UWB Communication For Indoor Wireless Systems By Keil IDE

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Abstract

This paper deals with the Ultra-Wideband (UWB) that uses extremely low power pulses of radio energy spread across a wide spectrum of frequencies. The system architecture and circuit design for a proposed Ultra-Wideband radio transceiver by using KEIL IDE has been proposed.

Keywords: *UWB, Indoor wireless systems, Keil IDE*

Introduction

Wireless connectivity has enabled a new mobile life style filled with convenience for mobile computing users. Wireless applications demand data transfer to be high Speed, long distance, large amount, less power, multicasting. The existing wireless networking technologies cannot meet the above requirements.

Ultra-wideband (UWB) radio is becoming a promising field for new generation's digital communication system. UWB has potential to fulfill above demands. This technique, based mainly on the impulse response radio paradigm, offer great flexibility and shows enormous potential in view of future fourth generation broadband wireless access in dense multipath environments.

Ultra-wideband (UWB) technology offers a solution for the bandwidth, cost, power consumption, and physical size requirements of next-generation consumer electronic devices. UWB enables wireless connectivity with consistent high data rates across multiple devices. UWB offers the promise of high data rate, low susceptibility to multipath fading, high transmission security low prime power requirements, low cost and simple design. This technology has a number of distinctive capabilities that would make it ideal for implementing very efficient wireless networks.

BANDWIDTH :

Ultra Wideband BW >> Wideband BW >> Narrowband BW

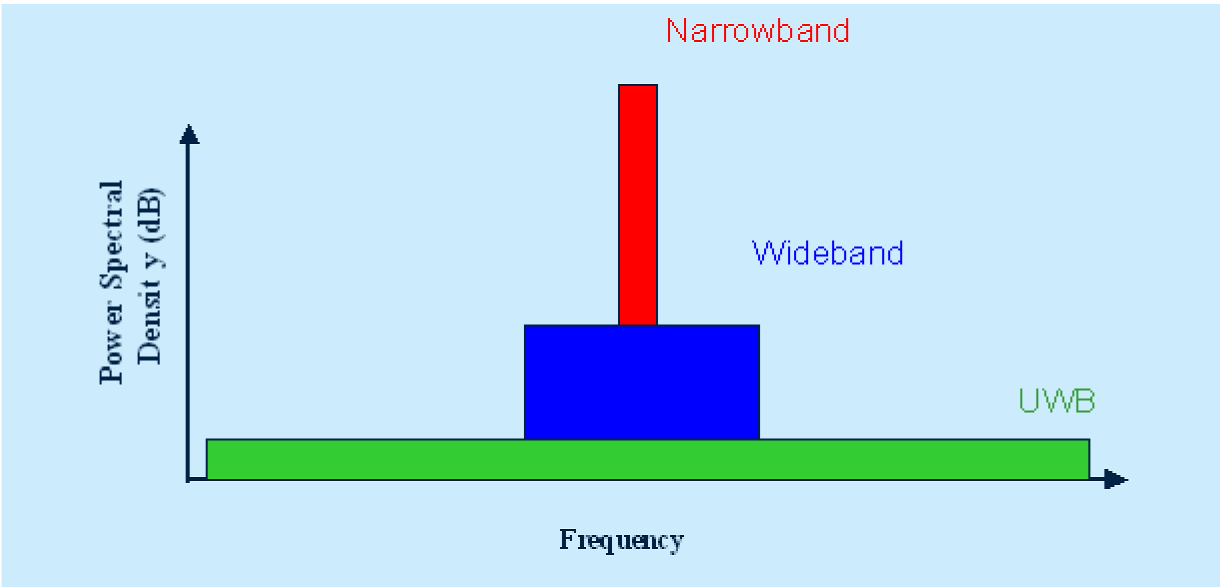

Fig : 1 Bandwidth comparison

INDOOR WIRELESS SYSTEMS

The characteristics low bit-rate, indoor wireless systems (i.e relaxed sensitivity, lower transmit power) due to shorter communication distances allow for the exploration of fundamentally different radio architectures that promise much lower power consumption, and higher integration, than current traditional approaches. Based on a “mostly-digital” conception, this radio communicates with short pulses, as opposed to conventional modulated sinusoid schemes, and attempts to bring the digital logic as close to the antenna as possible, thereby reducing analog complexity and power, and increasing integration.

