ANALOG COMMUNICATIONS USING INFRARED TRANSMISSION

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Abstract

The Baccalaureate Electrical Engineering Technology program at Penn State University at Erie, The Behrend College, offers a two-semester course sequence in communication systems. The first course is intended to introduce the fundamentals of analog communication systems, while the second course is intended to introduce the more advanced communication systems topics including digital/data communications and high frequency communication techniques. During the first course in analog communication systems, the students are introduced to communication circuits, Fourier series, noise analysis, amplitude modulation, frequency modulation, transmission lines, and antennas. Along with the lecture material, the students meet weekly in the lab for experimentation. Since the fundamentals of analog communications have been in existence for many years, there is a need to introduce current technology to students in this course.

In this paper, an innovative use of current technology within analog communication systems is presented. This paper describes a laboratory project which uses infrared transmission techniques with amplitude modulation for voice communications. The purpose of the laboratory project is to introduce the design for an AM transmitter/receiver which uses an infrared LED and a photodetector for infrared transmission and detection of voice signals.

First, a series of week] y lab experiments for students are presented to complete the overall lab project. This includes the design of an infrared transmitter which consists of the design of an AM modulator using an IC oscillator, the design of a pre-amp, and the design of a common-emitter transistor driver circuit for an infrared LED. The infrared receiver consists of a photodetector connected to an op-amp for current-to-voltage conversion, op-amps for amplification and filtering, a precision peak detector for demodulation, and an audio power amplifier to drive the speaker.

Next, results are presented to show what the students learned. This includes using IC oscillators for amplitude modulation, driver circuits for infrared LEDs, switching speed limitations for infrared LEDs and photodetectors, photodetector circuits, high-speed op-amps for improved frequency response, noise reduction techniques, and peak detector circuits.

Lastly, students' reactions are presented. Based upon their comments, much enthusiasm and interest was generated over this project, and most students were able to successful y complete the entire project.

Analog Communication Systems

A two-semester course sequence in communication systems is given to students in the Baccalaureate Electrical Engineering Technology program at Penn State University at Erie, The Behrend College. The first course, EETBD 330, taken in the junior year, is an analog communication systems course designed to introduce analog communication topics. The second course, EETBD 437, offered in the senior year, is an advanced communications course designed to introduce advanced communication topics such as digital/data communications and high frequency communication techniques.

During the analog communication systems course, students are introduced to four major topics: fundamentals of analog communications, amplitude modulation, frequency modulation, and transmission lines and antennas. Within the first major topic, students are introduced to some of the fundamentals of analog communications which includes communication circuits such as LC circuits and oscillators, Fourier series with emphasis on the frequency-domain representation of signals, and on noise analysis which includes noise calculations involving signal-to-noise ratio and noise figure and the representation of signal amplitudes in the decibel scale. The second major topic is amplitude modulation, where students are introduced to AM modulator circuits, AM transmitters, superheterodyne receivers, AM demodulator circuits, and single-sideband systems. The third major topic involves FM, where students are introduced to FM transmission, phase-locked loops, FM receivers, and FM stereo. Students are also introduced to transmission lines which includes topics such as transmission 1 ine equivalent circuits, incident and reflected waves, and impedance matching. Lastly, students are introduced to antennas which includes topics such as the Hertz antenna and the Marconi antenna. Most of these topics are covered in communication system textbooks available for electrical engineering technology students[1].

In addition to the above mentioned topics discussed in lecture, students meet weekly in the laboratory for experimentation. One of the major areas for laboratory experimentation is in analog modulation. Since analog modulation has been in existence for many years, there is a need to introduce new technology to students in this field for practical laboratory experimentation. This is beneficial since analog modulation is still used today and students can later apply this technology in the industrial workplace. One method of introducing new technology is to use a number of currently available IC transmitters and receivers. This approach will usually require the use of printed-circuit boards with a number of specialized parts such as ceramic filters and shielded tunable inductors. Because of financial considerations, this can sometimes preclude the use of this approach.

