Design of Micro-Strip Low Pass Filter for L Band Frequency

Saravanan.M, Agatha Janet.S

Abstract— In this paper we propose a stripline Low pass filter for 2.4 GHz application using Advanced design software. The filter is operated at L band frequency range in 2.4 GHz for various microwave applications & the filter is design on Roger Duroid 5880(tm) substrate with dielectric constant of 2.2, with dimension conductor thickness 0.035 mm and substrate height 0.787 mm. The proposed filter is design at a center frequency of 2 GHz. Simulation results show that the filter operation is optimum over the frequency range 1.8 GHz to 2.6 GHz which is best in this range. In this paper, band pass filter order n=4 development with the assistance of the Richards-Kuroda Transformation method is used.

Index Terms— Maximally flat LPF, Strip-line, ADS Software tool, Roger Substrate, L Band Spectrum, S Parameters

I. INTRODUCTION

The Butterworth filter has maximally flat frequency response and not has ripple [1] response on the pass band. However, the Butterworth filter has maximally flat response as possible from 0 Hz until cut off frequency at -3dB on the pass band with no ripple, and rolls off on the stop band are towards zero response. It can be describe and observed on the logarithmic bode plot [1,2], its shows that the response slopes off linearly towards negative infinity. Such as a first-order filter's response rolls off at −6 dB per octave (−20 dB per decade)[1-2] (all first-order low pass filters have the same normalized frequency response). A second-order filter decreases at −12 dB per octave, a third-order at −18 dB and so on. Butterworth filters have a monotonically changing magnitude function with ω, unlike other filter types that have non-monotonic ripple in the pass band and/or the stop band. [4-5].This is also because it has a 'quality factor', "Q" of just 0.707 [3, 4].

The Butterworth filter have specification characteristic that is defined as 'brick wall' [3], its represent the ideal frequency response and standard approximation of Butterworth filters measurement result. Butterworth filter have poor response of phase characteristic that is at stop band, [6-8] it's required the higher order to implement in the specifications particulars on this stop band parts And the disadvantages of Butterworth filters is the pass band of its always achieved the expense of wide transition band and the filters will make translation and from the pass band to the stop band. The characteristic of frequency band of radio are related with the performance of a radio system. If the output received of the performance of radio can be improved by frequency bands adjusted on it.

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The common frequency bands of two –ways radio can be categories into the UHF (ultra high frequency) and VHF (very high frequency). The wavelength of UHF bands are shortest that VHF. The advantages UHF shortest wavelength a suitable for use on the rugged terrain or inside of a building which signal easier to transfer and find the ways to pass through on it.[3] But for VHF have a longer wavelength and it can make signal transmit further under ideal condition. In general, lower radio frequencies are better when compare to longer range using in any electronics application. For design of Butterworth filter into radio communication applications, the important consideration includes type of elements circuit. The lumped elements circuit can work efficiency at lower frequency UHF because the wavelength will decrease to short on higher frequency and while for distributed elements suitable operate at higher frequency and wavelength will become too larger when into lower frequency range.

In this paper, Butterworth filter are development into VHF range portable 2 radio application by allow the desired frequency signal to pass through antenna and attenuate the higher signal frequencies and to reduce the minimal losses. Minimal losses on signal transmission reduce energy consumption during communication thus making this product potentially invaluable for signal transmission on regions whereby a power source is difficult to locate. To achieve better performance, the design of Butterworth is concentrate on lumped elements compare to distributed elements. The two ways radio experience harmonic produced by the transmitter and entering the receiver. These will damage the receiver circuit. In order to solve this, a low pass filter is to be employed such that it will attenuate the harmonic signal and allow the wanted signal to pass through antenna with minimum losses. Butterworth filter are devices of combination of two –port network which used on function as to control the certain frequency signal repossesses within a system by only allowing the transmissions of specify frequencies signal pass through in pass band and discriminate the unwanted frequency in the stop band.

II. LUMPED COMPONENT REALIZATION OF FILTER

The passive (LC) filters work quite well at frequencies up to a few hundred megahertz. Beyond this range, components deviate significantly from anything close to ideal. The microwave filters are based on distributed parameters rather than lumped inductors and capacitors. For low-power applications, stripline and microstrip filters are extensively used because of their low cost and repeatability. For high-power requirements, waveguide structures are utilized. Microstrip line is bimetallic which contain two metallic surface separated with a small distance, having a dielectric material between them.

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There are one metallic surface having the filter geometry and other surface having the ground plane at which the reflection of wave is occurs.

Richards' transformation is use for realizing the filter the conversion of lumped element filters into distributed filters. In this the short and open circuited transmission line stubs are use having the length of the order of λ/4 or λ/8. Kuroda's identities are also use in realization of filter, it allow the transformation of series stubs into shunt stubs and vice versa. This is an exact transformation and not an approximation. For obtaining the better results of filter combination of both techniques as described previous is used.

