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PERFORMANCE EVALUATION OF IR-UWB TRANSCEIVER SYSTEM USING PPV

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Abstract- UWB technology is based on transmission of very narrow electromagnetic pulses; having low repetition rate. Due to this reason the radio spectrum is spread over a very wide bandwidth—much wider than the bandwidth used in spread-spectrum systems. Due to the wide bandwidth and very low power UWB transmissions appear as background noise. In this paper impulse radio (IR) UWB system is designed based on the PPV (Pulse Period Variation) modulation technique. In this modulation technique binary data is modulated by varying the pulse repetition period. In the IR-UWB receiver mainly the low noise amplifier is the vital component. This work focuses on the design of LNA as well as the BER performance is evaluated for IR-UWB transceiver. The LNA design is carried out with help of the Agilent's ADS tool. The Simulations of the transceiver are carried out in the presence of Additive White Gaussian Noise (AWGN) under MATLAB by means of a SIMULINK model. This paper confers the BER performance of the IR-UWB transceiver system.
Keywords- UWB, AWGN, LNA

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Introduction

Ultra Wideband (UWB) technology has been designed to bring convenience and mobility of high speed wireless communication to homes and offices. UWB will plays a dynamic role to free people from wires and enabling video transmission or other high bandwidth data transmission that is rarely possible with a conventional wireless connection [1]. Since UWB communicates with short range pulses, it can be used for tracking various objects. The key benefits of UWB are it is having high data rates, low equipment cost and having high multipath immunity as well as it is ranging and communication at the same time [2]. Ultra-wideband transmission is virtually untraceable by ordinary radio receivers and therefore can exist concurrently with existing wireless communications without demanding additional spectrum [1]. Due to the wide bandwidth and very low power UWB transmissions appear as background noise. So they can readily be distinguished from unwanted multipath reflections because of the fine time resolution. The short range UWB technology will also complement other wireless standards such as Wi-Fi and Wi-Max. It can transmit data within the radius of 10 meters from the host device.UWB standard consumes very low average radiated power, which is usually expressed in units of miliwatts, though sometimes it depends on distance between the UWB transmitter and receiver. The FCC has allowed the UWB radio transmissions in the unlicensed frequency range from 3.1GHz to 10.6GHz at a limited transmit power of −41.3dBm/MHz, as also shown in Fig.(**1**).

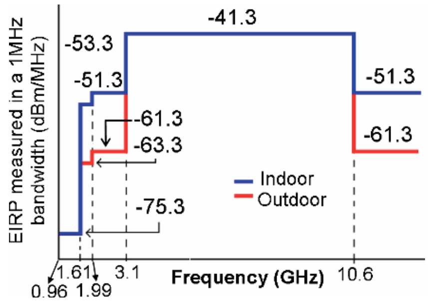

Fig 1- UWB spectral mask and FCC Part 15 limits [3]

There are different schemes of UWB system such as OFDM or

impulse radio UWB. In this paper impulse radio UWB system is used. A time-hopping (TH) sequence is applied in UWB system to eliminate catastrophic collisions in multiple accesses. For UWB system several modulation methods are proposed such as pulse position modulation (PPM) and variety of pulse amplitude modulations (PAMs), including binary phase-shift keying (BPSK) and on-off keying (OOK). In this work PPV is used. The BER performance of UWB receiver with different LNA specifications and with additive white Gaussian noise (AWGN) environment is calculated. The AWGN model is important in its own right for some UWB applications. Any information in UWB system is typically transmitted using collection of narrow pulses with a very low duty cycle of about 1%.
The organization of this paper is described as follows. The detailed architecture of IR-UWB is given in section II. The LNA performances with the gain and noise figure parameter is presented in section III. Section IV defines the PPV modulation technique. The SIMULINK model for PPV based IR-UWB is explained in section V. The result of the SIMULINK model is presented in section VI. Finally the conclusion is present in section VII.