Another approach involves the use of infrared transmission techniques for the transmission and reception of analog information such as voice signals. This approach is much less costly since the transmitter and receiver can be configured on a protoboard and very few specialized parts are required. The major focus for this paper will be a description of a laboratory project incorporating amplitude modulation for voice communication using infrared transmission.

Infrared Transmitter Design

The infrared transmitter schematic is shown in Figure 1 and consists of an XR-2206 IC function generator along with a pre-amplifier used as the AM modulator and the design of a common-emitter transistor driver circuit for the MLED81 infrared LED. The XR-2206 is initially designed to provide a specific carrier frequency by referencing the datasheets found in the databook[2]. By providing a bias voltage to pin 1 of the chip, the amplitude of the carrier can be adjusted. This provides the capability of generating an AM waveform. When an information signal at an audio frequency is applied to pin 1, the rate of the change in the carrier amplitude is the same as the rate of the change in the information signal. In addition, if a DC bias voltage is added to the information signal, the DC voltage is used to control the modulation index. This results in a double-sideband full carrier (DSBFC) waveform used for AM transmission.

This waveform is then applied to a transistor driver circuit for the MLED81 infrared LED. For this design, the LED current is chosen such that the power dissipation for the LED does not exceed the maximum value specified in the datasheets[3]. Based upon the forward drive current for the LED, the datasheets can also be referenced to determine the forward voltage across the LED. The base voltage for the transistor can then be determined. This voltage is used to determine the bias resistances for the transistor. Lastly, the collector resistor is used to control the collector-to-emitter voltage drop across the transistor.

Infrared Receiver Design

The infrared receiver schematic, shown in Figure 2, consists of an MRD821 photodiode used as a photodetector connected to an op-amp configured as a current-to-voltage converter. An LF4 11 op-amp is used to minimize the input bias currents into the input terminals as well as to improve the unity-gain bandwidth. The second op-amp is used to boost the signal voltage and to provide filtering as needed. The third op-amp is used as a precision half-wave rectifier/peak detector. In this design, two small-signal diodes are used. The series diode is placed inside the feedback loop of the op-amp to allow the op-amp to overcome the forward voltage drop across the diode as soon as the input voltage goes positive. The shunt diode is connected to the op-amp output to clamp the op-amp output voltage to one diode voltage drop below ground level. This provides a faster recovery time from saturation for the op-amp. Lastl y, an LM386 audio power amplifier is used to drive the speaker.

Results

The entire laboratory project took approximately six weeks to complete: three weeks for the transmitter design and three weeks for the receiver design. The students performed individual laboratory experiments which focused on each major section of the transmitter and receiver. For each experiment, the instructor provided the students with generalized schematics, much like the schematics found in Figures 1 and 2. The students were also given design guidelines or were referred to datasheets found in databooks available in the laboratory.

For the transmitter portion of the project, the students first learned how to construct an AM modulator using an IC function generator. Next, the students determined the proper carrier frequency by considering the switching speed limitations for both the LED and the photodiode. Then, the students learned how to select the proper forward drive current for the LED by considering the maximum power dissipation specified in the datasheets.

For the receiver portion of the project, the students first learned how to select a suitable op-amp to be used as a current-to-voltage converter and as a voltage amplifier by considering input bias currents and unity-gain bandwidth. Next, the students learned how to reduce noise levels by using bandpass filtering. Lastly, the students learned how to recover the information signal by designing an AM demodulator and using an audio power amplifier to drive the speaker.

The students demonstrated the operation of their completed design by transmitting and receiving an audio signal from a function generator over a distance of several feet in the laboratory.

Student Reactions

By designing individual laboratory experiments around a common project, students were able to successfully design a useful project. This helped to encourage enthusiasm for laboratory experimentation. Also, the infrared transmission and reception techniques developed within the laboratory introduced new practical technology to the students which can be used later in the industrial workplace. This project also helped to build enthusiasm for communication systems.

Conclusion

The laboratory project presented in this paper was designed to introduce new technology such as infrared transmission techniques to students taking an analog communication systems course. Overall, the project was well received by the students and most students were able to successfully complete the project.