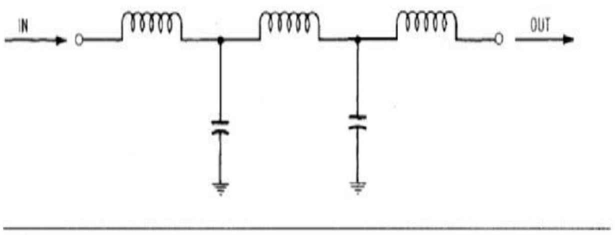

FIG 1 Low pass filter equivalent circuit

III. DESIGN METHODOLOGY

The design of microstrip low pass filters involves two main steps. The first one is to select an appropriate low pass prototype, The choice of the type of response, including pass band ripple and the number of reactive elements, will depend on the required specifications. The element values of the lowpass prototype filter, which are usually normalized to make a source impedance g0 = 1 and a cutoff frequency Ωc = 1.0, are then transformed to the L-C elements for the desired cutoff frequency and the desired source impedance, which is normally 50 ohms for microstrip filters. The next main step in the design of microstrip lowpass filters is to find an appropriate microstrip realization that approximates the lumped element filter.

A. Calculation of the Dimensions of the Filter:

Order of the filter:

$$LA(\omega) = 10\log10\{1+\varepsilon(\omega/\omega_c)2N\}$$

Where

$$\varepsilon = \{\text{Antilog10 } LA/10\} - 1$$

B. Prototype Values of the lowpass Filter:

The prototype values of the filter is calculated using the formula given by

g0 =1,

gk = 2sin {(2k-1)π/2N} where k = 1,2,…..N

and gN+1 =1

C. Lumped Model of the Filter

The Lumped values of the Lowpass filter after frequency and impedance scaling are given by

Ck'= Ck /R0ωc and Lk'=R0 Lk /ωc where R0 is 50Ω

D. Distributed model of the filter

For distributed design the electrical length is given by

Length of capacitance section (βLc) : Ck Z_l/R0,

Length of inductance section (βLi) : L_k R0/Z_h

Where Z_l is the low impedance value,

Z_h is the high impedance value,

R0 is the Source and load impedance,

ωc is the desired cutoff frequency

IV. RESULT AND DISCUSSION

The low pass filter (transmitter and receiver) operating frequency range is at 2.4GHz, cutoff 2.8 GHz on a substrate that had a dielectric constant of 2.2 and a thickness of .5 mm with the expected simulation result S parameter of software before and after tuning to low pass filters designed and it is shown as below graph, and for lumped elements capacitor and inductor value per design was done by using ADS software. Tuning method is using in order to perform better simulation result according to specification values required. The method are done by trying change some of parameter values and until make the simulation result close to specification

A.Calculation of the Dimensions of the Filter:

The prototype values of the filter is calculated using the formula given by

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gk = 2sin {(2k-1)π/2N} where k = 1,2,…..N

and gN+1 =1

The prototype values for the given specifications of filter are g1 = 0.7654 = C1, g2 = 1.8478 = L2, g3 = 1.8478 = C3 & g4 = 0.7654 = L4

B.Lumped Model of the Filter

The Lumped values of the Lowpass filter after frequency and impedance scaling are given by

Ck'= Ck /R0ωc and Lk'=R0 Lk /ωc where R0 is 50Ω

The resulting lumped values are given by

C1' = 1.218 pF, L2' = 7.35 nH,

C3' = 2.94 pF and L4' = 3.046 nH

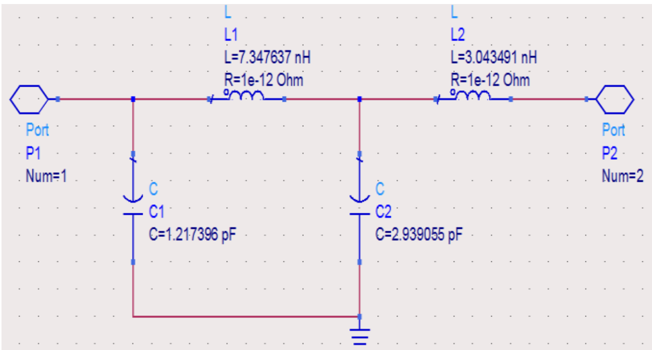

Fig 2. Lumped model of maximally flat LPF

Fig 2 show LC combination of maximally flat low pass filter with filter coefficients calculated from prototype model of the low pass filter. The input and output terminals are terminated by 50Ω resistance.

The S parameter for port (2,1) is shown in figure 3 which depicts the pass band and the stop band transition for the designed low pass filter along with attenuation at pass band and stop band frequencies.

