Miniature Ceramic Filters

XTREME-Q™

High Performance Filters from DLI

Typical Specifications

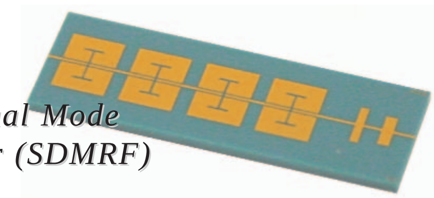
- Frequencies from 1 to > 67 GHz
- Insertion Loss ~ 2dB
- Return Loss 15 dB typical
- Rejection 45 dB typical
- Pass band Width <15%

Demonstrated capability of high frequency filter designs

- Lowpass, Highpass, and Bandpass
- Designs include:
  - Tchebyshev
  - Bessel cross-coupled responses in various topologies
  - Resonators (e.g. Ring and Dual mode)
  - Edge Coupled
  - End Coupled
  - Hair-Pin
  - Interdigitated
  - Custom Variants

Advantages of DLI Hi K materials for Microstrip Filters

- Temperature Stability: 8 fold improvement with CF material
- Filter size reduction: 1/15th the area of PWB materials
- High repeatability
- Reduced size & cost systems



Symetrical Dual Mode Resonator Filter (SDMRF)

DLI Variant on Hair-Pin

Hair-Pin

Interdigitated

Edge Coupled

End Coupled

Typical Filter Specifications

Center Freq FC (GHz)	Material Code	3dB Bandwidth (MHz)	Filter Type	# of Poles	Passband Insertion Loss (dB)	Low Side -40 dB Point (GHz) (1)	High Side -40 dB Point (GHz) (1)	Mounting Code (2)	Length inches (mm)	Width inches (mm)
2.14	CF	350 (16%)	Interdig	7	1.8	1.80 (3)	2.36 (3)	S	0.740 (18.8)	0.400 (10.2)
3.5	CF	165 (5%)	SDMRF	12	2.5	3.08	3.9	M	0.900 (22.9)	0.330 (8.4)
4.2	CF	250 (6%)	SDMRF	12	2.4	3.63	4.72	M	0.900 (22.9)	0.330 (8.4)
5.6	CF	410 (7%)	Edge Cpl	5	2.2	5.21	6.13	M	0.925 (23.5)	0.260 (6.6)
6	CF	590 (10%)	SDMRF	16	3.7	5.62	6.53	M	0.700 (17.8)	0.330 (8.4)
6.5	CF	390 (6%)	SDMRF	16	2.7	5.96	7.24	M	0.700 (17.8)	0.330 (8.4)
9.7	CF	420 (4%)	End Cpl	7	2.9	9.36	10.04	M	1.500 (38.1)	0.100 (2.5)
37	FS	760 (2%)	End Cpl	3	2.2	34.83	39.67	M	0.325 (8.3)	0.100 (2.5)

Note 1 : higher rejection can be achieved with a cover.
Note 2 : see definition of mounting codes on adjacent page.
Note 3 : data shown for this filter is for -30 dB point.

DIELECTRIC LABORATORIES
A DOVER COMPANY

Dielectric Laboratories Inc.
2777 Route 20 East
Cazenovia, New York, USA
13035-9433

phone 315.655.8710
fax 315.655.0445
www.dilabs.com

email sales@dilabs.com
or europesales@dilabs.com
or asiasales@dilabs.com

Miniature Ceramic Filters

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Part Number Identification					
AFL	**06000**	**B300**	**S**	**P**	**-xxxx**
Product Family	Center Frequency GGmmm Example: 06000=6.00GHz	Bandwith mmm B300=300MHz	Mounting Code S,W,M (see below)	Package T= Tape/Reel P=Tray	Drawing #

Filter Mounting, Interconnection and Metallization Schemes				
Mounting Code			**Backside Metallization**	**Topside Metallization**
Surface Mount S	Component to Substrate Interface and Input/Output Interconnect	Solder - Sn/Pb or Sn [Lead free] Or Conductive Epoxy	Nickel/Gold	Nickel/Gold
Microstrip Mount M	Component to Substrate Interface	Solder - Sn/Pb or Sn [Lead free] Or Conductive Epoxy	Nickel/Gold	-
	Input/Output Interconnect	Thermocompression - Wirebond Or Ribbon Lead	-	Gold

Mounting Codes and Metallization

S Surface Mount - Conductive epoxy or solder mount.
Nickel/Gold on the top and bottom surfaces of the device.
Nickel Metallization: 20 micro-inches typical.
Gold Metallization: 5 to 20 micro-inches typical.
For solder applications gold is held to a minimum to prevent embrittlement in the solder system.

W Microstrip Mount - Wirebond Interconnection - Conductive epoxy mount.
Gold on the mounting surface and Gold on the top surface.
Gold Metallization: 50 micro-inches minimum, 100 micro-inches typical.

M Microstrip Mount - Wirebond Interconnection - Conductive epoxy or solder mount.
Nickel/Gold on the mounting surface and Gold on the top surface.
Nickel Metallization: 20 micro-inches typical.
Gold Metallization Bottom Surface: 5 to 20 micro-inches typical.
For solder applications gold is held to a minimum to prevent embrittlement in the solder system.
Gold Metallization Top Surface: 50 micro-inches minimum, 100 micro-inches typical.

For customized metallization systems - consult factory.

