Phase Delays

Lagging and Leading
Calculation of Phase

• Suppose you have three signals that you have measured with your oscilloscope
  – One signal is your reference
    • I have chosen the reference to be the signal in Blue on the following slide
  – The phase of the other two signals will be calculated with respect to the reference signal.
    • The period of each signal should be the same, which means that all signals have the same frequency.
Steps

• Calculate the period, $T$, for the reference signal
  – This is the time for a full cycle to be completed.
    • $T = 500$ seconds for Signal 1
  – Calculate the difference in time between zero crossings of
    • Signal 2 and Signal 1: $\Delta t = 40$ seconds $- 0$ seconds
    • Signal 3 and Signal 1: $\Delta t = 480$ seconds $- 0$ seconds
Steps

• The sinusoidal function that describes Signal 1, the reference voltage, is
  \[ V(t) = 5V \sin (\omega t) \] where \( \omega = 1/T = 0.002 \text{ s}^{-1} \)

• To write the sinusoidal function that describes Signals 2 and 2, we need to address the fact that there is a shift in the zero crossings
  \[ V(t) = A \sin (\omega t + \phi) \] where \( \omega = 1/T \) and \( \phi = -2\pi \Delta t/T \)
  • \( \phi \) is called the phase shift
Lagging and Leading

• Don’t get fooled by the positions of the curves on the graph!

• Signal 2: $V(t) = 5V \sin \left((0.002 \text{ s}^{-1})t - 0.502\right)$
  – $\phi$ is 0.5 radians or 28.8 degrees
  – Signal 2 lags Signal 1 as it reaches 0V at a later time than Signal 1

• Signal 3: $V(t) = 5V \sin \left((0.002 \text{ s}^{-1})t + 0.251\right)$
  – $\phi$ is 0.251 radians or 14.4 degrees
  – Signal 3 leads Signal 1 as it reaches 0V at an earlier time than Signal 1