Chapter 2 Signals and Spectra

3. (a) What is the DC level of the signal in Figure T2.3?
   (b) Sketch the double-sided amplitude spectrum for the sinusoidal waveform in Figure T2.3.

Guided Solution

(a)

1. Determine if the signal contains DC voltage.
2. Find out how much is the DC voltage.

(b)

1. Determine if it is periodic or non-periodic.
2. If it is periodic, find the period.
3. Calculate the fundamental frequency.
4. Determine how many frequency components the signal contains.
5. Find the amplitude of each frequency component.
7. Convert single-sided amplitude to double-sided amplitude.
8. Plot the amplitude vs frequency for each frequency component for both positive and negative frequencies.

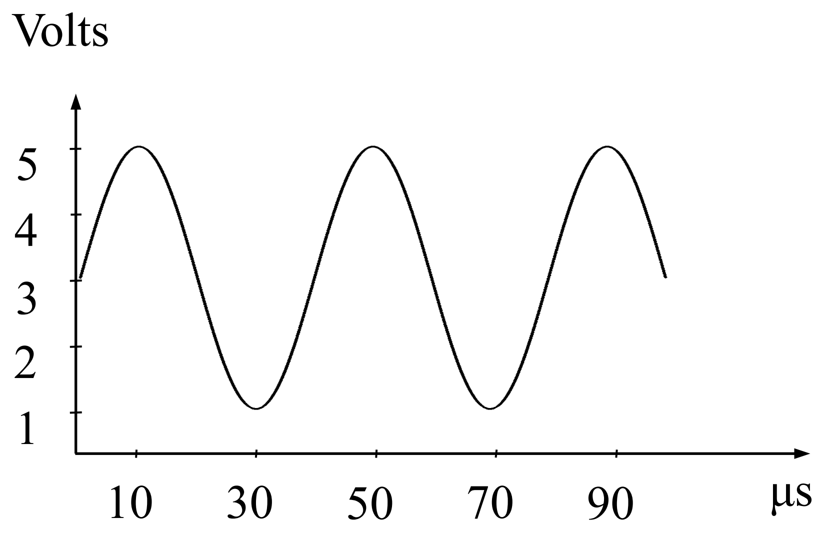
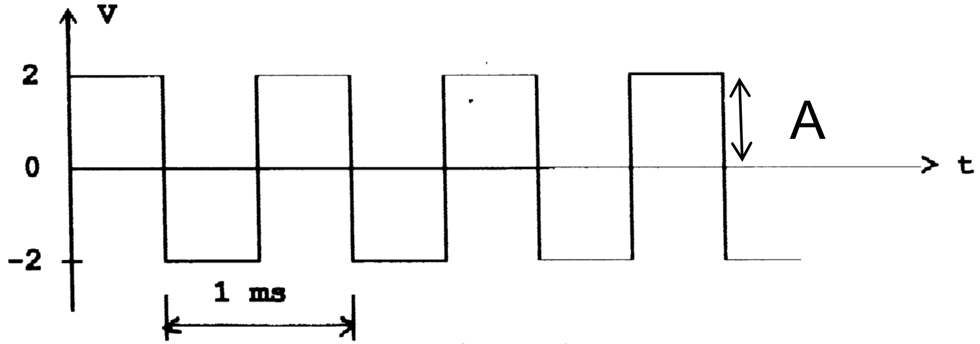


Figure T2.3 A sinusoidal waveform

4. The trigonometric Fourier series of the square wave in Figure T2.1 is given by

$$v(t) = \frac{4A}{\pi}\left(\sin\omega_0 t + \frac{\sin 3\omega_0 t}{3} + \frac{\sin 5\omega_0 t}{5} + \cdots\right)$$



Sketch the double-sided amplitude spectrum of the signal up to the fifth harmonic.
Indicate the frequency and peak amplitude of each component.

