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DESIGN AND PERFORMANCE ANALYSIS OF LOW NOISE AMPLIFIER WITH FILTERS FOR WBAN BASED HEALTH MONITORING SYSTEM

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ABSTRACT

In this paper, the design of LNA with filters structure is proposed for wireless health monitoring system. The receiver in wireless health monitoring system should have efficient LNA as received bio-medical signal should be analyzed very accurately for continuous monitoring of the patient's health. Low Noise Amplifier (LNA) plays an important role in communication system to suppress the noise in the received signal. This paper proposes a novel design of LNA with band pass filter, butter worth filter and chebychev filter. The proposed LNA has been designed using Advanced Design System tool. The performance of the LNA is analyzed for Gain, Input return loss, Output return loss Noise Figure. The performance of the LNA for different filters has been analyzed and it is found out that LNA with band pass filter provides good performance compared to LNA with butter worth filter and chebychev filters. The proposed LNA with band pass filter can be used for health monitoring system for providing accurate received signal.

Key words: Low noise amplifier, band pass filter, advanced design system, chebychev filter, Butterworth filter, Health Monitoring system.

I. INTRODUCTION

Nowadays, due to the hectic life style, many people are suffering from diseases like Hihg BP, Sugar, and heart problem. Due to this reason, many patients are dying in untreated manner. These diseases require continuous monitoring of the data and it is required to send the data to their family doctor. This is achieved by wireless body area network (WBAN) using Ultra Wide Band Communication (UWB).

Ultra wideband communication is one of the emerging technologies in Bio medical applications. It is the alternate approach for the existing narrow band communication system. UWB uses narrow pulses for communication. This provides very high speed in terms of GHz range. It has low electromagnetic radiation. This feature allows the use of UWB for medical applications. The UWB transceiver consists of low noise amplifier (LNA), multiplier and pulse generator. For medical applications, the received signal should be of very accurate. Hence, in the UWB transceiver, the important component is LNA. The LNA eliminates the noise present in the received signal. In this paper, design of LNA is proposed for continuous health monitoring. This heal monitoring system is used for the continuous monitoring the health parameters like BP, Sugar and ECG of aged and severely affected people. This health monitoring system can be used as a compact device. The measured parameters are sent to the family doctor in a fixed time interval. In a hospital, which has many specialized doctors, continuous monitoring of patients in ICU is also a tedious work. This health monitoring system is solution for them as they can monitor the details of the patients in ICU form his place itself. Figure 1 shows the general block diagram of the health monitoring system.

The sensors are connected to the patient's body and it continuously measures the parameters like ECG, BP and sugar. Then these parameters are sent to the doctor's unit through UWB transceiver. The first block of UWB receiver system is LNA. This amplifier can be used to provide high accurate signal as it reduces the noise level in the signal. Here the design process of transceiver system is mainly focused on LNA because receiving bio signal from the sensing chip which is very low signal strength. In this paper, a Low Noise Amplifier (LNA) with band pass filters has been designed. The proposed LNA with filters is mainly used in UWB receiver for providing high accurate signal. The designed low noise amplifier is operated at 5.8GHz frequency range because 23 non-over-lapping channels available at this range of frequency.

