Chapter 1

1-6

Let p_1 = prob. of sending a binary 1

(a) p_2 = prob. of sending a binary 0 $= 1 - p_1$

$$H = \sum_{i=1}^{2} P_i I_i = p_1 \log_2\left(\frac{1}{p_1}\right) + (1-p_1)\log_2\left(\frac{1}{1-p_1}\right)$$

$$H = \frac{1}{\ln 2}\left[-p_1 \ln(p_1) - (1-p_1)\ln(1-p_1)\right]$$

$$\frac{\partial H}{\partial p_1} = 0 \Rightarrow -(\ln p_1 + 1) - \left((-1)\ln(1-p_1) + \frac{1-p_1}{1-p_1}(-1)\right) = 0$$

$$\Rightarrow -\ln p_1 - \cancel{1} + \ln(1-p_1) + \cancel{1} = 0$$

or $\ln\left(\frac{1-p_1}{p_1}\right) = 0 = \ln 1$

thus $\frac{1}{p_1} - 1 = 1 \Rightarrow \underline{\underline{p_1 = \frac{1}{2} = p_2}}$

(b) $H_{max} = \frac{1}{2}\log_2 2 + \left(1 - \frac{1}{2}\right)\log_2 2 = \underline{\underline{1 \text{ bit}}}$

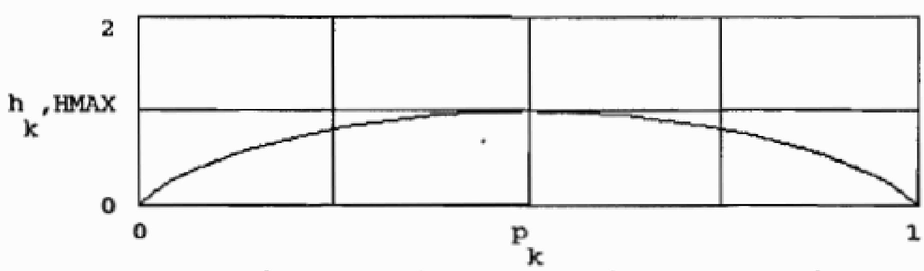
Math CAD Solution

LET p=The probability for sending a binary 1, then the probability for sending a binary 0 is (1-p). From the entropy formula for H(p), we can draw the figure of H(p) ,and from this figure , we can find the maximum entropy and the p.

H(p)=(p*ln(P)+(1-p)*ln(1-p))/(-ln(2))

$k \equiv 0 \,..50 \qquad p_k := \frac{k}{50} \qquad HMAX := 1$

$$h_k := \frac{-1}{\ln(2)}\left[p_k \ln\left[p_k\right] + \left[1 - p_k\right]\cdot\ln\left[1 - p_k\right]\right]$$



From the.above figure, we know the maximum entropy is 1 where the probability for sending 1 or 0 is 0.5.

1-8

$M = 10 \qquad P_j = \frac{1}{10} \quad j = 1, 10 \qquad R = \frac{H}{T} = 2\frac{b}{s}$

$$H = \frac{-10(.1)\ln .1}{\ln 2} = 3.322 \text{ bits}$$

$$T = \frac{H}{R} = \frac{3.322 \text{ bits}}{2 \text{ bits/sec}} = \underline{\underline{1.661 \text{ sec.} = T}}$$

1-11

(a) chars := 110 Number of characters available

$b := \text{ceil}\left[\frac{\log(\text{chars})}{\log(2)}\right]$ Number of bits required to represent a character

$\Longrightarrow$ b = 7 bits

(b) B := 3200 Hz Channel bandwidth
SNRdB := 20 dB Signal to noise ratio

$\text{SNR} := 10^{\frac{\text{SNRdB}}{10}}$ $\Longrightarrow$ SNR = 100 (Absolute power ratio)

$C := B\cdot\left[\frac{\log(1 + \text{SNR})}{\log(2)}\right]$ $\Longrightarrow$ $C = 2.131\cdot 10^4$ Channel capacity (bits/sec)

$C := \frac{C}{b}$ $\Longrightarrow$ $C = 3.044\ 10^3$ Channel capacity (chars/sec)

(c) Assuming equally likely characters,
information content of each character is:

$P := \frac{1}{\text{chars}}$ Probability of each character

$I := \frac{\log\left[\frac{1}{P}\right]}{\log(2)}$ $\Longrightarrow$ I = 6.781 bits

Chapter 2

2-1

$$v(t) = A\sin\omega_0 t \;;\quad V_{rms}^2 = \langle v^2(t)\rangle$$

$$\langle v^2(t)\rangle = \frac{1}{T_0}\int_0^{T_0} A^2\sin^2\omega_0 t\,dt = \frac{A^2}{T_0}\int_0^{T_0}\Big[1-\overset{\frac{1}{2}[1+\cos(2\omega_0 t)]}{\cancel{\cos^2(\omega_0 t)}}\Big]dt$$

