Design and Simulation of Five Stage Band Pass Filter for C band Applications

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Abstract - *Design and Simulation of five stage chebyshev band-pass passive filter having a 0.5dB equally ripple response for C Band applications. This work is designed using lumped components and distributed components with RT Duroid Substrate (Er=2.2, H=0.25mm, tanδ=0.0009 and t=1.35mm) using T network. The process is to first make a low pass prototype filter in C band. With the help of frequency and impedance scaling and the low pass filter is converted to band-pass filter. Filter is a frequency selective network which is used to select or reject desired band of frequency. The three stage band pass filter is compared to four stage and stage five stage band pass filters with similar configurations. The motive of this comparison would be to show the change in roll off factor with the increment in stages. The simulation will be worked out on the ADS/AWR software where the schematics would be used to design the filter and the responses would be plotted for the same designs. This software can be used as a 3D circuit simulator as well as EM simulator. The simulated results will be obtained using S parameters. The aim would be to try to achieve S11 below -15dB and S21 in the range of 0 to -3dB.*

Key Words: Filter, Chebyshev, Band Pass.

1 INTRODUCTION

Microwave filters are the type of electronic filter that are designed to operate on the signals in gigahertz frequency ranges (high frequency to extremely high frequency). Microwave range is used by most broadcast radio, television, wireless communication (cell phones, Wi-Fi, etc.), thus most microwave devices will include filtering on the signals transmitted and received. The aim is to design a filter which is frequently used as building units for duplexers to separate or combine multiple frequency bands. The resonator structure that has to be used in microwave filters is an LC tank circuit comprising of parallel or series inductors and capacitors. Inductors and Capacitors are used because of being very compact. Resistors are avoided because of their low quality factor. The unloaded quality factor of the resonators being used will generally set selectivity the filter can achieve.

1.1 Band Pass Filter

Band Pass Filter is one of the most important components of all microwave communication systems. Band pass filter is used to pass the frequency in the pass band and attenuate the frequency in the stop band. Thus band pass filter acts as a frequency selective circuit. To meet the demands of the consumers, the band pass filters are designed with a compact size, lower development cost and with assurance of quality in performance.

1.2 Five stage Band Pass Filter

A five stage band pass filter is one in which five combinations of inductance and capacitance is used to generate the output response. As five stage is comparatively easier to implement and is capable of producing a high quality response, it is a good option for getting a desired output. The element values for equally ripple low pass prototype and the converted band pass filter are symmetrical and thus the simplicity in the process of designing is majorly reduced.

1.3 Applications of Band Pass Filter

C band was the first band that was commercially opened for telecommunications via satellites. The frequencies used by most of the C band telecommunication satellites vary from 3.7to 4.2 GHz for downlink and from 5.92 to 6.42 GHz for uplink. The C band is also used for television reception. The response obtained with C band is better than the response obtained from Ku band when we consider television reception. The C band includes 5.8 GHz ISM band between 5.72 and 5.87 GHz which is used for industrial and medical heating processes. The band range is also houses unlicensed short range microwave communication systems, which include cordless phones and keyless entry systems.

1.4 Design of Low Pass Prototype Filter

The design of the low pass prototype filter is one of the most important steps in the design process of band pass filter. The low pass filter is used to provide a design template to the filter and is then modified to make a band pass filter. This modification is done with the help of impedance and frequency scaling. Prototype filters are designs of electronic filters that are used as a reference template to produce a modified filter design for a specific application. Low pass prototype filter is a lumped element network that has been synthesized to provide a required filter transfer function. The element values are normalized with respect to multiple filter designs parameters to offer ease of use and parameterization. The value of inductance and capacitance has been obtained by using the following equations.

$$L = g * \gamma * \frac{\Omega_c}{\omega_c}$$

$$C = g * \frac{1}{\gamma} * \frac{\Omega_c}{\omega_c}$$

Where,
L = Inductance
C = Capacitance
g = Element constant for 0.5db equally ripple method
γ = Propagation Constant
ω_c = Cut off frequency
Ω_c = Centre frequency

