ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

RF RECEIVER SUBSYSTEM DESIGN AT 2.4 GHz FREQUENCY USING MICROSTRIP LINES

K. Rakesh babu and V. J. K. Kishor Sonti
Sathyabama University, Chennai, Tamil Nadu, India
E-Mail: raki471@gmail.com

ABSTRACT

In this paper, performance analysis of RF subsystems like, band pass filter (BPF), low noise amplifiers (LNA) are performed. The center frequency is 2.4 GHz and the substrate used is FR4. The software used is Advance Designing Software (ADS). Noise Figure of LNA is 1.95 and the return loss of the BPF is -20.2dB.Achieved results are in agreement with theoretical values.

Keywords: micro strip line, Low Noise Amplifier (LNA), band pass filter (BPF).

1. INTRODUCTION

A 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 front-end 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.

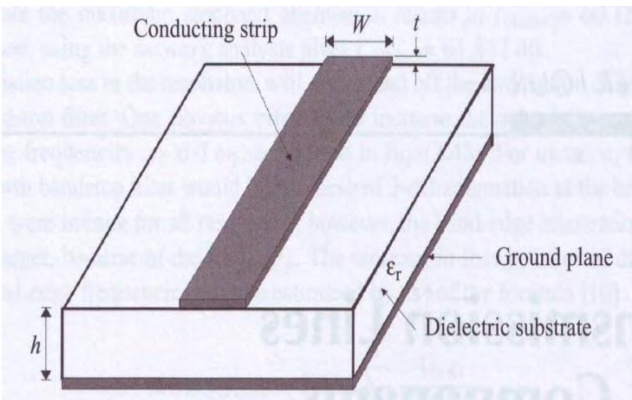

Figure-1. General Micro strip structure [6].

A high electron mobility transistor (HEMT) is a type of field effect transistor making a junction between two materials with different band gaps as the channel unlike a doped region in MOSFET. Generally used material combinations in this are GaAs with AlGaAs. [3]

All the work in this paper is performed at the centre frequency of 2.4 GHz and the substrate used is FR4

With dielectric constant 4.6 and 0.019mm is the thickness of copper line.

2. DESIGN OF SUBSYSTEMS USING MICROSTRIP

RF subsystems consist of major components as BPF, LNA and mixer. These designs are carried out centre frequency 2.4 GHz.

a) Band pass filter

The band pass filter designed in this paper is micro strip parallel coupled band pass filter. The general structure of a micro strip parallel coupled band pass filter as shown below.

ARPN Journal of Engineering and Applied Sciences

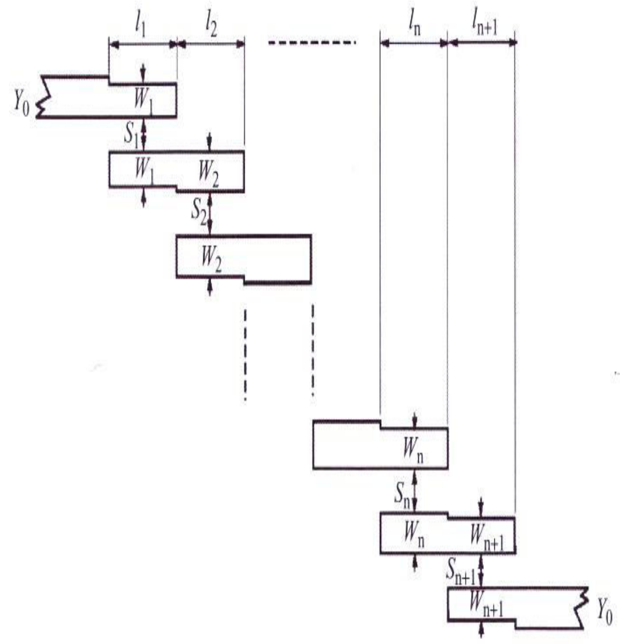

Figure-2. Micro strip parallel coupled band pass filter [7].