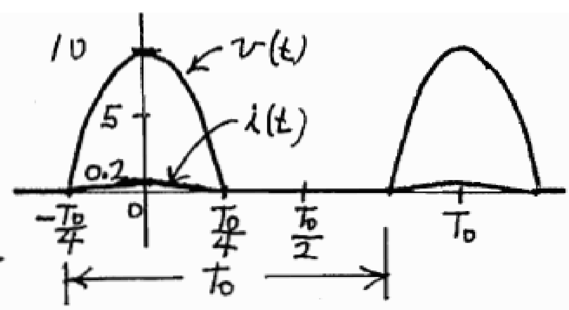
$$= \frac{A^2}{T_0}\Big[T_0 - \frac{T_0}{2} - \frac{1}{2}\underbrace{\int_0^{T_0}\cos(2\omega_0 t)\,dt}_{0}\Big] = \frac{A^2}{\cancel{T_0}}\left(\frac{\cancel{T_0}}{2}\right)$$

$$\Rightarrow V_{rms} = \sqrt{\langle v^2(t)\rangle} = \sqrt{\frac{A^2}{2}} = \underline{\underline{\frac{A}{\sqrt{2}}}}$$

2-3

(a.) $i(t) = \dfrac{v(t)}{R} = \dfrac{v(t)}{50}$

$$i(t) = \begin{cases} 0.2\cos(\omega_0 t), & |t-nT_0| < \frac{T_0}{2} \\ 0, & t \text{ elsewhere} \end{cases}$$



(b.)

$$V_{DC} = \langle v(t)\rangle = \frac{V_p}{T_0}\int_{-\frac{T_0}{4}}^{\frac{T_0}{4}}\cos(\omega_0 t)\,dt = \frac{2V_p}{T_0}\,\frac{\sin(\omega_0 \frac{T_0}{4})}{\omega_0}$$

$$= \frac{2V_p}{\cancel{T_0}}\,\frac{\sin\left(\frac{2\pi}{\cancel{T_0}}\frac{\cancel{T_0}}{4}\right)}{\frac{2\pi}{\cancel{T_0}}} = \frac{\cancel{2}}{\cancel{2}\pi}V_p\sin\left(\frac{\pi}{2}\right)$$

$$\Rightarrow V_{DC} = \frac{V_p}{\pi} \underset{V_p=10}{=} \frac{10}{\pi} = \underline{\underline{3.183 \text{ volts}}}$$

$$\Rightarrow I_{DC} = \frac{I_p}{\pi} \underset{I_p=0.2}{=} \frac{0.2}{\pi} = \underline{\underline{0.064 \text{ Amps}}}$$

2-3 (Continued)

(c.) $V_{rms}^2 = \langle v^2(t) \rangle = \frac{1}{T_0}\int_0^{T_0/2} v^2(t)dt = \frac{V_p^2}{T_0}\int_{-T_0/4}^{T_0/4} \cos^2\omega_0 t\, dt$

$\Rightarrow V_{rms}^2 = \frac{V_p^2}{T_0}\int_{-T_0/4}^{T_0/4} \frac{1}{2}[1+\cos(2\omega_0 t)]dt = \frac{V_p^2}{2T_0}\left[2\frac{T_0}{4} + \frac{\sin(2\omega_0 t)}{2\omega_0}\Big|_{-T_0/4}^{T_0/4}\right]$

$= \frac{V_p^2}{2T_0}\frac{2T_0}{4} = \frac{V_p^2}{4} = V_{rms}^2$

$\Rightarrow V_{rms} = \frac{V_p}{2} = \frac{10}{2} = \underline{\underline{5 \text{ volts rms}}}$

$I_{rms} = \frac{I_p}{2} = \frac{0.2}{2} = \underline{0.1 \text{ amps}}$

(d) $P = \langle p(t) \rangle = V_{rms} I_{rms} = (5)(0.1) = \underline{\underline{0.5 \text{ watts}}}$

2-7

(a.) $P_{in} = \frac{V_{rms}^2}{R_{in}} = \frac{(3.5\times10^{-6})^2}{300} = \underline{\underline{4.083\times10^{-14} W}}$

(b.) $dBm = 10\log_{10}\left(\frac{P}{10^{-3}}\right) = 10\log_{10}\left(\frac{4.08\times10^{-14}}{10^{-3}}\right) = \underline{\underline{-103.9\, dBm}}$

(c.) $P_{in} = \frac{V_{rms}^2}{75} = 4.08\times10^{-14}$

$\Rightarrow V_{rms} = \sqrt{75(4.08\times10^{-14})} = \underline{\underline{1.75\,\mu\text{volts}}}$

