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Software Defined Radio for PC to PC Data Communication

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***Abstract*—A combination of hardware and software technologies where some or all of the radios operating functions are implemented through adjustable software or firmware operating on programmable processing technologies is defined as Software Defined Radio (SDR). The basic concept of SDR is that the radio functions are configured by software and number of areas can be covered by using same platform. As software is used, configurations can be changed according to various radio functions which are not captured by classic radio. The tasks to be performed included the channels configuration, the management of the data transfer between two PC, the baseband data modulation and demodulation, and the data organization into packets solely by software. For the physical layer of this system Orthogonal Frequency-Division Multiplexing (OFDM) is chosen as the transmission multiplexing method. This choice has been made because of the advantages that OFDM has better channel capacity and provides larger data rates. In this paper, simple IR circuit is used as SDR platform. This IR circuit work as a transceiver which can transmit text, number or image from one PC to another PC. In order to verify the proper functionality of the communication scheme, the received data streams are further analyzed with the use of MATLAB.**

Keywords: Software Defined Radio; Orthogonal Frequency Division Multiplexing; IR Interfacing; Data Communication.

I. INTRODUCTION

A Software Defined Radio is a system that transmits or receives signals in the radio frequency (RF) part of the electromagnetic spectrum for the purpose of transferring information using same platform. The SDR approach is helpful because there is a scope of developing a system which is compatible with more than one mobile communication standard. This can be achieved by using reconfigurable software for different technologies. Software Defined Radios (SDRs) are driving the integration of digital signal processing (DSP) and radio frequency (RF) capabilities. This integration allows software to dynamically control communications parameters such as the frequency band used, filtering, modulation type, data rates and frequency hopping schemes.

Traditional hardware based radio devices can only be modified through physical intervention, which results in higher production costs. Moreover in case of supporting multiple waveform standards it is less flexible. On the other hand SDR technology is more efficient and cost effective, which allow multiform and multi-functional wireless devices that can be enriched by modifying software program [1].

II. ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING (OFDM)

In OFDM technique, input bit stream is divided into several parallel bit streams which are used to modulate several subcarriers. A guard band separates these sub-carriers to avoid overlapping with each other. In OFDM receiver side, no bandpass filter is required to separate the spectrum of individual sub carriers, because of the orthogonality nature of the subcarriers. This orthogonality is achieved by performing Fast Fourier Transform (FFT) on the input bit stream [2]. “Fig.1” shows the comparison between conventional FDM and OFDM.

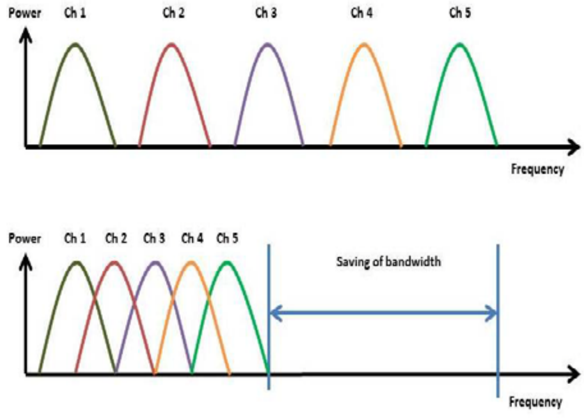

Figure 1: Comparison between conventional FDM and OFDM.

A. OFDM Generation and Reception

“Fig.2” shows the basic block diagram of OFDM transmitter and receiver. At transmitter side, frequency domain based source symbols are required for OFDM system. These symbols are feed to IFFT block to convert them into time domain. Suppose N numbers of sub-carrier are chosen then the function of IFFT are N orthogonal sinusoids of different frequency, finally receive N symbols at a time. Each of N complex valued input symbols determines both the amplitude and phase of the sinusoid for that subcarrier. These all N sinusoids make up a single OFDM symbol that is output of IFFT block [3].

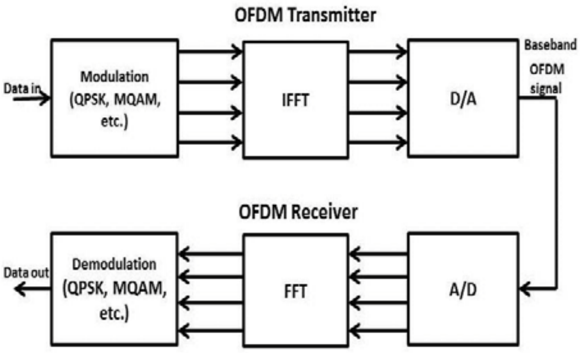

Figure 2: Basic OFDM transmitter and receiver.

