International Journal of Research in Engineering, Science and Management
Volume-2, Issue-2, February-2019
www.ijresm.com | ISSN (Online): 2581-5792

Development of Microstrip Filter for Telecommunication Application

S. C. Vinutha[1], Parvati Kadli[2]
[1]*M. Tech. Student, Department of ECE, Proudadevaraya Institute of Technology, Hosapete, India*
[2]*Associate Professor, Department of ECE, Proudadevaraya Institute of Technology, Hosapete, India*

***Abstract*: The advances of telecommunication technology arising hand in hand with the market demands and governmental regulations push the invention and development of new applications in wireless communication. These new applications offer certain features in telecommunication services that in turn offer three important items to the customers. The first is the coverage, meaning each customer must be supported with a minimal signal level of electromagnetic waves, the second is capacity that means the customer must have sufficient data rate for uploading and downloading of data, and the last is the quality of services (QoS) which guarantee the quality of the transmission of data from the transmitter to the receiver with no error. In order to provide additional transmission capacity, a strategy would be to open certain frequency regions for new applications or systems. In realization of such a system like WiMAX we need a complete new transmitter and receiver. A band pass filter is an important component must be found in the transmitter or receiver. Band pass filter is a passive component which is able to select signals inside a specific bandwidth at a certain center frequency and reject signals in another frequency region, especially in frequency regions, which have the potential to interfere the information signals. In designing the band pass filter, we are faced the questions, what is the maximal loss inside the pass region, and the minimal attenuation in the reject/stop regions, and how the filter characteristics must look like in transition regions**

***Keywords*: wimax, microstrip**

1. Introduction

Radio frequency receiver front end is very important as it provides the necessary gain, while introducing minimal noise, to achieve the required signal to noise ratio (SNR) for better performance. A RF frontend receiver consists of low noise amplifier (LNA), band pass filter (BPF) and mixer and many other depending on the type of the receiver. The band pass filter is a two port network which helps to control the frequency response at a specific point by providing transmission at frequencies within the pass band and attenuate other frequencies in the stop band of a filter [2]. The main advantage of micro strip line is it will give better compromise in terms of size and performance than other types of filters like lumped element filters. Another advantage is, for manufacturing the micro strip circuit process it is very similar to the processes used to manufacture printed circuit board. Other than that, its advantage would be of largely being planar. The micro strip transmission lines consist of a conductive strip of width (W) and thickness (t) and a wider ground plane, separated by a dielectric layer (Er) of thickness (h) as shown below.

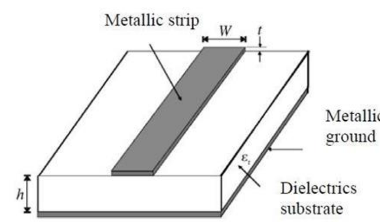

Fig. 1. General micro strip structure

In the process to fulfill these requirements there are several strategies taken in realization of the filters, for example, the choice of waveguide technology for the filter is preferred in respect to the minimal transmission loss (insertion loss). This strategy is still actual in satellite applications. The effort to fabricate waveguide filters prevents its application in huge amounts. As alternative, microstrip filter based on printed circuit board (PCB) offers the advantages easy and cheap in mass production with the disadvantages higher insertion losses and wider transition region. In this work we would like to give a way to conceive, design and fabricate bandpass filter for the WiMAX application at the frequency 3.2 GHz with parallel-coupled microstrips as opposed to which designed filter for wireless local area network 5.75 GHz, and which used the composite resonators and stepped impedance resonators for filter realization.

Radio frequency receiver front end is very important as it provides the necessary gain, while introducing minimal noise, to achieve the required signal to noise ratio (SNR) for better performance. A RF frontend receiver consists of low noise amplifier (LNA), band pass filter (BPF) and mixer and many other depending on the type of the receiver. The band pass filter is a two port network which helps to control the frequency response at a specific point by providing transmission at frequencies within the pass band and attenuate other frequencies in the stop band of a filter [2]. The main advantage of micro strip line is it will give better compromise in terms of size and performance than other types of filters like lumped element filters. Another advantage is, for manufacturing the

micro strip circuit process it is very similar to the processes used to manufacture printed circuit board. Other than that, its advantage would be of largely being planar. The micro strip transmission lines consist of a conductive strip of width (W) and thickness (t) and a wider ground plane, separated by a dielectric layer (Er) of thickness (h) as shown below.

2. Project objectives

Analyze and fabricate a micro strip band pass filter for 2.4 GHz. Basic design specifications for a band pass filter were considered are center frequency and bandwidth. The specifications are given in Table 1.