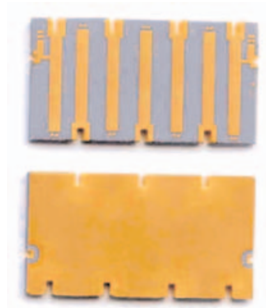
Ceramic Microstrip Filters

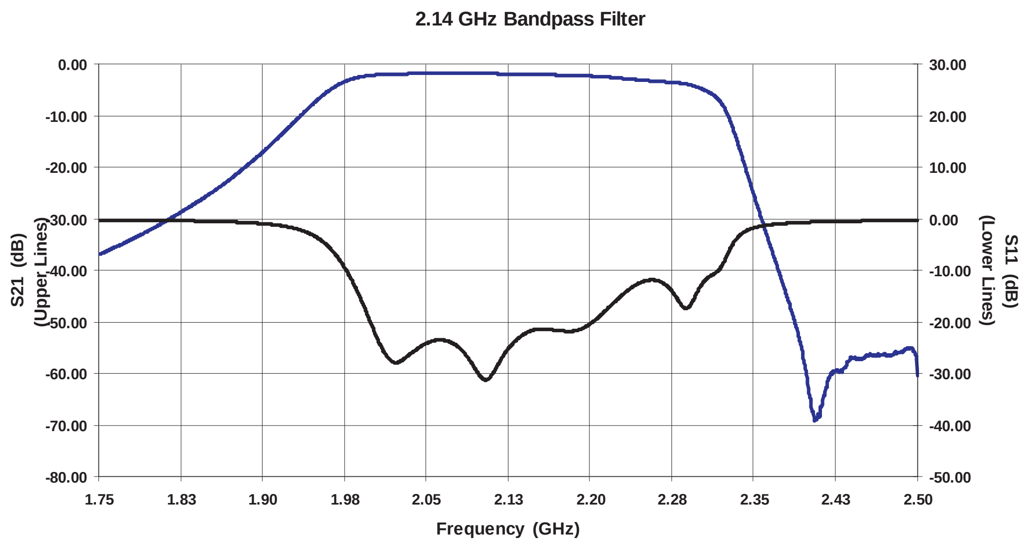
XTREME-Q™

2.14 GHz Bandpass Filter

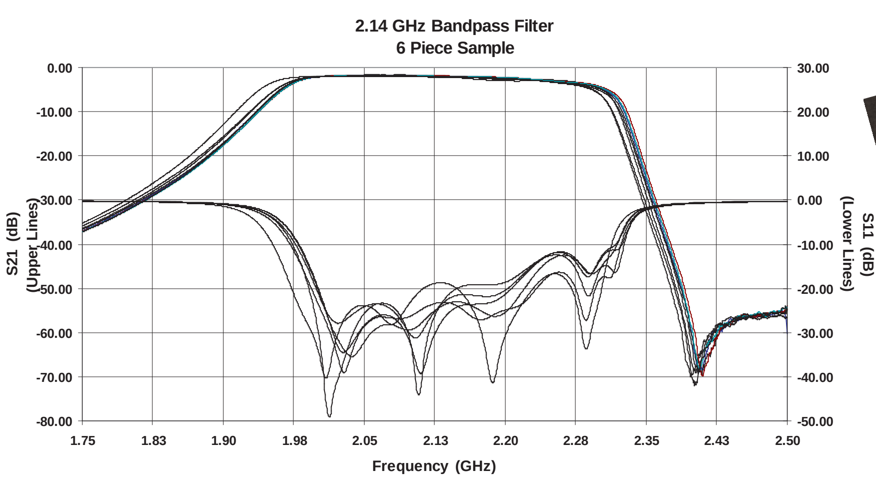
Unique Features

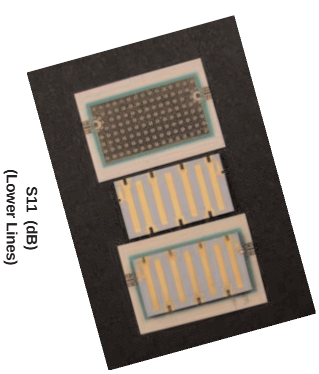
- 7-Pole Tchebyshev on K=23 ceramic
- Low loss: 1.8dB typical
- Temperature stable +/- 15ppm/°C
- Surface mountable
- Small size: 0.4 x 0.75 x 0.035 inches
- No tuning
- Good cost/size/performance tradeoff





The plot below illustrates filter performance repeatability in a surface mount comfiguration. Multiple devices fabricated on a single substrate, stringent material controls and precise processing enable excellent part repeatability at the lowest cost possible.





Dielectric Laboratories Inc.
2777 Route 20 East
Cazenovia, New York, USA
13035-9433
phone 315.655.8710
fax 315.655.0445
www.dilabs.com
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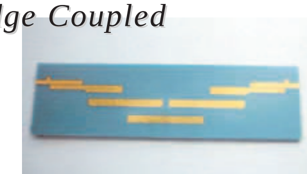
or europesales@dilabs.com
or asiasales@dilabs.com

