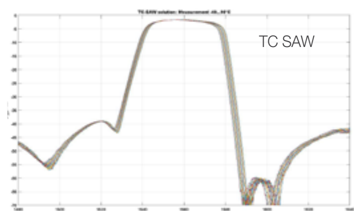


IDT in Microsemi's high power technology after comparable exposure

Temperature-Compensated SAW (TC-SAW) Solutions

Continuously increasing data traffic in wireless networks requires maximum utilization of available RF spectrum, which keeps cutting into available transition bands between existing and newly defined RF communication bands. To cope with these increasing coexistence requirements (and therefore with the need for steeper guaranteed filter roll-off), Microsemi has developed advanced technologies to minimize both process tolerances and temperature sensitivity of RF SAW solutions. Depending on the application, various solutions can be employed to significantly reduce the temperature sensitivity of RF SAW devices.

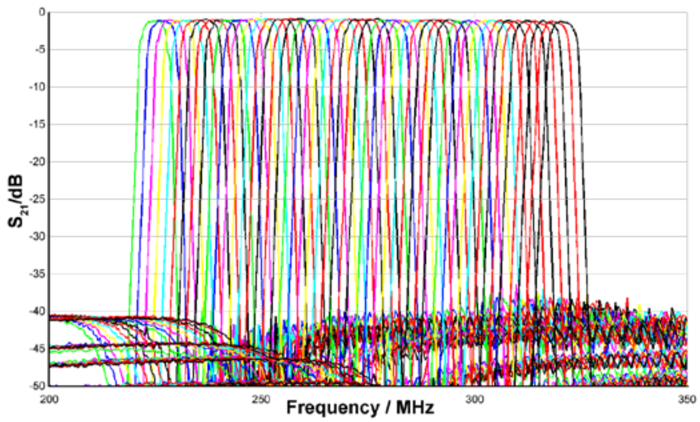




Standard SAW and TC SAW Solution measured between-40 and 90°C

Integrated Filter Solutions

The complexity of RF transceiver systems is increasing with the integration of numerous frequency bands into one radio unit. Microsemi is offering multi-band SAW filter solutions to cope with the challenges resulting from decreasing guard bands between radio channels and multi-channel usage within single radios. In addition to selected diplexer and duplexer solutions, Microsemi offers custom-designed discrete or integrated filter bank solutions to support radios with multiple transmission bands with constant absolute or constant relative channel bandwidths.



Fixed Absolute Bandwidth

Delay Lines

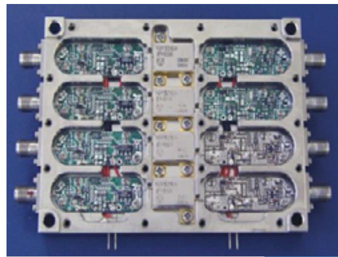
Dispersive and non-dispersive delay lines find multiple applications in electronic warfare, radar, and communications applications.

Dispersive delay lines (DDL) are used as matched filters to implement signal to noise improvement in pulsed systems. The most common waveform used is linear frequency modulation (LFM), though non-linear frequency modulation and phase shift keying are also used. For an LFM signal, the matched filter gain is 10*log(TB), where T is the signal dispersion and B is the signal bandwidth. This matched filter gain is a consequence of conservation of energy. Microsemi can implement dispersive delay lines with TB products exceeding 10,000, resulting in 40 dB of signal-to-noise improvement. For radar applications, the waveform bandwidth determines the range resolution of the system. Microsemi has implemented bandwidths up to 667 MHz.

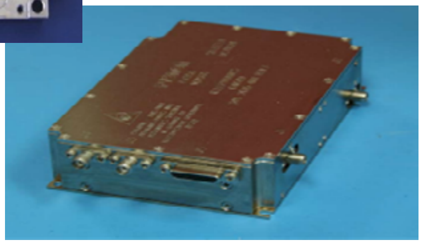
Non-dispersive delay lines implement a high dynamic range memory for signal processing. Applications include radar clutter rejection, calibration, and jamming, as well as frequency discrimination and buffering for gain control in analog-to-digital conversion. Microsemi can offer delays over 100 μs and fractional bandwidths exceeding 70%. Propagation attenuation increases with frequency, so there will be a trade-off between frequency, delay, and device attenuation. We will be happy to review your specific application and advise on relevant design considerations.