Basic Structure of IR-UWB Transceiver
The IR-UWB is frequently known as carrier-less technology; in which the modulated baseband signal is directly transmitted through the antenna into air. Fig.(**2**) shows the transmitter of IR-UWB. Due to low power emission requirement in IR-UWB transceiver the design of the transmitter side antenna pre-drivers are simple. However the narrowband transceivers use the high power PAs to commence the signal with sufficient power to the antenna [3].

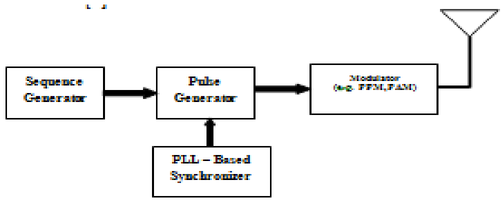

Fig. 2- Block diagram of IR-UWB transmitter

Fig.(3) shows the IR-UWB receiver block diagram. In which the first and crucial component is LNA (Low noise amplifier). The analog information is used by the correlator; which is nothing but the multiplier. The two inputs of the correlator are the input signal and template generated by the pulse generator. The product of these two input signals at the output of the multiplier is further integrated to produce a robust signal level with relatively low frequency content. This signal is fed to the ADC [3]. In this paper at the receiver side three different types of LNAs are used with PPV modulation and AWGN channel.

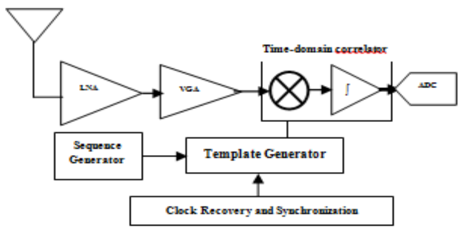

Fig 3- Block diagram of an IR-UWB receiver with a time-domain correlator

Lna Design
Low noise amplifier (LNA) is the first stage of a receiver, whose main function is to provide enough gain to overcome the noise of subsequent stages. In addition LNA should accommodate large signals without distortion and must also present specific impedance such as 50 Ω, to the input source. The LNA should have higher gain as well as lower noise figure. To develop a design strategy that balances gain, input impedance, noise figure and power consumption, this paper gives the details of design for such type of LNA. The Fig.(**4**) shows the schematic of cascode inductor source degeneration LNA topology [8].

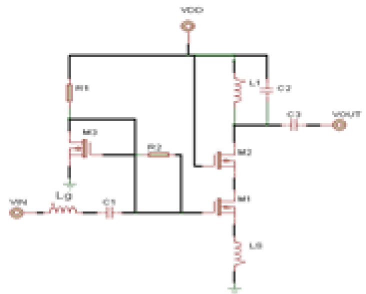

Fig. 4- LNA circuit schematic

There are two strategies of designing for IR-UWB system. The wide band as well as low band strategy. The range for low band is from 3 GHz to 5 GHZ and for wide it is 3.1 GHz to 10.6 GHz. In this work the LNAs are designed for both low band as well as wide band. The different LNA performances are calculated using Agilent's ADS software tool.

The Performance of low band LNA without noise cancellation
The LNA performance is measured with help of S parameters. Different parameter values of LNA are shown with Fig. (5, 6). The Fig. (5) gives the gain of LNA. The gain is increased by increasing the value of gate inductance (OBJ). The obtained gain for this LNA is 5.6 dB. According to Fig. 6 the noise figure is 2.54 dB.

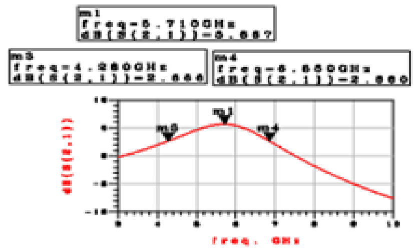

Fig. 5- The measured S_{21} versus frequency characteristics of 3 -5 GHz

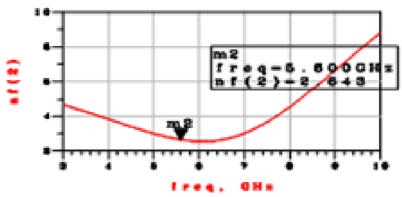

Fig. 6- The measured NF.

