A resonator can be made using a transducer between two SAW reflectors. The reflectors are arrays of metal strips with spacing λ/2, often called gratings. The resonator has two gratings forming a resonant cavity, with an IDT in the cavity to couple it to the electrical terminals, as in Fig. 4. The response of this device is basically a one-pole resonance.

Longitudinally Coupled Resonators (LCRs)

The LCR is another type of resonator filter. A typical arrangement consists of two transducers in the space between two reflecting gratings. This is somewhat similar to the one-port resonator, Fig. 4, but with two transducers. Using IDTs with strong internal reflections, the LCR can be designed to provide a filter with high-Q poles. A typical configuration is shown in Fig. 6. On a strong-coupling substrate such as lithium tantalate or niobate, this gives low loss. The substrate is almost always used as a transducer in between two SAW reflectors. The reflectors are arrays of metal strips with a spacing λ/2 such as 42 MHz (approx) dB MHz suppression ripple factor

Table 2. Performance Capabilities of SAW Bandpass Filters.

<table>
<thead>
<tr>
<th>Type</th>
<th>material</th>
<th>Centre freq. MHz (approx)</th>
<th>Loss</th>
<th>bandwidth MHz</th>
<th>stopband suppression</th>
<th>amplitude ripple</th>
<th>shape factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transversal</td>
<td>any</td>
<td>30–1500</td>
<td>15–30</td>
<td>20 %</td>
<td>&lt; 60 dB</td>
<td>0.1 dB</td>
<td>1:1</td>
</tr>
<tr>
<td>IEF</td>
<td>LiTaO₃</td>
<td>200–3000</td>
<td>1–5</td>
<td>&gt; 3</td>
<td>&lt; 45 dB</td>
<td>1 dB</td>
<td>3:1</td>
</tr>
<tr>
<td>LCR</td>
<td>LiTaO₃</td>
<td>30–2000</td>
<td>1–2</td>
<td>&lt; 0.2</td>
<td>&lt; 40 dB</td>
<td>1 dB</td>
<td>3:1</td>
</tr>
<tr>
<td>TCR</td>
<td>Quartz</td>
<td>30–1000</td>
<td>1–5</td>
<td>&lt; 2</td>
<td>&gt; 40 dB</td>
<td>1 dB</td>
<td>3:1</td>
</tr>
<tr>
<td>SPUDT</td>
<td>Quartz</td>
<td>30–1000</td>
<td>1–5</td>
<td>&lt; 2</td>
<td>&gt; 40 dB</td>
<td>1 dB</td>
<td>3:1</td>
</tr>
</tbody>
</table>

Super Q (SQ) filters are usually long transducers with strong internal reflections, plus a grating at each end, so that the resonators behave like capacitors whose values determine the rejection. The resonators are made of substrates. Insertion losses are usually 1 to 2 dB. Because the input and output transducers are in different tracks, not facing each other, the stopband rejection can be good. It is common to cascade two devices to improve this (giving a 4-pole filter), and a rejection of around 50 dB is obtainable. The response near the pass band is approximately that of a 4-pole filter, so the shape factor is not so small. The substrate is almost always quartz.

Impedance Element Filters (IEFs) / Ladder Filters

This technology was developed in response to the need for very low loss RF filters at 900 MHz and above, for mobile phone applications. The IEF uses elements that are connected electrically. The device circuit is a sequence of resonators connected alternately in series and in parallel, as indicated for a simple case in Fig. 7. The performance of the various types is summarized in Table 2. The data is only indicative of the performance obtainable, and for a specific requirement it is best to consult COM DEV directly. If appropriate, a better assessment can be obtained by doing a preliminary design and simulation. Devices using tantalite or niobate substrates can often be used without any matching or tuning components if the bandwidth is less than 4%. Many of these devices can be supplied in balanced form, so as to accept a balanced drive and load. Also, it is often possible to have one port balanced and the other unbalanced, so that the SAW device also serves the function of a balun transformer.

Table 2. Performance Capabilities of SAW Bandpass Filters.
The simplest type of SAW filter, illustrated in Fig. 1, consists of two interdigital transducers (IDTs) on a piezoelectric substrate. The concept of crystallographic materials such as quartz. The term ‘piezoelectric’ means that the material has a basic mechanism which couples electric and mechanical fields. Consequently, an acoustic wave excited on, such as a SAW in general, has an associated electric field in such a material. The IDTs have electrodes alternately connected to two bus-bars, so that a voltage supplied to the input IDTs and the bus-bar out of the transducer. All the output transducer on the right, the field associated with the incident wave induces voltages on the electrodes, and hence a corresponding voltage appears on the bus-bar connected to the output.

