MODULE - I

Multiple Choice Type Questions

1. The bit rate of a signal is 3000. If each signal unit carries 6-bits, what is the baud rate? [WBUT 2009, 2016]

a) 3000 b) 500 c) 600 d) none of these

Answer: (b)

2. What is the equivalent Hamming code of 1010? [WBUT 2010, 2016]

a) 1110010 b) 1010010 c) 1011010 d) 1111010

Answer: (c)

3. What is the bit rate, if a signal of a bandwidth of 5 kHz is sampled at Nyquist sampling rate and digitized into 8-bit per sample? [WBUT 2010]

a) 20 kB/s b) 40 kB/s c) 80 kB/s d) 160 kB/s

Answer: (c)

4. For doubling the data rate, the encoding system used is [WBUT 2011, 2013, 2018]

a) Manchester b) CMI c) AMI d) all of these

Answer: (b)

5. Which of the following is not a unit of information? [WBUT 2012]

a) bit b) decit c) nat d) Hz

Answer: (d)

6. In HDB3 coding technique, if the previous violation is –ve then the next violation will be [WBUT 2012]

a) +ve b) –ve
c) can be either –ve or +ve d) none of these

Answer: (a)

7. In Baudot Code, there are [WBUT 2012]

a) 5 data bits, 1 start bit (space) and 1 stop bit (mark)
b) 4 data bits, 1 start bit (space) and 2 stop bits (mark)
c) 5 data bits, 1 start bit and 2 stop bits
d) none of these

Answer: (c)

8. For frequency telemetry 4-20 mA signal is transformed into frequency range of [WBUT 2013, 2018]

a) 5-15 Hz b) 50-65 Hz c) 65-70 Hz d) 1-2 Hz

Answer: (a)

9. For generation of PAM signal we have to use [WBUT 2015]

a) sample and hold circuit b) Wein bridge oscillator circuit

c) Smith trigger circuit
d) integrator circuit
Answer: (a)

10. For step index fibre the RI across the core is [WBUT 2017]
a) variable
b) constant
c) either variable or constant
d) dependent on core radius
Answer: (b)

11. A parity check code can [WBUT 2017]
a) detect a single bit error
b) correct a single bit error
c) detect two bit error
d) correct two bit error
Answer: (a)

12. Which of the following materials is not suitable for making an LED? [WBUT 2017]
a) GaAs
b) Si
c) InGaAs
d) GaAlAs
Answer: (b)

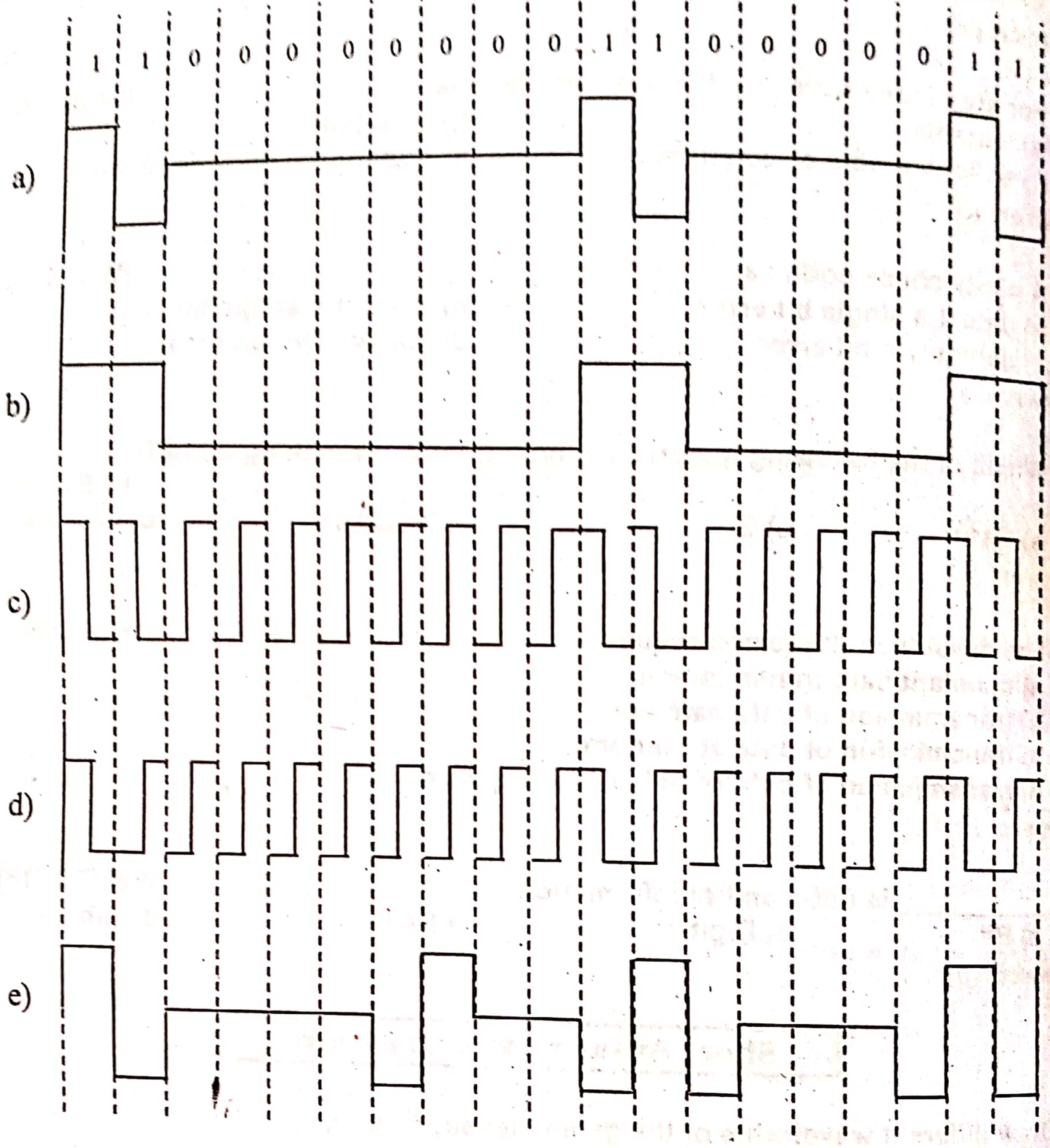
13. The division multiplexing requires [WBUT 2018]
a) constant data transmission
b) transmission of data samples
c) transmission of data at random
d) transmission of data of only one measurand
Answer: (d)

14. ___________ is not a unit of information. [WBUT 2018]
a) Bit
b) Digit
c) NAT
d) Nibble
Answer: (b)

Short Answer Type Questions

1. Draw different waveforms of the given message using
a) AMI
b) NRZ technique
c) Manchester coding
d) Differential Manchester coding
e) HDB3 coding
Message signal: $(11000000000110000011)_2$. [WBUT 2009, 2014, 2015, 2016]

Answer:



2. a) What are the different types of modulation codes used in telemetry system?
b) What do you mean by source coding and line coding? Explain with suitable example. **[WBUT 2009]**

Answer:

a) Different types of modulation codes used in telemetry system are PAM, PFM, PTM, PCM.

b) **Source Coding:** The analogue signal is converted into a data sequence through source coding.

Line coding is encoding of the symbols by means of pulses.
In fact, it is the generation of a waveform.

3. a) What are the different types of comparators used in telemetering equipments? **[WBUT 2009, 2011]**

b) What is a window comparator? Design a window comparator with two op-amps and an AND gate. Obtain its transfer characteristics. **[WBUT 2009, 2011, 2017]**

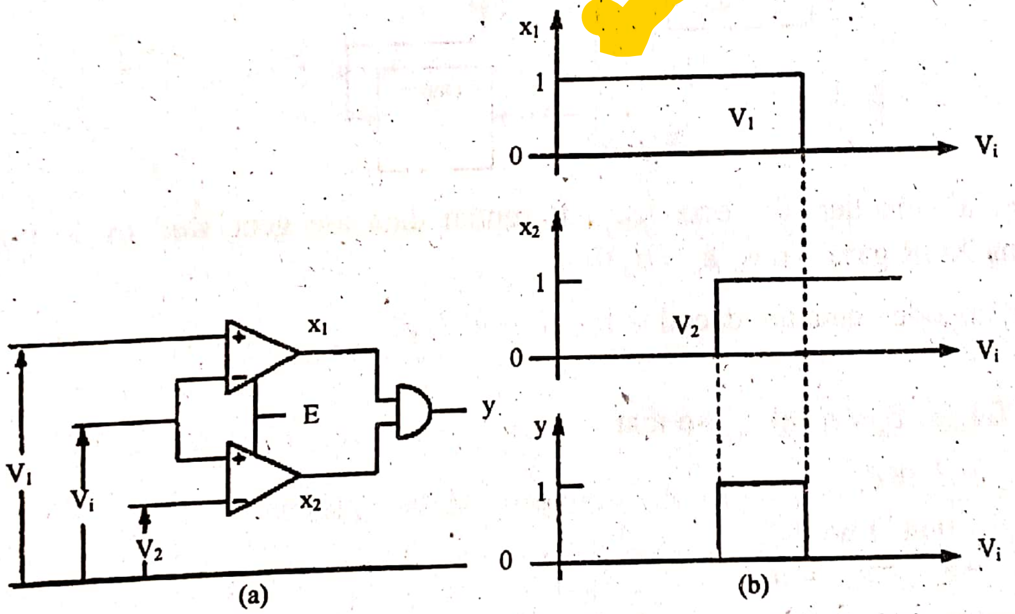
Answer:

a) Different types of comparators used in telemetering equipments are:

i) Inverting zero-crossing types
ii) Non-inverting zero-crossing types
iii) Inverting zero crossing types with hysteresis
iv) Non-inverting zero crossing types with hysteresis
v) Inverting level detectors
vi) Non-inverting level detectors
vii) Inverting level detectors with hysteresis
viii) non-inverting level detectors with hysteresis.

b) Window Comparator:

Window comparator is a special type of comparator used to determine if the input voltage lies between two specified voltages. Only under such a condition there should be an output. A typical scheme with two comparators and an AND gate for such a purpose is shown with its transfer characteristics.



A typical window comparator   Transfer characteristics of window comparator

4. a) What do you mean by differential coding? Explain with block diagram the scheme of differential coding.

b) Prove that in case of differential coding always we obtain the correct output. **[WBUT 2010, 2013, 2015, 2016]**

OR,

How can differential coding take care of the situation when the bit sequence gets inverted? **[WBUT 2013]**

Answer:

a) Differential Encoding

When serial data are passed through many circuits along a communication channel a problem arises. The waveform is likely to be inverted i.e. date complementation takes place. This means 1 may become 0 or 0 may become 1. This may occur in a twisted pair transmission line channel when a line code such as polar signaling is used.

To overcome this problem in polar signaling differential encoding is often used. A differential encoding system is shown below:

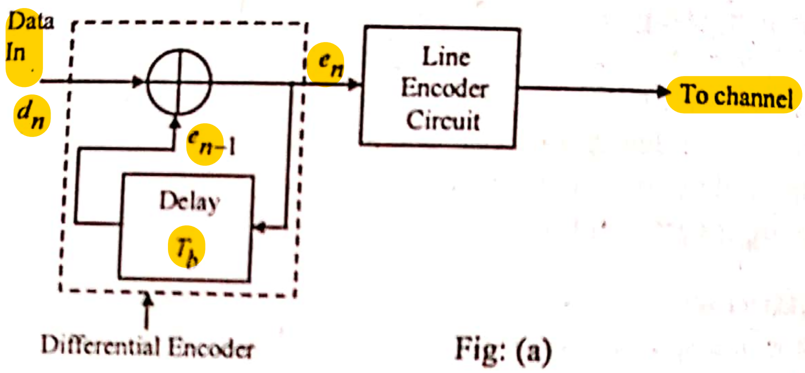


Fig: (a)

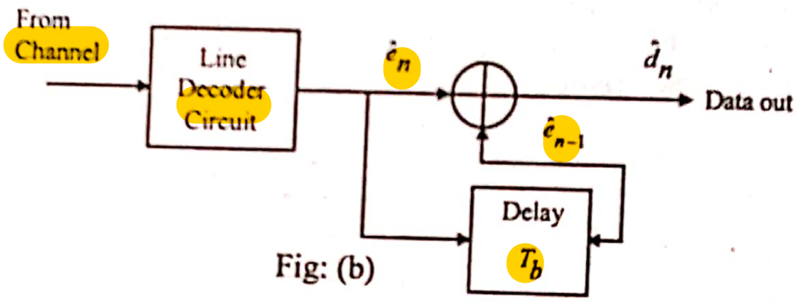


Fig: (b)

In a differential encoder, the encoded differential data are generated by a modulo 2 addition using XOR gate. Thus, $e_n = d_n \oplus e_{n-1}$

The received encoded data are decoded by, $\hat{d}_n = \hat{e}_n \oplus \hat{e}_{n-1}$ .... (i)

b) But from fig.(b) $\hat{e}_n = \hat{d}_n \oplus \hat{e}_{n-1}$ so that

$\bar{e}_n = \overline{d_n \oplus e_{n-1}} = d_n \oplus \bar{e}_{n-1}$

Using the equation (1) we get,

$\bar{e}_n \oplus \bar{e}_{n-1} = d_n \oplus \bar{e}_{n-1} \oplus \bar{e}_{n-1} = d_n$

Thus correct output is always obtained.

5. a) Why is frequency telemetry system considered more advantageous over voltage or current telemetry system even in short distance telemetry? Describe the frequency telemetry system with block diagram of a teletype channel based frequency telemetry system.

b) Mention the frequency ranges used in standard frequency telemetry systems.

[WBUT 2011]

Answer:

a) 1st Part:

Voltage, current, position telemetry requires a physical connection between the transmitter and the receiver. The physical connection is called as a channel, which consists of one or two or more wires depending upon the system. These systems have limited frequency response and though they transmit dc signals the effect of thermo electric e.m.f is also significant.

In a frequency telemetry system, the signal processing involves derivation of frequency in proportion to an electrical signal after it has been obtained from the transducer, by use of an appropriate unit such as a voltage-to-frequency converter, or a current-to-frequency converter.

2nd Part:

A schematic of such a telemetry system is shown in figure.

