CHAPTER 5

CONCLUSION

5.1 THESIS CONCLUSION

Recent research works indicate a huge amount of interest in the area of Wireless Body Area Networks (WBAN) and the energy efficiency and reliability of the hardware will be deciding the future existence and sustenance of such networks. The energy consumption of WBAN is the most important factor to determine the life of a bio sensor network since it is battery driven and operates in an energy restricted environment. This thesis work has mainly focused on the investigations of an energy efficient communication method for Wireless Body Area Network and the goal has been to design a power efficient wireless solution for reliable communication from a Body Sensor Unit (BSU) to the Body Central processing Unit (BCU) in a WBAN system. A detailed literature review has been carried out for WBAN communication methods, UWB channel models, low power transmitter implementation methods, energy efficient receivers for IR-UWB and performance optimization of UWB transceivers. The Impulse Radio UWB (IR-UWB) is identified as the technology of choice for this WBAN communication since it provides a reasonable communication range and data rate, with the radiated signal power low enough to be safe for human tissues. An important aspect of IR-UWB communication system is the design of the transmit signal to satisfy the performance and regulatory constraints. This thesis presents some proposals for the design and generation of IR-UWB signals to improve the wireless communication efficiency in WBAN. The designed system is validated for improvement in energy efficiency, tunability,
wave shaping for interference mitigation and reliable transmission using simulation results.

The enhancement in power efficiency and tunability feature for cognitive usage of interference free spectrum is considered as the key parameter for the design of the transmitters. The total performance of the system has been shown to improve by optimizing bandwidth, wave shape, range and transmission power. The designed IR-UWB transmit signals are validated with the Modified Saleh-Valenzuela channel models to identify the best suitable signal for implementing WBAN technology in hospital environment. The following conclusions are derived from the study:

- In chapter 2, to start with, the baseband design and the implementation of a Wide Band low power FCC complaint PHY for the WBAN application using the Wireless open Access Research Platform (WARP) Software Defined Radio and programming environment has been carried out. The transmission and reception of an ECG waveform with minimum errors over the designed PHY on the bandwidth constrained embedded hardware platform has been experimentally validated. The channel behavior measurement carried out for WB-IR signals are found to follow Rayleigh model due to bandwidth constraints. Further it has been shown that a negative dc shift of the Gaussian doublet pulse results in yielding an extremely low multipath and multipath interference at the receiver. The Peak Detection logic has been experimented at the receiver with minimum multipath impact, since the dc shifting of doublet pulse has reduced the multipath effect drastically. The performance of the system has been verified by measuring the MSE value by transmitting
the ECG signal over the system. Based on the study it is concluded that, the system requires interference mitigation and link optimization for improving the transmission range. Due to the limitation of hardware bandwidth, this implementation does not exactly fit UWB requirements, however has demonstrated the need for interference mitigation and link optimization when used for a practical WBAN application.

- In Chapter 3, low power IR-UWB transmit signal design approaches are reported, simulated and results verified. Tunability, power efficiency, interference reduction and simplicity are some of the constraints considered in the signal design approach. The transmitters are designed with Gaussian monocycle, triangular multicycle, wavelet based Gaussian sixth derivative signal generator and Gaussian third derivative transmitter with discrete HEMT components. An attempt has been made for making some of these designs tunable, power efficient, and FCC compatible.

- The Low power Gaussian monocycle transmitter has been designed with 130nm technology and validated in CMOS component with a power efficiency of 8.87% and has achieved a tunable bandwidth of 5.8GHz to 11.16GHz, and hence a possible range increase from 1m to 3.2m. The complete circuit operated in the turn on mode with a low average power consumption of less than 1.4mw. The same circuit design is then simulated with 180nm technology, verified for tunability and compared with design results reported in the literature.
The higher order impulse generators are normally implemented with LC components. But the power consumption of the passive circuit is very high and an alternate solution has been adopted with CMOS components for better power efficiency. The triangular multicycle signal UWB transmitter has also achieved good tunability with a power efficiency of $1.54 \times 10^{-3}\%$ and bandwidth tunability over the frequency range 0.9GHz-1.6GHz, suited for low data rate applications. The triangular wave shaping is realized using power efficient NMOS variable attenuator. The complete circuit has consumed an average power of 5.4mw. The future work would focus on improving the design for achieving a higher p-p amplitude of the transmitting signal.

Higher derivative IR-UWB signal generation using wavelet transform method with interference mitigation has been carried out and optimization of the wave shape for the higher order Gaussian impulse shows better FCC compliance and possibility for interference mitigation. The design can be validated in the future by physical implementation in an hardware platform supported with optimization algorithms.

The method of IR-UWB transmitter design with pHEMT component has been carried out as a low cost solution using of the shelf discrete component along with the design of an antenna compatible for WBAN application. The simulated result has generated a third order Gaussian impulse signal with 2V peak to peak, operating at a center frequency of 6.85GHz and bandwidth achieved is greater than 7.8GHz. This design approach is best suitable for fabricating with MMIC, which is
also important for practical UWB system realization WBAN application. The power consumption is also noted to be low.

- Finally in chapter 4, the complete IR-UWB wireless system including a transmitter with proper wave shaping, an appropriate wireless channel for signal propagation and an error free decoding logic for recovering the transmitted information have been simulated. The BER performance of a sixth derivative BPSK modulated Gaussian signal and the previously generated Gaussian monocycle signal, triangular wave shaped multicycle signal and wavelet based IR-UWB signal are obtained and compared for their transmission characteristics over the different channel scenarios defined in the Modified Saleh-Valenzuela (MSV) model. The four types of MSV channel models are Line Of Sight within 4m distance, Non Line Of Sight (NLOS) within 4m distance, NLOS with more than 4m distance and NLOS with maximum value of attenuation factor value. The validation has concluded that, higher order wave-shaped signals perform reasonably well in all the channel scenarios. However, comparing the different channel performances, it is concluded that all the methods of signal generation considered in the thesis are suited for channel type1 with reasonable reliability. Hence the proposed IR-UWB signal generators are suited for low data rate short range LOS wireless transmission of biological parameters in a WBAN application.
5.2 FUTURE WORK

Future research work would be focused on power optimization with gated IR-UWB CMOS based transmitter circuits and bandwidth optimized design of multi user system with IR-UWB. Research on bandwidth reduction using coding schemes and optimizing receiver design parameters for worse performing channel scenarios would also be undertaken in the future. The hardware realization of the system SOC concept is difficult due to the financial restrictions. The baseband analogy can be implemented on FPGA based SDR hardware board. But the RF board should be customized for avoiding the bandwidth constraints. Due to the low power transmission constraints, the error performance was higher for longer transmission distance. The performance can be improved by adopting high performance receivers like RAKE receivers and exploring MIMO concepts in reception part.