This device can be regarded as a basic bandpass filter. The reason is that the individual sources (electrodes) on the input IDT generate waves with alternating signs, and they add up in phase if the SAW wavelength (λ) is an exact multiple of the bus-bar separation (2d).

The maximum frequency possible is determined by electrode width. At the centre frequency the electrodes have spacing 2d, and width typically 1/4. In production, the smallest bandwidth obtainable is about 0.5 GHz and, for a typical SAW velocity of 3500 m/s this gives a maximum centre frequency the electrodes have determined by electrode width. At the overlaps. The filter is a special case, giving a ‘leaky surface wave’, a special type of SAW which penetrates deeper into the substrate. The transducer higher power densities and gives strong coupling with reasonable temperature stability. It is often used for RF filters needing low insertion loss.

Table 1: Common Substrate Materials

<table>
<thead>
<tr>
<th>Material</th>
<th>Max bandwidth</th>
<th>TCD (at 20°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ST Quartz, 34° Y-X</td>
<td>220 GHz</td>
<td>40 ppm/°C</td>
</tr>
<tr>
<td>LiNbO3, 128° X-Y</td>
<td>200 GHz</td>
<td>50 ppm/°C</td>
</tr>
<tr>
<td>tLiNbO3, 45° 1/2</td>
<td>180 GHz</td>
<td>70 ppm/°C</td>
</tr>
<tr>
<td>tLiNbO3, 45° 2</td>
<td>200 GHz</td>
<td>30 ppm/°C</td>
</tr>
</tbody>
</table>

There are many different types of SAW filters, all consisting of a metal film etched to a specific geometry using a photolithographic process similar to that used for semiconductor processing. The variety illustrates the versatility, which follows from the fact that almost arbitrary shapes can be made on the surface. Another factor is that a compact device, with length say 1 cm, can have many SAW wavelengths inside and hence many degrees of freedom. As long as the device is suitably ‘large’ so that many devices are made simultaneously, giving economies of scale.

SAW transversal filters can satisfy extremely exacting performance requirements. For example, the following performance can be achieved:

- In-band ripple can be as low as 0.2 dB (p-p).
- Group delay can be made flat within ±0.2 ns.
- Return loss can be as high as 40 dB.
- Resonant frequencies can be uniformly spaced.
- Channel stop-band rejection can be 60 dB.
- In-band ripple can be as low as 0.2 dB (p-p).
- Return loss can be as high as 40 dB.
- Resonant frequencies can be uniformly spaced.

Many techniques have been developed to obtain low-loss SAW filters without the ripple problem of transversal filters. One method is to modify IDTs designed to generate SAWs preferentially in one direction. Commonly, some IF filters use Single Phase Unidirectional Transducers (SPUDTs). The transducer’s behavior is obtained by using electrodes with different widths. As for semiconductors, the fabrication is done on a larger substrate, and the devices are made simultaneously, giving economies of scale.

There are various techniques for optimizing SAW filters, such as using one or two matching components, but in this condition the IDT reflects incident SAWs continuously works on its proprietary SAW design software in an ongoing effort to improve the performance. To obtain low loss, the IDTs can be electrically matched to the source and load (using one or two matching components), but in this condition the IDTs reflect incident SAWs perfectly, quite strongly. This is a consequence of the fact that the transducers are bidirectional, generating waves equally in two directions. As for semiconductors, the fabrication is done on a larger substrate, and the devices are made simultaneously, giving economies of scale.

Some data for common materials is given in Table 1. Data for maximum bandwidth is only representative. The maximum frequency possible is determined by electrode width. At the centre frequency the electrodes have spacing 2d, and width typically 1/4. In production, the smallest bandwidth obtainable is about 0.5 GHz and, for a typical SAW velocity of 3500 m/s this gives a maximum centre frequency the electrodes have determined by electrode width. At the overlaps. The filter is a special case, giving a ‘leaky surface wave’, a special type of SAW which penetrates deeper into the substrate. The transducer higher power densities and gives strong coupling with reasonable temperature stability. It is often used for RF filters needing low insertion loss.
The simplest type of SAW filter, illustrated in Fig. 1, consists of two interdigital transducers (IDTs) on a piezoelectric substrate. The transducers are made of a material such as quartz. The term 'piezoelectric' means that the material has a basic mechanism which couples electrostatic and mechanical fields. Consequently, an acoustic wave such as a SAW will in general have an associated electric field in such a material. The IDTs have electrodes alternately connected to two bus-bar, so that a voltage applied to the bus-bar excites the acoustoelectric fields in the gaps between the electrodes. The piezoelectric effect couples these fields to mechanical stresses which act as sources of the SAW, and the SAW propagates out of the transducer. At the output transducer on the right, the field associated with the incident wave induces voltages on the electrodes, and hence a corresponding voltage appears on the bus-bar connected to the output.