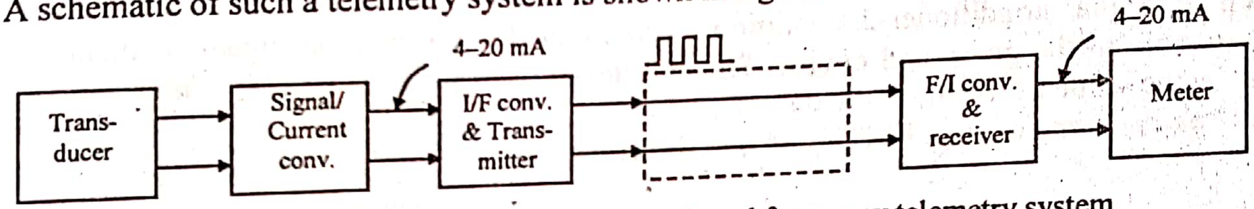


Fig: Block diagram of a teletype channel based frequency telemetry system

b) The frequency ranges used in standard telemetry systems are

Frequency ranges:

5 to 15 Hz	(10 Hz)	9 to 15 Hz	(6 Hz)
5 to 25 Hz	(20 Hz)	10 to 30 Hz	(20 Hz)
6 to 27 Hz	(21 Hz)	18 to 30 Hz	(12 Hz)
7.5 to 15Hz	(7.5Hz)		

6. a) What are the purposes of the telemetry systems? **[WBUT 2014]**

OR,

Why is telemetry necessary to use in a instrumentation system? **[WBUT 2018]**

b) Explain the frequency telemetry scheme with suitable diagram. **[WBUT 2014]**

Answer:

a) The purpose of a telemetry system is to collect data at a place that is remote or inconvenient and to relay the data to a point where the data may be evaluated. Typically, telemetry systems are used in the resting of moving vehicles such as cars, aircraft and missiles. Telemetry systems are a special set of communication systems. When the telemetry system is used for both control and data collection, the term supervisory control and data acquisition is applied.

b) In FMT, transmission signal for this telemetry system is a frequency modulated AC signal. Generally a RF sinusoidal signal is used as the carrier and a radio link a medium.

Transmission end:

Step 1: A transducer converts the given physical variable (measurand) into an electrical output, which is conditioned/ processed by an appropriate signal conditioner to yield a dc voltage proportional to the value of the measurand, M.

Step 2: The voltage signal, so obtained, is used for the frequency modulation by mixing it with a radio-frequency (RF) carrier.

Step 3: The frequency-modulated radio-frequency (FM-RF) signal is applied to a transmitting antenna.

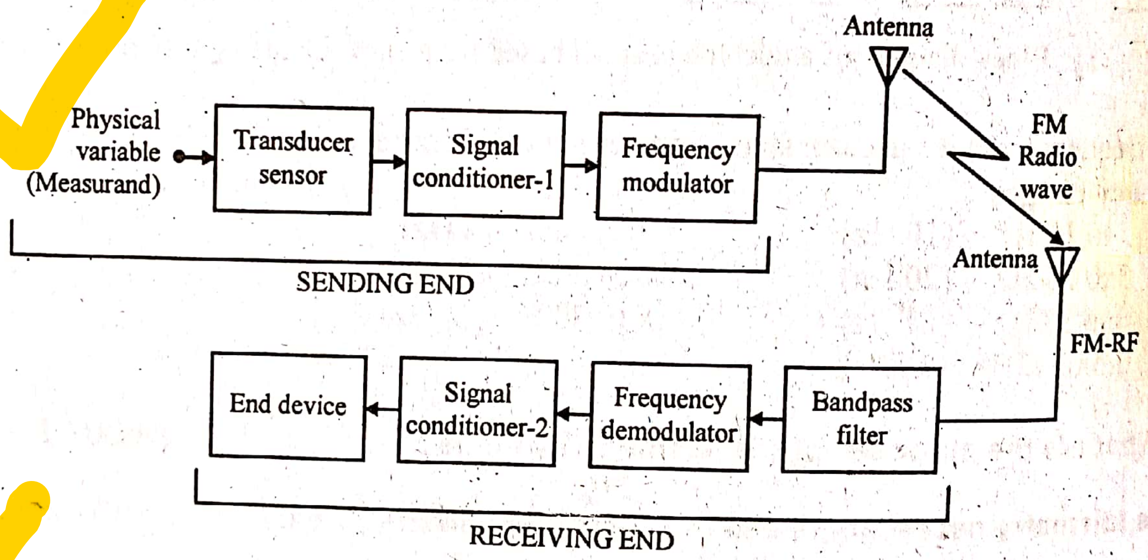
Receiving end:

Step 1: The receiving antenna catches the frequency modulated information as sent by the transmitting counterpart to feed to Band pass filter.

Step 2: The signal demodulated using a frequency demodulator thereby Recovering the original signal.

Step 3: Signal conditioner-2 conditions/ processes the information signal to make it compatible to the given end device. The end device thus gets the intended information, that is, the value of the measurand.

The basic scheme of such FMT system is shown below.



7. What are different types of comparators used in telemetering system? Draw their circuit diagram and their individual characteristics. [WBUT 2015]

Answer:

1st Part: ***Refer to Question No. 3(a) of Short Answer Type Questions.***

2nd Part:

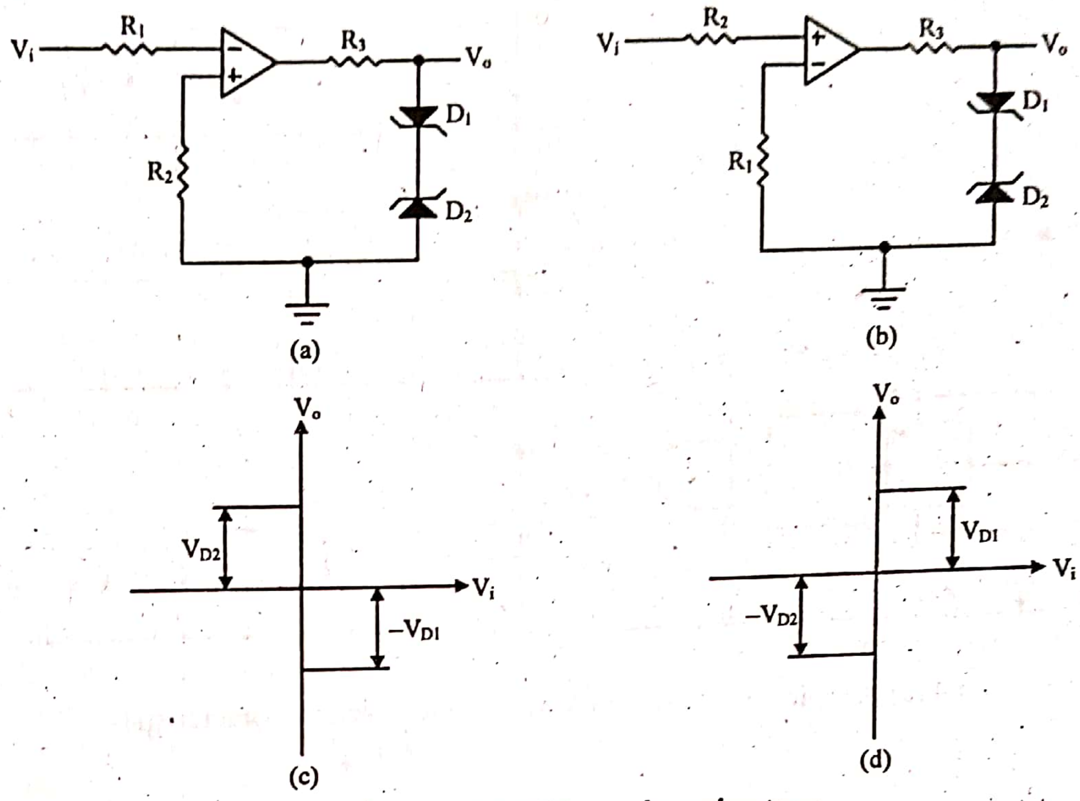


Fig: 1(a) ZCD-inverting type, (b) ZCD-non-inverting type
(c), (d) Transfer characteristics of the circuits of Fig. 1(a) and (b)

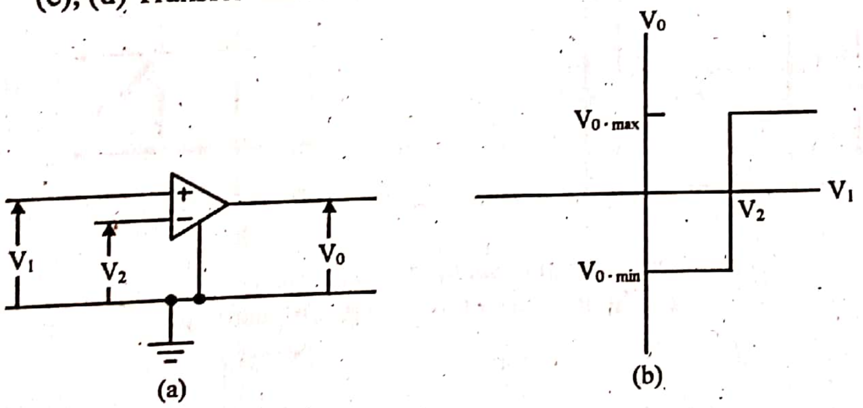


Fig: 2 (a) Level comparator (b) Its characteristics

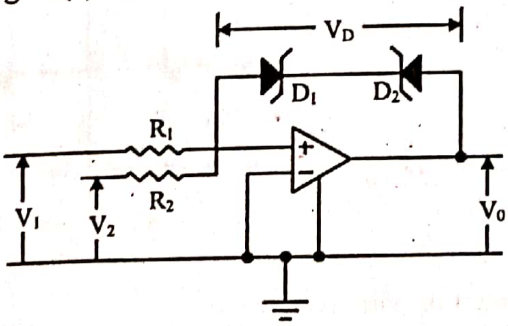


Fig: 3 Comparator with well-defined output voltage

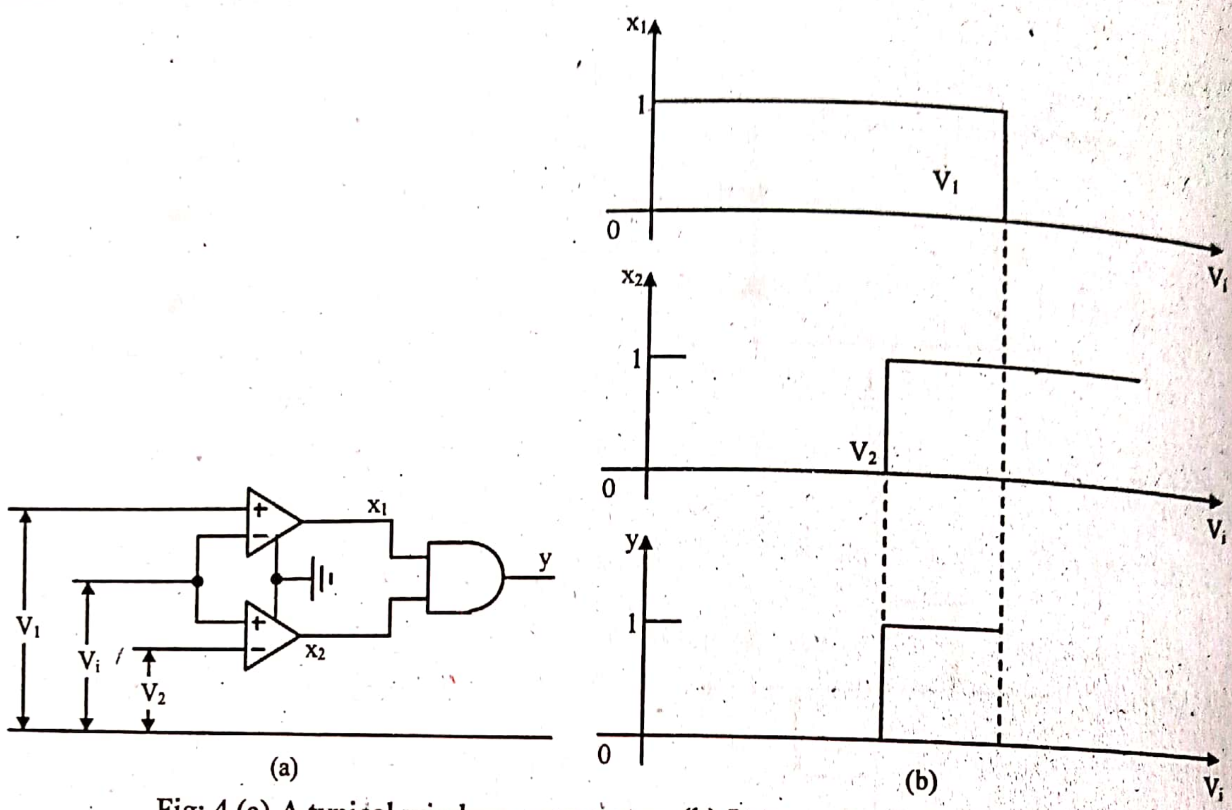


Fig: 4 (a) A typical window comparator, (b) Its transfer characteristics

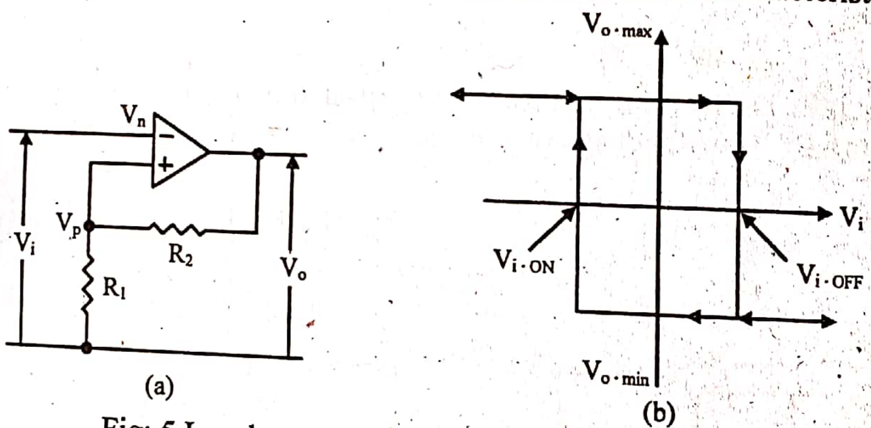


Fig: 5 Level comparator with hysteresis
(a) The inverting type (b) Its characteristic

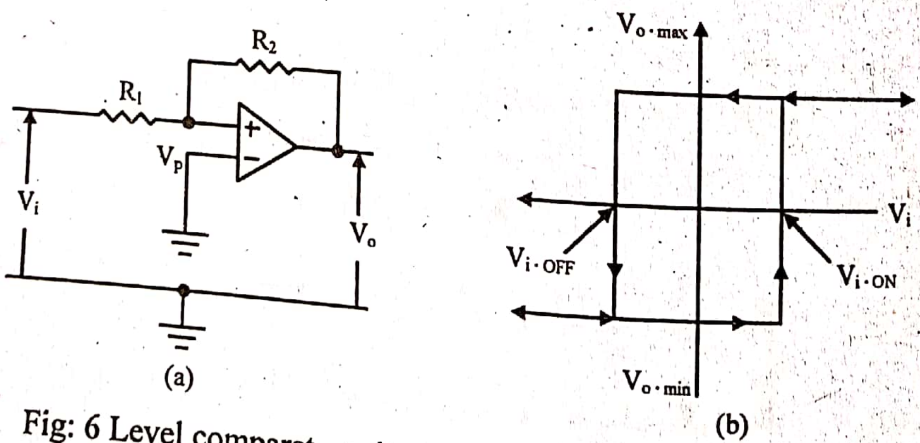


Fig: 6 Level comparator with hysteresis
(a) The non-inverting type (b) Its transfer characteristic

8. Discuss about advantages and disadvantage of current and voltage telemetry systems. **[WBUT 2015]**

Answer:

Advantages of current telemetry system:

i) The current systems can develop higher voltages than most voltage systems and consequently, it can be made more immune to the effect of thermal and inductance voltages in the interconnecting leads as well as line resistance.
ii) Simple D.C. milliammeters can be used with special calibration for line resistance.
iii) Several receivers can be operated simultaneously.
iv) The received signals can be added or subtracted directly.
v) Changes in line resistance are compensated by basic feedback method.
vi) The response of the system to an input change is almost instantaneous.
vii) The energy level is adequately high to minimize the effects of extraneous voltages.

