13.14 Problems

1. One cycle of a waveform $v(t)$ is shown in Fig. 13.14-1. It is a symmetrically clipped sinusoid. (i) Obtain a time-shifted version of this waveform such that the resulting waveform has odd symmetry. (ii) Find the trigonometric Fourier series of the shifted version and thereby obtain the discrete Fourier spectrum for $v(t)$.

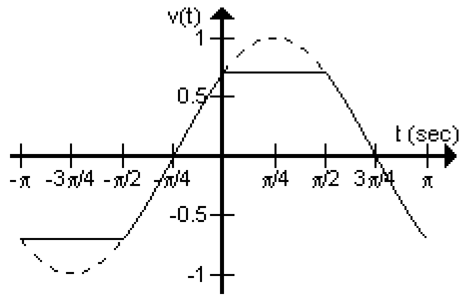

Fig. 13.14-1 Clipped Sinusoidal Waveform

2. One cycle of a periodic impulse train is shown in Fig. 13.14-2. Find its exponential Fourier series and plot the two-sided spectra.

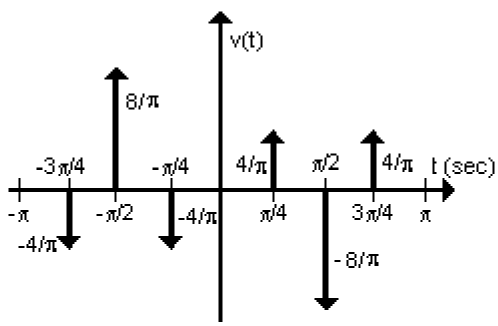

Fig. 13.14-2

3. One cycle of $v(t)$ is shown in Fig. 13.14-3 . (i) What is the relationship between this waveform and the one in Fig. 13.14-2 ? (ii) Obtain the exponential Fourier series of this waveform by using this relationship. (iii) Obtain the trigonometric Fourier series of this waveform and plot the one-sided spectrum of this waveform.

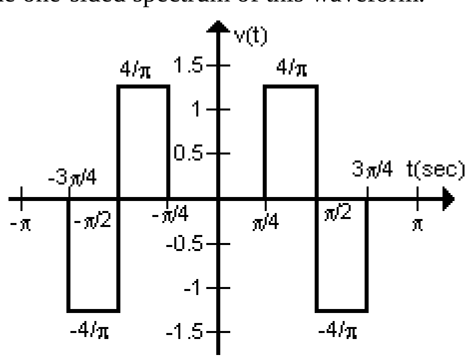

Fig. 13.14-3

4. One cycle of a periodic pulse train is shown in Fig. 13.14-4. (i) What is the relationship between this waveform and the one in Fig. 13.14-3? (ii) Obtain the exponential Fourier series of this waveform by using this relationship. (iii) Obtain the trigonometric Fourier series of this waveform and plot the one-sided spectrum of this waveform.

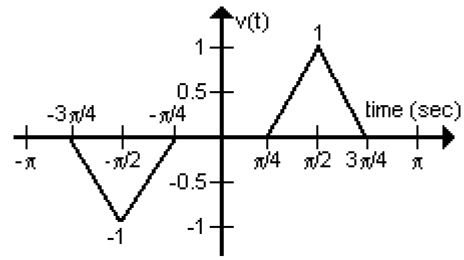

Fig. 13.14-4

5. Find the trigonometric Fourier series of the waveform $v(t)$ in Fig. 13.14-5 and plot its spectrum.

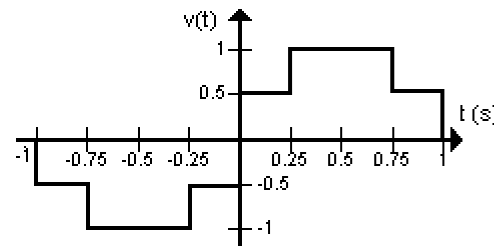

Fig. 13.14-5

6. $v(t)$ is a cosine wave and $v_1(t)$ is a square wave in Fig. 13.14-6. (i) Find $v_2(t) = v(t)\, v_2(t)$ and plot it. (ii) Find the trigonometric Fourier series of $v_3(t)$ from Fourier series of $v(t)$ and $v_1(t)$ and plot its spectrum.

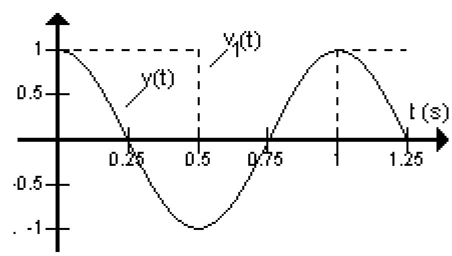

Fig. 13.14-6

7. $v(t)$ is a sine wave and $v_1(t)$ is a square wave in Fig. 13.14-7.(i) Find $v_2(t) = v(t)v_1(t)$ and plot it. (ii) Find the trigonometric Fourier series of $v_3(t)$ from Fourier series of $v(t)$ and $v_1(t)$ in terms of α. (iii) Plot its spectrum for $\alpha = \pi/6$.