Bibliography

1. Tomasi, Wayne, Electronic Communications Systems: Fundamentals Through Advanced, Prentice-Hall, 1994.

2. EXAR Databook, 1990.

3. MOTOROLA Optoelectronics Device Data, 1988.

Biographical Information

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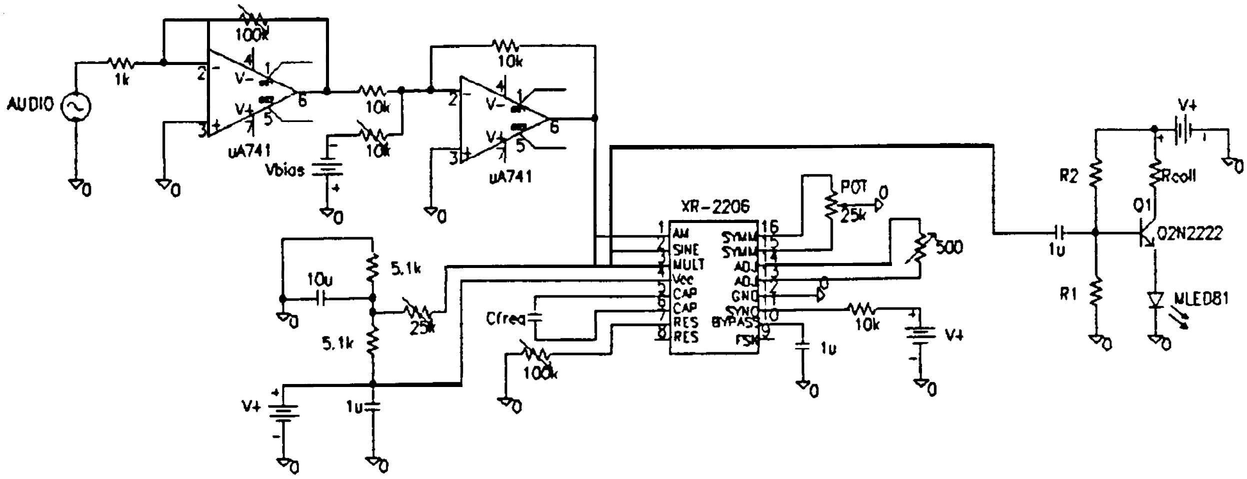

Figure 1. Infrared Transmitter

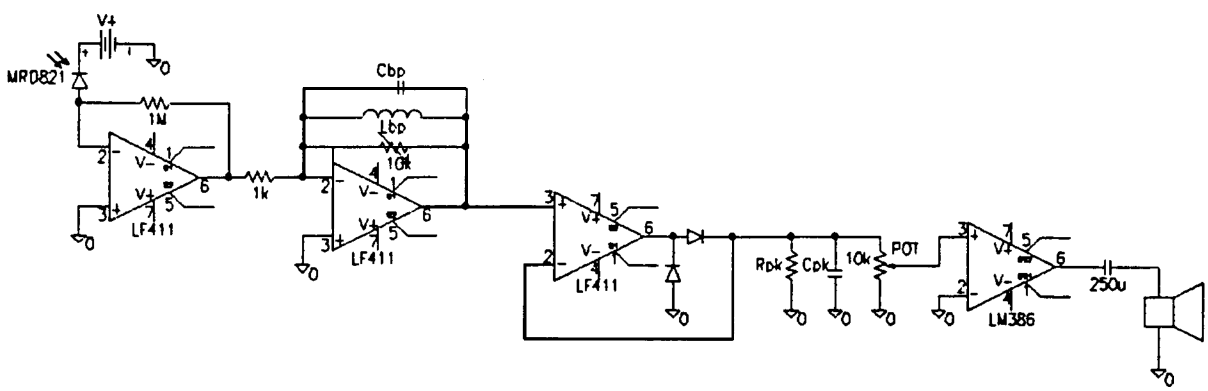

Figure 2. Infrared Receiver