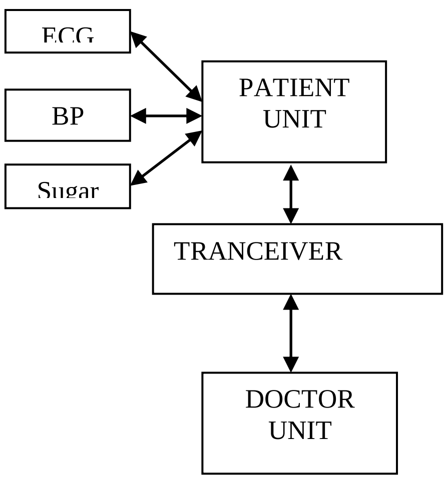


Fig.1. Health Monitoring System

II. RELATED WORK

Arvindkumar, et al., (2005) have used CMOS 0.35μm technology for the design of LNA and uses single ended configuration design. The LNA has been designed for low frequency of 1800MHz. For this low frequency, the noise figure achieved is high. The wide band LNA has been designed using HEMT transistor and coupler for low frequency bend only (Alpana and Bodhe, 2011). As the coupler is used to achieve high gain, it is not cost efficient and complexity in the design also increases. Federico and Indiveri (2015) have designed LNA using MESFET transistor for 5 to 6 GHz frequency range. For matching network LC combination, has been used. The Gain achieved is 15.83db. The author achieved the poor stability in the design and noise figure increases as the frequency is increased.

CMOS 0.18µm technology has been used to design LNA for cognitive radio frequency (Hu, et al., 2009). Two stages have been used for the design and the noise figure achieved is very high. The different combination of matching networks has been used for the design of LNA. The gain achieved is minimum and noise figure is high at 6 GHz frequency (Sahoolizadeh, et al., 2009). L-L Duality matching network has been used for input and output matching (Chen, et al., 2010). The stability achieved is minimum and gain also minimum at 6 GHz frequency. The LNA proposed does not work in low frequency and consumes high power (Karpagam, and Sampathm 2014). Kasun, et al., (2014) have used common gate and cascade amplifier for good matching and high gain. The gain achieved is comparatively low at 8.72 GHz. Since the author used two topologies the complexity also increases.

Maheshwari and Vimal, (2016) have described the novel method which is used to isolate the DC circuits from the AC signals. Generally, stubs are used for impedance matching for that radial stubs are used in the designed LNA circuit. it will give as low impedance at low frequency. Similarly, if it is high frequency means produces the high impedances. Maheshwari and Vimal, 2015) have described the analysis and design of Low noise amplifier (LNA) based on cascade circuit with resistive feedback. The LNA circuit has π-matching network with resistive shunt feedback for wideband input matching. Design a low noise amplifier for ultra-wideband receiver is discussed (Yuce, 2014). The design of LNA is based upon differential architecture with enables the balun transformer. This design may produce the improved noise figure at very low frequency. Madhura and Bhosale (2015) discussed the combined architecture of Low noise amplifier. This means micro strip antenna integrated with low noise amplifier. This design improves the complexity due to integrated architecture. A novel method of designing wideband low noise amplifier using a sub threshold technique is discussed (Marcuz, 2008). The design of LNA comprises common gate and common source stage. The power reduction is achieved by driving the front end common gate transistor in sub-threshold region. If the designed circuit operates beyond the threshold region means it will degrades the performance of an LNA.

The ultra-wide band imaging systems for breast cancer detection projects is discussed in the reference book (Mohdamed 2004). This has initiated many research projects based on ultra wide band communication technology. Neha and Sharma, (2013) describes the concept of health care monitoring systems. The physiological signals acquired from on body sensor nodes to remote location. Low power consumption is required since medical sensor nodes are battery powered. The integrated pulse based ultra-wide band technology was described (Phond, et al., 2010). This paper presents the concept of integration method which produces the high noise ratio in the output signal. Prabirkumar et al., (2007) have presented the analysis work of mobile health systems in emergency healthcare systems. Senthilkumar, et al., (2013) have reported the three different aspects and each design steps have been used to reduce the congestion problem while transmitting the bio signals to the network. The various transform has been used to avoid the congestion problem in the network. Sharad and Patil, (2015) have explained the concept of Brain machine interface (BMI). This paper shows how to construct and record the neural based bio signal and neural recording systems.

III. PROPOSED DESIGN

Today, ultra wide band communication is one of the emerging technologies in Bio medical applications. Since it's depends upon the electronic innovation technology. All kinds of communication have been taken in bio medical applications. Especially choice of ultra-wide band communication has some reasons: such as less power, high data rate transmission and information is encoded in very few nanoseconds. Whenever the health monitoring system is encountered in the field of bio medical applications while communication taken by wireless body area network (WBAN).