Modules

Microsemi can integrate any of our SAW components into a higher level of assembly, offering plug-and-play convenience to our customers. Modules may contain one or more SAW components, impedance matching, amplification, switching, ovenization, non-SAW filtering, voltage regulation, and calibration memory. The most common applications are multi-mode dispersive delay lines, switched filter banks, and multi-channel delay lines. In applications incorporating multiple SAW devices, matching and/or tracking of loss, phase, and delay performance channel-to-channel and over-temperature are frequently required. We accept these requirements and demonstrate compliance with comprehensive automated performance testing over temperature. In addition, we also offer popular screening testing per MIL-STD-883 including burn-in, shock, random vibration, and thermal cycling.



4 Channel Delay Line
With Matching



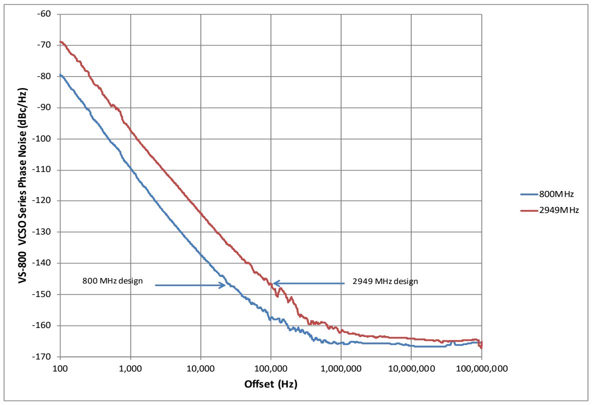
Multi-mode DDL With Oven

Voltage Controlled SAW Oscillators (VCSO)

For clocking applications where high frequencies and low phase jitter are required, SAW oscillators offer a superior solution over lower frequency crystal oscillators. Due to the much higher fundamental mode frequencies achievable with a SAW vs. a crystal resonator, no or less frequency multiplication is required to reach the desired output frequency, resulting in less or no (sub-)harmonics and better noise floor.

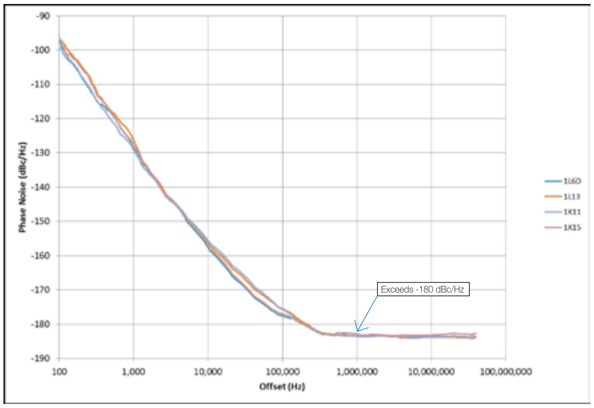
VS-800 Series VCSO

The VS-800 series VCSO is a perfect choice for high-performance data converters, OTN, and wireless applications. It offers sub-10 fs jitter performance (12 kHz – 20 MHz integration BW) in a 5.0 mm × 3.2 mm ceramic package, and a frequency range of 800 MHz to 3200 MHz. The use of an internal SAW element eliminates sub-harmonics in the frequency range up to 1600 MHz. Differential or single-ended output configurations are available.

