

Implementation of an End to End Full Duplex Communication System over an Ultrasonic Carrier

[MCS programme]

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Abstract

This project aims at implementing a synchronous data communication system using the ultrasonic waves as carrier. The ultrasonic waves enable to overcome the problem of interference due to the external audio sources, which can be quite a nuisance if ordinary sound waves are used. The input to this system is from keypads and the output is displayed on a liquid crystal display (LCD). Any input to the system is encoded in a scheme, and then it is modulated and transmitted through the wireless medium. When this scheme is received, it is demodulated and data is decoded and is displayed. The digital data is transmitted using modulation and demodulation techniques for efficient utilization of the communication channel. For this reason Frequency Shift Keying (FSK) modulation and demodulation techniques have been chosen. The modulators and demodulators of this scheme have been designed. For reliable communication, a simple protocol is implemented which handles synchronization between either ends of the system.



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Project Objective

The main objective is to study the work history related to this project. Such as different, carrier, modulation techniques, data communication techniques in the wireless domain. To transfer the signal on carrier frequency and to learn different modulation techniques, to find the best suitable technique and to implement it. After which we choose the best techniques, technology and methods that are to be use in our project. We tried our level best to implement them in our project. We implemented it by using both hardware and software. Finally we developed a prototype for the project in the lab.



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Chapter 1

INTRODUCTION



1. INTRODUCTION

Digital communication is immune to noise, easy to recover and simple to implement. Digital data is transmitted using many modulation and demodulation schemes. Modulation and demodulation schemes are used for efficient utilization of communication channel. In this study 40 kHz frequency range is used because the commercially available transmitters and receivers work in this frequency range.[1]

This project implements a full duplex digital data communication system. The main aim of this project is to observe the behavior of a wireless communication channel. For this purpose, ultrasonic waves are used as a carrier for synchronous transmissions. Ultrasonic is a branch of physics, dealing with high frequency sound waves usually in the range of 20 kHz and above, i.e. above the audible frequency range.

Ultrasonic waves have long been used for detection and communication devices called 'subsonic', which are of great importance in present-day navigation, especially in submarine communication. Following are some of the applications of ultrasonic waves: [2]

- Applications of ultrasonic in Physics include the determination of such properties of matter as compressibility, specific heat ratios, and elasticity, [3]
- Ultrasonic is employed in producing emulsions, such as homogenized milk and photographic film, and for detecting flaws in industrial materials. Strong screen illumination in television is accomplished by using ultrasonic waves modulated by light diffraction, [4]
- Ultrasound in the 1-1.2 GHz range can be used to produce an acoustic "microscope", able to study detail down to one micrometer, [5]
- Surface acoustic waves in ultrasonic frequency range. form an important component of electronic control devices, [6]
- In medicine, ultrasonic is used as a diagnostic tool, to destroy diseased tissue, and to repair damaged tissue. Ultrasonic waves have been employed to treat bursitis, various types of rheumatoid arthritis, gout, and muscular injuries and to break kidney stones in small pieces. [7]
- As a diagnostic tool, ultrasonic is often more revealing than X-rays, which do not prove as useful in detecting the subtle density differences found in certain forms of cancer. It is also widely used to produce images of the fetus during pregnancy and has no damaging effect. [8]
- When ultrasonic waves are passed through a tissue, the waves are reflected in varying degrees, depending on the density and elasticity of the tissue. Using an ultrasonic "scalpel," a surgeon can make a finer incision as compared to the incision made by a conventional surgical knife. Such techniques are widely used in delicate surgery such as the brain and ear surgery, [9]
- Diathermic devices, in which ultrasonic waves are used to produce heat internally as a result of tissue resistance is being successfully used in physical therapy. [10]



The ultrasonic waves are chosen for the reason that these waves overcome the problem of interference due to external audio sources, which create problems if sound waves in the audible frequency range are used. Moreover, ultrasonic communication system is above human hearing range, hence it is not annoying to the users and the observers. This project was divided into the following discreet steps:

- The display module,
- The input/output module,
- Transmission
 1. Simple wired communication between microcontrollers,
 2. FSK modulation and demodulation,
 3. Actual transmission using ultrasonic transmitters and receivers.

1.1 The Display Module

The display module consists of two LCD displays each on both sides. Each LCD display consists of two rows and sixteen columns. One row is use for displaying sending digits and the other row is use for displaying receiving digits on both sides.

1.2 The Input / Output Module

1.2.1 Input

Two 4x4 keypads are used for input each at both sides. The input routine scans the microcontroller port to which the keypad is connected at both sides and as soon as a key is found pressed from the numeric keypad on either side, the digit corresponding to that key is forwarded to the output module to which the display module is connected.

