COMPUTER SCIENCE TRIPOS Part II – 2015 – Paper 9

5 Digital Signal Processing (MGK)

(a) You have been asked to design a long-wave radio receiver that can simultaneously monitor two radio signals at 60 ± 10 kHz and 100 ± 10 kHz, that is two stations with 20 kHz bandwidth each. Analog filters in your antenna amplifier suppress all signals outside those two bands.

What is the lowest possible sampling frequency that you can use for a *single* time-domain discrete sequence that records signals from these two bands simultaneously and unambiguously if you use

(*i*) base-band sampling;   [2 marks]

(*ii*) IQ sampling.   [2 marks]

(b) Consider the following digital filter with two multipliers:
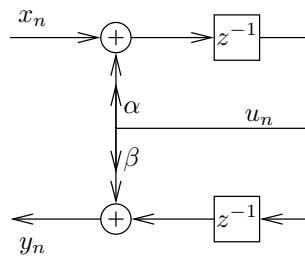
(*i*) State the equations that define the elements of the output sequence $\{y_n\}$ and the intermediate sequence $\{u_n\}$ in terms of other values from $\{x_n\}$, $\{y_n\}$ or $\{u_n\}$.   [4 marks]

(*ii*) Convert these equations into equivalent equations for the z-transforms $X(z)$, $Y(z)$ and $U(z)$ of these three discrete sequences, and then solve for $U(z)$ and $Y(z)$.   [4 marks]

(*iii*) What is the z-transform $H(z)$ of the impulse response of this digital filter?   [4 marks]

(*iv*) Draw the block diagram of an equivalent Direct Form I filter.   [4 marks]