The Figure 2 shows the proposed health care monitoring system in hospital environment. The monitoring system consists of patient unit, doctor's unit and wireless body area network. Wireless body area network is developing rapidly and its provides the platform to various sensors which are deployment in the human body for healthcare applications. The patient unit consists of various sensors so different physiological signals are received from sensors and then the combined signals are transmitted to the wireless sensor node. The sensed signals are transmitted through wireless body area network from the patient unit. The transmitted signals are received by doctor's unit with the help of wireless body area network. Hence the sensed signals are analyzed and the necessary actions are taken.

The UWB receiver consists of Low noise amplifier, multiplier and pulse generator from these components Low noise amplifier is very essential. Its primary responsibility is to increase the sensitivity of the receiver by amplifying weak signals without contaminating them with noise signal. These responsibilities must be satisfied by low noise amplifier. The received bio signal strengths are very low and the LNA amplifies the signal strength by suppressing the noise present in the signal. Hence the amplification factor would be satisfied by low noise amplifier.

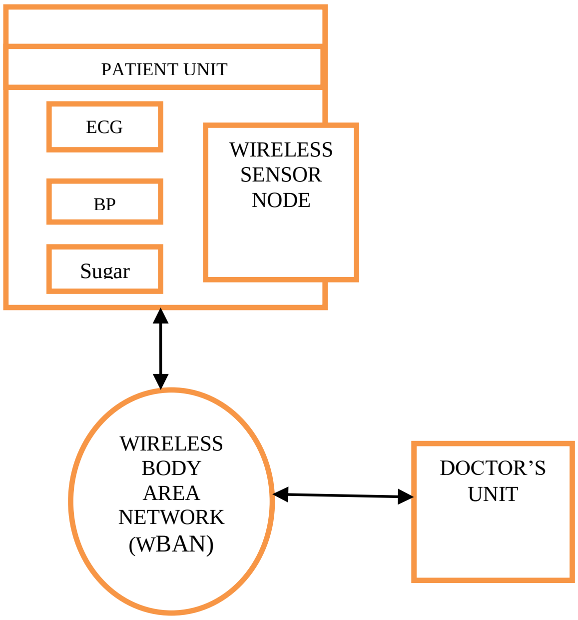


Fig.2. The proposed Device for health care monitoring system

IV. STRUCTURAL DESIGN OF LNA

Efficient design of low noise amplifier is very important in communication systems. LNA can be used to improve the signal strength by reducing the amount of noise which is present in the received signal from the antenna. In the design of LNA the choice of transistor is an important element as it is the heart of the amplifier. Each transistor has a unique current rating and operating voltage and specified the breakdown voltage which will not be exceeded by the applied dc voltage.

The design of LNA consists of three modules. There are

- Biasing circuit design
- Matching network design
- Stability network design

Biasing circuit design

The design of biasing network is to set the operating point of the transistor that means transistor is operate in the desired region. According to the transistor characteristics LNA should be maintained in strong and stable bias network.

Matching network Design

The purpose of using matching network is to provide impedance matching between two terminals. The impedance matching provides maximum power transfer between source and load terminal. If the matching network is not placed at both input and output ends, it will create standing waves on the transmission line.

Stability network Design

The stability of an amplifier is one of the important considerations in LNA design. RLC feedback is established from base terminal to ground terminal to increase the stability of LNA circuit. This RLC feedback is established at both input and output matching network. Due to oscillation, low noise amplifier is may fail to work in stable condition. To maintain the transistor is stable it requires the unconditional stability which is given in the following equation.

$$k = \frac{1 - |S_{11}|^2 - |S_{22}|^2 + |\Delta^2|}{2|S_{12}S_{21}|} > 1 \qquad (1)$$

$$\Delta = |S_{11}S_{22} - S_{12}S_{21}| < 1 \qquad (2)$$

V. RESULTS AND DISCUSSION

The complete structure of Low noise amplifier has been designed for certain frequency range and is tested using ADS software. The simulation results have been measured at 5.8 GHz frequency. The circuit shown in fig 1, has been designed the results for the same are shown in fig 2. The input reflection coefficient is -16.566dB, reverse transmission coefficient is-21.391 dB, forward transmission coefficient is 10.346dB, output reflection coefficient is -3.409dB, stability factor is 0.996 dB and noise figure is 1.821sdB. So, the stability factor is less than one it will show the conditional stability