1.2.2 Output

The output module is connected to the display module. The output module actually performs the switching operation and forwards the data that is to be displayed on the LCD.

1.3 Transmission

1.3.1 Simple wired communication using Microcontrollers

This module was the beginning of designing a protocol which is responsible for the real transmission taking place between the ultrasonic transmitters and receivers. In this module, simple wired communication was tested using microcontrollers. As shown in

figure 1.1 in this module a simple sequence of ones and zeroes was sent and received at the either side. This module actually successfully tested the scheme that has been used to transmit and receive the data.

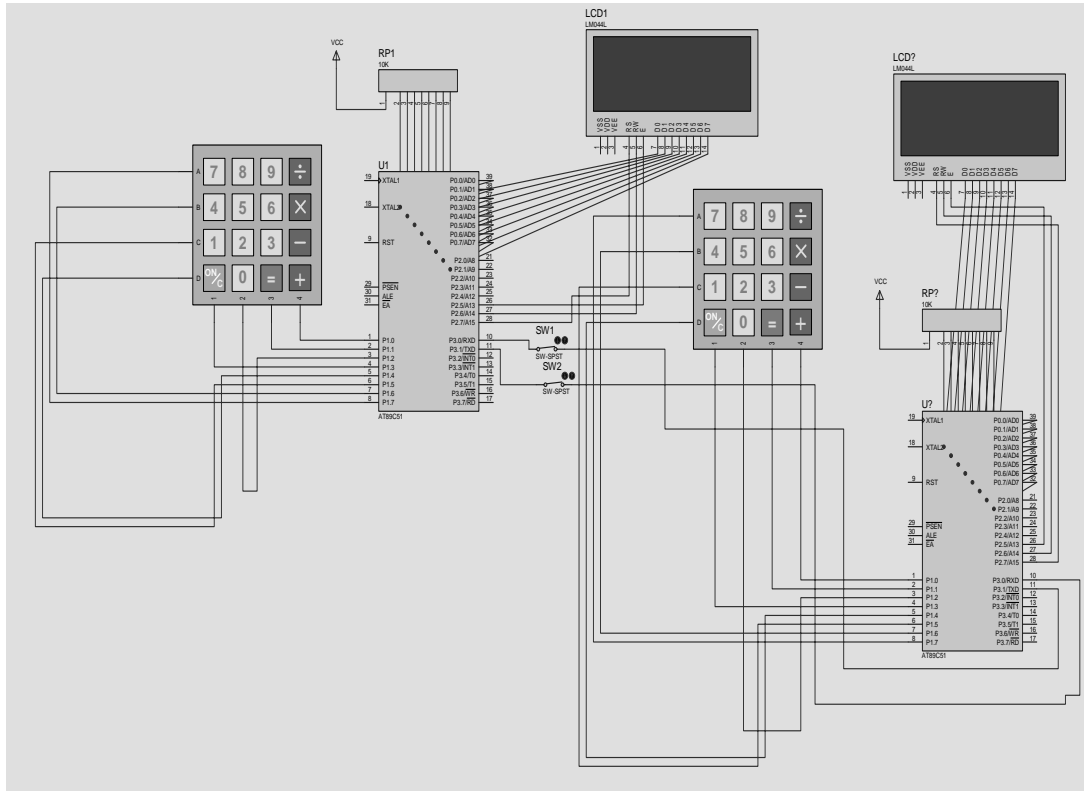


Figure 1.1 - Simple wired communication using Microcontrollers

1.3.2 FSK Modulation and Demodulation

As already discussed, modulation and demodulation techniques are used for efficient utilization of the channel. The Frequency Shift Keying (FSK) is used as modulation and demodulation technique. The main reason for using this technique is its simplicity and reliability. The data from the transmitter side will be FSK modulated and the demodulator on the receiver side would demodulate it. The modulator and demodulator were designed on the frequencies on which the commercially available ultrasonic transmitters and receivers work. The ultrasonic transmitters and receivers available in the market, work in 36 to 41 kHz range. Thus, the frequency chosen were 40 kHz. Similarly, the demodulator stage was designed so that it can demodulate any signal in this range. First, the modulator and demodulator were tested for wired communication which worked satisfactorily. Then, this scheme was tested for wireless medium (using ultrasonic transmitters and receivers).



