Indian Institute of Technology, Kharagpur

Department of Electronics & Electrical Communication Engineering

Subject: Digital Communication Laboratory (EC 39001)
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Experiment 2: Line Coding

Objective: To design a circuit for generation of different line coding schemes using a given PN sequence.

Key Components: IC 7486 (Quad 2-i/p XOR gate), IC 7495 (4-bit shift register), IC 7404(NOR gate), IC 7408 (AND gate), IC7476 (JK flip-flop), IC 741 (Op-Amp),), digital oscilloscope, function generator, breadboard, connecting wires, power supply.

Brief Theory: A line code is used for data transmission of a digital signal over a transmission line. This coding process is chosen to avoid the distortion of signals such as inter-symbol interference. The line code technique has the capability to do spectrum shaping and relocation without modulation or filtering. Line codes encoding process is chosen are suitable for transmission over baseband channels. There are many ways this conversion of bits to waveforms could be done. For example, a data value of 0 could be represented by a 1ms pulse and a data value of 1 could be represented by a 2ms pulse. There are dozens of different line codes in use. They have been developed to match the characteristics of different channels, different data rates, different implementation technologies and different cost/performance requirements. The choice of line code will depend on the requirements of the application and will include compromises between bandwidth, DC content, transition density and implementation complexity. There are 3 types of Line Coding (i) Unipolar (ii) Polar (iii) Bi-polar.

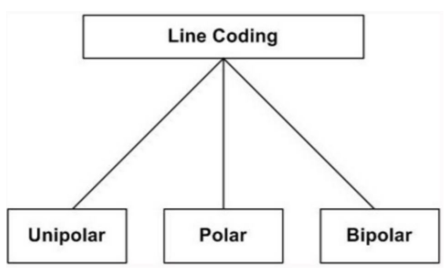

Figure 1: Types of Line codes

(i) ***Unipolar Signalling*** Unipolar signaling is also called as On-Off Keying or simply OOK. The presence of a pulse represents a 1 and the absence of a pulse represents a 0. It has the advantage of being compatible with TTL logic. There are two variations in Unipolar signalling.

(a) *Non-Return to Zero (NRZ)*: In this type of unipolar signalling, a High in data is represented by a positive pulse called a Mark, which has a duration equal to the symbol bit duration. A Low in data input has no pulse.

(b) *Return to Zero (RZ)*: In this type of unipolar signalling, a High in data, though represented by a Mark pulse, its duration is less than the symbol bit duration. Half of the bit duration remains high but it immediately returns to zero and shows the absence of pulse during the remaining half of the bit duration.

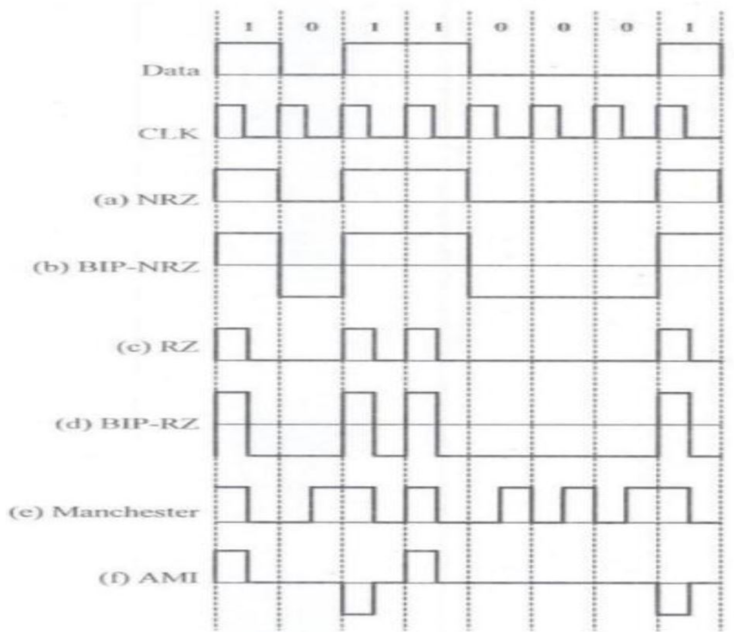

Figure 2: Different types of Line coding

(ii)***Polar Signalling:*** There are two methods of Polar Signaling. They are

(a) *Polar NRZ*: In this type of Polar signalling, a High in data is represented by a positive pulse, while a Low in data is represented by a negative pulse.

(b) *Polar RZ*: In this type of Polar signalling, a High in data, though represented by a Mark pulse, its duration is less than the symbol bit duration. Half of the bit duration remains high but it immediately returns to zero and shows the absence of pulse during the remaining half of the bit duration.

However, for a Low input, a negative pulse represents the data, and the zero level remains same for the other half of the bit duration.

(iii)***Bipolar Signalling:*** This is an encoding technique which has three voltage levels namely +, - and 0. Such a signal is called as duo-binary signal. An example of this type is Alternate Mark Inversion (AMI). For a 1, the voltage level gets a transition from + to or from to +, having alternate 1s to be of equal polarity. A 0 will have a zero voltage level. This is the code used on compact discs (CD), USB ports, and on fiber-based Fast Ethernet at 100-Mbit/s. We have two types.
(a) Bipolar NRZ
(b) Bipolar RZ

Manchester In Manchester code each bit of data is signified by at least one transition. Manchester encoding is therefore considered to be self-clocking, which means that accurate clock recovery from a data stream is possible. In addition, the DC component of the encoded signal is zero. Although transitions allow the signal to be self-clocking, it carries significant overhead as there is a need for essentially twice the bandwidth of a simple NRZ or NRZI encoding.

Application of Line Coding Technique

- Spectrum Shaping and Relocation without modulation or filtering. This is important in telephone line applications, for example, where the transfer characteristic has heavy attenuation below 300 Hz.
- Bit clock recovery can be simplified.
- DC component can be eliminated; this allows AC (capacitor or transformer) coupling between stages (as in telephone lines). Can control baseline wander (baseline wander shifts the position of the signal waveform relative to the detector threshold and leads to severe erosion of noise margin).
- Error detection capabilities.
- Bandwidth usage; the possibility of transmitting at a higher rate than other schemes over the same bandwidth.

Desireable properties of Line codes

- SelfSynchronisation: There is enough timing in formation built into the code so that bit synchronisers can extract the timing or clock signal. A long series of binary 1s or 0s should not cause a problem in time recovery.
- Low Probability of Bit Error: Receivers can be designed that will recover the binary data with a low probability of bit error when the input data is corrupted by noise or ISI.
- Transmission Bandwidth: as small as possible
- Power Efficiency: As small as possible for given BW and probability of error
- Error Detection and Correction capability: It should be possible to implement this feature easily by the addition of channel encoders and decoders, or the feature should be incorporated into the line code.
- Favorable power spectral density: dc=0
- Transparency: Prevent long strings of 0s or 1's.

Expected Outcome: Using the PN sequence generated in the previous lab as input data, design a circuit to generate an Unipolar RZ line code, Machester code and Alternate Mark Inversion code (AMI) and observe the corresponding outputs on the oscilloscope.

References:

1. Simon Haykin, 'Digital Communication System'.