Recently there has been a huge push towards wireless networking. Originally focused on high-rate WLAN’s, now attention is also being directed towards lower-rate applications that require modest communication, but high-levels of integration and low power consumption.

RF propagation obstacles can be termed hard partitions if they are part of the physical / structural components of a building. On the other hand, obstacles formed by the office furniture and fixed or movable / portable structures that do not extend to a buildings ceiling are considered soft partitions. Radio signals effectively penetrate both kinds of obstacles or partitions in ways that are very hard to predict.

Remember that in free space, an additional signal loss of 20 dB is incurred for each 10 to 1 increase in radio range. Thus, an obstacle with a measured loss of 20 dB or more from its materials is a significant loss! The equivalent of RF transparent is probably in the range of 3 to 6 dB loss from any obstacle's material properties.

We cannot do anything about the buildings, building materials or structures this system will be used in, however, we must still explore the realm of overall macroscopic signal propagation in a typical building. Electronic engineers (radio engineers, in particular) would like to be able to predict the signal levels and range of signal losses present in a building. To enable this prediction a number of studies and measurements have been made which grossly characterize in building signal propagation.

We can extrapolate this data for use at 2400 MHz with a fair amount of certainty, if we add a few dB (perhaps 5 to 6 dB) to account for the higher frequency we will use to each graph point. Interpretation of this data provides a level of understanding of the potential problem at hand.

Indoors situation is even worse. It is very difficult to design an "RF friendly" building that is free from multipath reflections, diffraction around sharp corners or scattering from wall, ceiling, or floor surfaces (let alone operate perfectly in a randomly chosen building location). The closest one could probably get to an "RF friendly" building would be an all wooden or all fiberglass structure -- but even this must have a structurally solid floor of some kind and this more ideal RF building will still have reflections, multipath and other radio propagation disturbances (as the materials properties section below shows) which will prove to be less than ideal. Radio wave propagation inside smooth walled metal buildings can be so bad that radio "dead spots" can exist where the signal is virtually non-existent. These dead spots arise because of almost perfect, lossless reflections from smooth metal walls, ceilings or fixtures that interfere with the direct radiated signals. The dead spots exist in 3 dimensional space within the building and motions of only a few inches can move from no signal to full signal. It will be the main purpose of this report to try to recommend solutions for this kind of problem

Due to the extremely low emission levels currently allowed by regulatory agencies, UWB systems tend to be short-range and indoors applications. However, due to the short duration of the UWB pulses, it is easier to engineer extremely high data rates, and data rate can be readily traded for range by simply aggregating pulse energy per data bit using either simple integration or by coding techniques. Conventional OFDM technology can also be used subject to the minimum bandwidth requirement of the regulations. High data rate UWB can enable wireless monitors, the efficient transfer of data from digital camcorders, wireless printing of digital pictures from a camera without the need for an intervening personal computer, and the transfer of files among cell phone handsets and other handheld devices like personal digital audio and video players

Indoor UWB devices, by the nature of their design, must be capable of operation only indoors. The emissions from indoor devices shall not be intentionally directed outside of the building in which the equipment is located, such as through a window or a doorway, to perform an outside function, such as the detection of persons about to enter a building. A communications system shall transmit only when the intentional radiator is sending information to an associated receiver. The UWB bandwidth for indoor devices must be contained between 3,100 and 10,600 MHz.. UWB handheld devices are relatively small devices that do not employ a fixed infrastructure. These devices shall transmit only when sending information to an associated receiver. Antennas may not be mounted on outdoor structures such as the outside of a building or on a telephone pole. Antennas may be mounted only on the handheld UWB device. Handheld UWB devices may operate indoors or outdoors. The UWB bandwidth of a handheld device must be contained between 3,100 and 10,600 MHz.

One of the most promising commercial application areas for UWB technology is the wireless connectivity of different home electronic systems. It is thought that many electronics manufacturers are investigating UWB as the wireless means to connect devices, such as televisions, DVD players, camcorders, and audio systems, together to remove some of the wiring clutter in the living room. This is particularly important when we consider the bit rate needed for high-definition television that is in excess of 30 Mbps over a distance of at least a few meters. An example of a possible home-networking setup using high-speed wireless data transfer of UWB is shown in Figure. Of course, UWB wireless connections to and from personal computers are also another possible consumer market area, with products expected in the next few years. In [92] a proposal is made to use UWB as the wireless link in a ubiquitous “homelink”, which consists of an amalgamation of wired and wireless technologies. The wired technology proposed by the authors is based on the IEEE 1394 standard. This is an attempt to effectively integrate entertainment, consumer communications, and computing within the home environment. The reason for the choice of IEEE 1394 is that it provides an isochronous mode, in which data are guaranteed to be delivered within a certain time frame after transmission has started.