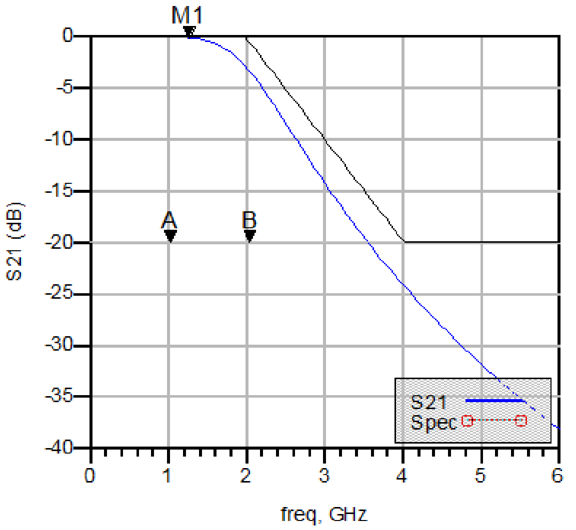

Fig 3. VSWR of S21 in dB

	Fp	Fs	Ap	As
Input Parameters	2.000E9	4.000E9	3.000	20.000
	PB Edge	SB Edge	Gain Dev (dB)	Delay Dev (ns)
Performance	1.980 GHz	3.540 GHz	2.829	0.103
	F	S11 (dB)	S21 (dB)	Delay (ns)

C. Distributed model of the filter

For distributed design the electrical length is given by
Length of capacitance section (βLc) : Ck Z_l/R0,
Length of inductance section (βLi) : L_k R0/Z_h
Where Z_l is the low impedance value,
Z_h is the high impedance value,
R0 is the Source and load impedance,
ωc is the desired cutoff frequency
If we consider Zl = 10Ω and Zh = 100Ω then βLc1 = 0.153, βLi2 = 0.9239,
βLc3 = 0.3695 and βLi4 = 0.3827
Since β = 2π/λ, the physical lengths are given by
Let substrate used for fabrication be Rogers RO3003(tm) whose permittivity be 3 and permeability be 1. Therefore

$$\beta = \frac{2\pi}{\lambda} = \frac{2\pi}{\frac{c}{f_r\sqrt{\varepsilon_r}}} = \frac{2\pi}{\frac{3\times10^8}{2\times10^9\sqrt{3}}} = 72.5519$$

Lc1 = 2.108 mm, Li2 = 12.734 mm,
Lc3 = 5.092 mm and Li4 = 5.274 mm.

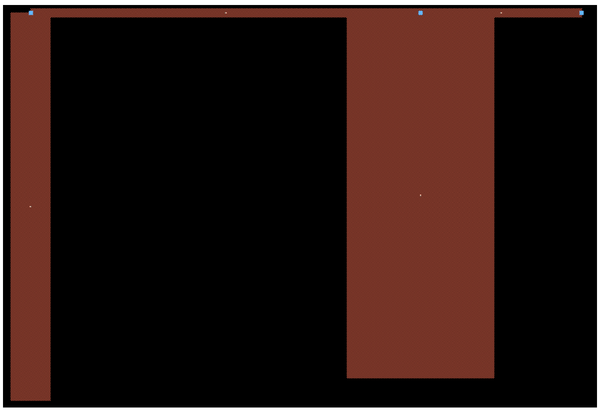

Fig 4. Distributed model of LPF

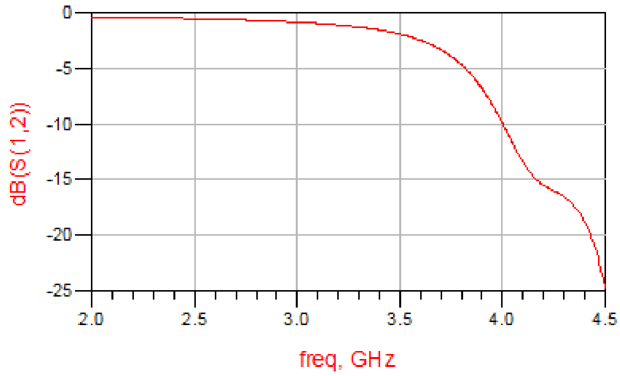

Fig 5. S (1, 2) for distributed LPF

V. CONCLUSION

From the simulation results, it is noticed that the ads software simulation show the ideal result of Butterworth filters is the best and able to perform the better filters response and all the S-parameter value are appropriated to the specification value required for filter design. But when in measurement result of filter response has the shape as low pass filter. So we conclude that design is not fail. By taking care all precaution a good filter can be designed. Overall, the simulation result and measurement result are agreed well with each other. The design can be further improved in accuracy through using a better technology for better fabrication and more pure substrate and copper that we using in fabrication. Besides, to improve the transition band, which gives us a better and narrower slope, we can increase the order of the filter, but in other way round, it also will increase the cost of the filter. In other words, to improve the cost effectiveness, we can reduce the order of the filter as well.

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