At receiver side, FFT block is used to perform the reverse operation which makes the received signal back into frequency domain[4].

B. Advantages of OFDM technique over other techniques

Though at present many modulation and demodulation technique are available, we choose OFDM technique because of some additional benefits over other techniques. OFDM technique shows high spectral efficiency because of overlapping spectra which is found by orthogonality nature. It provides low receiver complexity as the transmitter combat the channel effect to some extends. It has a low complexity multiple access schemes such as orthogonal frequency division multiple access (OFDMA). Moreover, it is suitable for high data rate transmission [5].

C. Simulation outcome

"Fig.3" shows the transmitted OFDM signal.

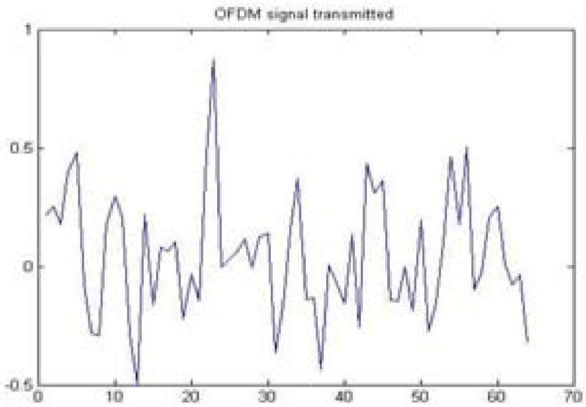

Figure 3: Transmitted OFDM signal.

"Fig.4" shows the simulation outcome of OFDM signal (power spectral density vs. frequency).

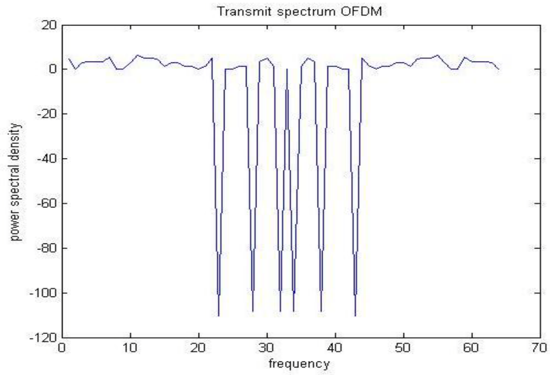

Figure 4: Transmitted OFDM spectrum.

"Fig. 5" shows the received OFDM signal without noise.

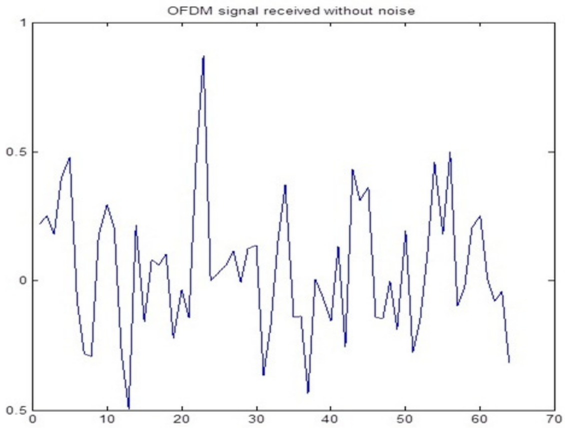

Figure 5: Received OFDM signal without noise.

"Fig. 6" shows the received OFDM signal with AWGN noise.

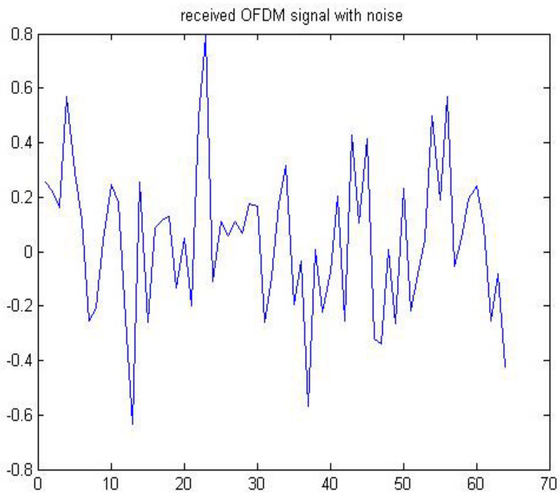

Figure 6: Received OFDM signal with noise.