PROPOSED ARCHITECTURE
3.1. PROPOSED SYSTEM ARCHITECTURE

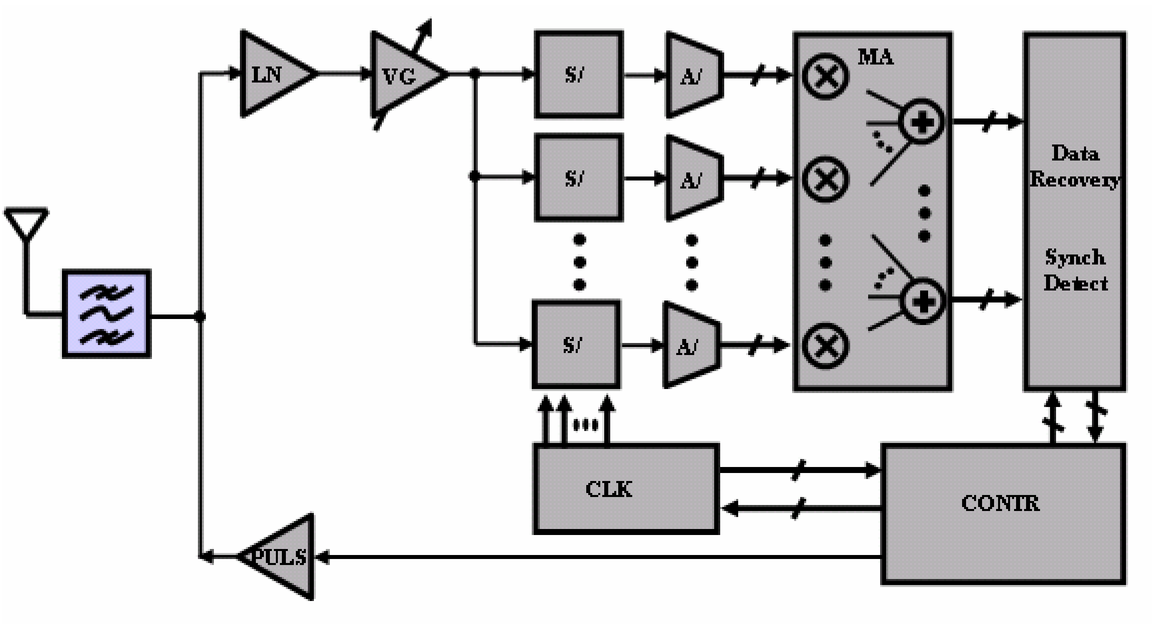

FIGURE 3.1. ANALOG FRONTEND

3.2. ANALOG FRONT END

Based on a "mostly digital" conception, the proposed architecture consists of a simple baseband analog section followed by a larger digital processing backend. We attempted to bring the digital logic as close to the antennas as possible to gain the benefits of robustness, flexibility, scalability and low power operation. The receiver is based on a digital matched filter, which is optimal for baseband pulse reception in the presence of white noise . Even in the presence of colored noise or narrowband interferers an FIR filter structure can approximate the optimal response. One goal of this architecture is to provide adequate flexibility for further experimentation. Towards that end, the trans- mitter circuit and receiver LNA need to be designed with the ability to support different antennas (i.e voltage driven versus current driven) and hence different antenna impedances. In addition, the matched filter coefficients and spreading gain sequences were kept fully programmable. The design also supports variable transmit power levels and pulse repetition frequencies. While the transmitter is able to generate both 2-PAM and 2-PPM modulations, for the sake of simplicity the receiver currently only implements 2-PAM reception.[5]

As the received energy from an impulse is localized in time to around the channel delay spread, the receiver need be concerned with only a relatively narrow window of time. To meet the Nyquist criterion, this window must be sampled at a high rate, viz. twice the highest frequency of the pulse that still contains significant energy. Hence, depending upon the pulse repetition rate, the receiver frontend may be turned off during the interval between expected pulses to save power.[6]

3.3. SYSTEM SNIR

In the interest of specifying the A/D and matched filter bit-widths, the 'Signal to Noise + Interference Ratio' (SNIR) at the matched filter output is calculated per pulse; taking into account limited gain, quantization noise, input-referred noise figure, and the effect of narrowband interferers.Simulations were run using a gaussian monocycle pulse [2], as depicted in Figure , sent at a 10MHz rate, with the received amplitude set such that the power spectral density of the received pulse was roughly equal to that of the thermal noise floor (-174 dBm/Hz). The UWB channel model was for a 3 meter path; derived from an in-house ray-tracing tool which estimates the impulse response using an 3-D indoor building model [13].