Guided Solution

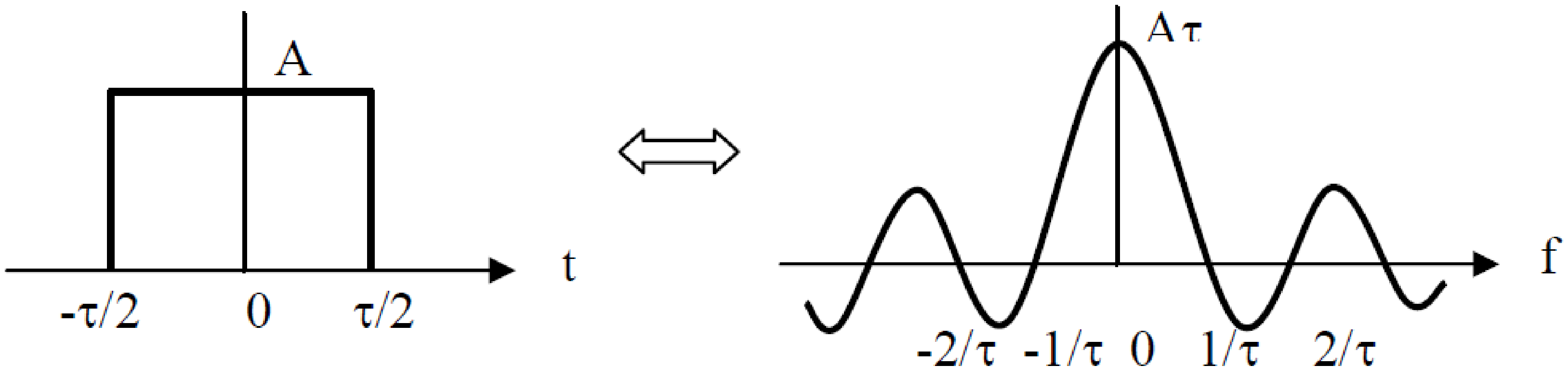
1. Determine if it is periodic or non-periodic.
2. If it is periodic, find the period.
3. Calculate the fundamental frequency.
4. Determine the harmonic frequencies.
5. Find the amplitude of each frequency component.
6. Convert single-sided amplitude to double-sided amplitude.
7. Plot the amplitude vs frequency for each frequency component for both positive and negative frequencies.

5. Sketch the amplitude spectrum of rect (t).

Guided Solution

1. Find the width and height of the rectangular pulse.
2. Determine if it is periodic or non-periodic?
3. Determine if it has discrete or continues spectrum.
4. Identify the shape of the spectrum.
5. Plot the spectrum and label the frequencies and the DC level.
6. Plot the amplitude spectrum.

$$A\mathrm{rect}\frac{t}{\tau} \Leftrightarrow A\tau\mathrm{sinc}f\tau$$



10. A zero DC rectangular wave with a fundamental frequency of 4 kHz is bandlimited to the first 5 components by a LPF. What is its bandwidth after bandlimiting?

Guided Solution

1. Determine the fundamental frequency and the harmonic frequencies.
5. Determine the bandwidth if only the first 5 components are present at the output of the LPF.

11. The trigonometric Fourier series of a waveform x(t) is given below.

$$x(t) = \frac{1}{2} - \frac{1}{\pi}\sum_{n=1}^{\infty}\frac{\sin n4000\pi t}{n}$$

(a) Sketch its double-sided amplitude spectrum up to the 4th harmonic.

(b) If the signal from part (a) is passed through an ideal BPF shown in Figure T2.4, sketch the resultant waveform and its amplitude spectrum.

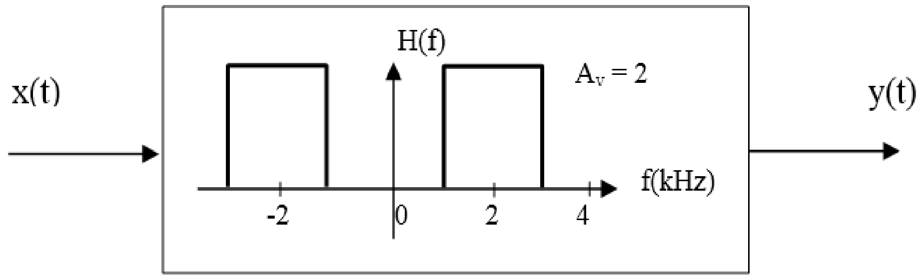


Figure T2.4

Guided Solution

(a)

1. Expand the Fourier series.
2. Find the fundamental frequency.
3. Determine the harmonic frequencies.
4. Find the amplitude of each frequency component and convert it to double-sided amplitude.
5. Plot the amplitude vs frequency for each frequency component for both positive and negative frequencies up to 4th harmonic.

