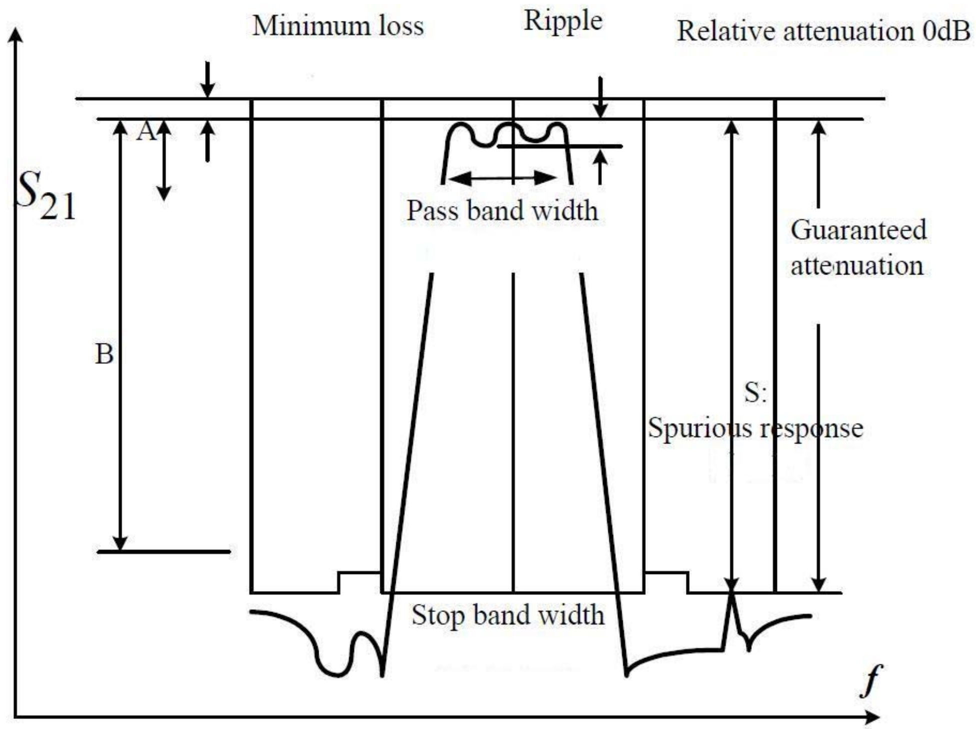
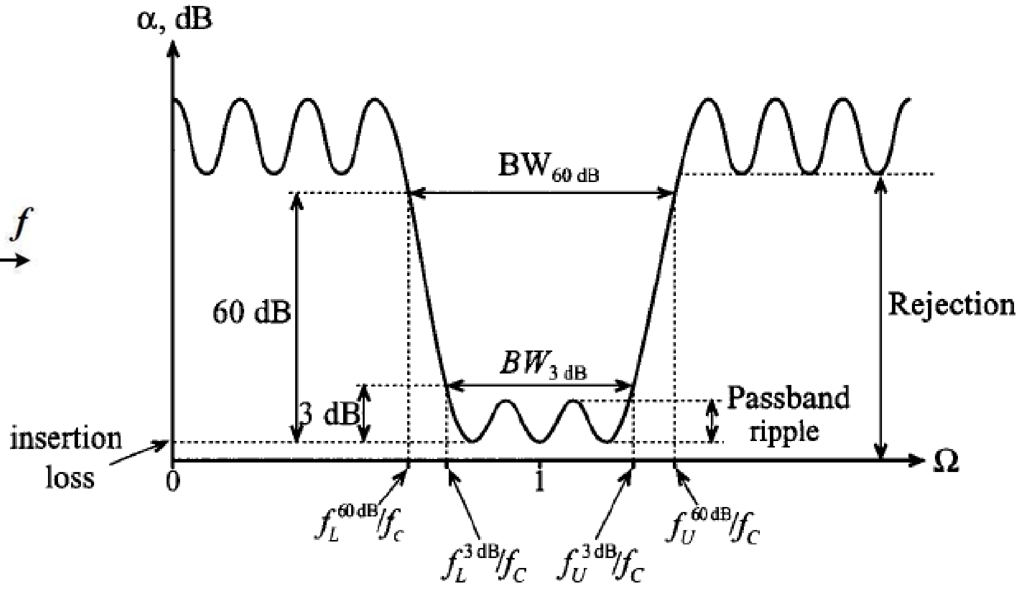
Filtri reali

Pierfrancesco Lombardo

Filtraggio Passabanda (I)



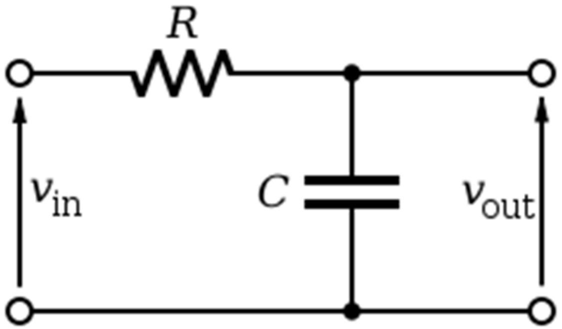
- **Insertion Loss (IL):** $IL = 10\log(P_{in} / P_L)$
- **Ripple; Bandwidth:** $BW_{3dB} = f_{U(3dB)} - f_{L(3dB)}$
- **Shape Factor:** describing filter **sharpness**
- **Rejection:** often specifying **60 dB as the rejection rate**



Filtraggio Passabanda (II)

Single element types : The simplest passive filters consist of a single reactive element. These are constructed of RC, RL, LC or RLC elements.

The quality or "Q" factor is a measure that is sometimes used to describe simple band-pass or band-stop filters. A filter is said to have a high Q if it selects or rejects a range of frequencies that is narrow in comparison to the centre frequency. Q may be defined for bandpass and band-reject filters as the ratio of centre frequency divided by 3dB bandwidth. It is not commonly employed with higher order filters where other parameters are of more concern, and for high-pass or low-pass filters Q is not normally related to bandwidth.



A low-pass electronic filter realised by an RC circuit

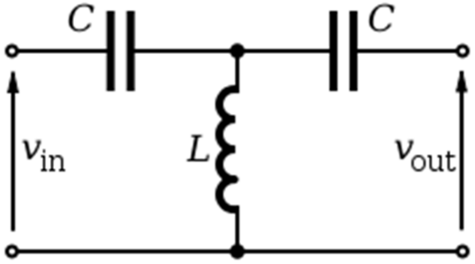
Filtraggio Passabanda (II)

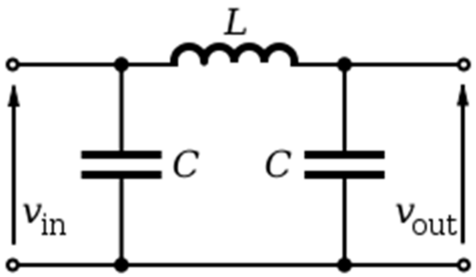
L filter: An L filter consists of two reactive elements, one in series and one in parallel.

T and π filters

Three-element filters can have a 'T' or 'π' topology and in either geometries, a low-pass, high-pass, band-pass, or band-stop characteristic is possible. The components can be chosen symmetric or not, depending on the required frequency characteristics. The high-pass T filter in the illustration, has a very low impedance at high frequencies, and a very high impedance at low frequencies. That means that it can be inserted in a transmission line, resulting in the high frequencies being passed and low frequencies being reflected. Likewise, for the illustrated low-pass π filter, the circuit can be connected to a transmission line, transmitting low frequencies and reflecting high frequencies. Using m-derived filter sections with correct termination impedances, the input impedance can be reasonably constant in the pass band.

Low-pass π filter
High-pass T filter





Filtraggio Passabanda (II)

Multiple element types

Multiple element filters are usually constructed as a ladder network. These can be seen as a continuation of the L,T and π designs of filters. More elements are needed when it is desired to improve some parameter of the filter such as stop-band rejection or slope of transition from pass-band to stop-band.

Filtraggio Passabanda (II)

Historically, linear analog filter design has evolved through three major approaches:

-The oldest designs are simple circuits where the main design criterion was the **Q factor** of the circuit. This reflected the radio receiver application of filtering as Q was a measure of the frequency selectivity of a tuning circuit.
- From the 1920s filters began to be designed from the **image point of view**, mostly being driven by the requirements of telecommunications.

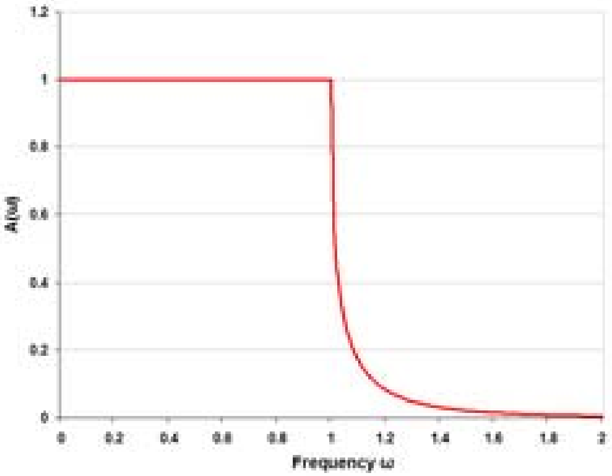
> -This approach analyses the filter sections from the point of view of the filter being in an infinite chain of identical sections. It has the advantages of simplicity of approach and the ability to easily extend to higher orders. It has the disadvantage that accuracy of predicted responses rely on filter terminations in the image impedance, which is usually not the case

After World War II the dominant methodology was **network synthesis**. The higher mathematics used originally required extensive tables of polynomial coefficient values to be published but modern computer resources have made that unnecessary. The network synthesis approach starts with a required transfer function and then expresses that as a polynomial equation of the input impedance of the filter. The actual element values of the filter are obtained by continued-fraction or partial-fraction expansions of this polynomial. Unlike the image method, there is no need for impedance matching networks at the terminations as the effects of the terminating resistors are included in the analysis from the start.[3]

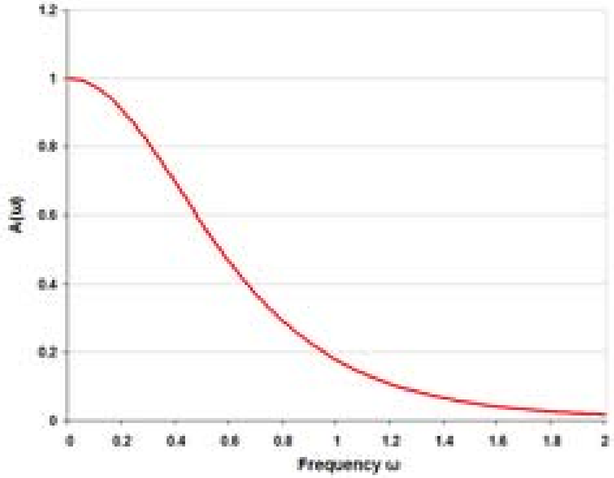
Filtraggio Passabanda (II)

Network synthesis filters	Image impedance filters	Simple filters
Butterworth filter	Constant k filter	RL filter
Chebyshev filter	m-derived filter	RC filter
Elliptic (Cauer) filter	General image filters	RLC filter
Bessel filter	Zobel network (constant R) filter	LC filter
Gaussian filter	Lattice filter (all-pass)	
Optimum "L" (Legendre) filter	Bridged T delay equaliser (all-pass)	
Linkwitz-Riley filter	Composite image filter	
	mm'-type filter	

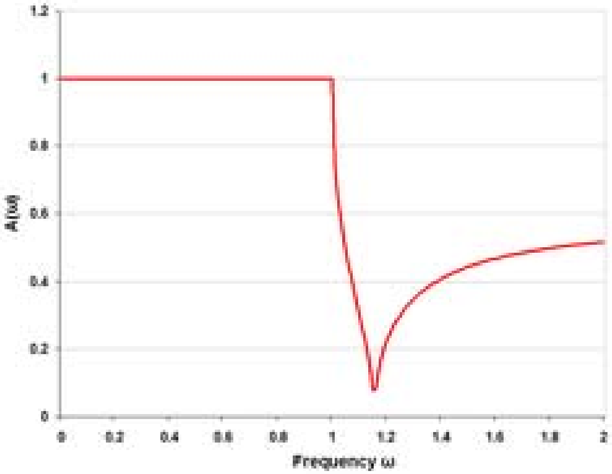
Tipologie di filtro: Image impedance



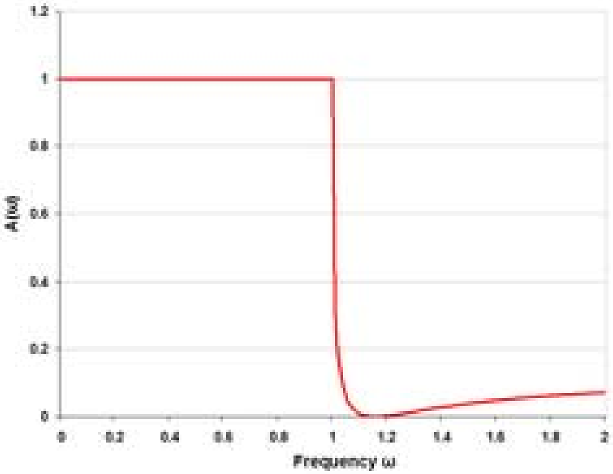
Constant k filter response with 5 elements



