

DSP EXAM MAY 2021

SOLUTIONS.

①. $y(n) + 0.45x(n) - 0.85x(n-1) - 0.6x(n-3) - 0.4y(n-1) + 0.02y(n-2) = 0.$

$$y(n) - 0.4y(n-1) + 0.02y(n-2) = -0.45x(n) + 0.85x(n-1) + 0.6x(n-3). \quad (1)$$

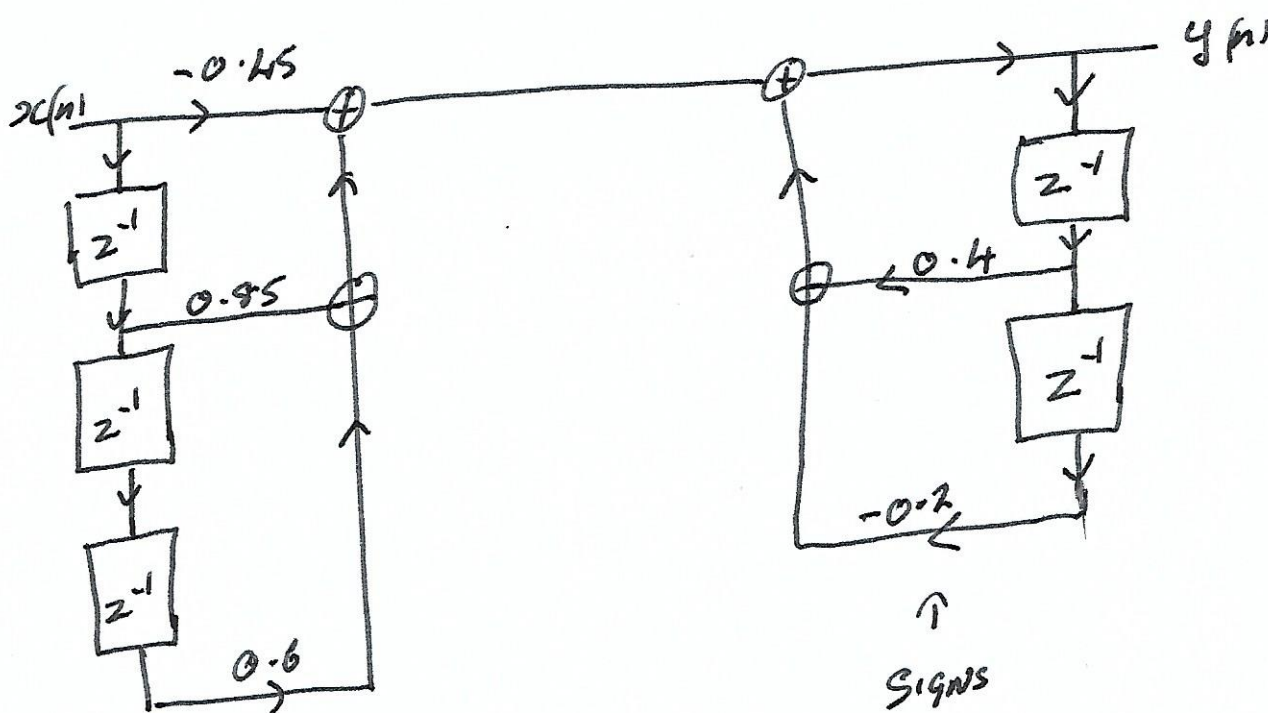
Z Transform.