Disadvantages of voltage telemetry systems:

These systems are affected by line resistance, leakage, interfering sources nearly, noise and require higher-quality circuits than current systems, especially for low voltages.

- The voltage telemetering system is limited for transmission upto 300 metres distances.
- A voltage telemetering system is very much suited for adding several input voltages in series provided the measurement is linear. However, this system needs a relatively more expensive receiving terminal. This system is normally not suitable to the use of many receivers at the same time.

9. Draw and explain the current telemetry system using LVDT. **[WBUT 2017]**

Answer:

The basic current telemetering system is as shown in the Fig. 1.

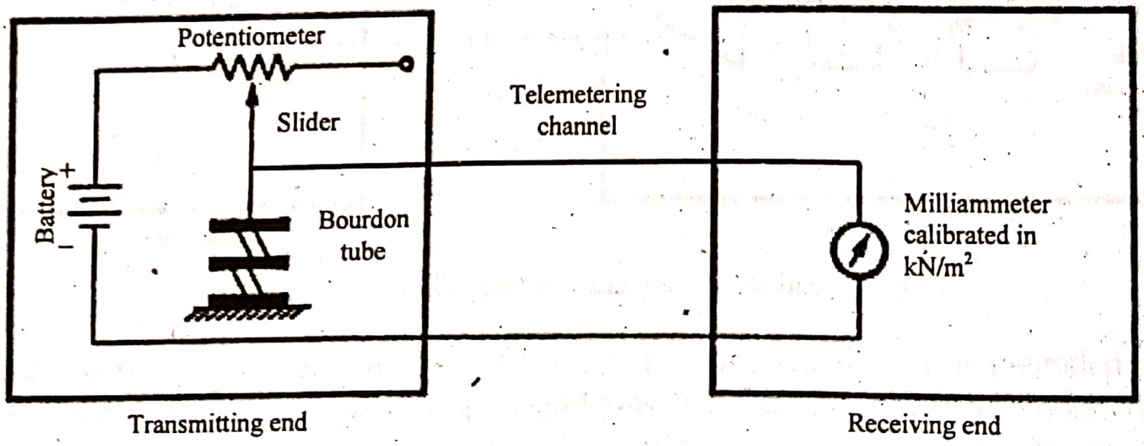


Fig: 1 Basic current telemetering system

Construction:

Similar to the voltage telemetering system, the current telemetering system also consists a slide wire potentiometer in series with a battery. Again the slider is connected to the bourdon tube which measures pressure. The telemetering channel is nothing but a pair of wires. At the receiving end the milliammeter is connected in series, which is calibrated in terms of pressure scale (kN/m^2)

Working:

When the pressure in the system changes, the bourdon tube moves the sliding contact thereby changing the current at the transmitting end: this current passes to the receiving end through the pair of wires and at the receiving end it is measured by the milliammeter. Now a days, the improved forms of the current telemetering system are extensively used. These modified forms are

i) Motion balance current telemetering system,

ii) Force balance current telemetering system.

A simple motion balance current telemetering system consists a displacement transducer used as position detector. The most commonly used transducers for motion balance current telemetering system are LVDT (Linear Variable Differential Transformer) and capacitive transducers. A motion balance current telemetering system with LVDT is as shown in the Fig. 2.

The change in the pressure is sensed by the bourdon tube which causes the displacement of the core of the LVDT. Because the null position gets disturbed, a differential voltage is produced. This voltage is amplified by an amplifier. This amplified output is then rectified which produces a d.c. current of the order of 4-20 mA in the telemetering channel. At the receiving end it is measured with the help of a milliammeter.

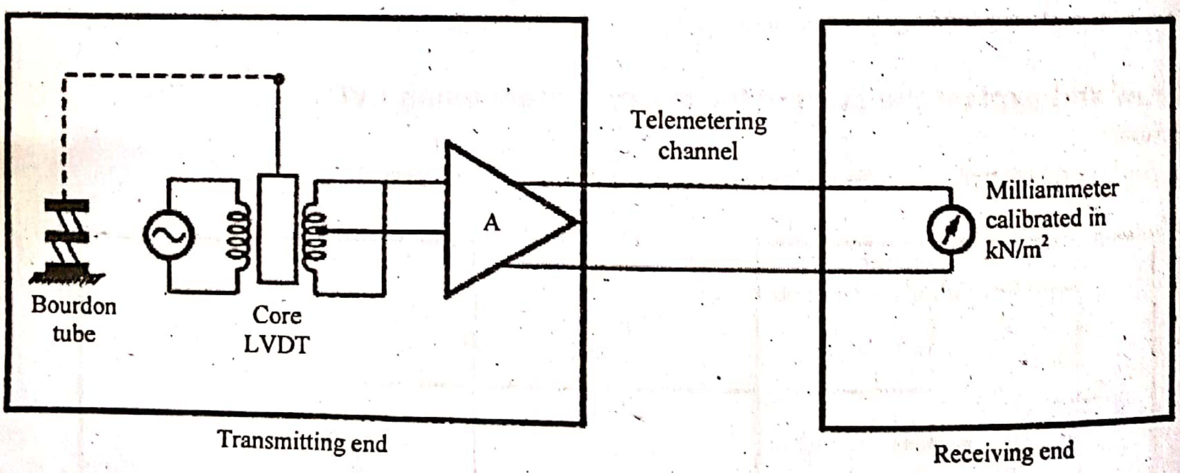


Fig: 2 Motion balance current telemetering system

In force balance current telemetering system, a part of output current is feedback to the input to oppose the motion of the input variable being measured. A simple force balance current telemetering system is as shown in the Fig. 3.

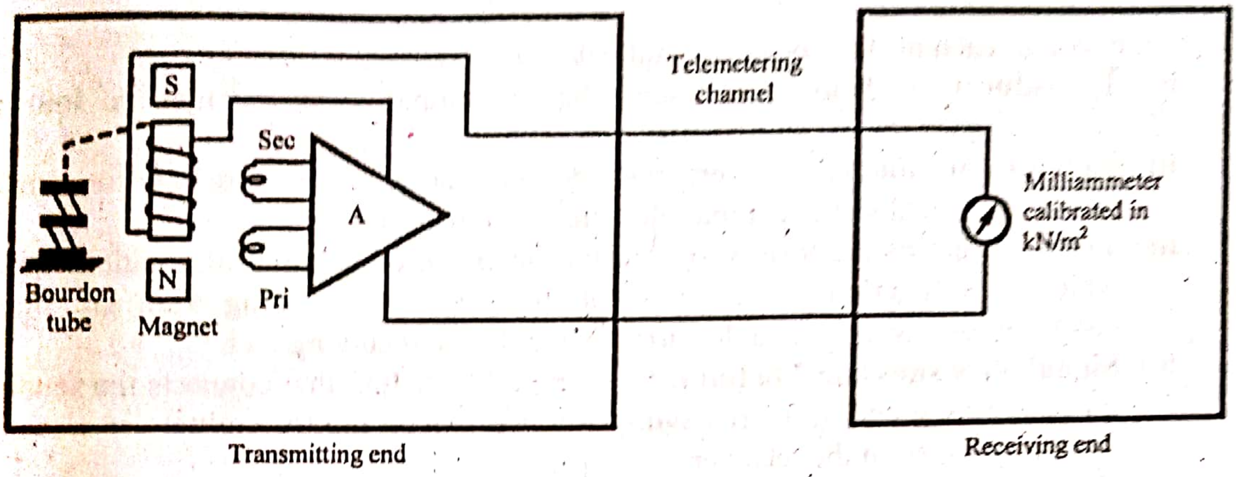


Fig: 3 Force balance current telemetering system

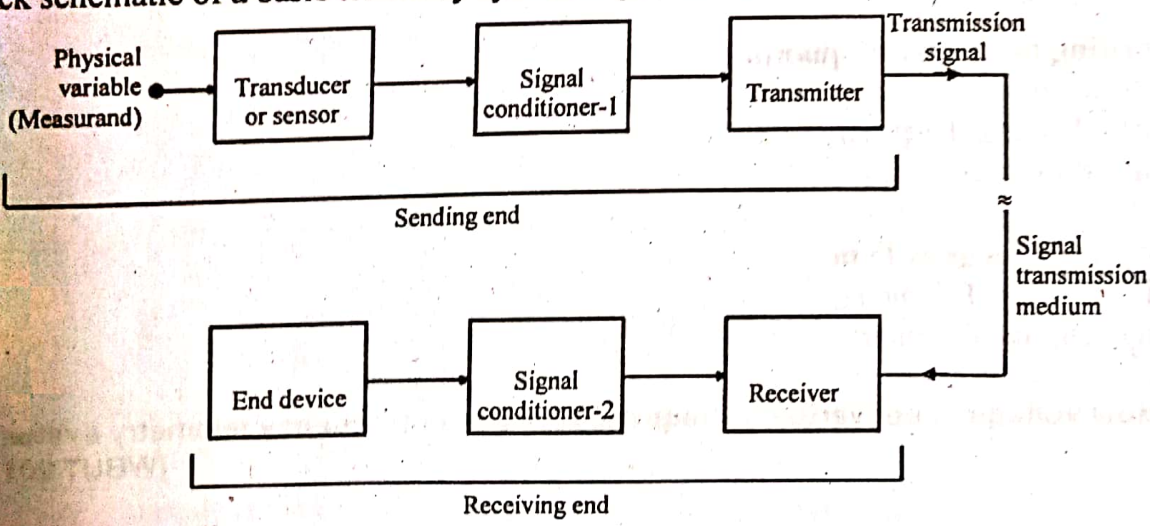
In this system, the bourdon tube after sensing change in pressure, rotates the feedback force coil. As the coil rotates, the flux linkages between the primary and secondary winding changes. So as the flux linkages change, the input to the amplifier changes and thus the amplitude of the amplifier changes. The output signal is taken from the feedback force coil which produces an opposing force to the bourdon tube input.

10. Draw and explain the general block diagram of telemetry system. [WBUT 2017]

Answer:

The term telemetry is derived from the two Greek terms: "tele" and "metron", which mean "remote" or "far off" and "measure", respectively. Accordingly, telemetry is the measurement of remote (or far-off) variables or quantities. A physical variable or quantity under measurement is called measurand.

Block schematic of a basic telemetry system is given below.



Block diagram of the telemetry system

The functions of each of the blocks are said below briefly.

i) **Transducer or Sensor:** Converts the measurand to be telemetered into an electrical quantity.

ii) **Signal Conditioner1:** Converts the electrical output of the transducer (or sensor) into an electrical signal compatible with the transmitter.

iii) **Transmitter:** Its purpose is to transmit the signal containing information signal, which is a function of the value of the measurand coming from the signal conditioner-1 using a suitable carrier signal to the receiving end.

iv) **Signal Transmission Medium:** It is a medium or link that connects the sending or transmitting end to the receiving end, over which the transmitter can transmit its output signal to the receiver.

v) **Receiver:** It receives and recovers the information coming from the transmitter (located at the sending end of the telemetry system) via the signal transmission medium through demodulation, amplification. For multiple measurands, demultiplexing is done.

vi) **Signal Conditioner-2:** Processes the receiver output as necessary to make it suitable to drive the given end device.

vii) **End Device:** The element that appears at the end of the telemetry system functions to display the measurand (s) either in analog or digital forms.

11. Classify the telemetry systems. **[WBUT 2017]**

Answer:

The Telemetry system can be classified as follow:

According to Energy Medium:

i) Pneumatic Telemetry
ii) Hydraulic Telemetry

According to Electrical quantity

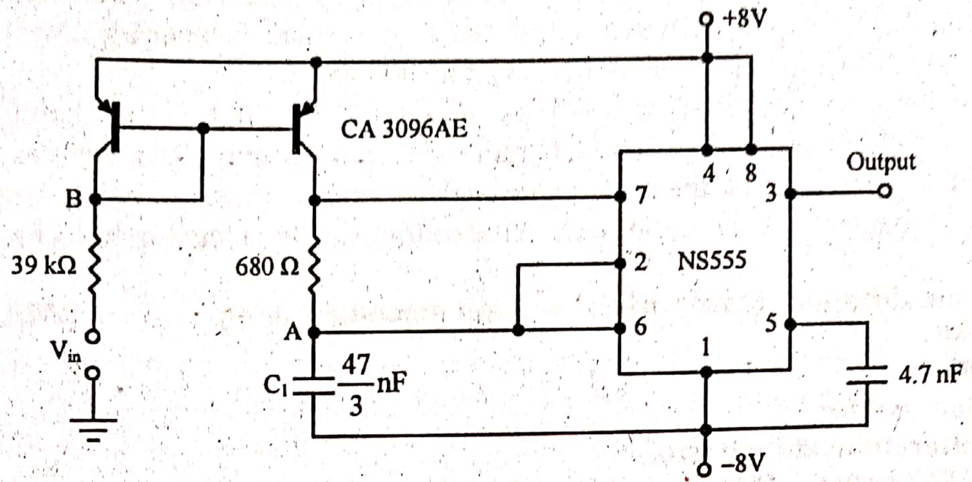
i) Current Telemetry
ii) Voltage Telemetry
iii) Pulse Telemetry

According to Signal Type

i) Analog Telemetry
ii) Digital Telemetry

12. How voltage is converted to frequency for use in frequency telemetry system? **[WBUT 2017]**

Answer:



13. a) Define the term telemetry. **[WBUT 2018]**

Answer:

The word Telemetry is derived from Greek roots: *tele* = remote, and *metron* = measure. Therefore, Telemetry is process wireless or wired transmission and reception of measured quantities at remote or inaccessible points for monitoring, recording and analysis.

b) Draw and explain the general block diagram of a telemetry system. [WBUT 2018]

Answer: ***Refer to Question No. 6(b) of Short Answer Type Questions.***

14. How is voltage converted to current for use in telemetry system? [WBUT 2018]

Answer:

Voltage Telemetry System - A voltage telemetry system transmits the measured variable as a function of AC or DC voltage. A slide wire potentiometer is connected in series with the battery. The signal transmitting medium is essentially a copper wireline. A voltage telemetry system is shown in Fig. 1.