2-10

$$W(f) = \int_{-\infty}^{\infty} w(t) e^{-j\omega t}\,dt = \int_{1}^{\infty} e^{-(\alpha+j\omega)t}\,dt$$

$$= \left.\frac{e^{-(\alpha+j\omega)t}}{-(\alpha+j\omega)}\right|_{1}^{\infty} = \underline{\underline{\frac{e^{-\alpha}\, e^{-j2\pi f}}{\alpha + j2\pi f} = W(f)}}$$

2-13

$$S(f) = \int_{-\infty}^{\infty} s(t)\, e^{-j\omega t}\,dt = \int_{0}^{T_0} A t\, e^{-j\omega t}\,dt$$

$$= A\left[e^{-j\omega t}\left(\frac{t}{-j\omega} + \frac{1}{\omega^2}\right)\right]\Bigg|_{0}^{T_0}$$

$$\int x e^{ax}\,dx = e^{ax}\left[\frac{x}{a} - \frac{1}{a^2}\right]$$

$$= A\left\{e^{-j\omega T_0}\left(\frac{T_0}{-j\omega} + \frac{1}{\omega^2}\right) - \frac{1}{\omega^2}\right\}$$

$$= \frac{A}{(2\pi f)^2}\left\{e^{-j2\pi f T_0} - 1\right\} + \frac{A T_0\, e^{-j2\pi f T_0}}{-j\,2\pi f}$$

$$\Rightarrow \underline{\underline{S(f) = \frac{-A}{(2\pi f)^2} + A\, e^{-j2\pi f T_0}\left(\frac{1}{(2\pi f)^2} + j\,\frac{T_0}{2\pi f}\right)}}$$

2-18

(a.)

$M := 8 \qquad N := 2^M \qquad N = 256 \qquad k := 0 \,..\, N-1 \qquad T := 40$

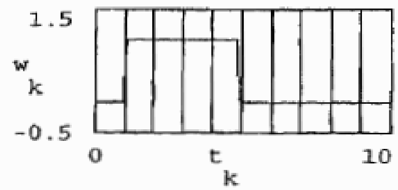
$dt := \frac{T}{N} \qquad t_k := k\,dt - 10$

$w_k := \Phi\left[t_k - 1.0\right] - \Phi\left[t_k - 5.0\right]$

$w_0 = 0 \qquad dt = 0.156$

$f4 := 4$

WAVEFORM



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

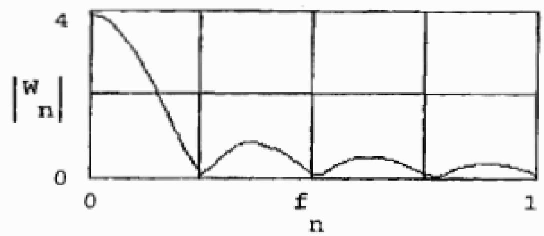
$W := dt\left[\sqrt{N}\right]\,\mathrm{icfft}(w)$

MAGNITUDE SPECTRUM out to 4th null

$f_n := \frac{n}{T} \qquad fs := \frac{1}{dt}$

$W_0 = 3.906 \qquad fs = 6.4$

$f_1 = 0.025 \qquad f4 = 4$

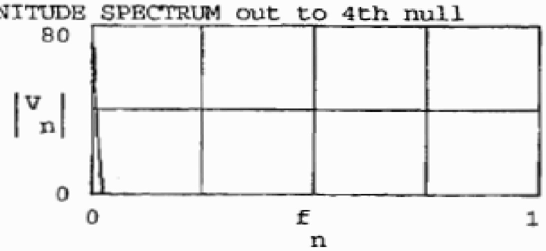


(b.) $v_k := 2.0$

$V := dt\cdot\left[\sqrt{N}\right]\,\mathrm{icfft}(v)$

$V_0 = 80$

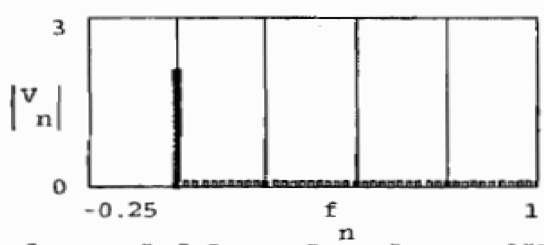
MAGNITUDE SPECTRUM out to 4th null



NOTE: The FFT cannot give the correct amplitude value for a delta function since the delta function has an infinite amplitude. However the area under the FFT result that approximates the delta function will be approximately the correct weight for the delta function. The value for the weight of the delta function may be calculated directily via the FFT by using (2-187). This is shown below.