A noise figure of 10dB was assumed for the analog frontend, and the gain was fixed at 80dB. Interference was generated based on measurements taken with a spectrum analyzer to represent 'typical' levels and scaled over the shown range. Additionally, offset of 10mV was assumed at the input to the A/D.

3.4. GAIN AND FILTERING

In the analog frontend, shown above in Figure , reception consists of gain and filtering followed by sampling. Transmission is achieved with a bank of parallel inverters; by changing the transmitter supply voltage and the effective width a variety of driving strengths may be obtained. All of the analog circuits are designed differentially to combat digital switching noise that is expected to couple into the circuitry.[7]

This comes at the expense of higher power consumption, but renders the digital spikes, which could easily corrupt the pulse reception, to common-mode. Also, all of the receive gain stages are designed to be turned on and off quickly to save power through duty-cycling.

Because these gain stages are wideband, the dominant time constant is small, on the order of a nanosecond or less, which makes for fast settling during these transitions. Also, the amplifiers are designed for fast overload recovery, so that large signals do not saturate the frontend.

The LNA is designed for impedance matching over a range of values to allow for different antennas to be used. At these frequencies (DC to 1GHz) it is difficult to design an UWB antenna that is physically small with low dispersion and high radiation efficiency.

Good candidates for such an antenna are the Large Current Radiator, a low impedance, current-mode antenna; and the terminated dipole, a higher impedance, voltage-mode antenna . As the design of an ultra-wideband matching network may be difficult, two LNA's may be designed for these two impedance extremes if one cannot be made with enough input variation to support them both. After the LNA, several stages of gain and filtering follow.[13]

The filtering attenuates interferers, in particular the cellphone band around 900MHz, and FM radio and most VHF TV signals below 110MHz. Ultra-Wideband cannot escape having in-band interferers, so it is beneficial to lessen their impact, if possible. Sampling is achieved with a bank of A/D's operating at the window rate, 62.5MHz. While a single A/D could be designed to run at 2GHz to sample the signal, power may be saved by running smaller sized A/D's at a lower rate.

The sampling clocks are generated from a DLL-based clock generation circuit, derived from the system oscillator running at the window rate. After sampling, the bits are aggregated into a larger block of samples and passed to the digital section shown.

In this case we see that a 1-bit matched filter coefficient is not necessarily adequate, as the performance is worse over all levels of interference. Intuitively, the matched filter is correlating against the zero-crossings of the input, so the more accurate our representation of the pulse, the better our estimate becomes.

When the A/D input is swamped in noise, the quantization error doesn't degrade performance much, but the matched filter coefficients need to be fairly accurate .