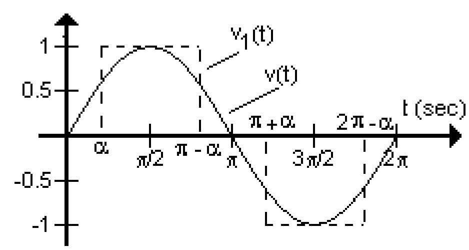

Fig. 13.14-7

8. Positive half-cycle of $v(t)$ with a period of 2 sec is shown in Fig. 13.14-8. The waveform has odd symmetry. Find the exponential and trigonometric Fourier series of this waveform and plot its one-sided spectrum. If this

waveform is used as an approximation to a sine wave find its THD.

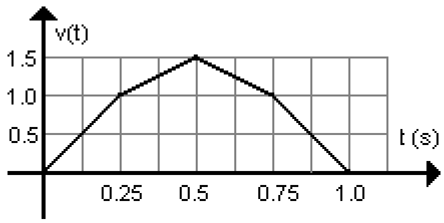

Fig. 13.14-8

9. $v_S(t) = 5|\sin\omega_o t|$ volts with $\omega_o = 100\pi$ rad/sec inFig. 13.14-9. Assume that the Opamp is ideal. Find the output voltage $v_o(t)$ as a function of time and draw its one-sided spectrum. What function does this circuit perform?

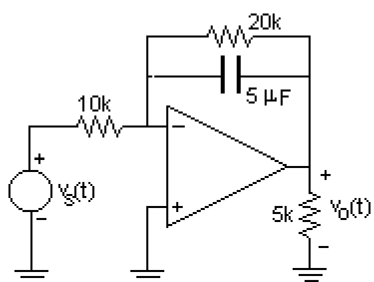

Fig. 13.14-9

10. The input voltage applied to the Opamp circuit in Fig. 13.14-10 is a symmetric triangle periodic waveform moving between +5 volts to –5 volts with a period of 1 ms. Find the plot the output voltage as a function of time. What function does this circuit perform?

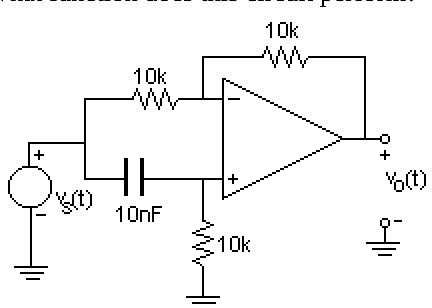

Fig. 13.14-10

11. The circuit in Fig. 13.14-11 is a *practical differentiator circuit* using an Opamp. The components C and R are sufficient to carry out differentiation. However, the non-ideal frequency response of the Opamp makes the circuit highly under-damped usually and the additional component, R_d, imparts damping to the circuit. But, with R_d present, the circuit is no more a differentiator at high frequencies. The input voltage applied to the practical differentiator circuit using Opamp in Fig. 13.14-11 is a ±1-volt symmetric triangular periodic waveform at 2.5 kHz. Obtain and plot the output voltage waveform. What is the expected output from a good differentiator for this input waveform? How does the calculated output compare with it?

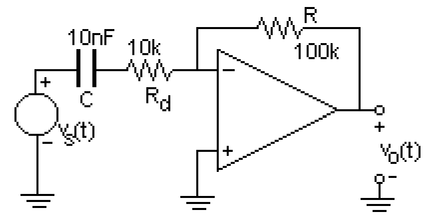

Fig. 13.14-11

12. The circuit in Fig. 13.14-12 is a *practical integrator* using an Opamp. The resistor R_{off} is needed to control the dc offset at output terminals. However, R_{off} makes the circuit an imperfect integrator. The input to this integrator is the waveform shown in Fig. 13.14-3. Find and plot the output taking the first five non-zero harmonics of input into account.

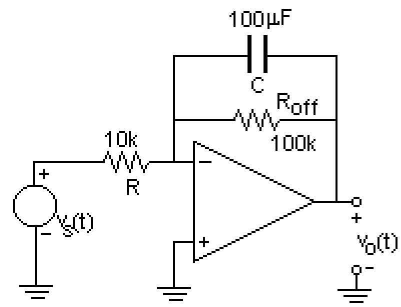

Fig. 13.14-12

13. (i) Predict the dc content in current through 6Ω and in voltage across the parallel combination without finding out Fourier series coefficients in the circuit in Fig. 13.14-13. (ii) Find the output voltage $v_o(t)$ as a function of time and plot its one-sided Fourier spectrum. (iii) Find the r.m.s value of current through 0.3Ω and the power dissipated in it.