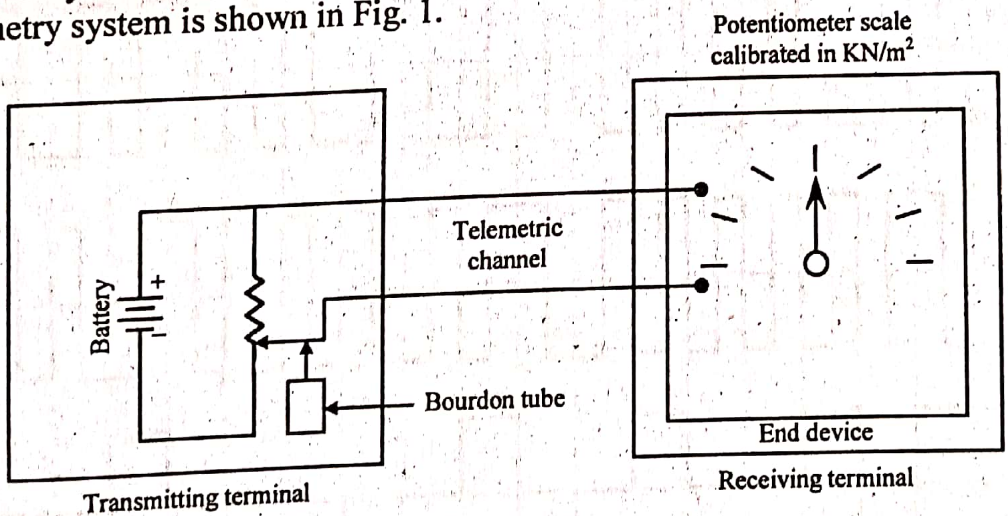
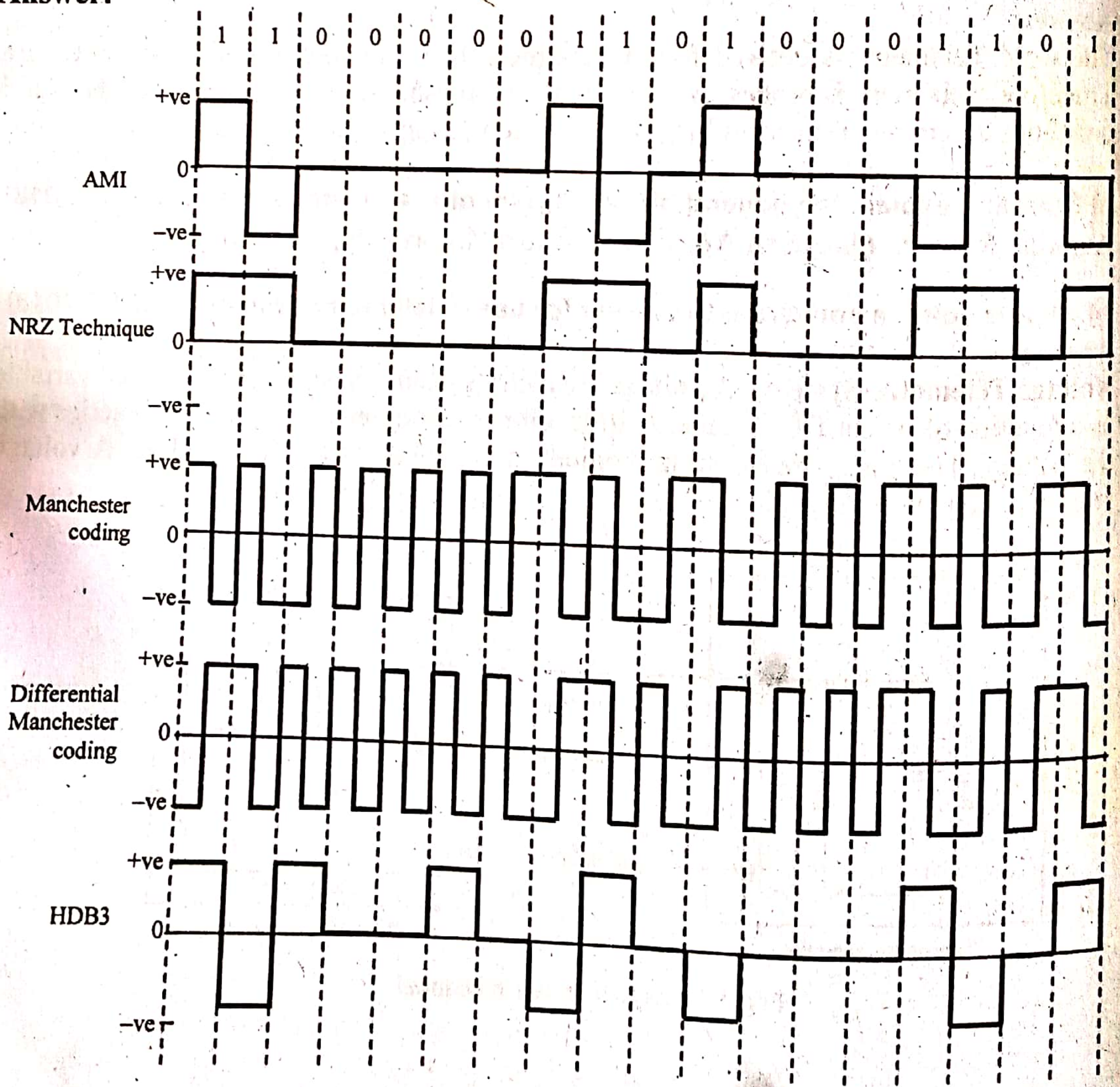


Fig: 1 Voltage telemetric channel

The sliding contact is positioned by a pressure sensitive, Bourdon Tube. The telemetric channel consists of a pair of wires connected to a voltage measuring device such as a voltmeter or a NULL balance DC potentiometer indicator.
As the pressure changes the Bourdon Tube actuates the sliding contact hereby changing the voltage at the receiving end. The DC null balance potentiometer measures the voltage and positions the pointer on the scale calibrated in terms of pressure being measured. The use of NULL balance DC potentiometer reduces the current carried by the channel.

15. Draw the different waveforms of a given message using: **[WBUT 2018]**
i) AMI
ii) NRZ
iii) Manchester
iv) Differential Manchester
v) HDB3 coding. Message signal: $(110000011010001101)_2$.

Answer:



Long Answer Type Questions

1. What is companding? Why it is used in PCM? How is companding done using suitable amplifier? Draw these amplifiers and the companding curves.

[WBUT 2009, 2015]

OR,

What is companding? Why is it used in PCM system? [WBUT 2013, 2016]

Answer:

1st part:

Non-uniform quantization is achieved through companding. This is a process in which compression of the input signal is done in the transmitter whereas expansion of the signal is done at the receiver. The combination of compressing and expanding is companding.

2nd part:

In linear quantization the small amplitude signals would have a poorer SNR than the large amplitude signals. This disadvantage of linear quantization has been removed by non-linear quantization in which the step size varies with the amplitude of the input signal. The step size variation is achieved in a more feasible way by distorting the input signal before the quantization process. This process of distorting the input signal before quantization is known as compression in which the signal is amplified at low signal levels and attenuated at high signal levels. After compression, uniform quantization is applied. A reverse operation known as expansion is done at the receiver. Here the signal is attenuated at low signal levels and amplified at high signal levels. The overall effect of compression and expansion is companding which makes the overall transmission distortionless.

Non-linear quantization can be achieved by using a compressor followed by a uniform quantizer. In the receiver there will be an expander to restore the original signal to their correct values. A typical input-output characteristic of a compander is shown in the figure below:

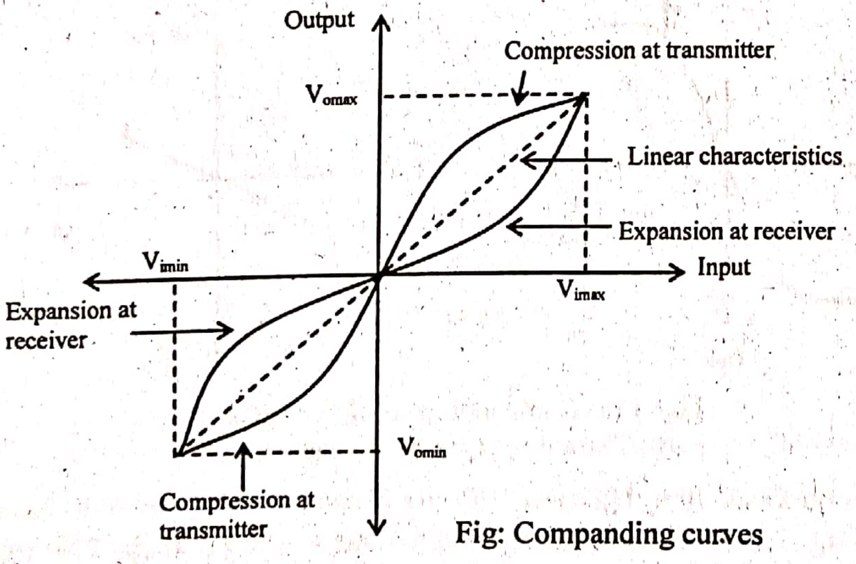


Fig: Companding curves

The process of companding is shown in block diagram below.

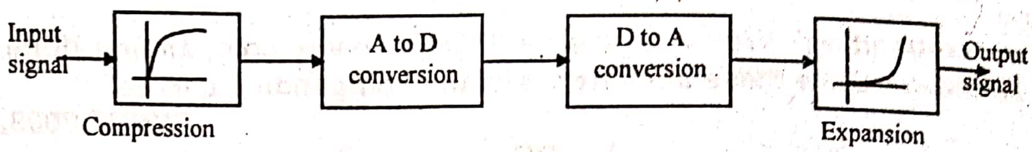


Fig: Process of Companding

3rd part:

Quantization error in low level signals, becomes large because the increment of quantization is quite a large percentage for such signals. Besides, such signals are very susceptible to noise and this introduces spurious spikes and pulses. Both the errors produce distortion. The problem is tackled by emphasizing the lower level signals and de-emphasizing the higher level ones, i.e., a process of signal expansion and compression is followed. This process is known as companding and is performed at the transmitting end and often in the ADC itself where quantizing steps are made unequal, by making it smaller at lower levels.

For recovery, the 'companded' signal is to be processed in a complementary fashion demphasizing the lower level signals and emphasizing the higher level ones. This allows the signal to be retrieved in the original condition. Non-linear amplifiers are designed for companding purposes. Figure 1(a) shows the companding amplifier curve at the transmitting side and fig. 1(b) shows the curve at the receiving side. The curve in fig. 1(a) shows that at lower signals, amplifier gain is high and at higher signals, the gain is low. The case is reverse in the receiving side amplifier. The process, however, reduces the dynamic range of the signal to a great extent. A range reduction from 1000:1 to 60:1 is quite common. This has one good aspect, however, and that is in the requirement of fewer bits. Often, a reduction in 6 bits can be made and a 7 bit ADC is good enough instead of a 12 or 13 bit one.

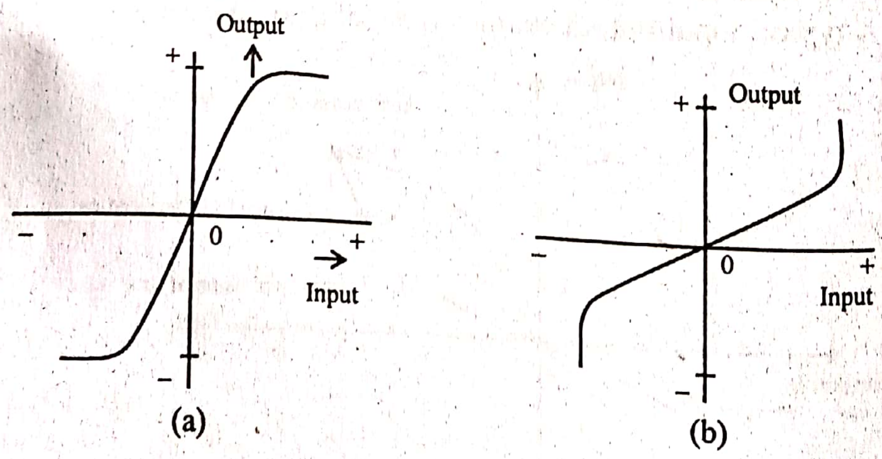


Fig: 1 (a) Companding amplifier curve
(b) The curve at the receiving side

The variable gain curvesof figs. 1(a) and 1(b), are obtained using a compression amplifier of the scheme of fig. 2(a) and the complementary scheme shown in fig. 2(b) respectively.

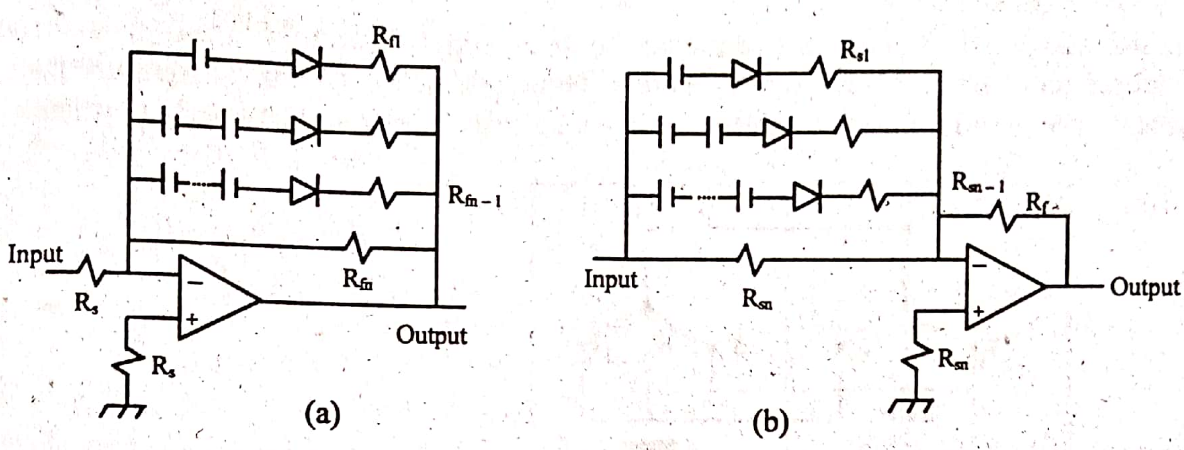
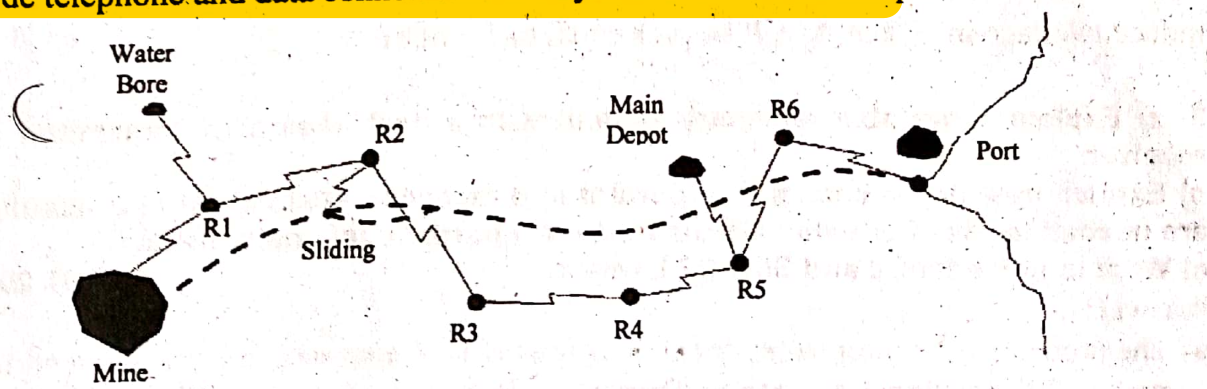


