EE321 First Homework Assignment

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1 Introduction to Signals and Systems

1. **Unit step function:**

   (a) Sketch a voltage signal $v(t) = |t| \cdot [u(t+3) - u(t-3)]$ (Volt) by hand and then plot the function with right time indices ($-10 \leq t \leq 10$) by using Matlab.

   (b) Do the same for a signal $x(t) = 10v(t)$ where $v(t)$ is function in the previous problem.

   (c) Do the same for signal $y(t) = v(3t)$.

   (d) Do the same for signal $w(t) = v(t-3)$.

   (e) Apply the voltage signal $v(t)$ across a 1000Ω resistor as shown in the figure (1). i) Find the function $p(t)$ describes the instantaneous power dissipation of the resistor. ii) Find the expression $E(t)$ of the energy dissipated at any given time instant by the resistor at a small time interval ΔT. iii) Find out what is the total energy dissipated by the resistor?

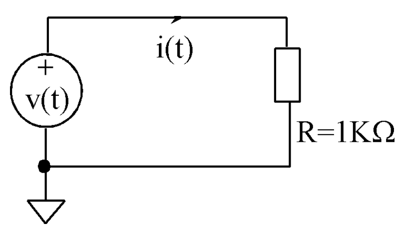

Figure 1:

   (f) Find out what are the corresponding energy dissipation by the resistor, if voltage signal $x(t)$, $y(t)$ and $w(t)$ are used respectively?

   (g) Can you draw some conclusions by generalizing the answers?

2. **Sinusoidal signals:**

   (a) Determine the period of signals: i) $f(t) = 2\cos(5t-2)$;ii) $x(t) = 10\cos(125\pi t - 2) + 5\sin(50\pi t)$. Plot 5 periods of each signal with 2 samples per period and 10 samples per period respectively using Matlab.

   (b) Determine the frequency (in Hz) and the time delay from the phase delay of signals: i) $f_1(t) = 20\cos(120\pi t - \frac{\pi}{3})$; ii) $f_2(t) = 30\cos(360\pi t - \frac{\pi}{3})$; iii) $f_3(t) = 2e^{j(20t-1)}$

   (c) Find the expression of the signal $x(t) = 3\cos(3t - \frac{\pi}{3}) - 2\sin(t-1)$ in sum of complex exponentials.

   (d) Find the sinusoidal expression of signals: i) $y(t) = je^{-j20\pi t} - je^{j20\pi t}$; ii) $x(t) = (1+j)e^{-j(5\pi t - 0.5)} + (1-j)e^{j5\pi t}e^{-j\frac{1}{2}}$

(e) Determine the power and RMS values of signals: i) $x_1(t) = 2\cos(120\pi t + 2)$; ii) $x_2(t) = 2\cos(100\pi t - 1)$ iii) $f(t) = 2e^{j2\pi t} + 3e^{-j5\pi t}$; iv) $y(t) = 3\cos(120\pi t - 1) + 4\sin(50\pi t + \frac{\pi}{4})$; v) $w(t) = \sin(3000\pi t) + 30$

(f) Can you draw some conclusions by generalizing the answers?

3. **Unit impulse function (sampling):**

(a) Evaluate or simplify the following expressions: i) $f_1(t) = \frac{\cos(2t^2)}{t+1} \cdot \delta(t)$; ii) $f_2(t) = (2\omega - \omega^2 - 2) \cdot \delta(\omega - 2)$; iii) $\int_{-\infty}^{\infty} \delta(t+3)e^{t-2}dt$; iv) $\int_0^{100} (\omega^3 + 2\omega + 2)\delta(\omega + 2)d\omega$

(b) Can you draw some conclusions by summarizing the answers?

4. **Pulse train signals:**

(a) A TTL (transistor-transistor-logic) voltage computer clock signal is illustrated in figure (2). Find the period (note: the time scale is in nS (10^{-9} Second)) and frequency of the clock signal. Plot 10 periods of the signal with correct time indices in Matlab.

