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Experiment no: 01

Experiment Name: To write a program for Unipolar Non Return to Zero(NZR) line coding.

Objective’s:

- To learn what is unipolar non return to zero.
- To learn how to implement unipolar non return to zero.

Theory:

Unipolar NRZ is a fundamental line coding scheme used in digital communication systems. It belongs to the broader category of unipolar coding, where all signal levels reside on the same side (positive or negative) of a reference voltage (usually zero).

Data Representation

- **Bit 1 (Mark):** Represented by a constant positive voltage pulse throughout the bit duration (T_b).
- **Bit 0 (Space):** Represented by the absence of a pulse, leaving the signal at zero voltage during the entire bit duration.

The key characteristic of NRZ is that the signal level does not return to zero in the middle of a bit period. This differentiation from other coding schemes like Unipolar RZ (Return to Zero) earns it the name "Non-Return to Zero."

Advantages of Unipolar NRZ:

- **Simple Implementation:** The design and implementation of NRZ encoders and decoders are straightforward due to the use of only one voltage level for data representation.
- **Lower Bandwidth Requirement:** Compared to some bipolar coding schemes, NRZ utilizes a narrower bandwidth as it avoids frequent transitions between positive and negative voltages.

Disadvantages of Unipolar NRZ:

- **DC Component:** The constant positive voltage representing a binary one introduces a DC component to the signal. This can be problematic for certain transmission channels that struggle with DC transmission.
- **Clock Recovery Challenges:** The absence of transitions during a string of zeros can make it difficult to recover the clock signal at the receiver end, which is crucial for accurate data interpretation.

Applications:

Unipolar NRZ finds applications in various digital communication systems due to its simplicity. Here are some examples:

- Manchester encoding utilizes NRZ pulses with additional transitions to incorporate clock information.

Experiment no: 02

Experiment Name: To write a program for Polar Non Return to Zero(NZR) line coding.

Theory:

Polar Non-Return-to-Zero (NRZ) is a digital line coding scheme used to represent binary data as electrical signals. Unlike other coding schemes, NRZ does not return to a neutral voltage level (zero) during bit transitions. Instead, it utilizes different voltage polarities to represent binary digits (bits).

There are three main variants of Polar NRZ:

- **Polar NRZ-L (Level):**
  - A constant positive voltage represents a binary "1".
  - A constant negative voltage represents a binary "0".
- **Polar NRZ-M (Mark):**
  - A transition in voltage level (positive to negative or vice versa) represents a binary "1" (mark).
  - No change in voltage level from the previous bit represents a binary "0".
- **Polar NRZ-S (Space):**
  - No change in voltage level from the previous bit represents a binary "1" (space).
  - A transition in voltage level represents a binary "0".

Characteristics of Polar NRZ:

- **Simple implementation:** Requires minimal circuitry for encoding and decoding.
- **Bandwidth efficient:** Uses only half the bandwidth compared to Manchester coding for the same bit rate.
- **DC component:**
  - NRZ-L has a non-zero DC component due to the constant positive or negative voltage levels. This can be problematic for certain transmission systems.
- **Clock recovery:**
  - NRZ-L lacks transitions within a bit period, making clock recovery challenging at the receiving end.

Applications of Polar NRZ:

- NRZ-L is commonly used in logic circuits due to its simplicity.
- NRZ-M finds application in magnetic recording of digital data (e.g., tape drives).
- NRZ-S can be used in certain optical communication systems.

Experiment no: 03

Experiment Name: To write a program for Unipolar Return to Zero(ZR) line coding.

Theory:

Unipolar Return-to-Zero (RZ) is a line coding scheme used in digital communication to represent binary data as electrical signals. It belongs to the broader category of unipolar encoding, where all signal levels reside on one side (positive or negative) of a reference voltage (usually zero).

Data Representation:

- **Bit 1:** Represented by a positive voltage pulse for half the bit duration (T_b). The signal returns to zero for the remaining half of the bit duration.
- **Bit 0:** Represented by the absence of a pulse. The signal remains at zero voltage throughout the entire bit duration.

Key Characteristics:

- **Simple Implementation:** Easy to implement due to the use of only positive voltage levels.
- **Self-Clocking:** The transitions between the signal level and zero voltage provide clocking information for data recovery at the receiver. This eliminates the need for a separate clock signal.
- **Reduced DC Component:** Compared to unipolar NRZ (Non-Return-to-Zero), RZ eliminates the constant positive bias, reducing the DC component in the signal. This translates to lower power consumption.
- **Spectral Efficiency:** The presence of transitions at the bit rate allows for clock recovery through spectral filtering.

