Digital Communication

1 Objective

1. Study and understand how the pulse-code modulation (PCM) technique works.
2. Study the line coding and channel coding techniques.

2 Theory

Pulse-code modulation (**PCM**) is a method used to digitally represent sampled analog signals. It is the standard form of digital audio in computers, Compact Discs, digital telephony and other digital audio applications. In a PCM stream, the amplitude of the analog signal is sampled regularly at uniform intervals, and each sample is quantized to the nearest value within a range of digital steps.

Line coding consists of representing the digital signal to be transported by an amplitude- and time-discrete signal that is optimally tuned for the specific properties of the physical channel (and of the receiving equipment). The waveform pattern of voltage or current used to represent the 1s and 0s of a digital data on a transmission link is called *line encoding*. The common types of line encoding are unipolar, polar, bipolar, and Manchester encoding.

In digital communications, a **channel code** is a broadly used term mostly referring to the forward error correction code and interleaving in communication and storage where the communication media or storage media is viewed as a channel. The channel code is used to protect data sent over it for storage or retrieval even in the presence of noise (errors).

3 Prelab Questions

1. Explain the PCM technique succinctly.
2. Explain the significance of line coding and Channel Coding.
3. Explain the advantage of the HDB3 line coding scheme.

4 Equipment

1. Oscilloscope (OSC)
2. Function Generator
3. PCM training set comprising
   PAM Modulator 736061
   PAM Demodulator 736071
   PCM Modulator 736101
   PCM Demodulator 736111
4. Line and channel coding set comprising
   Data source / Parity Generator 73693
   Display / Parity Check Indicator 73692
   AMI/HDB3 Coder 73694
   AMI/HDB3 Decoder 73691
5. Power Supply (72686)

5 Experiment

Experiment 1 PCM Operation

Experiment Procedure

1. Assemble PCM training set and set the transmitting-receiving method on boards 736101, 736111 to be PCM.

2. Apply the sine wave with frequency 3 kHz and magnitude 5 V_{pp} to the CH1 input of the 736061 board.
3. Record the waveforms at the following test points:
    a. Clock of 736061
    b. PAM1 of 736061
    c. PCM of 736101
    d. CH1 of 736101
4. Apply the sine wave with frequency 5 kHz and magnitude 5 V_{pp} to the CH1 input of the 736061 board and repeat step 3.
5. Change the transmitting-receiving method on boards 736101, 736111 to be DPCM, then repeat steps 2-3. Compare the result with those of PCM.
6. Apply the sine wave with frequency 3 kHz and magnitude 5 V_{pp} to the CH1 input and the CH2 input of the 736061 board, then repeat step 3 and record the waveform at CH2 of 736071. Use PCM method.
7. Apply the sine wave with frequency 3 kHz and magnitude 5 V_{pp} to the CH1 input and the sine wave with frequency 2 kHz and magnitude 5 V_{pp} to the CH2 input of the 736061 board, then repeat step 3 and record the waveform at CH2 of 736071. Use PCM method.

Experiment 2 Line Coding

Experiment Procedure

1. Connect board 73693 to board 73694, and select 8-bit data transmission.
2. Set the data on board 73693 to be all 1's, then record AMI, HDB3 signals.
3. Set the data on board 73693 to be all 0's, then record AMI, HDB3 signals.
4. Set the data on board 73693 to be 10101010, then record AMI, HDB3 signals.
5. Set the data on board 73693 to be all 10000001, then record AMI, HDB3 signals.

Experiment 3 Digital data transmission system

Experiment Procedure

1. Connect boards 73693, 73694, 73693 and 73692 together, then select 8-bit data transmission as well as AMI line coding.
2. Set the data on board 73693 to be 10011010, then observe the output on 73692 and record the AMI signal.
3. Try changing data on board 73693 one bit at a time, then observe the output on 73692.
4. Change to 8+2 bit data transmission, then repeat step 2.
5. Change to 9+2 bit data transmission, then repeat step 2.

Experiment 4 Channel Coding

Experiment Procedure

1. Connect boards 73693, 73694, 73691 and 73692 together, then select 12-bit data transmission as well as AMI line coding.
2. Set the data on board 73693 to be 00000000, then observe the parity bits and output on 73692.
3. Change the data on board 73693 to be 00000001, 00000010, …, 10000000, sequentially, and repeat step 2.
4. Set the data on board 73693 to be 10011010, then observe the parity bits, the syndrome bits and output on 73692, and record AMI signal.
5. Try changing data on board 73693 one bit at a time, then observe the output on 73692.

6. Try increasing error, then observe the parity bits, the syndrome bits and output on 73692.

6 Postlab Questions

1. Explain the difference between PCM and DPCM.
2. Explain the difference between AMI and HDB3.
3. Explain the channel coding method used in this experiment, and determine the error correctability of this method.