$V := \left[\frac{1}{\sqrt{N}}\right]\,\mathrm{icfft}(v)$

$V_0 = 2 \qquad$ <--Weight of δ

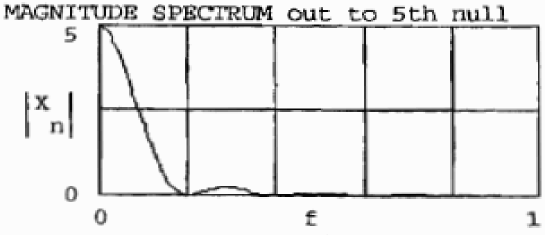


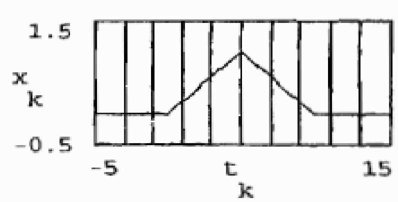
(c.)

$x_k := 0.2\left[t_k\left[\Phi\left[t_k\right] - \Phi\left[t_k - 5\right]\right] - \left[t_k - 10\right]\left[\Phi\left[t_k - 5\right] - \Phi\left[t_k - 10\right]\right]\right]$

$X := dt\left[\sqrt{N}\right]\,\mathrm{icfft}(x)$

MAGNITUDE SPECTRUM out to 5th null



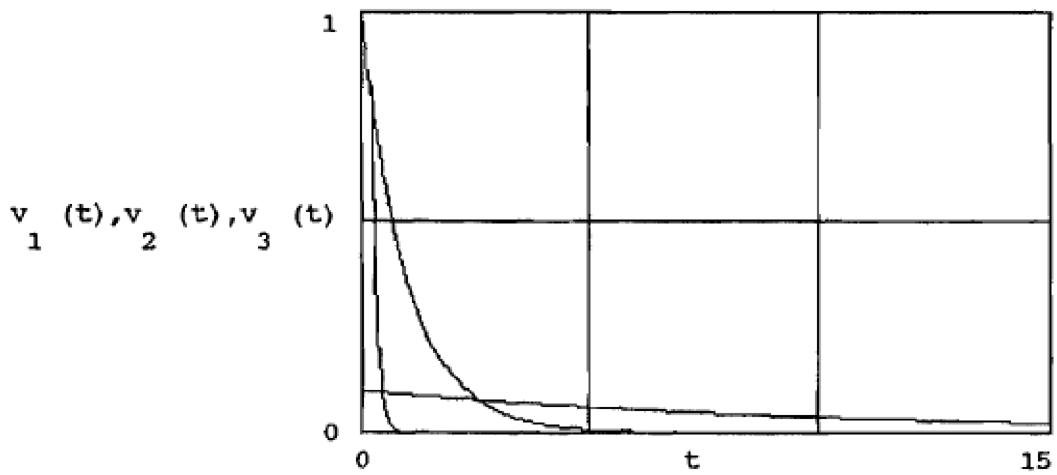


$X_0 = 5$

2-25

(a) $t := 0, 0.05 .. 15$

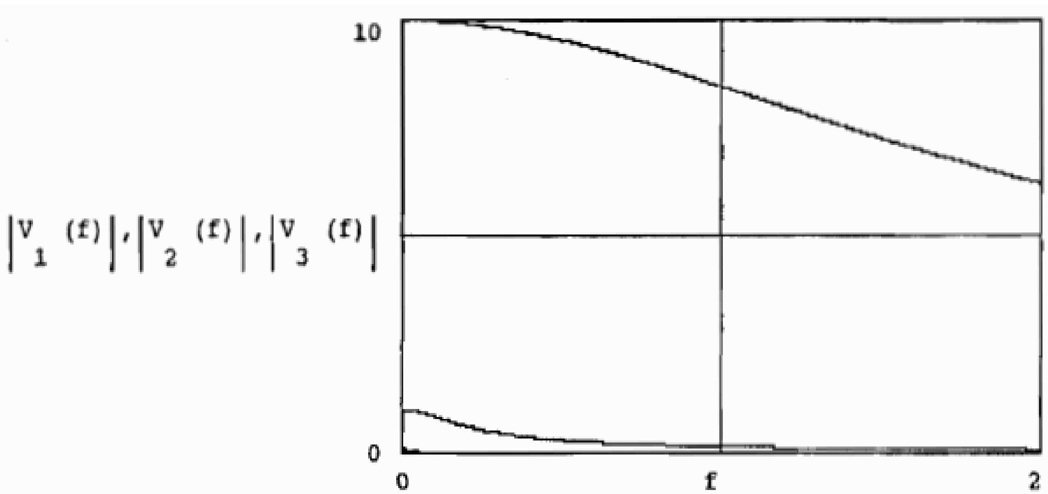
$v_1(t) := 0.1 \cdot e^{-0.1\,t}$ $\quad v_2(t) := e^{-t}$ $\quad v_3(t) := 10 \cdot e^{-10 \cdot t}$