Limitations:

- **Bandwidth Efficiency:** Transitions between signal and zero levels introduce higher-frequency components compared to NRZ. This can lead to a wider bandwidth requirement for transmission.
- **Long String of Zeros:** A continuous string of zeros results in no transitions in the signal, making clock recovery challenging at the receiver. Techniques like pulse stuffing can be employed to mitigate this issue.

Applications:

- Short-distance data transmission due to bandwidth limitations.
- Manchester code, a popular encoding scheme, utilizes the principles of RZ combined with transitions in the middle of the bit for both data and clock information.

Experiment no: 04

Experiment Name: To write a program for Bipolar Return to Zero(BZR) line coding.

Theory:

Bipolar Return-to-Zero (BPRZ) is a digital communication technique used for encoding binary data onto a transmission medium. It belongs to the family of Return-to-Zero (RZ) encoding schemes, where the signal level returns to zero between data bits.

Key characteristics of BPRZ:

- **Three voltage levels:** BPRZ utilizes three voltage levels: positive (+V), negative (-V), and zero (0V). This allows for representation of both binary digits ("0" and "1").
- **DC Balanced:** Standard BPRZ implementations strive for DC balance. The signal spends equal time in the positive and negative states, minimizing baseline wander and simplifying transmission.
- **Data Encoding:**
    - **Binary "1":** Represented by a positive voltage pulse (+V) during the designated bit time.
    - **Binary "0":** Represented by a negative voltage pulse (-V) during the bit time.
    - **Idle State:** When no data is being transmitted, the line returns to zero voltage (0V).

Benefits of BPRZ:

- **DC Balance:** Eliminates baseline wander, a phenomenon where the average voltage level drifts over time, which can cause data errors.
- **Clock Recovery:** Transitions between voltage levels aid in clock recovery at the receiver side, simplifying synchronization.
- **Error Detection:** Certain error detection techniques can be implemented based on the presence or absence of transitions.

Applications of BPRZ:

- **ARINC 429 bus:** Used in avionics for communication between aircraft systems.
- **Telemetry:** Employed in data transmission applications where DC balance and clock recovery are crucial.

Limitations of BPRZ:

- **Bandwidth:** Requires a wider bandwidth compared to some binary encoding schemes due to the presence of both positive and negative voltage transitions.
- **Complexity:** Decoding circuitry might be slightly more complex compared to simpler binary encodings.

Experiment no: 05

Experiment Name: To write a program for Split Phase (Manchester Code).

Theory:

Split-phase Manchester coding, also known as Manchester code or bi-phase encoding, is a digital encoding technique used in data transmission and storage. It represents digital data (bits) by transitions in the signal level during a bit period.

Encoding

In Manchester coding, each data bit is encoded using a transition in the middle of the bit period. A logic "1" is represented by a transition from low to high in the first half of the bit period, followed by a transition from high to low in the second half. Conversely, a logic "0" is represented by a transition from high to low in the first half of the bit period, followed by a transition from low to high in the second half.

Key Features

- **Self-Clocking:** The frequent transitions in the signal level provide a built-in clock signal for the receiving device. This eliminates the need for a separate clock signal, simplifying receiver design.
- **No DC Component:** The average voltage level of the encoded signal is zero (DC component is absent) regardless of the data being transmitted.
- **Bandwidth:** Manchester code requires twice the bandwidth compared to transmitting the raw data signal due to the mid-bit transitions.

Advantages:

- **Synchronization:** The embedded clock signal facilitates synchronization between the transmitter and receiver, making data recovery easier.
- **Noise Immunity:** The frequent transitions improve noise immunity compared to encoding schemes without transitions.
- **Transformer Coupling:** The lack of a DC component allows for transmission using transformers, which provide galvanic isolation between circuits.

Disadvantages:

- **Bandwidth Consumption:** The increased bandwidth requirement can be a limitation in applications with bandwidth constraints.

Applications:

Split-phase Manchester coding finds applications in various digital communication systems, including:

- Ethernet (10BASE-T standard)
- Infrared (IrDA) data transmission
- Magnetic recording (early implementations)

Experiment no: 06

Experiment Name: To write a program for binary Amplitude Shift Keying (ASK) Modulation and Demodulation.

Theory:

Amplitude-Shift Keying (ASK) is a fundamental digital modulation technique used to transmit digital data streams over communication channels. In ASK, the information contained in a binary data signal (0s and 1s) is superimposed onto a carrier signal by varying the amplitude of the carrier in accordance with the data. This allows the digital information to be transmitted over channels that are designed for analog signals.