1.3.3 Actual Transmission using Ultrasonic Transmitters and Receivers

After testing the successful working of the modulation and demodulation scheme for the wireless medium, the communication system was tested using microcontrollers. The micro-controller on the transmitting sides sends data to the FSK modulator. The modulator, after performing the modulation, forwards the data to the ultrasonic transmitters. The ultrasonic receivers on the either side, after receiving the data which is forwarded to it, sends this data to the demodulator, which provides the demodulated data to the micro-controller on the receiving side. This micro-controller, after deciphering the appropriate digit pressed from either of the two keypads, forwards it to the display module.



Chapter 2

SYSTEM OVERVIEW



2. SYSTEM OVERVIEW

The most important and critical issue while designing and implementing a complete system is the decomposition of the main task into sub-tasks. The project "implementation of an end to end full duplex communication system over an ultrasonic carrier" had certain main blocks as well. The aim was to simulate a wireless data communication system and explore various aspects while implementing this system. The main blocks of such a system are display module, input module, transmission module and the protocol.

2.1 Input Module

The first requirement in the input module is a user interface. The first step was to determine the type of data that is to be transmitted. Initially, numbers were transmitted as data but later alphabets from A, B, C, D, E and F are also added.

The second step was to determine the method of storing and processing the data entered by the user. This was a simple exercise. A device was needed which could take this data as input and then transmit it. Another step was to determine what hardware can be used to interface the two keypads to the system. It was then determined that micro-controllers can be used for this purpose, as they can provide flexibility and efficiency of data processing. This completes the input module, which consists of a keypad interfaced with a micro-controller.

2.2 Display Module

The user must be able to see the data that is entered and is to be transmitted and this data should be displayed at both ends. One solution was to use a 7-segment display, but the alphabets displayed by this arrangement are not pleasant to the eye. Thus, an output device was needed. Therefore, LCD displays were used. Again, the question of interface to these LCD displays arose, and again the answer was microcontrollers. The primary reason for using microcontrollers was to keep consistency in the design.

2.3 Transmission Module

The transmission module has two parts: the receiver and the transmitter. The first task of the transmitter side is to amplify the input signal. Then, a device with a well defined transmission scheme, such as amplitude modulation, is used. After the signal is modulated, it is fed to the transmitter which transmits the signal. On the other end, the receiver must receive the signal, amplify the signal and filter it to remove unwanted frequency components. The transducers used are ordinary ultrasonic transmitter and receiver. These transducers are basically tuned frequency transducers, the frequency that is given as input to the receiver was received in electrical form. According to their range of operation, 40 kHz frequency was selected and FSK was used as the transmission scheme.

Therefore, a device is needed at the transmitter end which takes input from the user, uses some encoding scheme to represent data and gives a signal (that is, representation of the data using that encoding scheme) which will be the input for the transmission module. Similarly, a device is needed at the receiver end which takes the

signal received and decodes it according to the encoding scheme used at the transmitter end and displays it. These devices act as interfaces between the transmission module and the input and output modules, at receiver and transmitter ends. The best choice was to use microcontrollers for interfacing as jobs can be scheduled according to their priorities.

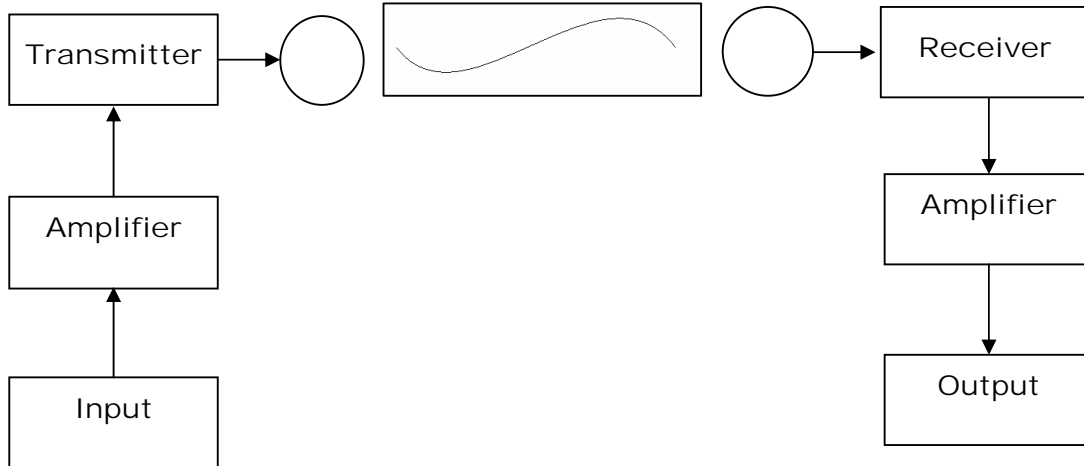


Figure 2.1 - Transmission Diagram

2.4 Protocol

Another very important part was the protocol and the coding issues involved in it. In the protocol, before starting the communication the microcontrollers on both ends will synchronize by sending the synchronization bit and a look up table was inserted in both micro-controllers to detect errors and unwanted signals. When a data is received the microcontroller will check it in the look up table and decide whether its a data or noise.

