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
\[
H(z) = \frac{z^2 - \frac{1}{4}}{z^2 + \frac{49}{64}}.
\]

(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 \( x(t) = \cos(2\pi ft) \) is sampled into \( x_n = x(n/f_s) \), with rate \( f_s = 4 \text{ kHz} \), 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]