(b) $f := 0, 0.001 .. 2$

$V_1(f) := \dfrac{0.1}{1 + j \cdot 20\,\pi \cdot f}$ $\quad V_2(f) := \dfrac{1}{1 + j\; 2 \cdot \pi \cdot f}$ $\quad V_3(f) := \dfrac{10}{1 + j \cdot 0.2 \cdot \pi \cdot f}$

$V_1(0) = 0.1$ $\quad V_2(0) = 1$ $\quad V_3(0) = 10$



2-29

$$w(t) = w_1(t)\,w_2(t)$$

$$W(f) = \int_{-\infty}^{\infty} w(t)\,e^{-j\omega t}\,dt = \int_{-\infty}^{\infty} w_1(t)\,w_2(t)\,e^{-j\omega t}\,dt$$

$$= \int_{-\infty}^{\infty}\left[\int_{-\infty}^{\infty} W_1(\lambda)\,e^{j2\pi\lambda t}\,d\lambda\right] w_2(t)\,e^{-j2\pi f t}\,dt$$

$$= \int_{-\infty}^{\infty} W_1(\lambda) \underbrace{\int_{-\infty}^{\infty} w_2(t)\,e^{-j2\pi(f-\lambda)t}\,dt}_{W_2(f-\lambda)}\,d\lambda = \int_{-\infty}^{\infty} W_1(\lambda)\,W_2(f-\lambda)\,d\lambda = W(f)$$

2-34

(a.) $\int_{-\infty}^{\infty} \frac{\sin 4\lambda}{4\lambda}\,\delta(t-\lambda)\,d\lambda = \underline{\underline{\frac{\sin(4t)}{4t}}}$

(b.) $\int_{-\infty}^{\infty} (\lambda^3-1)\,\delta(2-\lambda)\,d\lambda = 2^3-1 = \underline{\underline{7}}$

2-40

$$s(t) = A_1\cos(\omega_1 t+\phi_1) + A_2\cos(\omega_2 t+\phi_2)$$

2-40 (Continued)

$\phi_2 = 0$ for simplicity

(a.) $\omega_1 = \omega_2$; $\phi_1 = \phi_2 = 0$

$$s(t) = (A_1 + A_2)\cos\omega_1 t$$

$$s_{rms}(t) = \left[(A_1+A_2)^2 \frac{1}{T}\int_0^T \cos^2(\omega_1 t)\,dt\right]^{1/2}$$

$$= (A_1+A_2)\left[\frac{1}{2\pi}\int_0^{2\pi}\left(\frac{1}{2} + \frac{1}{2}\cos(2\theta)\right)d\theta\right]^{1/2}$$

$\omega t = \theta$

$dt = \frac{d\theta}{\omega_1} = \frac{d\theta\, T}{2\pi}$

$$= (A_1+A_2)\left[\frac{1}{2\pi}\left(\frac{1}{2}\right)2\pi\right]^{1/2} = \underline{\underline{\frac{(A_1+A_2)}{\sqrt{2}}}}$$

(b.) $\omega_1 = \omega_2$; $\phi_1 = \phi_2 + \pi/2 = \pi/2$

$$s(t) = A_1\cos(\omega t + \pi/2) + A_2\cos(\omega t)$$

$$= A_1(0 - \sin\omega t\,\sin\pi/2) + A_2\cos\omega t$$

$\cos(A+B) = \cos(A)\cos(B) - \sin(A)\sin(B)$

$$= -A_1\sin\omega t + A_2\cos\omega t$$

$$\langle s^2(t)\rangle = \langle A_1^2\sin^2(\omega t)\rangle - \langle A_1A_2\sin(\omega t)\cos(\omega t)\rangle \xrightarrow{} 0 \text{ odd}$$

$$+ \langle A_2^2\cos^2(\omega t)\rangle = \frac{A_1^2 + A_2^2}{2}$$

$$\therefore s_{rms}(t) = \underline{\underline{\frac{\sqrt{(A_1^2+A_2^2)}}{\sqrt{2}}}}$$

2-40 (Continued)

(c.) $\omega_1 = \omega_2$; $\Phi_1 = \Phi_2 + \pi = \pi$

$$s(t) = A_1 \cos(\omega t + \pi) + A_2 \cos \omega t$$

$$= (A_2 - A_1) \cos \omega t$$

$$\underline{\underline{s_{rms}(t) = \frac{(|A_2 - A_1|)}{\sqrt{2}}}}$$ from (a.) above

