CS : 215
Signal & Data Communication Laboratory

Experiment: VI-B

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Total Harmonic Distortion(THD)

Aim

- To plot ideal signal, actual signal and error in the first subplot along with numerical value of signal power of ideal signal and actual signal.
- To plot fundamental signal and sum of other harmonics in the second subplot along with numerical value of signal power of the fundamental signal, sum of other harmonics and THD.

Theoretical Background

Any Periodic Signal in itself can be broken up into number of sinusoidal components. The more the periodic signal departs from pure sinusoidal nature, the stronger the harmonic components are. The Addition of these higher frequencies or harmonic components is called as Harmonic Distortion.

Total Harmonic Distortion(THD) is the measure of harmonic distortion present in the signal. The higher the THD, the higher is the harmonic disruption.

Methodology

1. The ideal signal is generated and all values > 7 and < -7 are replaced for real signal.
2. The ideal signal, real signal and error between them is plotted.
3. The Fundamental frequency of the signal is found using Fourier Transform.
4. Using Fourier transform, the fundamental signal and other harmonics are seperated as two.
5. Their inverse Fourier transform is taken and the resulting time domain signals are plotted.
6. Power of the signal is plotted are computed using NORM function, i.e., $P_x = \dfrac{NORM(x)^2}{LENGTH(x)}$

Code

```
clc;
clear all;

s_ rate = 1e-6;
t = [0:s_ rate:1e-3];
ideal_ sgl = 10*sin(8000*pi*t);
subplot(2,1,1);
hold on;
```

```
plot(t, ideal_ sgl, 'b', 'linewidth', 1);
set(gca, ...
      'Box', 'off', ...
      'Ytick', [-10:5:10], ...
      'TickDir', 'out', ...
      'YGrid', 'on', ...
      'FontSize', 15);

real_ sgl = ideal_ sgl;
real_ sgl(real_ sgl> 7) = 7;
real_ sgl(real_ sgl< -7) = -7;
plot(t, real_ sgl, 'r', 'linewidth', 1);

error = ideal_ sgl-real_ sgl;
plot(t, error, 'm', 'linewidth', 1);

legend('Ideal Response', 'Real Response', 'Error',...
      'Location','northoutside', ...
      'Orientation', 'horizontal');
legend('boxoff');
pbaspect([4,1,1]);
hold off;

ft = fft(real_ sgl);
len = int32(length(ft)/2);

fndmtl = ft;
fndmtl(fndmtl < max(ft)) = 0;
```

```
fndharm = ifft(fndmtl,'symmetric');
subplot(2,1,2);
hold on;
plot(t, fndharm, 'b', 'linewidth', 1);
set(gca, ...
      'Box', 'off', ...
      'Ytick', [-10:5:10], ...
      'TickDir', 'out', ...
      'YGrid', 'on', ...
      'FontSize', 15);

highft = ft;
highft(highft >= max(ft)) = 0;
highharm = ifft(highft, 'symmetric');
plot(t, highharm, 'r', 'linewidth', 1);

legend('Fundamental Harmonic', 'Higher Harmonic',...
      'Location','northoutside', ...
      'Orientation', 'horizontal');
legend('boxoff');
pbaspect([4,1,1]);
hold off;

freq = (1/s_ rate);
freq_ range = (-len+1:  len-1)*freq/(2*len);
freq_ range = round(double(freq_ range), 2,
'significant');

```

```
subplot(1,1,1);
plot(freq_ range, abs(fftshift(ft)));
freq_ data = zeros(len,2);
freq_ data(:, 1) = abs(ft(1:len))';
freq_ daa(:, 2) = freq_ range(len:end)';
freq_ data = sortrows(freq_ data, 'descend');
freq_ data(freq_ data(:,1)<freq_ data(4,1),:)=[];

text(freq_ data(:,2), freq_ data(:,1), ...
      num2cell(freq_ data(:,2)'),...
      'VerticalAlignment', 'bottom');
set(gca, ...
      'Box', 'off', ...
      'TickDir', 'out', ...
      'YGrid', 'on', ...
      'FontSize', 15);
axis([0, freq_ range(end)/6 , -500, 4500]);
pbaspect([2,1,1]);
```

Input Data Description

Given an input sinusoidal signal with nominal gain 100, with peak amplitude voltage 100mV and frequency 4KHz.Thus,

$$x(t) = 0.1\sin(8000\pi t)$$

Amplified Response $= 10\sin(8000\pi t)$
Saturation Voltage $= \pm 7$ volts
The Sampling Rate is $10^6\ \sec^{-1} or 1MHz$