Fig: 2 (a) Compression amplifier circuit to obtain the curve of fig. 1(a);
(b) The complementary scheme

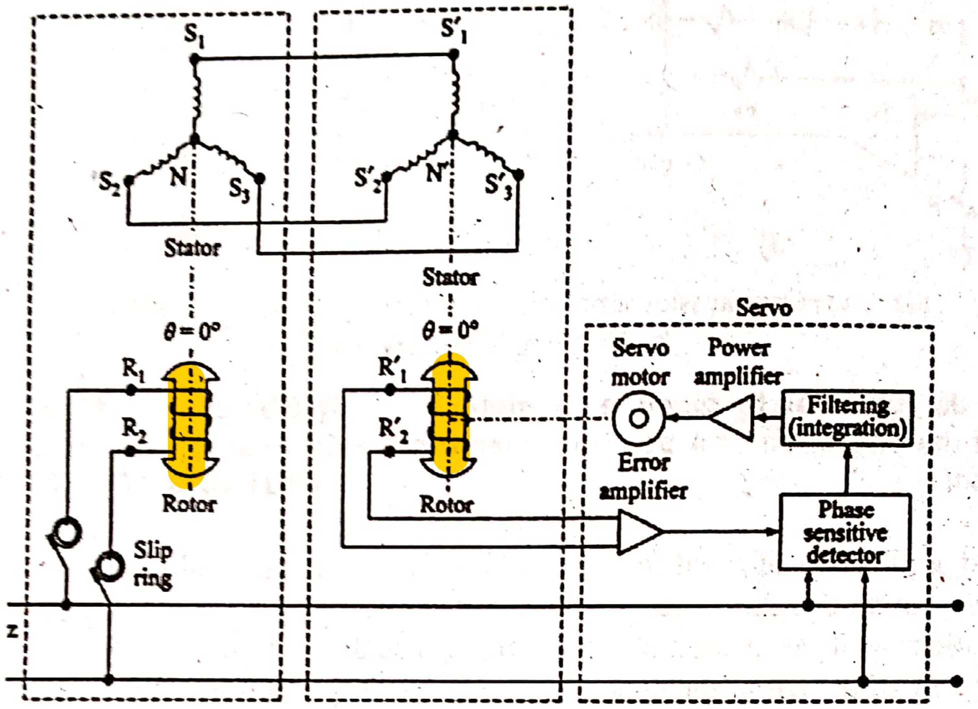
2. a) What do you mean by pipeline telemetry? **[WBUT 2010, 2012, 2014, 2018]**
b) Explain the operation of a position telemetry system using synchro transmitter and receiver. **[WBUT 2010, 2011, 2014, 2018]**

Answer:

a) A typical application of point-to-point radio is shown if figure and it is used to provide a variety of communications services for railroad and pipeline systems. A series of repeater stations will be located along the route, usually spaced 30 to 50 km apart. The radio link will often carry telephone and data circuits, to mines or petroleum fields located at the distant end. At each repeater site, some circuits will be dropped out of the link to connect into mobile radio base stations, which will provide good communications for maintenance staff working on the railroad or pipeline. Other drops will be used to relay railroad signaling information or pipeline telemetry data to wayside stations. Some railroad operators use wayside hotbox detectors, which contain an infrared sensor, mounted close to the passing wheels of rolling stock. When an overheated bearing is detected, the device can signal the details to the railroad controller via the radio system and possibly avoid a serious accident, caused by a seized bearing. Still more drops will provide telephone and data connections to wayside maintenance camps.



b) Figure below uses two identical synchros – one at the transmitting terminal, called **synchro generator** and the other at the receiving terminal, called **synchro motor.** The synchro motor is identical to the synchro generator. Three wires are used to connect the three stator winding ends of the two synchro. The two rotor windings of the synchro generator and synchro motor are connected to an ac supply directly. 'Tele' means 'form a distance' and 'metry' means 'to measure'. Thus 'telemetry' means 'to measure from a distance'. An angular position transducer is used for the position telemetering system.



Circuit diagram of a servo system using control synchros

In the initial position of the rotor, the rotor winding has maximum coupling with the stator winding S_1 of the synchro generator. The other two stator winding S_2 and S_3 of the synchro generator do not have their axes aligned with that of the rotor winding. The induced voltages in S_2 and S_3 will be a cosine function of the angle between the axis of the respective stator winding and the axis of the rotor winding. This angle is 60° for both S_2 and S_3. If V is the magnitude of the induced voltage in stator winding S_1, then the induced voltage in S_2 and S_3 will be each equal to $V \cos 60° = V/2$.

3. a) Explain a portable telemetry system with a neat sketch of transmitter and receiver.
b) Explain how noise becomes important in a receiving system. What precautions are needed to avoid or eliminate the noise in a portable telemetry system?
c) What is noise figure and SINAD? Explain. [WBUT 2011]

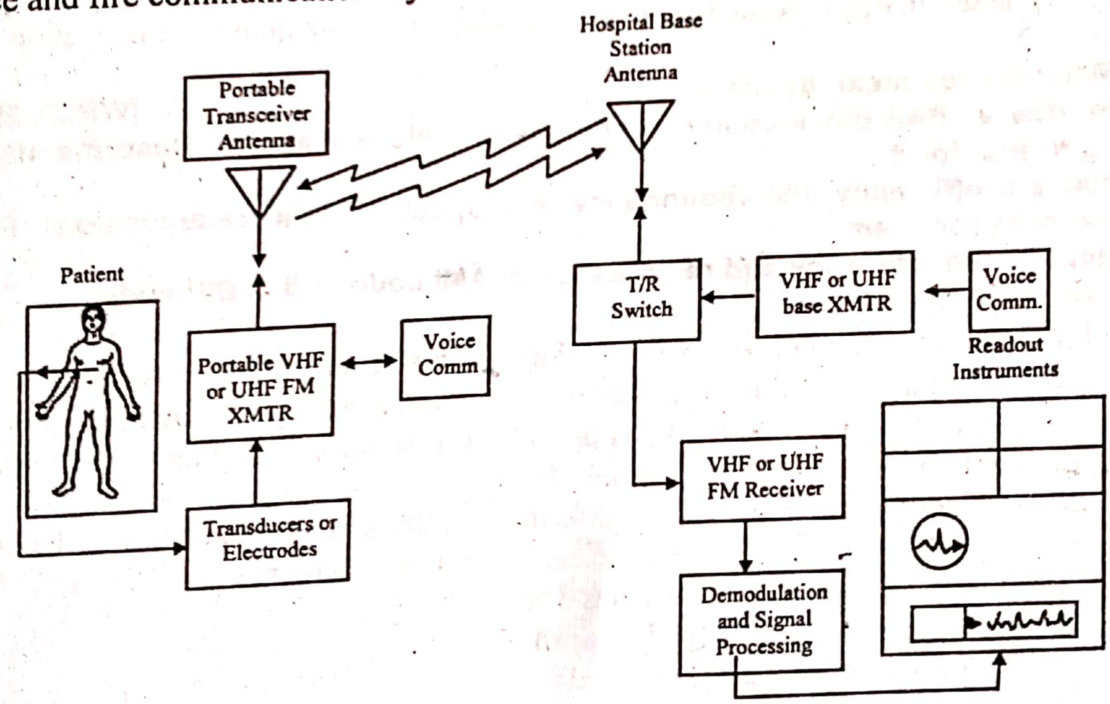
Answer:

a) The portable system for telemetry applications is a solution which gathers in a portable computer full functionalities and performances. Based on Data acquisition software etc. Example of a portable telemetry system discussed below-

The increase in emergency medical technicians (EMTs) in the rescue services of local communities gives us an immensely useful tool in dealing with trauma and coronary victims outside the hospital. Although very highly trained, the EMT is not a physician, so some means is often required to communicate physiological data to the local hospital emergency department to be interpreted by a trained physician. In addition, two-way voice communications must be established for the EMT team to converse with and receive instructions from the physician at the hospital. Specialized communications equipment is needed for this.

Figure below shows a portable telemetry system that has the range and power needed for the EMT or ambulance crew to establish a data link to the hospital. The transmitter might be a special unit, or a modified version of the standard handheld transceivers normally used by fire, police and other services. The modulating signal, however, is either the analog or digitized ECG. The signal is transmitted over the airwaves to a base station transceiver at the hospital. From there, the demodulation and display is similar to that of other telemetry systems.

Because the size of handheld radio transceivers used for telemetry and voice communications is necessarily very small, the available radio frequency (RF) power is low. As a result, the range is short for these units. When the required range is greater, however, a repeater system can be used. At critical locations around the city, receiver sites can pick up a small signal from handheld units. This scheme is commonly used in police and fire communications systems.



b) An important aspect of telemetering system is the signal to noise ratio (S/N). Signal is generally referred to as the power of the transmitted message and noise is the interference that occurs during the transmission. Noise is of special consideration in voltage telemetry system as in this the current is very low and the signal power (i.e., voltage × current) is very small. The tranmsmission system is to be specially designed to keep the interference to a minimum making the ratio S/N>>2.

The current telemetry system can develop higher signal power making it more immune to interferences arising mainly due to thermal and induced emf effects.

c) ***Noise figure:*** It can be defined as the ratio of the signal to noise power ratio supplied to the input terminals of a receiver or amplifier to the signal to noise power ratio supplied to the o/p or load resistor.

Hence, Noise figure, $I = \frac{I/P\ SNR}{O/P\ SNR} = \frac{(SNR)_i}{(SNR)_o}$

It may be noted that the noise figure F is one for an ideal receiver which introduces no amount of noise, at its own, due to which the SNR does not deteriorate as we pass from its i/p side to the o/p side at the receiver. The noise figure at a practical receiver can be expressed as an actual ratio or in decibels (dBs).

SINAD: Signal to noise and distortion (SINAD) is a measure at the quality at a signal from a communications device often defined as:

$$\text{SINAD} = \frac{P_{signal} + P_{noise} + P_{distortion}}{P_{noise} + P_{distortion}}$$

where P is the average power at the signal noise and distortion components. SINAD is usually expressed in dB. It is used for relative evaluation of the quality of a receiver.

4. a) What do you mean by block-coding?
b) Describe a 3B4B block-coding scheme with a block-diagram. Describe also the coding format for it. **[WBUT 2011]**
c) What are efficiency and redundancy in respect of data transmission? Find a relation between them.
d) Calculate the efficiency and redundancy of AMI code and 24BIP code.

Answer:

a) Codes formed by taking a block of k information bits and adding r redundant bits to form a code word are called block codes. Code word has a length n such that $n = r + k$. Block codes are designated as (n, k) codes where n is the no. of bits in the codeword corresponding to a block of k information bits.

When an n-bit codeword consists of k information bits and r redundant bits the code is said to be systematic. A (7, 4) systematic code has 4 information bits. There are 7 bits in each code word so that each codeword has 3 redundant bits.

Let T_b = bit duration of the uncoded word
T_c = bit duration of the coded word
k = No. of information bits
n = No. of bits in the codeword.

Then $nT_c = k\ T_b$ or, $\frac{T_b}{T_c} = \frac{n}{k}$

Since $T_c = \frac{1}{f_c}$ and $T_b = \frac{1}{f_b}$ we get $\frac{f_c}{f_b} = \frac{T_b}{T_c} = \frac{n}{k}$

The rate efficiency of the code is defined as $R_c = \dfrac{k}{n}$

Then $\dfrac{f_c}{f_b} = \dfrac{1}{R_c}$

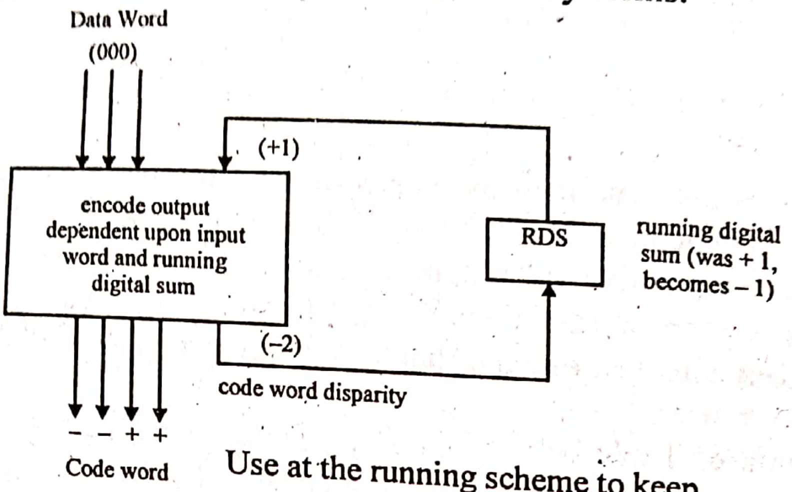
b) 3B4B Block codes are described by means of a coding table which shows how each possible input word is encoded. Table below is a coding table for a 3B4B code. '+'s and '–' have been used for positive and negative pulses respectively. It is more usual to see binary code tables written out as is and 0s, but for the explanation of the principles of block codes it is convenient to assume that 1s are being represented by a positive pulse and 0s by a negative pulse.

The left hand column of Table below lists all possible 3-bit binary inputs; the next three columns contain the possible binary outputs according to the coding rule. Some inputs have a choice between two codings; the reason for this will become clear.

Input	Negative	0	Positive	Disparity	
001		−−++		0	balanced words
010		−+−+		0	
011		−++−		0	
100		+−−+		0	
101		+−+−		0	
110		++−−		0	
000	−−+−		++−+	±2	unbalanced words
111	−+−−		+−++	±2	

The fifth column of Table contains the code word disparity. The disparity, or digital sum, of a code word is a count of the imbalance between the number of positive and negative pulses, and is therefore a normalized measure of the mean voltage of the word. A word with equal numbers of positive and negative pulses would have a zero disparity and zero mean voltage, and is described as balanced. Unbalanced words can have either positive disparity (more positive pulses than negative and therefore a positive mean voltage).
To ensure that there is no short-term mean voltage offset, balanced code words are used in Table above for the output where possible, that is, for input words 001 to 110. The remaining input words have to be encoded to unbalanced words. To maintain the zero offset each of these input words can be encoded to either a word with a positive mean voltage or a negative mean voltage. The choice between the two for a particular input word is made at the time of encoding, in such a way to reduce the mean voltage Fig. below illustrates how this works. The encoder keeps a record of the running sum of disparity (the running digital sum) of each transmitted word. That is to say, the coder has a register which records a number, called the running digital sum, to which it adds the disparity of each word as it is transmitted. The encoder consults this sum whenever an unbalanced word must be transmitted. If the sum is negative, the positive disparity option

is chosen. Whenever it is zero or positive, the choice is for the negative disparity option. Clearly, if the input word is encoded by a decoded binary forms.



