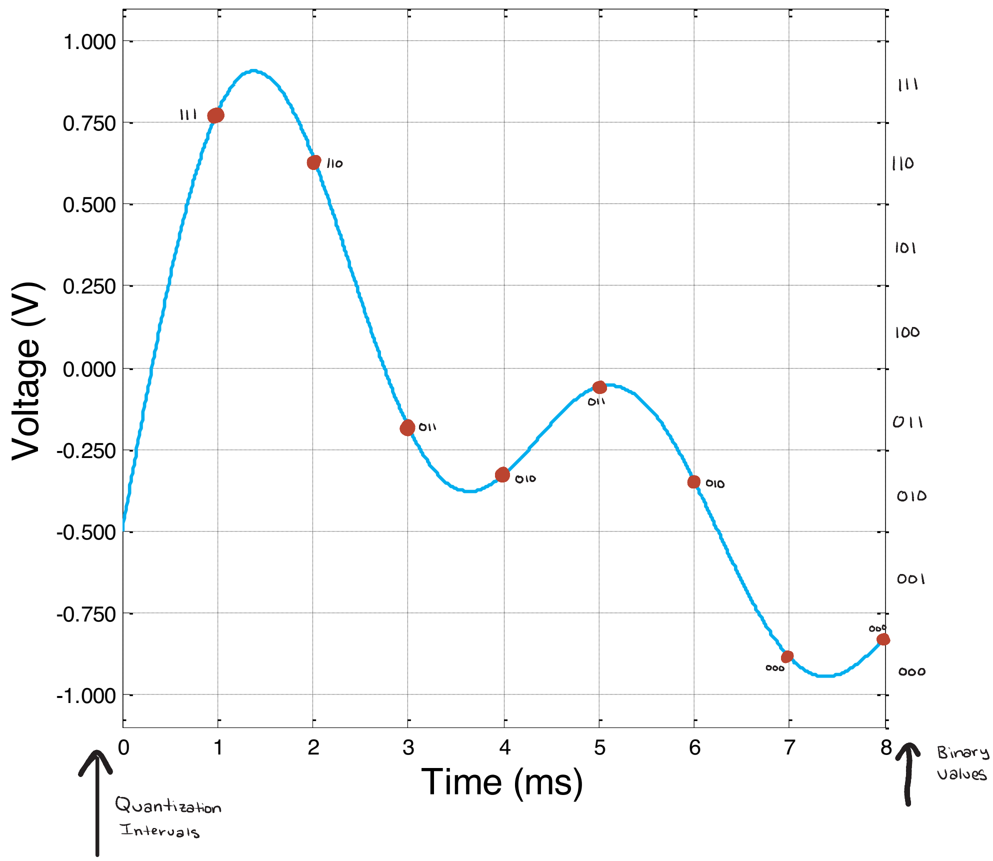
SY310

Networking & Wireless Communications

Analog-to-Digital Conversion Worksheet

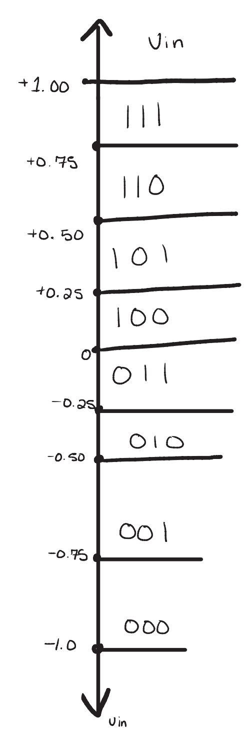
Name: McKenzie Eshleman

Consider the following analog waveform. This waveform is to be sampled at a 1-kHz rate and quantized with a 3-bit quantizer (input range -1.0 to +1.0 V).



a. What is the resolution (q) of this quantizer?

$$q = \frac{1-(-1)}{2^3} = \frac{2}{2^3} = \frac{1}{4} = 0.25$$



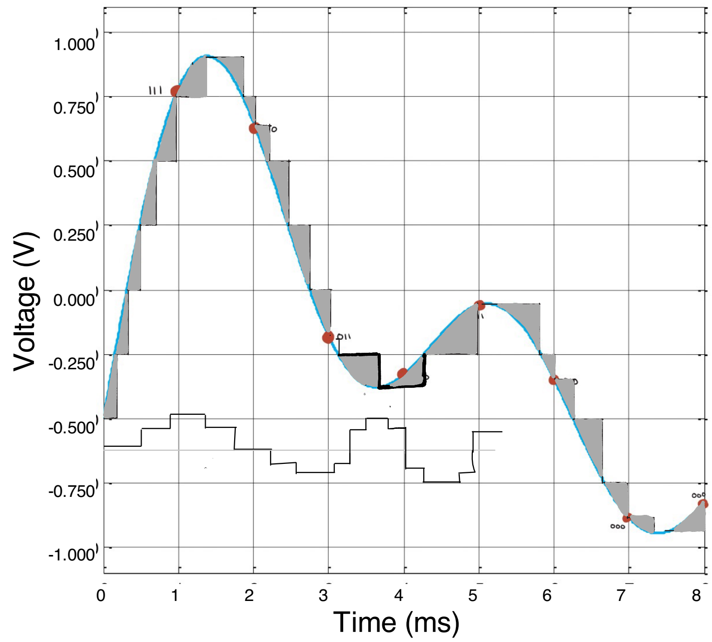
b. Circle the sample points on the analog waveform above.

c. Indicate the quantization intervals and corresponding binary values.

d. Indicate the binary number assigned to each sample point.

e. What is the bit stream to be transmitted?

f. Sketch the reconstructed waveform at the D/A.



g. Assume the bits are transmitted and received. When the information is recovered, it does not look identical to the original analog signal. What is the term to describe this difference and what can be done to minimize this difference?

This can be due to a quantizing error, we can use non-linear encoding to effect the space of the quantization levels

h. Why use digital signals instead of analog signals if digital signals introduce the problem of part (g)?

Digital signal, while it can produce some errors, it can be easily compressed. Digital can also convey information with less noise, distortion, and interference, it can also be transmitted a longer distance.

i. Now consider a CD-quality recording with a sampling rate of 44.1 kHz with a 16-bit quantizer.

What is the data rate (bits/second) for this case?

44.1 KHz/16 bits

44,100 x 16 = 705,600 bps

Recall that CDs are stereo, so we have to double this data rate because both the right and left channels are encoded. What is the data rate for stereo?

44.1 KHz/16 bits

44,100 x 16 x 2 = 1,411,200 bps = 1.4 Mbps

Using this information we can estimate the capacity (in minutes) of a compact disk. If a CD contains 700 MB (1 megabyte = 8 388 608 bits), how many minutes of music can it contain?

$$\frac{700\ \cancel{MB}}{} \Big| \frac{8{,}388{,}608 \text{ bits}}{1\ \cancel{MB}} = 5{,}872{,}025{,}600 \text{ bits}$$

$$5{,}872{,}025{,}600 \times \frac{1}{1{,}411{,}200} = 4161.02 \text{ sec} = 69.35 \text{ min}$$

(In reality, the actual number of bits on the CD is far higher than what the 700 MB would indicate due to administrative data and error correcting coding used to protect against bit errors caused by physical defects in the CD surface.)