5.6 GHz Bandpass Filter

Edge Coupled



Hair-Pin

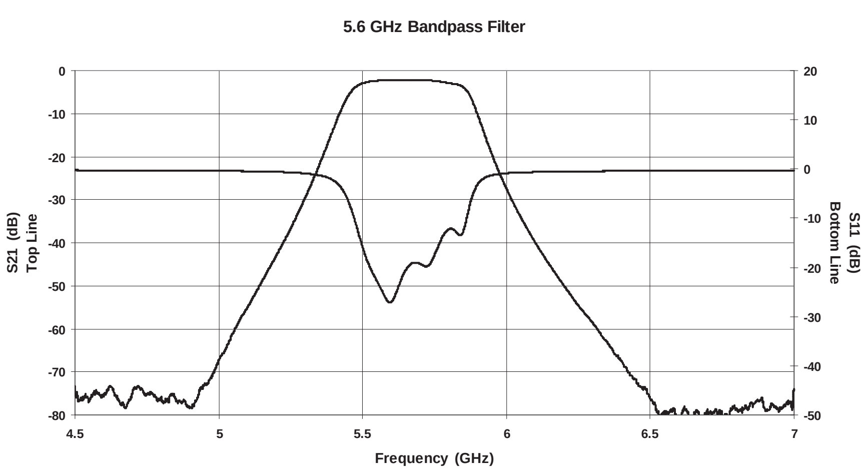
Ring Resonator

DLI's engineers select from numerous filter topologies to solve your frequency management problem. Size, cost, and performance tradeoffs are considered. Whether you have a new requirement or are trying to architect a topology to fit an existing slot, consider a ceramic solution.

Classical filter topologies can yield excellent performance in a small footprint when fabricated on ceramic substrate materials. Miniaturization reaches new levels by employing DLI high-k ceramic formulations. Different techniques of placing the resonant structures are observed in the accompanying photographs. Lower frequency implementations rely on folded resonators whereas high frequency designs generally use end coupled designs. Coupling is managed to yield the desired pass band/reject band performance. The correct placement of the input/output structures manage the impedance of the structure.

Performance requirements are easily converted to an implementation with the aid of classical modeling tools. The final physical implementation is verified using electromagnetic simulators and DLI proprietary software. Design and prototype time is minimized.

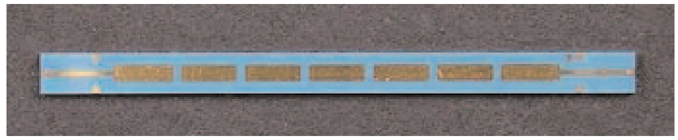
5.6 GHz Edge Coupled Bandpass Filter



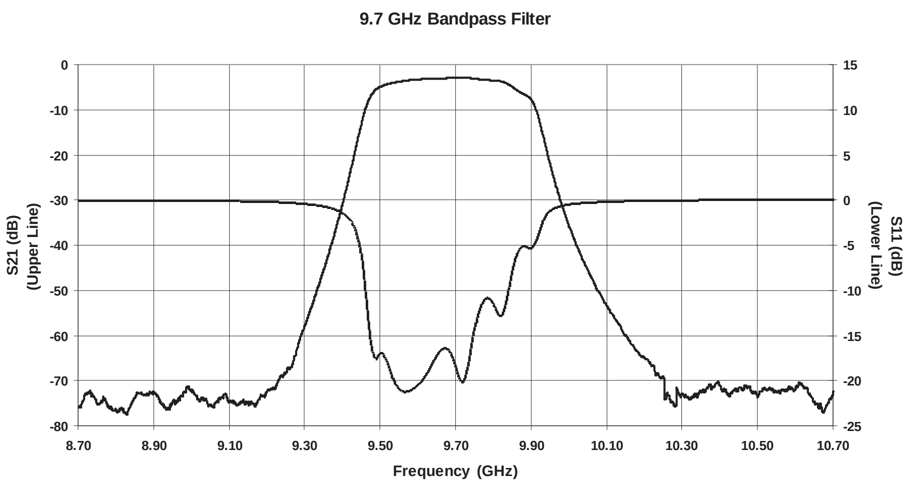
XTREME-Q™ Ceramic Microstrip Filters

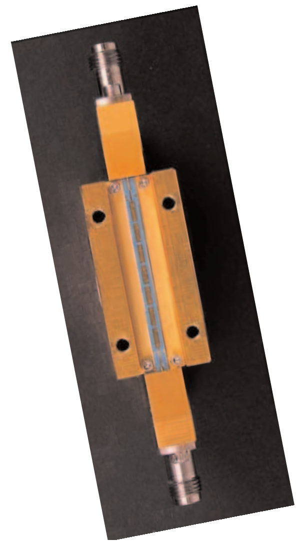
9.7 GHz Bandpass Filter

- 7-Pole End Coupled Filter
- 4% Bandwidth (400 MHz)
- Insertion Loss < 2.7dB
- Manufactured on CF Material, K=23
- Small size (1.1”x0.1”x0.03")