This device can be regarded as a basic band-pass filter. The reason is that the individual sources (alternating gaps in the output IDT) act as equivalent secondary sources, and they add in phase if the SAW velocity is correct. This occurs at the centre frequency. If the frequency is changed the waves generated by the sources are not quite in phase, and the total amplitude decreases proportionately as the frequency is changed. Hence the device has a band-pass characteristic, with the strongest response at the centre frequency. The bandwidth is approximately 1/7, where T is the transducer length in time units (physical length x SAW velocity). A typical SAW Bandpass Filter characteristic is shown in Fig. 2.

The device will usually be hermetically packaged to protect the sensitive surface from contamination. Often, one or two passive components must be added at each end, outside the package. An inducer may be needed because the IDTs have capacitance which may need to be bypassed. Also, L-C circuits are often used to transform the source or load impedance (usually 50 Q) to an impedance more suitable for the device.

The maximum frequency possible is determined by electrode width. At the centre frequency the electrodes have spacing 0.2, and width typically 0.4. In production, the smallest breadths obtainable are about 0.3, and for a typical SAW velocity of 3500 m/s this gives a maximum centre frequency of about 3 GHz. The fractional bandwidth change is 30 x 10^6 / 3 x 10^9, where 3 is the deviation from the turn-on temperature. Lithium niobate is the opposite, exhibiting strong coupling but rather bad temperature stability. Lithium tantalate is intermediate in both respects. The 45° rotated lithium tantalate is a special case, giving a ‘leaky wave effect’, a special type of SAW which penetrates deeper into the substrate. The transducers higher power densities and give strong coupling with reasonable temperature stability. It is often used for RF filters needing low insertion loss.

<table>
<thead>
<tr>
<th>Material</th>
<th>Max bandwidth (GHz)</th>
<th>TCD (ppm/°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ST Quartz, 34° X-Y</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>LiNbO3, 138° X-Y</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td>LiTaO3, 34° Y</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>LiTaO3, 42° Y</td>
<td>20</td>
<td>30</td>
</tr>
</tbody>
</table>

There are many different types of SAW filters, all consisting of a metal film etched to a specific geometry using a photolithography process similar to that used for semiconductor processing. The variety illustrates the versatility, which follows from the fact that almost arbitrary shapes can be made on the surface. Another factor is that a compact device, with length say 1 cm, can have many SAW wavelengths inside it and hence many degrees of freedom, compared with a wider device. In both cases the devices are made simultaneously, giving economies of scale.

Types of Bandpass Filters

Transversal Filters - Apodisation

The basic filter of Fig. 1 can be modified in many ways. The electrode overlaps can be varied so that the SAW beams generated by individual gaps have different widths. This occurs at the centre frequency. A particular advantage is the slow acoustic velocity, much slower than that of EM waves. This enables long delays to be obtained in a small space.

The performance is constrained by the properties of the substrate material. For SAW devices, the substrate is usually one of a number of ‘standard’ materials already known to have suitable SAW properties. One property of interest is the piezoelectric constant d31, which determines the strength of coupling between electrical and mechanical fields. Generally, larger d31 enables lower insertion loss to be obtained, or wider bandwidth for the same loss. Another important parameter of delay (TCD), which specifies how the delay varies with temperature (this involves velocity and dimensional changes). This also gives information on bandwidth and insertion loss. Some data for common materials is given in Table 3. For maximum bandwidth is only limited by the SAW velocity. Quarts has low piezoelectric coupling, but particular substrate orientations give good temperature stability. The TCD is zero at a particular temperature, around 20°C. The fractional delay change is 30 x 10^6 / 3 x 10^9, where 3 is the deviation from the turn-on temperature. Lithium niobate is the opposite, exhibiting strong coupling but rather bad temperature stability. Lithium tantalate is intermediate in both respects. The 45° rotated lithium tantalate is a special case, giving a ‘leaky wave effect’, a special type of SAW which penetrates deeper into the substrate. The transducers higher power densities and give strong coupling with reasonable temperature stability. It is often used for RF filters needing low insertion loss.