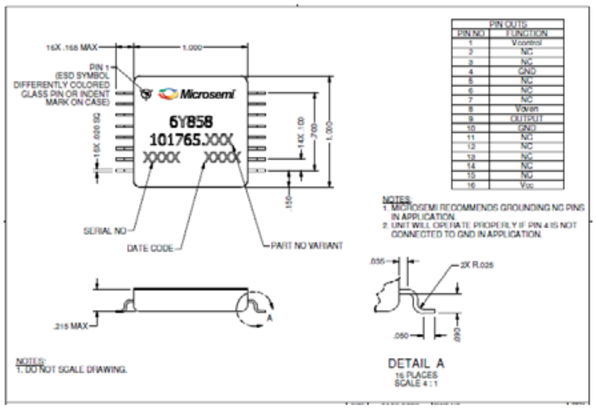


101765 Series VCSO

The 101765 series VCSO targets applications in radar and instrumentation that require the best phase noise performance available. Our patented micro-oven technology allows us to use higher Q resonators in our designs while consuming modest size, weight, and power (SWaP). This enables us to achieve better phase noise performance for frequencies below 1 GHz (as compared to non-ovenized solutions).



Example performance at 750 MHz



101765 Outline Drawing

Applications

Industrial, Scientific, and Medical Applications

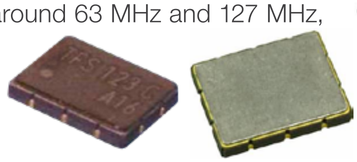
The need for high power efficiency in many RF systems for industrial, scientific, and medical (ISM) applications requires SAW filters with low insertion loss. To achieve this, resonant or recursive SAW filter design principles are applied, allowing the achievement of various specification goals (such as lowest insertion loss or steep filter transitions).

A variety of solutions for ISM and medical implant communication service (MICS) band applications are readily available, suiting different filtering requirements in terms of insertion loss, stop-band rejection, and transition regions.

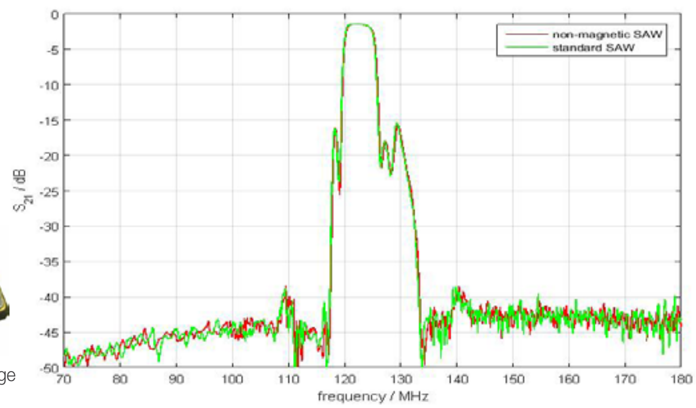
Product	Center frequency (MHz)	Bandwidth (MHz)	Insertion Loss (dB)	Package size (mm)
TFS403A	403.5	3.0	5.5	3.8 × 3.8
TFS403B	403.5	3.0	2.5	3.8 × 3.8
TFS403G	403.5	3.0	3.0	2.5 × 2.0
TFS403L	403.5	3.0	4.0	2.0 × 1.6
TFS433V	433.92	0.32	3.0	3.8 × 3.8
TFS433Z	433.92	0.32	3.0	5.0 × 5.0
TFS433AD	433.9	0.3	2.6	3.0 × 3.0
TFS868C	868.30	0.50	5.5	3.8 × 3.8
TFS868H	868.3	0.6	3.8	3.8 × 3.8
TFS869N	869.0	2.0	3.5	3.0 × 3.0
TFS915L	915.0	0.7	5.5	3.8 × 3.8
TFS915P	915.0	26.0	2.9	3.0 × 3.0
TFS915D	915.0	7.0	3.0	3.0 × 3.0

SAW Solutions for MRI Applications

The trend in modern magnetic resonance imaging (MRI) systems to integrate increasing portions of the signal processing chain into the receiver coil units requires implementation of non-magnetic electronic components to ensure negligible distortions of the magnetic fields. Microsemi has developed SAW filter solutions at typical required Larmor frequencies around 63 MHz and 127 MHz, designed for 1.5 T and 3 T systems, that combine small size, highest filter performance, and completely non-magnetic assembly technology.