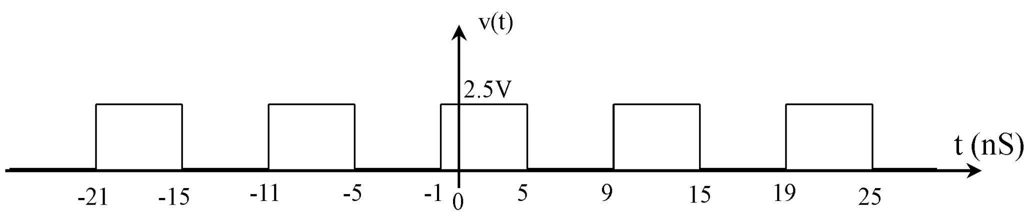

Figure 2:

(b) This signal is applied over a 1000Ω loading resistor as show in figure (1). Find the function of the instantaneous power $P(t)$ dissipated over the resistor. Find the peak (maximum) instantaneous power dissipation and the average power dissipation of the resistor.

(c) What is the RMS voltage across the resistor?

(d) Can you decide if a resistor with power rating of 1/16W is suitable for this application?

(e) Repeat all the questions above using the following video scan timing signal in figure (3).

5. **Problems in the text book:** 1.1-2, 1.3-3 and 1.4-11.

6. **System Models:**

(a) Given a power noise filtering circuit as in figure (4) where 10Ω resistor is the load.
i) Find the differential equations relating input voltage $f(t)$ and output voltage $y(t)$; ii) Find the polynomials $A(s)$ and $B(s)$ of the differential equations and its transfer function $H(s)$; iii) Show that the filtering circuit model is a linear time invariant system.

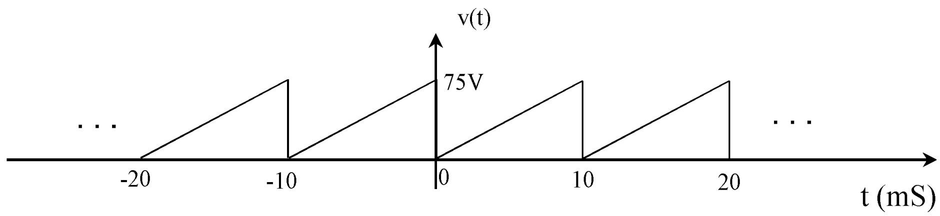

Figure 3:

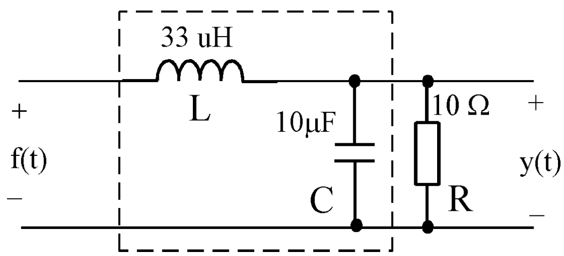

Figure 4:

(b) Find the transfer function and the ordinary differential equation of the circuit in figure (4) using impedance method.

(c) Figure (5) illustrates an instrument with mass M is mounted on a vibration absorber on a vehicle where $x(t)$ is the position of the instrument, $f(t)$ is the vertical vibrational force and Mg is a constant force caused by gravity that sets the equilibrium position of the instrument. K_d and K_s are the damping coefficient and spring stiffness coefficient respectively. i) Set up the system model in differential equation using $x(t)$ and $f(t)$

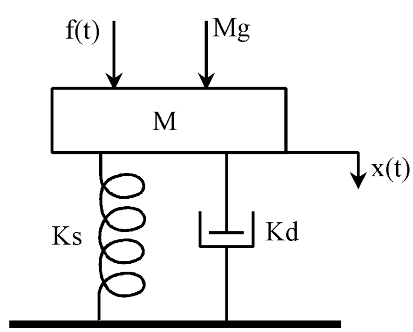

Figure 5:

as output and input respectively; ii) Find the corresponding transfer functions.

(d) Problems in the text book: 1.8-1, 1.8-2 and 1.8-3