Zobel network (constant R) filter, 5 sections



m-derived filter response, m=0.5, 2 elements

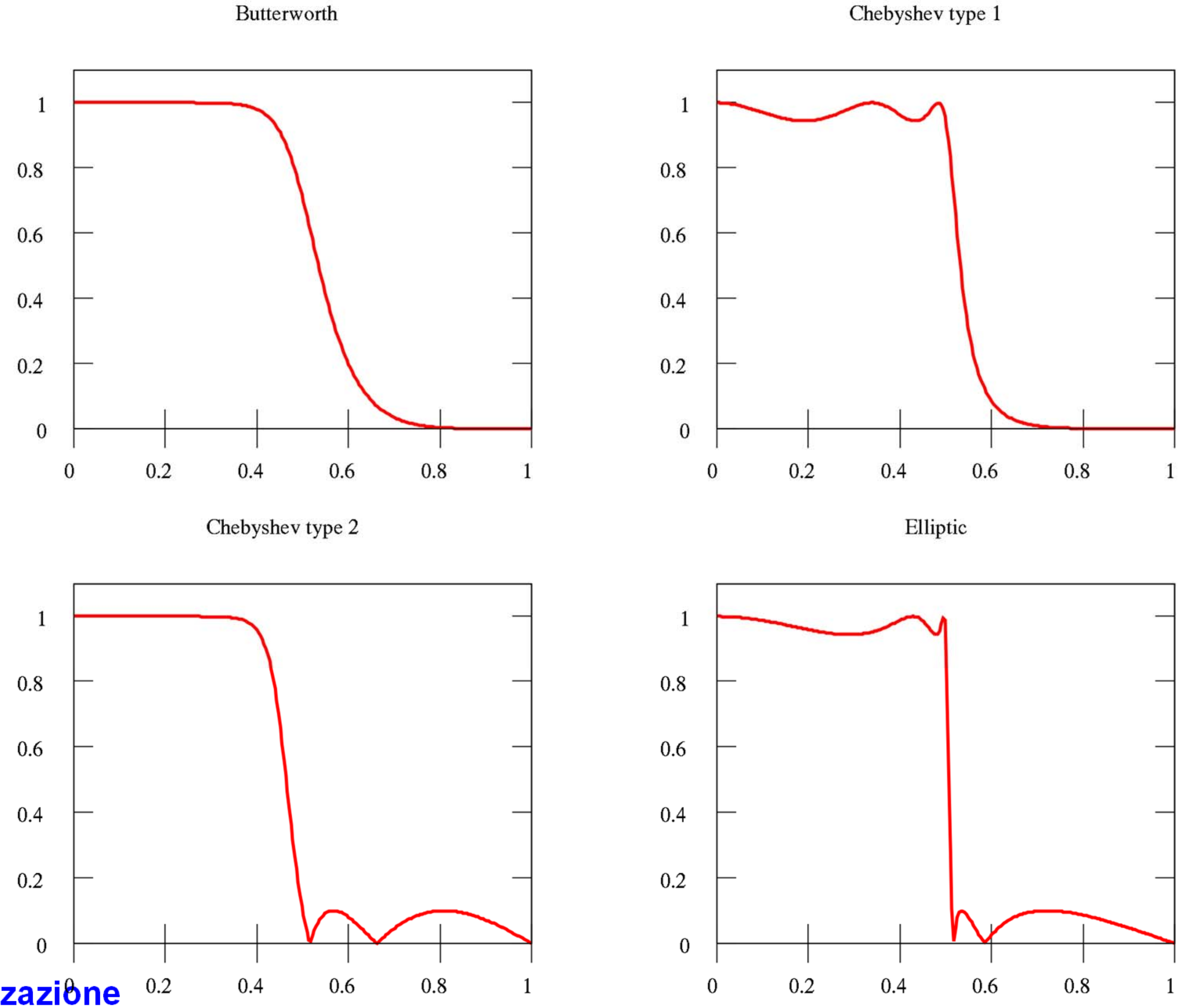


m-derived filter response, m=0.5, 5 element

Tipologie di filtro: Network synthesis

Here is an image comparing Butterworth, Chebyshev, and elliptic filters. The filters in this illustration are all fifth-order low-pass filters.

As is clear from the image, elliptic filters are sharper than all the others, but they show ripples on the whole bandwidth.



Tipologie di filtro: Network synthesis (I)

- **Active filters**

Active filters are implemented using a combination of passive and active (amplifying) components, and require an outside power source. Operational amplifiers are frequently used in active filter designs. These can have high *Q*, and can achieve resonance without the use of inductors. However, their upper frequency limit is limited by the bandwidth of the amplifiers used.

- **Digital filters**

Main article: digital filter
A general finite impulse response filter with *n* stages, each with an independent delay, d_i and amplification gain, a_i.
Digital signal processing allows the inexpensive construction of a wide variety of filters. The signal is sampled and an analog-to-digital converter turns the signal into a stream of numbers. A computer program running on a CPU or a specialized DSP (or less often running on a hardware implementation of the algorithm) calculates an output number stream. This output can be converted to a signal by passing it through a digital-to-analog converter. There are problems with noise introduced by the conversions, but these can be controlled and limited for many useful filters. Due to the sampling involved, the input signal must be of limited frequency content or aliasing will occur.

Tipologie di filtro: Network synthesis (II)

- **Quartz filters and piezoelectrics**

See also: Mechanical filter
In the late 1930s, engineers realized that small mechanical systems made of rigid materials such as quartz would acoustically resonate at radio frequencies, i.e. from audible frequencies (sound) up to several hundred megahertz. Some early resonators were made of steel, but quartz quickly became favored. The biggest advantage of quartz is that it is piezoelectric. This means that quartz resonators can directly convert their own mechanical motion into electrical signals. Quartz also has a very low coefficient of thermal expansion which means that quartz resonators can produce stable frequencies over a wide temperature range. Quartz crystal filters have much higher quality factors than LCR filters. When higher stabilities are required, the crystals and their driving circuits may be mounted in a "crystal oven" to control the temperature. For very narrow band filters, sometimes several crystals are operated in series.
Engineers realized that a large number of crystals could be collapsed into a single component, by mounting comb-shaped evaporations of metal on a quartz crystal. In this scheme, a "tapped delay line" reinforces the desired frequencies as the sound waves flow across the surface of the quartz crystal. The tapped delay line has become a general scheme of making high-*Q* filters in many different ways.

Tipologie di filtro: Network synthesis (III)

- **SAW filters**

SAW (surface acoustic wave) filters are electromechanical devices commonly used in radio frequency applications. Electrical signals are converted to a mechanical wave in a device constructed of a piezoelectric crystal or ceramic; this wave is delayed as it propagates across the device, before being converted back to an electrical signal by further electrodes. The delayed outputs are recombined to produce a direct analog implementation of a finite impulse response filter. This hybrid filtering technique is also found in an analog sampled filter. SAW filters are limited to frequencies up to 3 GHz.

- **BAW filters**

BAW (Bulk Acoustic Wave) filters are electromechanical devices. BAW filters can implement ladder or lattice filters. BAW filters typically operate at frequencies from around 2 to around 16 GHz, and in may be smaller or thinner than equivalent SAW filters. Two main variants of BAW filters are making their way into devices, Thin film bulk acoustic resonator or FBAR and Solid Mounted Bulk Acoustic Resonators.

Tipologie di filtro: Network synthesis (IV)

- **Garnet filters**

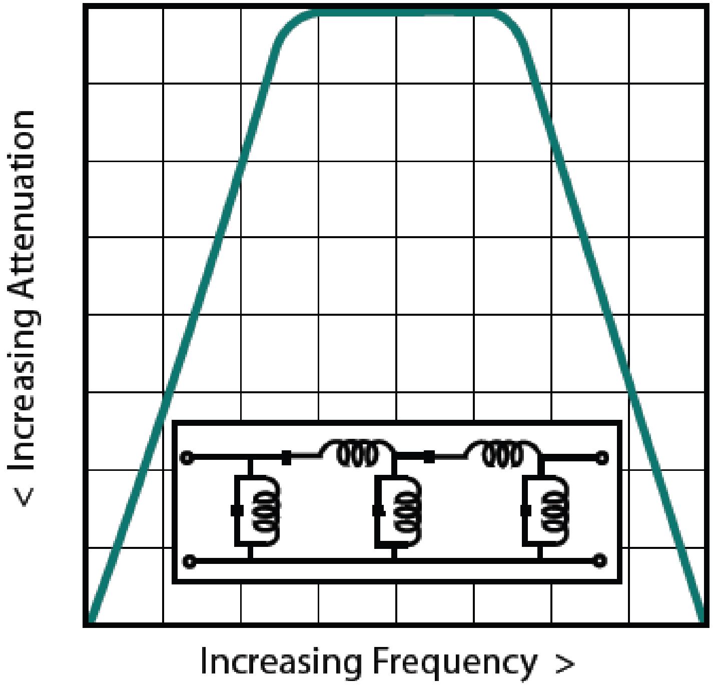
Main article: Yttrium iron garnet filter

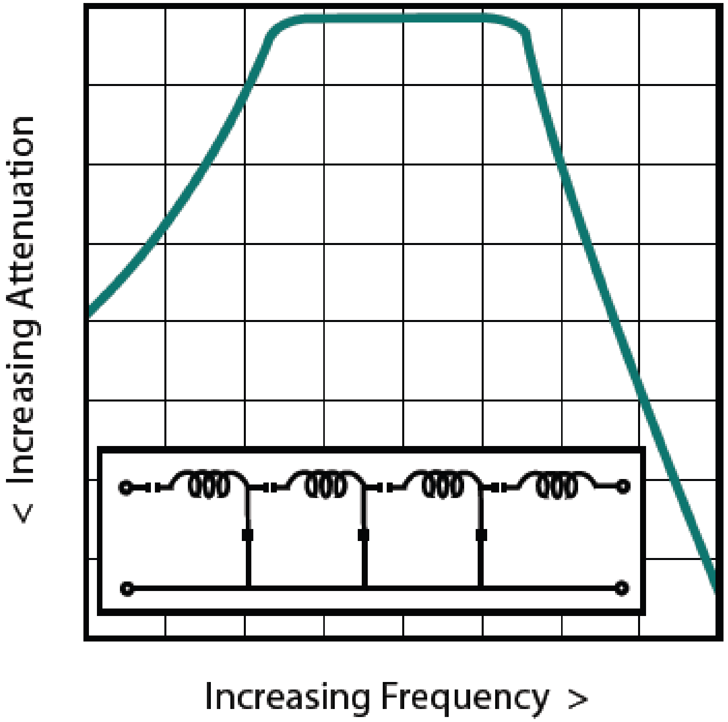
Another method of filtering, at microwave frequencies from 800 MHz to about 5 GHz, is to use a synthetic single crystal yttrium iron garnet sphere made of a chemical combination of yttrium and iron (**YIGF**, or **yttrium iron garnet filter**). The garnet sits on a strip of metal driven by a transistor, and a small loop antenna touches the top of the sphere. An electromagnet changes the frequency that the garnet will pass. The advantage of this method is that the garnet can be tuned over a very wide frequency by varying the strength of the magnetic field.

- **Atomic filters**

For even higher frequencies and greater precision, the vibrations of atoms must be used. Atomic clocks use caesium masers as ultra-high *Q* filters to stabilize their primary oscillators. Another method, used at high, fixed frequencies with very weak radio signals, is to use a ruby maser tapped delay line.

Topologie di filtro Passabanda (I)





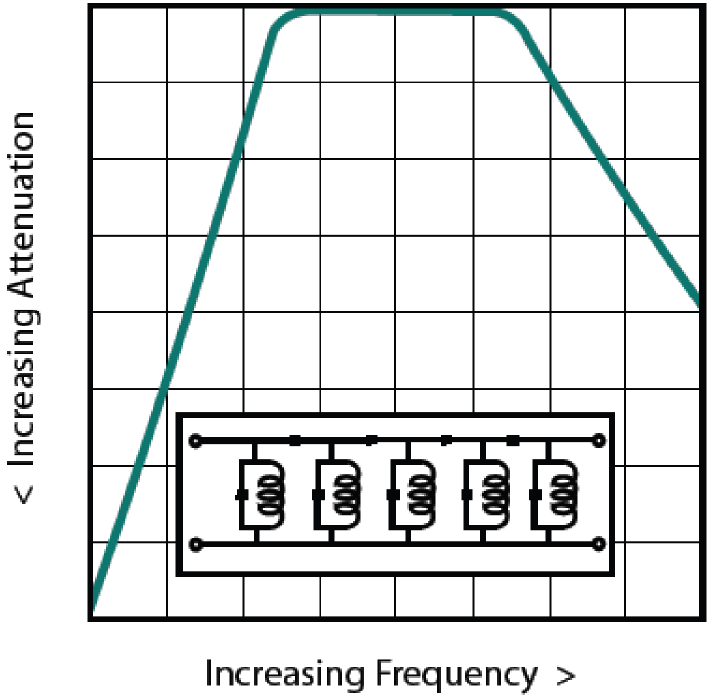
Direct Scaled Bandpass Filters

This is the classical "resonant ladder" used in wideband applications. The circuit is obtained by a lowpass to bandpass transform. Its advantages are geometric symmetry and a small spread of element values when used in circuit transforms.

