Exercise Solutions for EEE 113

Communications - Basics of Communication Systems

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1.1 Suppose we sample a signal at frequency F_s. If we collect 9.1 kilo-samples in 4.7 seconds, what is F_s in Hz (samples/second)? Please provide your answer in at least 5 significant figures.

$\Rightarrow F_s = \frac{9.1 \text{ kilo-samples}}{4.7 \text{ seconds}}$	$F = \frac{S}{t}$
$\Rightarrow F_s = 1936.1$ Hz	Final answer.
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1.2 Compact discs record two channels (left and right) of music at a sampling frequency of $F_s = 44.1$ kHz for each channel. If each sample is encoded with 16 bits, and one byte is 8 bits, how many bytes are required to store 51.2 seconds of music?

$\Rightarrow F = 44.1 \text{ kHz} \cdot 2 \text{ channels}$	Note that we need two channels.
$\Rightarrow F = 88.2 \text{ kHz}$	
$\Rightarrow S = 88.2 \text{ kHz} \cdot 51.2 \text{ seconds}$	$S = Ft$
$\Rightarrow S = 4.51584 \times 10^6 \text{ samples}$	
$\Rightarrow b = 4.51584 \times 10^6 \text{ samples} \cdot 16 \text{ bits/sample}$	$b = S \cdot b_s$
$\Rightarrow b = 72.25344 \times 10^6 \text{ bits}$	
$\Rightarrow B = \frac{72.25344 \times 10^6 \text{ bits}}{8 \text{ bits per byte}}$	$B = \frac{b}{b_B}$
$\Rightarrow B = 9.03168 \times 10^6$ bytes	Final answer.
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1.3 Consider a system that uses 8-bit ASCII codes to encode letters. How long (in microseconds) will it take to transmit the bit sequence encoding "Hello-World!" if we use a bit time of 4 samples per bit, and transmit samples at a rate of 1 MHz?

$\Rightarrow c = 12$ characters	There are 12 characters in the string "Hello-World!".
$\Rightarrow b = 12 \text{ characters} \cdot 8 \text{ bits/character}$	Get the total amount of bits in the string.
$\Rightarrow b = 96$ bits	
$\Rightarrow S = 96 \text{ bits} \cdot 4 \text{ samples/bit}$	$S = b \cdot S_b$
$\Rightarrow S = 384$ samples	
$\Rightarrow t = \frac{384 \text{ samples}}{1 \text{ MHz}}$	$t = \frac{S}{F}$
$\Rightarrow t = 384$ microseconds	Final answer.
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1.4 The process of converting a discrete-time continuous-valued signal into a digital signal by expressing each sample as a finite number of digits is called (a); (b) is the difference between sampled analog signal and digitized signal; (c) refers to the difference between the minimum and maximum value of the discrete-time signal; (d) is the assignment of a unique binary number to each quantization level.

$\Rightarrow$ a: quantization	Final answer.
$\Rightarrow$ b: quantization error	
$\Rightarrow$ c: dynamic range	
$\Rightarrow$ d: coding	
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1.5 An analog waveform is described as

$$x(t) = 2u(t) - 5u(t-1) + 3u(t-2) + 3u(t-3) - 2u(t-4) - u(t-5)$$

where $u(t)$ is the continuous-time unit step function. If the quantization level is 0.02, determine the minimum number of bits needed to represent the full range of the analog signal $x(t)$.

$\Rightarrow R = 3 - (-5)$	dynamic range = maximum value − minimum value
$\Rightarrow R = 8$	
$\Rightarrow Q = \frac{8}{0.02}$	number of levels = $\frac{\text{dynamic range}}{\text{resolution}}$
$\Rightarrow Q = 400$	
$\Rightarrow b = \lceil \log_2 400 \rceil$	number of bits = $\lceil \log_2$ number of levels$\rceil$
$\Rightarrow b = \lceil 8.64385618977 \rceil$	
$\Rightarrow b = 9$	Final answer.
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