

## CSE3020 Network Technology Semester 2, 2003

### Tutorial 2 - Week 3

**Question T2.1** - If the solid curve in Figure 1 represents  $\sin(2\pi t)$ , what does the dotted curve represent? That is, the dotted curve can be written in the form:  $A \sin(2\pi f t + \phi)$ ; what are  $A$ ,  $f$  and  $\phi$ ?

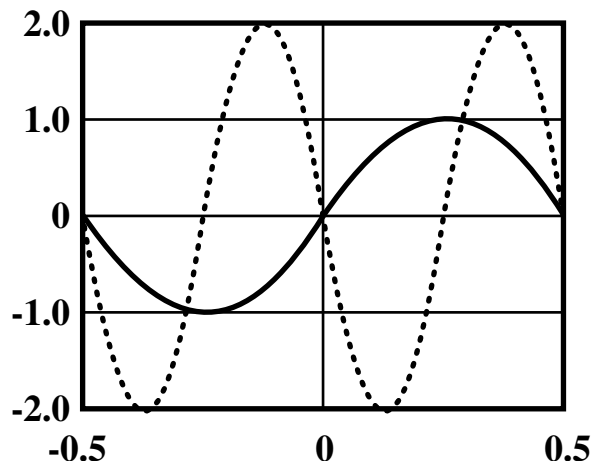


Figure 1: Sine plots for Question T2.1.

$2 \sin(4\pi t + \pi)$ ;  $A = 2$ ,  $f = 2$ ,  $\phi = \pi$  ←— *This one was preferred.*

OR

$-2 \sin(4\pi t)$ ;  $A = -2$ ,  $f = 2$ ,  $\phi = 0$

OR

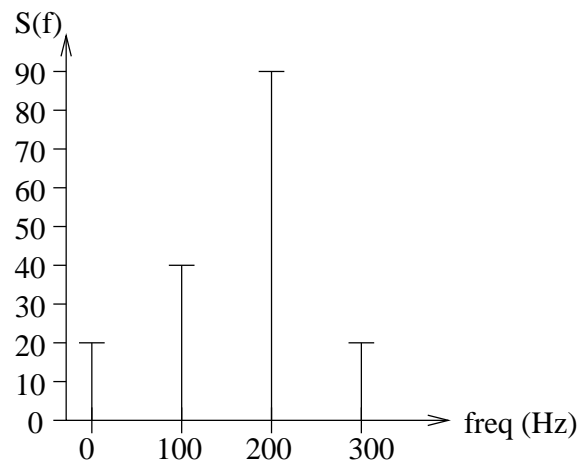
$2 \sin(-4\pi t)$ ;  $A = 2$ ,  $f = -2$ ,  $\phi = 0$

**Question T2.2** - If given the following signal:

$$s(t) = 20 + 40 \sin(200\pi t) + 20 \sin(600\pi t) + 90 \sin(400\pi t),$$

plot its amplitude frequency-domain function,  $S(f)$ . What is the bandwidth of the signal?

*Bandwidth = 300 - 0 = 300 Hz.*



**Question T2.3** - Briefly discuss why a frequency-domain analysis of communications signals is important as compare with a time-domain analysis?

- *An communications signal (or an electromagnetic signal) is made up of many frequencies (and thus a composite signal).*
- *Frequency-domain graph shows the composite signal as a series of component frequencies. It shows the signal as a set of independent frequencies.*
- *Time-domain graph illustrates a composite signal as a single entity. It shows the impact of each component on the others.*
- *The vertical bars of the frequency-domain graph give a more concise view of the relative frequencies and amplitudes of the composite sine waves.*

**Question T2.4** - Study the works of Shannon and Nyquist on channel capacity. Each places an upper limit on the bit rate of a channel based on two different approaches. How are the two related.

- *Nyquist analyzed the theoretical capacity of a noiseless channel; therefore that case, the signaling rate is limited solely by the channel bandwidth.*
- *Shannon addressed the question of what signaling rate can be achieved over a channel with a given bandwidth, a given signal power, and in the presence of noise.*
- *Error free channel.*

**Question T2.5** - Given a channel with an intended capacity of 50 Mbps, and the bandwidth is 5 MHz. According to Shannon, what signal-to-noise ratio is required to achieve this capacity?

*By using Shannon's capacity formula,*

$$C = B \log_2(1 + S/N) \quad (1)$$

$$50 \times 10^6 = 5 \times 10^6 \times \log_2(1 + S/N) \quad (2)$$

$$\log_2(1 + S/N) = 10 \quad (3)$$

$$1 + S/N = 1024 \quad (4)$$

$$S/N = 1023 \quad (5)$$

$$SNR_{dB} = 10 \log_{10}(1023) = 30.10dB \quad (6)$$

**Question T2.6** - A digital system is required to operate at 19,200 bps.

- (a) How many signaling levels are required if the channel bandwidth is 1920 Hz?
- (b) If a signal element encodes a 6-bit word, what is the minimum required bandwidth of the channel?

*By using Nyquist's capacity formula,*

(a)

$$C = 2B \log_2 M \quad (7)$$

$$2(1920) \log_2 M = 19,200 \quad (8)$$

$$\log_2 M = 5 \quad (9)$$

$$M = 32 \quad (10)$$

(b)

$$C = 2B \log_2 M \quad (11)$$

$$B = \frac{C}{2 \log_2 M} \quad (12)$$

$$= \frac{19,200}{2 \times 6} \quad (13)$$

$$= 1600Hz \quad (14)$$