Homework 5

Wednesday, March 24, 2021 10:35 PM

"I pledge my honor I have abided by the Stevens Honor system."

- Alex Gaskins

4.3 Convert the decimal number 1149 to 12-bit simple binary.

1024	512	256	128	64	32	16	8	4	2	1
1	0	0	0	1	1	1	1	1	0	1

$\boxed{0100\ 0111\ 1101}$

4.11 How many bits are required for a digital device to represent the decimal number 27,541 in simple binary? How many bits for 2's-complement binary?

16384	8192	4096	2048	1024	512	256	128	64	32	16	8	4	2	1
1	1	0	1	0	1	1	1	0	0	1	0	1	0	1

$\boxed{15 \text{ bits}}$ $[27541 < 2^n]$

$$(27541)_{10} = (110101110010101)_2$$

4.24 An A/D converter has an input range of ±10 V. If the input is 8.0 V, what is the quantization error in volts and as a percent of input voltage if the converter has 8 bits, 12 bits, and 16 bits.

Input resolution error:

$$\pm .5 \left[\frac{V_{r\,up} - V_{r\,low}}{2^n}\right]$$

$$\pm .5 \left[\frac{10 - (-10)}{2^n}\right]$$

$$\pm .5 \left(\frac{20}{256}\right) = \boxed{\pm .0391 \text{ V}}$$

$$\pm .5 \left(\frac{20}{4096}\right) = \boxed{\pm .00244 \text{ V}}$$

$$\pm .5\left(\frac{20}{4096}\right) = \boxed{\pm .00244 \text{ V}}$$

$$\pm .5\left(\frac{20}{65536}\right) = \boxed{\pm .0001526 \text{ V}}$$

Quantization error:

$$\pm \text{ 8-bit: } \frac{.0391}{V_{in}} = \frac{.0391}{8}(100) = \boxed{.489\ \%}$$

$$\pm \text{ 12-bit: } \frac{.00244}{V_{in}} = \frac{.00244}{8}(100) = \boxed{.0305\ \%}$$

$$\pm \text{ 16-bit: } \frac{.0001526}{V_{in}} = \frac{.0001526}{8}(100) = \boxed{.00191\ \%}$$

4.26 A 12-bit A/D converter has an input range of −5 to +5 V. Estimate the quantization error (as a percentage of reading) for an input −2.46.

$$\pm .5\left(\frac{5-(-5)}{2^{12}}\right) = \pm \frac{10}{2(4096)} = \pm .00122 \text{ V}$$

Quantization error:

$$\frac{\pm .00122}{-2.46}(100) = \boxed{\pm .049\ \%}$$

The output of an ideal (perfect) low-pass filter is connected to the input of an analog-to-digital converter (ADC). The corner (or cutoff) frequency of this ideal low-pass filter is 250 Hz. The input analog signal to this ideal low-pass filter has a maximum frequency of 375 Hz. The ADC samples the input analog signal to the ADC at 750 samples/sec. (Note; for those colleagues who are familiar with the sampling theorem, this sampling rate is higher than the required minimum sampling rate. This ADC "over-samples" the analog input signal to the ADC; the sampling rate of this ADC is higher than the minimum required sampling rate). Each sample is then quantized ("measured") by comparing the amplitude of each sample to a standard set of 16,384 levels. Determine the total number of bits generated in a six-minute interval.

Sampling rate $= 2f_c = 2(250) = 500\text{ Hz}$

$1.5(500) = 750\text{ Hz}$

samples per second

$6(60)[750] = 27000$ samples

Each sample is quantized into 16384 levels

$16384 = 2^n$

$n = 14$ bits per sample

$14(27000) = \boxed{3780000\text{ bits}}$