EECS 360 Signal and System Analysis

Lab 5. Fourier Series

1. (a) Plot the signal below:

$$x(t) = e^{j4\pi t} + e^{-j4\pi t}$$
$$y(t) = \left(e^{j4\pi t} - e^{-j4\pi t}\right)/j$$

   (b) Plot the signal $z(t) = 8\cos(2\pi t + \Theta)$

   for: $\Theta = \left[-\frac{\pi}{2}, -\pi, -\frac{3\pi}{2}\right]$, and time interval: $0 \le t \le 8$

   (c) Repeat part (b) for the signal $w(t) = 3\cos(8\pi t + \Theta)$

   (d) What is the time delay between each of the signals in parts b and c?

   (Hint: The signal $w(t) = A\cos(\omega t + \Theta)$ can also be expressed as $w(t) = A\cos(\omega(t - t_1))$, where Θ denotes time delay.)

2. Listed below are the first three terms of the Cosine Fourier Series representations of three different signals (x(t), y(t) and z(t)). Each complete Fourier Series representation requires an infinite number of terms. For each signal, the remaining terms of the Fourier Series representation follow the pattern that is present in the first three terms. For each signal, use this pattern to write a general expression for the n-th term of the Fourier Series representation.

$$x_1(t) = \frac{4}{\pi} \bullet \cos\left(1 \bullet \omega_0 t - \frac{\pi}{2}\right)$$

$$x_2(t) = \frac{4}{\pi} \bullet \frac{1}{3}\cos\left(3 \bullet \omega_0 t - \frac{\pi}{2}\right)$$

$$x_3(t) = \frac{4}{\pi} \bullet \frac{1}{5}\cos\left(5 \bullet \omega_0 t - \frac{\pi}{2}\right)$$

$$y_1(t) = \cos(1 \bullet \omega_0 t)$$
$$y_2(t) = \cos(2 \bullet \omega_0 t)$$
$$y_3(t) = \cos(3 \bullet \omega_0 t)$$

$$z_1(t) = \cos(1 \bullet \omega_0 t)$$
$$z_2(t) = (1/3)^2\cos(3 \bullet \omega_0 t)$$
$$z_3(t) = (1/5)^2\cos(5 \bullet \omega_0 t)$$

3. Complete the following calculations for each of the three F.S. described above.
    a. Create a figure with 6 subplots (each plot should contain at least 2 periods)
        i. Subplot 1: Plot the first term of the F.S.
        ii. Subplot 2: Plot the first term, the second term, and the sum of the first two terms.
        iii. Subplot 3: Plot the first term, the second term, the third term, and the sum of the first three terms.
        iv. Subplot 4: Plot the sum of the first 10 terms of the F.S.
        v. Subplot 5: Plot the sum of the first 25 terms of the F.S.
        vi. Subplot 6: Plot the sum of the first 50 terms of the F.S.
    b. Identify the waveform each F.S. is approximating.

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% Example code
clear, clc
n = 0:9;        % define the number of terms of the F.S.
% define the time index. The range is from [0:1], but with
% step size of 0.001 for fine resolution
t = 0:0.001:1;
y = cos(2*pi*t);

for i = 2:length(n)
    x(i,:) = cos(2*n(i)*pi*4*t);
end

% plot the first term, the second term
% the third term, and the Sum of the first three terms
% approach 1:
figure(1)
plot(t,x(1,:)),hold on
plot(t,x(2,:),'g')
plot(t,x(3,:),'m')
plot(t,x(1,:)+x(2,:)+x(3,:),'r')
hold off
xlabel('t')
legend('x(1)','x(2)','x(3)','x(1)+x(2)+x(3)')

% approach 2:
figure(1)
plot(t,x(1,:)),hold on      % plot the first term
plot(t,x(2,:),'g')          % plot the second term
plot(t,x(3,:),'m')          % plot the third term
plot(t,sum(x(1:3,:),1),'r') % plot the sum of the first
three terms
hold off
xlabel('t')                 % add xlabel
legend('x(1)','x(2)','x(3)','x(1)+x(2)+x(3)');  % add
legends to the plots.
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