Indian Institute of Technology Bombay

Department of Electrical Engineering

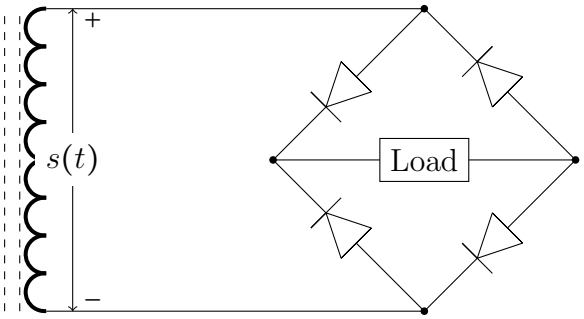
Handout 5 EE 229 Signal Processing

Tutorial 3 Sep 14, 2020

Question 1) Consider a $T-$ periodic function $x(t)$ having Fourier Series (FS) coefficients $\alpha_i, i \in \mathbb{Z}$. Suppose it is given that $\alpha_n = 0$ for $|n| \geq 2$. What is the Fourier Transform of the signal $x(t)\text{rect}_T(t)$.

Question 2) A power supply of 230Volt 50Hz is stepped down to a symmetric 30V peak-to-peak waveform $s(t)$. Can the waveform $s(t)$ be used to generate a 18Volt dc source. How will your answer change if we the supply frequency is changed to 400Hz, and a 15Volt dc supply is needed.

Question 3) Suppose $s(t) = 15\cos(100\pi t)$ is the output from the step down transformer. Let us design a full wave bridge rectifier to generate a stable dc supply. This is depicted in the figure below, where ideal electrical/electronic components are assumed. No specialized ICs for dc voltage regulation is available, so our design should be robust. Thus, only small fluctuations around the dc voltage are permitted in steady state operation.



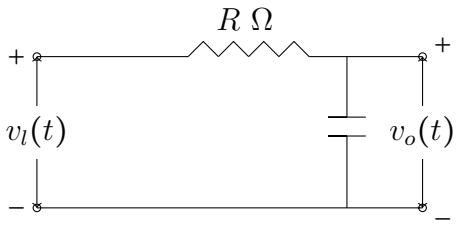
(a) Draw the waveform $v_l(t)$ across the load, if it is purely resistive ($3-4$ cycles good enough, mark the voltages as well as time axis).

(b) What is the average value of the output voltage $v_l(t)$.

(c) What are the Fourier Series coefficients of $v_l(t)$, and mark a few of the line spectra components in a plot.

(d) Ripple is the unwanted sinusoidal variations around the desired dc voltage. Using a purely resistive node, *ripple factor* can be defined as the ratio $\frac{V_{rrms}}{V_{dc}}$, where $V_{rrms} = \sqrt{V_{rms}^2 - V_{dc}^2}$, with V_{rms} being the rms value of $v_l(t)$, and V_{dc} is the average dc value. Find the *ripple factor* of the bridge rectifier.

(e) Now, let us imagine that the waveform $v_l(t)$ is directly available from a voltage source (not from the rectifier). Note that this waveform will contain dc voltage as well as the sinusoidal harmonics. We can reduce the ripple of $v_l(t)$ by using a low pass filter, which kills/dampens the higher frequencies. In the following circuit let $C = 10\mu F$ and $R = 100\text{K}$. Sketch the output waveform $v_o(t)$, and mark its expected dc output.



(f) Suppose the capacitor is initially charged to a voltage of 14Volts. What will be the expected dc output at stead state, in the last part of the question.

(g) Assume now that the filter above is connected to the output of the bridge rectifier, and a load resistance of R_L is connected across $v_o(t)$. Let us take R = 1KΩ, C = 10μF and $R_L >> R$. What is the expected dc output voltage if R_L = 1 MΩ. Also, what do you think is the minimum voltage appearing across the load.

(h) How do you reconcile the parts (e) and (g) of this question.