

## Experiment No. - 5

Aim -To Design and Simulate planar Band pass filter at a frequency of  $f = 2$  GHz.

Software Required -CST Software

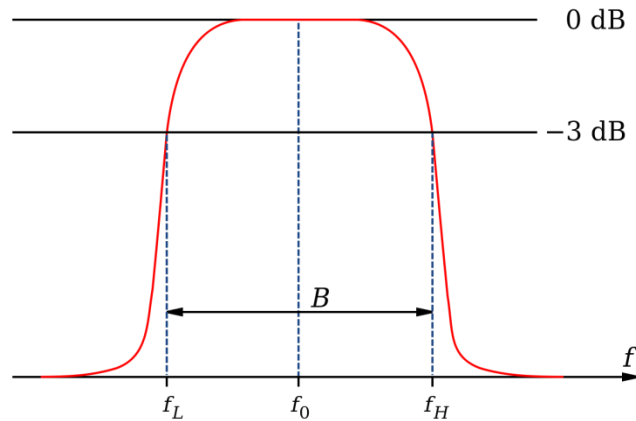


Fig. Band pass Filter

Theory -

A band pass filter is an electronic circuit or device that allows a specific range of frequencies, called the "passband," to pass through while attenuating or blocking frequencies outside of this range. Here's a brief overview of the theory behind a band pass filter:

**Frequency Range** - A band pass filter is designed to pass a particular range of frequencies, typically defined by a lower and upper cutoff frequency.

**Filter Response** - It exhibits a characteristic frequency response curve, with maximum signal transmission (gain) within the passband and reduced gain or attenuation outside of it.

**Components** - Band pass filters can be constructed using various electronic components like capacitors, inductors, and resistors. Different filter designs, such as LC (inductor-capacitor) filters or active filters with operational amplifiers, are used depending on the application.

**Formula** - The bandwidth is given by:

$$BW = f_H - f_L$$

The center frequency ( $f_c$ ) of the bandpass filter is the midpoint between the lower and

upper cutoff frequencies:

$$f_c = \frac{f_L + f_H}{2}$$

Types - There are different types of band pass filters, including passive and active filters.

Passive filters use passive components (capacitors, inductors, resistors) and are generally simple but may have limited performance.

Active filters incorporate active components like operational amplifiers to achieve better control and performance.

Applications – Band pass filters are used in a wide range of applications, including radio receivers, audio processing, communication systems, and instrumentation, where isolating a specific frequency range or rejecting unwanted frequencies is essential.

### Constructing a Band pass Filter

Figure 1(a) shows how a band-pass filter can be constructed by simply cascading high-pass and low-pass filter stages. The typical gain/frequency response for this arrangement is shown in Figure 1(b). The cutoff frequency of the high-pass circuit becomes the low cutoff frequency for the band pass filter, and the cutoff frequency for the low-pass circuit becomes the high cutoff frequency ( $f_2$ ), as illustrated.

