Midterm

Q.1)

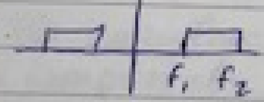
a. 5G supports different verticals, that have diverse requirements. Instead of the 'one-fits-all' network, 5G introduces network models that can support diverse use cases. ex: autonomous vehicles & online surgeries, smart grid.

b. FTN :- faster than Nyquist rate. FTN operates at capacities higher than Nyquist no-ISI limit. The main challenge is the complexity at T_x & R_x because of the complex signal processing.

c. $P_N = N_o . BF$ & the $SNR = \frac{P_R}{P_N}$

d. This is because 5G should support mission critical applications such as online surgeries & autonomous vehicles which require 5-10 msec delay compared to 4G latency of 30-40 msec.

e. The absolute BW is suitable for passband signals

ex: 

, where the BW is zero for freq greater than f_2.

This definition will not be suitable for signals such as sinc, where f_2 might be ∞.

$\boxed{K = C^\circ + 273}$

f) $SNR_1 = 13.1\,dB$, $T_1 = 21°C$, $T_2 = 30°C$, SNR_2 ?

$SNR = \frac{P_R}{P_N} = \frac{P_R}{TKBF} = \frac{a}{T}$

$\frac{a}{T_1} = SNR_1 \Rightarrow a = T_1 SNR_1 = (21)(10^{1.3}) = 419$

$SNR_2 = \frac{419}{30} = 13.96$

$= \boxed{11.45\,dB}$

g) There are several ways to interpret the PSD. one way is that the PSD is equivalent to ~~the expected~~ ~~value~~ $\Rightarrow S_x(f) = \sum P_i |x_i(f)|^2$ which is the expected value of squared signal components and in this equation PSD can only be positive.

h) While it is true that the Rate supported by the BS is much larger than UE_i rate , the sum of the total rates will add up to R. $R = \sum_i B_i \log_2 M_i \frac{r_i}{1+\beta}$

i) The zero-forcing equalizer attempts to remove ISI components introduced by the channel.

$h(t) = g_{Rx}(t) * g_{Tx}(t) * g_{ch}(t)$, $g_{ch}(t) \neq \delta(t)$

$\Rightarrow h_{eq}(t) = \frac{1}{g_{ch}(t)}$

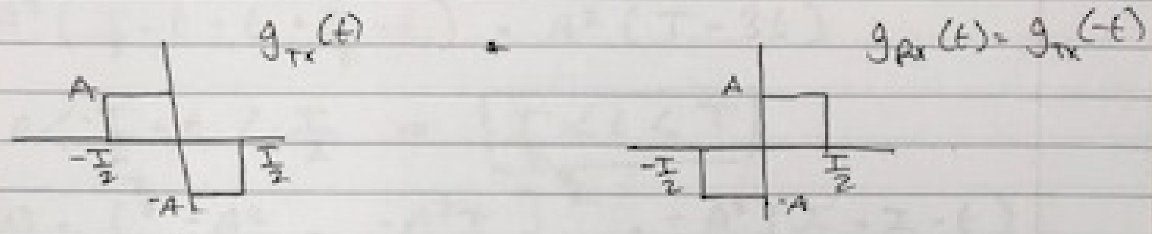
(j) $M = 256$, code rate $= \frac{3}{4}$, $\alpha = 0.2$, $B = 40\,MHz$

$n = 4$.

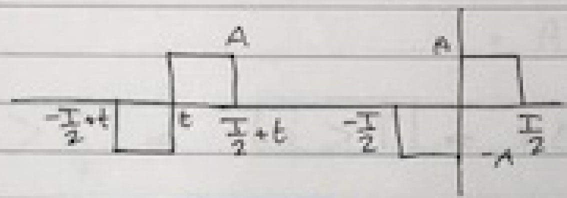
$R = \frac{n r B \log_2 M}{1+\alpha} = \frac{3(40M)}{1+0.2} \log_2 256 = 800\,M\,b/sec$

Question # 2

b) $h(t) = g_{Tx}(t) * g_{Rx}(t)$



$\Rightarrow$



$\Rightarrow \frac{T}{2} + t < -\frac{T}{2} \Rightarrow \boxed{t < -T}$, $h(t) = 0$

$\Rightarrow -\frac{T}{2} < \frac{T}{2} + t < 0 \Rightarrow \boxed{-T < t < -\frac{T}{2}}$

$$h(t) = \int_{-\frac{T}{2}}^{\frac{T}{2}+t} -A^2 \, d\tau = -A^2\tau \Big]_{-\frac{T}{2}}^{\frac{T}{2}+t} = -A^2\left(\frac{T}{2} + t + \frac{T}{2}\right)$$

$$= -A^2(t + T)$$

$\Rightarrow 0 < \frac{T}{2} + t < \frac{T}{2} \Rightarrow \boxed{-\frac{T}{2} < t < 0}$

$$h(t) = \int_{0}^{\frac{T}{2}+t} A^2 \, d\tau + \int_{-\frac{T}{2}}^{t} A^2 \, d\tau + \int_{t}^{0} -A^2 \, d\tau$$

$$= A^2\tau \Big]_{0}^{\frac{T}{2}+t} + A^2\tau \Big]_{-\frac{T}{2}}^{t} - A^2\tau \Big]_{t}^{0}$$

$$= A^2\left(\frac{T}{2} + t\right) + A^2\left(t + \frac{T}{2}\right) + A^2 t = A^2(3t + T)$$