ASK Modulation:

The ASK modulator takes a binary data stream, typically represented by a voltage waveform with two distinct levels (e.g., high for 1 and low for 0), and modulates a carrier signal (usually a sinusoid) by varying its amplitude based on the data bits. There are two main approaches to ASK modulation:

- **On-Off Keying (OOK):** In this scheme, a high data bit (1) corresponds to transmitting the carrier signal at its full amplitude, while a low data bit (0) completely suppresses the carrier, resulting in zero amplitude.
- **Carrier Modulation:** Here, the carrier maintains a constant amplitude, but its amplitude is varied between two distinct levels depending on the data bit. A high data bit (1) might correspond to a higher amplitude carrier compared to a low data bit (0).

ASK Demodulation:

The ASK demodulator recovers the original binary data stream from the received modulated carrier signal. The demodulation process typically involves:

- **Envelope Detection:** This technique uses an envelope detector to extract the envelope of the received signal, which represents the variations in amplitude caused by the data. Depending on the specific ASK scheme (OOK or Carrier Modulation), a threshold detector is then used to determine whether the envelope value corresponds to a high (1) or low (0) data bit.
- **Coherent Detection:** This approach utilizes a reference signal synchronized with the original carrier signal to demodulate the data. By multiplying the received signal with the reference, the carrier component is removed, leaving behind the baseband data signal which can be filtered and thresholded to recover the original data.

Experiment no: 07

Experiment Name: To write a program for Frequency Shift Keying (FSK) Modulation and Demodulation.

Theory:

Frequency Shift Keying (FSK) is a digital modulation technique used to transmit digital information by varying the frequency of a carrier signal. Unlike Amplitude Shift Keying (ASK), which modulates the amplitude of the carrier, FSK utilizes discrete frequency shifts to represent binary data (0s and 1s). This makes FSK less susceptible to noise in the transmission channel compared to ASK.

FSK Modulation:

The basic principle of FSK modulation involves using two distinct carrier frequencies, often referred to as "mark" and "space" frequencies. A binary '1' is typically represented by the mark frequency (f_m), while a binary '0' is represented by the space frequency (f_s). The modulator circuit switches the carrier signal between these two frequencies based on the input binary data stream.

There are two main categories of FSK:

- **Binary FSK (BFSK) or 2-FSK:** This is the simplest form of FSK, employing only two discrete frequencies to transmit binary data.
- **Multi-level FSK (MFSK):** This technique utilizes more than two distinct frequencies to represent multiple bits per symbol. For example, 4-FSK uses four different frequencies to transmit two bits per symbol, offering higher data rates compared to BFSK.

The choice of frequency separation between mark and space frequencies is crucial. A larger separation improves noise immunity but reduces the data rate. Conversely, a smaller separation increases data rate but makes the signal more susceptible to noise.

FSK Demodulation:

At the receiving end, the demodulator circuit recovers the original binary data from the received FSK signal. The demodulator typically employs a bandpass filter tuned to the carrier frequency range. This filter isolates the FSK signal from other frequency components.

Following the filter, a frequency discriminator circuit detects the changes in the carrier frequency. This discriminator can be implemented using various techniques, such as phase-locked loops (PLLs) or frequency comparators. Based on the detected frequency (mark or space), the demodulator outputs a binary '1' or '0', reconstructing the original data stream.

Applications of FSK

FSK finds applications in various communication systems, including:

- Low-speed data transmission like caller ID and fax machines.
- Radio frequency identification (RFID) tags.
- Wireless remote controls for garage door openers and keyless entry systems.
- Weather balloon radiosondes for atmospheric data transmission.

Experiment no: 08

Experiment Name: To write a program for Phase Shift Keying (PSK) Modulation and Demodulation.

Theory:

Phase Shift Keying (PSK) is a digital modulation technique that conveys digital information by varying the phase of a carrier signal. In contrast to FSK, which modulates the carrier frequency, PSK utilizes distinct phase shifts to represent binary data. This offers several advantages, including better spectral efficiency compared to FSK.

PSK Modulation:

The basic principle of PSK modulation involves using a reference carrier signal and modulating its phase based on the input binary data stream. Each digital symbol (a group of bits) is mapped to a specific phase shift of the carrier.

There are several variations of PSK, categorized by the number of phases used and the number of bits represented per symbol:

- **Binary Phase Shift Keying (BPSK):** This is the simplest form of PSK, using two distinct phases (often 0° and 180°) to represent binary data (0 and 1). BPSK is the most robust PSK variant against noise but offers the lowest data rate.
- **Quadriphase Shift Keying (QPSK):** QPSK employs four distinct phase shifts (typically 0°, 90°, 180°, and 270°) to represent two bits per symbol. This allows for higher data rates compared to BPSK.
- **M-ary PSK (M-PSK):** This generalizes the concept to M distinct phases, enabling the transmission of log2(M) bits per symbol. However, higher-order M-PSK schemes are more susceptible to noise.