(d.) $\omega_1 = 2\omega_2$; $\phi_1 = \phi_2 = 0$

$$s(t) = A_1 \cos(2\omega_2 t) + A_2 \cos(\omega_2 t)$$

$$\langle s^2(t) \rangle = \langle A_1^2 \cos^2(2\omega_2 t) \rangle + A_1 A_2 \langle \cos(2\omega_2 t) \cos(\omega_2 t) \rangle + \langle A_2^2 \cos^2(\omega_2 t) \rangle$$

0

$$\therefore \underline{\underline{s_{rms}(t) = \frac{\sqrt{(A_1^2 + A_2^2)}}{\sqrt{2}}}}$$

(e.) $\omega_1 = 2\omega_2$; $\phi_1 = \Phi_2 + \pi = \pi$

$$s(t) = A_1 \cos(2\omega_2 t + \pi) + A_2 \cos(\omega_2 t)$$

$$= -A_1 \cos(2\omega_2 t) + A_2 \cos(\omega_2 t)$$

$$\langle s^2(t) \rangle = \frac{(A_1^2 + A_2^2)}{2}$$

$$\underline{\underline{s_{rms}(t) = \frac{\sqrt{(A_1^2 + A_2^2)}}{\sqrt{2}}}}$$

2-43

Use (2-110) and (2-112)

(a.) $c_n = f_0 \, P(f)\Big|_{f=nf_0}$

where $P(f) = \mathcal{F}[p(t)] = \int_{-\infty}^{\infty} p(t)\, e^{-j\omega t}\, dt$

For $f=0$

$$P(0) = \int_0^T At\, dt = \frac{At^2}{2}\Big|_0^T = \frac{AT^2}{2}, \quad f=0$$

For $f \neq 0$

$$P(f) = \int_0^T At\; e^{-j\omega t}\, dt$$

Let $u = At \quad dv = e^{-j\omega t}$
$du = A\,dt \quad v = e^{-j\omega t}/-j\omega$

$$P(f) = \frac{Ate^{-j\omega t}}{-j\omega}\Big|_0^T + \frac{A}{j\omega}\int_0^T e^{-j\omega t}\, dt$$

$$= \frac{jATe^{-j\omega T}}{\omega} + \frac{A}{\omega^2}\left(e^{-j\omega T} - 1\right)$$

$$P(f) = \frac{A\left[e^{-j\omega T} + j\omega T e^{-j\omega T} - 1\right]}{\omega^2}, \quad f \neq 0$$

$$c_n = \frac{1}{T_0} P\left(\omega = \frac{n2\pi}{T_0}\right) = f_0\, P(\omega = n2\pi f_0)$$

$$c_n = \begin{cases} \dfrac{AT^2}{2T_0}, & n=0 \\[2ex] \dfrac{A\left[e^{-j2\pi n f_0 T}(1 + jn2\pi f_0 T) - 1\right]}{T_0\,\omega^2}, & n \neq 0 \end{cases}$$

(b.) $x_n = \mathrm{Re}\{c_n\}$; $y_n = \mathrm{Im}\{c_n\}$

$$c_n = \frac{A\left\{\left[\cos(n2\pi f_0 T) - j\sin(n2\pi f_0 T)\right] \cdot \left[1 + jn2\pi f_0 T\right] - 1\right\}}{T_0\,\omega^2}$$

2-43 (Continued)

$$x_n = \begin{cases} \dfrac{AT^2}{2T_0}, & n=0 \\ A\left\{\dfrac{\cos(n2\pi f_0 T) + n2\pi f_0 T \sin(n2\pi f_0 T) - 1}{T_0 \omega^2}\right\}, & n \neq 0 \end{cases}$$

$$y_n = \begin{cases} 0, & n=0 \\ A\left\{\dfrac{n2\pi f_0 T \cos(n2\pi f_0 t) - \sin(n2\pi f_0 T)}{T_0 \omega^2}\right\}, & n \neq 0 \end{cases}$$

(c.)

$$D_n = \begin{cases} c_0, & n=0 \\ 2\sqrt{x_n^2 + y_n^2}, & n \geq 1 \end{cases}, \quad \phi_n = \begin{cases} 0, & n=0 \\ \tan^{-1}\left(\dfrac{y_n}{x_n}\right), & n \geq 1 \end{cases}$$

