Tutorial Sheet

Signals, time domain, frequency domain, Fourier Series

1. Draw the waveform of this signal function

$$v(t) = [1 + m\cos(2\pi f_m t + \phi)]\, A \sin(2\pi f_c t)$$

How many frequency components are there in

2. A periodic non-sinusoidal voltage signal $v(t)$ can be expressed as

$$v(t) = \frac{A_o}{2} + \sum_{k=0}^{N} A_k \cos k\,\omega_o t + B_k \sin k\,\omega_o t$$
$$= \frac{A_o}{2} + \sum_{k=0}^{N} C_k \cos(k\,\omega_o t + \phi_k)$$

Express C_k and ϕ_k in terms of A_k and B_k.

3. (a) What is the total voltage v_{tot} if two voltage sources, v_1 and v_2, are connected in series as shown below.

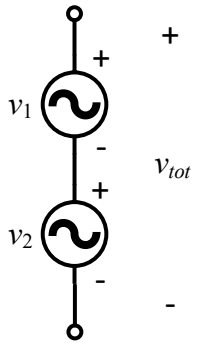


Fig. 3(a)

(b) Discuss the total current i_{tot} if two current sources, i_1 and i_2, are connected in parallel as shown below.

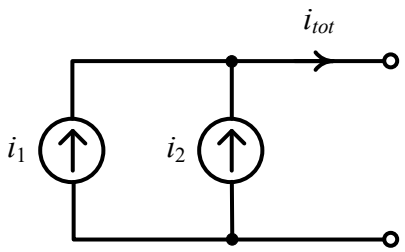


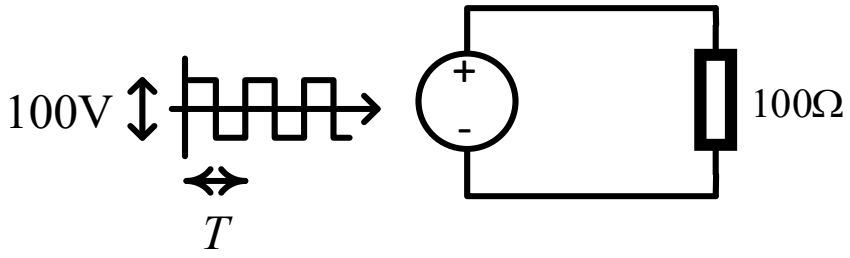
Fig. 3(b)

4. Table 4 shows the relationships between the time- and frequency-domain characteristics of different waveforms.

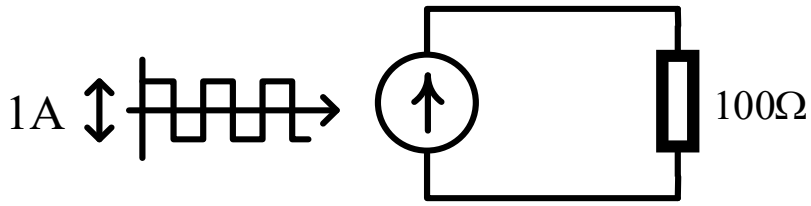
Time Domain	Frequency Domain	
a. Pulse (A, d = k/T, T, t = 0)	A; 0; 0 f 2f 3f 4f 5f 6f	$a_0 = A\,d$ $a_n = \frac{2A}{n\pi}\sin(n\pi d)$ $b_n = 0$ (d = 0.27 in this example)
b. Square (A, t = 0)	A; 0; 0 f 2f 3f 4f 5f 6f	$a_0 = 0$ $a_n = \frac{2A}{n\pi}\sin\left(\frac{n\pi}{2}\right)$ $b_n = 0$ (all even harmonics are zero)
c. Triangle (A, t = 0)	A; 0; 0 f 2f 3f 4f 5f 6f	$a_0 = 0$ $a_n = \frac{4A}{(n\pi)^2}$ $b_n = 0$ (all even harmonics are zero)
d. Sawtooth (A, t = 0)	A; 0; 0 f 2f 3f 4f 5f 6f	$a_0 = 0$ $a_n = 0$ $b_n = \frac{A}{n\pi}$
e. Rectified (A, t = 0)	A; 0; 0 f 2f 3f 4f 5f 6f	$a_0 = 2A/\pi$ $a_n = \frac{-4A}{\pi(4n^2-1)}$ $b_n = 0$
f. Cosine wave (A, t = 0)	A; 0; 0 f 2f 3f 4f 5f 6f	$a_1 = A$ (all other coefficients are zero)

Table 4

(a) If a square-wave voltage generator with peak-to-peak voltage of 100V and fundamental frequency of 1kHz is connected to a 100Ω resistor, determine the value of T and the peak value of the 5kHz current component through the resistor.



(b) If a square-wave current generator with peak-to-peak current of 1A and fundamental frequency of 2kHz is connected to a 100Ω resistor, determine the peak value of the 6kHz voltage component across the resistor.



5*. How many frequency components are there in $v(t)$ given in Question (1)? What are they?

6* Is $v(t) = \cos t + \cos 2\pi t$ periodic?