The choice of the number of phases depends on the desired data rate and noise tolerance. Higher-order PSK offers increased data efficiency but requires a cleaner channel due to smaller phase separations.

PSK Demodulation:

The demodulation process in PSK aims to recover the original digital data from the received PSK signal. The demodulator typically employs a phase detector circuit that compares the phase of the received signal with a reference carrier.

There are two main demodulation techniques for PSK:

- **Coherent Detection:** This method requires a synchronized reference signal at the receiver, identical to the carrier used for modulation. The phase difference between the received signal and the reference is measured, and based on this difference, the original data is recovered.
- **Non-coherent Detection:** This technique does not require a synchronized reference carrier. Instead, it relies on comparing the received signal with multiple possible phase references. The demodulator chooses the phase reference that best matches the received signal, allowing data recovery. However, non-coherent detection is generally less efficient compared to coherent detection.

Experiment no: 09

Experiment Name: To write a program for Quadrature Phase Shift Keying (QPSK) Modulation.

Theory:

Quadrature Phase Shift Keying (QPSK) is a digital modulation technique that transmits two bits of information per symbol by manipulating the phase of a carrier signal. It offers a balance between spectral efficiency and data rate, making it a popular choice for various communication systems.

QPSK Modulation Principle:

QPSK utilizes four distinct phase shifts of a carrier signal, typically spaced at 90° intervals (0°, 90°, 180°, and 270°), to represent two bits of data per symbol. The input binary data stream is divided into pairs (digits), and each digit is mapped to a specific phase shift according to a pre-defined constellation diagram.

Constellation Diagram:

The constellation diagram visually depicts the mapping between digits and phase shifts. It represents four points equally spaced on a circle, symbolizing the four possible phase states. Each point is assigned a specific digit value (00, 01, 10, or 11).

Modulation Process:

The QPSK modulator employs two quadrature carriers with the same frequency but a 90° phase difference. These carriers are independently modulated with the two separate data streams obtained by splitting the original binary data into even and odd bits. The modulated in-phase and quadrature carriers are then summed to generate the final QPSK signal.

Applications of QPSK:

QPSK finds applications in various communication systems due to its balance between data rate and complexity, including:

- **Wi-Fi (IEEE 802.11) standards:** Many Wi-Fi protocols utilize QPSK or higher-order PSK variations for data transmission.
- **Digital satellite communications:** QPSK offers a good balance between data rate and noise immunity for satellite communication links.
- **Microwave radio links:** QPSK is used in some microwave radio links for data transmission between base stations and user equipment.

Experiment no: 10

Experiment Name: To write a program for Pulse Amplitude Modulation (PAM).

Theory:

PAM is a technique for representing an analog signal by a series of pulses whose amplitudes are proportional to the instantaneous amplitude of the analog signal at the sampling instants. It essentially converts a continuous-time analog signal into a discrete-time signal suitable for further processing and transmission in digital communication systems.

Key Concepts in PAM:

- **Sampling:** The core principle of PAM lies in sampling the analog signal at regular intervals. The sampling frequency (f_s) determines how often the analog signal is sampled. According to the Nyquist-Shannon sampling theorem, the sampling frequency must be at least twice the highest frequency component present in the analog signal to avoid information loss during reconstruction.

- **Quantization:** In basic PAM, the sampled amplitudes are not necessarily discrete values. However, for digital transmission, the continuous amplitude levels are often quantized into a finite number of discrete levels. This process introduces quantization noise, which can be minimized by increasing the number of quantization levels.

Types of PAM:

There are two main types of PAM used in the context of digital communication:

- **Natural PAM:** This is the simplest form, where the sampling pulses maintain a constant width and their amplitude directly reflects the sampled value of the analog signal.

- **Flat-Top PAM:** In this variation, the sampling pulses have a fixed amplitude for their entire duration (flat top), with the varying amplitude information embedded within the pulse itself. This approach can offer better spectral efficiency compared to natural PAM.

Significance of PAM in Digital Communication:

PAM serves as a crucial stepping stone towards digital communication by converting a continuous analog signal into a discrete-time representation. This allows for further processing like quantization and coding, making the signal suitable for transmission in digital systems. Digital communication techniques like Pulse Code Modulation (PCM) build upon PAM by not only sampling the analog signal but also quantizing the sampled amplitudes into discrete digital codes (binary words) for efficient and reliable transmission.

While PAM itself doesn't directly transmit digital data, it plays a fundamental role in the process of converting analog information into a format compatible with digital communication channels.