"Fig. 7" shows BER vs SNR curve.

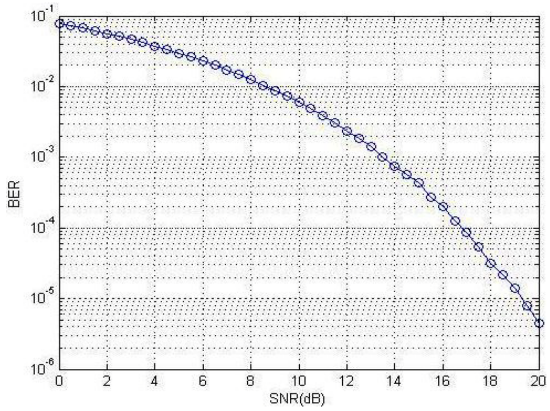

Figure 7: BER vs SNR curve.

III. DESIGN AND FABRICATION

Various methods of data communication are available all over the world. Some of the method show higher data rates, some show better channel capacity, but in this paper the combination of all expected data transfer characteristics are highlighted by using simple IR circuit. Two IR circuits are used; one for sending and one for receiving. Each of the circuit contains:

- Voltage regulator (LM-7805)
- Resistor (1k ohms)
- Capacitor (10mikroferad)
- Crystal oscillator (8MHz)
- Micro-controller (PIC-18F2550)
- MAX-232
- Breadboard
- IR emitter
- IR receiver
- LED
- Power supply
- USB converter (U-232)
- Connecting wire

A. *Implementation*

At first output of the voltage regulator (LM-7805) is connected to the positive pin of power supply. Then input voltage regulator (LM-7805) is connected to power line. A resistance of 1kΩ is connected to the power line with a LED to check whether the circuit gets power. The pin number of 13 of PIC-18F2550 is connected to IR emitter which is connected to a resistance of 1kΩ; this 1k ohm resistance is further connected to ground. IR emitter is used for data transmit [6, 7].

The pin number of 3 of PIC-18F2550 is connected to one of the pin of IR receiver. Second pin of IR receiver is connected to power line. Third pin is connected to ground. IR receiver is used for data receive.

The pin number of 1 of PIC is connected to a resistance of 1k ohm which connected to power line. The pin number of 9 and 10 of PIC is connected to 8MHz crystal oscillator. This is used to give oscillation. Voltage is supplied to 23 pin and 24 pin is grounded of PIC.

The output pin of 25 and 26 of PIC are connected to input pin of 9 and 10 respectively of MAX-232. Voltage is supplied at 16 pin and 15 pin is grounded of MAX-232. There are four capacitors (10□F) is connected to MAX-232 which is shown in our diagram. The pin number of 7 and 8 are to USB converter (U-232) [8].

"Fig.8" shows IR transceiver for PC1 that works as either transmitter or receiver. As two PC is needed for data communication. Both PC must have the IR circuit; one for data sending purpose and another for data receiving purpose and vice-versa.

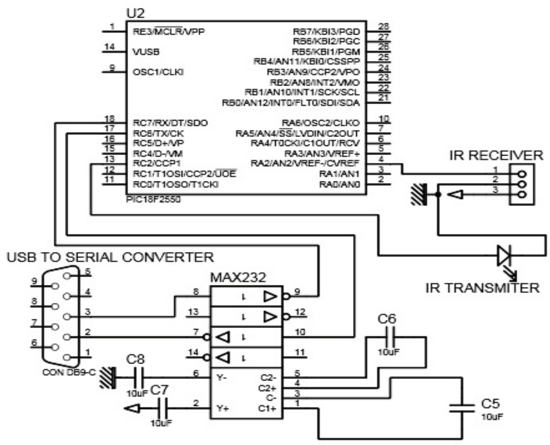

Figure 8: Schematic diagram of transceiver for PC1.