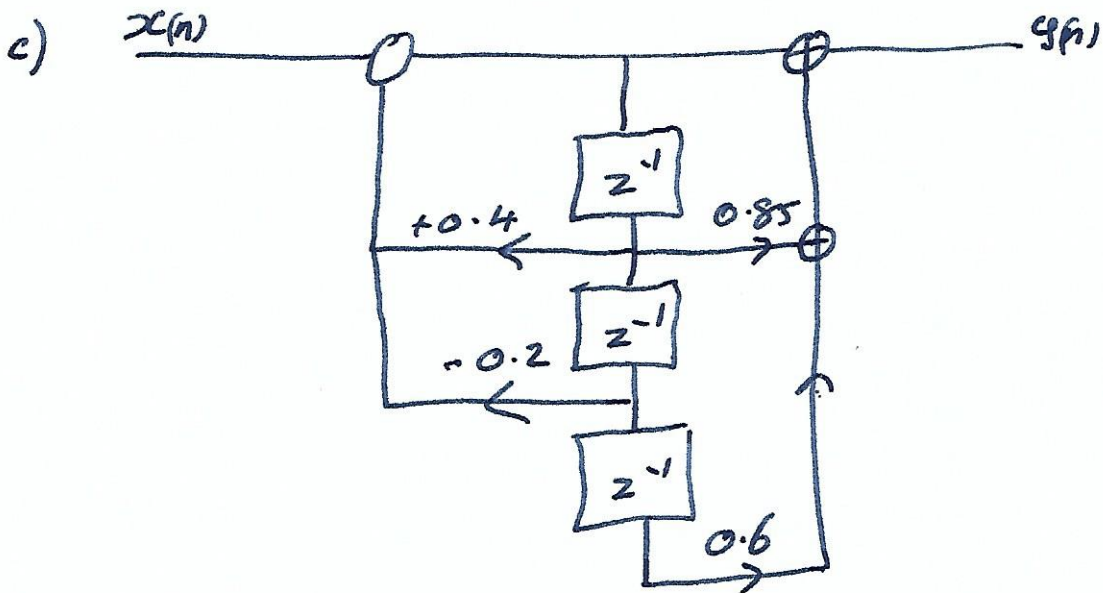
$$\Rightarrow Y(z) - 0.4Y(z)z^{-1} + 0.02Y(z)z^{-2} = -0.45X(z) + 0.85X(z)z^{-1} + 0.6X(z)z^{-3}.$$

$$\Rightarrow Y(z)(1 - 0.4z^{-1} + 0.02z^{-2}) = X(z)(-0.45 + 0.85z^{-1} + 0.6z^{-3}).$$

$$\text{T.F. } \frac{Y(z)}{X(z)} = \frac{-0.45 + 0.85z^{-1} + 0.6z^{-3}}{1 - 0.4z^{-1} + 0.02z^{-2}} \quad (2)$$

b). DIRECT FORM I.





②

②

d) Eg LESS REAL ESTATE IN H/W

①

e) Eg ADVANTAGE — MUCH LESS TAPS

1

DISADVANTAGE — MAY BE UNSTABLE.

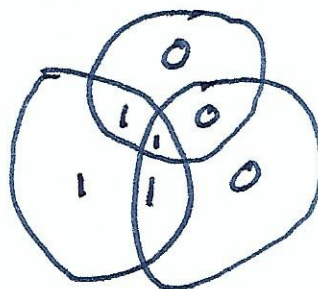
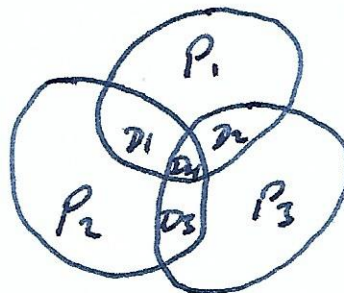
①

— NON LINEAR PHASE RESP.

2)

1 0 1 1.

GRAPHIC METHOD.



= 1 0 1 1 0 1 0
D P.

②

26/.

$\begin{array}{ccccccc} 1 & 0 & 1 & 1 & 0 & 0 & 1 & 0 & 1 & 0 & 1 & 0 & 0 & 1 & 0 \\ \hline P_1 & P_2 & P_4 & & & & P_8 & & & & & & & & \end{array}$

③.

