# Frequency Domain View of Electronic Signals: Practical Application of the Fourier Theory

Objectives: The Fourier Theory

1. State the Fourier theory in non-mathematical terms.
2. Define the term harmonic and calculate harmonic frequencies.
3. Recognize a Fourier expression and explain each term.
4. Identify the Fourier expressions for non-sinusoidal signals such as square, sawtooth, triangle, and rectified sine waves.

1. Any complex repetitive, non-sinusoidal waveform may be expressed mathematically as a fundamental sine wave at the
   a. Harmonic frequency minus the signal frequency
   b. Pulse width and duty cycle of a rectangular wave
   c. Signal frequency plus an infinite number of harmonic signals

2. If the 5th harmonic is 75 MHz, what is the fundamental?
   a. 5 MHz
   b. 15 MHz
   c. 25 MHz

3. $F_0$, $F_3$, $F_7$, $F_9$ =
   a. 4 MHz, 8 MHz, 12 MHz, 16 MHz
   b. 15 MHz, 45 MHz, 105 MHz, 135 MHz
   c. 20 MHz, 30 MHz, 50 MHz, 80 MHz
   d. 1200 Hz, 3600 Hz, 7200 Hz, 9000 Hz

4. What is a harmonic?
   a. A sine wave whose frequency is some integer multiple of a fundamental sine wave frequency
   b. A sine wave whose fundamental signal is divided by the frequency of the sine wave frequency
   c. A sine wave whose frequency is some integer submultiple of the fundamental frequency
   d. The signal frequency added to the duty cycle of the sine wave frequency
   e. The sum of the frequency signals

5. True or False. You always need an infinite number of harmonics to create the desired waveform.

6. In the general expression of the Fourier theory, y is
   a. Cosine amplitude
   b. Sine amplitude
   c. Some signal that is a function of frequency
   d. Some signal that is a function of time

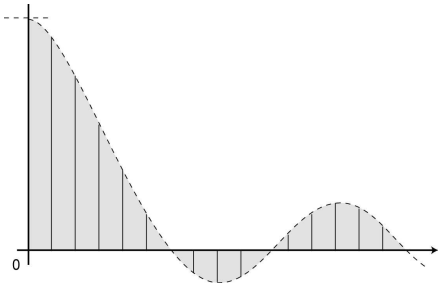
7. In the general expression of the Fourier theory, what does n represent?
   a. Cosine amplitude
   b. Higher integer values of the harmonics
   c. Sine amplitude
   d. Some signal that is a function of time

8. In the general expression of the Fourier theory, what does $A_n$ represent?
   a. Cosine amplitude
   b. Higher integer values of the harmonics
   c. Sine amplitude
   d. Some signal that is a function of time

9. In the general expression of the Fourier theory, what does $B_n$ represent?
   a. Cosine amplitude
   b. Higher integer values of the harmonics
   c. Sine amplitude
   d. Some signal that is a function of time

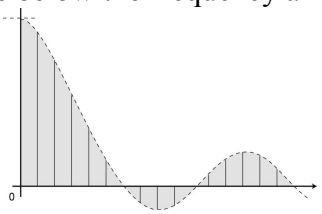
10. What is the general expression of the Fourier theory?
    a. $Y = A_o + \sum[A_n \sin 2\pi(nf)t + B_n \cos 2\pi(nf)t\ ]$
    b. $Y = A_o - \sum[A_n \sin 2\pi(nf)t + B_n \cos 2\pi(nf)t\ ]$
    c. $Y = A_o / \sum[A_n \sin 2\pi(nf)t + B_n \cos 2\pi(nf)t\ ]$
    d. $Y = A_o + \sum[A_n \sin 2\pi(nf)t - B_n \cos 2\pi(nf)t\ ]$

11. In the figure shown, how are the points on this curve where the sin x /s (sinc) curve crosses the frequency axis determined?




    a. Envelope
    b. Even harmonics
    c. Odd harmonics
    d. Pulse width

12. In the figure shown, what does the curve below the frequency axis indicate?




a. 90° phase shift
b. 180° phase shift
c. Lagging phase shift
d. Leading phase shift

13. In the frequency domain plot of the square wave, the _____ of the harmonics decrease in proportion to their _____.
a. Amplitudes, frequency
b. Duty cycle, pulse width
c. Frequency, amplitudes
d. Sinc curve, envelope

14. What is the square wave made up of if put through a rigorous Fourier analysis?
a. A fundamental sine wave and a finite number of even harmonics
b. A fundamental sine wave and a finite number of odd harmonics
c. A fundamental sine wave and an infinite number of even harmonics
d. A fundamental sine wave and an infinite number of odd harmonics

15. Which of the following is the mathematical expression for a full wave rectified?
a. $y = Vp + 4Vp/\pi\ [\sin\omega t + (\sin 3\omega t)/3 + (\sin 5\omega t)/5 + (\sin 7\omega t)/7 + \ldots.]$
b. $y = 2Vp/\pi\ [\sin\omega t + (\sin 2\omega t)/2 + (\sin 3\omega t)/3 + (\sin 4\omega t)/4 + \ldots.]$
c. $y = 8Vp/\pi^2\ [\sin\omega t + (\sin 3\omega t)/9 + (\sin 5\omega t)/25 + (\sin 7\omega t)/49\ldots.]$
d. $y = 2Vp/\pi + 4Vp/\pi\ [(\cos\omega t)/3 - (\cos 2\omega t)/15 + (\cos 3\omega t)/35 + \ldots.)$
e. $y = Vp/\pi + Vp/2(\sin\omega t) - 2Vp/\pi\ [(\cos 2\omega t)/3 + (\cos 4\omega t)/15 + (\cos 6\omega t)/35\ldots.]$