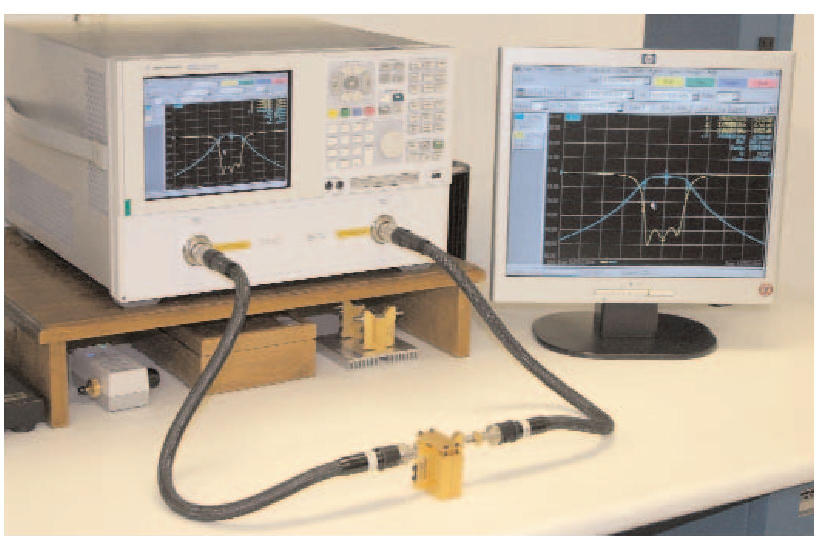


Measured Response of Filter in Fixture





The End Coupled resonator topology employed here is well suited for low percentage bandwidths (typically in the 2~5% range) and high out of band rejection. The 9.7 GHz filter is pictured both individually and attached to a carrier, which enables screw assembly and form /fit /function substitution for a larger more costly alternative. DLI’s high K material is utilized here for size and weight reduction. In a typical application conductive epoxy attachment to the floor of a channeled shield housing would be employed. With proper shielding, very high levels of rejection are possible. Approximately 70 dBc was achieved in this design. If designed for printed circuit materials the performance and repeatability would be inferior, and the filter length would be over 3 inches.



Dielectric Laboratories Inc.
2777 Route 20 East
Cazenovia, New York, USA
13035-9433
phone 315.655.8710
fax 315.655.0445
www.dilabs.com
email sales@dilabs.com
or europesales@dilabs.com
or asiasales@dilabs.com

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Ceramic Microstrip Filters

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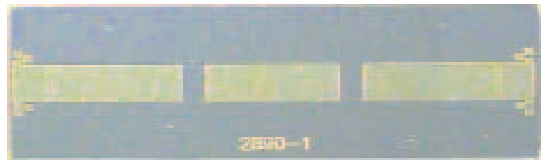
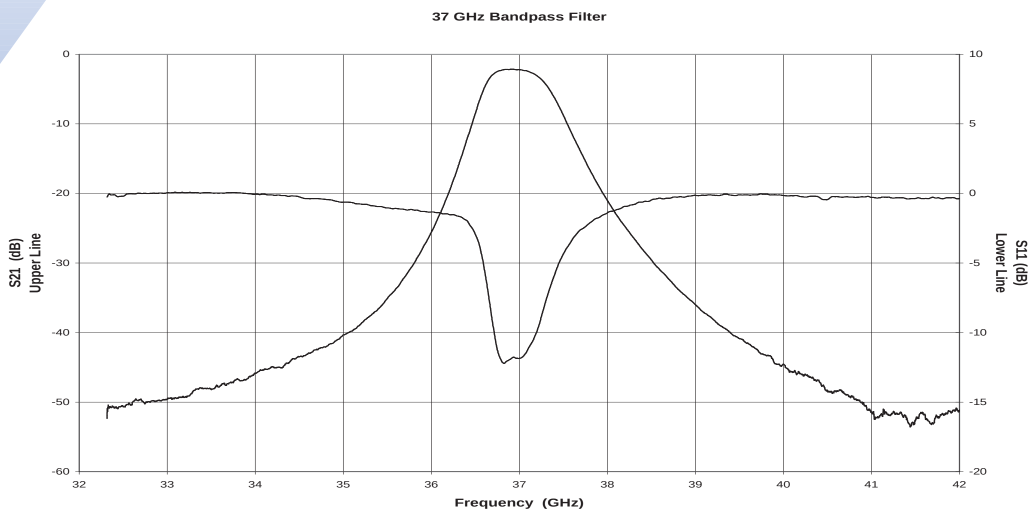
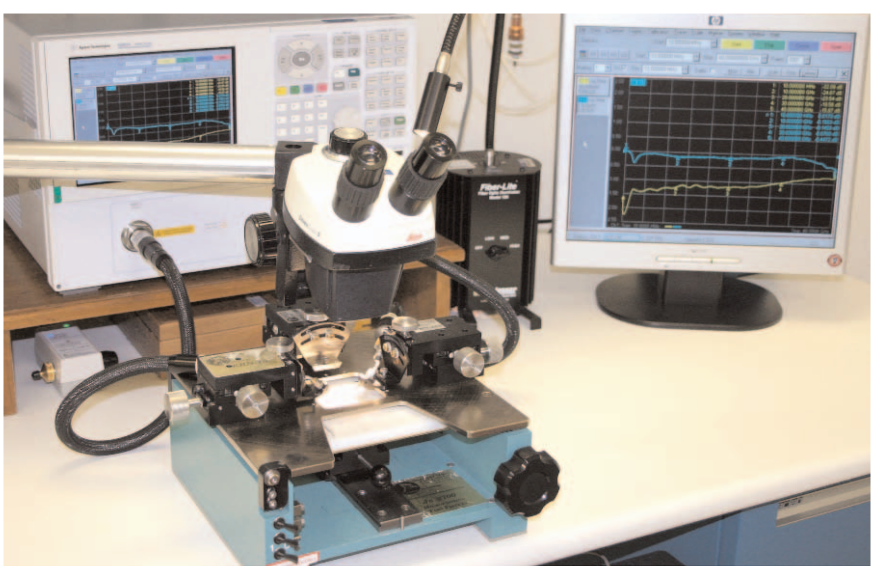
37 GHz Bandpass Filter

- Thin Film Gold on Fused Silica
- 3-Pole End-Coupled Tchebyshev
- 600 MHz Band-width (1.6% BW)
- <2.2 dB Insertion loss
- Size: 0.32 x 0.10 x 0.01 inches





The End Coupled resonator topology is applied to this 2% bandwidth filter. The narrow width (0.100 inches) of this filter design facilitates high isolation by enabling a below waveguide cut-off shielded housing. In a typical application conductive epoxy attachment to the floor of a channeled shield housing would be employed. Precision photolithography enables excellent unit to unit repeatability at low cost. DLI has precision measurement capability up to 67 GHz with the Vector Network Analyzer shown below. Both fixture and RF coplanar probe testing are employed, depending on the application.