Use at the running scheme to keep disparity to zero

c) In data communication redundancy is the difference between the number at bits required to transmit a data and the number of bits actually present in that data. It is mainly the amount of wasted space used to transmit certain data.
Data compression and checksums are the two processes of eliminate and add desired redundancy for the purpose of error detection when such a noisy channel with limited capacity is used for data communication.
The efficiency of a code is just an alternative measure at the same quantity. Efficiency is defined as –

$$\text{Efficiency} = \frac{\text{information per symbol used}}{\text{information per symbol available}}$$

Efficiency and redundancy are therefore related by,
Efficiency = 1 – redundancy.

d) We know that,

$$\text{Redundancy} = \frac{\text{information per symbol available} - \text{information per symbol used}}{\text{information per symbol available}}$$

As we know,

$$\text{Redundancy} = 1 - \text{Efficiency}$$

For AMI code, information per symbol on average $\log_2 3 = 1.58$
(as AMI code is a 3 level or a ternary code)
In AMI code each binary input bit is coded as a single ternary symbol; it therefore carrier only 1 bit's worth of information per symbol instead at the theoretical maximum of 1.58.
∴ Redundancy at AMI is, $(1.58-1)/1.58 = 0.367$
The efficiency of a code is just an alternative measure of the same quantity.

$$\text{Efficiency} = 1 - \text{redundancy}$$

∴ Efficiency of AMI is 0.633 or 63.3%

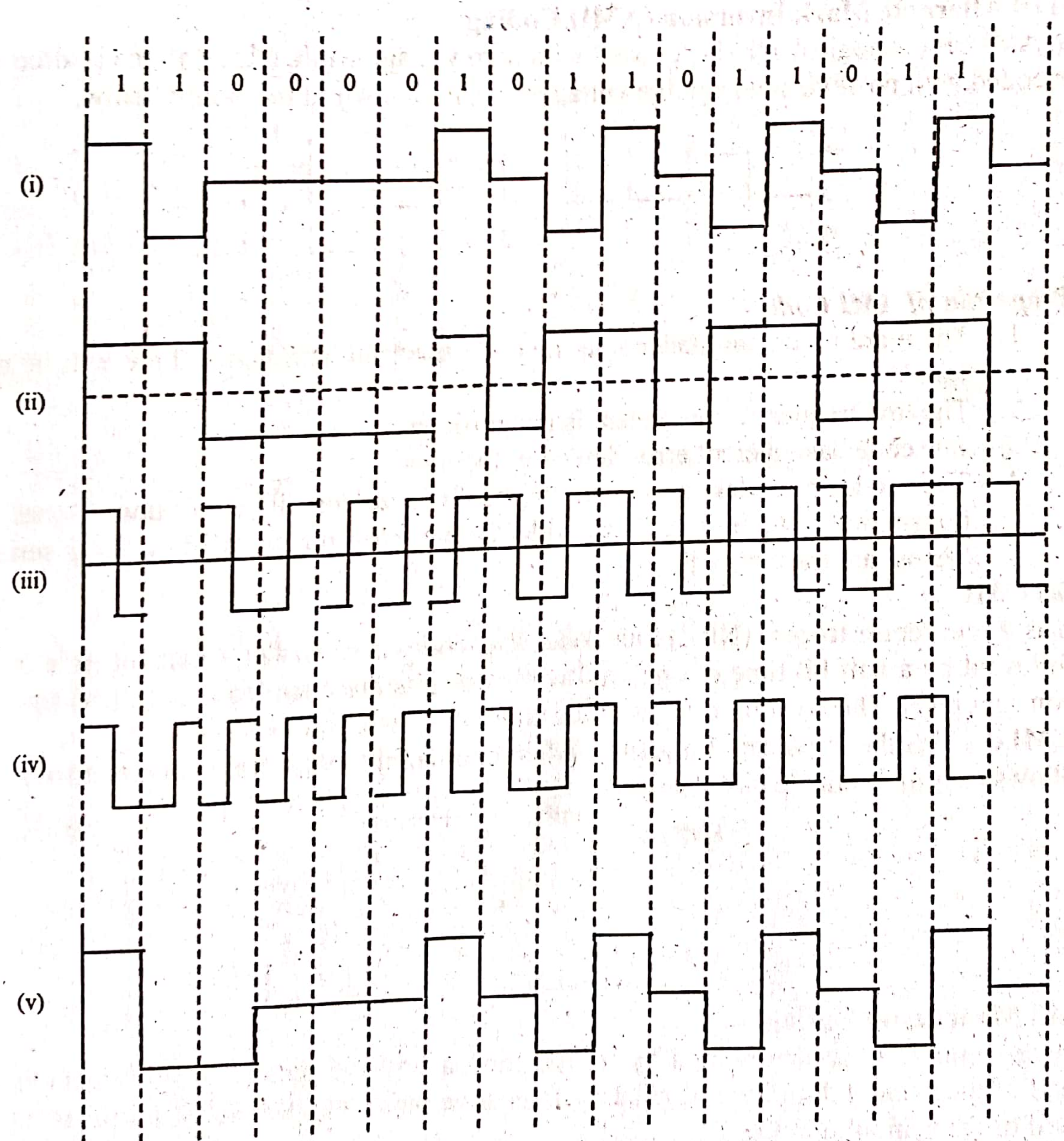
In case of 24B1P code, Efficiency = $[1-(25-24)/25] = 0.96 = 96\%$

5. a) Why companding is used in PCM? Draw the circuit used for companding and the companding curves.
b) Draw the different waveforms of the given message using:
i) AMI
ii) NRZ technique
iii) Manchester coding
iv) Differential Manchester coding
v) HDB3 coding
The signal is : $(11\ 00001011011011)_2$ **[WBUT 2011]**

Answer:

a) *Refer to Question No. 1 of Long Answer Type Questions.*

b)



6. a) Explain the following terms: **[WBUT 2012]**
(i) AMI
(ii) CMI
(iii) Manchester coding
(iv) Differential coding.
b) Given a (6, 3) linear block code with the following parity check matrix H.

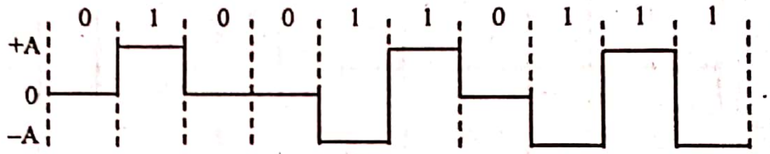
$$[H]=\begin{bmatrix}1 & 0 & 1 & 1 & 0 & 0\\ 0 & 1 & 1 & 0 & 1 & 0\\ 1 & 1 & 1 & 0 & 0 & 1\end{bmatrix}$$

(i) Find the generator matrix G
(ii) Find the code word for the data bit 101.

Answer:

a) (i) Alternate Mark Inversion (AMI) Coding

In AMI code, a logical zero is encoded with zero voltage while a logical one is alternately encoded with positive and negative voltages. This is shown in the figure below.



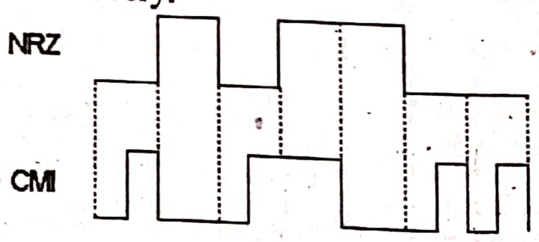
Properties of AMI Code

1. There are no dc components in the code spectrum and hence there will be no dc wander.
2. The low frequency component is insignificant.
3. The code has inherent error detection features.
4. The code provides excellent timing information if continuous 'ones' are transmitted. But it fails to provide timing information when a long series of 'zeros' are transmitted.

(ii) CMI

It is a non-return-to-zero (NRZ) line code. It encodes *zero* bits as a half bit time of zero followed by a half bit time of one, and while *one* bits are encoded as a full bit time of a constant level. The level used for *one* bits alternates each time one is coded.

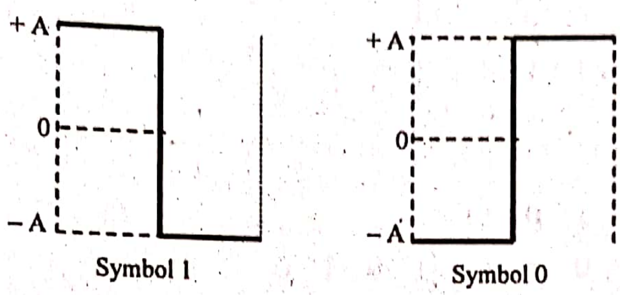
CMI doubles the bit stream frequency, when compared to its simple NRZ equivalent, but allows easy and reliable clock recovery.



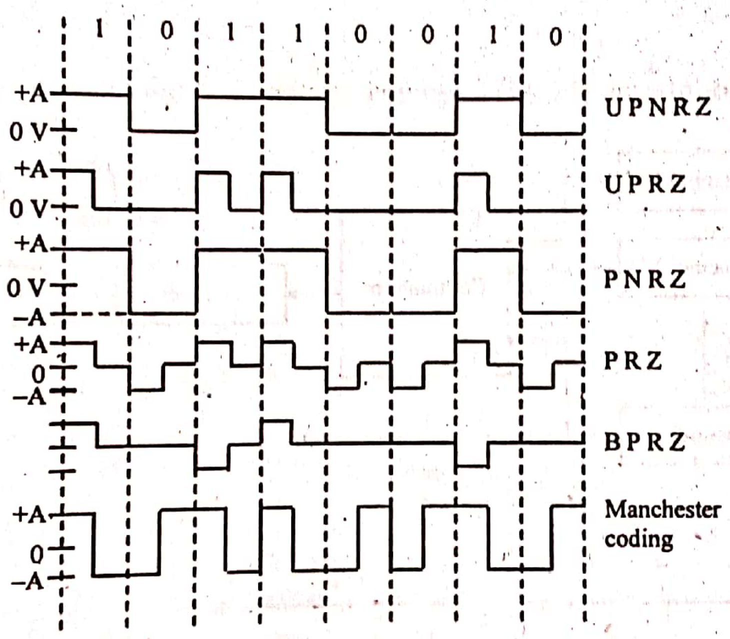
(iii) Manchester coding

Here symbol '1' is represented by transmitting a positive pulse (say +A volts) for one half of the symbol duration followed by a negative pulse (say – A volts) for the remaining half of the symbol duration.

Similarly symbol '0' is represented by a negative half-bit period pulse followed by a positive half-bit period pulse.



Manchester Coding is also called split-phase (biphase) encoding.
Let us draw the waveforms of various binary signaling formats for the bit sequences 10 11 00 10



(iv) Differential coding
Refer to Question No. 4(a) of Short Answer Type Questions.

b) i) We know,

$$[H] = \left[P^T : I_{n-k}\right]$$

$$\therefore P^T = \begin{bmatrix} 1 & 0 & 1 \\ 0 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

$$\therefore P = \begin{bmatrix} 1 & 0 & 1 \\ 0 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

So, $G=[I:P]=\begin{bmatrix} 1 & 0 & 0 & 1 & 0 & 1 \\ 0 & 1 & 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 & 1 & 1 \end{bmatrix}$

ii) Again, $C=DG$

$$=\begin{bmatrix} 1 & 0 & 1 \end{bmatrix}\begin{bmatrix} 1 & 0 & 0 & 1 & 0 & 1 \\ 0 & 1 & 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 & 1 & 1 \end{bmatrix}=\begin{bmatrix} 1 & 0 & 1 & 0 & 1 & 0 \end{bmatrix}$$

7. Draw and explain the block diagram of PCM transmitter and receivers. **[WBUT 2013]**

Answer:

The Pulse Code Modulation (PCM) telemetry system is shown in the Fig. 1.

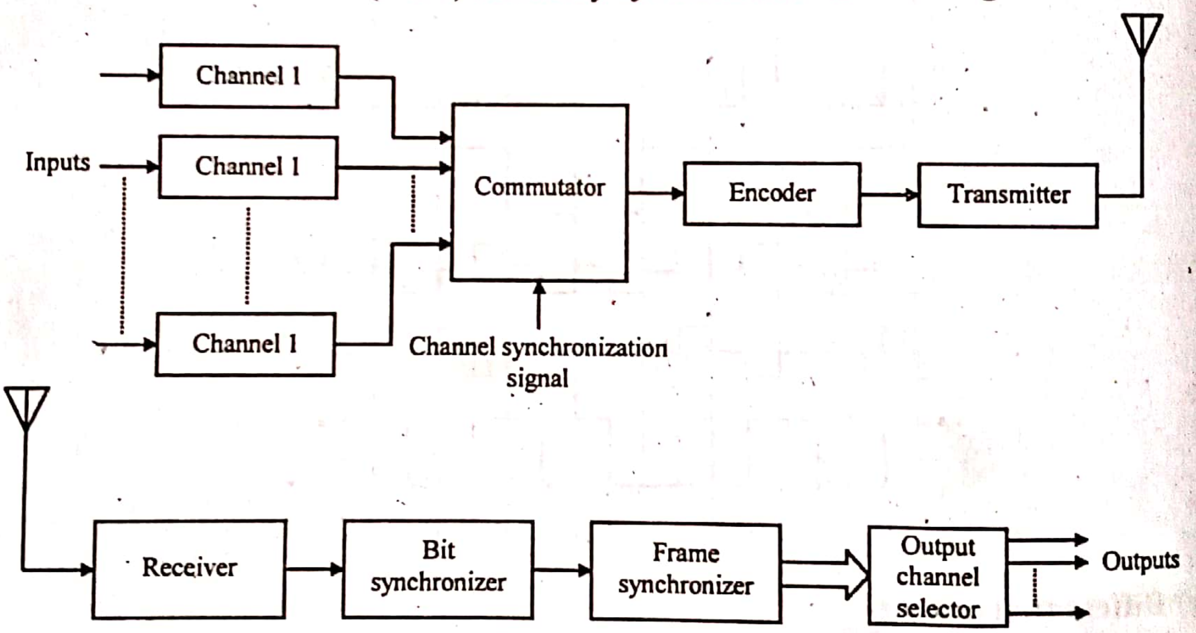


Fig: 1 PCM telemetry system

The PCM telemetry system also make used of the time division multiplexing system. The main difference with the PAM telemetry system is that in the PCM telemetry system, an encoder is used after the commutator stage. The function of the encoder is to accept each PAM sample and convert it into a binary number and shift the bits of each number serially. The encoder converts zero amplitude pulse to the binary number "0"; while the full-scale pulse into binary number "1023" for examples. Each number is exactly proportional to the instantaneous amplitude of the signal at the measuring point.

The receiver section is synchronized on the serial data stream. The bit synchronizer and the frame synchronizer identify each sequence of bits and converts it into useful outputs. As the measured data is represented in the form of binary weighted codes, the system is known as pulse code modulation telemetry system.

8. Distinguish between a three-line and a two-line electrical type transmitters. Which one is more popular in industry and why? **[WBUT 2013, 2015]**

Answer:

1st part:

Fig. 1 (a) and (b) show two schemes of a transmitter-receiver system using three-wire true zero loop and two-wire live zero loop. In the former, a three-wire cable supplies power to the transmitter and carries the output as well, as shown, the earth return (common) being the same or shared by both, while the live-zero type of Fig. 1(b) uses a two-wire cable, the transmitter being given power by 4 mA live zero.

