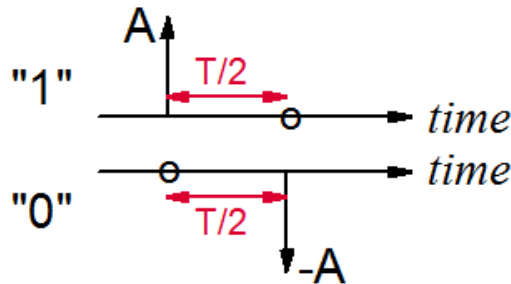


EE3101 Tutorial 2 Solutions

- (1) The waveform of “1” ($s_1(t)$) is not equal to the negative waveform of “0” ($s_2(t)$), i.e. $s_1(t) \neq -ks_2(t)$ { k is a constant and $k=1$ here}, $\rightarrow$ we can’t use single discrete impulse with separation T , amplitudes A and $-A$ to represent the coded waveforms for “1” and “0” respectively.

One possible solution is to use the following discrete impulses for represent “1” and “0”.



(2)

Method I

Assume that binary “1” and “0” are represented by discrete impulses with amplitude A and $-A$ respectively.

$$R_0 = (A)^2 / 2 + (-A)^2 / 2 = A^2$$

$$\forall r \neq 0, R_r = (A)(A) / 4 + (A)(-A) / 4 + (-A)(A) / 4 + (-A)(-A) / 4 = 0$$

$$P(\omega) = \frac{1}{T} \sum_{r=-\infty}^{\infty} R_r \exp(-jr\omega T) = \frac{A^2}{T}$$

Since each impulse generates two pulses (with $T/2$ apart), i.e.

$$\begin{aligned} H(\omega) &= \frac{T}{4} \frac{\sin(\omega T / 8)}{(\omega T / 8)} + \exp(-j\omega T / 2) \left[\frac{T}{4} \frac{\sin(\omega T / 8)}{(\omega T / 8)} \right] \quad \{\text{Assume } t=0 \text{ is at the middle of the 1st pulse}\} \\ &= \frac{T}{4} \frac{\sin(\omega T / 8)}{(\omega T / 8)} \exp(-j\omega T / 4) [\exp(j\omega T / 4) + \exp(-j\omega T / 4)] \end{aligned}$$

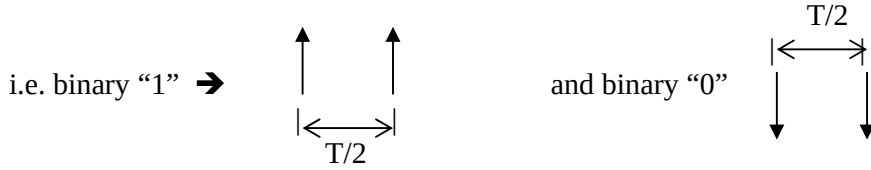
$$|H(\omega)|^2 = \frac{T^2}{4} \frac{\sin^2(\omega T / 8)}{(\omega T / 8)^2} \cos^2(\omega T / 4)$$

$$S(\omega) = |H(\omega)|^2 P(\omega)$$

$$S(\omega) = \frac{A^2 T}{4} \frac{\sin^2(\omega T / 8)}{(\omega T / 8)^2} \cos^2(\omega T / 4)$$

Method II

Assume that “1” is represented by 2 discrete impulses with amplitude A and with $T/2$ separation, “0” is represented by 2 discrete impulses with amplitude $-A$ and with $T/2$ separation, as shown in the following figure.