Table 1
Filter specifications

Feature	Value or Type
Center frequency f_0	2.4 GHz
Bandwidth	10 % = 240 MHz
Return loss	> 10Db
Fabrication technology microstrip	Microstrip
Size constraint	+/- 3 x 8 cm
Price target	≤ 30 RM
Circuit board material	FR4
Substrate thickness	1.6 mm
ε_r	4.7
Characteristic impedance	50 Ω

A. *Insertion loss method*

The insertion loss method, however, allows a high degree of control over the pass band and stop band amplitude and phase characteristics, with a systematic way to synthesize a desired response. The necessary design trade-offs can be evaluated to best meet the application requirements. To have, a minimum insertion loss, a binomial response could be used; for the requirement of sharpest cut -off a Chebyshev response could satisfy a requirement.. If it is possible to sacrifice the attenuation rate, a better phase response can be obtained by using a linear phase filter design. In addition, in all cases, the insertion loss method allows filter performance to be improved in a straightforward manner, at the expense of a higher order filter.

B. *Impedance and admittance inverters*

The Impedance and admittance inverters are two port network, those has a phase shift of +-90degrees.The inverters have the ability to shift load impedance or admittance levels depending on the values of K or J parameters. These property enable to transform series-connected element to shunt-connected elements, or vice versa to convert a filter circuit to equivalent form for the implementation. Such inverters are especially useful for Band pass or Band stop filters with narrow (<10%) Bandwidth.

3. Methodology

Basic design specifications for a band pass filter were considered are center frequency and bandwidth. The other specifications are given in Table 1. For this research a center frequency of 2.4 GHz, which corresponds to the free-space wavelength of 12.5 cm, was chosen for hand-based dimensions fabrication. With using formula related to calculate dimension of parallel couple filter, found L (length), W (width), and S (spice). The filter designed was fabricated with the aid of Correl Draw 12 and CAD tools to print exact dimension on PCB for simulation purpose. The filter characteristics were measured. As the results of literature review recommendations, +/- 10 % bandwidth, which corresponds to 240 MHz at 2.4 GHz center frequencies, was chosen for further research and development process. The choice of the parallel-coupled lines filter has been explained analytically with the help of Microwave Office 2004 to aid design process for the evaluation of calculated result and simulation frequency response.

A. *Block diagram*

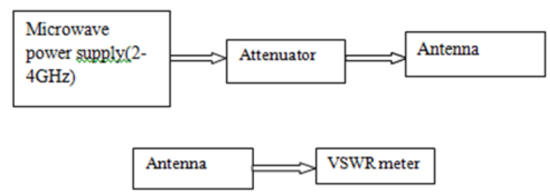

Fig. 2. Transmitter & receiver diagrams

4. Working

Microwave power supply of 2 to 4GHz is fed into attenuator pad. Attenuator is connected to Antenna. Microwave power supply and attenuator acts as transmitter. At the receiver side antenna is connected to VSWR meter .The current distribution in the patch can be changed and thus resonance frequency by using active switches based on micro electro mechanical system and p-i-n diodes or using a mechanical movement of different patches by using stepper motor or even using photo conducting switch.

A. *Filter design procedure*

- The first thing is to find the order of the filter. For the Chebyshev response, with 0.5 ripple in passband and 15dB attenuation at 2 GHz, we calculate the order of filter from graph of normalized frequency versus attenuation. So Order for our filter is (N=2).
- The design is simplified by beginning with low-pass filter prototypes that are normalized in terms of impedance and frequency. The low-pass prototype filter design can be transformed to have the band pass response as,
  $\omega=1/\Delta(\omega/\omega_0=\omega_0/\omega)$ (1)
  Where $\Delta = \omega_2\text{-}\omega_1/\omega_0$
- To change the cut off frequency of low prototype from unity to ω we required to scale the frequency dependent of the filter by the factor 1/ωc/c, which is accomplished by replacing ω/ω
- For microwave applications, designs usually must be modified to employ distributed elements using Richard's Trans formation. Richard's transformation allows the inductors and capacitors of lumped-element

filter to be replaced with short-circuited and open – circuited transmission line stubs.

- To derive the equation for the Coupled line filter design, show that a single line section can be
- Approximately modeled by the equivalent circuit shown in Fig. 3.