Result

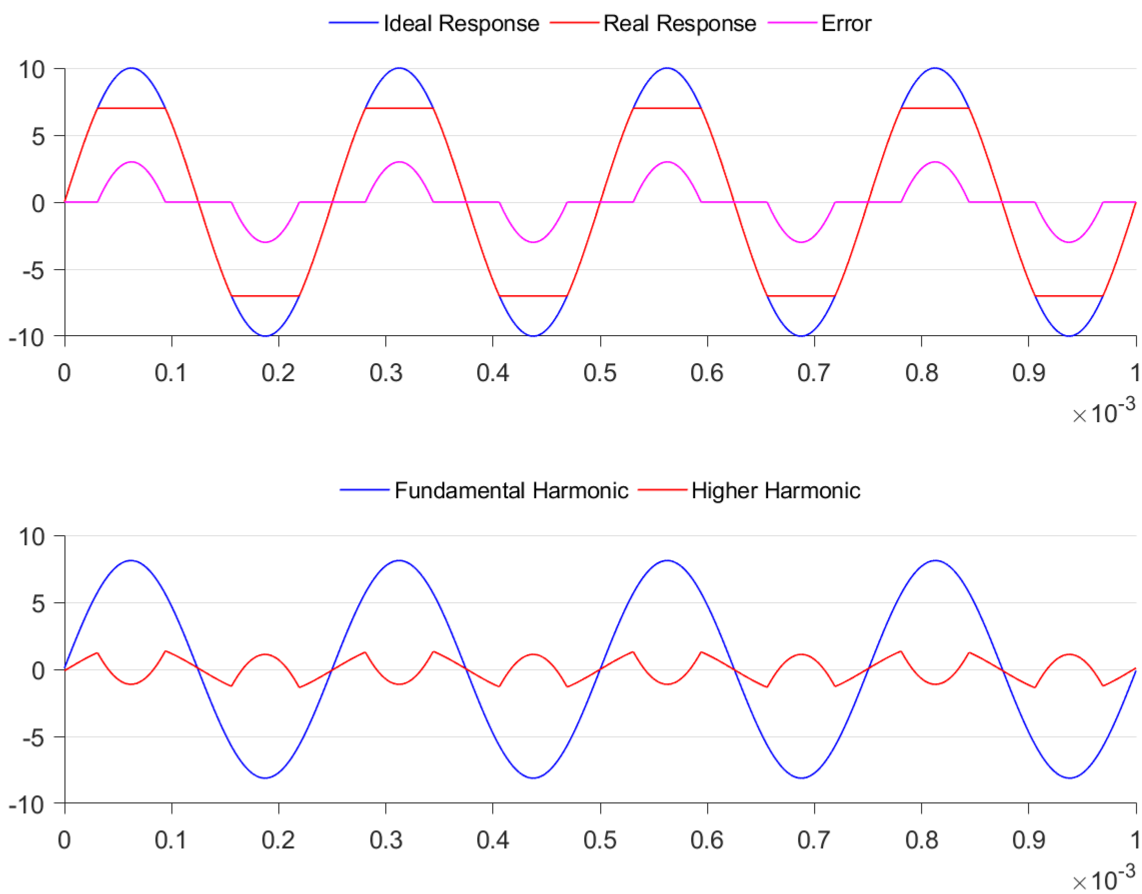

Figure 1: Different Signals and their Harmonic Decomposition

Power of

Ideal Signal = 49.95 J

Real Signal = 33.54 J

Fundamental Signal = 32.92 J

Other harmonics = 0.62 J Since,

$$\text{THD} = \frac{power\ of\ higher\ harmonic}{power\ of\ fundamental\ harmonic} = \frac{0.6195}{32.9291}.100\% = 1.88\%$$

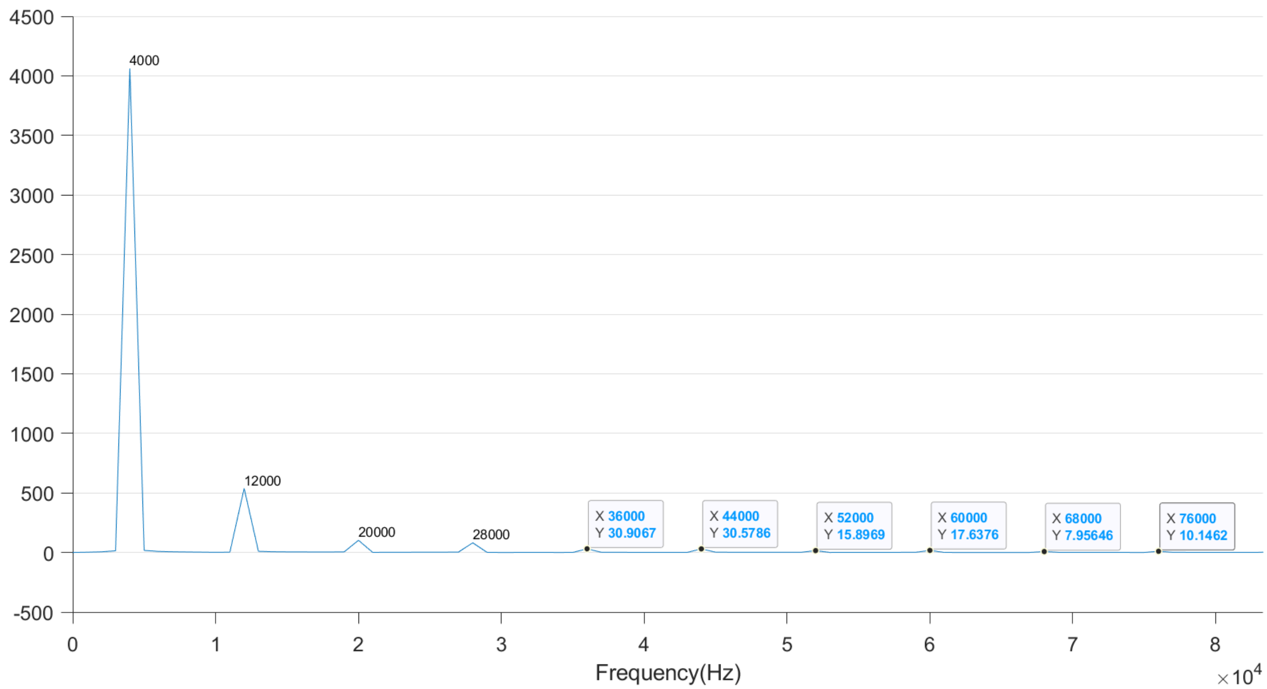

Figure 2: Fourier Transform

Note: Here amplitude is the real absolute value of Fourier Transform.

Conclusion

- It is observed that the fundamental harmonics contributes maximum power to the total power of real response.
- The amplitude in Fourier transform plot varies similar to power and thus using this, we can approximately find the power distribution for different harmonics.