Figure no 2.2 shows that if an obstacle is placed between the transmitter and receiver module the communication will stop.

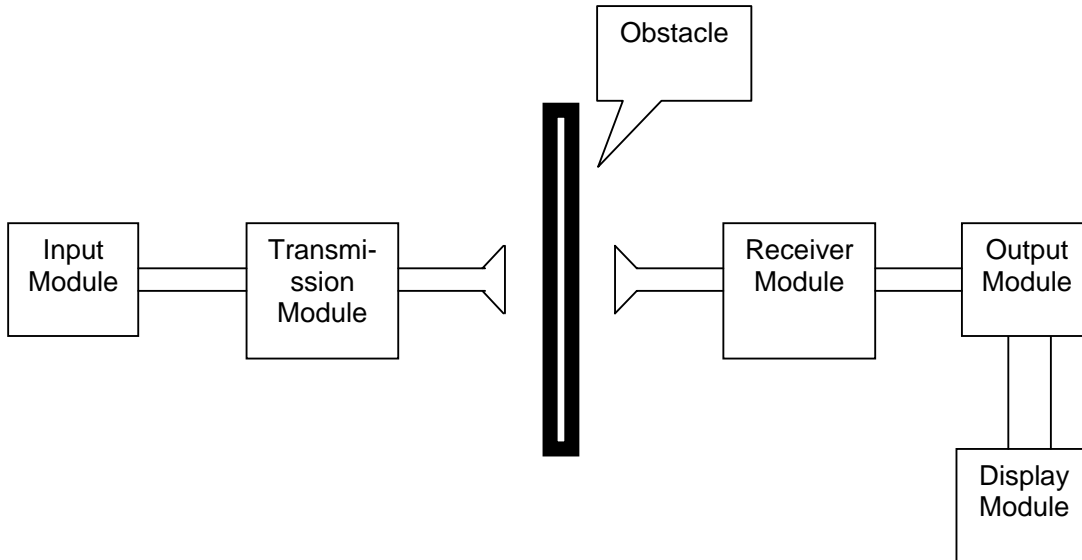


Figure 2.2 (a) - Block Diagram of the system in sending mode

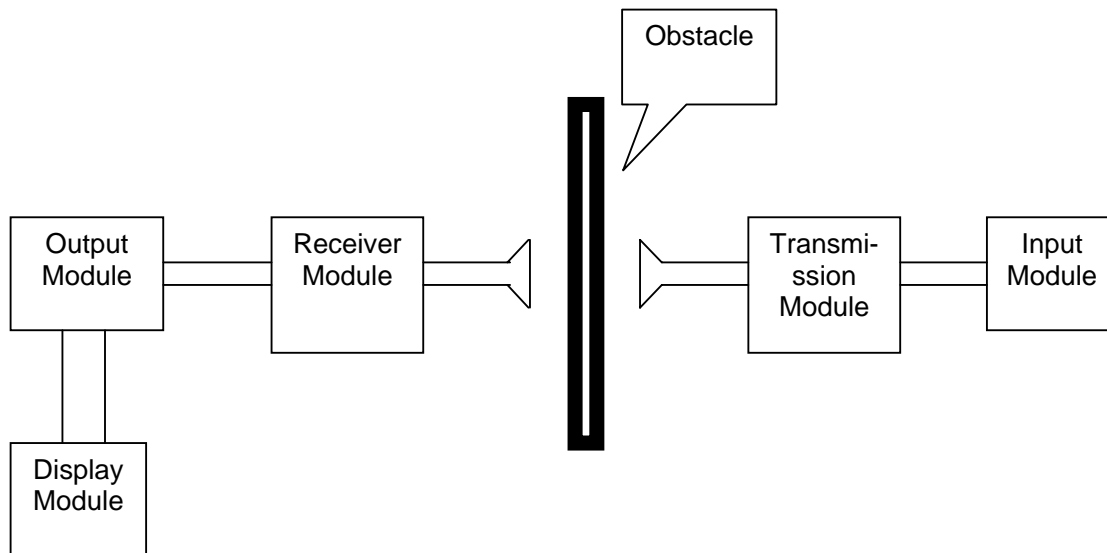


Figure 2.2 (b) - Block Diagram of the system in receiving mode



Chapter 3

INPUT MODULE