Symmetrical Dual Mode Resonator Filters

XTREME-Q™

Miniature 12 and 16 Pole Bandpass Filters

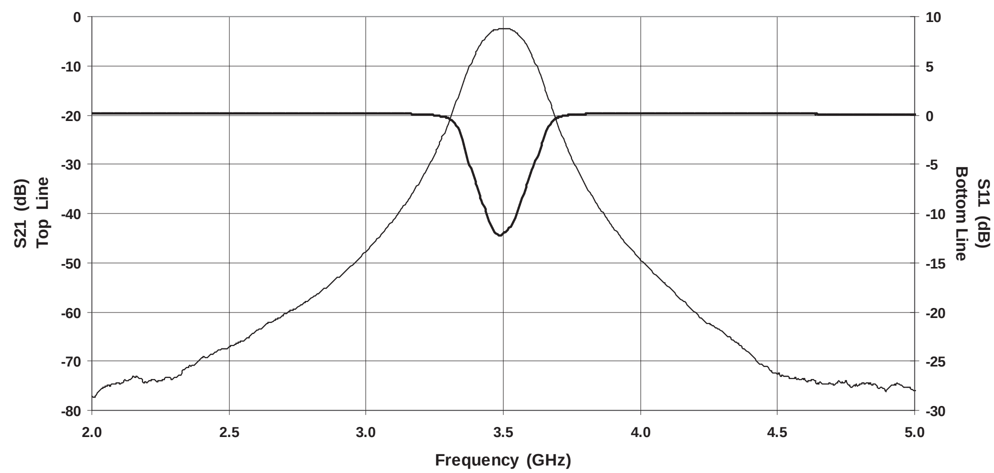
Symmetrical Dual Mode Resonators

- High selectivity
- Low Insertion Loss
- Compact size

High K ceramic

- Miniaturization
- Temperature stable
- Hi-Q (low loss)

3.5 GHz Dual Mode Bandpass Filter



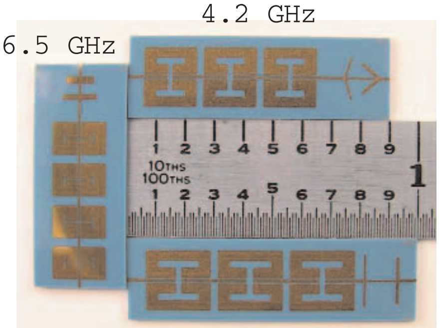
Applications for Dual Mode Resonator Bandpass Filters

The small size, low insertion loss and the sharp cutoff of the dual mode bandpass filters make then ideal for:

- Communications Receivers RF and IF Applications
- Frequency Synthesizer and Oscillator Applications
- Instrumentation
- RADAR Applications