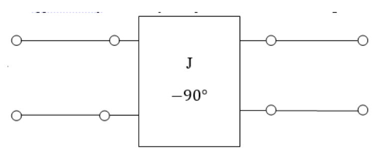

Fig. 3. Equivalent Circuit of the Coupled Line Section

- Then by calculating the image impedance and propagation constant of the equivalent circuit and showing that they are approximately equal to those of the coupled line section for θ = p/2. Will correspond to the center frequency of the band pass response.
- The equations of Image impedance and propagation at(θ = p/2) cab be solved to give an even and odd mode line characteristics impedances as given,

Z_0e=$Z_0[1 + JZ_0z(JZ_0)2]$ (2)

$Z_00 = Z_0[1 - JZ_0 + (JZ_0)2]$ (3)

8) The design equations for a band pass filter with N+1 coupled line are given as from (1)

$Z_0J_1 = \sqrt{\frac{\Pi\Delta}{2g_1}}$ (4)

Where J is Admittance inverter

B. Band pass filters

The cut-off frequency or f_c point in a simple RC passive filter can be accurately controlled using just a single resistor in series with a non-polarized capacitor, and depending upon which way around they are connected either a low pass or a high pass filter is obtained. One simple use for these types of Passive Filters is in audio amplifier applications or circuits such as in loudspeaker crossover filters or pre-amplifier tone controls. Sometimes it is necessary to only pass a certain range of frequencies that do not begin at 0Hz, (DC) or end at some high frequency point but are within a certain frequency band, either narrow or wide.

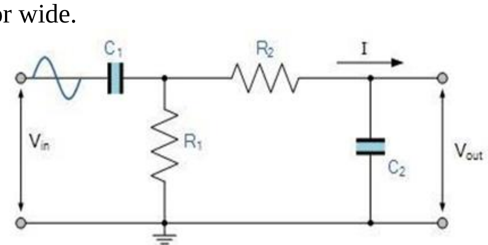

Fig. 4. RC implementations of the band pass Filter

By connecting or "cascading" together a single Low Pass Filter circuit with a High Pass Filter circuit, we can produce another type of passive RC filter that passes a selected range or "band" of frequencies that can be either narrow or wide while attenuating all those outside of this range. This new type of passive filter arrangement produces a frequency selective filter known commonly as a Band Pass Filter or BPF for short. Using capacitors and inductors, a bandpass filter has a structure similar to the one shown in the Fig. 4.

Unlike a low pass filter that only pass signals of a low frequency range or a high pass filter which pass signals of a higher frequency range, a Band Pass Filters passes signals within a certain "band" or "spread" of frequencies without distorting the input signal or introducing extra noise. This band of frequencies can be any width and is commonly known as the filters Bandwidth**.**

Bandwidth is commonly defined as the frequency range that exists between two specified frequency cut-off points (fc), that are 3dB below the maximum center or resonant peak while attenuating or weakening the others outside of these two points. Then for widely spread frequencies, we can simply define the term "bandwidth", BW as being the difference between the lower cut-off frequency ($f_{c\ LOWER}$) and the higher cut-off frequency ($f_{cHIGHER}$) points. In other words, BW = $f_H - f_L$. Clearly for a pass band filter to function correctly, the cut-off frequency of the low pass filter must be higher than the cut-off frequency for the high pass filter.

The "ideal" Band Pass Filter can also be used to isolate or filter out certain frequencies that lie within a particular band of frequencies, for example, noise cancellation. Band pass filters are known generally as second-order filters, (two-pole) because they have "two" reactive component, the capacitors, within their circuit design. One capacitor in the low pass circuit and another capacitor in the high pass circuit.

5. Design and development of a microstrip filter

A. Development of microstrip filters

In this section, a sample ultra-wideband microstrip filter design and development is presented. Filter details including circuit model, simulations, optimizations, layout creation, manufacturing, testing and troubleshooting are explained. The essential design flow in this study is given in the flow chart Fig. 5.

After determining the prototype and specifications for the filter, the circuit simulation optimizations are done by using AWR Microwave Office. EM Simulation is followed the circuit simulation. Sonnet EM Simulation and CST EM Simulation Tools are used for the EM Simulation to have accurate results with a good comparison performance. A tolerance analysis is also done using the simulation tools. Then filter layout is generated and fabricated using the circuit milling machine. Filter response is measured using a vector network analyzer (VNA). Once it is observed that the filter basically is functioning near the specifications, a minor troubleshooting is applied to tune the filter. The filter design in this study starts with an ideal model composed of quarter wavelength shorted stubs separated with half wavelength inverters. This topology has been adopted for its simple structure. In this thesis, design and manufacturing of an ultra-wideband microstrip line filter covering the 2.4Ghz strip is considered. The ideal electrical

International Journal of Research in Engineering, Science and Management
Volume-2, Issue-2, February-2019
www.ijresm.com | ISSN (Online): 2581-5792

model for the filter is based on half wavelength separated shorted stub resonators using distributed microstrip lines. The electrical design prototype of the filter is shown in Fig. 6.