Mesh Circuit Bandpass Filter

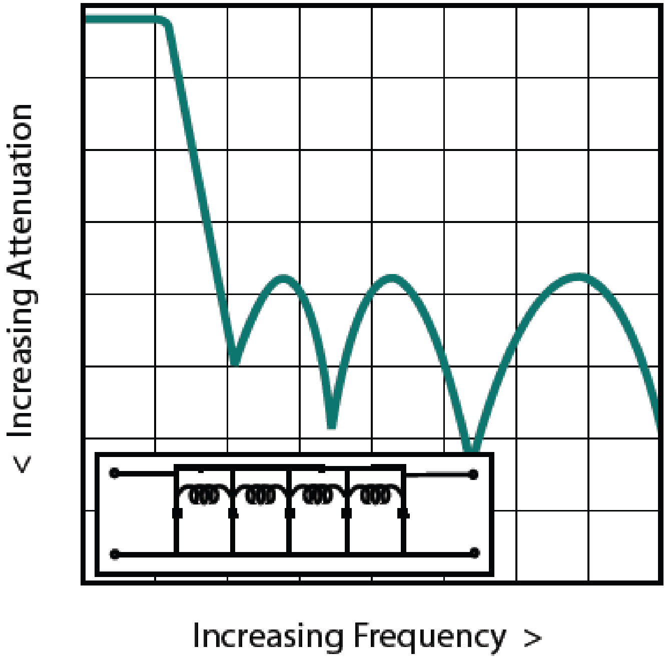
This is the "dual" of the nodal circuit shown. It provides a steeper high side response due to the greater number of zeroes at infinity. This circuit may also use a variety of transforming networks to provide symmetry to the response.

Topologie di filtro Passabanda (II)



Nodal Circuit Bandpass Filters

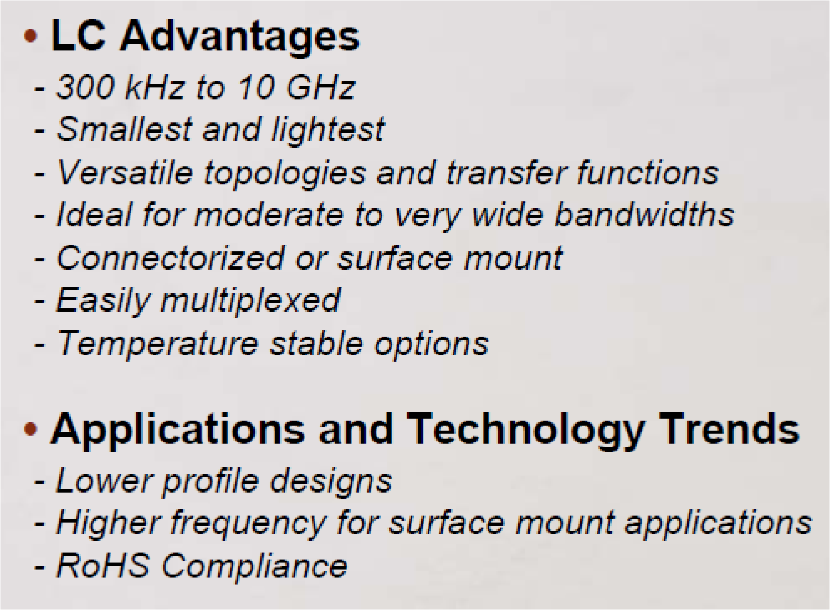
The capacitively coupled nodal circuit provides an excellent configuration for narrowband use. The highside response may be sharpened by the use of a variety of transforming networks.



Elliptic Filter

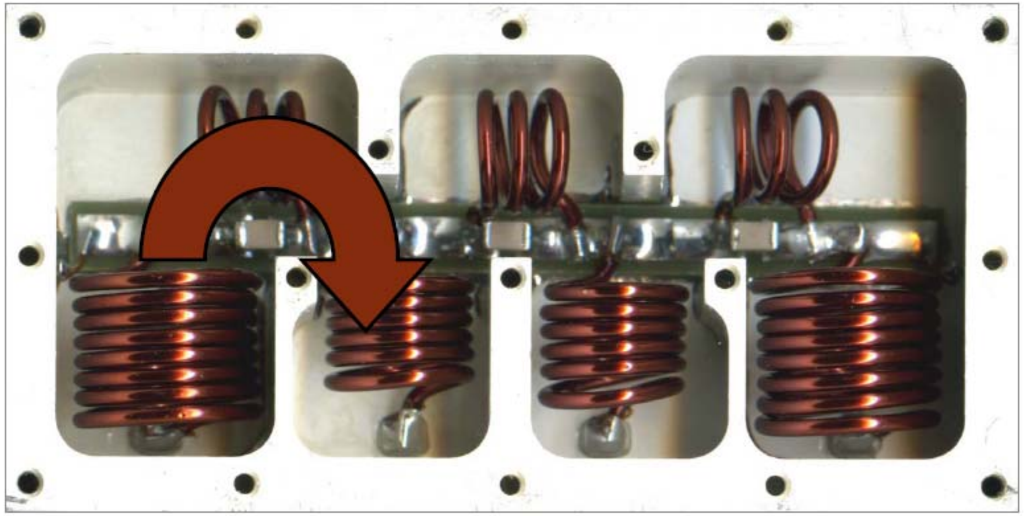
The Elliptic filter (also known as a Cauer response) provides the steepest out of band attenuation of any filter response. This is achieved by adding anti-resonance, or notch sections to the filter. These responses are available in Lowpass, Highpass, Bandpass and Bandstop.

Lumped element filters



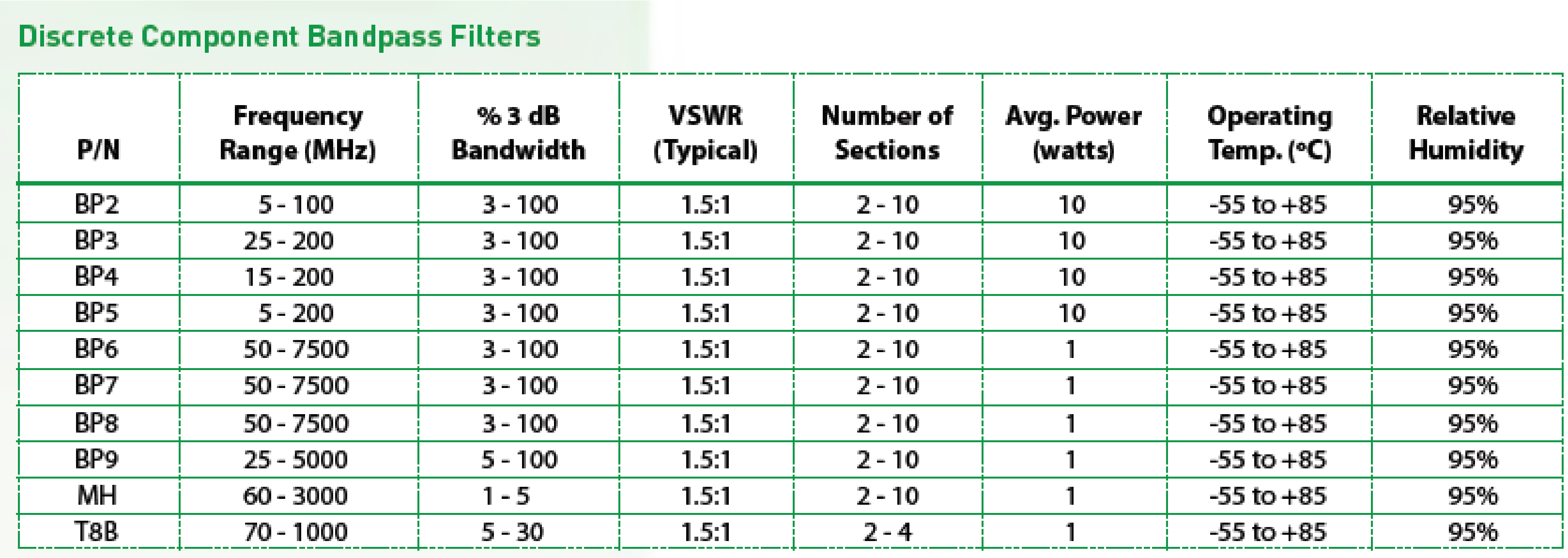
- **LC Advantages**
  - *300 kHz to 10 GHz*
  - *Smallest and lightest*
  - *Versatile topologies and transfer functions*
  - *Ideal for moderate to very wide bandwidths*
  - *Connectorized or surface mount*
  - *Easily multiplexed*
  - *Temperature stable options*

- **Applications and Technology Trends**
  - *Lower profile designs*
  - *Higher frequency for surface mount applications*
  - *RoHS Compliance*



Discrete component filters (I)

- 5 MHz to 7.5 GHz
- 3 dB Bandwidths from 1% to >100%
- Computer-Aided Designs
- 10 Stock Series
- Custom & Dielectric Resonator Designs

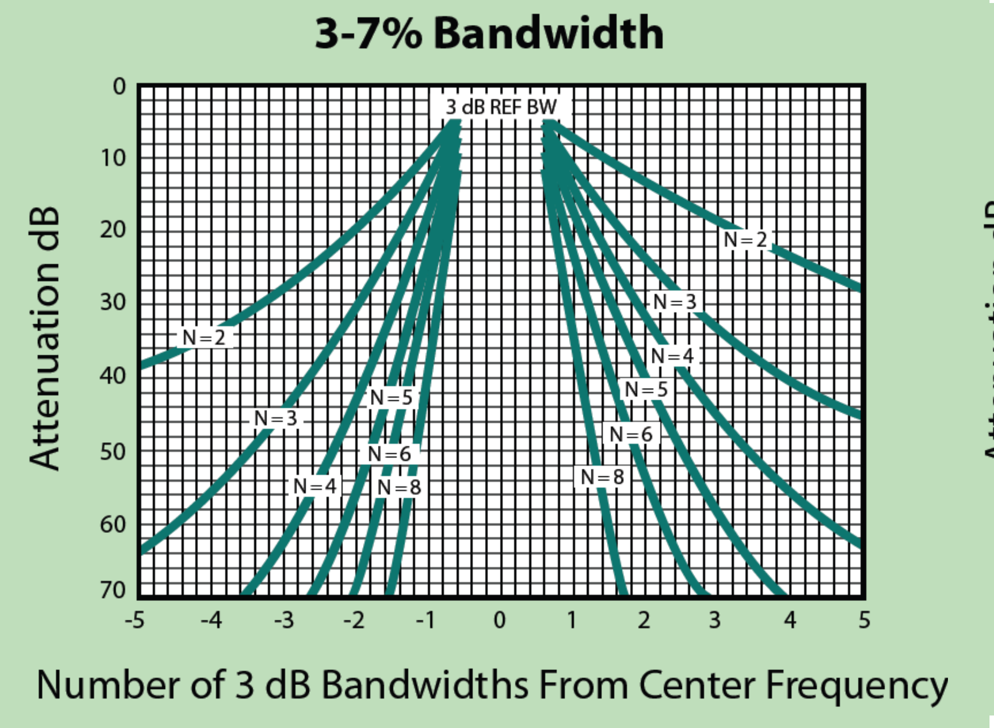


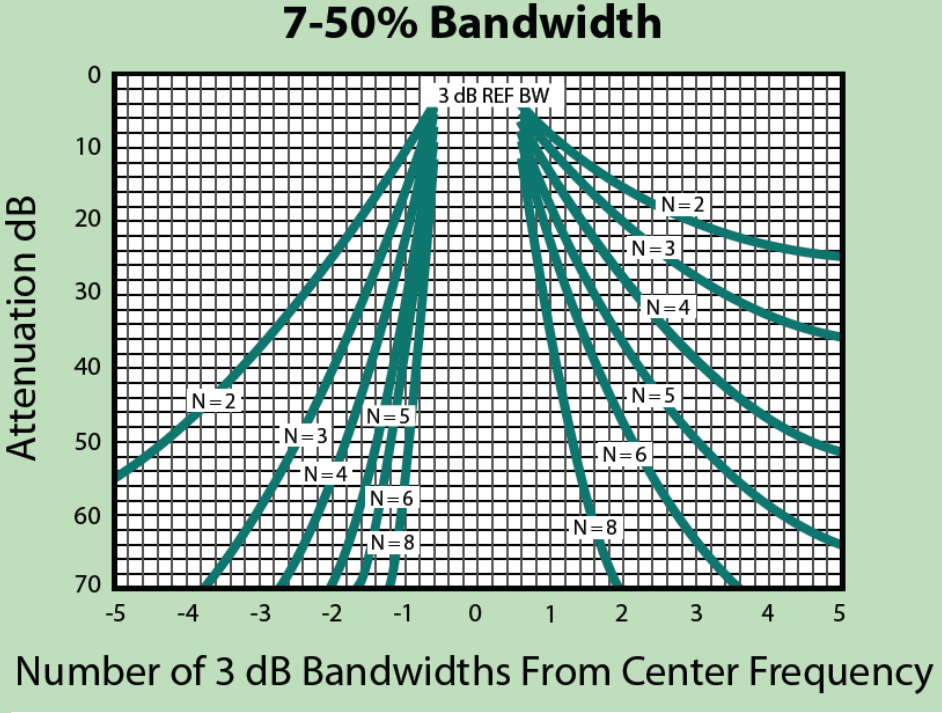
Discrete Component Bandpass Filters

P/N	Frequency Range (MHz)	% 3 dB Bandwidth	VSWR (Typical)	Number of Sections	Avg. Power (watts)	Operating Temp. (°C)	Relative Humidity
BP2	5 - 100	3 - 100	1.5:1	2 - 10	10	-55 to +85	95%
BP3	25 - 200	3 - 100	1.5:1	2 - 10	10	-55 to +85	95%
BP4	15 - 200	3 - 100	1.5:1	2 - 10	10	-55 to +85	95%
BP5	5 - 200	3 - 100	1.5:1	2 - 10	10	-55 to +85	95%
BP6	50 - 7500	3 - 100	1.5:1	2 - 10	1	-55 to +85	95%
BP7	50 - 7500	3 - 100	1.5:1	2 - 10	1	-55 to +85	95%
BP8	50 - 7500	3 - 100	1.5:1	2 - 10	1	-55 to +85	95%
BP9	25 - 5000	5 - 100	1.5:1	2 - 10	1	-55 to +85	95%
MH	60 - 3000	1 - 5	1.5:1	2 - 10	1	-55 to +85	95%
T8B	70 - 1000	5 - 30	1.5:1	2 - 4	1	-55 to +85	95%