BUTTERWORTH FILTER DESIGN

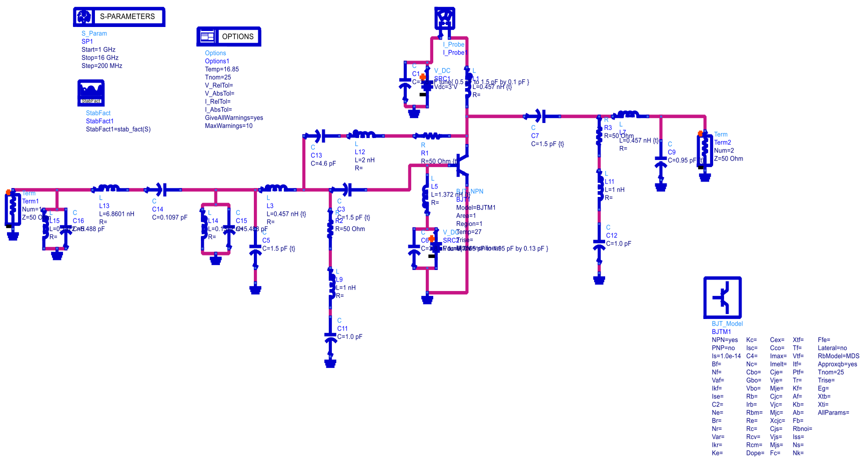
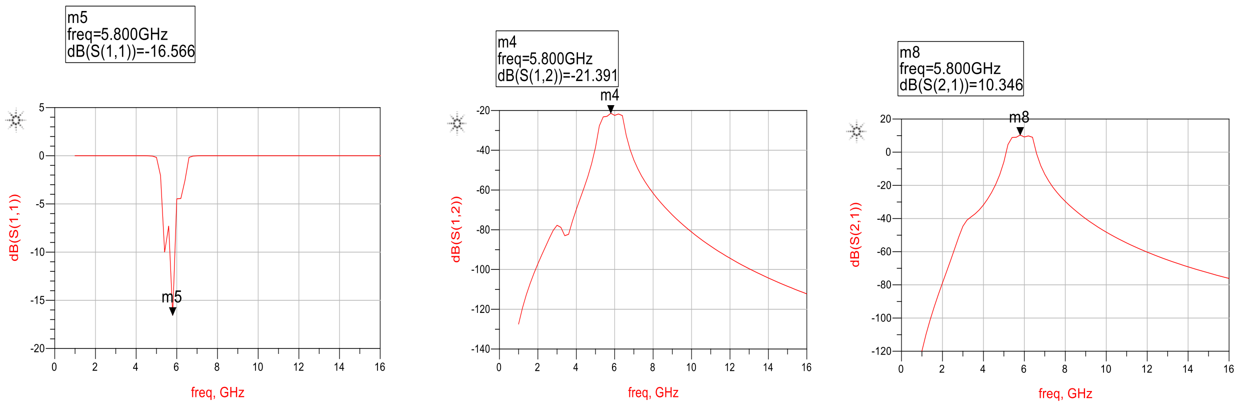
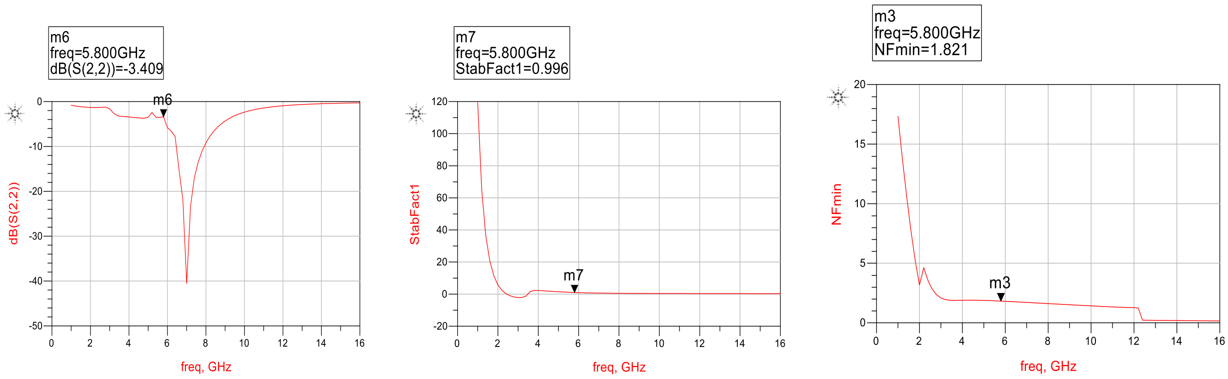