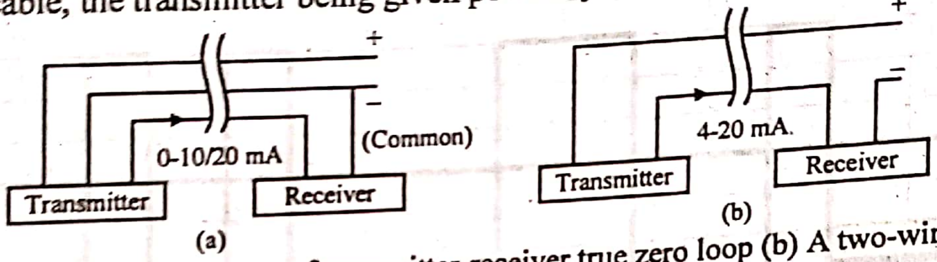


Fig: 1 (a) A three wire scheme of transmitter-receiver true zero loop (b) A two-wire live zero loop

2nd part:

Two line electrical type transmitter technique is suited better for intrinsic safety. It also provides loop break two-wire live zero loop detection and has lower cable and installation cost.

9. a) What do you mean by CMI?

b) Switch the waveform of 10111001.

c) For a (6, 3) code, *H* matrix is given by $[H]=\begin{bmatrix} 1 & 0 & 1 & 1 & 0 & 0 \\ 0 & 1 & 1 & 0 & 1 & 0 \\ 1 & 1 & 0 & 0 & 0 & 0 \end{bmatrix}$.

Determine all the code words and Hamming distance of the code.

d) Explain differential Manchester coding with suitable example. **[WBUT 2014]**

Answer:

a) Coded mark inversion (CMI): It is a binary coded data format with two line bits for each associated binary digit.. Its 1's are full-width pulses and follows the rules of AMI, whereas 0's are $\frac{1}{2}$ - width negative and $\frac{1}{2}$- width positive as shown in Figs. 1 (a) and (b). Figure 2 shows the waveform of the word 1100101 in CMI coding.

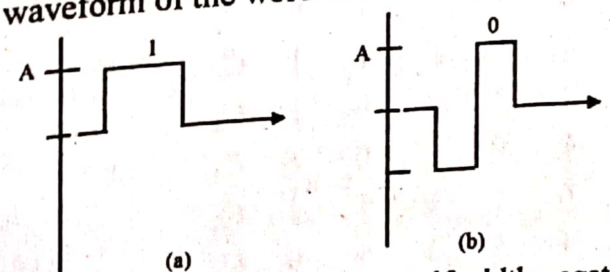


Fig: 1 (a) I as full width pulse, (b) as half width negative and half-width positive pulse

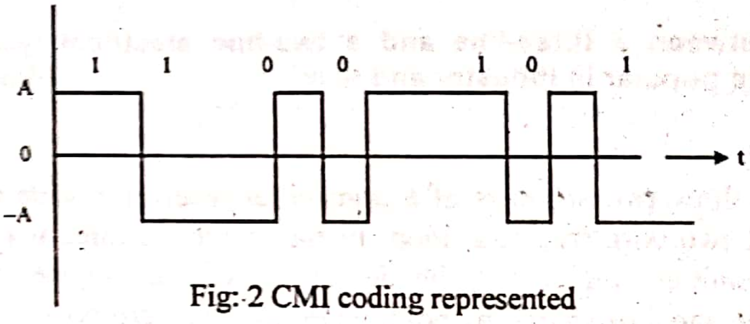
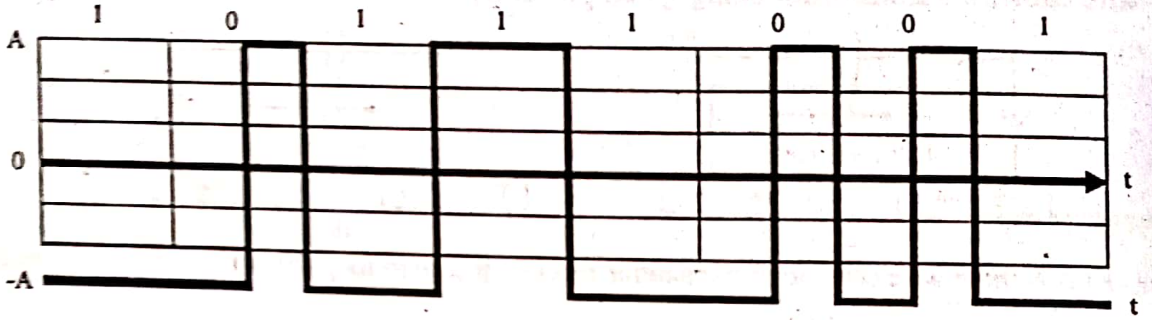


Fig:-2 CMI coding represented

b)



c) The generator matrix is

$$G=\begin{bmatrix}1 & 0 & 0 & 1 & 0 & 1\\ 0 & 1 & 0 & 0 & 1 & 1\\ 0 & 0 & 1 & 1 & 1 & 0\end{bmatrix}$$

Code word $\quad C=D.G$

Since, the code is (6, 3) code, the possible no. of data words is 2^3 (since $k=3$).

The general code word is $(d_1d_2d_3r_1r_2r_3)$

$$\therefore \quad (d_1d_2d_3r_1r_2r_3)=[d_1\ \ d_2\ \ d_3]\begin{bmatrix}1 & 0 & 0 & 1 & 0 & 1\\ 0 & 1 & 0 & 0 & 1 & 1\\ 0 & 0 & 1 & 1 & 1 & 0\end{bmatrix}$$

$$\therefore \quad r_1=d_1+d_3;\ r_2=d_2+d_3;\ r_3=d_1+d_2$$

Data word			Code word						
d_1	d_2	d_3	d_1	d_2	d_3	r_1	r_2	r_3	
0	0	0	0	0	0	0	0	0	C_1
0	0	1	0	0	1	1	1	0	C_2
0	1	0	0	1	0	0	1	1	C_3
0	1	1	0	1	1	1	0	1	C_4
1	0	0	1	0	0	1	0	1	C_5
1	0	1	1	0	1	0	1	1	C_6
1	1	0	1	1	0	1	1	0	C_7
1	1	1	1	1	1	0	0	0	C_8

To find the Hamming distance, the procedure is as follows:

X-OR of different code word combinations	No. of 1's in the X-OR ed O/P
C_1, C_2	3
C_1, C_3	3
C_1, C_4	4
C_1, C_5	3
C_1, C_6	4
C_1, C_7	4
C_1, C_8	3
C_2, C_3	4
C_2, C_4	3
C_2, C_5	4
C_2, C_6	3
C_2, C_7	3
C_2, C_8	4
C_3, C_4	3
C_3, C_5	4
C_3, C_6	3
C_3, C_7	3
C_3, C_8	4
C_4, C_5	3
C_4, C_6	4
C_4, C_7	4
C_4, C_8	3
C_5, C_6	3
C_5, C_7	3
C_5, C_8	4
C_6, C_7	4
C_6, C_8	3
C_7, C_8	3

The minimum value of no. of 1's is 3. Since the minimum no. of bit positions in which any two code words of a code differ is the Hamming distance, for the above (6, 3) code, $d_{min} = 3$.

d) Differential Manchester

- In differential Manchester encoding, a binary 0 is marked by a transition at the beginning of an interval, whereas a 1 is marked by the absence of a transition. In this encoding method, detecting changes is often more reliable, especially when there is a noise in the channel.
- Figure below shows the differential Manchester encoding for 8 bit data stream 101011100.

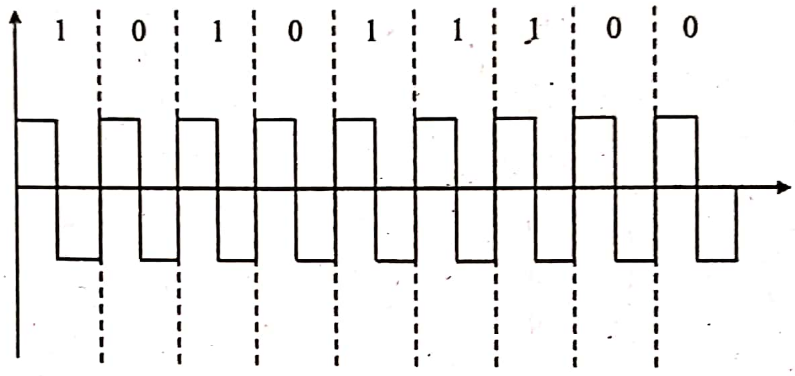


Fig: 1 Differential Manchester

10. Draw and explain the block diagram of basic telemetry system. [WBUT 2015]

Answer:

Basic Telemetry System

The block diagram of a basic telemetry system is as shown in the Fig. 1.

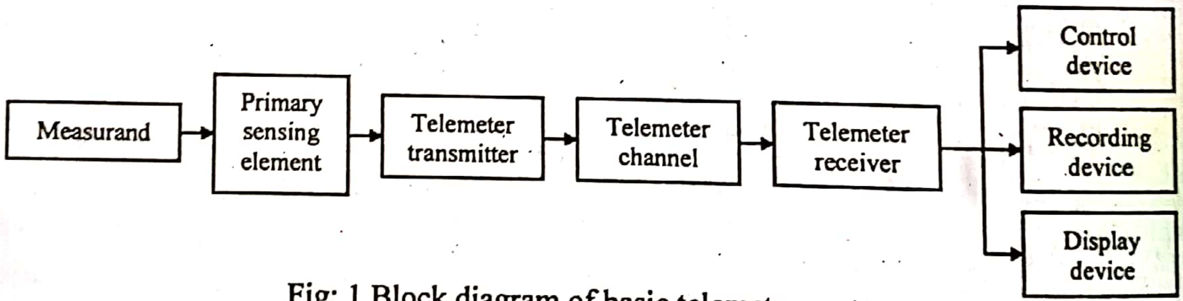


Fig: 1 Block diagram of basic telemetry system

The basic telemetry system consists three stages namely input stage, intermediate stage and output stage. The input stage consists primary sensing element which actually measures the physical quantity. The intermediate stage is made up of particularly three elements are follows.

a) **Telemeter transmitter:** This element converts the output of the primary sensing element into an electrical signal by means of appropriate electronic circuitry.

b) **Telemeter channel:** The electrical signal in relation with the input physical quantity being measured is transmitted over a distance through a channel. This is called Telemeter channel.

c) **Telemeter receiver:** This element of the intermediate stage receives the electrical signal transmitted through the telemeter channel. This receiver is placed over a distance from the measuring point at remote location. The function of the telemeter receiver is to convert the received electrical signal into a usable form so that it can be recorded or displaced.

The output stage consists end devices such as recording device to record data, display device to display the data or control device to take corrective action on measurand through feedback loop to control the output.

11. a) Explain with suitable block diagram about Frequency telemetry system.
b) Sketch the frequency transmitter circuit as used in frequency telemetering system and explain its operation. Deduce the relation between output frequency and input voltage. **[WBUT 2016]**

Answer:

a) A schematic of such a telemetry system is shown in Fig. 1.

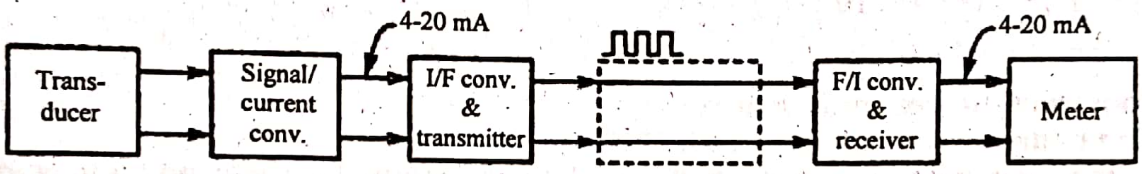


Fig: 1 Block diagram of a teletype channel based frequency telemetry system

b) Current conversion of transducer signal is well known and commercial circuits are available. Current-to-frequency converter transmitters are also no available a typical scheme of such a converter is shown in Fig. 2. In this scheme

$$V_{in} = -IR_1 \quad \text{.... (1)}$$

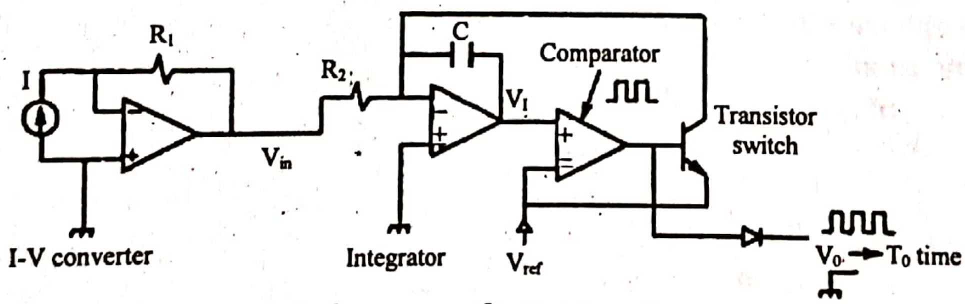


Fig: 1 A typical current to frequency converter

The output voltage capability of the operational amplifier (OA) and the input current size are important for such a simple I-V converter. The dc input voltage V_{in} given to the integrator ramps from zero to a predetermined value V_{ref}, the comparator reference input which also is a dc voltage. The ramp when equals the reference voltage, the comparator output switches from one state to the other, in turn, saturating the transistor switch which effectively becomes a short circuit making the reference voltage zero. Capacitor C which was charged to V_{ref}, now starts discharging through the transistor driving, in turn, the integrator output to zero. With the input of the comparator coming to zero level, recycling starts, or resetting of integrator occurs, as the transistor switch also returns to cut off condition.

The time required for the integrator output to reach V_1 from zero is inversely proportional to dc input V_{in}. When $V_1 = V_{ref}$, one can write, for integrator time constant T_1,

$$\left(\frac{1}{T_1}\right)\int_0^t V_{in}\,dt = V_{ref}$$

$$t = \frac{(T_1 V_{ref})}{V_{in}}$$

The series of pulses obtained by such conversion is actually voltage-keyed output as shown, with a diode, for sending through the channel.

12. The parity check matrix of a particular (7, 4) linear block code **[WBUT 2016]**

$$[H] = \begin{bmatrix} 1 & 0 & 11 & 1 & 00 \\ 1 & 1 & 01 & 0 & 10 \\ 0 & 1 & 11 & 0 & 00 \end{bmatrix}$$

i) Construct the generator matrix.
ii) The code word that begins with 1010.
iii) If the received code word Y is 0111100, then decode this received code word.