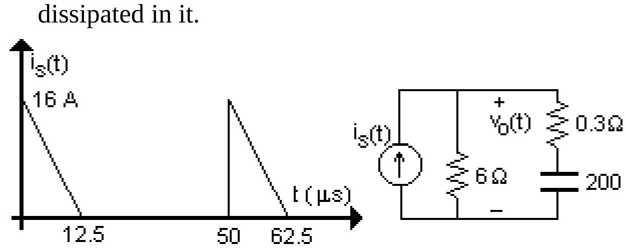

Fig. 13.14-13

14. Find the output voltage $v_o(t)$ in the circuit in Fig. 13.14-14 considering the dc component and first two non-zero harmonics in the input current source.

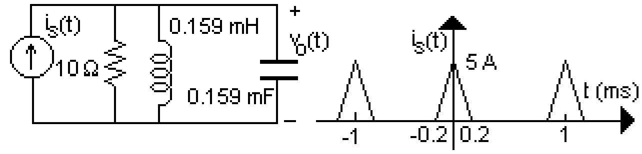

Fig. 13.14-14

15. R = 1kΩ and C = 1μF in the circuit in Fig. 13.14-15 . The source voltage is a periodic impulse train given by

$v_S(t) = \sum_{n=-\infty}^{\infty} \delta(t - n \times 10^{-3})$ volts. Find and plot the two-sided discrete power spectrum of $v_o(t)$.

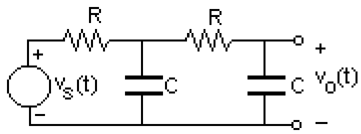

Fig. 13.14-15

16. The output voltage of a Power Electronic Inverter Circuit is related to the dc voltage used in the inverter by the equation $v_o(t) = V_{dc} \times m \sin 100\pi t$, where m is the so-called modulation index. Assume that V_{dc} is not a pure dc source and it contains ac components. Let V_{dc} = 400 + 20cos200πt-10cos400πt volts and m = 0.8. (i) Find and plot the output $v_o(t)$ of the Inverter. (ii) Find the THD and r.m.s value of Inverter output. (iii) Plot the two-sided power spectrum of output.
17. The switch S in the circuit in Fig. 13.14-16 operates periodically with a frequency of 10 kHz, spending 27μs in position-1 and 73μs in position-2. (i) Find the average charging current in the 12 V Battery under periodic steady-state operation. (ii) Find the exponential Fourier series of $i(t)$ under steady-state operation and plot its power spectrum. (iii) Find the r.m.s value of $i(t)$ and the power dissipated in the resistor.

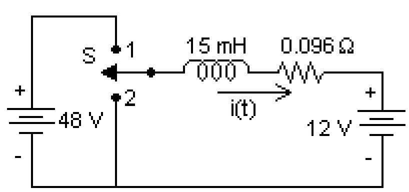

Fig. 13.14-16

18. The switch S in the circuit in Fig. 13.14-17 operates periodically with a frequency of 10 kHz, spending 77μs in position-1 and 23μs in position-2. (i) Find the average current delivered by the 12 V Battery under periodic steady-state operation. (ii) Find the exponential Fourier series of $i(t)$ under steady-state operation and plot its power spectrum. (iii) Find the r.m.s value of $i(t)$, the power dissipated in the resistor and the power delivered by the 12 V Battery. (iv) Thereby find the average charging current in 48 V Battery. (v) Can this circuit be used to charge the 12 V Battery from the 48 V Battery? Discuss.

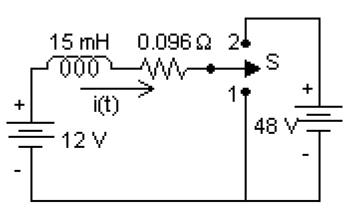

Fig. 13.14-17

19. The applied voltage $v_S(t)$ in the circuit in Fig. 13.14-18 is 320 sin100πt – 40 sin300πt – 20sin 500t volts. (i) Find the r.m.s value of applied voltage. (ii) Find the current delivered by the source as a function of time. (iii) Find the power delivered by the source and the VA delivered by it.

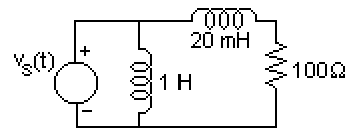

Fig. 13.14-18

20. The exponential Fourier series coefficients of $i(t)$ in the circuit in Fig. 13.14-19 are $\tilde{i}_o$ = 1 A, $\tilde{i}_1$ =1-j1 A, $\tilde{i}_{-1}$ = 1+j1, $\tilde{i}_3$ = 0.3+j0.2 and $\tilde{i}_{-3}$ = 0.3-j0.2. The value of L is 10 mH and value of R is 100 Ω. The period of $v_S(t)$ is 50 ms. Find the exponential Fourier series of $v_S(t)$.

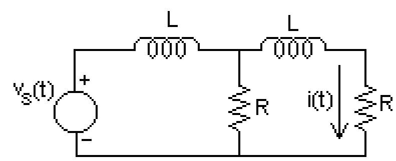

Fig. 13.14-19