$\boxed{2\text{-}82.}$ $\omega_0 = 2\pi f_0 = 500 \Rightarrow f_0 = \frac{500}{2\pi}$

$$f_s > 2f_0 = \frac{2(500)}{2\pi} = \frac{500}{\pi}$$

(a.) $T_s = \frac{1}{f_s} \leq \frac{\pi}{500} = \underline{\underline{6.28\text{ msec}}}$

(b.) $N = \frac{1\text{sec}}{6.28 \times 10^{-3}\text{ sec/sample}} = \underline{\underline{160\text{ samples}}}$

2-86.

2-86 $\quad fo := 5$

$A1 := 4 \quad f1 := 2\ fo \quad \theta1 := 30$

$A2 := 2 \quad f2 := 5\ fo \quad \theta2 := -10 \quad T := \frac{1}{fo}$

$M := 5 \quad N := 2^M$

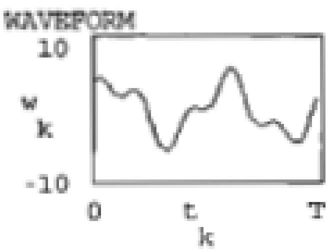
$N = 32 \quad k := 0\ ..N-1 \quad T := \frac{1}{fo}$

$dt := \frac{T}{N} \quad t_k := k\ dt$

$w1_k := A1\ \sin\left[2\ \pi\ f1\ t_k + \left[\frac{\pi}{180}\ \theta1\right]\right] \quad w2_k := A2\ \cos\left[2\ \pi\ f2\ t_k + \left[\frac{\pi}{180}\ \theta2\right]\right]$

$w_k := w1_k + w2_k$

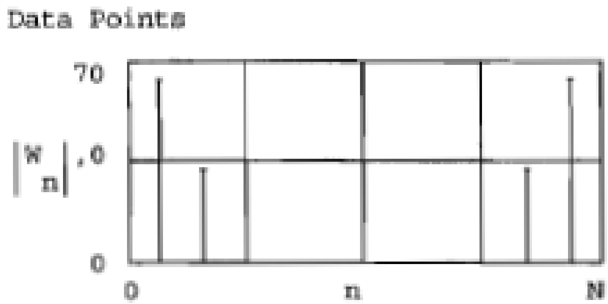
$w_0 = 3.97 \quad dt = 0.006$



Compute the FFT data points.

$n := 0\ ..N-1$

$W := \sqrt{N}\ \mathrm{icfft}(w)$



$n := \frac{-N}{2}, \frac{-N}{2} + 1\ ..\frac{N}{2}$

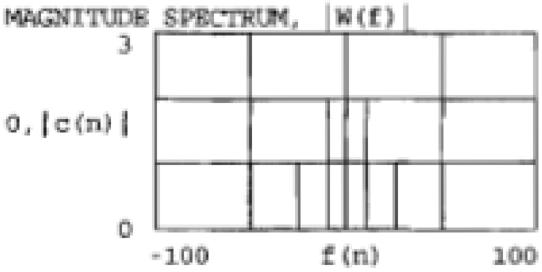
Since the waveform is periodic, the spectrum will contain only delta functions. ===> Evaluate the weights of the delta functions by using the FFT to calculate the complex Fourier series coefficients.
=====> Use (2-187) and (2-178) along with (2-109).

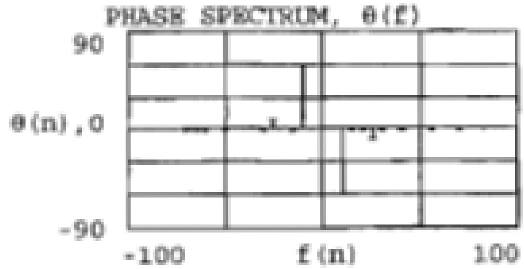
$c(n) := \mathrm{if}\left[n \ge 0, \frac{1}{N} W_n, \frac{1}{N} W_{N+n}\right] \quad f(n) := \frac{n}{T} \quad fs := \frac{1}{dt}$