The major advantage of parallel coupling methods than other end coupling are the length reduced approximately by half, a symmetrical insertion loss versus frequency response obtained with the first spurious response which occurred at three times center frequency, the larger gap between strips allows for higher power rating filter and permits a broader bandwidth at tolerance.

There are three main existing approaches to realize a band pass filter. The first is micro strip or coplanar waveguide (CPW) multiple-mode resonator (MMR) with the assistance of a coupling mechanism. Secondly, a Broadside coupled micro strip line with a CPW at the back. Lastly, a direct or indirect combination of a low pass and high pass filter [8]. However, there are many new developments in material and fabrication technologies. For example, high-temperature superconductors (HTS), low-temperature co fired ceramics (LTCC), monolithic microwave integrated circuits (MMIC), micro electro mechanic system (MEMS), and micromachining technology [1].

The filter design is desired in small size the coupled line filter with minimum order of N equal to 4 with 0.5 equal-ripple responses is selected. The order of the filter can give us the attenuation at the specified frequency from the following figure.

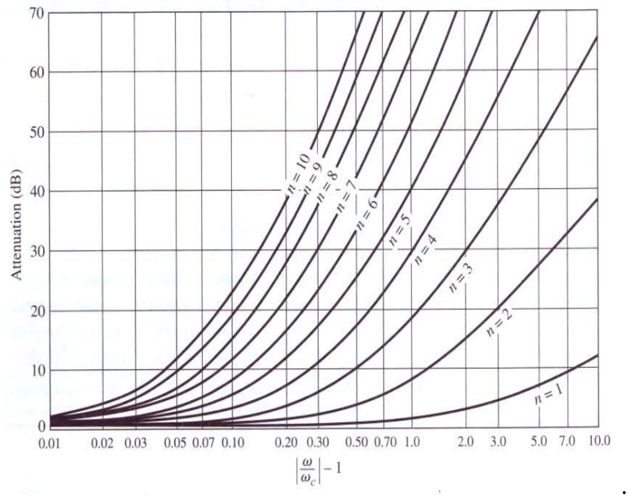

Figure-3. Attenuation versus normalized frequency for 0.5dB ripples [4].

The fractional bandwidth (FBW) is calculated using equation

$$FBW = (w2 - w1)/w0 \tag{1}$$

Where w1, w2 are the edges of pass band frequency. Then using the line calculation in Advanced Design System (ADS), Agilent Technologies software, dimensions of width, spacing and length of each stage are calculated by using even and odd characteristic impedance. The characteristic impedance typically assumed as 50 Ohms everywhere. Whereas it corresponds to an electrical length (Eeff) as 90º. The calculated dimensions of width gap and length of each stage are shown in table below.

Table-1. Values of width, gap, and length of MCLIN

Stage	**Width** (W)	**Gap** (S)	**Length** (L)
1	1.228	0.018	18.449
2	1.382	0.254	18.241
3	1.382	0.254	18.241
4	1.228	0.018	18.449

ARPN Journal of Engineering and Applied Sciences

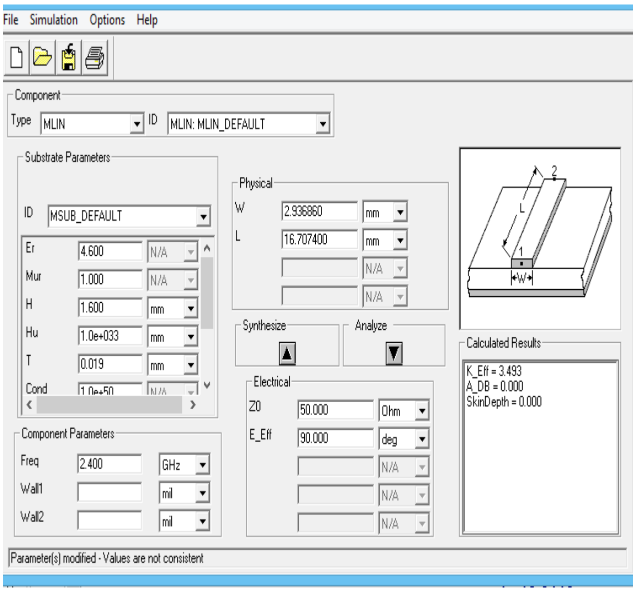

Figure-4. Line calculation with FR4 substrate.

