11 Digital Signal Processing (mgk25)

This question can only be attempted by Part II 50% candidates.

(*a*) Name one advantage and one disadvantage of Finite-Impulse-Response (FIR) filters over Infinite-Impulse-Response (IIR) filters. [2 marks]

(*b*) For each of the following discrete systems $\{y_n\} = T\{x_n\}$, either show that T is equivalent to a convolution operation, by providing an impulse response $\{h_n\}$ such that

$$y_n = \sum_{i=-\infty}^{\infty} h_i x_{n-i}$$

or explain why the system cannot be described through convolution.

(*i*) $y_n = \frac{1}{2}(x_{2n} + x_{2n+1})$ [2 marks]

(*ii*) $y_n = x_{n+4}$ [2 marks]

(*iii*) $y_n = \frac{3}{2}x_{n-1} - \frac{1}{2}y_{n-2}$ [4 marks]

(*c*) What is the z-transform of the impulse response of the system in Part (*b*)(*iii*)? [4 marks]

(*d*) Consider a digital filter where the z-transform of the impulse response is

$$H(z) = \frac{z^2 - 1}{z^2 + \frac{49}{64}}.$$

(*i*) Draw the location of poles and zeros of $H(z)$ in the z-plane. [2 marks]

(*ii*) What is this kind of filter called? [1 mark]

(*iii*) A test signal $x(t) = \cos(2\pi f t)$ is sampled into $x_n = x(n/f_s)$, with rate $f_s = 4$ kHz, and then passed through this filter. For what values of f will the root-mean-square level at the filter output be maximal? [3 marks]