DSP First

Second Edition

TLH LECTURE 2_2
Section 2-3.2, 2-4

Chapter 2

Sinusoids

PLOTTING COSINE SIGNAL from the FORMULA

$$5\cos(\underline{0.3\pi}t + 1.2\pi)$$

- Determine **period**:

$$T = 2\pi / \omega = 2\pi / 0.3\pi = 20/3$$

- Determine a **peak** location by solving

$$(\omega t + \varphi) = 0$$

$$0.3\pi t + 1.2\pi = 0$$

- **Peak at t=-4**

```
% Lecture Ch2_2
%
% 5*cos(0.3*pi*t +1.2*pi)
% Find the radian frequency, the frequency, and period
omega = 0.3*pi              %  0.9425 rad/sec
omega_deg = 0.3*180         %  54 degrees per second
f = omega/(2*pi)            %  0.1500 Hertz (cycles/sec)
T = 1/f                     %  6.6667 seconds in a period
```

```
%
% Find phase shift and time shift 0.3*pi*t+1.2*pi =0
%
phi_shift = 1.2*pi        %  3.7699 rad
tpeak= -1.2*pi/(0.3*pi) % -4 seconds (shift to LEFT)
% CHECK 1.2*pi/2*pi  and -4/T
rad_shift_ratio = -1.2*pi/(2*pi)  %  0.6000  (60%)
t_shift_ratio  = -4/T                    %  0.6000  Same ratio
```

TIME-SHIFT

- In a mathematical formula we can replace t with $t\text{-}t_m$

$$x(t-t_m) = A\cos(\omega(t-t_m))$$

- Thus the t=0 point moves to $t=t_m$

- Peak value of $\cos(\omega(t\text{-}t_m))$ is now at $t=t_m$

PHASE ←→ TIME-SHIFT

- Equate the formulas:

$$A\cos(\omega(t - t_m)) = A\cos(\omega t + \varphi)$$

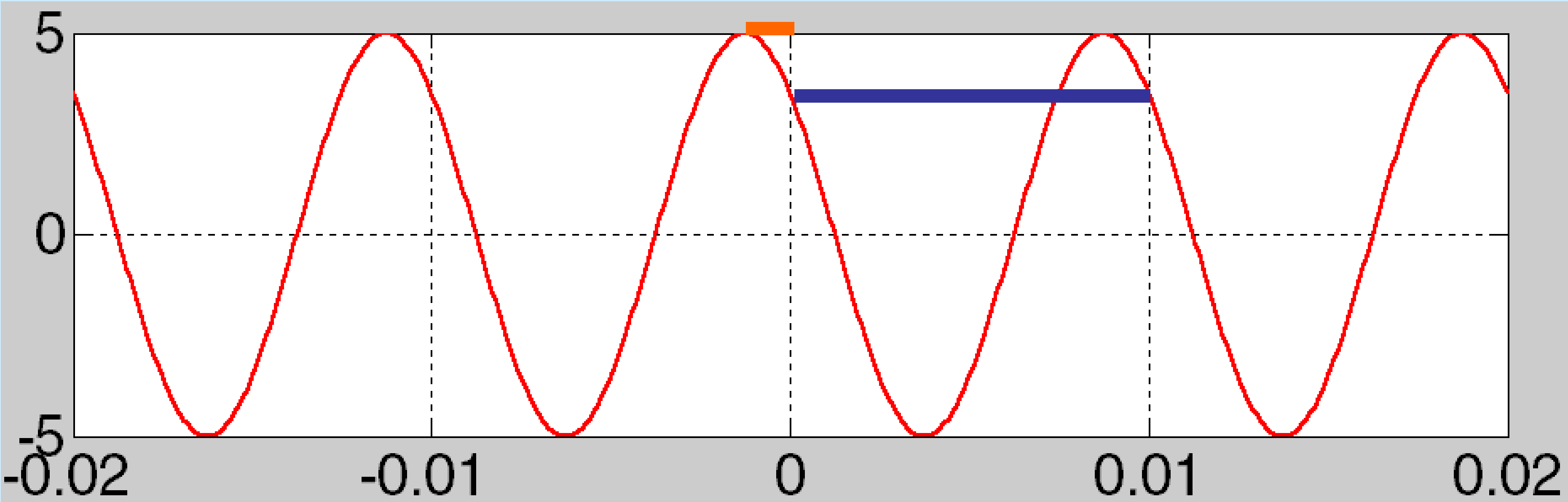
- and we obtain:

$$-\omega t_m = \varphi$$

- or,

$$t_m = -\frac{\varphi}{\omega}$$

(A, ω, ϕ) from a PLOT



$$T = \frac{0.01\text{sec}}{1\,\text{period}} = \frac{1}{100}$$

$$\omega = \frac{2\pi}{T} = \frac{2\pi}{0.01} = 200\pi$$

$$t_m = -0.00125\text{sec}$$

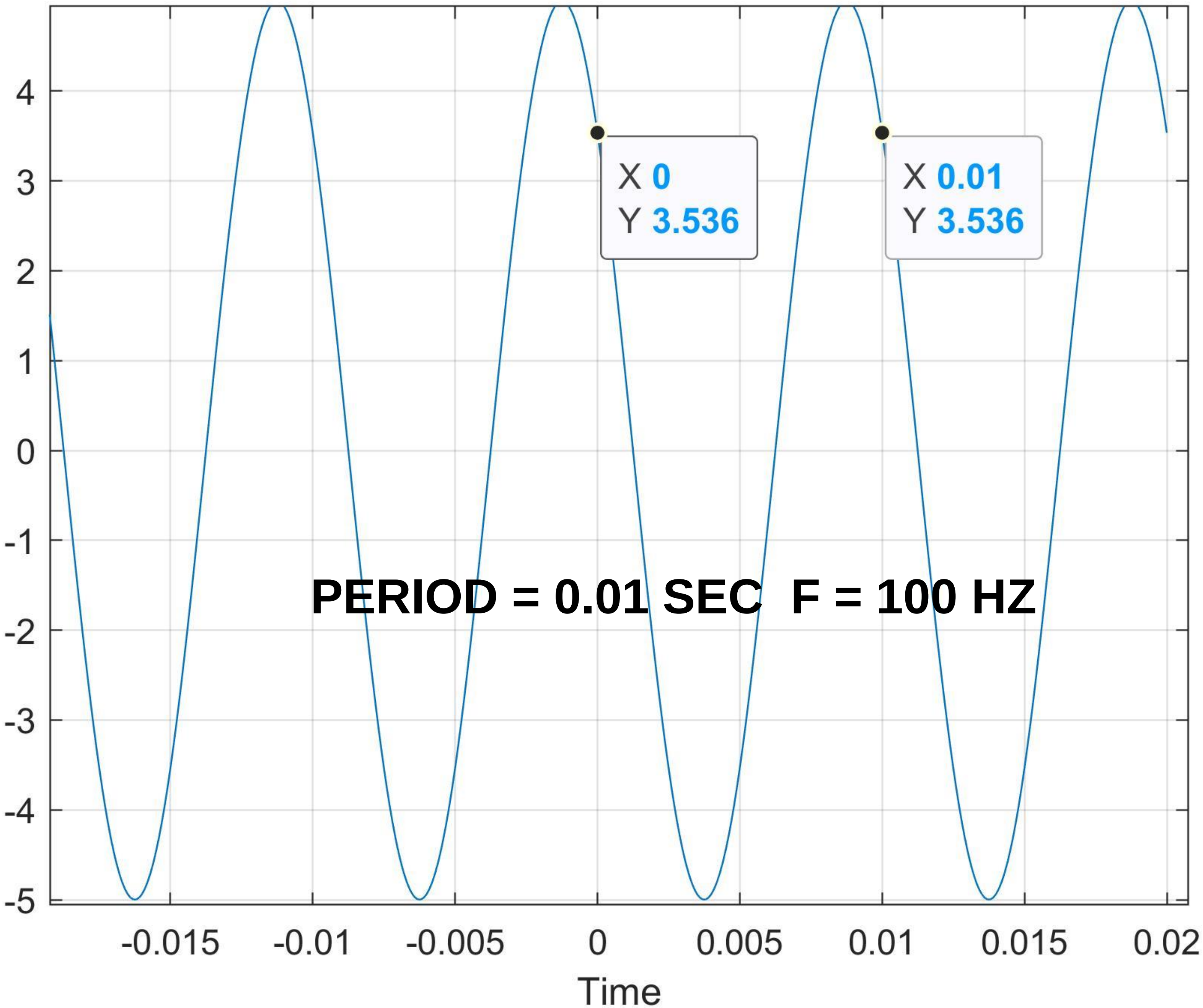
$$\varphi = -\omega t_m = -(200\pi)(t_m) = 0.25\pi$$

```
%
format long    % Get full precision
figure(1)
t=-0.02:.0001:.02;
y=5*cos(200*pi*t + 0.25*pi);

plot(t,y),grid,xlabel('Time')


t_shift = -.25*pi/(2*pi)*(1/100)  % -0.001250000000000 s

sprintf('%0.5f', t_shift)     %  ans = '-0.00125'
```