16. Which of the following is the mathematical expression for a square wave?
a. $y = Vp + 4Vp/\pi\ [\sin\omega t + (\sin 3\omega t)/3 + (\sin 5\omega t)/5 + (\sin 7\omega t)/7 + \ldots.]$
b. $y = 2Vp/\pi\ [\sin\omega t + (\sin 2\omega t)/2 + (\sin 3\omega t)/3 + (\sin 4\omega t)/4 + \ldots.]$
c. $y = 8Vp/\pi^2\ [\sin\omega t + (\sin 3\omega t)/9 + (\sin 5\omega t)/25 + (\sin 7\omega t)/49\ldots.]$
d. $y = 2Vp/\pi + 4Vp/\pi\ [(\cos\omega t)/3 - (\cos 2\omega t)/15 + (\cos 3\omega t)/35 + \ldots.)$
e. $y = Vp/\pi + Vp/2(\sin\omega t) - 2Vp/\pi\ [(\cos 2\omega t)/3 + (\cos 4\omega t)/15 + (\cos 6\omega t)/35\ldots.]$

17. Which of the following is the mathematical expression for a triangle wave?
a. $y = Vp + 4Vp/\pi\ [\sin\omega t + (\sin 3\omega t)/3 + (\sin 5\omega t)/5 + (\sin 7\omega t)/7 + \ldots.]$
b. $y = 2Vp/\pi\ [\sin\omega t + (\sin 2\omega t)/2 + (\sin 3\omega t)/3 + (\sin 4\omega t)/4 + \ldots.]$
c. $y = 8Vp/\pi^2\ [\sin\omega t + (\sin 3\omega t)/9 + (\sin 5\omega t)/25 + (\sin 7\omega t)/49\ldots.]$
d. $y = 2Vp/\pi + 4Vp/\pi\ [(\cos\omega t)/3 - (\cos 2\omega t)/15 + (\cos 3\omega t)/35 + \ldots.)$
e. $y = Vp/\pi + Vp/2(\sin\omega t) - 2Vp/\pi\ [(\cos 2\omega t)/3 + (\cos 4\omega t)/15 + (\cos 6\omega t)/35\ldots.]$

18. Which of the following is the mathematical expression for a sawtooth wave rectified?
    a. $y = Vp + 4Vp/\pi [\sin\omega t + (\sin 3\omega t)/3 + (\sin 5\omega t)/5 + (\sin 7\omega t)/7 + \ldots.]$
    b. $y = 2Vp/\pi [\sin\omega t + (\sin 2\omega t)/2 + (\sin 3\omega t)/3 + (\sin 4\omega t)/4 + \ldots.]$
    c. $y = 8Vp/\pi^2 [\sin\omega t + (\sin 3\omega t)/9 + (\sin 5\omega t)/25 + (\sin 7\omega t)/49\ldots.]$
    d. $y = 2Vp/\pi + 4Vp/\pi [(\cos\omega t)/3 - (\cos 2\omega t)/15 + (\cos 3\omega t)/35 + \ldots.)$
    e. $y = Vp/\pi + Vp/2(\sin\omega t) - 2Vp/\pi [(\cos 2\omega t)/3 + (\cos 4\omega t)/15 + (\cos 6\omega t)/35\ldots.]$

19. Which of the following is the mathematical expression for a half wave rectified?
    a. $y = Vp + 4Vp/\pi [\sin\omega t + (\sin 3\omega t)/3 + (\sin 5\omega t)/5 + (\sin 7\omega t)/7 + \ldots.]$
    b. $y = 2Vp/\pi [\sin\omega t + (\sin 2\omega t)/2 + (\sin 3\omega t)/3 + (\sin 4\omega t)/4 + \ldots.]$
    c. $y = 8Vp/\pi^2 [\sin\omega t + (\sin 3\omega t)/9 + (\sin 5\omega t)/25 + (\sin 7\omega t)/49\ldots.]$
    d. $y = 2Vp/\pi + 4Vp/\pi [(\cos\omega t)/3 - (\cos 2\omega t)/15 + (\cos 3\omega t)/35 + \ldots.)$
    e. $y = Vp/\pi + Vp/2(\sin\omega t) - 2Vp/\pi [(\cos 2\omega t)/3 + (\cos 4\omega t)/15 + (\cos 6\omega t)/35\ldots.]$

20. Which wave forms contain both even and odd harmonics?
    a. Full wave rectified and sawtooth
    b. Full wave rectified and square
    c. Square and sawtooth
    d. Triangle and half wave rectified

21. Which wave form contains only even harmonics?
    a. Half-wave rectified
    b. Sawtooth
    c. Square
    d. Triangle

22. Which wave forms contain only odd harmonics?
    a. Half wave rectified and sawtooth
    b. Half wave rectified and square
    c. Square and triangle
    d. Triangle and half wave rectified