Line Coding

1) Objective

To convert a given Binary Sequence into various forms of Line Codes

2) Equipment Required

1) ED – 2970 A: Data Source Module (1 piece)
2) ED – 2970 B: Data Format Module (1 piece)
3) ED – 2970 M: Power Supply Module (1 piece)
4) Oscilloscope

3) Theory

Information sources that provide digital data deliver numbers that are not suitable for transmission. The data must be formatted in a proper way to make them suitable for transmission through a communication channel. **Line coding** is the process of converting binary data (a sequence of bits) into voltage pulses that represent the information. When a pulse is used to represent each bit it is called binary communication. If a pulse is used to represent multiple bits it is called m-ary communication.

Desirable properties of a line code:

(a) **Error detection capability:** The receiver needs to be able to distinguish the waveform associated with a "high" from the waveform associated with a "low", even if there is a considerable amount of noise and distortion in the channel.

(b) **DC content:** Many telecom channels are AC coupled (DC blocking), so it is desirable to have zero DC in the waveform produced by a given line code. If a signal with significant DC content is used in AC coupled lines, it will cause DC wander (received signal baseline will vary with time). Furthermore, it is not possible to pass DC through transformers and DC blocking capacitors.

(c) **Power Spectrum & Bandwidth:** The power spectrum and bandwidth of the transmitted signal should be matched to the frequency response of the channel to avoid significant distortion. The bandwidth should be minimized as much as possible to improve efficiency.

(d) **Self-synchronization:** The waveform produced by the line code should contain enough timing information such that the receiver can synchronize with the transmitter and decode the received signal properly. This can be achieved if there are transitions in the signal that alert the receiver to the beginning, middle, or end of the pulse.

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The following line codes are provided in the Data Format (ED – 2970 B) module:

(1) Non Return to Zero (NRZ)

Bit 1 = Positive voltage for the whole bit interval

Bit 0 = Zero voltage for the whole bit interval

(2) Return to Zero (RZ)

Bit 1 = Positive voltage for 1st half of bit interval, then returns to zero voltage for 2nd half of bit interval

Bit 0 = Zero voltage

(3) Bi-phase (Manchester) – (According to G.E. Thomas)

Bit 1 = High to low transition in the middle of the bit interval

Bit 0 = Low to high transition in the middle of the bit interval

(4) Bipolar NRZ – (As per ED – 2970 B Module)

Bit 1 = Positive voltage for the whole bit interval

Bit 0 = Negative voltage for the whole bit interval

(5) Bipolar RZ – (As per ED – 2970 B Module)

Bit 1 = Positive voltage for 1st half of bit interval, then returns to zero voltage for 2nd half of bit interval

Bit 0 = Negative voltage for 1st half of bit interval, then returns to zero voltage for 2nd half of bit interval

(6) Ternary – (As per ED – 2970 B Module)

Bit 1 = Consecutive ones are represented by an alternating positive and negative voltage for 1st half of bit interval, then returns to zero voltage for 2nd half of bit interval

Bit 0 = Zero voltage

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4) Procedure

(1) Provide power supply to all modules

(2) On the Data Source Module (ED – 2970 A) make the following connections:

(2.1) Connect the 160 KHz output to the "Clock In" socket
(2.2) Place the switch on the "Data Source" position
(2.3) Provide a "Ground" connection

(a) Observe and sketch the bit clock pattern on the oscilloscope. Calculate the bit interval (T_b) and the transmission rate (R_b) in bits per second (bps). Calculate the frequency of the bit clock pattern.

(b) Observe and sketch the word clock pattern on the oscilloscope. Calculate the frequency of the word clock pattern. How is the word clock pattern related to the bit clock pattern?

(3) Connect the Data Source Module (ED – 2970 A) and the Data Format Module (ED – 2970 B) together as follows:

(3.1) Connect the "Bit Clock" of ED – 2970A to the "Bit Clock" of ED – 2970B
(3.2) Connect the "Word Clock" of ED – 2970A to the "Word Clock" of ED – 2970B
(3.3) Connect the "NRZ Data" of ED – 2970A to the "NRZ Data" of ED – 2970B
(3.4) Connect the "Ground" of ED – 2970A to the "Ground" of ED – 2970B

(4) Provide the following binary sequence from the Data Source Module (ED – 2970 A) and observe the output of the Bit Clock and the following Line Codes on the oscilloscope.

Make sketches in your notebook for each case.

Binary Sequence	Bit Clock	NRZ	RZ	Bi-phase	Bipolar NRZ	Bipolar RZ	Ternary
1 0 0 1 1 0 0 1							
1 1 1 0 0 1 1 1							
1 0 1 0 1 0 1 0							
1 0 0 0 0 0 0 1							
1 1 1 1 1 1 1 1							