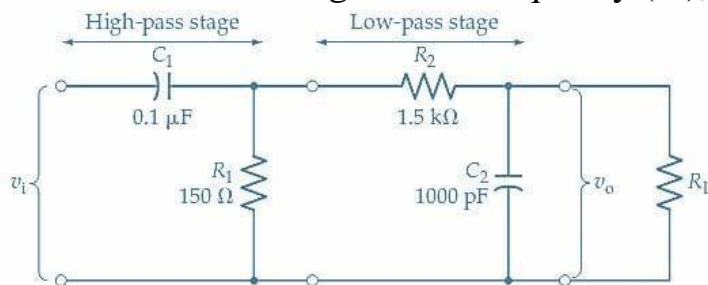


Figure -1 (a) Band pass filter constructed of high-pass and low-pass stages

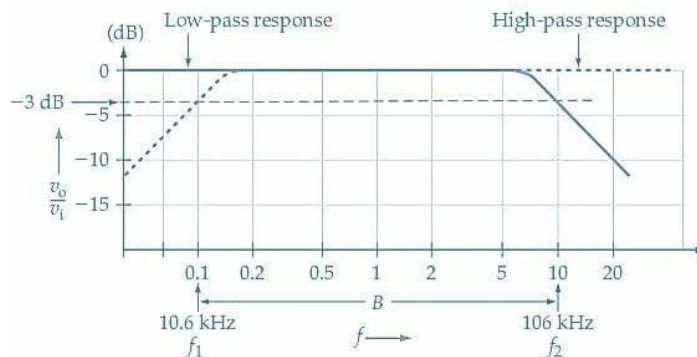


Figure -1 (b) Band pass frequency response of combined stages

Band pass filter consisting of cascade high pass and low pass stages. The high pass

stages blocks signal frequency up to  $f_1$  and the low pass stages blocks frequencies above  $f_2$ , thus passing the band of frequency between  $f_1$  and  $f_2$ .

## Filter

Definition - A filter is a device, mechanism, or method used to selectively allow certain elements, substances, or signals to pass through while blocking or attenuating others. Filters are employed in various fields and applications to refine, separate, or modify what can pass and what should be excluded. Filters can be physical objects, electronic circuits, software algorithms, or natural phenomena, depending on their application.

## Types of Filter

### Butterworth filter

### Chebyshev filters

### Elliptic filter

### Butterworth filter

A Butterworth filter, named after the British engineer and physicist Stephen Butterworth, is a type of electronic filter that has a smooth and maximally flat frequency response within its passband. In other words, it is designed to have a uniform gain or attenuation for frequencies within a certain range, with no ripples in the passband.

### Chebyshev filters

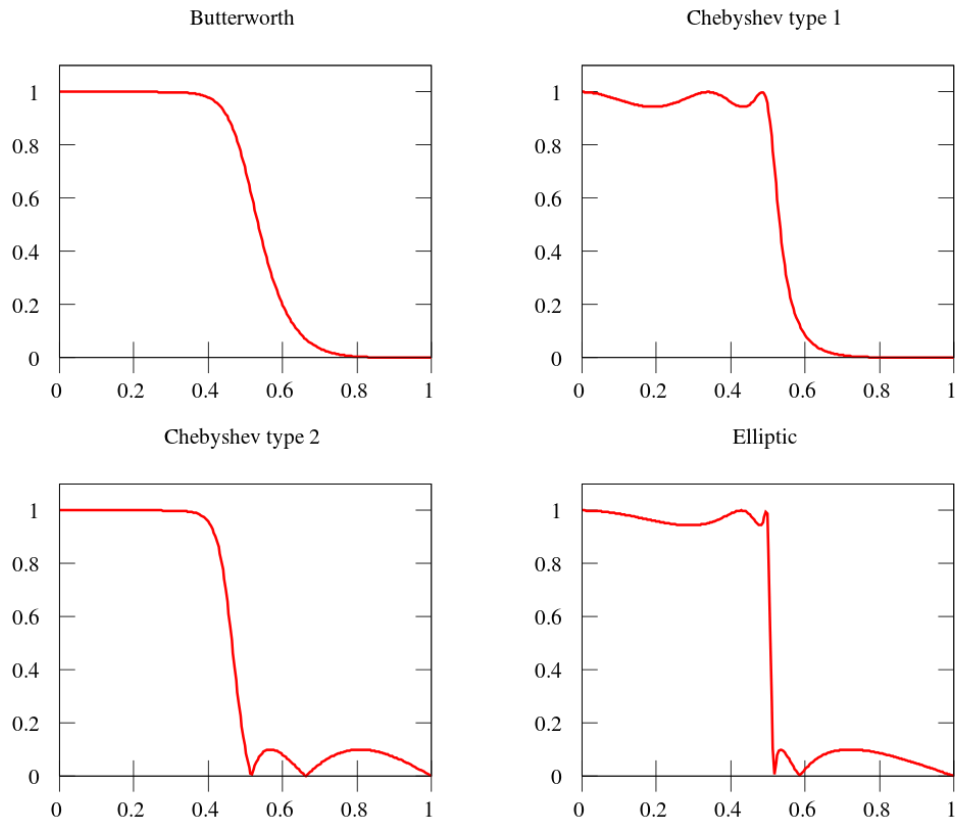
The Chebyshev filter is a type of electronic filter designed to have a specific frequency response in the passband and stopband. It is characterized by its ability to achieve a steeper roll-off rate (i.e., a more abrupt transition between passband and stopband) compared to other filter types like Butterworth filters. There are two common variations of Chebyshev filters:

**Chebyshev Type I:** This filter is designed to have a ripple in the passband. In other words, the filter allows for some variation in gain or attenuation within the passband to achieve a steeper roll-off in the stopband. Chebyshev Type I filters are used when it is acceptable for the signal to have some variation in amplitude within the passband.

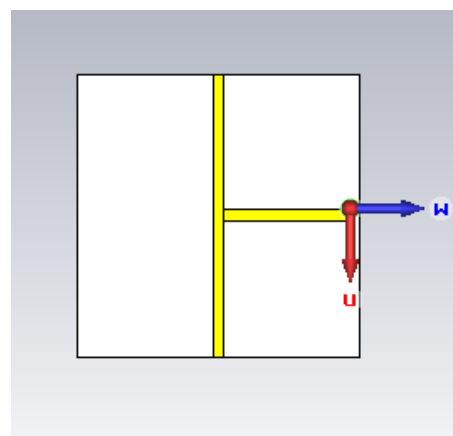
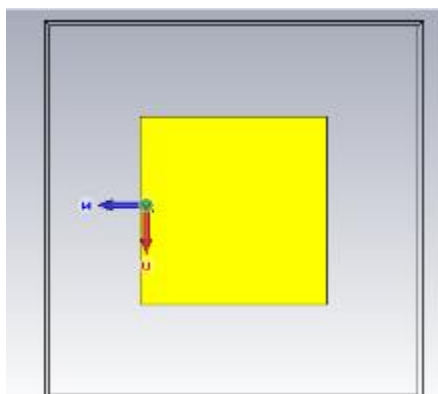
**Chebyshev Type II:** This filter, on the other hand, has no ripple in the passband. It is used when a flat frequency response is required within the passband. This type of Chebyshev filter achieves a steeper roll-off than the Butterworth filter at the expense of a less flat response in the passband.

### Elliptic filter

An elliptic filter, also known as a Cauer filter or Zolotarev filter, is a type of electronic filter designed to have a very sharp transition between its passband and stopband while allowing for a specified level of ripple in both regions. This characteristic makes elliptic filters suitable for applications where a high degree of selectivity is required, and some variation in amplitude response is acceptable.

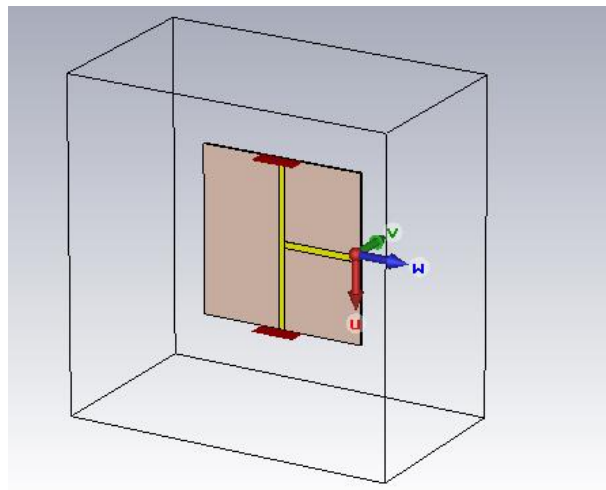


### Design Band pass Filter



### Design Measurement

Name	Values
(1) Substrate	30 X 30
(2) Substrate thickness	0.787 (mm)
(3) Substrate material	Rogers RT 5870 (lossy)
(4) Ground	30 X 30
(5) Ground thickness	0.035
(6) Ground material	Copper
(7) Feed	1.175 X 30
(8) Feed thickness	0.822
(9) Feed material	Copper
(10) Stub	1.175 X 1.175
(11) Stub thickness	0.787 0.787 + 0.035
(12) Stub material	Copper



## Procedure – Band pass filter

Designing a band pass filter using CST Microwave Studio (CST MWS) or any other electromagnetic simulation software involves several steps. Below is a general procedure for designing a band pass filter, along with measurements you can perform in CST:

### Step 1: Define Specifications

Determine the center frequency ( $f_0$ ) of your band pass filter.