Compared with a transversal filter, a SPUTD filter has much less loss for a given amount of ripple. In addition, the SPUTD filter can often be designed to have a longer delay than that of a corresponding transversal filter. This is advantageous for a compact system such as a mobile phone, and it also reduces the cost of the substrate material and the packaging. A typical SPUTD filter characteristic is shown in Fig. 3.

SAW Bandpass Filters

SAW transversal filters can satisfy extremely exacting performance requirements. For example, the following performance can be achieved:

- In-band ripple can be as low as 0.2 dB p-p.
- Out-of-band rejection can be as high as 60 dB, but the shape factors (ratio of bandwidths at 3 dB and 50 dB points) can be as low as 1.1.

These parameters are often the primary considerations when a new SAW filter design is undertaken, and the actual choice of SAW transducer or other optimisation methods is used for design, including compensation for various second-order effects (e.g. diffraction). The main limitation comes about because of unwanted reflections of the SAWs. COM DEV continuously works on its proprietary SAW design software in an ongoing effort to improve SAW performance. To obtain low loss, the SAWs can be electrically matched to the source and load (using one or two matching components), but in this condition the IDTs reflect incident SAWs quite strongly. This is a consequence of the fact that the transducers are bidirectional, generating waves equally in two directions. The result is an unwanted signal due to multiple reflections of the waves, giving ripples in the amplitude and phase of the response. This effect is called Triple Transit Response and the ripples are often unacceptable; to minimize it is necessary to adjust the matching or loading. For this reason, the insertion loss of high-performance transversal filters is usually quite high, for example in the order of 25 or more. The large length of a SAW filter is related to skirt width, so filters with narrow skirts are generally very long.
SAW Bandpass Filters

The simplest type of SAW filter, illustrated in Fig. 1 consists of two interdigital transducers (IDTs) on a piezoelectric substrate, a plate of crystalline material such as quartz. The term ‘piezoelectric’ means that the material has a basic mechanism which couples electric and mechanical fields. Consequently, an acoustic wave such as a SAW will generally have an associated electric field in such a material. The IDTs have electrodes alternately connected to two bus-bars, so that a voltage applied to the bus-bars sets up alternating electric fields in the gaps between the electrodes. The piezoelectric effect couples these fields to mechanical stresses which act as sources of SAWs, and the SAWs travel out of the transducer. At the output transducer on the right, the field associated with the incident wave induces voltages on the electrodes, and hence a corresponding voltage appears on the bus-bars connected to the output.

This device can be regarded as a basic bandpass filter. The reason is that the individual source/ detector pairs on the IDTs generate waves with alternating signs, and they add up in phase if the IDT geometry is adjustable to make this occur. This occurs at the ‘centre frequency’. If the frequency is changed the waves generated by the sources are not quite in phase, and the total amplitude decreases proportionately as the frequency changes. Hence the device has a bandpass characteristic, with the strongest responses at the centre frequency. The bandwidth is approximately 1/7, i.e., the deviation from the centre frequency. This is a consequence of the fact that the transducers are bidirectional, generating waves equally in two directions. The basic SAW filter has a bandpass characteristic, with the strongest responses at the centre frequency. This occurs at the ‘centre frequency’. If the frequency is changed the waves generated by the sources are not quite in phase, and the total amplitude decreases proportionately as the frequency changes. Hence the device has a bandpass characteristic, with the strongest responses at the centre frequency. The bandwidth is approximately 1/7, i.e., the deviation from the centre frequency.

There are many different types of SAW filters, all consisting of a metallic film etched to a specified geometry using a photolithography process similar to that used for semiconductor processing. The variety illustrates the flexibility, which follows from the fact that almost every geometry can be released in the material. Another factor is that a compact device, with length say 1 cm, can have many SAW wavelengths inside it and hence many degrees of freedom. For many devices are made simultaneously, giving economies of scale.

The device will usually be hermetically packaged to protect the sensitive surface from contamination. Often, one or two reactive components must be added at each end, outside the package. An inducer may be needed because the IDTs have capacitance which may need to be tuned out. Also, L-C circuits are often used to transform the source or load impedance (usually 50 Ω) to an impedance more suitable for the device.