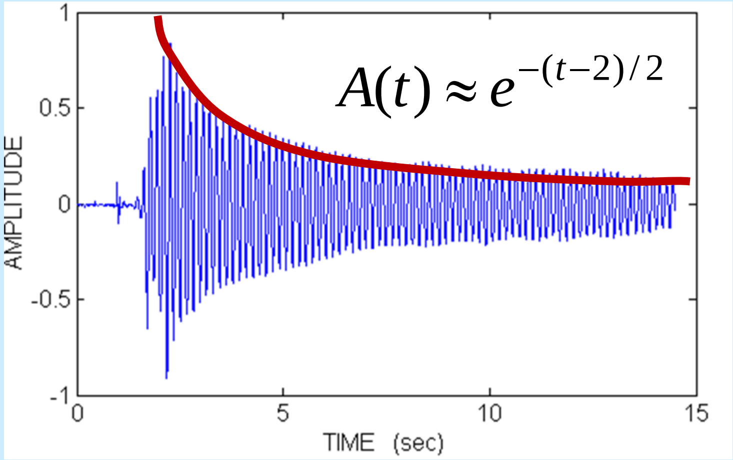
4
3
2
1
0
-1
-2
-3
-4
-5
X 0
Y 3.536
X 0.01
Y 3.536
PERIOD = 0.01 SEC F = 100 HZ
-0.015
-0.01
-0.005
0
0.005
0.01
0.015
0.02
Time

Attenuation

In real waves, there will always be a certain degree of attenuation, which is the reduction of the signal amplitude over time and/or over distance.

$$x(t) = A\cos(\omega t + \varphi)$$

In a sinusoid, A **is a constant.**



However, the amplitude can have exponential decay, e.g.,

$$A(t) = Ae^{-t/\alpha}$$

$$x(t) = Ae^{-t/\alpha}\cos(\omega t + \varphi)$$

MATLAB Example (I)

Generating sinusoids in MATLAB is easy:

```
% define how many values in a second
fs = 8000;
% define array tt for time
% time runs from -1s to +3.2s
% sampled at an interval of 1/fs
tt = -1 : 1/fs : 3.2;
xx = 2.1 * cos(2*pi*440*tt + 0.4*pi);
```

The array `xx` then contains a "sampled" signal of:

$$x(t) = 2.1\cos(880\pi t + 0.4\pi)$$

MATLAB Example (II)

Introducing attenuation with time

```
% fs defines how many values per second
fs = 8000;
tt = -1 : 1/fs : 3.2;
yy = exp(-abs(tt)*1.2);% exponential decay
yy = xx.*yy;
soundsc(yy,fs)
```

Array `yy` contains a signal with changing amplitude:

$$y(t) = 2.1e^{-1.2|t|}\cos(880\pi t + 0.4\pi)$$

`Soundsc` **lets you hear the signal** `yy`

Plotting the Signal

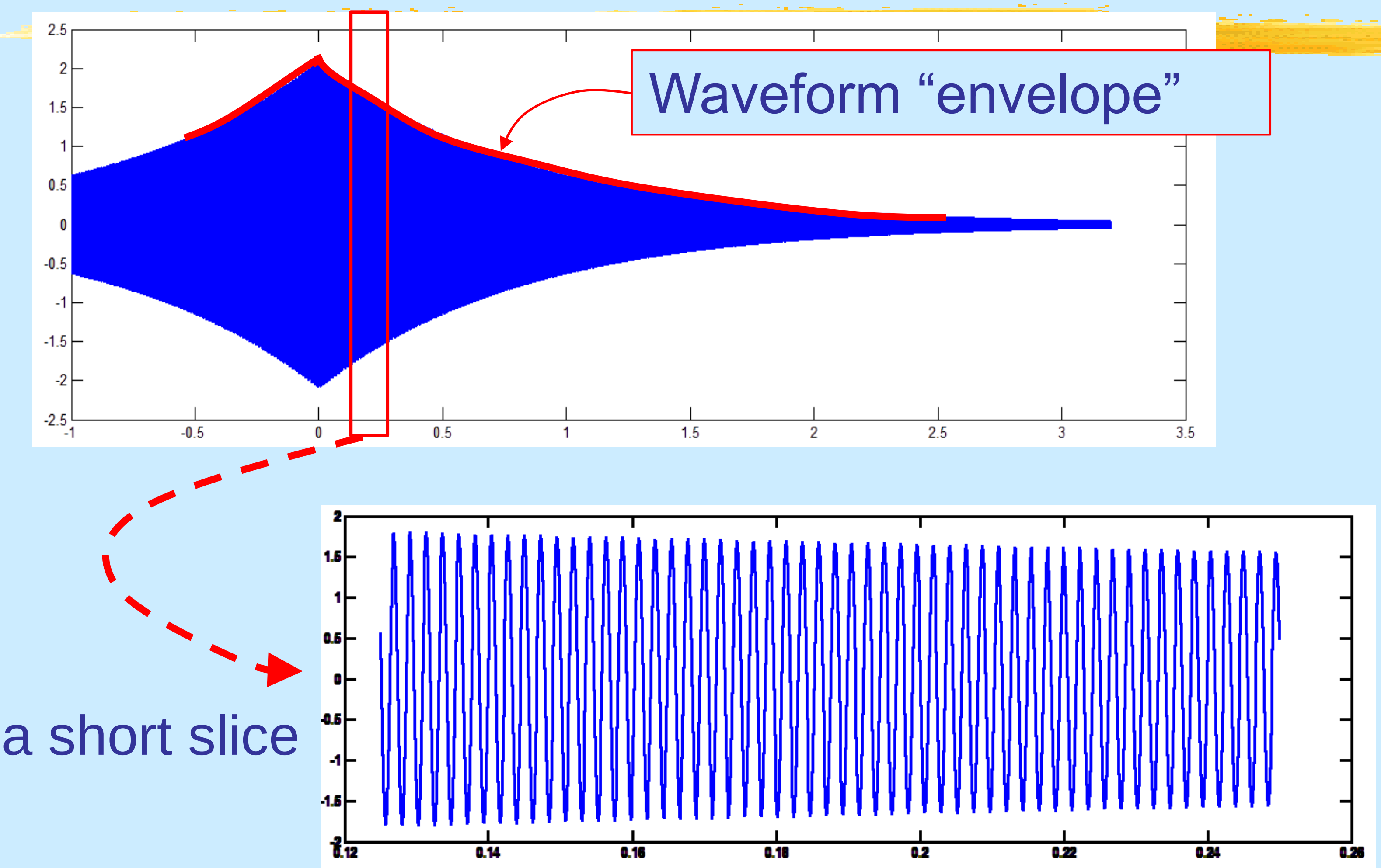


Figure 2-9: Plotting the 40-hz Sampled Cosine 2.8(b) for (A) $T_s = 0 \cdot 005\ S$; (B) $T_s = 0 \cdot 0025\ S$; (C) $T_s = 0 \cdot 0005\ S$

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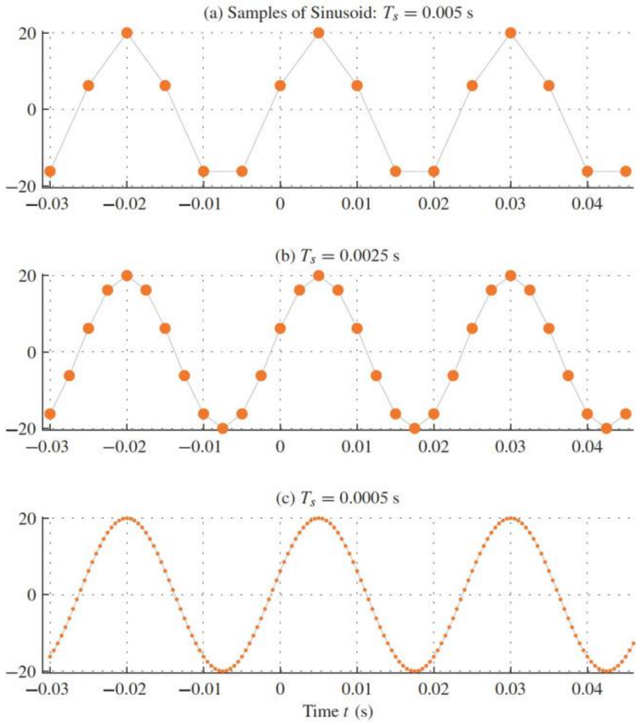

STRAIGHT LINE INTERPOLATION