Specify the desired bandwidth (BW) of the filter.

Define the filter's insertion loss (IL) and return loss (RL) requirements.

Decide on the filter topology (e.g., coupled resonator, waveguide, micro strip, etc.).

### Step 2: Initial Design

Create a new project in CST MWS.

Choose the appropriate solver and set up the simulation environment (e.g., 3D, 2D, frequency domain, or time domain).

Start with an initial filter design based on your specifications.

### Step 3: Simulation and Optimization

Simulate the initial design to obtain S-parameters ( $S_{11}$ ,  $S_{21}$ , etc.) and analyze the performance.

Use the optimization tools in CST to fine-tune the filter parameters (e.g., dimensions, coupling coefficients, resonator positions, etc.) to meet your specifications.

Iterate the optimization process until the desired filter response is achieved.

### Step 4: Manufacturing and Fabrication

Once you have a finalized design, export the layout or design specifications for fabrication.

This may include generating Gerber files for PCB fabrication or detailed drawings for other manufacturing methods.

Select the appropriate materials and manufacturing processes for your filter design.

### Step 5: Simulation Validation

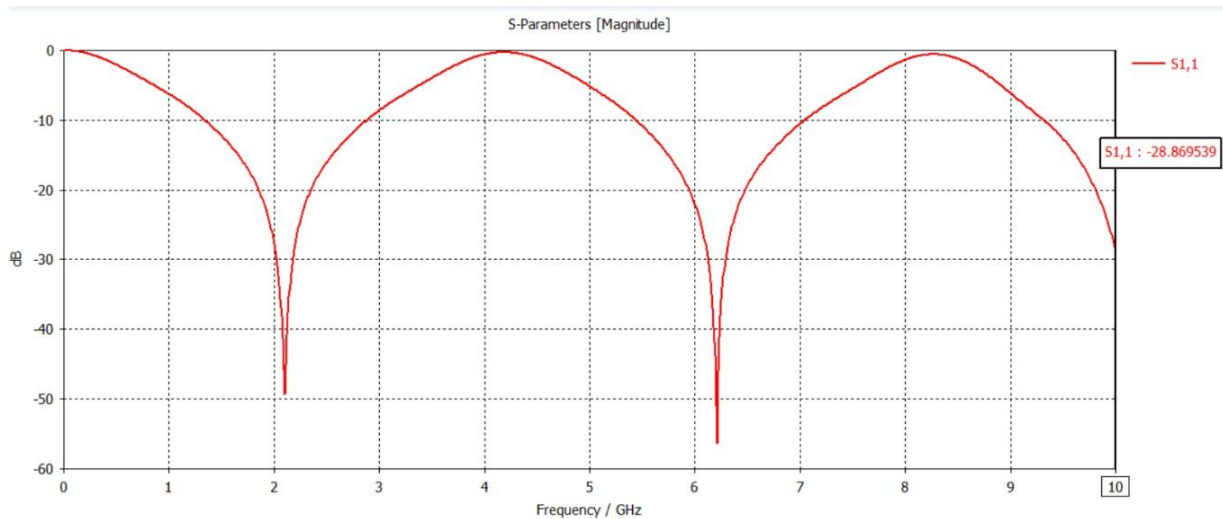
Import the fabricated filter structure into CST MWS for validation.

Simulate the fabricated filter to compare the actual performance with the simulated results.

Adjust any discrepancies between simulation and measurement by fine-tuning the physical design if necessary

### Result

#### S – Parameter



Conclusion: Band pass filter at a frequency 2 GHz has been designed and simulated.