EXPERIMENT #7
WIRELESS TRANSMISSION OF DIGITAL DATA

Introduction

Many modern applications of data communications technology rely on wireless transmission of information. Products such as digital garage door openers, television remote controls, and remote-entry vehicle systems all use these techniques in one form or another. In factories, wireless communication allows control of mobile equipment, such as automated guided vehicles (AGVs), which are used to transport heavy parts such as automobile bodies.

By the use of hand-held data transmitters, retail operations can accomplish inventory checks faster than ever, since stock data is sent directly to the store's computer. One chain of supermarkets has a fleet of digital shopping carts, each equipped with a notebook-sized video screen (actually a small computer). Transmitters located in each part of the store transmit their data to the carts' displays; by pressing a button, consumers can search the store's inventory to find the location and price of any item.

Transmission Methods

There are three primary paths by which wireless data are sent. These are ultrasonic, optical, and radio frequency. All of these methods work in a similar fashion; the only difference is the type of carrier that is used. A carrier is a signal that "carries" the information from point to point.

Ultrasonic transmission uses sound waves to carry the information. The sound waves are well above the frequency range audible to humans; carrier frequencies between 30 KHz and 40 KHz are common. Ultrasonic transmission cannot penetrate walls, and the high-frequency transducers necessary to transmit and receive the energy are moderately expensive. Because of the relatively low carrier frequency, the available bandwidth is quite small, so this mode is primarily useful only for very low data rate operation.

Light is the workhorse of optical transmission. Extremely high data rates are possible, as in fiber-optic networks. Infra-red light is commonly used since it is invisible to the eye, and also because detectors can be built that filter out visible light while passing infra-red, which is desirable to reduce interference. Light does not easily bend around corners, and there are many "dead spots" in a room caused by carrier "shadows." This technology is very inexpensive, and it is the one of choice for low-cost applications such as VCR remote controls.

Of the three methods described, RF transmission is the most flexible; yet it presents the most design problems. RF carrier energy freely moves through most walls (except concrete and steel), so interference becomes a issue for system designers. Transmitters must be carefully designed to avoid interference with other services, such as fire and police agencies. In some cases, special licensing is required, adding expense to the system. Because of the ease of obtaining long-distance communication with RF methods, they are well suited for applications such as digital paging and messaging. RF is often used to deliver medium-speed Internet service to areas where DSL and cable delivery are not practical, such as in rural areas. Bandwidth (and data transmission speed) are limited because all users must share the same frequencies; in general, the obtainable data rates are higher than that attainable with ultrasonic transmission, but less than that obtained by using light.

The Experiment

A simple FSK (Frequency Shift Keyed) system has been constructed to demonstrate how a simple RF digital communications system operates. The components of the system are shown below in Figure 1.