3.5. CIRCUIT DIAGRAM

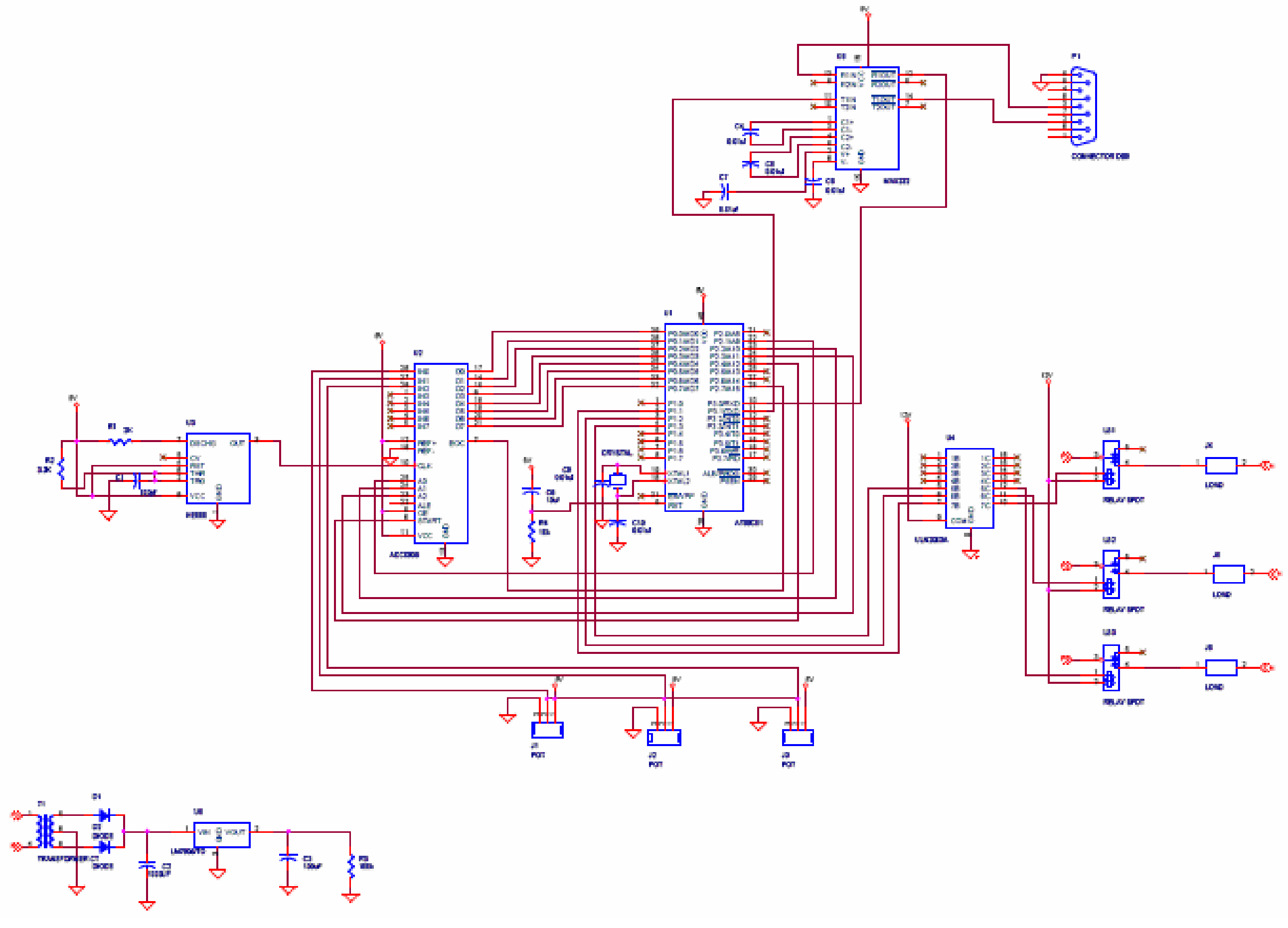

FIGURE 3.2. CIRCUIT DIAGRAM

3.6. ADC

The ADC0808, ADC0809 data acquisition component is a monolithic CMOS device with an 8-bit analog-to-digital converter, 8-channel multiplexer and microprocessor compatible control logic. These are 8-bit microprocessor compatible a/d converters with 8-channel multiplexer The 8-bit A/D converter uses successive approximation as the conversion technique. The converter features a high impedance chopper stabilized comparator, a 256R voltage divider with analog switch tree and a successive approximation register. The 8-channel multiplexer can directly access any of 8-single-ended analog signals. The device eliminates the need for external zero and full-scale adjustments. Easy interfacing to microprocessors is provided by the latched and decoded multiplexer address inputs and latched TTL TRI-STATE outputs. The design of the ADC0808, ADC0809 has been optimized by incorporating the most desirable aspects of several A/D conversion techniques. The ADC0808, ADC0809 offers high speed, high accuracy, minimal temperature dependence, excellent long-term accuracy and repeatability, and consumes minimal power. These features make this device ideally suited to applications from process and machine control to consumer and automotive applications.

3.7 PULSE RATE CONSIDERATIONS

As aforementioned, a spreading sequence is used to increase the SNIR; however, we have another degree of freedom with an impulse radio: we can directly trade-off pulse rate for pulse amplitude, maintaining the same power spectral density. As the spreading gain is proportional to the square root of the spreading-gain sequence length, there exists an optimal rate and amplitude for a given SNIR per pulse. Slowing the pulse rate down, while improving the BER, lowers the throughput. Likewise, speeding up beyond the peak lowers the amplitude, requiring a longer sequence for the same BER, thereby lowering throughput.

