Example with sample and hold

Plot the output versus time for an analog-to-digital (A/D) converter applied to the waveform for (x(t). Assume the following

a) you are sampling at 8 samples per 10 Hz cycle

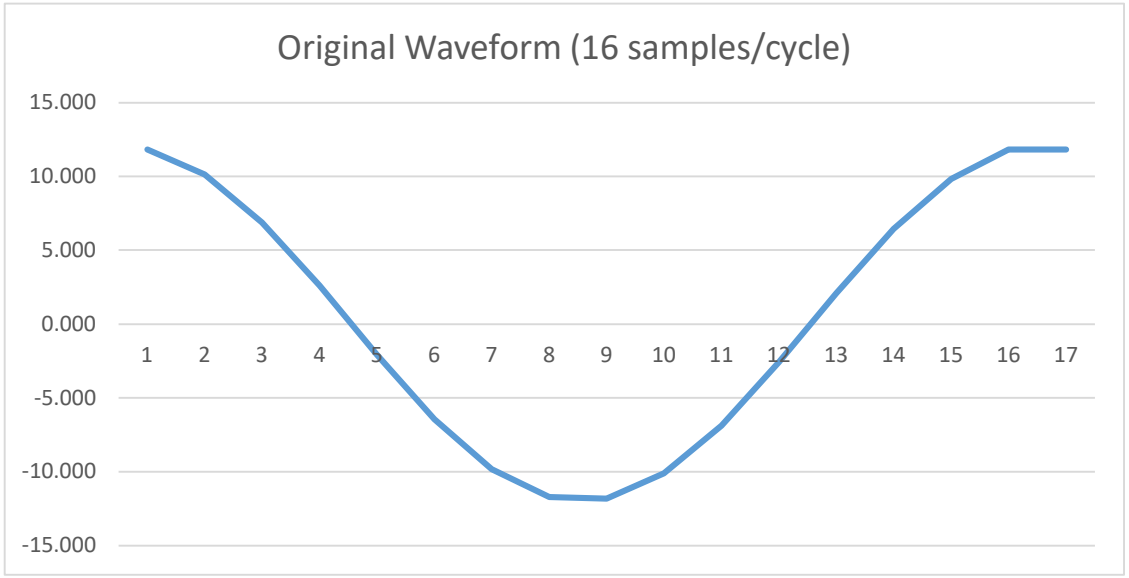
b) You have a 4 bit A/D where the most significant bit is a sign bit (MSB). Use the signed magnitude to represent the negative number (0 is positive and 1 is negative). In your plot, simply put the negative number below zero. Assume full scale for you're A/D converter is -15 to + 15.

Frequency (Hz)	Period	t_sample (8) sec	π	amplitude (A)	ϕ (deg)
10	0.1	0.0125	3.142	12	10
					in Radians
					0.175

Waveform: $x(t) = 12*\cos(2*\pi*10\ Hz * t + \phi)$

Xrms= 12/SQRT(2) 8.49

Original Waveform	Time	Value
0	0	11.818
1	0.00625	10.121
2	0.0125	6.883
3	0.01875	2.597
4	0.025	-2.084
5	0.03125	-6.448
6	0.0375	-9.830
7	0.04375	-11.716
8	0.05	-11.818
9	0.05625	-10.121
10	0.0625	-6.883
11	0.06875	-2.597
12	0.075	2.084
13	0.08125	6.448
14	0.0875	9.830
15	0.09375	11.818
16	0.1	11.818



* Analog scale: Maximum positive and negative value has magnitude of 15
* We have 2n combinations of the magnitude bits, where n=2 (
* in this case two of which are 0, that step up as:

Num Magnitude Bits (n): 2

Current change per amplitude per bit

15A/(2^n -1) = 5

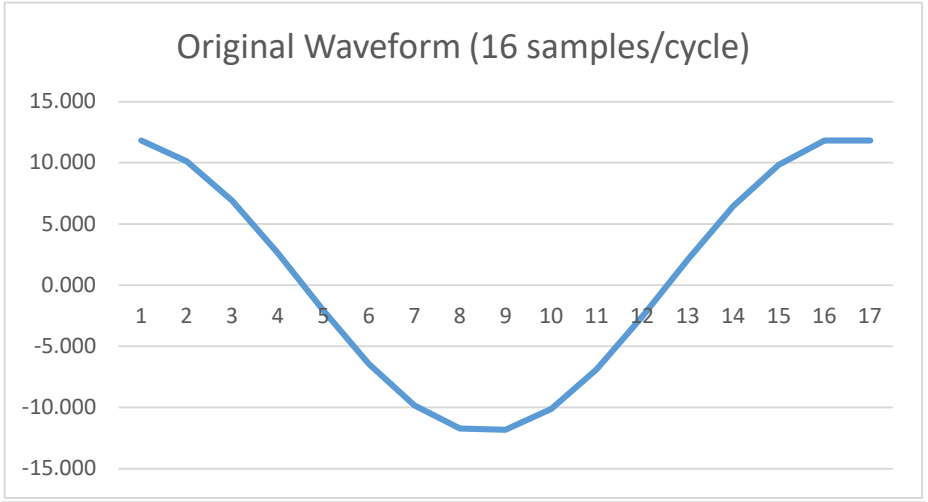
Mapping digital bit combinations to analog values (MSB is

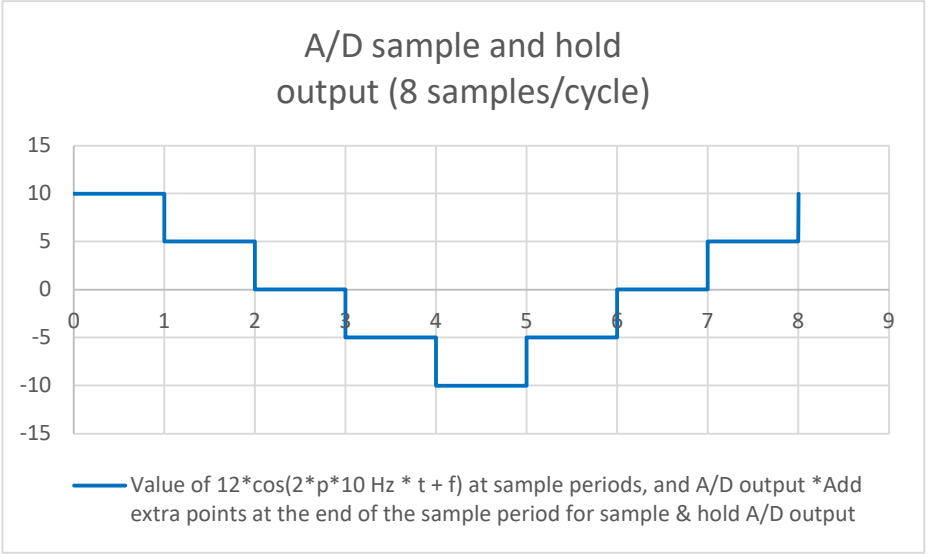
0,0,0	0
0,0,1	5
0,1,0	10
0,1,1	15
1,0,0	-0
1,0,1	-5
1,1,0	-10
1,1,1	-15

Value of 12*cos(2*π*10 Hz * t + ϕ) at sample periods, and A/D output

*Add extra points at the end of the sample period for sample & hold

Sample number	Time	Value	A/D output
0	0.000	11.818	10
0.99999	0.012	11.818	10
1	0.013	6.883	5
1.99999	0.025	6.883	5
2	0.025	-2.084	0
2.99999	0.037	-2.084	0
3	0.038	-9.830	-5
3.99999	0.050	-9.830	-5
4	0.050	-11.818	-10
4.99999	0.062	-11.818	-10
5	0.063	-6.883	-5
5.99999	0.075	-6.883	-5
6	0.075	2.084	0
6.99999	0.087	2.084	0
7	0.088	9.830	5
7.99999	0.100	9.830	5
8	0.100	11.818	10





Now calculate RMS current

* Implement the following formula in pieces
* Remember that integal is a sum of areas

$$X_{RMS} = \sqrt{\frac{1}{T} \cdot \int_0^T \left(i(t)^2\right) dt}$$

Sample num	Current from A/D	Integrals by parts (t.sample * v^2)	
0	10	1.25	
1	5	0.3125	
2	0	0	
3	-5	0.3125	
4	-10	1.25	
5	-5	0.3125	
6	0	0	
7	5	0.3125	
	Sum	3.75	
	Sum/T	37.5	Where T is the period
Take SQRT	X_RMS_a/d	6.124	

Compare to original waveform

	Xrms= 12/SQRT(2	8.49	Significant difference due to quantization