2. CIRCUIT SCHEMATICS

2.1 Low Pass Prototype Circuit

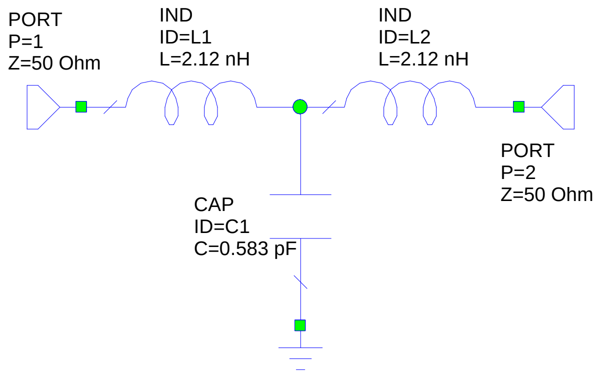

Fig 1: Low pass prototype circuit for C band Applications

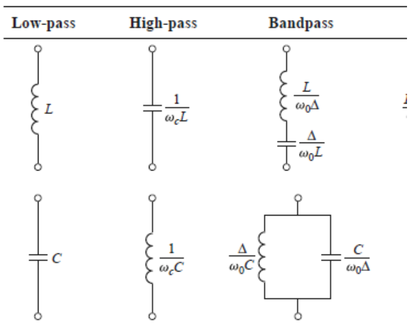

Fig 2: Conversion of low pass prototype filter into band pass filter

$$\Delta = \frac{\omega_2 - \omega_1}{\omega_0}$$

$$\omega_0 = \sqrt{\omega_2 - \omega_1}$$

The schematic diagram of the band pass filter is derived from the low pass prototype filter by the introduction of elements and placing shunt and series resonators. It is a low pass to band pass transformation which is performed with the help of the following formulae,