LORCH MICROWAVE

Discrete component filters (II)


3-7% Bandwidth


7-50% Bandwidth

Bandpass Filter Electrical Performance

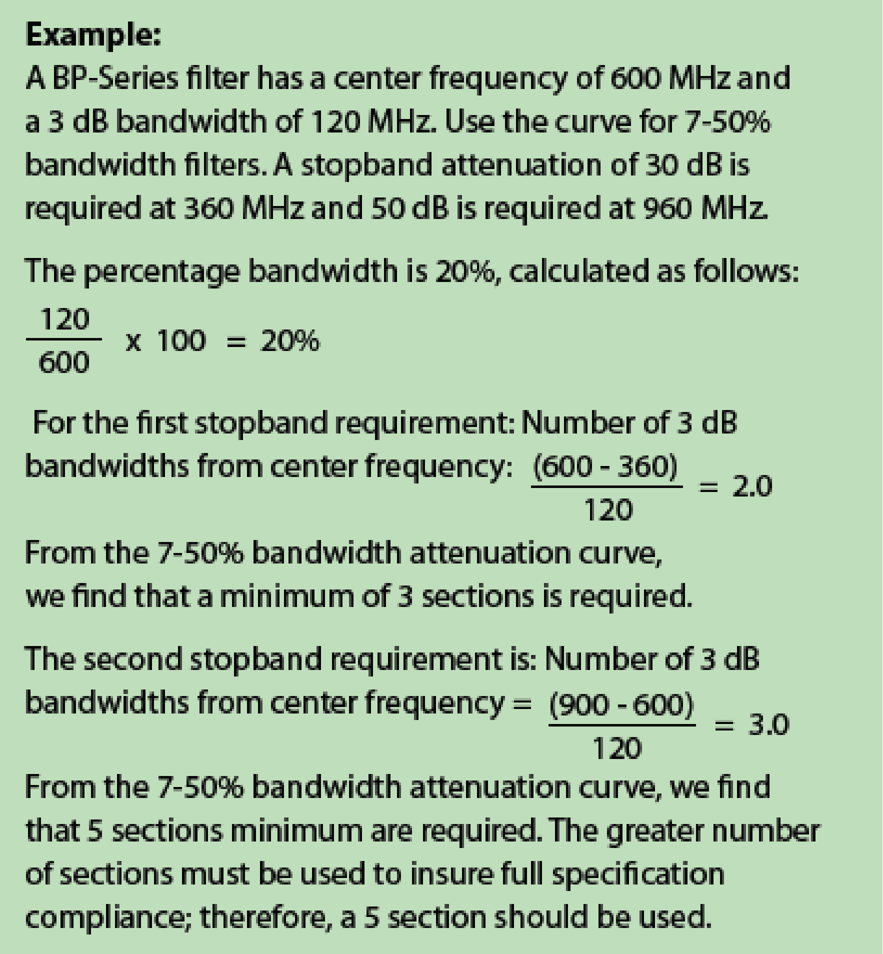
Series	Frequency (MHz)	Loss Constant
BP2-BP9, T8B	5 - 100	9.5
BP3-BP9, T8B	101 - 1000	6.8
BP6-BP9, T8B	1001 - 7500	5.0
MH	60 - 3000	4.0

Insertion Loss Calculation

Knowing the number of sections, center frequency and bandwidth of the filter, insertion loss may be calculated using the following formula:

$$IL = \frac{(\text{Loss Constant}) \times (N - 1.5)}{(\%3\text{dB BW})} + 0.2$$

Discrete component filters (III)



Example:

A BP-Series filter has a center frequency of 600 MHz and a 3 dB bandwidth of 120 MHz. Use the curve for 7-50% bandwidth filters. A stopband attenuation of 30 dB is required at 360 MHz and 50 dB is required at 960 MHz.

The percentage bandwidth is 20%, calculated as follows:

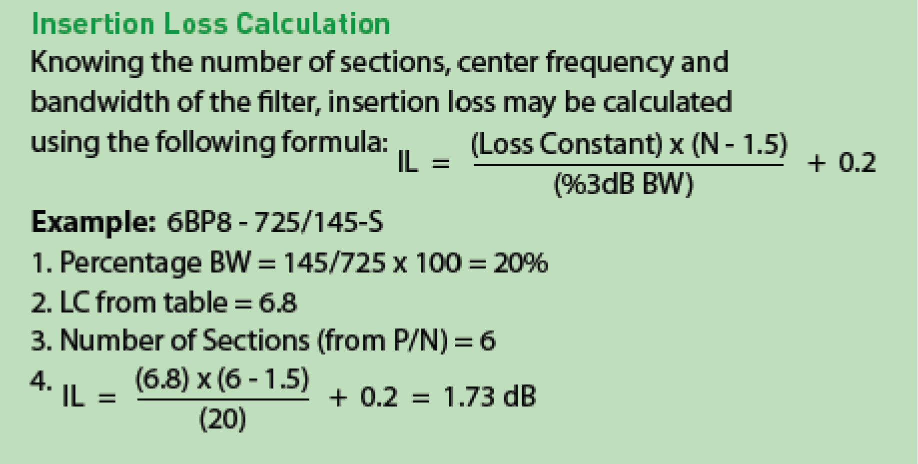
$$\frac{120}{600} \times 100 = 20\%$$

For the first stopband requirement: Number of 3 dB bandwidths from center frequency: $\frac{(600 - 360)}{120} = 2.0$

From the 7-50% bandwidth attenuation curve, we find that a minimum of 3 sections is required.

The second stopband requirement is: Number of 3 dB bandwidths from center frequency = $\frac{(900 - 600)}{120} = 3.0$

From the 7-50% bandwidth attenuation curve, we find that 5 sections minimum are required. The greater number of sections must be used to insure full specification compliance; therefore, a 5 section should be used.



Insertion Loss Calculation

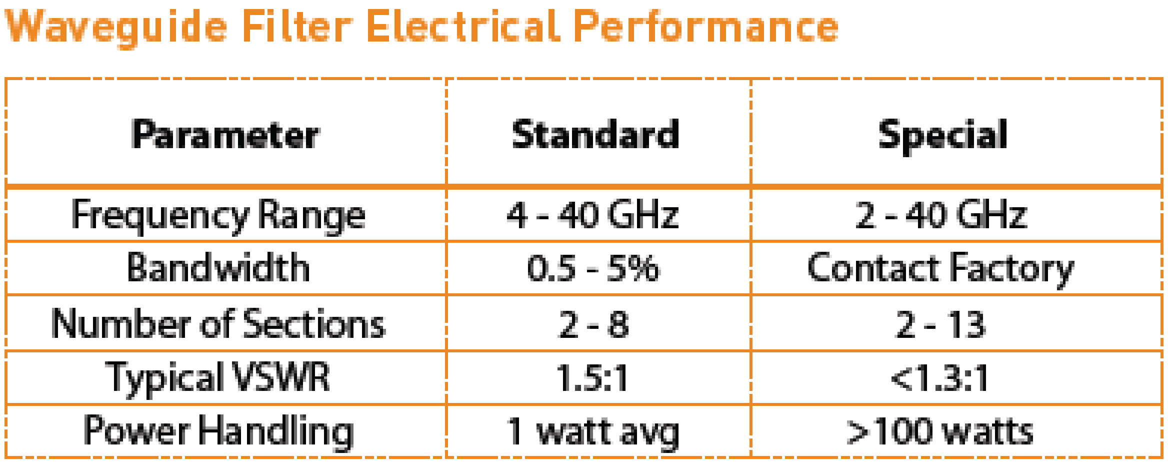
Knowing the number of sections, center frequency and bandwidth of the filter, insertion loss may be calculated using the following formula: $IL = \frac{(\text{Loss Constant}) \times (N - 1.5)}{(\%3\text{dB BW})} + 0.2$

Example: 6BP8 - 725/145-S

1. Percentage BW = 145/725 x 100 = 20%
2. LC from table = 6.8
3. Number of Sections (from P/N) = 6
4. $IL = \frac{(6.8) \times (6 - 1.5)}{(20)} + 0.2 = 1.73\text{ dB}$