Answer:

Considering the number in the last column and the third row is 1 instead of 0.

$$H = \left[\begin{array}{cccc|ccc} 1 & 0 & 1 & 1 & 1 & 0 & 0 \\ 1 & 1 & 0 & 1 & 0 & 1 & 0 \\ 0 & 1 & 1 & 1 & 0 & 0 & 1 \end{array}\right]$$ Linear block code (7, 4)

So, length of code = 7

Dimension = 4

$$H = \left[P^T \middle| I_{n-k}\right]$$

$$I_{(7-4)} = I_3 = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$P^T = \begin{bmatrix} 1 & 0 & 1 & 1 \\ 1 & 1 & 0 & 1 \\ 0 & 1 & 1 & 1 \end{bmatrix} \Rightarrow P = \begin{bmatrix} 1 & 1 & 0 \\ 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

$$G = \left[I_k \middle| P\right]$$

$$I_k \Rightarrow I_4 = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\therefore \quad G = \begin{bmatrix} 1 & 0 & 0 & 0 & 1 & 1 & 0 \\ 0 & 1 & 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 1 & 1 & 1 & 1 \end{bmatrix} \quad \text{.... (1) **Ans.**}$$

Given code starts with 1010. This is actually a row vector. Thus, codeword = row vector$\times G$

$$\Rightarrow \quad [1 \ 0 \ 1 \ 0]\begin{bmatrix} 1 & 0 & 0 & 0 & 1 & 1 & 0 \\ 0 & 1 & 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 1 & 1 & 1 & 1 \end{bmatrix} = [1 \ 0 \ 1 \ 0 \ 2 \ 1 \ 1] \Rightarrow \text{Apply modulo 2.}$$

$$= [1 \ 0 \ 1 \ 0 \ 0 \ 1 \ 1] \quad \text{.... (2) Ans.}$$

(iii) Given codeword $y = 0 \ 1 \ 1 \ 1 \ 1 \ 0 \ 0$

$$H_r^T = \begin{bmatrix} 1 & 0 & 1 & 1 & 1 & 0 & 0 \\ 1 & 1 & 0 & 1 & 0 & 1 & 0 \\ 0 & 1 & 1 & 1 & 0 & 0 & 1 \end{bmatrix}\begin{bmatrix} 0 \\ 1 \\ 1 \\ 1 \\ 1 \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} 3 \\ 2 \\ 3 \end{bmatrix} \Rightarrow \text{Apply modulo 2}$$

$$= \begin{bmatrix} 1 \\ 0 \\ 1 \end{bmatrix}$$

$$= 1 \ 0 \ 1 \quad \text{.... (3) Ans.}$$

13. Write short notes on the following:
a) Differential coding **[WBUT 2009, 2010]**
b) Smart and intelligent telemetry system **[WBUT 2010, 2011]**
c) Frequency telemetry system **[WBUT 2010]**
d) SCADA vs. telemetry **[WBUT 2011]**
e) Pipeline telemetry **[WBUT 2011, 2016]**
f) BAUDOT coding **[WBUT 2012, 2013]**
g) Voltage telemetry system **[WBUT 2015]**

h) Position telemetry [WBUT 2017]
i) HDBn coding [WBUT 2017, 2018]

Answer:

a) Differential coding:

Refer to Question No. 4(a) of Short Answer Type Questions.

b) Smart and intelligent telemetry system:

An instrument which not only measures a variable, but also carries out further processing in order to refine the data obtained before presentation either to an observer or to some other stage of the system, is generally termed intelligent or smart. In practice, additional functions are usually available as well as the data-processing facility and these are all normally contained within the transmitter of the measuring device. These so-called smart transmitters are microprocessor-based and enable the device:

(a) To produce a higher accuracy of measurement through automatic compensation for systematic errors and changes in ambient conditions.
(b) To change measurement ranges automatically as required.
(c) To provide automatic calibration.
(d) To communicate to the operator or maintenance personnel via a computer interface or hand-held communicator.

The cost of an intelligent instrument can be twice that of the equivalent device without the smart facility (the latter is termed a dumb instrument). However, the use of a smart transmitter does generally improve the inherent accuracy of the sensor itself.

A common feature of smart devices is the ability, either to provide the normal 4–20mA analogue output (which is digitally linearised and compensated where necessary) or to provide digital communication with other devices as desired. Digital communication with a smart transmitter can be implemented from a microprocessor within the control room or by the use of a hand-held terminal. The latter can be inserted at any point within the 4–20 mA current loop and instructions to change the range, calibration, etc. can be sent to a specific smart device.

One counting difficulty with intelligent devices is their compatibility within a given distributed control system or LAN. This problem is particularly acute when individual instruments and other devices within the LAN are purchased from different manufacturers, each of whom employs its own protocol. In such cases, the devices will generally be unable to talk to each other without substantial additional hardware. Attempts are being made to overcome this problem by establishing a common industry communication standard termed Fieldbus. Currently, the nearest approach to a cross-company or open standard protocol is HART (the *Hiway Addressable Remote Transducer* protocol). This is effectively an interim solution in which existing 4–20mA two wire systems can be used to transmit digital information. It employs the FSK technique and permits two modes of operation, viz. a 4–20mA mode with digital signals imposed upon it and an all-digital mode which allows up to 15 intelligent devices to be connected to one cable. Hence, instruments that employ the HART protocol can be accessed by other HART devices, although they may have been purchased from different sources.

c) Frequency telemetry system:
Refer to Question No. 5 of Short Answer Type Questions.

d) SCADA System:
SCADA stands for System Control and Data Acquisition. SCADA consists of a collection of computers, sensors, and other equipment interfaced by telemetry to monitor and control processes. The uses of SCADA systems are endless as they are only limited by the designer's imagination. Some typical applications include high and low voltage power distributions, broadcasting stations, and environmental measurements.
An example of SCADA application is in water management. Water conservation is critical not only in drought stricken areas but everywhere, as water is becoming a limited resource due to increases in consumption. Application of SCADA system enables the remote and effective monitoring and controlling of water levels.
Another application of SCADA in industry is digital pager alarming system. If an unusual situation occurs in a process, the SCADA system can alert key personnel by sending message to their pagers. SCADA systems also archive information and generate reports and graphs that are critical to processes.
An important advantage of SCADA systems is that the existing sensors in an application can be incorporated into the overall SCADA system. In doing so, the SCADA system simply adds a new level of intelligence and provides additional capabilities to the existing controls in the plant.
Telemetry is the highly automated communications process by which measurements are made and other data collected at remote or inaccessible points and transmitted to receiving equipment for monitoring.
The changing situations in industries and technoeconomic and/or technosupermatic developments across the world have rendered simple measurement at the laboratories or working sites insufficient and incomprehensive. In industries, for example, monitoring and control of the entire plant is now being done from a centralized control room; the launching and flight of a rocket are controlled from the ground station; a satellite is monitored and data collected by its measurement systems are received and decoded at a specific ground station. Instances galore to show that specific variables measured at sites need be transmitted in some form over short to very long distances – from ground-to-ground, ground-to-orbital or even cosmic height and vice-versa – so that the information do not lose any of its content while being transmitted. The sent coded signals are decoded at the receiving centres to be used for various purposes.
The variables sensed or measured at sites are treated as signals which require to be processed before being transmitted over a distance, using land link consisting of solid (wire) or air (pneumatic) media, or radio frequency link (air or vacuum), and then received at the receiving end for indication, recording or simply display. This is what is called telemetry system.
In another system, close to this. Known as the remote sensing system, the 'sensing' and 'measurement' is done from a remote place or distance, such as the position of clouds or types of clouds or flying aircrafts measured by radar systems, or measurement of pollution by LIDAR system etc.

e) Pipeline telemetry:
Refer to Question No. 2(a) of Long Answer Type Questions.

f) BAU DOT Coding:
The 5-unit Baudot code was invented by the French engineer Emile Baudot in 1860. The Baudot code uses five elements to represent an alphabet, and unlike the Morse code, all of these symbols are of equal duration. The symbols are denoted by pulses of positive and zero (or negative) voltage levels. The Baudot code is shown in Table 1.
The following are the features of the Baudot code:

1. There are 5 symbols in a code word.
2. In all, there are $2^5 (=32)$ such combinations of code words.
3. Each symbol may be represented by binary 0 or 1.

Table 1 The Five-unit Baudot Code

Letter	Figure	Code word
A	—	11000
B	?	10011
C	:	01110
D	$	10010
E	3	10000
F	!	10110
G	&	01011
H	#	00101
I	8	01100
J	'	11010
K	(	11110
L	)	01001
M	.	00111
N	,	00110
O	9	00011
P	0	01101
Q	1	11101
R	4	01010
S	Bell	10100
T	5	00001
U	7	11100
V	;	01111
W	2	11001
X	/	10111
Y	6	10101
Z	"	10001

4. The combinations of symbols include all binary numbers from 00000 to 11111.
5. To represent alphabets in English, we require 26 such combinations. Then, out of the 32, only 6 are left to represent numbers and punctuation marks.

6. As such, we require one more set of such combinations of symbols to represent the punctuation marks and numbers. So, the same combinations are used again with the help of a shift key.

g) Voltage Telemetry System:

In the voltage telemetry system, the information is transmitted as a function of a.c. or d.c. voltage. In the voltage telemetry system shown in Fig. 1. a slidewire potentiometers is supplied by a battery and position of sliding contact is varied in accordance with the variation in pressure using a force summing member such as bourdon tube, a bellow or a diaphragm.

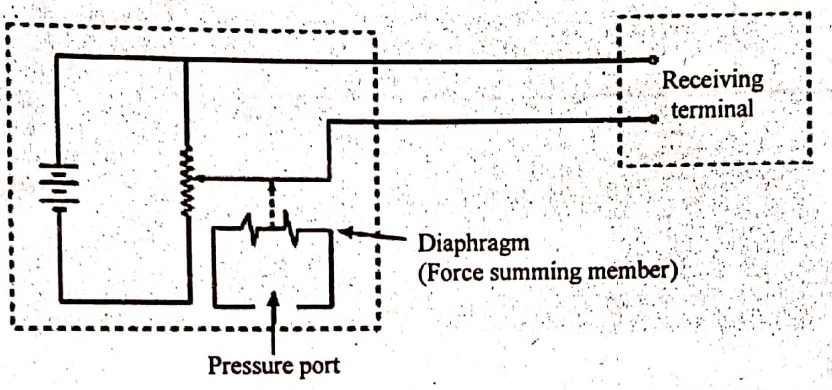


Fig: 1 Voltage telemetry system

The information is transmitted over a telemetry channel consisting of a pair of wires connected to a voltage-measuring device which may be a null balance d.c. potentiometer or a recorder. The d.c. null balance potentiometer measures the variation in voltage which may be calibrated in terms of the variation in pressure. In the voltage telemetry system, the primary sensing elements include thermocouple, tachogenerator or L.V.D.T., which produce a voltage signal. The voltage telemetry system is used industrially up to a distance of 300 metres.

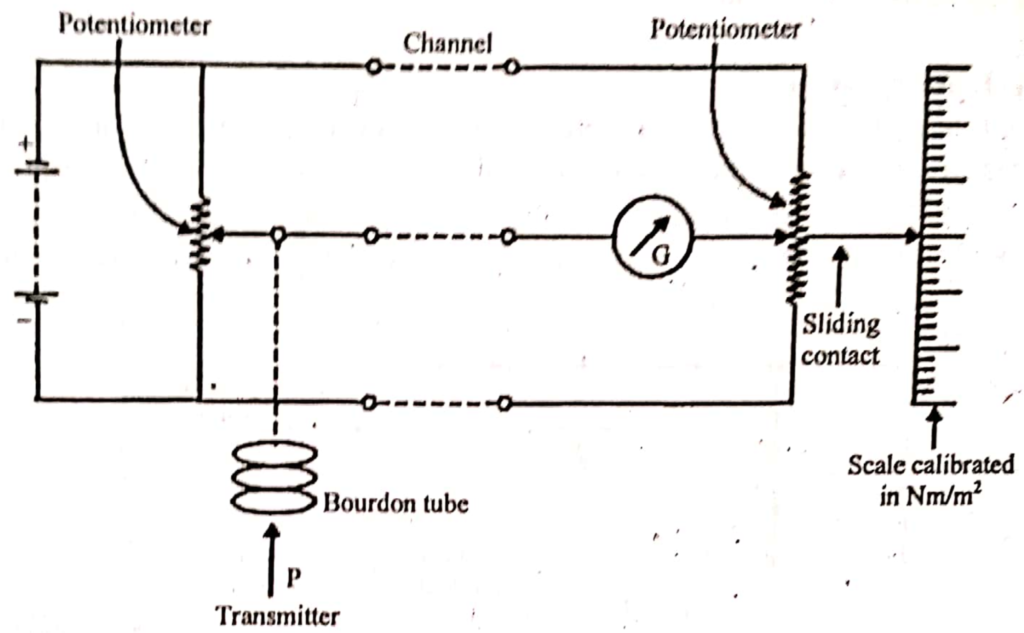
h) Position telemetry:

In this system, the transmitter adjusts the relation between the signal in correspondence to the measurement. The receiver converts the signals into displacement to represent the measurement. In this way the operation is based on comparison of two or more electrical quantities (voltage current etc;). So the system requires at least 3 conductors between the two ends. Out of three, one conductor is taken common. The value of one quantity is adjusted with the help of the potentiometer/rheostat potential divider.

There are two methods of position telemetry.

i) Bridge type position telemetry.
ii) Position telemetry using synchros.

The figure below shows the Bridge type position telemetry system. The circuit operates on the principle of wheat stone bridge. There are two potentiometers, one at transmitting end and other at receiving end. Both are energized by a common supply. The slide contact at the transmitting end is positioned by Bourdon tube, when pressure is applied on the tube. If sliding contact at the receiving end is positioned, till the galvanometer indicates zero; the position of the contact will assume the same position as the contact at the transmitter end. The receiving end sliding contact moves the pointer, which indicates the pressure to be measured needless to tell that the scale is calibrated in Nm/m^2.



i) HDBn coding:
HDBn coding is a scheme that eliminates the non-transparent problem of the bipolar signal by adding pulses when the number of consecutive 0's exceeds n. Such a modified coding is called high-density bipolar (HDB) coding and denoted by HDBn, where n can take on any value $1, 2, 3, \ldots\ldots$ The most important of the HDB codes is the HDB3 format, which has been adopted as an international standard. The basic idea of the HDBN code is that when a run of $n+1$ zeros occurs, this group of zeros is replaced by one of the special $n+1$ binary digit sequences. The sequences are chosen to include some binary 1's in order to increase the timing content of the signal.

Algorithm:

1. Get the signal
2. Convert it to Alternate Mark Inversion (AMI) form
3. Look for 4 consecutive zeros and replace them with either 000V or B00V, Rule: If number of + and – at the left hand site of the consecutive 4 zeros is odd then use B00V else 000V
4. If it is 000V then V polarity should be as same as the polarity of the preceding pulse of those 4 consecutive zeros. If it is B00V, B and V are in same polarity but opposite to the preceding pulse of those 4 consecutive zeros.

Example:
1010000000000010

Steps:

AMI: +0–0000000000+0

+0–000V000000+0

+0–000–B00V00+0

+0-000–+00+00–0

It is to be noted that V is known as the violation bit. If the polarities of the violation bit and the immediate AMI bit are similar then change the polarity of all AMI bits at the right hand side of the violation bit to their opposite polarity , keep this repeating for violation bits which satisfy the rule.

As soon a four (4) consecutive zeros is found convert it and proceed, because one has to count + and – for the next 4 consecutive zeros including the + and – on the last 4 consecutive zeros which you finished converting.

A bit patterns, HDB3 code and timing diagram are illustrated below:

BIN	1	0	1	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0
AMI	+A	0	–A	0	0	0	0	0	+A	–A	0	0	0	0	+A	–A	0	0	0	0	0	0
HDB3	+A	0	–A	0	0	0	–AV	0	+A	–A	+AB	0	0	+AV	–A	+A	–AB	0	0	–AV	0	0