SEMESTER 1 EXAMINATION – 20012/2013

Module Code: EEEN30110 , Module Title: Signals and Systems

Time Allowed: 2 hours

Answer all questions. The percentages in the right margin give an approximate indication of the relative importance of each part of a question. All rough work should be entered in your answer books

1. A signal $f(t)$ is periodic of period 1 sec. Over the time-interval -0.2 sec to 0 sec the signal is constant at -1. Over the time-interval 0 sec to 0.8 sec the signal ramps, (i.e. rise linearly) from -1 to 10. At time 0.8 sec the signal resets back to -1.

   Plot three cycles of the signal vs time. **10**

   Determine whether or not the signal has discontinuities and hence select a suitable value for the number of samples per cycle, N, arising in the approximate evaluation of the Fourier coefficients. Find the first eight non-zero terms of the trigonometric Fourier series of $f(t)$. **80**

   Determine the DC component, the fundamental, the second harmonic and the third harmonic of $f(t)$. **10**

2. A plotter with input $v(t)$, a voltage, and output $x(t)$, the position of a pen, is described by the linear, constant-coefficient, ordinary differential equation:

$$\frac{d^4x(t)}{dt^4} + 1{,}090\frac{d^3x(t)}{dt^3} + 90{,}800\frac{d^2x(t)}{dt^2} + 1{,}450{,}000\frac{dx(t)}{dt} + 9{,}750{,}000x(t) = 650{,}000\frac{dv(t)}{dt} + 9{,}750{,}000v(t)$$

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   Determine the transfer function $H(j\omega)$ of the system from input $v(t)$ to output $x(t)$. Plot the magnitude of the frequency response vs frequency and hence or otherwise discuss the filtering properties of the system. **10**

   If the input voltage is a unit step and the initial position is constant at 1 cm, find a formula for subsequent position of the pen as a function of time. Identify the forced response and the free response. Identify also the transient and the steady-state response. **70**

Given that the input voltage to the plotter system is the signal $f(t)$ of the first part of question 1 find the first eight non-zero terms of the trigonometric Fourier series of the steady-state output of the system. **20**

3. An LTI, SISO, causal, discrete-time system with input $x(n)$ and output $y(n)$ is governed by the recursion/difference equation:

$$y(n) - 2.501y(n-1) + 2.1157y(n-2) - 0.5917y(n-3) = 0.0013x(n-1) + 0.0024x(n-2) + 0.0001x(n-3) \quad \text{for } n \geq 0$$

subject to the initial conditions $y(-1) = 0$, $y(-2) = 0$, $y(-3) = 0$. Given an input $x(n)$ which is zero for n not equal to 0 or 1 and 0.5 for n equal to 0 or 1, find a formula for the resulting output of the system for $n \geq 0$. **50**

Let the input to the system be a periodic signal of period 9. For $n = 0$ and 1 this signal equals 0.5. For $n = 2, 3, \ldots, 8$ this signal is equal to 0. Find the resulting steady-state output of the system. **50**

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