4.2 GHz

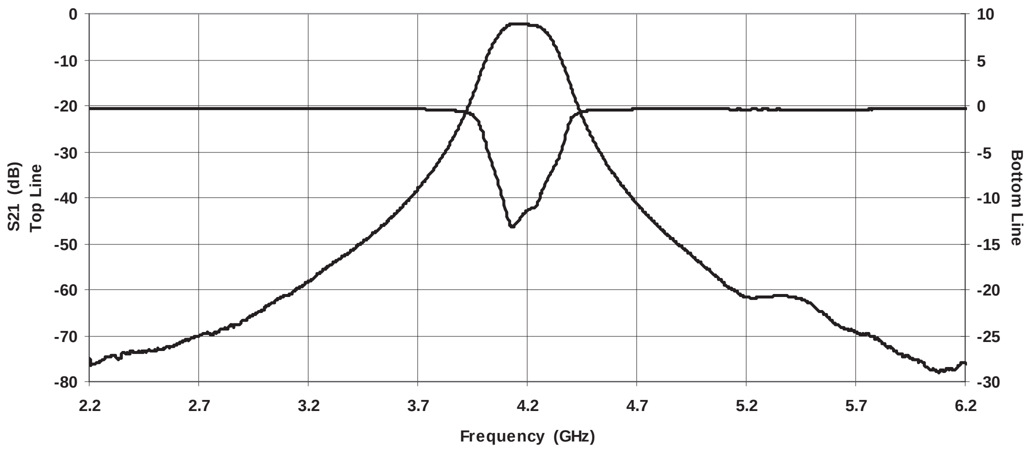
6.5 GHz



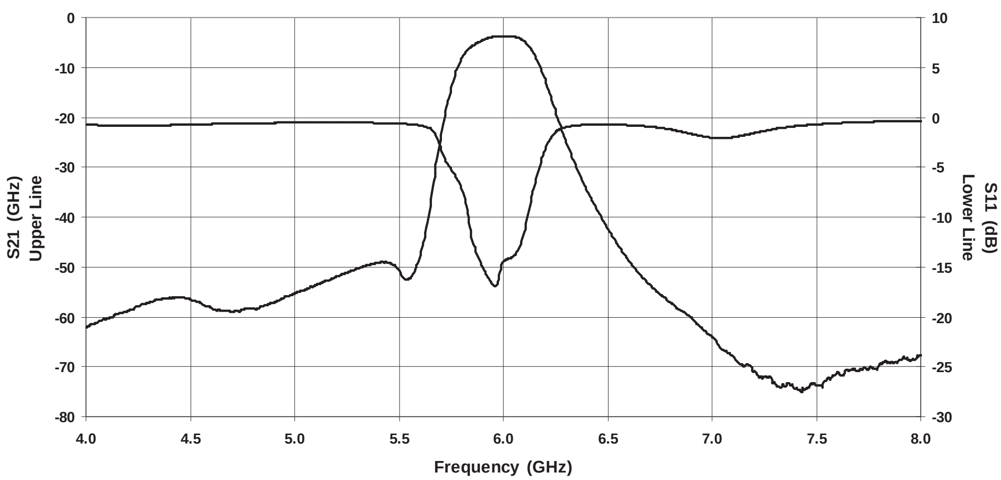
3.5 GHz

Dielectric Laboratories Inc.
2777 Route 20 East
Cazenovia, New York, USA
13035-9433
phone 315.655.8710
fax 315.655.0445
www.dilabs.com
email sales@dilabs.com
or europesales@dilabs.com
or asiasales@dilabs.com

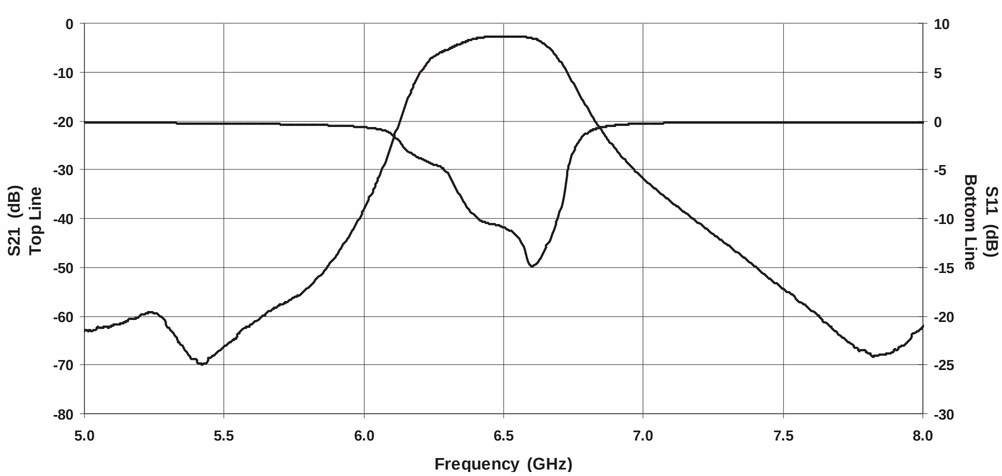
4.2 GHz Dual Mode Bandpass Filter



6 GHz Dual Mode Bandpass Filter



6.5 GHz Dual Mode Bandpass Filter

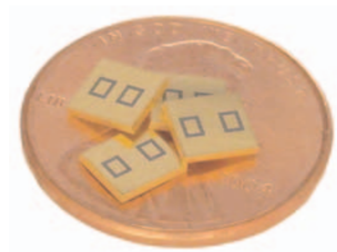


Ceramic Cavity Filters™

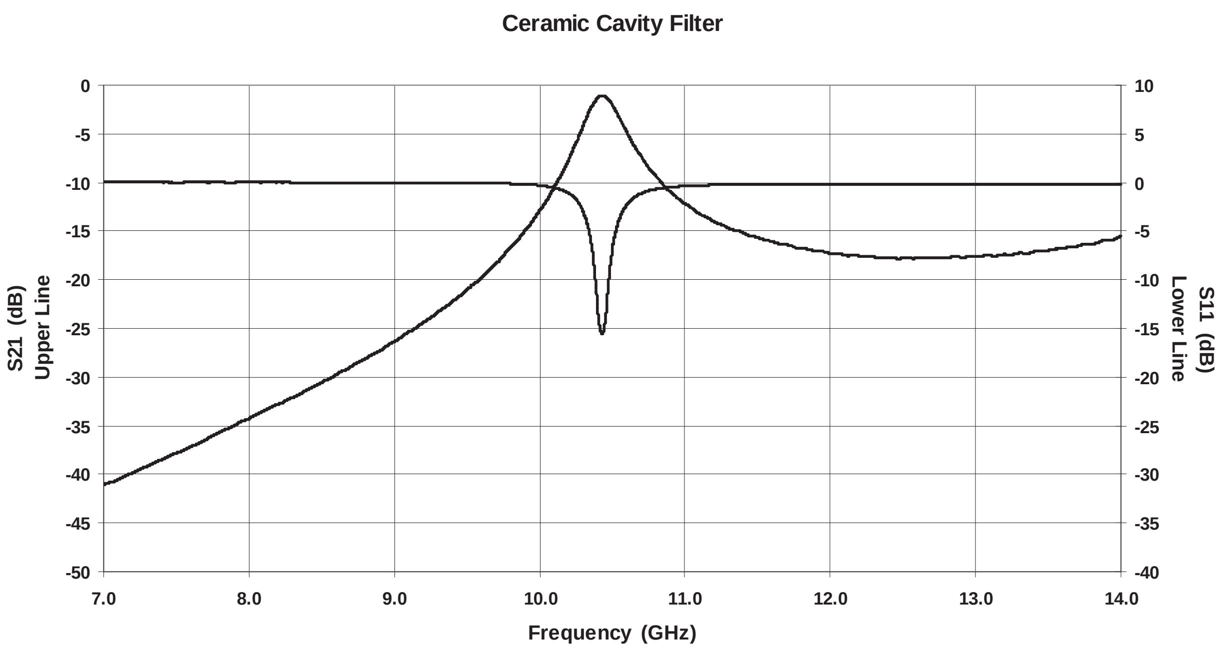
Patent Pending

Ceramic Cavity Filters

- Utilizes single pole ceramic cavity resonator design
- Small Size - 0.17 X 0.2 X 0.03 inches for a 10.5 GHz filter
- LO/Multiplier chains/RF pre-select/image filtering
- Patent Pending



