LECTURE #12

Problems 4.3
A Sine wave has a frequency of 6 Hz. What is its period?
Solution

$$T = \frac{1}{f} = \frac{1}{6} = 0.17\,\text{sec}$$

Problems 4.5
A Sine wave completes one cycle in 4 seconds. What is its frequency?
Solution:

$$f = \frac{1}{T} = \frac{1}{4} = 0.25Hz$$

Another Way to look at Frequency

- Measurement of the rate of change
- The rate at which a sine wave moves from its lowest to its highest point is its frequency
- A 40 Hz signal has half the frequency of a 80 Hz signal, therefore each cycle takes twice as long to complete one cycle I.e. to go from its lowest to its highest
- Change in a short Time = High Frequency

Two Extremes Frequency

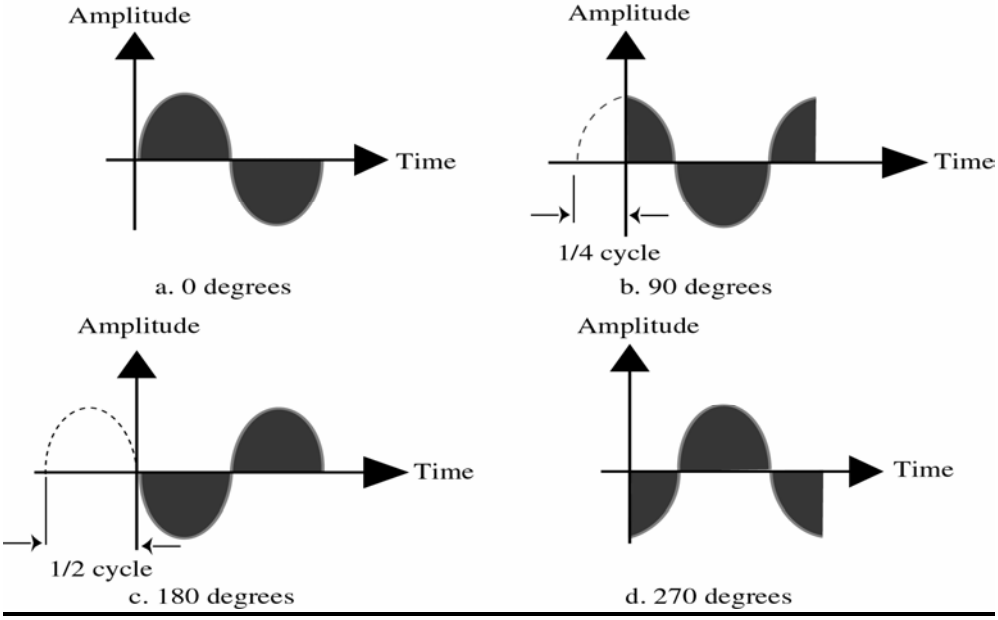
- What if a signal does not change at all?
- What if it maintains a constant voltage level the entire time?
  - ✓ In such cases , Frequency is going to be zero

- If a signal does not change, it will never complete any cycles, and frequency is no. of cycles in 1 second so Freq = 0
- No change at all ⇒
  - Zero frequency
- Instantaneous changes ⇒
  - Infinite frequency

Phase

- Phase describes the position of the waveform relative to time zero
- If we think of the wave as something that can be shifted backward or forward along the time axis
- Phase describes the amount of that shift
- It indicates the status of the first cycle
- Phase is measured in Degrees or Radians
- 360 degrees – 2 pi Radians

- A phase shift of 360 degrees correspond to a shift of a complete period
- A phase shift of 180 degree correspond to a shift of half a period
- A phase shift of 90 degree correspond to a shift of quarter a period



Problem 4.7
A sine wave is offset $\frac{1}{6}$ of a cycle with respect to time zero. What is its phase?
Solution