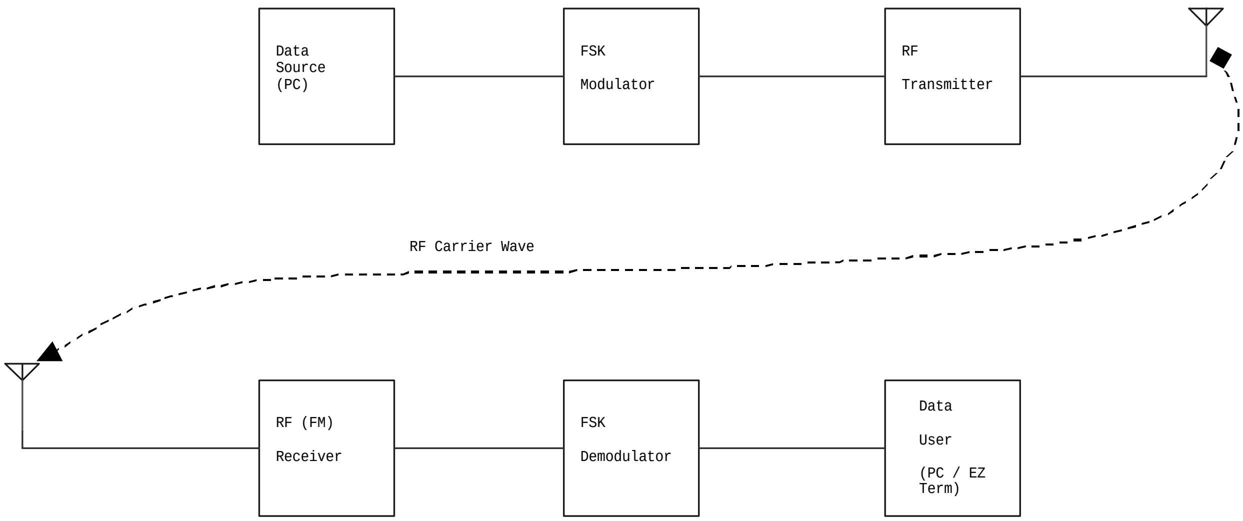


Figure 1: Components of the Wireless Communications System

The data source is an IBM PC. The actual data to be transmitted consists of several text files that will be sent using binary ASCII codes. A computer program controls the transmission of the data, and also controls the transmission of a voice identification which is automatically sent before each file.

The FSK Modulator converts the binary signal from the computer into one of two audio frequencies, 2225 Hz for a logic "1" and 2025 Hz for a logic "0." This step is necessary so that the digital data can be passed to the transmitter, which needs an analog input.

The RF Transmitter sends the audio tones (representing the digital data) out over a radio frequency. For this experiment, 91.9 MHz will be used as the carrier frequency. This frequency was chosen to allow a conventional FM broadcast-band receiver to be used. The transmitter's power output is very small in order to comply with FCC regulations regarding unlicensed operation in the FM broadcast band.

The first step in reception, demodulation of the RF carrier, is performed by the RF Receiver. The remaining steps are merely a reversal of those in the transmission process. The resulting audio tones from the RF receiver are fed into the FSK Demodulator, which converts the audio tones back into digital data (1s and 0s.) Finally, the Data User receives the digital information and displays it. In this experiment, the data user is a computer running terminal emulation software. The terminal emulation program will display all received data on the video display so that it can be read.

SUGGESTED EXPERIMENTAL PROCEDURE

1. Construct the FSK DATA RECEIVER from the supplied schematic diagram. Pay attention to power supplies and grounds.

2. Connect the RS232 output of the DATA RECEIVER (P1) to the SERIAL CONNECTOR of a suitable receiving computer.

3. Set the PARAMETERS of the receiving computer (using terminal emulation software such as EZ Terminal) to 300 BPS, 8 Data , No Parity, 1 Stop bit.

4. Using clip leads, couple the AUDIO INPUT of the FSK DATA RECEIVER to the SPEAKER OUTPUT of any available FM receiver. Do not disconnect the receiver's speaker. Be careful to connect the circuit ground to the receiver ground.

5. Tune the radio receiver to 91.9 MHz on the FM dial. You will hear one of the following; a dead carrier, a modulated carrier, or a voice identifier. If you hear only a dead carrier, simply wait a few minutes for the voice ID to come across.

6. When the transmitter is sending data, you should observe it on your computer's screen. If the data appears garbled (it should be plain text), double-check the PARAMETER settings on the computer, and also try adjusting the receiver volume. (If there is any distortion of the signal, it will not be demodulated accurately.) Note: it is possible for the receiver UART in the PC to become unsynchronized to the transmitted data stream if a connection is made in the middle of a transmission. Wait until the next transmitted message to "fix" this problem.