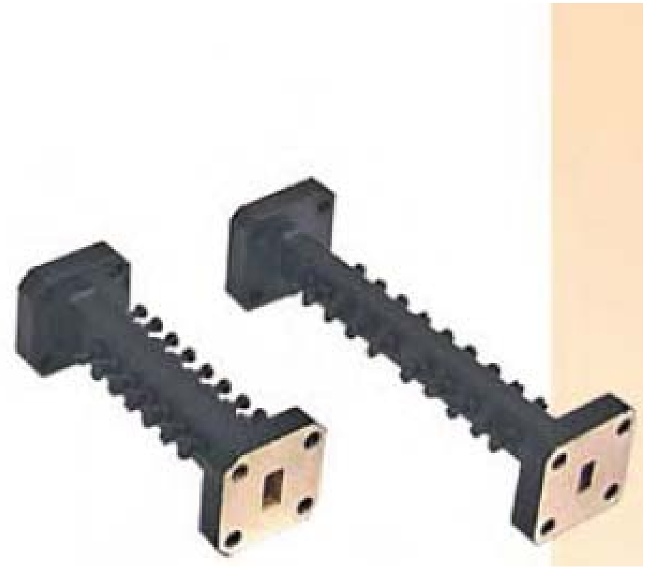
LORCH MICROWAVE

Waveguide filters

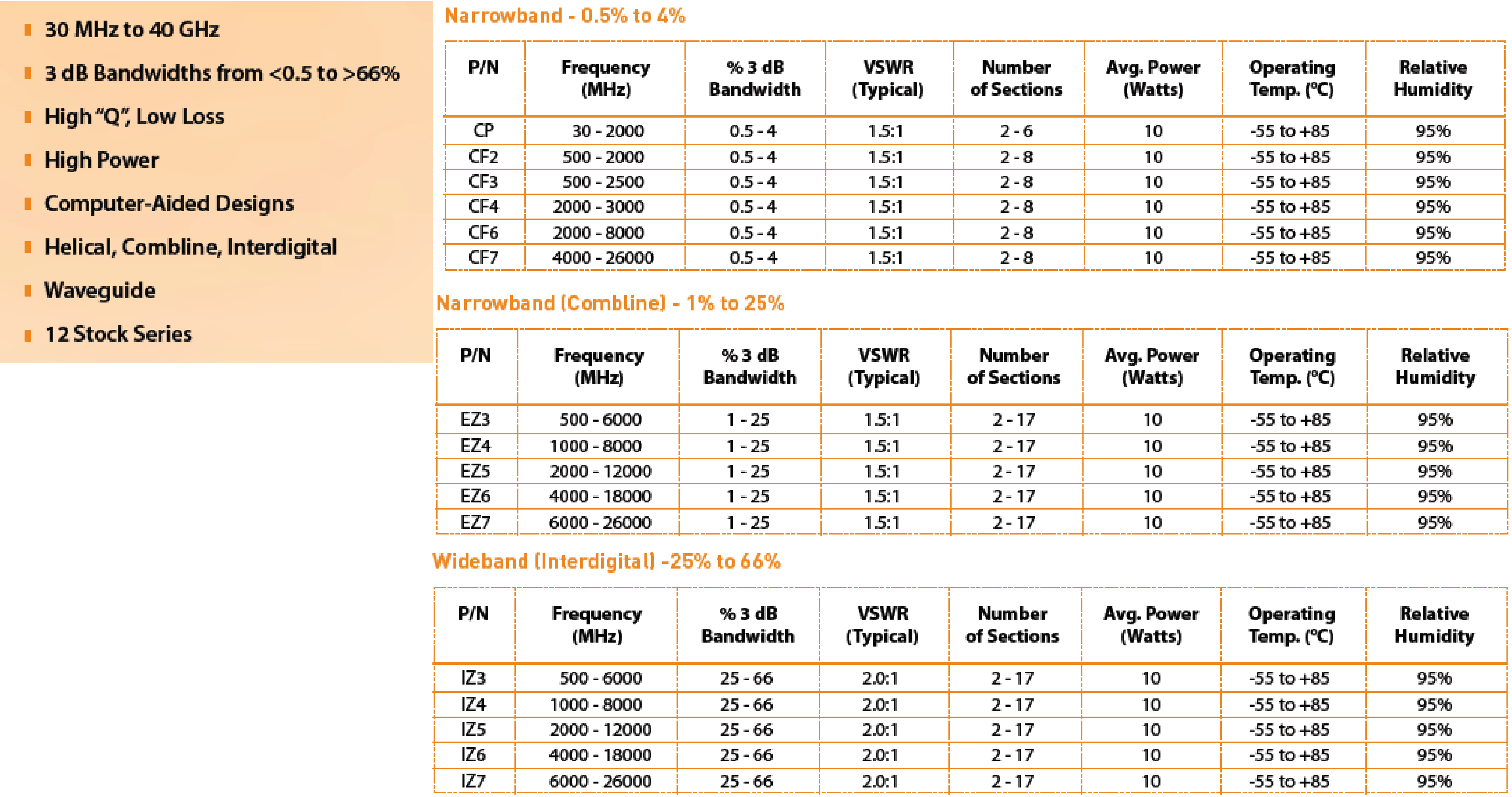


Waveguide Filter Electrical Performance

Parameter	Standard	Special
Frequency Range	4 - 40 GHz	2 - 40 GHz
Bandwidth	0.5 - 5%	Contact Factory
Number of Sections	2 - 8	2 - 13
Typical VSWR	1.5:1	<1.3:1
Power Handling	1 watt avg	>100 watts



Cavity filters (I)



- 30 MHz to 40 GHz
- 3 dB Bandwidths from <0.5 to >66%
- High "Q", Low Loss
- High Power
- Computer-Aided Designs
- Helical, Combline, Interdigital
- Waveguide
- 12 Stock Series

Narrowband - 0.5% to 4%

P/N	Frequency (MHz)	% 3 dB Bandwidth	VSWR (Typical)	Number of Sections	Avg. Power (Watts)	Operating Temp. (°C)	Relative Humidity
CP	30 - 2000	0.5 - 4	1.5:1	2 - 6	10	-55 to +85	95%
CF2	500 - 2000	0.5 - 4	1.5:1	2 - 8	10	-55 to +85	95%
CF3	500 - 2500	0.5 - 4	1.5:1	2 - 8	10	-55 to +85	95%
CF4	2000 - 3000	0.5 - 4	1.5:1	2 - 8	10	-55 to +85	95%
CF6	2000 - 8000	0.5 - 4	1.5:1	2 - 8	10	-55 to +85	95%
CF7	4000 - 26000	0.5 - 4	1.5:1	2 - 8	10	-55 to +85	95%

Narrowband (Combline) - 1% to 25%

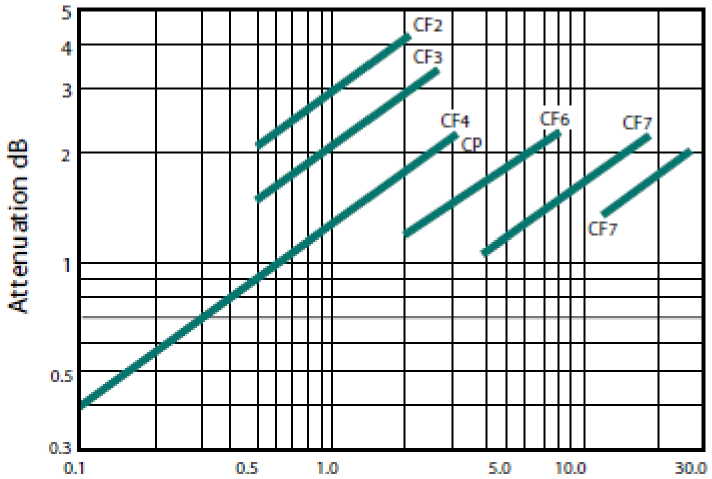
P/N	Frequency (MHz)	% 3 dB Bandwidth	VSWR (Typical)	Number of Sections	Avg. Power (Watts)	Operating Temp. (°C)	Relative Humidity
EZ3	500 - 6000	1 - 25	1.5:1	2 - 17	10	-55 to +85	95%
EZ4	1000 - 8000	1 - 25	1.5:1	2 - 17	10	-55 to +85	95%
EZ5	2000 - 12000	1 - 25	1.5:1	2 - 17	10	-55 to +85	95%
EZ6	4000 - 18000	1 - 25	1.5:1	2 - 17	10	-55 to +85	95%
EZ7	6000 - 26000	1 - 25	1.5:1	2 - 17	10	-55 to +85	95%

Wideband (Interdigital) -25% to 66%

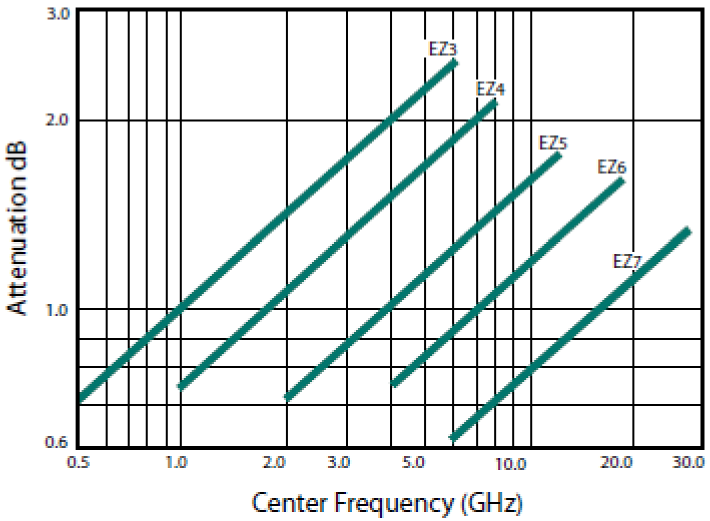
P/N	Frequency (MHz)	% 3 dB Bandwidth	VSWR (Typical)	Number of Sections	Avg. Power (Watts)	Operating Temp. (°C)	Relative Humidity
IZ3	500 - 6000	25 - 66	2.0:1	2 - 17	10	-55 to +85	95%
IZ4	1000 - 8000	25 - 66	2.0:1	2 - 17	10	-55 to +85	95%
IZ5	2000 - 12000	25 - 66	2.0:1	2 - 17	10	-55 to +85	95%
IZ6	4000 - 18000	25 - 66	2.0:1	2 - 17	10	-55 to +85	95%
IZ7	6000 - 26000	25 - 66	2.0:1	2 - 17	10	-55 to +85	95%

Cavity filters (II)

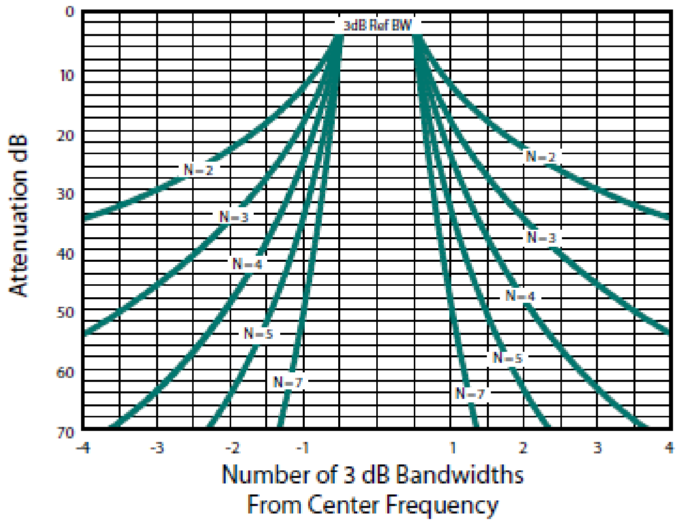
“Q”-CF, CP Series, Narrowband Cavities



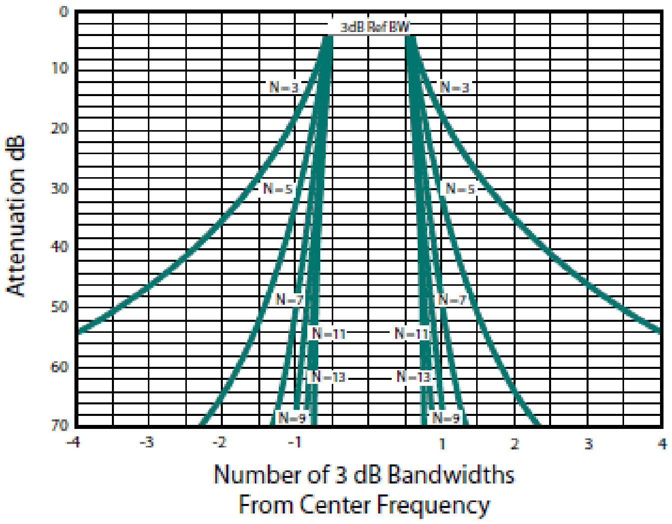
“Q”-EZ, IZ Series, Wideband Cavities



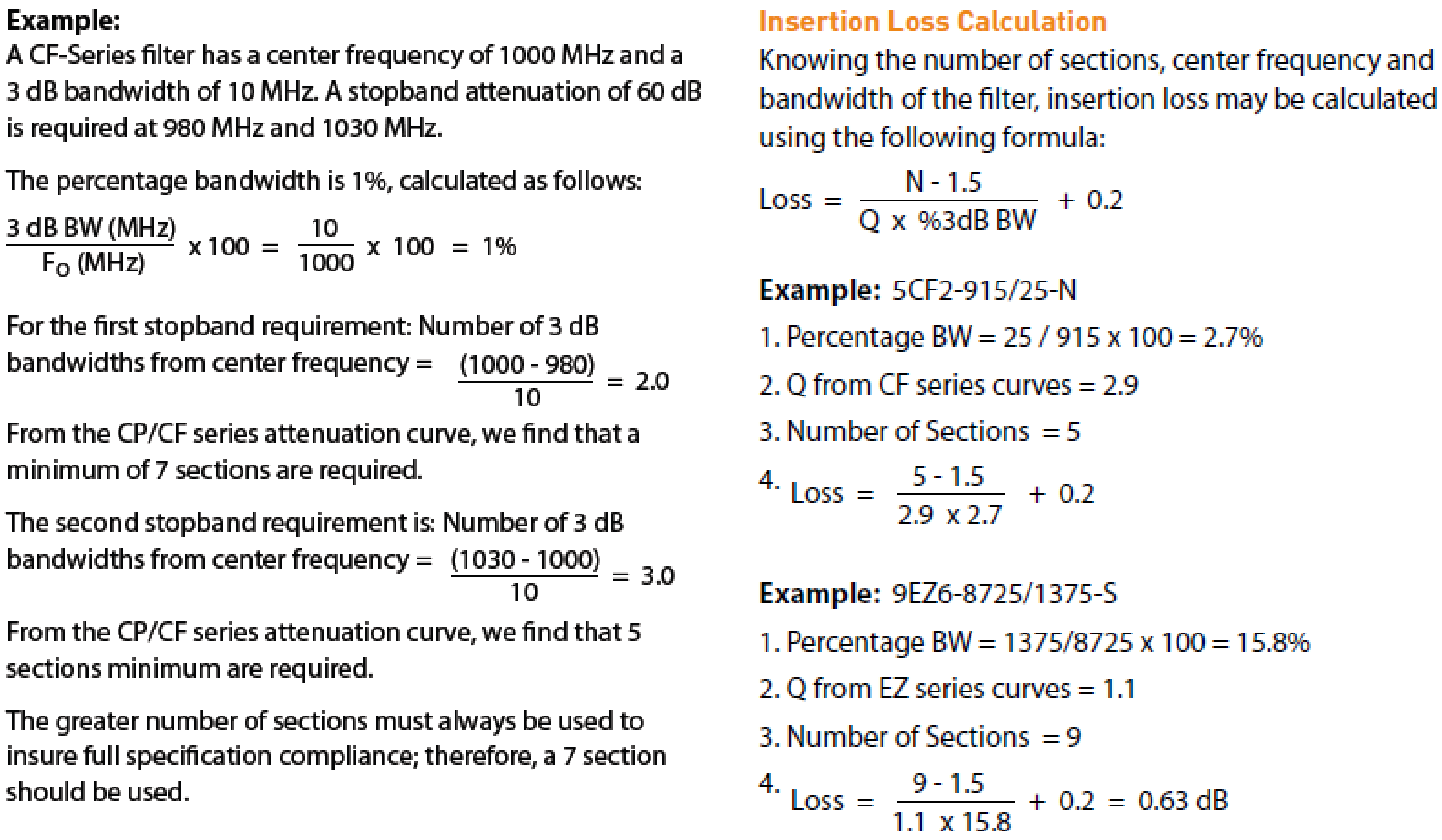
CP and CF Series Attenuation Characteristics



EZ and IZ Series Attenuation Characteristics



Cavity filters (III)



Example:
A CF-Series filter has a center frequency of 1000 MHz and a 3 dB bandwidth of 10 MHz. A stopband attenuation of 60 dB is required at 980 MHz and 1030 MHz.