10.5 GHz Ceramic Cavity Filter

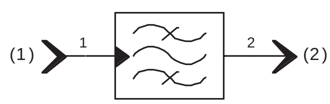


Ceramic cavity resonator technology can be employed in conjunction with DLI's stable, high Q ceramics to create precise, small, low loss bandpass filters. Using a two port implementation, a very small robust filter can be created. Wide reject band performance without spurious modes is possible. The small, shielded nature of the ceramic cavity filter implementation makes it an ideal choice for integration in low noise receiver front ends with the antenna and pre-amplifier.

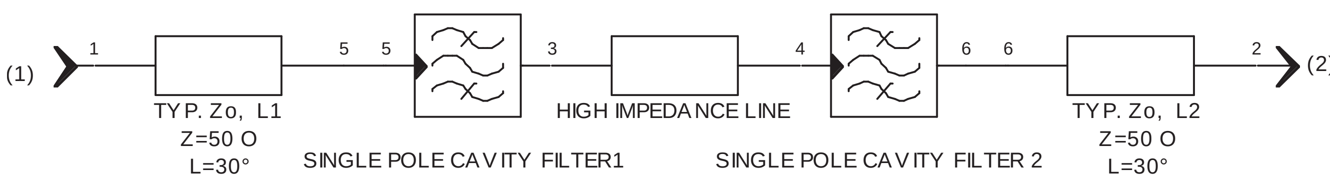
Dielectric Laboratories Inc.
2777 Route 20 East
Cazenovia, New York, USA
13035-9433
phone 315.655.8710
fax 315.655.0445
www.dilabs.com
email sales@dilabs.com
or europesales@dilabs.com
or asiasales@dilabs.com

Cascading of Filters

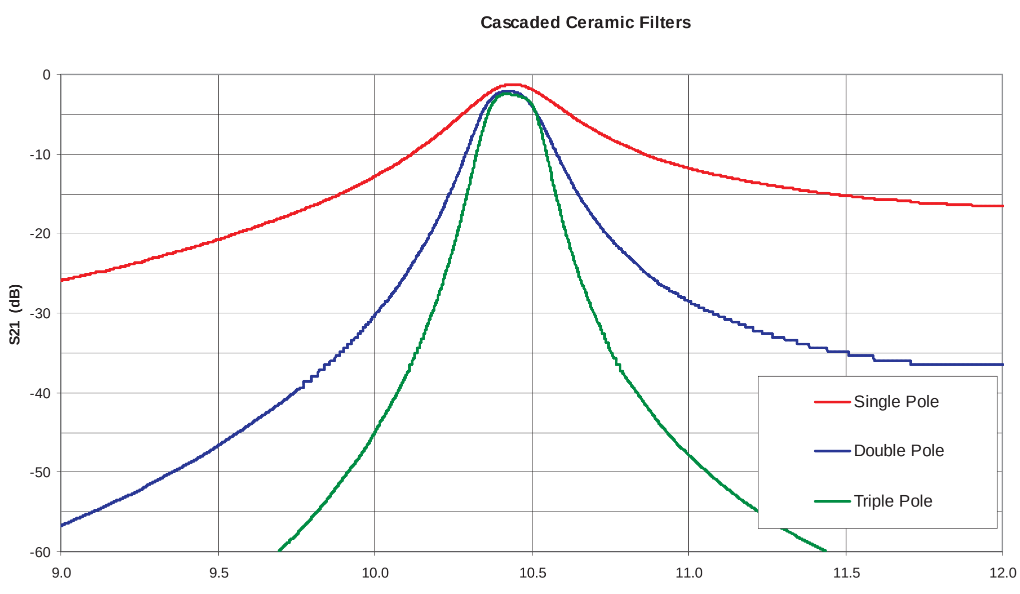
The filtering characteristics of a series-cascading ceramic cavity resonator is demonstrated below. The single ceramic cavity resonator which contains one resonator and generates one transmission zero is introduced as the most basic building block for modular design of Bandpass filters. Higher-order Bandpass filters are designed by cascading single cavity resonators to generate the required transmission zeros. A simple example model filter is designed to validate the model and the design approach. The performance of the cavity resonator filter, especially the bandwidth ratio, is improved significantly in comparison with that of the single cavity resonator filter. The synthesis and design of these filters are based on models which cascade the designed cavity resonator at the vicinity of center bandwidth frequency. In early designs, up to 3% relative bandwidths have been achieved.