$P_1 \quad 1 \quad 1 \quad 0 \quad 1 \quad 1 \quad 1 \quad 0 \quad 0 = \underline{5 \text{ ODD}}$

$P_1 \text{ ERROR}$

$P_2 \quad 0 \quad 1 \quad 0 \quad 1 \quad 0 \quad 1 \quad 1 \quad 0 = 4 \text{ EVEN}$

$P_2 \text{ OK.}$

$P_4 \quad 1 \quad 0 \quad 0 \quad 1 \quad 0 \quad 0 \quad 1 \quad 0 = 3 \text{ ODD.}$

$P_4 \text{ ERROR}$

$P_8 \quad 0 \quad 1 \quad 0 \quad 1 \quad 0 \quad 0 \quad 1 \quad 0 = 3 \text{ ODD}$

$P_8 \text{ ERROR.}$

$P_1 + P_4 + P_8 = 13$

BIT 13 ERROR

CORRECT MESSAGE

10 11 00 10 10 10 11 0

①

①

①.

2 c).

POOR PEOPLE PAY

(4)

P = 4

O = 3

R = 1

□ = 2

E = 2

L = 1

A = 1

Y = 1

15 CHAR.

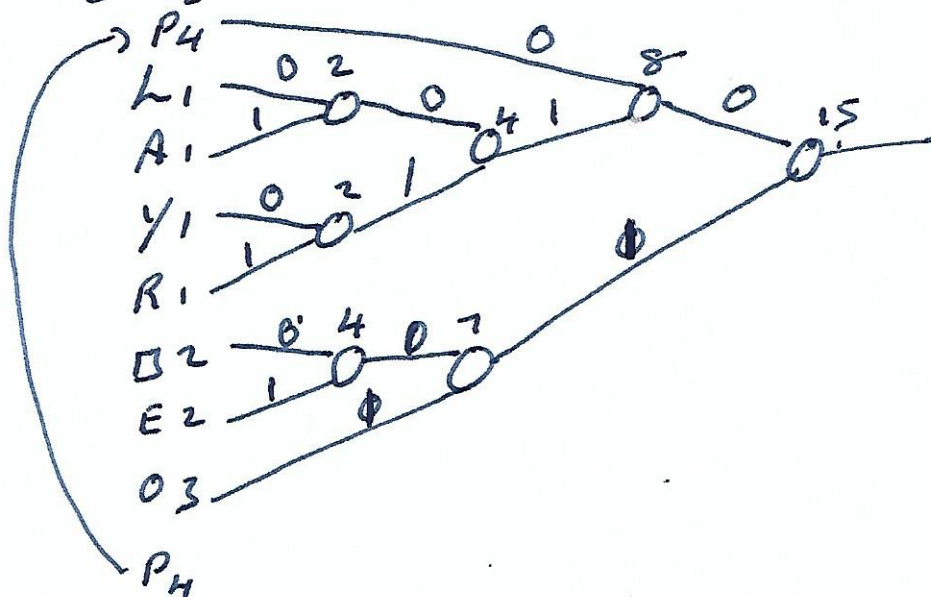
8 CHARACTER TYPES.

MIN 3 BITS / CHARACTER.

MIN TOTAL BITS = $15 \times 3 = \underline{45 \text{ BITS}}$

(1)

CODE EXAMPLE.



(2)

GIVING.

P =

L =

A =

Y =

R =

□ =

E =

O =

0 0 = $2 \times 4 = 8$

0 1 0 0 = $4 \times 1 = 4$

0 1 0 1 = $4 \times 1 = 4$

0 1 1 0 = $4 \times 1 = 4$

0 1 1 1 = $4 \times 1 = 4$

1 0 0 = $3 \times 2 = 6$

1 0 1 = $3 \times 2 = 6$

1 1 = $2 \times 3 = 6$

TOTAL 42 BITS

SAVE 3 BITS

(1)

(1)

3/

(5).

$$x(t) = 4 \cos(6000\pi t) + 2 \cos(16000\pi t) - 2 \cos(8000\pi t)$$

$$f_1 = \frac{6000\pi}{2\pi} = 3000 \text{ Hz}$$

$$f_2 = \frac{16000\pi}{2\pi} = 8000 \text{ Hz} \quad (1)$$

$$f_3 = \frac{8000\pi}{2\pi} = 4000 \text{ Hz}$$

$$\text{HIGHEST} = 8000 \text{ Hz} \quad (1)$$

$$N_{\text{NYQUIST}} = 2 \times 8000 \text{ Hz} = 16000 \text{ s/s} \quad (1)$$

b). SAMPLE @ 10000 S/S.