The percentage bandwidth is 1%, calculated as follows:

$$\frac{\text{3 dB BW (MHz)}}{F_O\ \text{(MHz)}} \times 100 = \frac{10}{1000} \times 100 = 1\%$$

For the first stopband requirement: Number of 3 dB bandwidths from center frequency = $\frac{(1000 - 980)}{10} = 2.0$

From the CP/CF series attenuation curve, we find that a minimum of 7 sections are required.

The second stopband requirement is: Number of 3 dB bandwidths from center frequency = $\frac{(1030 - 1000)}{10} = 3.0$

From the CP/CF series attenuation curve, we find that 5 sections minimum are required.

The greater number of sections must always be used to insure full specification compliance; therefore, a 7 section should be used.

Insertion Loss Calculation

Knowing the number of sections, center frequency and bandwidth of the filter, insertion loss may be calculated using the following formula:

$$\text{Loss} = \frac{N - 1.5}{Q \times \%3\text{dB BW}} + 0.2$$

Example: 5CF2-915/25-N

1. Percentage BW = 25 / 915 x 100 = 2.7%
2. Q from CF series curves = 2.9
3. Number of Sections = 5
4. $\text{Loss} = \frac{5 - 1.5}{2.9 \times 2.7} + 0.2$

Example: 9EZ6-8725/1375-S

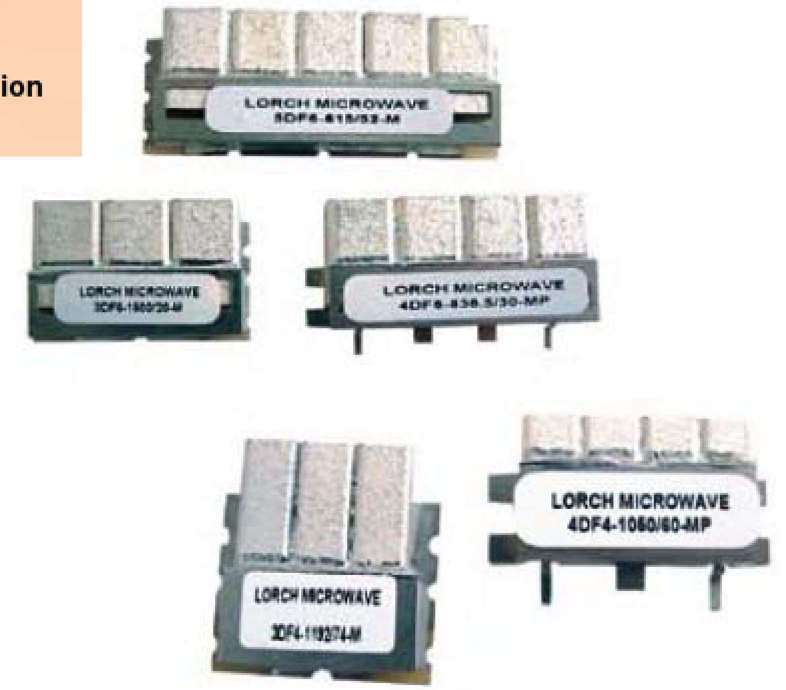
1. Percentage BW = 1375/8725 x 100 = 15.8%
2. Q from EZ series curves = 1.1
3. Number of Sections = 9
4. $\text{Loss} = \frac{9 - 1.5}{1.1 \times 15.8} + 0.2 = 0.63\ \text{dB}$

Ceramic filters (I)

- 400 MHz to 6000 MHz
- Bandwidths: 0.5 to 10%
- Surface Mount, PC Mount, Connectorized Options
- Custom Configurations Available
- 2 to 6 Poles in Single, Diplexed or Triplexed Configurations
- Low Cost, High Performance
- Fast Delivery
- Low to High Volume Production Quantities

Ceramic Electrical Performance

Parameter	Standard	Special
Frequency Range	400 - 5000 MHz	400 - 6000 MHz
Bandwidth	0.5 - 5%	0.1 - 25%
Number of Sections	2 - 6	2 - 8
Typical VSWR	2.0:1	<1.5:1
Power Handling	1 watt average	Contact Factory
Temperature Range	-20 to + 70° C	-55 to + 125° C

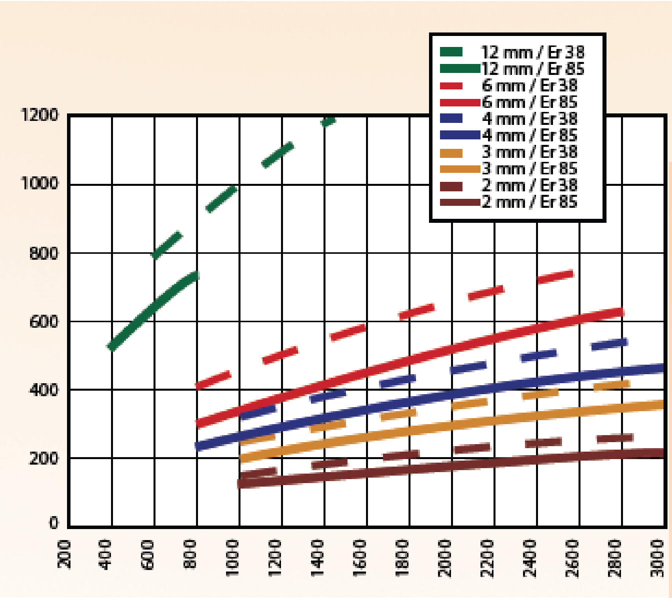


Ceramic filters (II)

Filter Attenuation

The attenuation curve below shows the typical shape for the coaxial resonators for n=2 thru n=6. Use the formula below to determine the number of sections needed for the required attenuation.

$$\frac{\text{Stopband Frequency - Center Frequency}}{\text{3 dB Bandwidth}}$$



Insertion Loss Calculation

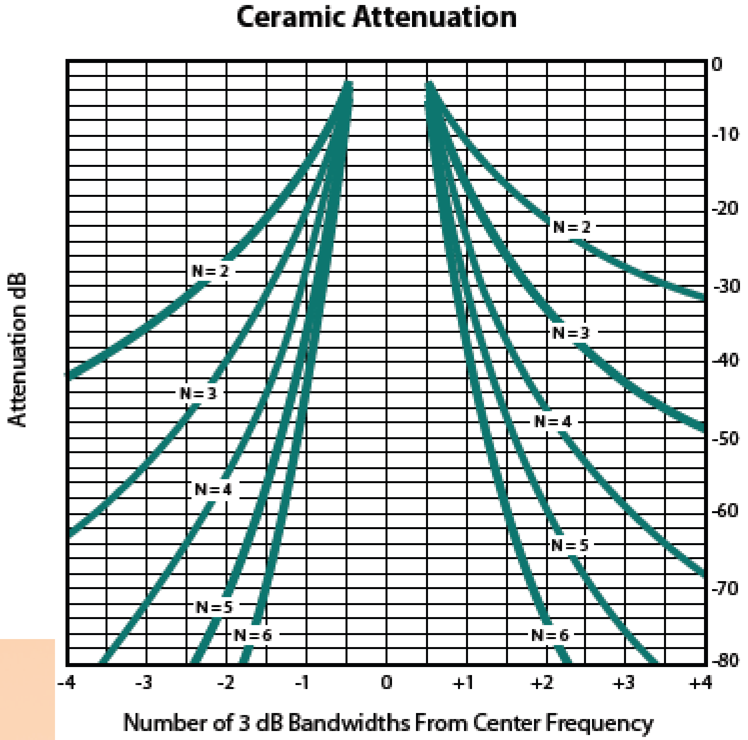
Parameters needed:

1) Number of Sections (N)
2) Typical Resonator Qu (Qu)
3) Center Frequency (F_O)
4) 3 dB Bandwidth (BW)

$Ql = F_O/BW$
$K = Qu/Ql$

The formula is as follows:

$I.L. = N*.63*20*LOG10(1+(1/(K-1)))$



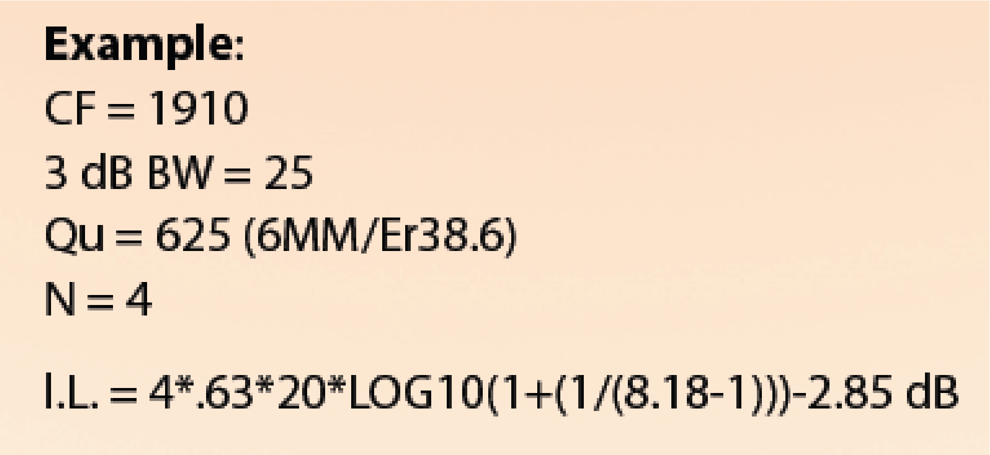
Ceramic filters (III)

Example:

Center frequency = 1910 MHz
3 dB BW = 25 MHz
Stopband Frequency = 2000 MHz
Attenuation = >50 dB

$$\frac{2000 - 1910}{25} = +3.6$$

It is determined that 4 sections are required to meet >50 dB attenuation at 2000 MHz



Example:

CF = 1910
3 dB BW = 25
Qu = 625 (6MM/Er38.6)
N = 4

I.L. = 4*.63*20*LOG10(1+(1/(8.18-1)))-2.85 dB

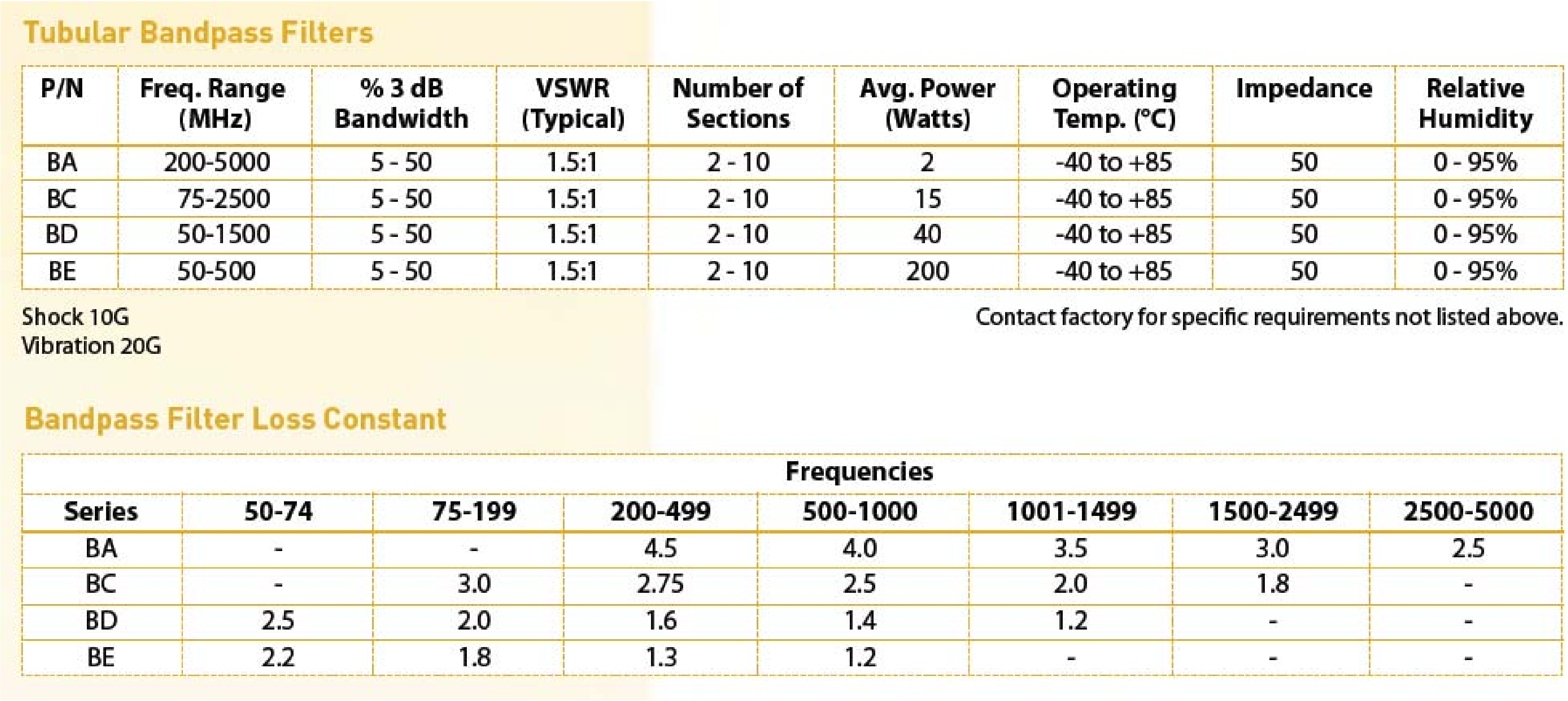
Tubular filters (I)

- 50 MHz to 20 GHz
- Chebyshev Response Standard
- Four Convenient Sizes
- Reliable Sturdy Construction

Lorch Microwave tubular filters are available in bandpass and lowpass configurations. A low ripple Chebyshev transfer function is standard for both models. These units are available with up to a 10 section response. The bandpass units exhibit high side sharp attenuation characteristics. All tubular filters are available in diameters of .25, .5, .75, and 1.25 inches respectively.