Figure-4 gives the synthesized width and length values of the substrate at center frequency.

Below Figure-5 shows the schematic of the band pass filter. In order to design the micro strip band pass filter both the ends are terminated with 50 Ohm term.

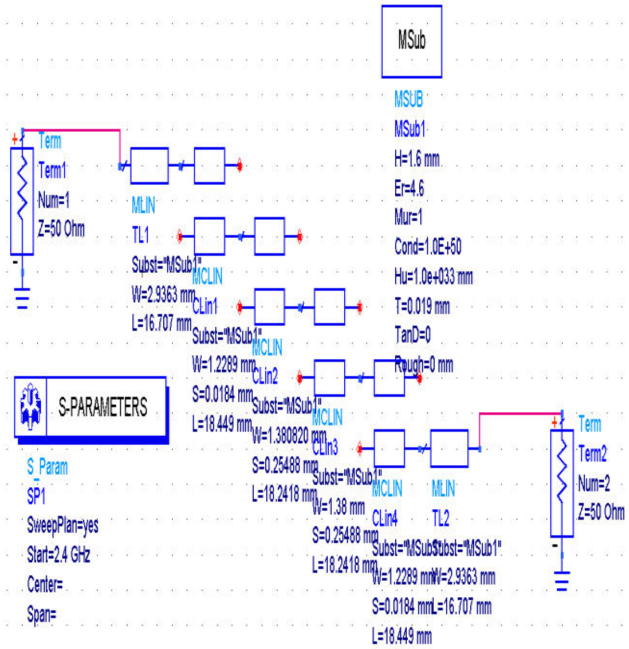

Figure-5. Model of the band pass filter in ADS.

b) Low noise amplifier

In this paper the low noise amplifier is designed using micro strip model technology and EE_HEMT transistor. From the synthesized line calculations outputs W=2.9363 mm, L=16.707 mm and providing the input and output matching the low noise amplifier for the specified frequency is as shown below.

The steps followed to design optimum LNA is as follow:

a) Selection of active device
b) Biasing and stability analysis
c) Input and output matching

The condition is verified with the following equations as followed

$$\Delta = S_{11}S_{22} - S_{12}S_{21} \quad |\Delta| < 1 \tag{2}$$

$$K = (1 - |S_{11}|^2 - |S_{22}|^2 + |\Delta|^2)/2|S_{12}S_{21}| \quad K>1 \tag{3}$$

These HEMT'S are good because of the fact that they are high speed, radiation hard circuits with lower power consumption values.

Following Figure-6 shows the ADS schematic of the EE_HEMT low noise amplifier.

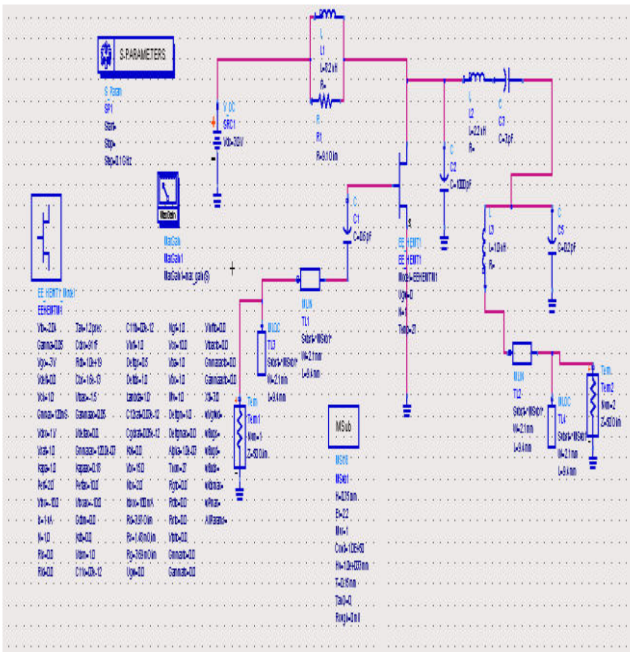

Figure-6. ADS schematic of EE_HEMT LNA.