$\theta(n) := \left[\frac{180}{\pi}\right] \arg(c(n) + 0.001)$

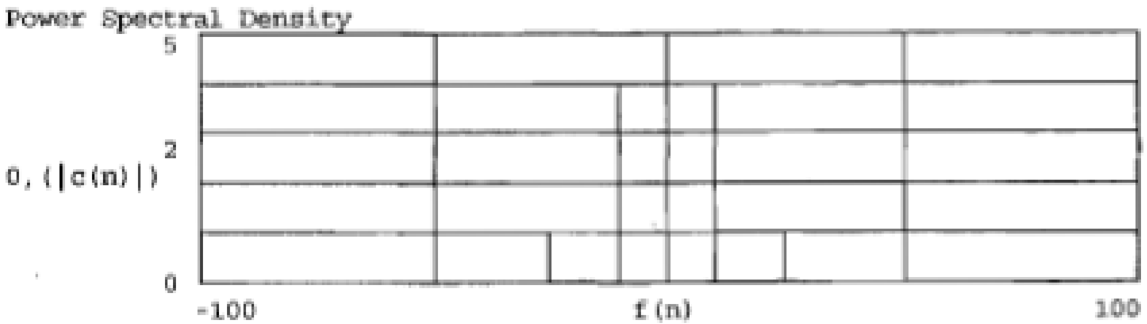
2-86 Cont'd.

(a) See next screen for a plot of the magnitude and phase spectrum.





(b) Use (2-126) to get PSD



$\boxed{2\text{-}89}$ $H(f) = \frac{1}{1+j(f/f_1)}$ where $f_1 = \frac{1}{2\pi RC} = B_{3dB}$

Since $|H(f)|^2 = \left|\frac{1}{1+j1}\right|^2 = \frac{1}{2}$, f_1 is the 3dB bandwidth.

(a)

$$B_{eq} = \frac{1}{|H(f_0)|^2}\int_0^\infty |H(f)|^2 df = \int_0^\infty \frac{1}{1+(f/f_1)^2} df$$

$$= \int_0^\infty \frac{1}{1+x^2}(f_1 dx) = f_1 \tan^{-1}(x)\Big|_0^\infty = f_1 \frac{\pi}{2}$$

Let $x = f/f_1 \Rightarrow dx = (1/f_1)df$

$$\Rightarrow B_{eq} = \frac{\pi}{2} B_{3dB} = \frac{1}{4RC}$$

(b.) Since $|H(f)| = 0$ only as $f \to \pm\infty$, the null bandwidth is ∞. In this case the null bandwidth definition does not give a very useful measure of bandwidth because all RC low-pass filters will have $B_{null} = \infty$ regardless of the value of RC.

(C.) Answer is same as for Part (b.) above.

$\boxed{2\text{-}92.}$ $s(t) = \Lambda\left(\frac{t}{T_0}\right) \xleftrightarrow[\text{Table 2-2}]{} S(f) = T_0\left[S_a(\pi f T_0)\right]^2$

(a.) Using results in 2-61 (1.) above $\Rightarrow$ $\underline{\underline{B_{abs} = \infty}}$

(b.) $S(f_{3dB}) = \frac{T_0}{\sqrt{2}} = T_0\left[S_a(\pi f_{3dB} T_0)\right]^2$

$\Rightarrow \pi f_{3dB} T_0 \simeq (2)^{1/4} \Rightarrow$ $\underline{\underline{B_{3dB} = f_{3dB} = \frac{1.19}{\pi T_0} = 0.38/T_0}}$

(c.) $B_{eq} = \frac{1}{|H(f_0)|^2}\int_0^\infty |H(f)|^2 df = \frac{1}{T_0^2}\int_0^\infty T_0^2\left[S_a(\pi f T_0)\right]^4 df$

$= \frac{1}{\pi T_0}\left(\frac{\pi}{3}\right) = \frac{1}{3T_0}$ $\Rightarrow$ $\underline{\underline{B_{eq} = \frac{1}{3T_0}}}$

(d.) $B_{zero\ cross} = \frac{1}{T_0}$ (Similar to 2-90(d) above)