Tubular filters are an excellent choice when the designer has space available and needs a cost effective approach. The BC series (½ inch) diameter is the model most often selected as the best compromise between performance and cost with the fastest delivery. Units are of rugged construction and may be found in a variety of military and commercial applications.

Tubular filters (II)



Tubular Bandpass Filters

P/N	Freq. Range (MHz)	% 3 dB Bandwidth	VSWR (Typical)	Number of Sections	Avg. Power (Watts)	Operating Temp. (°C)	Impedance	Relative Humidity
BA	200-5000	5 - 50	1.5:1	2 - 10	2	-40 to +85	50	0 - 95%
BC	75-2500	5 - 50	1.5:1	2 - 10	15	-40 to +85	50	0 - 95%
BD	50-1500	5 - 50	1.5:1	2 - 10	40	-40 to +85	50	0 - 95%
BE	50-500	5 - 50	1.5:1	2 - 10	200	-40 to +85	50	0 - 95%

Shock 10G
Vibration 20G

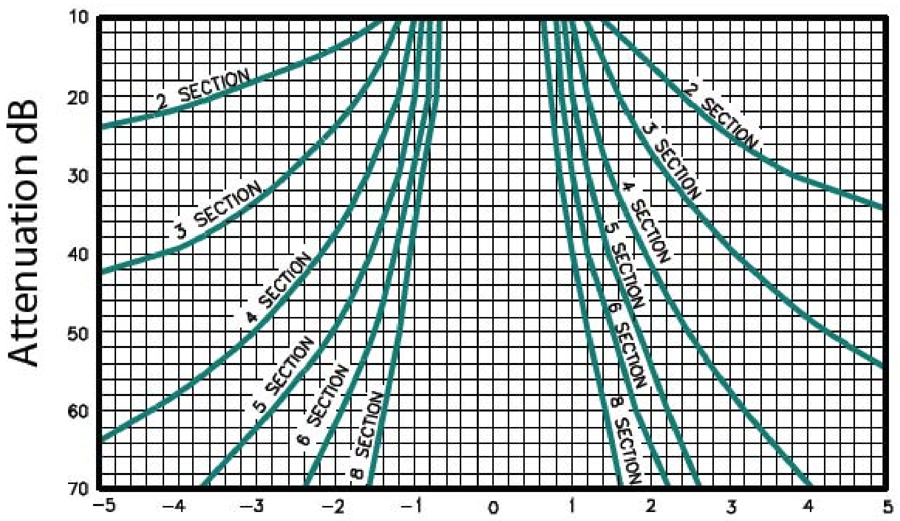
Contact factory for specific requirements not listed above.

Bandpass Filter Loss Constant

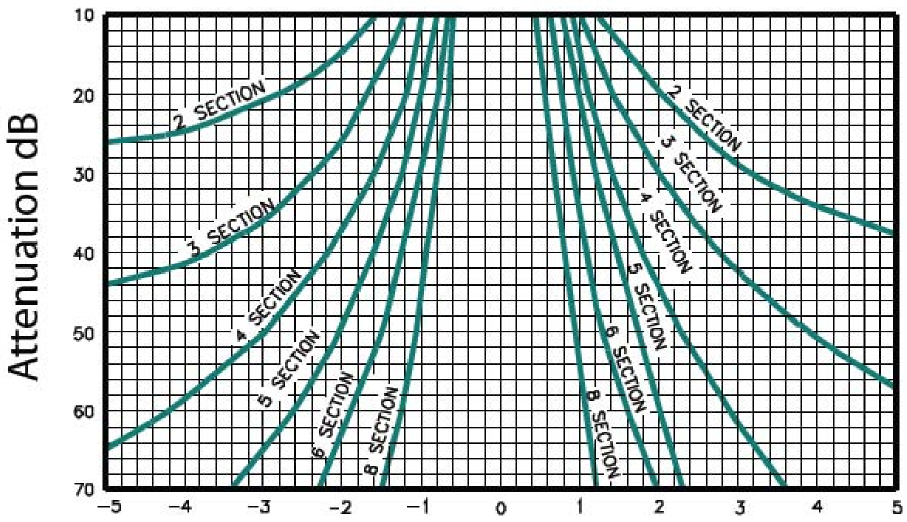
	Frequencies						
Series	50-74	75-199	200-499	500-1000	1001-1499	1500-2499	2500-5000
BA	-	-	4.5	4.0	3.5	3.0	2.5
BC	-	3.0	2.75	2.5	2.0	1.8	-
BD	2.5	2.0	1.6	1.4	1.2	-	-
BE	2.2	1.8	1.3	1.2	-	-	-

Tubular filters (III)

3-10% Bandwidth



10-50% Bandwidth



Calculating Number of Sections

The following curves show the stopband frequencies normalized to the 3 dB bandwidth for filters with 2 to 8 sections. A ratio of stopband frequency to 3 dB bandwidth is used.

The curve given below shows an asymmetric frequency response resulting from the circuit used. Other schematics may be utilized to yield different attenuation characteristics (i.e. steeper on the high frequency side of the passband and shallower on the low side).

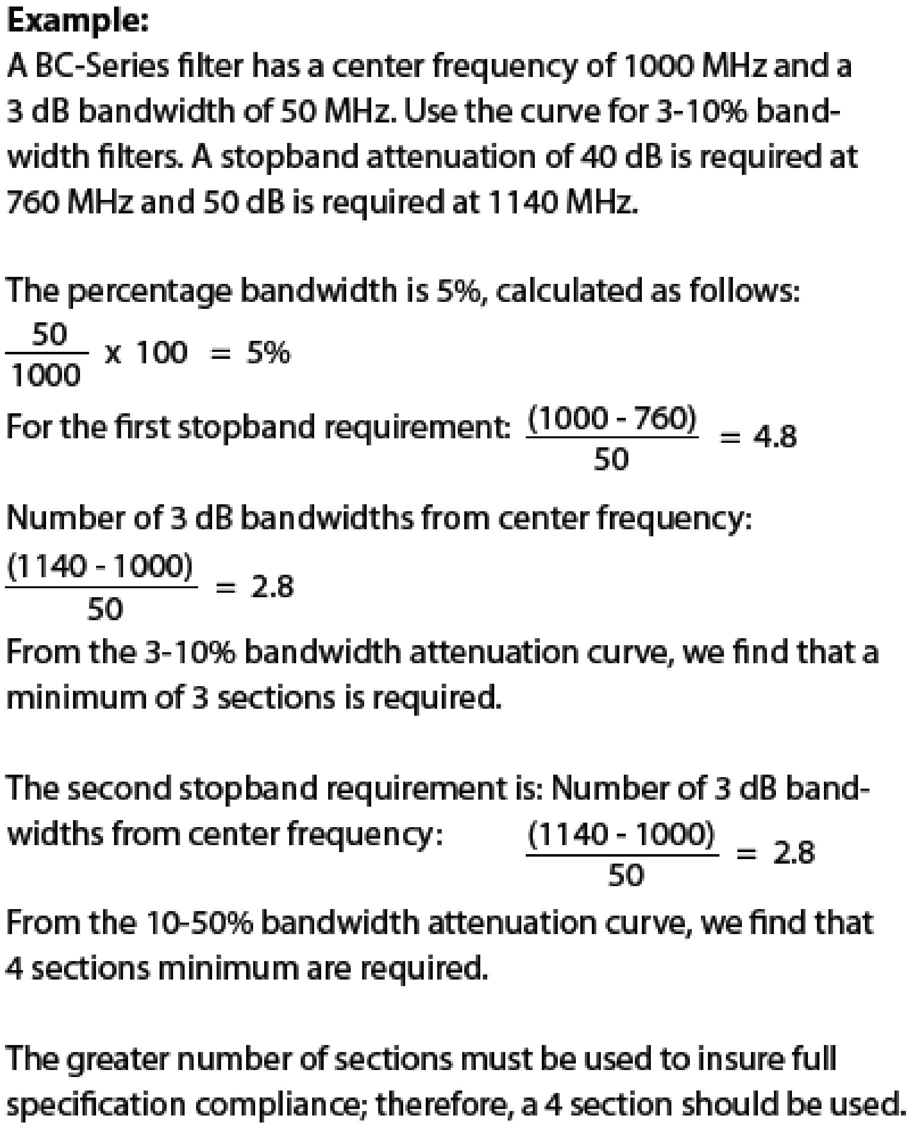
When considering the use of a tubular bandpass filter the following "Rule of Thumb" is useful: "For a given bandwidth, the larger the diameter of the tubular…a) the lower the frequency of operation; b) the lower the insertion loss; c) the greater the selectivity. The inverse is true when decreasing the diameter."

Insertion Loss Calculation

Knowing the number of sections, center frequency and bandwidth of the filter, insertion loss may be calculated using the following formula:

$$IL = \frac{(\text{Loss Constant}) \times (N - 1.5)}{(\%3\text{dB BW})} + 0.2$$

Tubular filters (IV)



Example:

A BC-Series filter has a center frequency of 1000 MHz and a 3 dB bandwidth of 50 MHz. Use the curve for 3-10% bandwidth filters. A stopband attenuation of 40 dB is required at 760 MHz and 50 dB is required at 1140 MHz.

The percentage bandwidth is 5%, calculated as follows:

$$\frac{50}{1000} \text{ x } 100 = 5\%$$

For the first stopband requirement: $\frac{(1000 - 760)}{50} = 4.8$

Number of 3 dB bandwidths from center frequency:

$$\frac{(1140 - 1000)}{50} = 2.8$$

From the 3-10% bandwidth attenuation curve, we find that a minimum of 3 sections is required.

The second stopband requirement is: Number of 3 dB bandwidths from center frequency: $\frac{(1140 - 1000)}{50} = 2.8$

From the 10-50% bandwidth attenuation curve, we find that 4 sections minimum are required.

The greater number of sections must be used to insure full specification compliance; therefore, a 4 section should be used.

Tubular filters (IV)

Ceramic

Uses coaxial ceramic resonators.

Advantages:

May achieve higher "Q" than a lumped element filter in a comparable package

Extremely temperature stable

Good choice where bandwidth doesn't exceed 10%

Combline

Combline filters replace the inductors in a lumped element filter with distributed inductors or lengths of transmission line leaving the capacitors lumped, although distributed capacitance is sometimes used.

Advantages:

High "Q" factors can be obtained (3500)

Small size can be traded off with "Q"

Bandwidths from 3% to 50% can be obtained

Designs cover 500 MHz to 26.5 GHz

Tubular filters (IV)

Interdigital

Interdigital filters are entirely distributed networks consisting of an array of short circuit quarter wavelength lines.

Advantages:

High "Q" factors can be obtained (5500)

Small size can be traded off with "Q"

Bandwidths from 5% to 66% can be obtained

Designs cover 500 MHz to 26 GHz

Lumped Component

The elements in the filter are lumped (i.e. concentrated over a small area). The inductors are coils of wire wound around cylindrical formers, and the capacitors are parallel plate chips or simpler portions of substrate material.

Waveguide

Waveguide filters consist of half wavelength cavities separated by inductive irises.