(b)

1. Find the passband and Gain of the BPF.
2. Determine the frequency component present at the output of the BPF.
3. Apply the gain on the frequency component.
4. Plot the resultant double-sided amplitude vs frequency for the frequency component.
5. Convert the double-sided amplitude to single-sided amplitude and frequency.
6. Plot the waveform based on the single-sided amplitude and frequency.

14. The Trogonometric Fourier series of a waveform which repeats itself every 125 μs is given by

$$v(t) = 0.4 + \frac{0.8\sin 0.2\pi \cos\omega_0 t}{0.2\pi} + \frac{0.8\sin 0.4\pi \cos 2\omega_0 t}{0.4\pi}$$

$$+ \frac{0.8\sin 0.6\pi \cos 3\omega_0 t}{0.6\pi} + \frac{0.8\sin 0.8\pi \cos 4\omega_0 t}{0.8\pi} + \ldots$$

(a) Draw the double-sided amplitude spectrum, showing the amplitude and frequency of each component.

(b) Draw the resultant spectrum if the siganl is passed through the BPF in Figure T2.6 which has a passband from 8 kHz to 32 kHz.

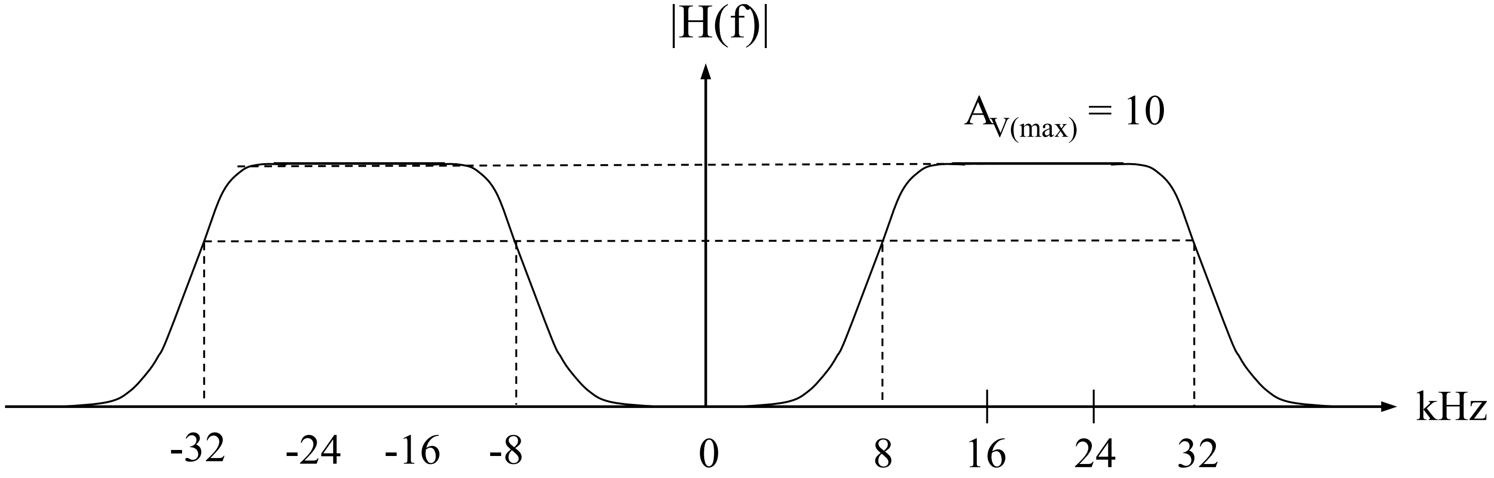


Figure T2.6 BPF

14.

Guided Solution

(a)

1. Identify the DC component, fundamental and harmonic frequency components.
2. Determine the period and calculate the fundamental frequency.
3. Calculate the amplitude of each frequency component.
4. Convert single-sided amplitude to double sided amplitude.
5. Plot the amplitude vs frequency for each frequency component for both positive and negative frequencies.

(b)

1. Find the gain of the BPF.
2. Find the gain at 3dB cut-off frequency.
3. Determine the lower and upper 3 dB cut-off frequencies.
4. Determine the passband of the BPF.
5. Determine the frequency components present at the output of the BPF.
6. Apply the gain on those frequency components.
7. Plot the resultant double-sided amplitude vs frequency for those frequency component.