The maximum frequency possible is determined by electrode width. At the centre frequency the electrodes have spacing L/2, and width typically L/4. In production, the smallest breadths obtainable are about 0.3 μm, and for a typical SAW velocity of 3500 m/s this gives a maximum centre frequency of about 2 GHz. For this type of device the reflections, and hence the ripples, are minimized when the specified loading is used. So, unlike the transversal filter above, SAW transversal filters can satisfy extremely exacting performance requirements.

For example, the following performance can be achieved:

- In-band ripple can be as low as 0.2 dB p-p.
- An insertion loss of 2.1 dB at 100 MHz.
- Frequency selectivity of at least 15 dB per octave.
- Bandwidths down to 0.005%.
- Spectral purity of 10-12 THz, or better.
- Low noise figure.
- Very low sensitivity to temperature changes.

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Low-loss Filters - TCRs

A quite different technology is based on SAW resonators. A resonator can be made using a Transverse-Coupled Resonator or TCR. The reflectors are arrays of metallic strips with spacing λ/2, often called gratings. The resonator has two gratings forming a resonant cavity, with an IDT in the cavity to couple it to the electrical terminals, as in Fig. 4. The response of this device is basically a one-pole resonance.

Longitudinally Coupled Resonators (LCRs)

The LCR is another type of resonator filter. A typical arrangement consists of two transducers in the space between two reflecting gratings. This is somewhat similar to the one-port resonator, Fig. 4, but with two transducers. By using IDTs with strong internal reflections, the LCR can be designed to provide a filter with high-Q poles. A typical configuration is shown in Fig. 6. On a strong-coupling substrate such as lithium tantalate, this filter can give low insertion losses, e.g. 2 dB, at 1 GHz and above. Bandwidths up to 5% can be obtained without the need for tuning components. The LCR can also be used on quartz substrates.

Fig. 4. SAW One-port Resonator.

Fig. 5. Transverse Coupled Resonator (TCR).

Fig. 6. LCR configuration.

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<table>
<thead>
<tr>
<th>Type</th>
<th>material</th>
<th>Centre freq. MHz (approx)</th>
<th>Loss dB</th>
<th>bandwidth MHz</th>
<th>stopband suppression</th>
<th>ripple amplitude</th>
<th>shape factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transversal</td>
<td>any</td>
<td>30–1500</td>
<td>&lt;0.1</td>
<td>&lt;40 dB</td>
<td>0.1 dB</td>
<td>1.1:1</td>
<td></td>
</tr>
<tr>
<td>SPUDT</td>
<td>Quartz</td>
<td>30–1000</td>
<td>0.5</td>
<td>&lt;40 dB</td>
<td>0.1 dB</td>
<td>3:1</td>
<td></td>
</tr>
<tr>
<td>TCR</td>
<td>LiTaO₃</td>
<td>50–400</td>
<td>1–2</td>
<td>&lt;40 dB</td>
<td>1 dB</td>
<td>3:1</td>
<td></td>
</tr>
<tr>
<td>LCR</td>
<td>LiTaO₃</td>
<td>20–2000</td>
<td>&gt;2</td>
<td>&lt;45 dB</td>
<td>1 dB</td>
<td>3:1</td>
<td></td>
</tr>
<tr>
<td>IF</td>
<td>LiTaO₃ or LiNbO₃</td>
<td>800–3000</td>
<td>1–2</td>
<td>&lt;45 dB</td>
<td>2 dB</td>
<td>3:1</td>
<td></td>
</tr>
</tbody>
</table>

Impedance Element Filters (IEFs) - Ladder Filters

A quite different technology is based on SAW resonators. A resonator can be made using a Transverse-Coupled Resonator or TCR. The reflectors are arrays of metallic strips with spacing λ/2, often called gratings. The resonator has two gratings forming a resonant cavity, with an IDT in the cavity to couple it to the electrical terminals, as in Fig. 4. The response of this device is basically a one-pole resonance.

Fig. 5. Transverse Coupled Resonator (TCR).

Fig. 6. LCR configuration.

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A resonator can be made using /2, often called gratings. The resonator has two gratings forming a resonant cavity, with an IDT in the cavity to couple it to the electrical terminals, as in Fig.1. The response of this device is basically a one-pole resonance.