Non-Magnetic (left) and Standard (right) Package



Navigation Applications

Microsemi offers a comprehensive family of RF front-end and inter-stage filters, as well as selected fully integrated front-end diplexers for global navigation satellite systems (GNSS) applications, supporting the full range of single- and multi-mode (GPS, GLONASS, Galileo, BeiDou) and single- and multi-band (lower/upper L-band) system applications.

<table>
<tr><th>GNSS Band</th><th>f_{start}</th><th>f_{stop}</th><th>Single-Band Solutions</th><th colspan="6">Multi-Band Solutions</th><th colspan="2">Diplexers</th></tr>
<tr><td>E5a</td><td>1164</td><td>1189</td><td>TFS1176 (se)</td><td rowspan="2">TFS1188 (se)</td><td rowspan="2"></td><td rowspan="5">TFS1210D (bal)
TFS1210F (se)</td><td rowspan="3">TFS1191 (se)
TFS1191C (bal)</td><td rowspan="2"></td><td rowspan="8">TFS1225C (se)</td><td rowspan="5">TDX1210</td><td rowspan="3"></td></tr>
<tr><td>E5b</td><td>1189</td><td>1214</td><td>TFS1204A (se)</td></tr>
<tr><td>B2</td><td>1192.14</td><td>1222.14</td><td></td><td></td><td rowspan="3">TFS1225D (bal)</td><td rowspan="6">TFS1238 (se)</td></tr>
<tr><td>L2</td><td>1215</td><td>1237</td><td>TFS1227B (se)
TFS1227C (bal)</td><td rowspan="2">TFS1237 (se)
TFS1237C (bal)</td><td rowspan="5">TFS1255A (se)</td><td rowspan="2">TDX1227</td></tr>
<tr><td>G2</td><td>1237</td><td>1254</td><td>TFS1245A (bal)</td></tr>
<tr><td>B3</td><td>1248.52</td><td>1288.52</td><td></td><td rowspan="3" colspan="3"></td><td rowspan="3"></td><td rowspan="3"></td></tr>
<tr><td>E4</td><td>1254</td><td>1258</td><td></td></tr>
<tr><td>E6</td><td>1260</td><td>1300</td><td>TFS1245A (bal)</td></tr>
<tr><td colspan="12"></td></tr>
<tr><td>L-band</td><td>1525</td><td>1559</td><td>TFS1542D (se)</td><td rowspan="3" colspan="3"></td><td rowspan="2"></td><td></td><td rowspan="2"></td><td rowspan="8">TDX1210</td><td rowspan="4"></td></tr>
<tr><td>SAR</td><td>1544</td><td>1545</td><td></td><td rowspan="7">TFS1578 (bal)</td></tr>
<tr><td>B1</td><td>1555.42</td><td>1595.42</td><td>TFS1575Z (se)</td><td rowspan="5">TFS1575AG (se)</td><td rowspan="3">TFS1581 (bal)</td></tr>
<tr><td>E2</td><td>1559</td><td>1563</td><td></td><td rowspan="4">TFS1575Z (se)</td><td rowspan="5"></td><td></td></tr>
<tr><td>L1</td><td>1563</td><td>1587</td><td>TFS1575AC (se)</td><td rowspan="4">TFS1575Z (se)</td><td>TDX1227</td></tr>
<tr><td>L1 C/A</td><td>1574.22</td><td>1576.62</td><td>TFS1575AD (se)</td><td rowspan="3">TFS1581B (bal)</td><td rowspan="3"></td></tr>
<tr><td>E1</td><td>1587</td><td>1591</td><td></td></tr>
<tr><td>G1</td><td>1593</td><td>1610</td><td>TFS1601A (bal)</td><td></td></tr>
</table>

Systems: GPS | Glonass | Beidou | Galileo | others   Se= single-ended (unbalanced operation) Bal= balanced (differential operation)

A comprehensive range of IF filters for professional navigation systems, designed for high isolation between signals in multi-mode systems are available off the shelf.