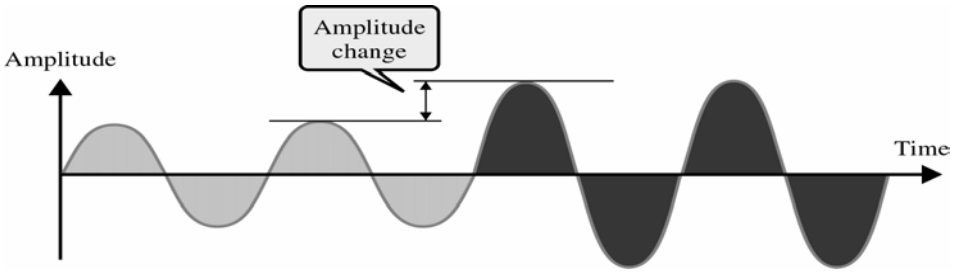
One Cycle = 360 Degrees

$\frac{1}{6}$ of a cycle $= \frac{360}{6} = 60$ Degrees

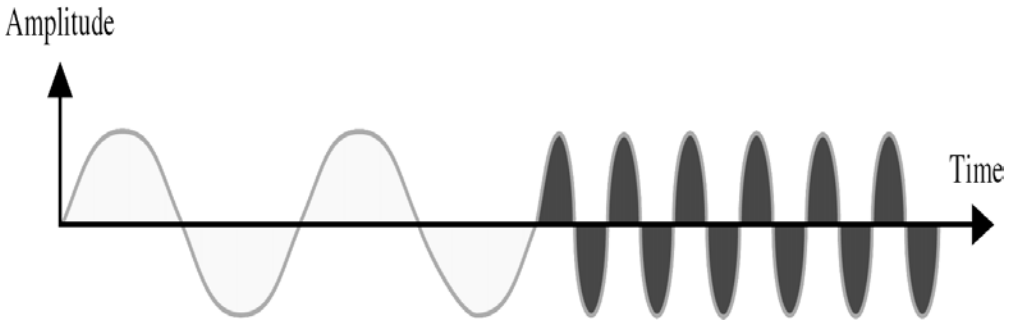
Control of Signals

- Signal can be controlled by three attributes:
  - Amplitude
  - Frequency
  - Phase