Fig -3: Structure of Low noise amplifier with Butterworth Filter



a) Input return loss b) Reverse transmission gain c) Forward transmission gain



d) Output return loss e) Stability factor f) Noise figure

Fig. -4: Simulation results of LNA with Butterworth Filter
a) input return loss (S_{11}) b) reverse gain (S_{12}) c) Forward gain (S_{21}) d) output return loss (S_{22}) e) Stability factor f) Noise figure

CHEBYSHEV FILTER DESIGN

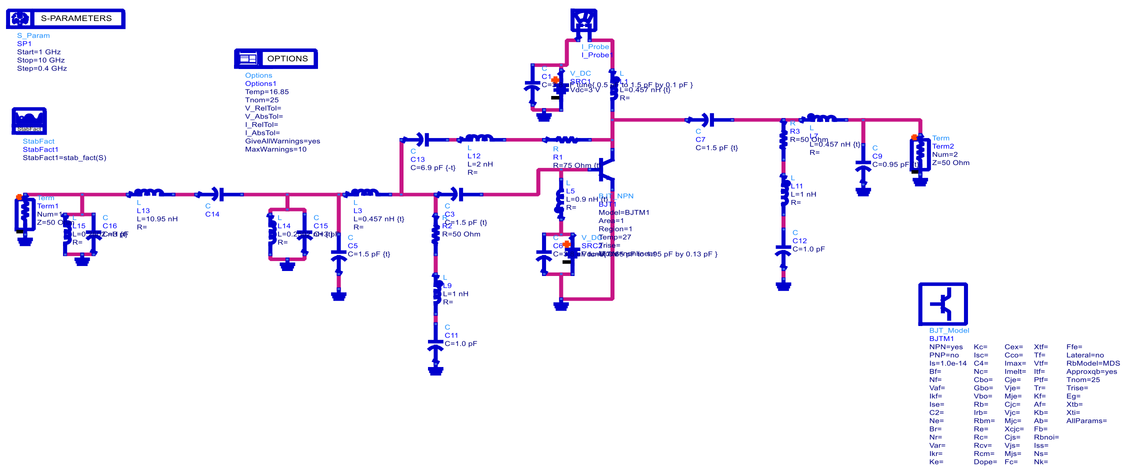
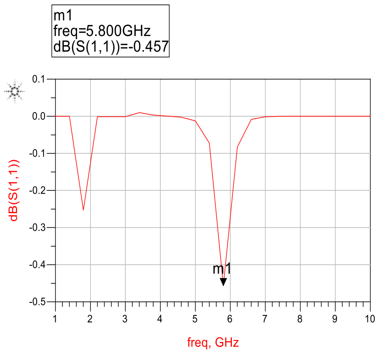
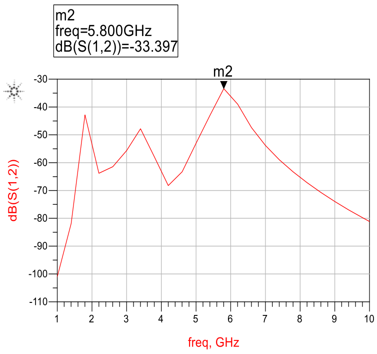