3. RESULTS AND ANALYSIS

Performance evaluation of the above designs was done by comparison and the results obtained for the designs are as shown below.

VOL. 10, NO. 10, JUNE 2015 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

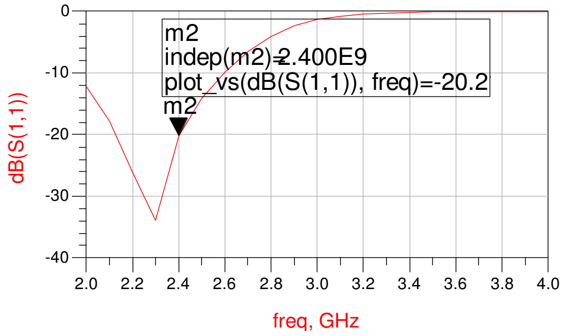

Figure-7. Variation of S11 of BPF w.r.to frequency.

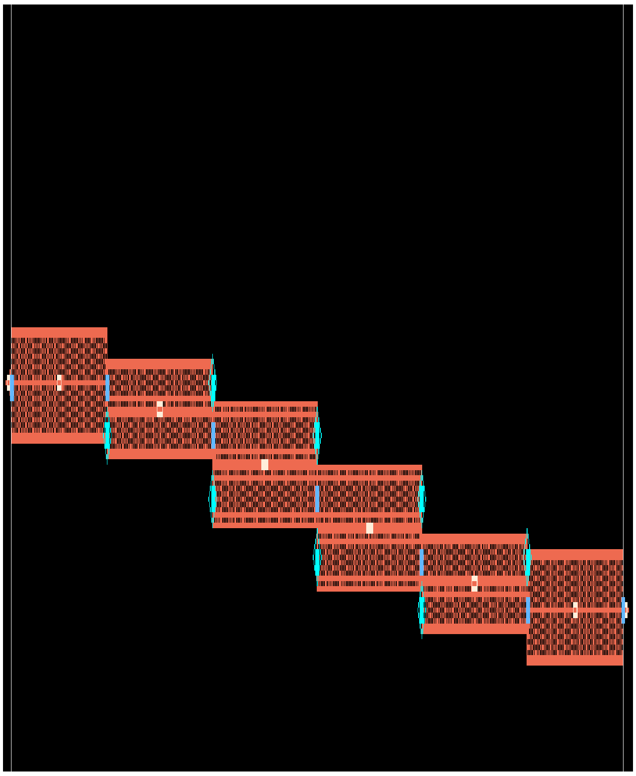

Figure-8. Generated layout of BPF.

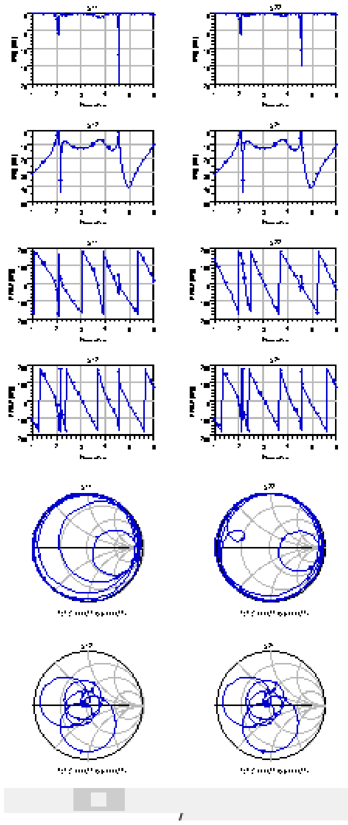

Figure-9. Display results after momentum.

The designed parallel coupled BPF is working in the frequency range 2.2 GHz to 2.4 GHz.the return loss obtained is -20.2 dB at center frequency. The generated layout and simulated results after momentum are shown in Figures 8 and 9, respectively.