$$x(n) = 4 \cos\left(\frac{6000\pi}{10000}\right)n + 2 \cos\left(\frac{16000\pi}{10000}\right)n - 2 \cos\left(\frac{8000\pi}{10000}\right)n \quad (1)$$

$$x(n) = 4 \cos\left(\frac{3000 \times 2\pi}{10000}\right)n + 2 \cos\left(\frac{8000 \times 2\pi}{10000}\right)n - 2 \cos\left(\frac{4000 \times 2\pi}{10000}\right)n \quad (1)$$

$$x(n) = 4 \cos\left(\frac{3}{10} \times 2\pi\right)n + 2 \cos\left(\frac{8}{10} \times 2\pi\right)n - 2 \cos\left(\frac{4}{10} \times 2\pi\right)n.$$

$$x(n) = 4 \cos\left(\frac{3}{10} \times 2\pi\right)n + 2 \cos\left(\left(1 - \frac{2}{10}\right) \times 2\pi\right)n - 2 \cos\left(\frac{4}{10} \times 2\pi\right)n \quad (1)$$

$$x(n) = 4 \cos\left(\frac{3}{10} \times 2\pi\right)n + 2 \cos\left(\frac{2}{10} \times 2\pi\right)n - 2 \cos\left(\frac{4}{10} \times 2\pi\right)n \quad (1)$$

RECOVERED SIG.

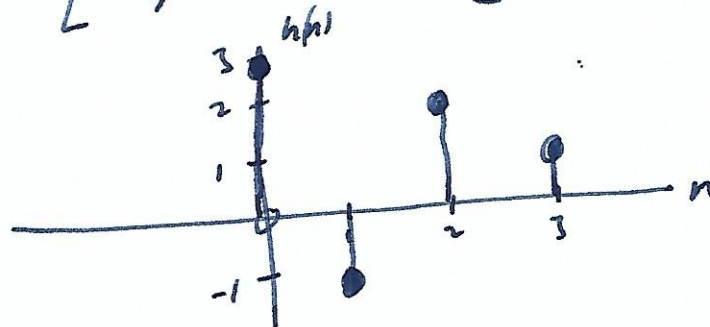
$$x(t) = 4 \cos\left(\frac{3 \times 10000 \times 2\pi t}{10}\right) + 2 \cos\left(\frac{2 \times 10000 \times 2\pi t}{10}\right) - 2 \cos\left(\frac{4 \times 10000 \times 2\pi t}{10}\right) \quad (1)$$

$$x(t) = 4 \cos(6000\pi t) - 2 \cos(4000\pi t) - 2 \cos(8000\pi t) \quad (1)$$

3c). POSSIBLE DESIGN FEATURES.

- 1). ANTI ALIAS LP FILTER
- 2). INCREASE SAMPLE RATE

4) $h(n) = [3, -1, 2, 1]$



6)

n	-3	-2	-1	0	1	2	3	4	
$h(n)$	0	0	0	3	-1	2	1		①
$h(n-1)$	0	0	0	0	3	-1	2	1	①
$2h(n-1)$	0	0	0	0	6	-2	4		①
$h(-n)$	1	2	-1	3	0	0	0	0	①
$h(-n+2)$	0	0	1	2	-1	3	0	0	①

4c).

⑦.

n	0	1	2	3	4	5	6	7	8
$h(n)$	3	-1	2	1					
$x(n)$	1	1	-3	-1	2				
$h(n)x_0$	3	-1	2	1					
$h(n-1)x_1$		3	-1	2	1				
$h(n-2)x_2$			-9	3	-6	-3			
$h(n-3)x_3$				-3	+1	-2	-1		
$h(n-4)x_4$					6	-2	4	2	
$y(n)$	3	2	-8	3	2	-7	3	2	

①

③.