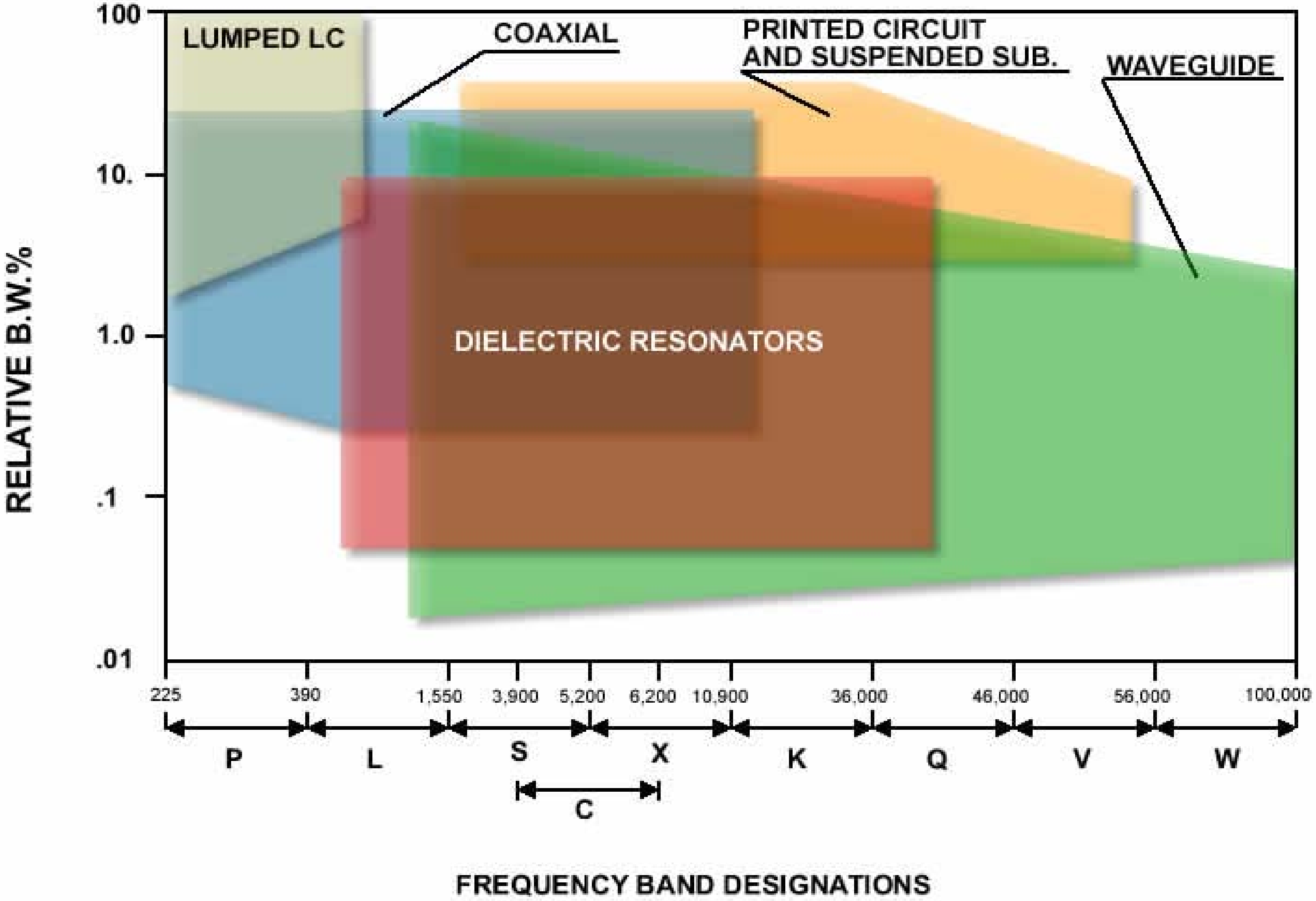
Advantages:

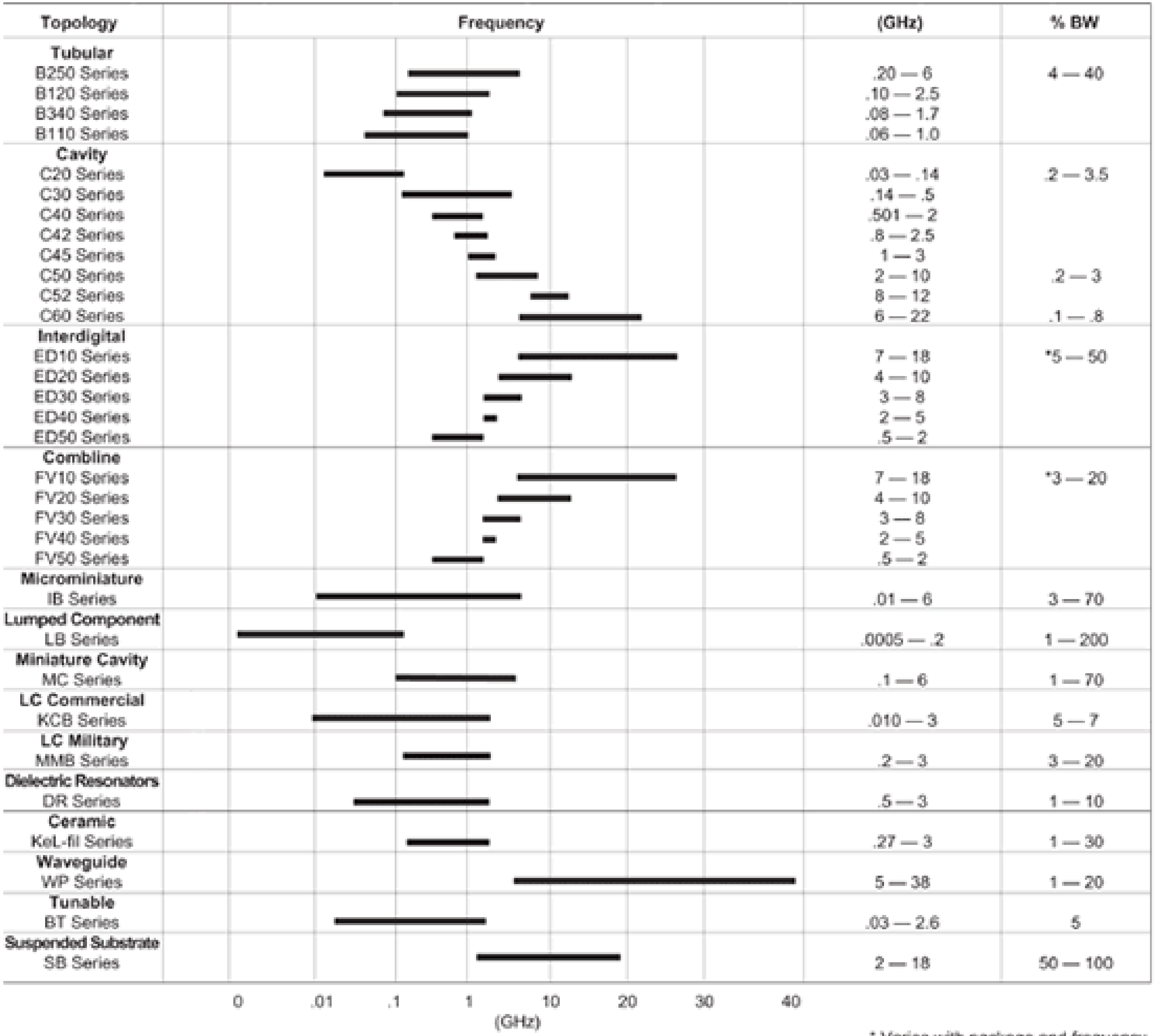
Extremely high "Q" factor can be realized

Very selective devices can be made

Designs cover 1 GHz to 40 GHz

FILTERS TRANSMISSION MEDIA

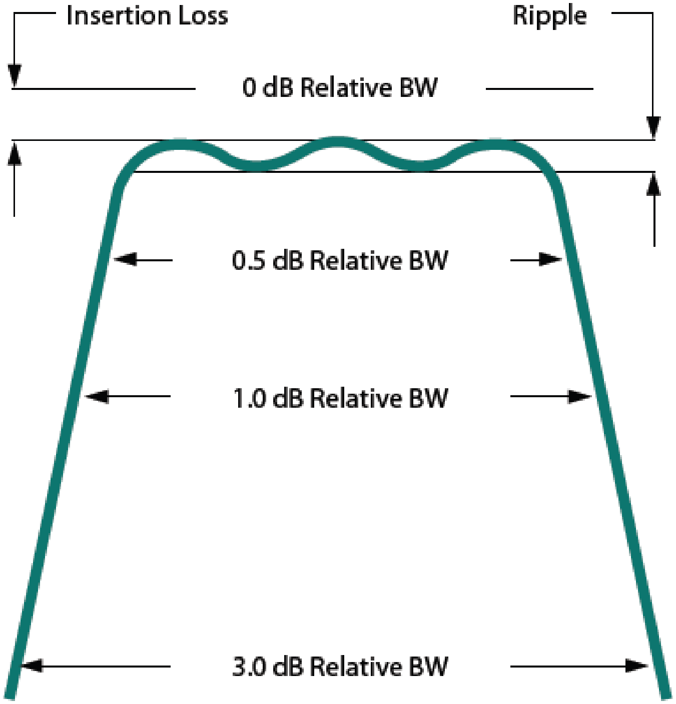




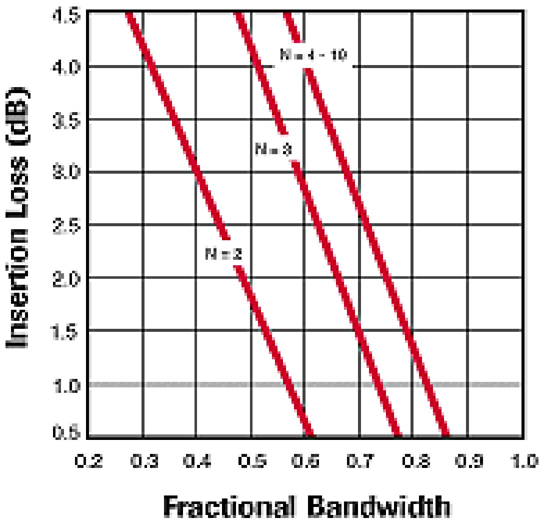
Topology	Frequency	(GHz)	% BW
Tubular			
B250 Series		.20 — 6	4 — 40
B120 Series		.10 — 2.5	
B340 Series		.08 — 1.7	
B110 Series		.06 — 1.0	
Cavity			
C20 Series		.03 — .14	.2 — 3.5
C30 Series		.14 — .5	
C40 Series		.501 — 2	
C42 Series		.8 — 2.5	
C45 Series		1 — 3	
C50 Series		2 — 10	.2 — 3
C52 Series		8 — 12	
C60 Series		6 — 22	.1 — .8
Interdigital			
ED10 Series		7 — 18	*5 — 50
ED20 Series		4 — 10	
ED30 Series		3 — 8	
ED40 Series		2 — 5	
ED50 Series		.5 — 2	
Combline			
FV10 Series		7 — 18	*3 — 20
FV20 Series		4 — 10	
FV30 Series		3 — 8	
FV40 Series		2 — 5	
FV50 Series		.5 — 2	
Microminiature			
IB Series		.01 — 6	3 — 70
Lumped Component			
LB Series		.0005 — .2	1 — 200
Miniature Cavity			
MC Series		.1 — 6	1 — 70
LC Commercial			
KCB Series		.010 — 3	5 — 7
LC Military			
MMB Series		.2 — 3	3 — 20
Dielectric Resonators			
DR Series		.5 — 3	1 — 10
Ceramic			
KeL-fil Series		.27 — 3	1 — 30
Waveguide			
WP Series		5 — 38	1 — 20
Tunable			
BT Series		.03 — 2.6	5
Suspended Substrate			
SB Series		2 — 18	50 — 100

* Varies with package and frequency.

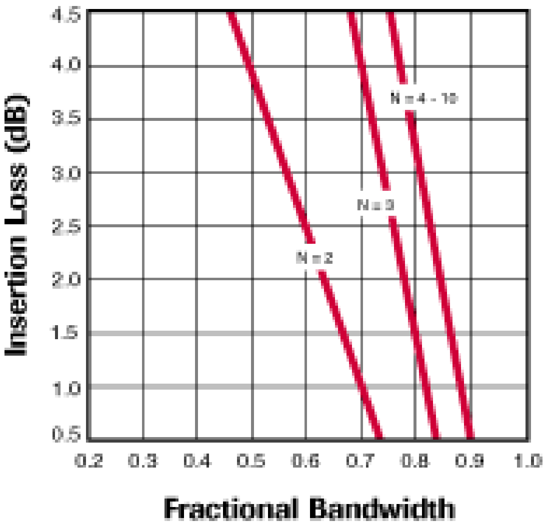
Filtraggio Passabanda (II)



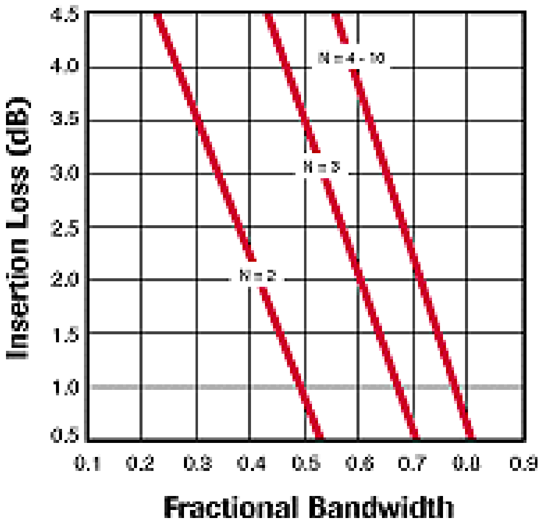
0.5 dB Relative Bandwidth



1.0 dB Relative Bandwidth



± 5° dB Relative Phase Bandwidth



1.5:1 VSWR Bandwidth