Solutions for Midterm #2 - EECS 145M Spring 2000

PROBLEM 1

1a Flash

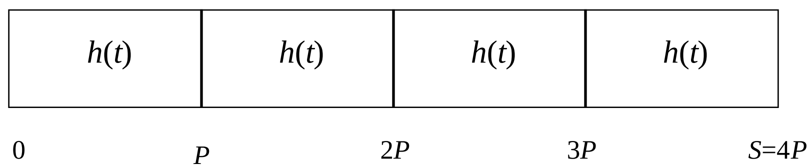
1b Successive approximation

1c Integrating or dual slope

1d Successive approximation

PROBLEM 2

2a Non-zero amplitudes would be expected at H_{4m} and H_{M-4m}, for each harmonic m of the primary frequency $1/P$ present in $h(t)$.



[4 points off if no mention of harmonics] [8 points off for H_0 and H_1 only] [5 points off for H_0, H_4 and H_8 only]

2b. The Fourier amplitudes $H_{M/8}$ and $H_{7M/8}$ would change.

2c. Due to spectral leakage, all Fourier amplitudes would be non-zero, but the largest H_n would be at frequency indices near $n = 3.5m$ and $n = M - 3.5m$.

2d. The Hanning window would reduce the spectral leakage and the non-zero Fourier amplitudes H_n would be at the 2 or 3 frequency indices near $n = 3.5m$ and $n = M - 3.5m$.

PROBLEM 3

3a v = 3 m/s f = 100 kHz (1 + 3/300) = 101,000 Hz

v = 30 m/s f = 100 kHz (1 + 30/300) = 110,000 Hz

v = 30.3 m/s f = 100 kHz (1 + 30.3/300) = 110,100 Hz

v = 60 m/s f = 100 kHz (1 + 60/300) = 120,000 Hz

The exact calculation gives 101,010; 111,111; 111,235; and 125,000 Hz; both were OK.

3b $\Delta f = 100$ Hz, so the minimum length of the sampling window must be $S = 1/\Delta f = 0.01$ s

3c The spectral leakage from 100 kHz to 101 kHz will be severe, so a Hanning window would be useful in nearly eliminating it. Since there is only one echo frequency to worry about, the broadening caused by the Hanning window will still allow the echo frequency to be determined to within one Fourier frequency index, to a resolution of $\Delta f = 100$ Hz. So there is no need to increase S.

An alternative, a precise number of 100 kHz cycles could be sampled. The much smaller echo signal would still have spectral leakage, but that would be OK.

Another alternative was to subtract 1 V 100 kHz from the echo signal.

3d The maximum signal frequency is 120 kHz at 60 m/s, so we would want the Butterworth filter to pass all frequencies below $f_1 = 120$ kHz.

It was allowed to let the filter $f_c = 120$ kHz and solve for $f_1 \approx 90$ kHz

[4 points off for $f_1 = 60$ kHz, which would cause the filter to reject the signal at $2 f_1 = 120$ kHz.]

3e The low pass filter accepts frequencies below $f_1 = 120$ kHz and rejects frequencies above $f_2 = 240$ kHz. So the minimum sampling frequency $f_s = f_1 + f_2 = 360$ kHz

$f_s = 2 f_2 = 480$ kHz was also accepted.

[3 points off for $f_s = 2 f_1$, which would alias all frequencies between f_1 and $2 f_1$ onto the range from 0 to f_1.]

3f Sampling at 360 kHz for 0.01138 s (just above the minimum *S* value from part 3b) would produce 4096 samples. (480 kHz would require 8192 samples.)

[1 point off if not a power of two]

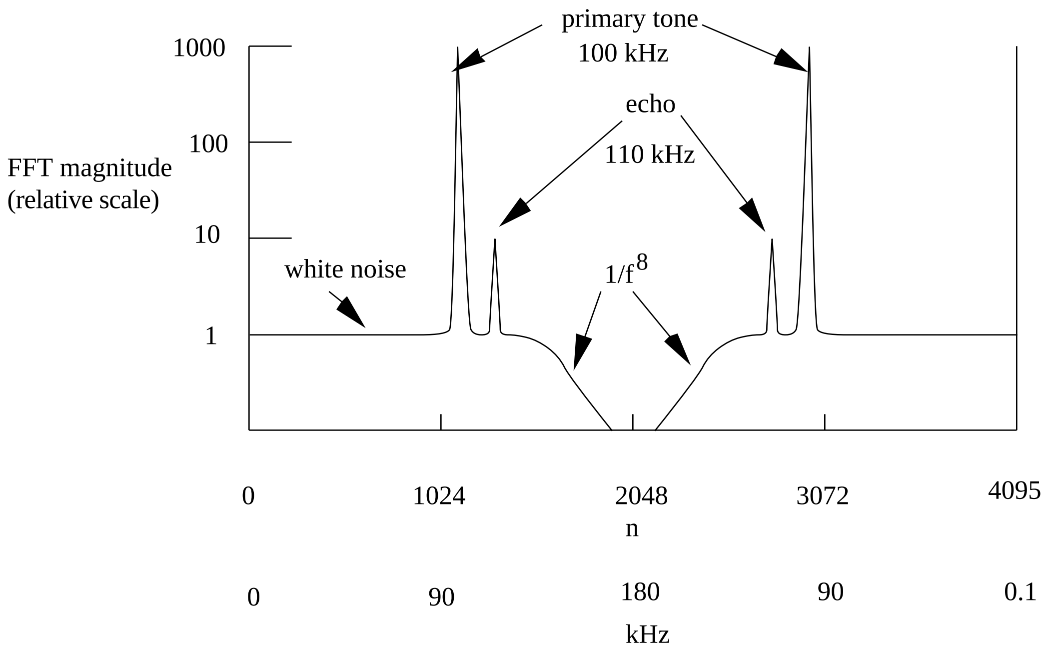
3g The echo is 100 times smaller than the 100 kHz tone and the white noise is 10 times smaller than the peak echo. The low pass filter falls off as $1/f^8$.

[2 points off if no FFT frequency index] [2 points off if no frequency scale in Hz]

[2 points off if white noise not shown] [4 points off if primary tone or echo not shown]

[3 points off for blank vertical scale] [2 points if vertical scale is not numbered]

[2 points off if effect of filter not shown]



Midterm #2 class statistics:

Problem	max	average	rms
1	20	14.8	2.4
2	35	24.3	7.3
3	45	38.9	3.8
total	100	78.0	9.5

Grade distribution:

Range	number	*approximate* letter grade
56-60	1	C
61-65	1	C+
66-70	1	B-
71-75	2	B
76-80	3	B+
81-85	4	A-
86-90	2	A
91-95	1	A+
96-100	0	A+