The following graphs show the results of simulated low noise amplifier.

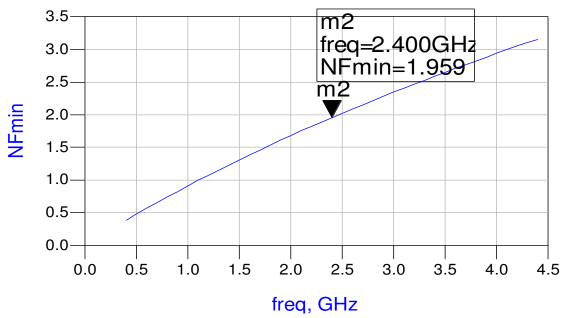

Figure-10. NF min w.r.t Frequency.

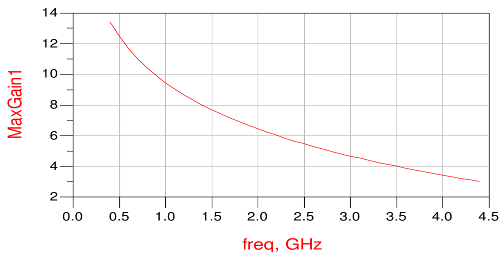

Figure-11. MAX Gain vs Frequency.

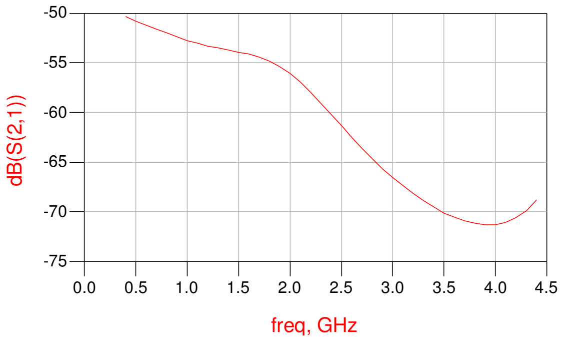

Figure-12. Variation of S21 w.r.to Frequency.

The low noise amplifier is having noise figure of 1.95 and maximum available gain is 6dB.the designed low noise amplifier is in agreement with theoretical calculations.

REFERENCES

[1] Wan-Rone Liou, Mei-Ling Yeh, Chun-An Tsai and Shun-Hsyung Chang. 2010. Design And Implementation Of Alow-Voltage 2.4-Ghz Cmos Rf Receiver Front-End For Wireless Communication.

[2] Othman A. R, Hamidon A. H, Abdul Wasli. C, Mustaffa M. F, Ting J. T. H, Ibrahim a. B. 2010. Low noise high gain RF front end receiver at 5.8 GHz for wimax application:

[3] V.J.K. Kishor Sonti, V.Kannan. 2012. Evaluation of effect of noise on MODFET LNA designed using different substrates.

[4] Fang Xu1, Zongjie Wang1, Mi Xiao1, Jizong Duan1, Jiayang Cui1, Zhe Zhu1, Mu Ju2 and Yang Liu1. 2013. A Compact Dual-Band Band-Pass Filters With Wide Stop-Band Using Two Resonators Combined By Via-Hole:

[5] D. Senthilkumar, Dr. Uday Pandit khot. 2013. Prof. Santosh Jagtap Design and Comparison of Different Matching Techniques for Low Noise Amplifier Circuit International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622, www.ijera.com. 3(1): 403-408.

[6] Md. Maruf hossain. 2008. Design of RF Front End for Multi-Band Multi-System GNSS Receivers.

[7] S. B. Cohn. 1958. Parallel-Coupled Transmission-Line-Resonator Filters. Microwave Theory and Techniques, IRE Transactions on. 6(2): 223-231.

[8] 2014. A Novel Hair Pin Line Band Pass Filter design for WIMAX applications K.SandhyaRani, Principal Research Scientist, SAMEER-CEM, Chennai, Monisha. B. Project Assistant-A, SAMEER-CEM, Chennai International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE). 3(4).