2-52

$$x(t) = e^{-400\pi t} \longleftrightarrow X(f) = \frac{1}{400\pi + j2\pi f}$$

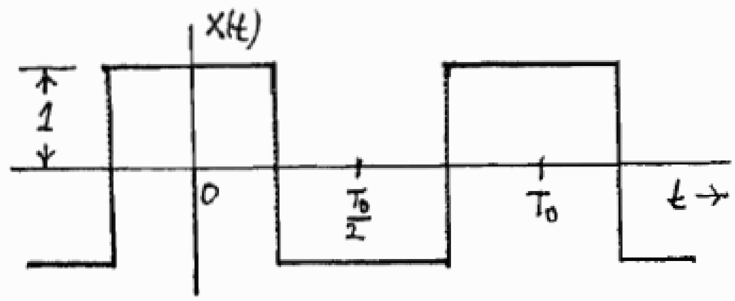
$$\text{Energy in } x(t) = E_x = \int_{\infty} x^2(t)\,dt = \int_0^{\infty} e^{-800\pi t}\,dt = \frac{1}{800\pi} \text{ Joules}$$

$$E_{out} = \frac{1}{2}E_x = \frac{1}{1600\pi} = 2\int_0^B |X(f)|^2 df = 2\int_0^B \frac{\frac{1}{4\pi^2}}{4\times10^4 + f^2}df = \frac{1}{2\pi}\left[\frac{1}{200}\tan^{-1}\left(\frac{B}{200}\right)\right]$$

$$\Rightarrow \frac{400\pi\cancel{\pi}}{\cancel{1600}\pi} \frac{}{4} = \tan^{-1}\left(\frac{B}{200}\right) \Rightarrow \frac{B}{200} = \tan\left(\frac{\pi}{4}\right) = 1$$

$$\Rightarrow \underline{\underline{B = 200\text{ Hz}}}$$

2-57



Let the input square wave be represented by the Fourier series:

$$x(t) = \sum_{n=-\infty}^{\infty} c_n e^{jn\omega_0 t}$$

where

$$c_n = \begin{cases} \dfrac{2\sin\left(n\frac{\pi}{2}\right)}{n\pi}, & n \neq 0 \\ 0, & n = 0 \end{cases}$$

for the waveform shown above.

Then the output waveform is, using (2-140),

$$y(t) = \sum_{-\infty}^{\infty} H(nf_0)\, c_n e^{jn\omega_0 t} = \sum_{-\infty}^{\infty} d_n e^{jn\omega_0 t}$$

where $d_n \triangleq H(nf_0)\, c_n$, $\quad H(f) = \dfrac{1}{1 + j\left(\frac{f}{f_1}\right)}$

and $f_1 = 1{,}500$ Hz for the RC low-pass filter.

2-57 (Continued)

We also know that $d_{-n} = d_n^*$ since $x(t)$ is real and the impulse response of the filter is real.

Now reduce the output Fourier series to a form that can be easily plotted. Using (2-103),

$$y(t) = D_0 + \sum_{n=1}^{n=\infty} D_n \cos(n\omega_0 t + \phi_n)$$

where $D_0 = 0$ since $c_0 = 0$

and $D_n = 2|d_n| = 2|H(nf_0)c_n|$, $n>0$

or

$$\Rightarrow D_n = 2\left|\frac{1}{1+j\left(\frac{nf_0}{f_1}\right)}\right|\left|\begin{cases}\frac{2}{n\pi}, & n=\text{odd}\\ 0, & n=\text{even}\end{cases}\right| = \underline{\frac{4}{\sqrt{1+\left(\frac{nf_0}{f_1}\right)^2}\,(n\pi)}, \quad n=\text{odd}}$$

$$\phi_n = \angle d_n = \angle 2H(nf_0)c_n = \underline{-\tan^{-1}\left(\frac{nf_0}{f_1}\right) + \pi\left(\frac{1-\sin\left(\frac{n\pi}{2}\right)}{2}\right), \quad n=\text{odd}}$$

$$\Rightarrow y(t) = \underline{\underline{\sum_{\substack{n=1\\ n=\text{odd}}}^{\infty} D_n \cos(n\omega_0 t + \phi_n)}}$$

The following MathCAD program plots this $y(t)$.

```
fo := 300        f1 := 1500        n := 1,3 .. 11

                                   t := 0,0.00005 ..0.004
```

$$D_n := \frac{4}{n\,\pi\sqrt{1+\left[n\,\frac{fo}{f1}\right]^2}}$$

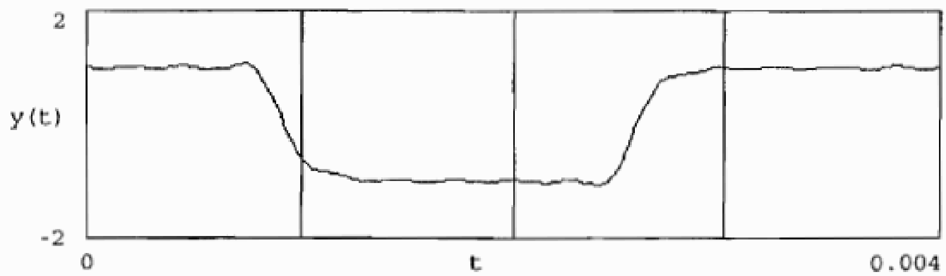
2-57 (Continued)

