Pulse Code Modulation

Lesson 16

Sec 1.1.6

BME 333 Biomedical Signals and Systems
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Homework

- Problem (1)
  - A BL signal with maximum frequency 1000 Hz is sampled at the Nyquist rate of 2000 samples per second. It is then quantized to 8 levels. What is the bit rate of the coded signal? Repeat for 16 levels and 256 levels.
- Problem (2)
  - 20 BL signals (1000 Hz) are sampled at the Nyquist Rate and then quantized to 16 levels. Calculate the pulse width of each bit to support the multiplex of these 20 signals. Calculate the bit rate. Repeat for 200 signals.
- Problem (3)
  - Consider N signals, each BL (1 Hz) and is quantized to 16 levels. If a transmission system can handle 40 bits per second, how many messages can be sent? Repeat for 10Mbps.
- Problem (4)
  - Consider a BL signal with maximum frequency 1000 Hz is sampled at the Nyquist rate. The signal is quantized into 8 levels. The SNR_{db} for this channel is 10db. Will this channel work? What would you have to do to make this channel work?

Homework Answers #1

- Problem (1)
  - A BL signal with maximum frequency 1000 Hz is sampled at the Nyquist rate of 2000 samples per second. It is then quantized to 8 levels. What is the bit rate of the coded signal? Repeat for 16 levels and 256 levels.

  - Each signal is sampled at a rate of 2000 samples per second. If the samples are quantized to 8 levels then 3 bits are required. Therefore, there are 3 X 2000 bits /per second or a bit rate of 6,000 bps.

  - For 16 levels, 4 bits are required and the bit rate is 8,000 bps or 1,000 Bps (bytes per second).

  - For 256 levels, 8 bits are required and the bit rate is 16,000 bps or 2,000 bytes per second.

Homework Answers #2

- Problem (2)
  - 20 BL signals (1000 Hz) are sampled at the Nyquist Rate and then quantized to 16 levels. Calculate the pulse width of each bit to support the multiplex of these 20 signals. Calculate the bit rate. Repeat for 200 signals.

  - Each signal is sampled at a rate of 2000 samples per second. If the samples are quantized to 16 levels then 4 bits are required per signal. Therefore, for one signal are 4 X 2000 bits /per second or a bit rate of 8,000 bps or 1,000 bytes per second.

  - For 20 BL signals the bit rate is then the total bit rate is 160,000 bps or 20,000 bytes per second. The pulse width, assuming a duty cycle of 50%, is ½ of the period of 1/160000 = 3.125μseconds

  - For 200 BL signals the bit rate is then the total bit rate is 1,600,000 bps or 200,000 bytes per second. The pulse width is then 0.03125 μseconds or 31.25nseconds

Homework Answers #3

- Problem (3)
  - Consider N signals, each BL (1 Hz) and is quantized to 16 levels. If a transmission system can handle 40 bits per second, how many messages can be sent? Repeat for 10Mbps.
  - Each signal is sample at 2 samples per second and is quantized to 16 level (4 bits) and the bit rate will be 8 bits per second per signal.
  - If the capacity of the transmission system is 40 bps, the system can handle 40/8 = 5 messages.
  - If the capacity of the transmission system is 10 Mbps, the system can handle 10M/8 = 1.25 Million messages.

Homework Answers #3

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  - Each signal is sample at 2 samples per second and is quantized to 16 level (4 bits) and the bit rate will be 8 bits per second per signal.
  - If the capacity of the transmission system is 40 bps, the system can handle 40/8 = 5 messages.
  - If the capacity of the transmission system is 10 Mbps, the system can handle 10M/8 = 1.25 Million messages.

Homework Answers #4

- Problem (4)
  - Consider a BL signal with maximum frequency 1000 Hz is sampled at the Nyquist rate. The signal is quantized into 8 levels. The SNR_{db} for this channel is 10db. Will this channel work? What would you have to do to make this channel work?

  - Each signal is sampled at a rate of 2000 samples per second. If the samples are quantized to 8 levels then 3 bits are required. Therefore, there are 3 X 2000 bits /per second or a bit rate of 6,000 bps.

  - The Channel Capacity in noise is $1000 \text{ X } \log_2(1+10^{10/10})$ = 3459.4 bps which is less than 6,000 bps and therefore this channel will not work.

  - Use error correcting coding or less noisier channel.