The Performance of low band LNA with noise cancellation

Inductive series and shunt peaking techniques are used for the noise cancellation [5]. In this LNA two common matching techniques are used. First is known as common gate and second is known as resistive shunt feedback. With this the noise figure is obtained near about 4 dB shown in Fig. (8). The Fig. (7) shown the gain obtained is 11.3 dB at 5 GHZ.

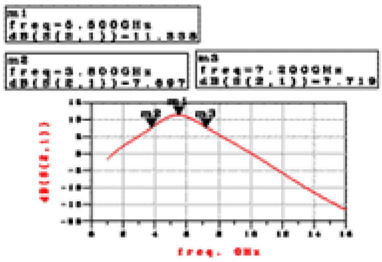

Fig. 7- The measured S_{21} versus frequency characteristics of 3 -5 GHz

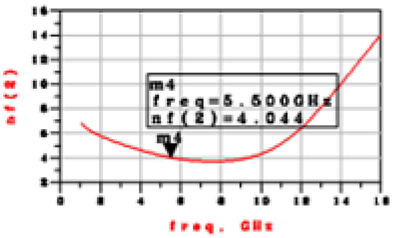

Fig. 8- The measured NF

The Performance of wide band LNA with phase linearity

The Fig. (9) shows the gain of the LNA. According to Fig. (9), UWB LNA is having high and flat gain which is greater than 12 dB. The gain remains flat from 3.1GHz to 10.6 GHz in the band of interest. The peaking inductance in this design helps to increase the forward gain . The Fig. (10) shows the noise figure measured in low band LNA. The noise figure achieved with the designed LNA is 3.3 ~ 2.7 dB over the band of interest.

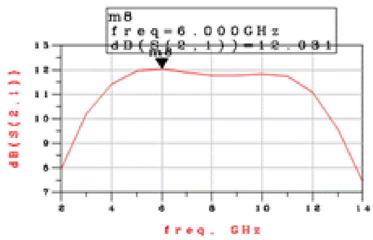

Fig. 9- The measured S_{21} versus frequency characteristics of the 3.1 -10.6 GHz

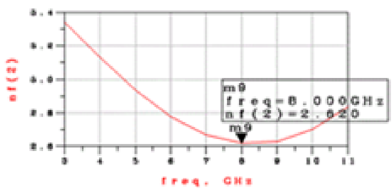

Fig. 10- The measured NF

PPV Modulation

In this paper Pulse Period Variation (PPV) data modulation technique is used. In PPV binary data is modulated by varying the pulse repetition period. This modulation technique is having better noise immunity than BPSK and PAM technique [4]. In the PPV modulation, defining a basis pulse with arbitrary shape $p(t)$, the binary data is modulated by sending the pulses with a different pulse repetition period depending on the bit is ‘1’ or ‘0’, as represented in (1) and shown in Fig. (**11**).

$$s(t) = \sum_{m=0} p\left(t - mT_{\left\lfloor \frac{m}{N_j} \right\rfloor}\right) \qquad (1)$$

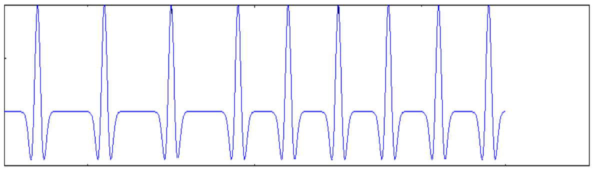

Fig. 11- Pulse Period Variation Modulation.

PPV Based UWB Transceiver System Using SIMULINK

The transceiver system is simulated with AWGN (Additive white Gaussian noise) channels. AWGN is a fundamental limiting factor in communication systems, and must be considered in receiver design. It could be a result of a number of phenomena that include atmospheric noise, RF interference, and thermal energy that causes random Brownian motion of electrons within the receiver circuit elements. AWGN is characterized by a Gaussian probability density function (PDF) as follows:

$$p(t) = \frac{1}{\sqrt{2\pi}\sigma_\upsilon} e^{-\frac{(\upsilon-\bar{\upsilon})^2}{2\sigma_\upsilon^2}} \qquad (2)$$

Where υ symbolizes the amplitude of the noise samples with a variance of $\sigma_\upsilon^2 = 1$ and a mean of $\bar{\upsilon} = 0$ [6].