A transverse-coupled resonator (TCR) consists of two identical resonators fabricated close together, as in Fig. 5 and relies on acoustic coupling between the two resonators. The waves in one resonator extend slightly outside to physical structure, and this enables some energy to leak from one resonator to the other. This couples the two resonators, and the device gives a 2-pole response. The use of resonances enables very narrow bandwidths to be obtained. In fact, this device is limited to bandwidths below about 0.2% because the coupling between the two resonators is weak. Insertion losses are typically 1–2 dB. Because the input and output transducers are in different tracks, not facing each other, the stop band rejection can be good. It is common to cascade two devices to improve this (giving a 4-pole filter), so the shape factor is not so small. The substrate is almost always quartz. Impedance Element Filters (IEFs) / Ladder Filters

Longitudinally Coupled Resonators (LCRs)

The LCR is another type of resonator filter. A typical arrangement consists of two transducers in the space between two reflecting gratings. This is somewhat similar to the one-port resonator, Fig.4, but with two transducers. Using ETs with strong internal reflections, the LCR can be designed to provide a filter with high-Q poles. A typical configuration is shown in Fig.6. On a strong-coupling substrate such as lithium tantalate or niobate, this gives low insertion losses, e.g. 1 dB at 1 GHz, with a 10% bandwidth. However, the stopband rejection is not generally so good as other filter types. A typical Ladder frequency response is shown in Fig.8.

Fig. 5. Transverse Coupled Resonator (TCR).

Table 2. Performance Capabilities of SAW Bandpass Filters.

<table>
<thead>
<tr>
<th>Type</th>
<th>material</th>
<th>Centre freq. MHz (approx)</th>
<th>Stopband suppression dB</th>
<th>Bandwidth %</th>
<th>Amplitude ripple db</th>
<th>Phase factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transversal</td>
<td>any</td>
<td>30–1500</td>
<td>&lt; 50 dB</td>
<td>20%</td>
<td>0.1 dB</td>
<td>1:1</td>
</tr>
<tr>
<td>SPUDT Quartz</td>
<td>30–1000</td>
<td>1–50</td>
<td>&lt; 40 dB</td>
<td>2%</td>
<td>0.5 dB</td>
<td>2:1</td>
</tr>
<tr>
<td>TCR</td>
<td>LiTaO 3</td>
<td>50–400</td>
<td>&lt; 45 dB</td>
<td>1%</td>
<td>1 dB</td>
<td>3:1</td>
</tr>
<tr>
<td>LCR</td>
<td>LiTaO 3</td>
<td>20–2000</td>
<td>&lt; 45 dB</td>
<td>3%</td>
<td>1 dB</td>
<td>3:1</td>
</tr>
<tr>
<td>IEF</td>
<td>LiTaO 3</td>
<td>800–3000</td>
<td>&lt; 45 dB</td>
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Low-loss Filters - TCRRs

Fig. 6. LCR configuration.

A quite different technology is based on SAW resonators. A resonator can be made using a Transducer in between two SAW reflectors. The reflectors are arrays of metal strips with spacing λ/2, often called gratings. The resonator has two gratings forming a resonant cavity, with an IDT in the cavity to couple it to the electrical terminals, as in Fig.1. The response of this device is basically a one-pole resonance.

Fig. 4. SAW One-port Resonator.

This technology was developed in response to the need for very low loss RF filters at 900 MHz and above, for mobile phone applications. The SAW device also serves the function of a balun transformer. It is only possible to have one port balanced and the other unbalanced, so the SAW device also serves the function of a balun transformer.

Longitudinally Coupled Resonators (LCRs)

The LCR is another type of resonator filter. A typical arrangement consists of two transducers in the space between two reflecting gratings. This is somewhat similar to the one-port resonator, Fig.4, but with two transducers. Using ETs with strong internal reflections, the LCR can be designed to provide a filter with high-Q poles. A typical configuration is shown in Fig.6. On a strong-coupling substrate such as lithium tantalate or niobate, this gives very low loss, e.g. 1 dB at 1 GHz, with up to 5% bandwidth. However, the stopband rejection is not generally so good as other filter types. A typical Ladder filter response is shown in Fig.8.

The performance of the various types is summarized in Table 2. The data is only indicative of the performance obtainable, and for a specific requirement it is best to consult COM DEV directly. If appropriate, a better assessment can be obtained by doing a preliminary design and simulation. Devices using tantalate or niobate substrates can often be used without any matching or tuning components if the bandwidth is less than 4%.

Many of these devices can be supplied in balanced form, so as to accept a balanced drive and load. Also, it is often possible to have one port balanced and the other unbalanced, so that the SAW device also serves the function of a balun transformer.