①

$$y(n) = 3, 2, -8, 3, 2, -7, 3, 2.$$

5). $f = 3512 \text{ MHz.}$

$BANDW = 3524 - 3500 = 24 \text{ MHz}$

$PATH \text{ LOSS} = 20 \log(15) + 20 \log(3512) + 32.44.$
 $= \underline{126.87 \text{ dB.}}$

$TX \text{ POWER} = 1 \text{ W} = 30 \text{ dBm.}$

$ANTENNA \text{ GAIN} = +9 \text{ dB}$

$\therefore TX \text{ Sig} = 39 \text{ dBm}$

$AT \text{ RX Sig} = 39 \text{ dBm} - 126.87 \text{ dB}$
 $= -87.87 \text{ dBm. or } -117.87 \text{ dBW.}$
 $= 1.633 \times 10^{-12} \text{ W.}$

NOISE CALC

$THERMAL \text{ NOISE} = KTB. \text{ 1 Hz.}$

$T = 25 + 273 \text{ } ^\circ\text{K}$
 $= 298 \text{ } ^\circ\text{K.}$

$\therefore \text{ NOISE POWER}$
 $= 298 \times 1.38 \times 10^{-23} \times 24 \times 10^6$

$= 9.869 \times 10^{-14} \text{ W.}$

$\frac{Sig}{Noise} = \frac{1.633 \times 10^{-12}}{9.869 \times 10^{-14}} = \underline{16.547.}$

Max. Chan Capacity.

$C = B \log_2$

$C = B \log_2 \left(1 + \frac{S}{N} \right)$

$C = 24 \times 10^6 \log_2 (1 + 16.547)$

$= \underline{99,195,659 \text{ BIT/SEC.}}$

6/

PASS BAND 0.1 dB.

ATTENUATION = 50 dB.

PASS BAND $0 \rightarrow 300$ Hz.

TRANSITION 100 Hz

SAMPLE RATE 8000.

⑨.

$$\text{EDGE FREQUENCY } 300 \quad \text{NORMALISED } F_p = \frac{300}{8000} = 0.0375.$$

$$\text{TRANSITION } \Delta F = \frac{100}{8000} = 0.0125.$$

$$\text{PASS BAND RIPPLE } \delta_p = A_p = 20 \log_{10}(1 + \delta_p).$$

$$\therefore \delta_p = \log_{10}^{-1} \left(\frac{0.1}{20} \right) - 1 = 0.116. \text{ (3dp).}$$

Using Table.

HAMMING WINDOW. > 53 dB ATTENUATION. ✓

RIPPLE = 0.0194 ✓

$$\frac{\Delta F}{N^0} = \frac{3.3}{N}$$

$$\therefore N = \frac{3.3}{0.0125} = \underline{264 \text{ TAPS}} \Rightarrow \underline{265}^{\text{ODD.}}$$

$$\text{HAMMING WINDOW } W_n = 0.54 - 0.46 \cos \left(\frac{2\pi n}{N-1} \right)$$

LP FILTER.

$$h_{\text{DFT}} = 2 F_c \frac{\sin n \Omega_c}{n \Omega_c} = \frac{\sin n \Omega_c}{n \pi}.$$

$$\Omega_c = 2\pi \left(F_p + \frac{\Delta F}{2} \right) = \left(0.0375 + \frac{0.0125}{2} \right) \times 2\pi$$

$$= \boxed{0.04375} \times 2\pi$$

$$\Omega_c = \underline{0.275}.$$

FILTER

$$= \frac{\sin n 0.275}{n \pi} \cdot \left(0.54 - 0.46 \cos \left(\frac{2\pi n}{264} \right) \right)$$

For $n = 5$.

$$= \frac{\sin (5 \times 0.275)}{5 \pi} \left(0.54 - 0.46 \cos \left(\frac{2\pi 5}{264} \right) \right)$$

$$= 0.06244 \times 0.08325.$$

$$= \underline{5.198 \times 10^{-3}}$$