This ability to trade-off pulse amplitude versus rate with constant bandwidth in order to improve SNIR is characteristic to an impulse UWB system. Using this trade-off, along with conventional spreading gain allows an UWB system to have low impact on existing narrowband users, while still maintaining a reasonable bit-rate. The interference value used in Figure 6 is -40dBm, the average from the spectrum analyzer measurements in our lab. Note that the maximum expected throughput for this case is greater than 1Mbit/s.

3.8. GAIN AND NOISE CONSIDERATIONS

Ideally, a comparator switches exactly when one input is infinitesimally larger than the other. If we had this level of accuracy, no gain stages would be necessary as we could simply sample the antenna voltage directly. In practice, the offset voltage seen at the input of the comparator will determine the minimum amount of gain necessary to ensure accurate sampling. The worst case situation arises in the absence of interferers with a minimum pulse amplitude that is equal to or less than the noise floor, as this represents the maximum gain scenario for the radio. In such a situation, we can calculate the probability of a comparator error due to offset .

3.9. CLOCK GENERATION

Accurate generation of timing signals is another critical aspect of the UWB receiver. Jitter on the A/D sampling operation degrades the pulse SNIR, and any mismatch between the transmit and receive clocks will cause the pulse correlation peak to drift out of the sample window. These mismatch and jitter requirements may be converted into constraints on the oscillator design. The matching between the transmit and receive clocks must be accurate enough to allow the digital backend to track the drift. In our design the correlation results are compared at the symbol rate, thus requiring the drift over a symbol's reception to be a fraction of a sampling bin to keep the energy within that correlator Given a minimum symbol rate of 10kHz, then for a 100ps drift the worst-case allowable $\Delta f/f_c$is 0.5PPM. This is rather stringent but only necessary to support the slowest symbol rate: a 1MHz pulse rate with a length=1000 spreading-gain sequence From the oscillator we also have to derive the pulse repetition clock for transmission. A programmable divider will provide for the flexibility to send pulses at the desired rates. The per-stage divider jitter is proportional to the output slope[15], and in a 0.13μm CMOS process, these edges are around 30ps. The actual per-stage jitter is expected to be less than that. With careful design, this jitter is not expected to be the dominant contribution

NEED FOR KEIL

The µVision3 Debugger incorporates a C script language you can use to create Signal Functions. Signal functions let you simulate analog and digital input to the microcontroller. Signal functions run in the background while µVision3 simulates your target program.

The µVision3 simulator simulates the timing and logical behavior of serial communication protocols like UART, I²C, SPI, and CAN. But µVision3 does not simulate the I/O port toggling of the physical communication pins on the I/O port.

To provide fast simulation speed and optimum access to communication peripherals, the logic behavior of communication peripherals is reflected in virtual registers that are listed with the DIR VTREG command. This has the benefit that you can easily write debug functions that stimulate complex peripherals.

RESULT ANALYSIS:

This paper presents relatively simple low-power IR-UWB architecture by KEIL IDE. The architecture is based on a Frequency Hopping OOK (FH-OOK) modulation and standard non-coherent energy detector in the receiver. In order to evaluate the system performance, a CMOS chip including the RF transmitter, receiver and base band circuitry was designed and tested. Measurement in a real office environment shows that a 20Mbit/s data rate with a low BER is possible at a distance of 5m. The chip offers the possibility of very accurately controlling the shape of the transmitted RF signal, as well as of adapting the RF spectrum to different regulations (European or US). The IC is suitable for use in battery powered communication objects, such as multimedia players or cell phones. The circuit is interfaced to a standard microcontroller and can be used with different medium access layers (MAC). One possible way of increasing the reliability of the link would be to use a direct sequence spread spectrum approach. A data bit can be coded with a sequence of Q pulses (8 or 16 for example). Of course, in this approach the data throughput would be decreased by a factor of Q. The coding and decoding processes can be performed by the microcontroller or specialized circuit. The goal of our work was to demonstrate the feasibility of a simple-pulsed UWB system in a point-to-point link. Nevertheless, by introducing a TDMA frame structure it is possible to use the circuit in a network environment. UWB has the potential to become a competitive short-range, low-power, low-cost RF technology and to fill the gap between low data rate (less than 1Mbit/s) and high data rate (more than 50Mbit/s) wireless communications.