Fig. (**12**) gives the detailed PPV based transceiver system of IR-UWB using AWGN channel. In the transmitter of IR-UWB two different delays are used to vary the pulse repetition period. In the receiver block different modules are combined such as LNA, multiplier, and integrator; which are used to demodulate and integrates the signals.

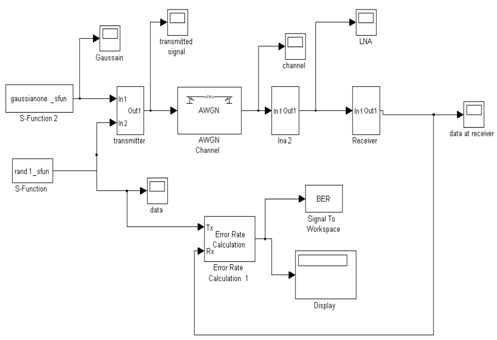

Fig. 12- PPV based model of UWB transceiver system using SIMULINK

The Fig.(**12**) shows the model of IR-UWB transceiver system using low band LNA with noise cancellation. In this work the three types of LNAs BER performances are calculated. In the receiver model the LNA specifications are changed and the BER is computed. All LNA types are implemented using the Agilent's ADS tool and the specifications are used in the receiver model. The BER performances are computed with the help of SIMULINK model.

Result

The Fig. (**13**) shows the BER performance of the PPV based IR-UWB transceiver system. The BER performance for the LNA with noise cancellation is better than without noise cancellation. The two LNAs are designed for low band. Whereas the wide band LNA gives the flat gain response as compared to the lower band. The BER performance for wide band LNA is better after 6 dB SNR.

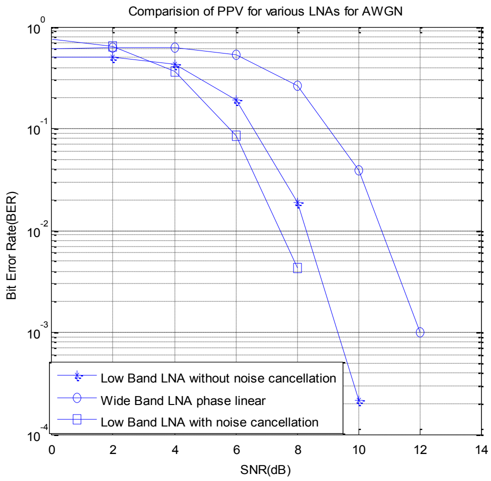

Fig. 13- BER performance of IR-UWB transceiver system using SIMULINK

The Table 1 lists the numerical values of all LNA performances. The simulation is carried out with 3000 samples for three iterations with SNR varied from 0 to 16 dB in steps of 2.

Table 1-
BER performance values for different SNR with variation in LNA for PPV based IR-UWB transceiver system

BER Performance			
SNR (dB)	Low Band LNA without noise cancellation	Wide Band LNA phase linear	Low Band LNA with noise cancellation
0	0.4976	0.611	0.762
2	0.5076	0.6247	0.6387
4	0.4229	0.632	0.362
6	0.1911	0.537	0.0843
8	0.0187	0.2633	0.0043
10	0.000216	0.0393	0
12	0	0.001	0
14	0	0	0
16	0	0	0

Conclusion

In this work we have implemented IR-UWB technology with different LNA circuits, such as low band and wide band LNA. The modulation technique used for realization is PPV. The SIMULINK model for IR-UWB is designed and the designed LNA circuit is incorporated in SIMULINK model. The BER performances are computed for AWGN channel. It is observed that the BER performance of LNA with noise cancellation is 55% better than without noise cancellation LNA at 6 dB SNR and at 10 dB SNR the performance increases to 100%. On the other hand for wide band LNA the improvement is 98% than the low band LNAs. It is concluded that PPV is best suited modulation for LOW BAND UWB systems.

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