$$\phi_n := \pi \left[\frac{1 - \sin\left[n \frac{\pi}{2}\right]}{2}\right] - \operatorname{atan}\left[n \frac{fo}{f1}\right]$$

$$y(t) := \sum_n D_n \cos\left[n\, 2\, \pi\, fo\, t + \phi_n\right]$$

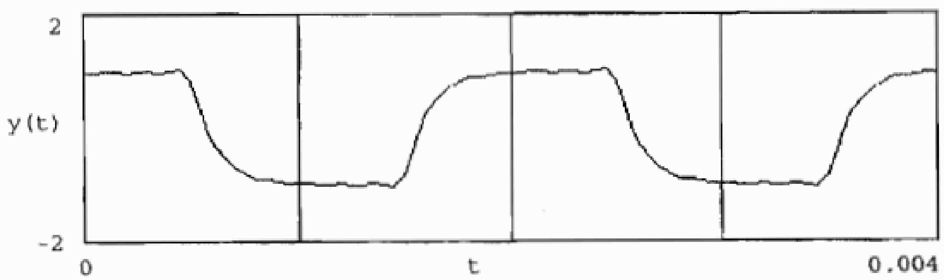
(a)

fo = 300



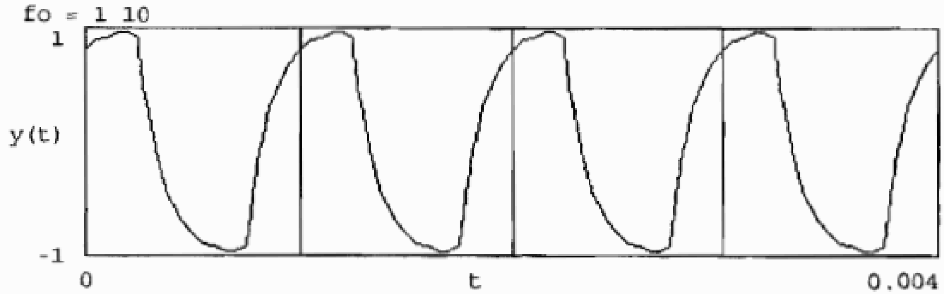
(b)

fo = 500



(c)

$fo = 1\ 10^{3}$



2-60

$$\omega_0 = 2\pi f_0 = 500 \Rightarrow f_0 = \frac{500}{2\pi}$$

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

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

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

2-62

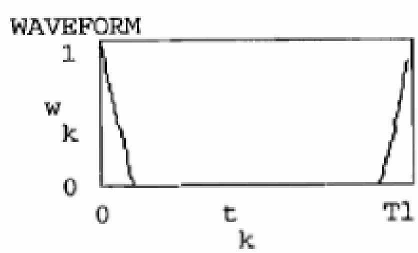
$M := 6 \qquad N := 2^M \qquad N = 64 \qquad k := 0 .. N-1 \qquad T1 := 10 \qquad T := 1$

$dt := \frac{T1}{N} \qquad t_k := k\, dt$

NOTE: In FFT time domain, points for negative time are the same as those measured from the end of the data span-length T1 for positive time.

$$w_k := \mathrm{if}\left[t_k < T, \left[\frac{-1}{T}\right]\left[t_k - T\right], 0\right] + \mathrm{if}\left[t_k > (T1 - T), \frac{t_k - (T1 - T)}{T}, 0\right]$$

$w_0 = 1 \qquad dt = 0.156$

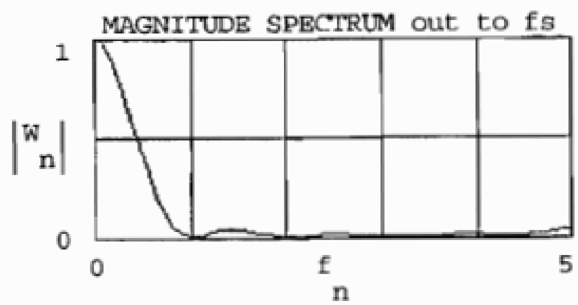


$n := 0 .. N-1$

$W := dt\left[\sqrt{N}\right] \mathrm{icfft}(w)$

$f_n := \frac{n}{T1} \qquad fs := \frac{1}{dt}$

$f_1 = 0.1 \qquad fs = 6.4$



2-68

$$s(t) = \Lambda\left(\frac{t}{T_0}\right) \xleftrightarrow{} S(f) = T_0\left[S_a(\pi f T_0)\right]^2$$

Table 2-2

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

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

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

(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 (4) above)