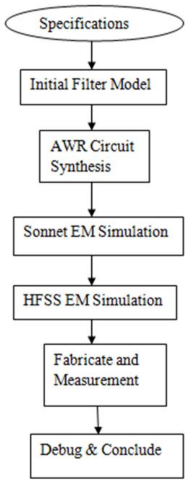

Fig. 5. Flow chart for the implementation of the filter

The design specifications for this filter as follows:

- -30 dB rejection at 2.1 GHz
- Return Loss better than -10 dB within the band

B. Design model

The structure and dimension of micro strip base on calculation as follows:

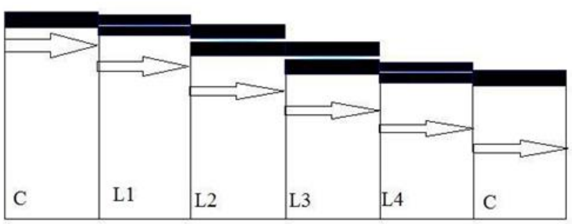

Fig. 6. Structure of couple line band pass filter microstrip N= 3

Structure dimension of a couple line BPF microstrip, N= 3, εr = 4.2 (FR4)

Table 2
Dimension of a BPF Microstrip

Section	**0**	**1**	**2**	**3**	**4=(N+1)**
W(mm)	2.91	1.68	2.48	2.66	1.16
S(mm)	-	0.19	1.21	0.85	0.46
L(mm)	16.51	17.04	16.53	16.53	17.64

6. Results

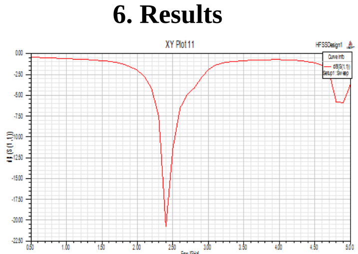

Fig. 7. Graph 1

A. Hard ware result

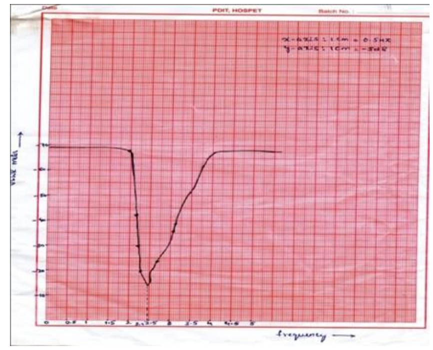

Fig. 6. Graph 2

The hardware result is matched with the software result.

7. Conclusion

It is hoped that this design examples show how I used many different design resources. To create these filter and coupler circuits, the experience of several other works was combined with published data, advanced circuit theory simulation, EM analysis and, finally, fabrication and measurement. Each step in the process contributed to the overall design success. Designing of band pass filter with Butterworth approach in combination with concentrated components, i.e. inductors and capacitors and its computational verification in form of parallel-coupled microstrip lines with the program AWR Design Environment give very good filter characteristics at the center frequency 2.4 GHz with frequency bandwidth of about 100 MHz as required at the specification stage. At the center frequency the insertion loss and reflection factor has the values about -2 dB and better than -15 dB, respectively. The measurement gives also very good filter characteristics at the frequency 2.4 GHz, however with larger insertion loss of about -7.5 dB and smaller bandwidth of about 50 MHz. This larger loss originates likely from losses of the coaxial connectors and their poor contacts to the microstrip line.

References

[1] Bahl and P. Bhartia., "Microwave and solid state Circuit Design", Wiley. 2003.

[2] R. Mongia, "RF and Microwave Coupled Line Circuits," Artech House.,1999.

[3] EH. Fooks. "Microwave Engineering using Microstrip Circuit," Prentice Hall, 1990.

[4] R. M. Kurzok, "General four-resonator filters at microwave frequencies," *IEEE Trans. Microwave Theory Tech*., vol. MTT-14, pp. 295–296, July 1966.

[5] R. Levy, "Filters with single transmission zeros at real and imaginary Frequencies," *IEEE Trans. Microwave Theory Tech*., vol. MTT-24, pp. 172–181, Apr. 1976.

[6] M. J. Lancaster, "Passive Microwave Device Applications of Superconductors," Cambridge, U.K.: Cambridge Univ. Press, 1997.

[7] S. J. Hedges and R. G. Humphreys, "An extracted pole microstrip elliptic Function filter using high temperature superconductors," in Proc. Eu MC, 1994, pp. 517–521.

[8] K. T. Jokela, "Narrow-band stripline or microstrip filters with transmission Zeros at real and imaginary frequencies," *IEEE Trans. Microwave Theory Tech*., vol. MTT-28, pp. 542–547, June 1980.