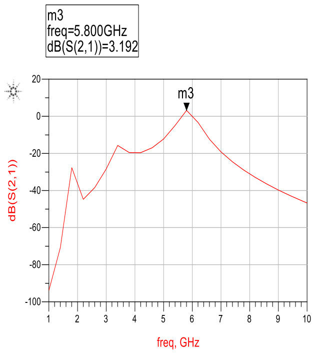
Fig. -5: Structure of Low noise amplifier with Chebyshev filter



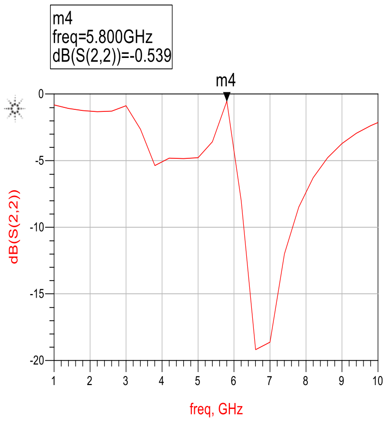
a) Input return loss



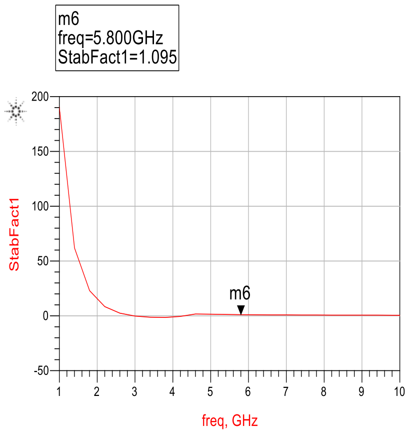
b) Reverse transmission gain



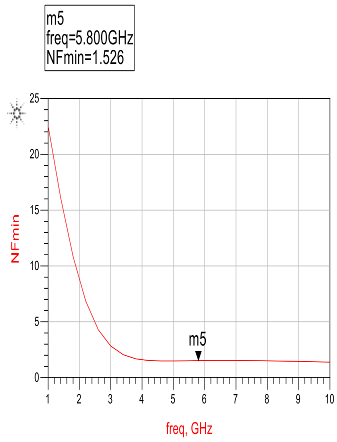
c) Forward transmission gain



d) Output return loss



e) Stability factor



f) Noise figure

Fig. -6: Simulation results of LNA with Chebyshev filter a) input return loss (S_{11}) b) reverse gain (S_{12}) c) Forward gain (S_{21}) d) output return loss (S_{22}) e) Stability factor f)Noise figure

TABLE 1. COMPARISON OF THE PROPOSED LNA WITH VARIOUS FILTER

Frequency = 5.8GHz			
PARAMETERS (IN dB)	**(LNA- BANDPASS FILTER)**	**(LNA- BUTTERWORTH FILTER)**	**(LNA- CHEBYSHEV FILTER)**
S_{11}	**-14.469**	-16.566	-0.457
S_{12}	**-23.547**	-21.391	-33.397
S_{21}(GAIN)	**13.042**	10.346	3.192
S_{22}	**-4.424**	-3.409	-0.539
NOISE FIGURE	**1.526**	1.821	1.095
STABILITY FACTOR	**1.095**	0.996	1.526

CONCLUSION AND FUTURESCOPE

In this paper, Low Noise Amplifier (LNA) for health monitoring system using wireless Body Area network has been proposed. UB transceiver has been used for the health monitoring system. The design of LNA which is an important component in the UWB receiver is proposed. The performance of the LNA has been improved with band pass filter, butter worth filter and chebychev filter. A Comparative performance analysis has been proposed. The proposed LNA can be used in the frequency range of 5 to 6 GHz. The pro-posed LNA with three filters are analyzed and it is observed that LNA with band pass filter performs well compared to other filters. In future, it is planned to provide the prototype model of the health monitoring system with the proposed LNA.

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