$$L_s = \frac{\Omega_c}{\Delta\omega_0} * \gamma * g$$

$$C_s = \frac{1}{\omega_0^2} * \frac{1}{L_s}$$

$$C_p = \frac{\Omega_c}{\Delta\omega_0} * \frac{1}{\gamma} * g$$

$$L_p = \frac{1}{\omega_0^2} * \frac{1}{C_p}$$

In the paper the cut off frequency is set at 6 GHz.
Hence,

Δ=0.16725

ω_0=5.59791 E 09 GHz

γ=50 Ω

2.2 Band Pass Filter Circuit Schematics

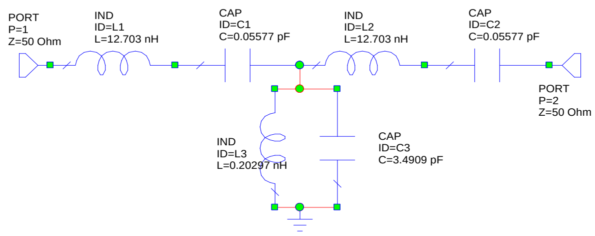

Fig 3: Three stage band pass filter for C band Applications

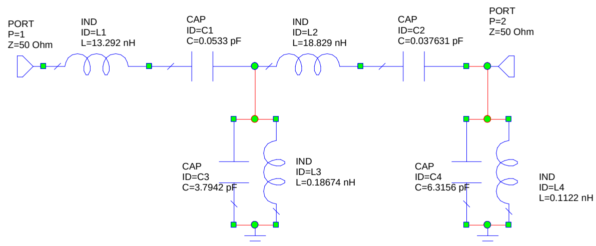

Fig 4: Four stage band pass filter for C band Applications

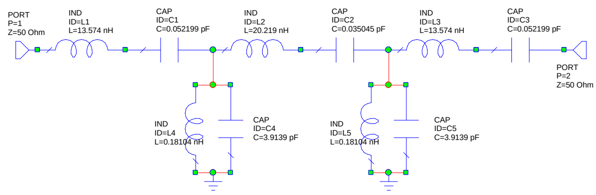

Fig 5: Five stage band pass filter for C band applications

3. OUTPUT RESPONSE

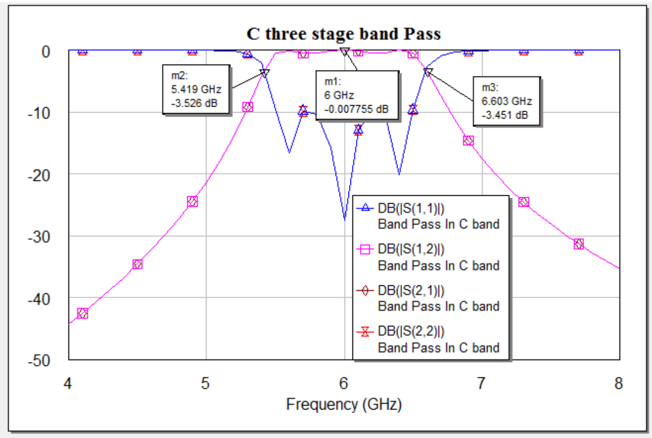

Fig 6: Output response of three stage band pass filter for C band applications

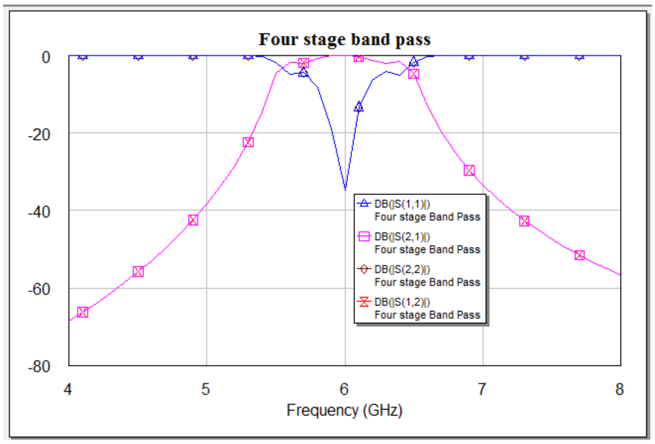

Fig 7: Output response of four stage band pass filter for C band applications

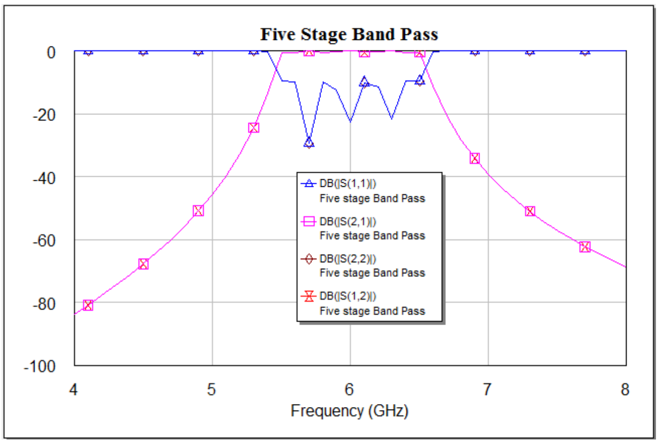

Fig 8: Output response of five stage band pass filter for C band applications

4. CONVERSION TO DISTRIBUTED COMPONENTS

Although lumped components are very effective to understand the concept of designing the filter circuit and the responses that can be obtained by changing the parameters, the circuit cannot be used to fabricate the circuit. Here the distributed components come into play. Distributed element circuits are the type of electrical circuits which are composed of lengths of transmission lines and some other distributed components.00The circuits perform similar functions as the conventional circuits which are composed of passive components, such as resistors, capacitors, inductors, and transformers. Distributed components are mostly used at microwave frequencies, where conventional components are not easy to realize.

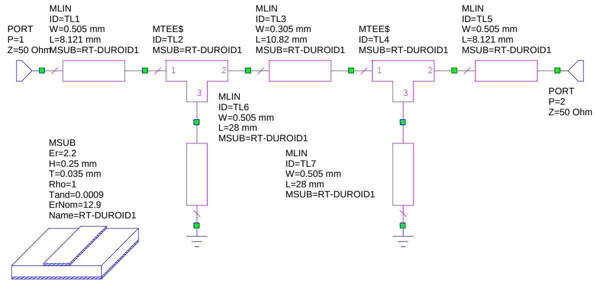

Fig 9: Five stage band pass filter for C band applications using distributed elements and substrate as RT Duroid

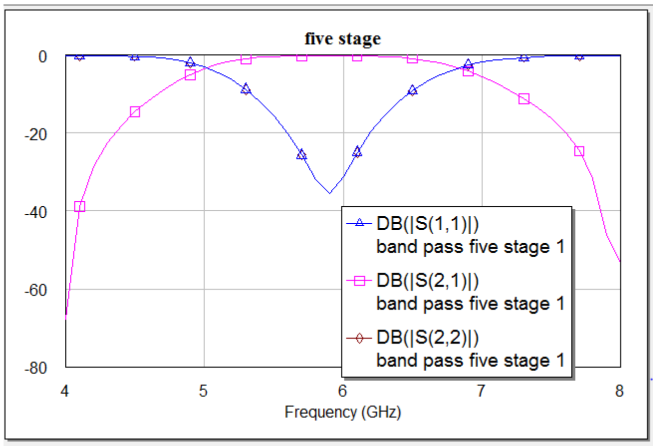

Fig 10: Output response of five stage band pass filter with distributed components

5. CONSCLUSION

The roll off factor is the measure of excess bandwidth of filter meaning that the bandwidth occupied 0beyond the Nyquist00bandwidth of 1/2T. The roll off factor has to be less in order to achieve a better result in the filter response. When comparing the responses of the third stage, fourth stage and the fifth stage filter, the change in roll factor can be very easily observed. The roll factor decreases as the number of stages increases, thus leading to a more defined response.

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BIOGRAPHIES

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