Oscillator and Narrow-Band Filtering Applications

Microsemi offers a unique portfolio of narrow-band, high-Q, and temperature- and aging-stable filters in frequency ranges up to 2.5 GHz, suiting professional and high-reliability requirements for narrow-band filtering or extreme precision SAW-based oscillator applications.

SAW Filters for Wireless and Telecommunication Applications

Microsemi offers a comprehensive portfolio of available SAW filter solutions for today's communication systems. Within the communication bands defined in the 3GPP standard, RF SAW filter solutions for most common bands are available in high reliability packaged versions, with more solutions under development.

All RF filter products are optimized towards the lowest insertion loss and steepest filter transitions, to support highest signal-to-noise ratio requirements.

A wide variety of SAW IF filters for multiple communication applications, ranging from kHz-bandwidth narrow-band signals to full-band LTE IF filtering applications are available in various frequency ranges, supporting popular chipset designs.

Additional single-band LTE RF filters and diplex filters for several common dual-band combinations are available (for instance, B5 uplink + B12 uplink, B25 uplink + B66 uplink).

Please visit www.Microsemi.com for a comprehensive selection of our SAW solutions for wireless and telecommunications applications.

Band	Center Freq. Uplink (MHz)	Center Freq. Downlink (MHz)	Mode	Bandwidth (MHz)	Uplink	Downlink
1	1950	2140	FDD	60	TFS1950F	TFS2140D
2	1880	1960	FDD	60	TFS1880	TFS1960F
3	1747.5	1842.5	FDD	75	TFS1747	TFS1842G
4	1732.5	2132.5	FDD	45	TFS1732A	
5	836.5	881.5	FDD	25	TFS836G	TFS881D
7	2535	2655	FDD	70	TFS2535D	TFS2655B
8	897.5	942.5	FDD	35	TFS897G	TFS942G
9	1767.4	1862.4	FDD	35		
10	1740	2140	FDD	60	TFS1747	TFS2140D
11	1437.9	1485.9	FDD	20	TFS1437	
12	707.5	737.5	FDD	17	TFS707	TFS737B
13	782	751	FDD	10	TFS782	TFS751
14	793	763	FDD	10	TFS793	
19	837.5	882.5	FDD	15	TFS837	
20	847	806	FDD	30	TFS847B	TFS806A
23	2010	2190	FDD	20	TFS2010	
24	1643.5	1542	FDD	34	TFS1643D	TFS1542E
25	1882.5	1962.5	FDD	65		
27	815.5	860.5	FDD	17		TFS860E
28	725.5	780.5	FDD	45	TFS725B	
31	455	465	FDD	5	TFS455D	TFS465A
33	1910		TDD	20	TFS1910B	
34	2017.5		TDD	15	TFS2017B	
35	1880		TDD	60	TFS1880	
36	1960		TDD	60	TFS1960F	
38	2595		TDD	50	TFS2595A	
39	1900		TDD	40	TFS1900	
41	2593		TDD	194	TFS2593A	
45	1457		TDD	20	TFS1457	
65	1965	2155	FDD	90		TFS2155
66	1745	2155	FDD	70		TFS2155
71	680.5	634.5	FDD	35		TFS634
73	452.5	462.5	FDD	5		TFS462A

Aerospace and Defense

- Surface-mount, through-hole, and connector-type packages available
- Qualification according to MIL-STD-883 and/or pre-defined (for instance, ESCC 3502) or custom space qualification plans
- Ruggedized SAW modules with internal matching
- High-reliability versions of standard designs available

The aerospace and defense family of Microsemi SAW products offers highest reliability levels for harsh and mission-critical environments. With each application having unique requirements, Microsemi offers not only a wide range of packaging technologies for ruggedized applications, but also the full range of SAW device designs covering a center frequency range from 30 MHz to 2.7 GHz. Our facility in Simsbury, CT can support projects with security concerns such as ITAR, EAR, and classified specifications/ hardware.

In addition to multi-layer ceramic and metal can assembly technologies, package designs with integrated matching circuitry in electrically and environmentally isolated cavities offer superior electrical performance in combination with outstanding environmental reliability.