SIGNAL ENCODING

8.0 OBJECTIVES

The objectives of this chapter are: 1. Understand what is signal encoding 2. Different ways of converting analog signal to digital 3. Different ways of converting digital signal to analog 4. Modulation

INTRODUCTION TO SIGNAL ENCODING

Data can be analog or digital, so can be the signal that represents it.

Signal encoding is the conversion from analog/digital data to analog / digital signal.

Figure: Signal Encoding In the Figure above,

A) Demonstrates Digital Signaling where data from an analog/digital source is encoded into Digital Signal

B) Demonstrates Analog signaling in which the analog/digital source modulates a continuous carrier signal to produce an analog signal.

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The possible encodings are:

1. Digital data to Digital Signal
2. Digital data to Analog Signal
3. Analog data to Digital Signal
4. Analog data to Analog Signal

8.2 SYNCHRONIZATION

In order to receive the signals correctly, the receivers bit intervals must correspond exactly to the senders bit intervals.

The clock frequency of the transmitter and receiver should be the same.

If the clock frequency at the receiver is slower or faster than the bit intervals are not matched and the received signal is different than the transmitted one.

Figure : Synchronization

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In the above figure, the receiver clock frequency is twice that of the transmitter frequency. Hence the received data is totally different than the transmitted one

To avoid this, receiver and transmitter clocks have to be **synchronized.**

To achieve this the transmitted digital signal should include timing information which forces synchronization

8.3 Digital Data to Digital Signal Coding methods Coding methods are used to convert digital data into digital signals. There are two types of coding methods:

1 Line Coding
2 Block Coding

Scrambling is also one of the ways to convert digital data to digital signals but is not used. **8.3.1 Line Encoding It is the process of converting Digital data into digital signal.** In other words, it is converting of binary data(i.e. A sequence of bits) into digital signal (i.e. a sequence of discrete, discontinuous voltage pulses) **Figure: Line Coding 8.3.2 Classification of Line Codes** The following figure shows the classification of Line coding schemes:

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Figure : Classification of line coding schemes 8.3.2.A Unipolar

All signal levels are either above or below the time axis.

NRZ - Non Return to Zero scheme is an example of this code. The signal level does not return to zero during a symbol transmission.

8.3.2.B Polar

NRZ-voltages are on both sides of the time axis.

Polar NRZ scheme can be implemented with two voltages. E.g. +V for 1 and -V for 0.

There are two variations:

- **NZR - Level (NRZ-L)** - positive voltage for one symbol and negative for the other

- **NRZ - Inversion (NRZ**-I) - the change or lack of change in polarity determines the value of a symbol. E.g. a ―1‖ symbol inverts the polarity a ―0‖ does not.

Polar – RZ

- The Return to Zero (RZ) scheme uses three voltage values. +, 0, -.

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- Each symbol has a transition in the middle. Either from high to zero or from low to zero

- More complex as it uses three voltage level. It has no error detection capability

Polar - Biphase: Manchester and Differential Manchester

Manchester coding is a combination of NRZ-L and RZ schemes.

Every symbol has a level transition in the middle: from high to low or low to high.

It uses only two voltage levels.

Differential Manchester coding consists of combining the NRZ-I and RZ schemes.

Every symbol has a level transition in the middle. But the level at the beginning of the symbol is determined by the symbol value. One symbol causes a level change the other does not.

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.C Bipolar - AMI

This coding scheme uses 3 voltage levels: - +, 0, -, to represent the symbols

Voltage level for one symbol is at ―0‖ and the other alternates between +

Bipolar Alternate Mark Inversion (AMI) - the ―0‖ symbol is represented by zero voltage and the ―1‖ symbol alternates between +V and -V.

Pseudoternary is the reverse of AMI

8.3.2.D Multilevel

Here the number of data bits is increased per symbol to increase the bit rate.

2 types of data element a 1 or a 0 are available, it can be combined into a pattern of ***n*** elements to create 2_m symbols.

Using L signal levels we can have ***n*** signal elements to create L_n signal elements. The following possibilities can occur:

With 2_m symbols and L_n signals:

If $2_m > L_n$ then we cannot represent the data elements, we don‘t have enough signals.

If $2_m = L_n$ then we have an exact mapping of one symbol on one signal.

If $2_m < L_n$ then we have more signals than symbols and we can choose the signals that are more distinct to represent the symbols and therefore have better noise immunity and error detection as some signals are not valid

These types of codings are classified as **mBnL** schemes. In ***mBnL*** schemes, a pattern of *m* data elements is encoded as a pattern of *n* signal elements in which $2_m \leq L_n$.

2B1Q (two binary, one quaternary**)**

Here m = 2; n = 1 ; Q = 4. It uses data patterns of size 2 and encodes the 2-bit patterns as one signal element belonging to a four-level signal.

8B6T(eight binary, six ternary**)**

Here a pattern of 8 bits is encoded a pattern of 6 signal elements, where the signal has three levels

Here m = 8; n = 6 ; T = 3

So we can have 2^8 =256 different data patterns and 3^6 =478 different signal patterns.

4D-PAM5 (Four Dimensional Five-Level Pulse Amplitude Modulation)

4D -means that data is sent over four channels at the same time.

It uses five voltage levels, such as -2, -1, 0, 1, and 2.

8.3.2.E Multitransition

Because of synchronization requirements we force transitions. This can result in very high bandwidth requirements -> more transitions than are bits (e.g. mid bit transition with inversion).

Codes can be created that are differential at the bit level forcing transitions at bit boundaries. This results in a bandwidth requirement that is equivalent to the bit rate.

In some instances, the bandwidth requirement may even be lower, due to repetitive patterns resulting in a periodic signal.

MLT-3

- Signal rate is same as NRZ-I
- Uses three levels (+*v,* 0, and - *V)* and three transition rules to move between the levels.
  - If the next bit is 0, there is no transition.
  - If the next bit is 1 and the current level is not 0, the next level is 0.
  - If the next bit is 1 and the current level is 0, the next level is the opposite of the last nonzero level.