A subsampling analog front-end combined with analytic signal processing has been proposed for passband UWB communications. The architecture minimizes the building blocks for a low-complexity implementation with the potential for full integration. By exploiting the analytic matched filter output, timing recovery can be done without oversampling or interpolation. The proposed system also achieves a high time resolution, which implies high accuracy ranging capability. There are many applications such as sensor nodes, pulse-rate monitoring system, etc. EEG system is a medical instrument that measures signal from human brain and reports to display panel. The measure system needs only amplifiers and ADC. So, this part could be small. The display panel is normally large and not movable. Separation of these two parts will make this instrument to be portable. This is convenient for the doctor to measure samples from patients from rural areas and stores data wirelessly at the local hospital.

By this method, Fractional Bandwidth > 20%,Pulse Width 0.1–2 ns,
Pulse Repetition Frequency 1 kHz–2 GHz, Average Transmitted Power < 1 mW can be obtained.

Conclusion:

An integrated, low power, ultra-wideband transceiver architecture has been designed using KEIL IDE & AT89C51 for low rate indoor wireless systems. Analog front end for UWB transceiver has been designed by using KEIL IDE. Digital Back end for UWB signal processing can also be designed and implemented by KEIL IDE. This system is suitable for low-power short-range wireless RF transceiver design.

REFERENCES:

1. D.Cassioli, M.Z.Win, A.F.Molisch, "**The Ultra-Wide Bandwidth Indoor Channel: From Statistical Model to Simulations**," IEEE J. Select Areas Comm., vol. 20, no. 6, p. 1247-57, Aug. 2002.
2. J.A.Crawford, **Frequency Synthesizer Design Handbook**, Artech House, Norwood, MA, 1994.
3. R.A.Fleming, C.E.Kushner, "**Spread Sprectrum Localizers**," U.S. Patent 5,748,891, May 5, 1998.
4. **FCC, First Report and Order**, FCC 02-48, Feb. 14,2002.
5. R.Hoctor, H.Tomlinson, "**Delay-Hopped Transmitted Reference RF Communications**," IEEE Conf. on Ultra- Wideband Systems and Technologies 2002, May 20-21, 2002.
6. Q.Huang, P.Basedau, "**A 200µA, 78MHz CMOS Crystal-Oscillator Digitally Trimmable to 0.3PPM**," Int. Symp. on Low Power Elect. and Design, pp. 305-8, 390. Aug., 1996.
7. B.Kim, T.C.Weigandt, P.R.Gray, "**PLL/DLL System Noise Analysis for Low Jitter Clock Synthesizer Design**," IEEE Int. Symp. Circuits and Systems, vol. 4, p. 31-4, June 1994
8. C.J.Le Martret, G.B.Giannakis, "**All-Digital PAM Impulse Radio for Multiple-Access Through Frequency- Selective Multipath**," Proceedings of GLOBECOM '00, vol. 1, pp. 77-81.
9. G.M.Maggio, N.Rulkov, L.Reggiani, "**Pseudo-Chaotic Time Hopping for UWB Impulse Radio**," IEEE Trans. Circuits and Systems-I, pp. 1-12, Dec. 2001
10. **Ultra Wideband Signals and Systems in Communication Engineering ,** M.Ghavami, King's College London, UK, L.B.Michael**,** Japan, R.Kohno**,**Yokohama National University, Japan.
11. W. Namgoong, "**A Channelized DSSS Ultra-Wideband Receiver**," Proceedings RAWCON 2001, pp. 105-8, Aug. 19-22 2001.
12. J.G.Proakis, **Digital Communications**, 3rd Edition, McGraw Hill, New York, 1995.
13. R.A.Scholtz, "**Multiple Access with Time-Hopping Impulse Modulation**," Proceedings of MILCOM '93, pp. 447-50, vol. 2, Oct. 11-14, 1993
14. H. Tang, Ph. D.Thesis, University of California at Berkeley, Expected Dec. 2002.
15. J.D.Taylor (Ed.), **Introduction to Ultra-Wideband RADAR Systems**, CRC Press, Boca Raton, FL, 1995.
16. T.C.Weigandt, B.Kim, P.R.Gray, "**Analysis of Timing Jitter in CMOS Ring Oscillators**," IEEE Int. Symp. Circuits and Systems, vol. 4, p. 27-30, June 1994.
17. P.II.Withington, L.W.Fullterton, "**An Impulse Radio Communications System**," Proc. of the Intl. Conf. on Ultra-Wideband, Short-Pulse Electromagnetics, pp. 113-20, Oct. 1992.

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