P1 see Hw13 problem 6

P2. $ENOB = n - 1 - \frac{\log_{10} V}{\log_{10} 2} = 12 - 1 - \log_2 3 = 9.415 \approx 9$ bits

P3 $10 \log_{10} \frac{A_2^2}{A_1^2} = -75 \Rightarrow \frac{|A_2|}{|A_1|} = 10^{-3.75}$

$\therefore SFDR = \frac{|A_1|}{\max_{1<k} |A_k|} = \frac{|A_1|}{|A_2|} = 10^{3.75} = 5623.4$

or $SFDR_{dB} = 20 \log \frac{|A_1|}{|A_2|} = 10 \log \frac{A_1^2}{A_2^2} = 75\,dB$

P4 worst case $|A_2| = |A_3|$

$\therefore THD_{dB} = 10 \log_{10} \frac{A_2^2 + A_3^2}{A_1^2} = 10 \log_{10} 2 + 20 \log \frac{|A_2|}{|A_1|} = 3 - (-60)$

$= 63\,dB$

note: in general, $SFDR_{dB}$ should be larger than zero if it is defined as $SFDR_{dB} = 20 \log \frac{|A_1|}{\max_{2 \le k} |A_k|}$ as the amplitudes of the harmonic frequencies are usually less than that of fundamental frequency.

P5 12 bit $V_{noise\,total} = 25\,mV + \frac{5}{2^{12}\sqrt{12}} = 25.4\,mV_{RMS}$

16 bit $V_{noise\,total} = 25\,mV + \frac{5}{2^{16}\sqrt{12}} = 25.02\,mV_{RMS}$

$V_{signal} = \frac{2}{2\sqrt{2}} = 0.707\,V_{RMS}$

$SNR_{dB}^{12bits} = 20 \log \frac{0.707V}{25.4mV} = 28.9\,dB$ $SNR_{dB}^{16bits} = 29.02$

slightly better due to less quantization noise

P6 $N_p = 11$ index of $A_1 = 12$

— — — $A_2 = 23$

— — — $A_3 = 34$

P7 $\frac{T \cdot 11}{T_s} = 4096$ $\therefore$ $\frac{f_s}{f_{Nyquist}} = \frac{\frac{1}{T_s}}{\frac{2}{T}} = \frac{T}{2T_s} = \frac{4096}{2 \cdot 11}$

$f_{Nyquist} = \frac{2}{T}$

$= 186.2.$

P8

(a) $T_s = \frac{1}{10MHz} = 100\,ns$

$\therefore$ total time $= T_s \cdot 4096 = 409.6\,us$

(b) 5 MHz

P9. (a) $N_p = 11$ $\therefore$ $A_{1dB} = 12.001\,dB$ $A_{2dB} = -43.2\,dB$

index 12 index 23

$A_{3dB} = -67.9\,dB$

index 34

neglect others as they are too small.

$\therefore$ $A_1 = 10^{\frac{A_{1dB}}{20}} = 3.98\,V_{Rms}$

(b) $\frac{T \cdot 11}{T_s} = 4096 \Rightarrow T = \frac{4096}{11} \cdot 1ms = 0.372\,S$

(c) $SFDR_{dB} = A_{1dB} - A_{2dB} = 55.2\,dB$

(d) $THD_{dB} = 20 \log_{10} \frac{\sqrt{A_2^2 + A_3^2}}{A_1} = 20 \log_{10} \frac{\sqrt{10^{\frac{A_{2dB}}{10}} + 10^{\frac{A_{3dB}}{10}}}}{10^{\frac{A_{1dB}}{20}}}$

$= -55.18\,dB$