$\Rightarrow \boxed{0 < t < \frac{T}{2}}$

$$h(t) = \int_{t}^{\frac{T}{2}} A^2 \, d\tau + \int_{0}^{t} -A^2 \, d\tau + \int_{-\frac{T}{2}+t}^{0} A^2 \, d\tau$$

$$h(t) = A^2\tau \Big]_t^{\frac{T}{2}} + -A^2\tau \Big]_0^{t} + A^2\tau \Big]_{-\frac{T}{2}+t}^{0}$$

$$= A^2\left(\frac{T}{2} - t - t + \frac{T}{2} - t\right) = A^2(T - 3t)$$

$$\Rightarrow 0 < -\frac{T}{2} + t < \frac{T}{2} \Rightarrow \boxed{\frac{T}{2} < t < T}$$

$$h(t) = \int_{-\frac{T}{2}+t}^{\frac{T}{2}} -A^2 = -A^2\tau \Big]_{-\frac{T}{2}+t}^{\frac{T}{2}} = -A^2\left(\frac{T}{2} + \frac{T}{2} - t\right)$$

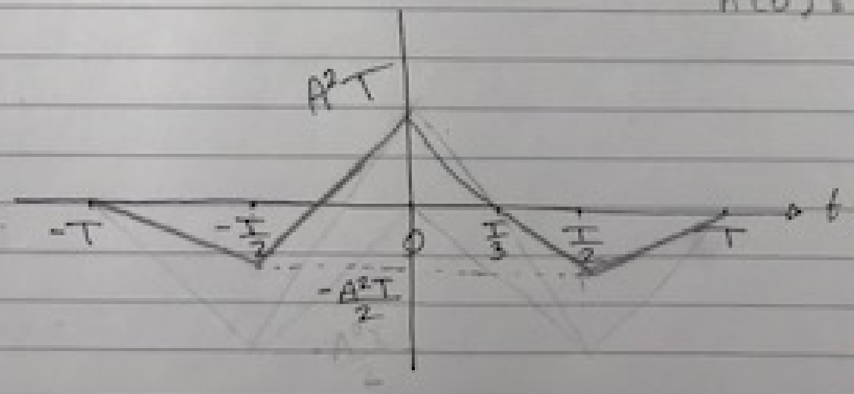
$$= A^2 t - A^2 T$$

$$\Rightarrow -\frac{T}{2} + t > \frac{T}{2} \Rightarrow \boxed{t > T} \Rightarrow h(t) = 0$$

$$h(t) = \begin{cases} 0 & , \quad t < -T & , \quad 0 \\ -A^2(t+T) & , \quad -T < t < -\frac{T}{2} & , \quad A^2(-t-T) \\ \cancel{3A^2t+T}\ A^2(3t+T) & \quad -\frac{T}{2} < t < 0 & , \quad A^2(3t+T) \\ -3A^2t + A^2T & , \quad 0 < t < \frac{T}{2} & , \quad A^2(T-3t) \\ A^2t - A^2T & , \quad \frac{T}{2} < t < T & , \quad A^2(t-T) \\ 0 & , \quad t > T & \end{cases}$$

$$h\left(\frac{T}{2}\right) = -\frac{A^2T}{2}$$

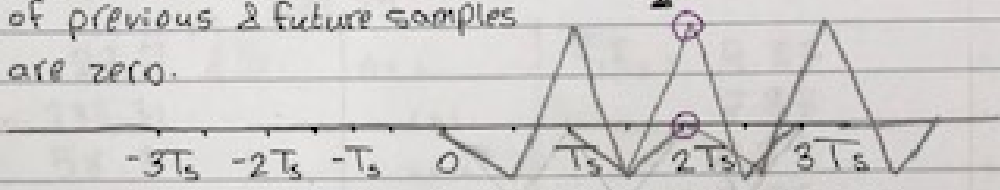
$$h(0) = A^2T$$



⇒ $h(t)$ results in ISI?

Since $h(t) \sum \delta(t-KT_s) = \delta(t)$ So No-ISI condition is satisfied.

At multiples of T_s the values of previous & future samples are zero.



Q3) $h(t) = \alpha \delta(t)$

$\alpha_n = 0.5\,\alpha_{n-1}$

linear

$SE_n = \log_2(1 + SNR_n)$ b/s/Hz

$= 933.25$

$SNR_i = 29.7$ dB	$n = i$	$SE_i = 9.87$
$= 233.31$	$i+1$	7.87
58.3	$i+2$	5.89
14.58	$i+3$	3.46
3.65	$i+4$	2.22
0.911	$i+5$	0.93

$SNR_i = \frac{P_{Rx}}{BN_0} = \frac{\alpha_i^2 P_{Tx}}{BN_0} = 29.7\text{dB} = 933.25$

$SRR_{i+1} = 0.25\,\frac{\alpha_i^2 P_{Tx}}{BN_0} = 0.25\,(933.25) = 233.31$