SINGLE POLE CAVITY FILTER



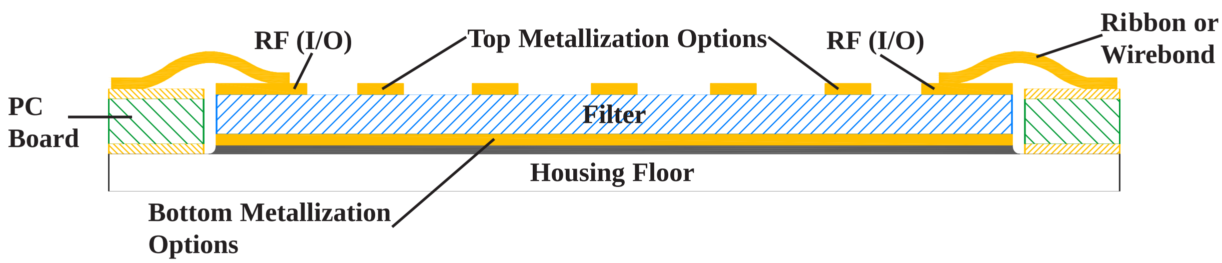
Two Single-Cavity Filters Cascaded at 10.4 GHz



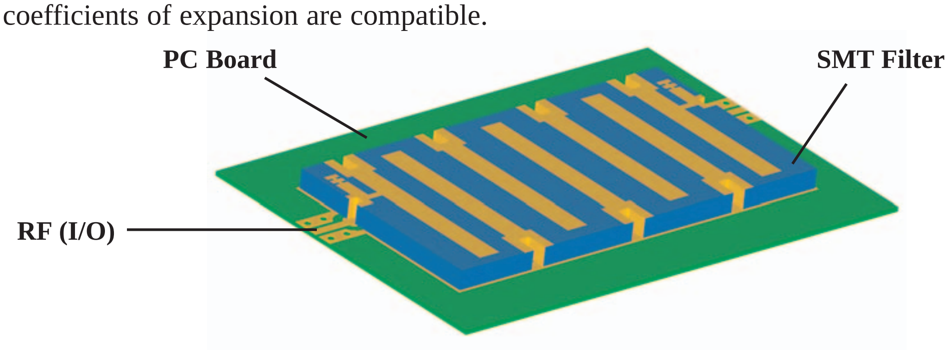
Cascaded Cavity Filter Performance

Mounting

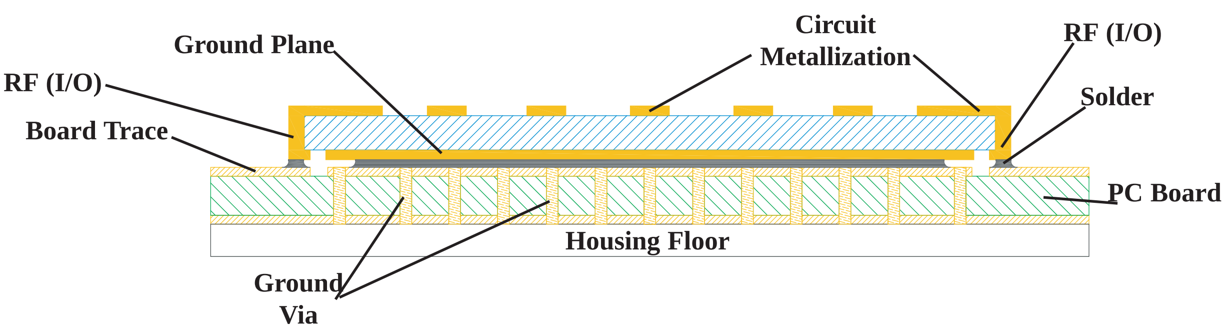
Two mounting techniques in common usage are designed to optimize performance of filters at microwave frequencies. Reliable connectivity is assured by selecting the correct metallization for the signal traces and mounting surfaces for the desired mounting and interconnecting technique. The metallization schemes offered support these mounting techniques. Customized metallization systems are available upon request.



The above illustration demonstrates a microstrip mounting technique. The circuit is relieved to accommodate the filter. The bottom surface of the filter is attached directly to the system ground plane using conductive epoxy. A minimum of 50 micro-inches and typically 100 micro-inches of gold are provided on the top surface to facilitate reliable wirebonding. [Cleaning of the surfaces using UV ozone etch or ultra-sonic techniques is always recommended to insure the highest quality of bonds.] Metallization codes W or M are suitable for this assembly method. If metallization code M is selected, solder attach of the part is enabled if thermal coefficients of expansion are compatible.



Surface mounting techniques typically rely on solder bond between the bottom conductor of the component and the ground conductor of the circuit. Note the use of multiple ground vias between the component and the system ground plane to insure optimal performance. The input/output signal connection can be realized using castellations and solder reflow. Nickel metallization is provided for solder attachment. A thin outer layer of gold is provided to prevent oxidation of the nickel. The gold is minimized to eliminate embrittlement in the solder joint. This metallization code is S.



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fax 315.655.0445
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or asiasales@dilabs.com

Custom Filters

Defining a Custom Filter

Type –Bandpass (BP), Lowpass (LP), Highpass (HP)	
Center Frequency, Fc (GHz)	Fc=__________ GHz
3 dB Bandwidth (MHz)	BW3dB=_________ MHz
Insertion Loss (IL) @ Fc (dB)	IL=________ (dB)
Return Loss (RL) @ Fc: dB Reference - 50 Ohms	RL=_______ (dB)
Upper Frequency Rejection:	- _____ dB @ ______ MHz
Lower Frequency Rejection:	- _____ dB @ ______ MHz
Power Handling (Watts)	Power (average) =__________ Watts Power (peak) = __________ Watts
Operating Temperature Range:	T min =_______°C, T max =_______°C
Mounting Technique: Surface Mount (S) or Microstrip (M)	Circle one: **S** or **M**
Size (limits):	Length_____, Width______, Thickness_____, circle one: **inches** or **mm**