Each impulse generates one pulse with pulsewidth $T/4$, i.e.

$$H(\omega) = \frac{T}{4} \frac{\sin(\omega T / 8)}{(\omega T / 8)}$$

$$R_0 = (A)^2 / 4 + (A)^2 / 4 + (-A)^2 / 4 + (-A)^2 / 4 = A^2$$

$$R_1 = \frac{AA}{4} + A \frac{\frac{A}{2} + \frac{-A}{2}}{4} + \frac{(-A)(-A)}{4} + (-A) \frac{\frac{A}{2} + \frac{-A}{2}}{4} = \frac{A^2}{2}$$

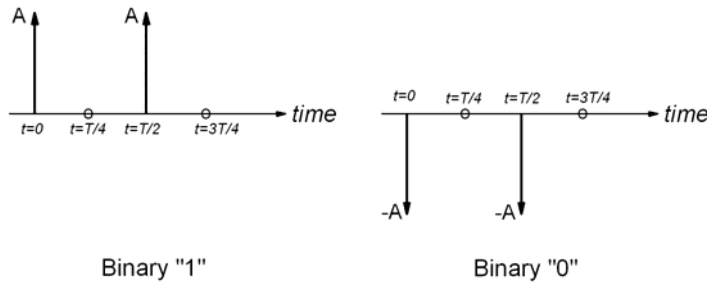
$$\forall r \neq 0, 1 \quad R_r = 0$$

$$\begin{aligned} P(\omega) &= \frac{1}{T/2} \sum_{r=-\infty}^{\infty} R_r \exp(-jr\omega T / 2) \\ &= \frac{2A^2}{T} \left[\frac{\exp(j\omega T / 2)}{2} + 1 + \frac{\exp(-j\omega T / 2)}{2} \right] \\ &= \frac{2A^2}{T} [1 + \cos(\omega T / 2)] \\ &= \frac{4A^2}{T} \cos^2(\omega T / 4) \end{aligned}$$

$$S(\omega) = \frac{A^2 T}{4} \frac{\sin^2(\omega T / 8)}{(\omega T / 8)^2} \cos^2(\omega T / 4)$$

Method III

Assume that “1” is represented by 4 discrete impulses with amplitude A , 0, A , 0 and with $T/4$ separation, “0” is represented by 4 discrete impulses with amplitude $-A$, 0, $-A$, 0 and with $T/4$ separation, as shown in the following figure.



T: Bit duration

Each impulse generates one pulse with pulsewidth $T/4$, i.e.

$$H(\omega) = \frac{T}{4} \frac{\sin(\omega T / 8)}{(\omega T / 8)}$$

$$R_0 = (A)^2 / 8 + (0)^2 / 8 + (A)^2 / 8 + (0)^2 / 8 + (-A)^2 / 8 + (0)^2 / 8 + (-A)^2 / 8 + (0)^2 / 8 = A^2 / 2$$

$$R_1 = A(0)/8 + 0(A)/8 + A(0)/8 + 0[A/2 + (-A)/2]/8 \\ + (-A)(0)/8 + (0)(-A)/8 + (-A)(0)/8 + 0[A/2 + (-A)/2]..... = 0$$

$$R_2 = A(A)/8 + 0(0)/8 + A[A/2 + (-A)/2]/8 + 0(0)/8 + (-A)(-A)/8 + 0(0)/8 \\ + (-A)[A/2 + (-A)/2]/8 + 0(0)/8.$$

$$= A^2 / 4$$

$$\forall r \neq 0, 2 \quad R_r = 0$$

$$P(\omega) = \frac{1}{T/4} \sum_{r=-\infty}^{\infty} R_r \exp(-jr\omega T/4) \\ = \frac{4A^2}{T} \left[\frac{\exp(j2\omega T/4)}{4} + \frac{1}{2} + \frac{\exp(-j2\omega T/4)}{4} \right] \\ = \frac{2A^2}{T} [1 + \cos(\omega T/2)] \\ = \frac{4A^2}{T} \cos^2(\omega T/4)$$

$$S(\omega) = \frac{A^2 T}{4} \frac{\sin^2(\omega T/8)}{(\omega T/8)^2} \cos^2(\omega T/4)$$

(3) (a) CD: ~650MB; DVD: 4.7GB

(b) (i) CD: 650M x 8/3600 ~1.4Mb/s

DVD: 4700M x 8/7200 ~ 5.2Mb/s

(ii) CD: 1.4M/3 = 0.47MHz

DVD: 5.2M/3 =1.7MHz

(4) (a) (i) 3dB; (ii) 11.8dB; (iii) 21.8dB

(b) (i) 6dB; (ii) 23.5dB; (iii) 43.5dB