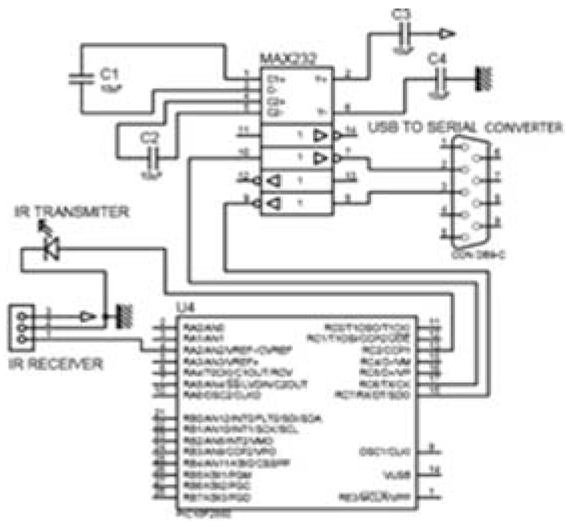

Figure 9: Schematic diagram of transceiver for PC2.

"Fig.9" shows another IR transceiver that works as either transmitter or receiver.

B. *Working Principle*

At first voltage is supplied to the network diagram.USB converter (U-232) is connected to PC. Data is sent through IR emitter which is received by IR detector. In this way data communication is performed from one PC to another PC. "Fig.10" shows the snap of simple IR circuit as a SDR platform.

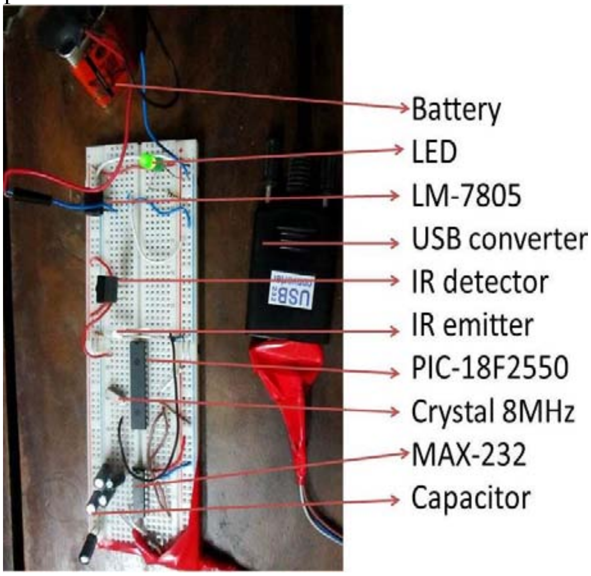

Figure 10: Snap of the IR circuit.

Designing a proper Data Communication System network and implement its function will give a good output of any system and using it for many purposes in networking activity.

IV. METHODOLOGY OF DATA COMMUNICATION

A. *Steps of Data Transmit*

- Connect the USB to USB port of one PC.
- Check the serial port number of that pc from"mycomputer/device manager/port".
- Run mikroC.
- Go to tool bar;"tools/USART terminal".
- Select COM port from"COM port setting" tab.
- Choose any"data format".
- Then press"connect" from"command" tab.
- Type"S" two times; be sure that whether the systemis in sending mode.

Desired data transmission can be performed by running MATLAB program.

B. *Steps of Data Reception*

Data reception procedure is similar to data transmission procedure except the last step. In this case:

- Type 'R' two times for checking that whether the system is in receiving mode.
- Finally receive the expected data on mikroC.

Desired data can also be received by running the"receiving"program on MATLAB.

V. BENEFITS

A. *Benefits of SDR over Conventional Radio*

As more and more of the conventional hardware circuitry is being replaced by software, SDR receiver's functionality can be changed by software upgrade only. Thus affords far greater flexibility and reliability to the designer. Parameters of hardware components are subject to temperature changes, manufacturing variations and aging. However, software always performs the same. This is why SDR exhibits far better parameter predictability and performance consistency. Hardware products are hard and expensive to improve and upgrade. In contrast, SDR products are to a significant degree future proof and can be improved by a simple software upgrade only, with minimum equipment downtime. Due to a reduced number of hardware parts and software reusability, an SDR product is easier and cheaper to manufacture and maintain. Moreover, SDR also shows reusability, reconfigurability and enhanced functionality features which are not found in conventional radio.

In word, SDR can be flexible enough to avoid the "limited spectrum" assumptions of designers and it provides more easy inter-operability [9].

B. *Benefits over Other System of Data Communication*

Data transfer by using simple IR circuit has additional benefits in this respect.

- Spectrum analysis
- Higher data rates
- Real time data transfer
- Better channel capacity
- Wide range networking
- Reliable and modifiable
- Low cost
- Easy inter-operability

Moreover, if IR can be replaced by antenna a certain area is being under the network coverage.