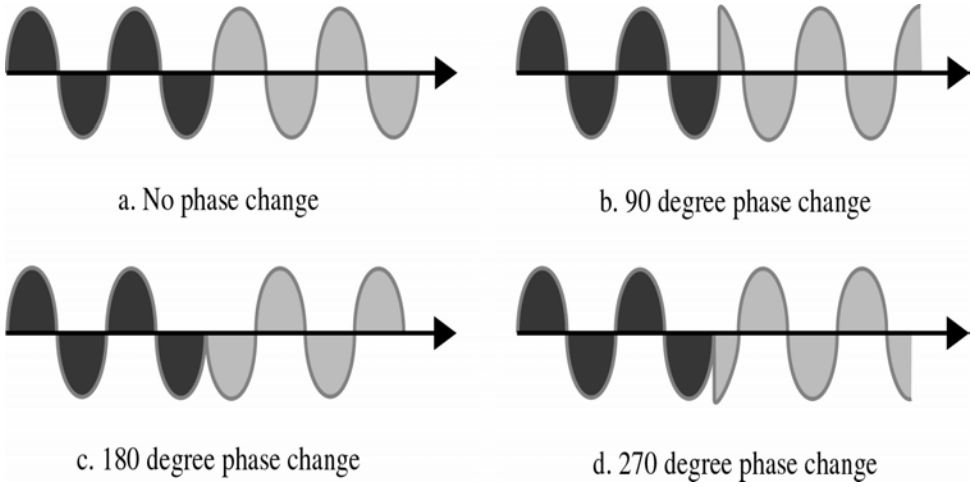
Control of Signals- Amplitude



Control of Signals- Frequency

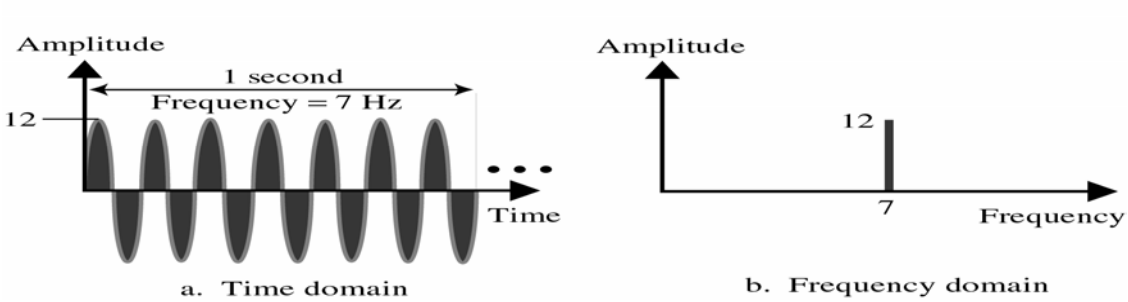


Control of Signals- Phase

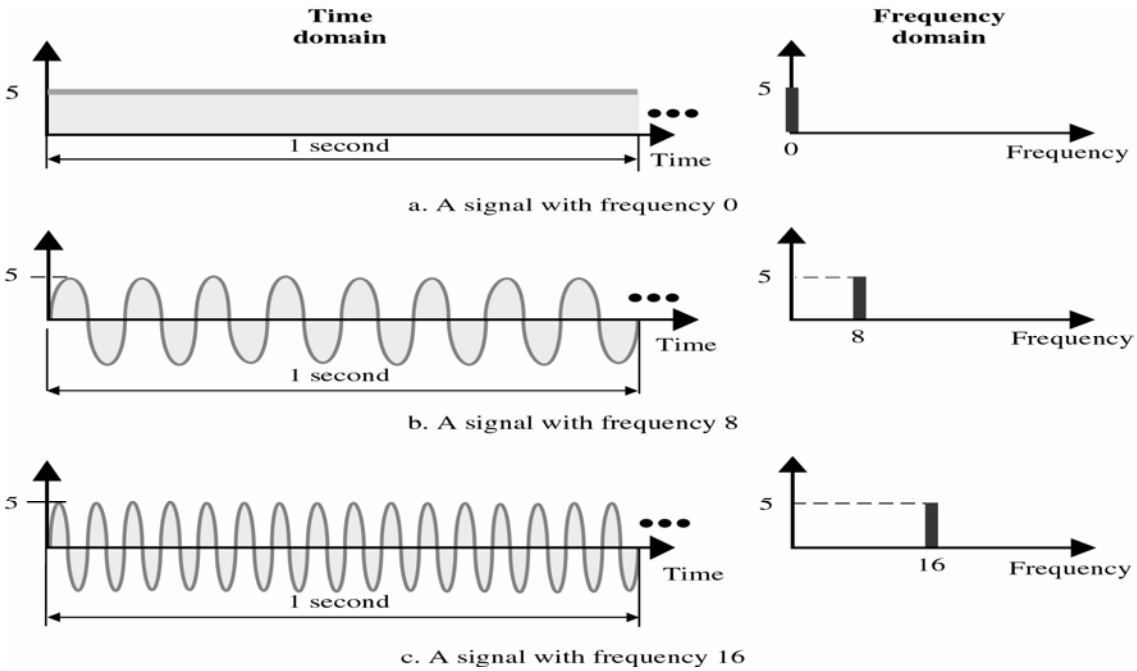


Time and Frequency Domain

- Time Domain plots show changes in signal amplitude w.r.t Time
- It is an Amplitude versus Time Plot
- Phase and Frequency are not explicitly measured on a Time domain plot
- To show the relationship between amplitude and Frequency, we can use what is called a ***Frequency Domain Plot***