Transmitter Operating Cycle

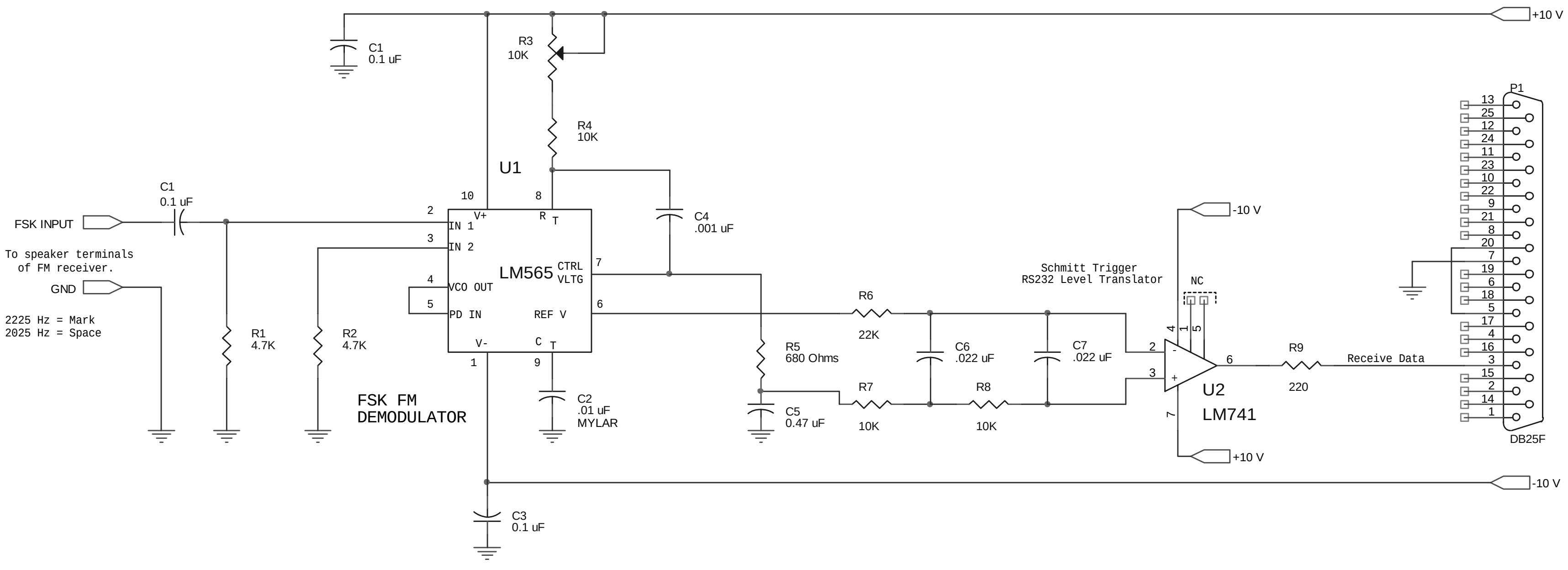
If you wish to listen in on the data transmissions without building any circuitry, you can do so by tuning a standard FM broadcast receiver to 91.9 MHz. Every few minutes, the following events will take place:

(a) The computer will generate a voice identification lasting from 10 to 16 seconds. The voice ID will state the nature of the transmission to follow.

(b) After the identification, the computer will transmit an ASCII text file using Frequency Shift Keying (FSK). The sound of the FSK data is unmistakable; it is very dissonant (some listeners might describe it as shrill).

(c) After the data file has been sent, the transmitter will go silent for a variable interval, 1 minute or so, before the cycle begins again.

(d) A different data file will be sent during each cycle. Therefore, the length of each transmission will vary.



Note:

To properly adjust R3:

1. Disconnect the FSK INPUT from any audio source (the receiver).
2. Connect a frequency counter or accurate scope to pin 4 of U1 (VCO Output).
3. Carefully adjust R3 for a free-running VCO frequency of 2100 Hz.

If R3 is not adjusted correctly, no data will be received!
You may need to "tweak" R3 to get clean data during
receive.

Figure 2: FSK Demodulator Circuitry