VI. EXPERIMENTAL RESULT

Experimental result is shown in "Table 1" where different bits are transmitted and received. Comparisons between them are also shown in this Table.

Table 1: Comparative Results of Different Data Communication

Parameters / No. of bits	Time Taken According to Distances(sec.) 0.5m	1m	2m	Data Rates (app.)
100	6.5	6.5	7	15.02bps
400	27	27	27.5	14.72bps
500	34.5	34.5	35	14.42bps
1000	69.5	69.5	70	14.36bps
2000	140.5	140.5	141	14.21bps

"Table 2" shows the variation of bit error in percentage according to distances in meter for 5000 bits.

Table 2: Variation of Bit Error according to Distances for 5000 bits

Distance (meter)	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00
Percentage of Error (%)	0.02%	0.02%	0.04%	0.1%	0.12%	0.14%	0.18%	0.18%

"Fig. 11" shows graphical representation of table II. This curve is a non-linear curve. From this curve we come to a decision that percentage of error is non-linearly increase with the increase of distances.

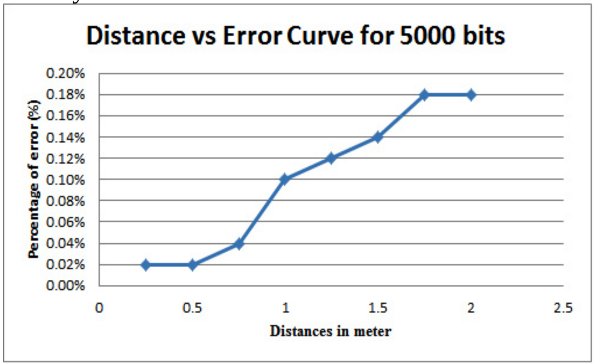

Figure 11: Percentage of Error vs Distance Curve for 5000 bits

"Table 3" shows the variation of bit error in percentage according to deviations in degree for 5000 bits.

Table 3: Variation of Bit Error according to Deviations for 5000 bits

Deviation of line of sight (degree)	0	2	4	6	8
Percentage of Error (%)	0.02%	0.08%	0.18%	0.26%	0.4%

"Fig.12" shows graphical representation of "Table 3". The curve is a non-linear curve. From this curve we come to a decision that percentage of error is non-linearly increase with the increase of deviations of line of sight. And gradually no data is transmitted and received if the deviation is far greater than 8 degree or non line of sight.

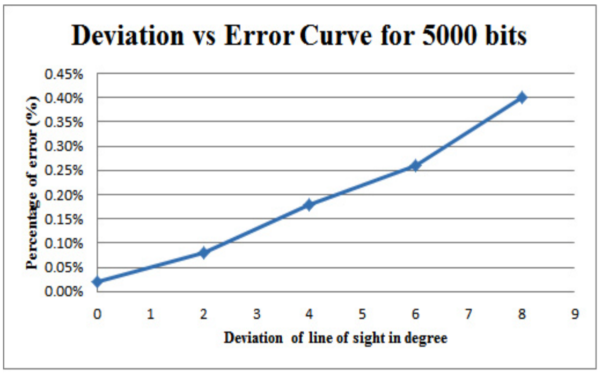

Figure 12: Percentage of Error vs Deviation Curve for 5000 bits

VII. FUTURE TRENDS

The Data communication system using simple IR circuit can be further modified and implemented. Some upcoming improvements are as follows.

- Smart networking system
- RFID Application
- Management of Information Flow
- Smart Calibration
- Smart Bridge (recognize the need for two or more legacy to communicate and connect them through a bridge)
- Data rates for correct processing of radio signals
- Development of software technologies, platforms and tools
- Applications of Spread Spectrum in SDR systems [10].

VIII. CONCLUSION

In this paper, we proposed and implemented a reconfigurable SDR platform by combining it with data communication system using simple IR circuit. Furthermore, realization of digital data

communication is achieved by applying SDR approach. SDR approach avoid the radio interference, which causes lower transmit performance, and provide an efficient wireless digital communication.
In word, SDR is a promising technology that facilitates development of multi-band, multi-service, multi-standard, multifeature data communication and future-proof network infrastructure.

This paper shows the feasibility of implementation and the performance of a Software Defined Radio data link, using two PC and a high level programming language.

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