Time and Frequency Domain Example

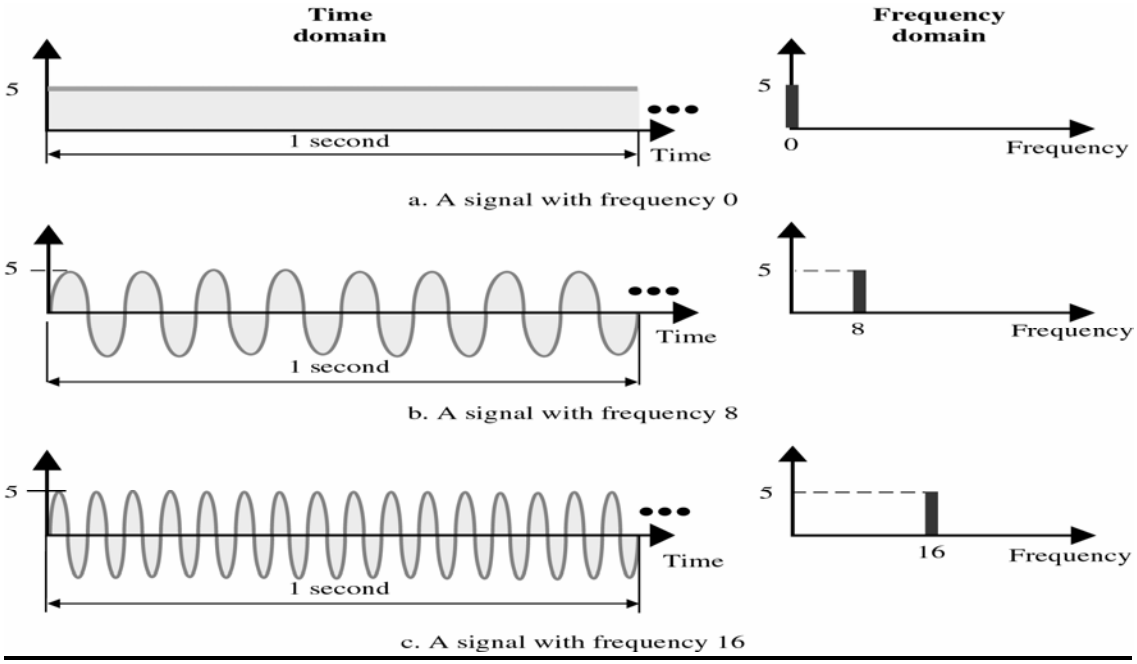


- Figure compares the time domain (instantaneous amplitude w.r.t Time) and the Frequency domain (Max amplitude w.r.t Frequency)
- Low Frequency signal in frequency domain corresponds to a signal with longer period in Time domain & vice versa.
- A signal changing rapidly in Time domain corresponds to High frequency in Frequency domain
- Figure shows 3 signals with different frequencies and its time and frequency domain presentations

Composite Signals

- Second type of Analog Signals, that is composed of multiple sine waves
- So far we have been focused on simple periodic signals or sine waves

- Many useful sine waves do not change in a single smooth curve b/w minimum and a maximum amplitude.
- They jump, slide , wobble and spikeAs long as as any irregularities are consistent, cycle after cycle, a signal is still Periodic
- It can be shown that any periodic signal no matter how complex can be decomposed into a collection of sine waves, each having a measurable amplitude, frequency & phase
- We need FOURIER ANALYSIS to decompose a composite signal into its components



- Figure shows a periodic signal decomposed into two sine waves
- First sine wave (middle one) has a frequency of '6' while the second sine wave has a frequency of '0'
- Adding these two signals point by point results in the top graph
- Original signal looks like a sine wave that has its time axis shifted downward
- This shift is because of DC Component or zero frequency component in the signal
- If you look at the signal in time domain, a single point is there while in frequency domain , two component freq.'s are there

Summary

- Sine Waves and its Characteristics
- Control of Signals
- Time and Frequency Domain
- Composite Signals

Reading Sections

- Section 4.4, 4.5 "Data Communications and Networking" 2nd Edition by Behrouz A. Forouzan