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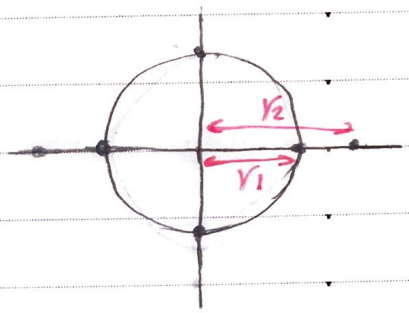
SUBJECT: Day Month Year (20)

Problem 1.

1- $E_{avg} = \frac{1}{M}\sum_{i=0}^{M-1} E_i = \frac{1}{M}\sum_{i=0}^{M-1} |s_i|^2$



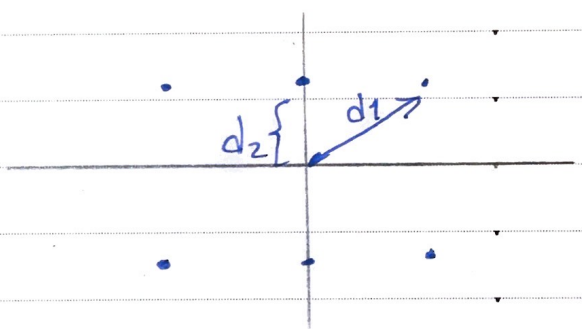
$1 = \frac{1}{6}[4r_1^2 + 2r_2^2]$

$6 = 4r_1^2 + 2r_2^2$

$3 = 2r_1^2 + r_2^2 \Rightarrow r_2^2 = 3 - 2r_1^2$

$$\boxed{r_2 = \sqrt{3 - 2r_1^2}}$$

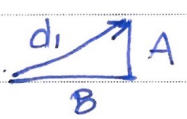
2- $E_{avg} = \frac{1}{M}\sum_{i=0}^{M-1} E_i = \frac{1}{M}\sum_{i=0}^{M-1} |s_i|^2$



$1 = \frac{1}{6}[4d_1^2 + 2d_2^2]$

$d_1 = \sqrt{A^2 + B^2}$

$d_2 = \sqrt{A^2 + 0}$



$E_{avg} = \frac{1}{6}[4(A^2+B^2) + 2A^2]$

$6 = 4A^2 + 4B^2 + 2A^2$

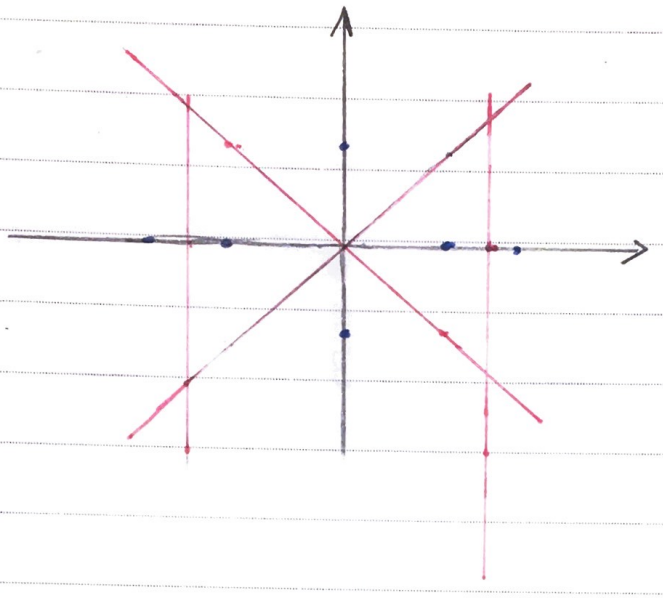
$6 = 6A^2 + 4B^2$

$2B^2 = 3 - 3A^2 \Rightarrow B^2 = \frac{3 - 3A^2}{2}$

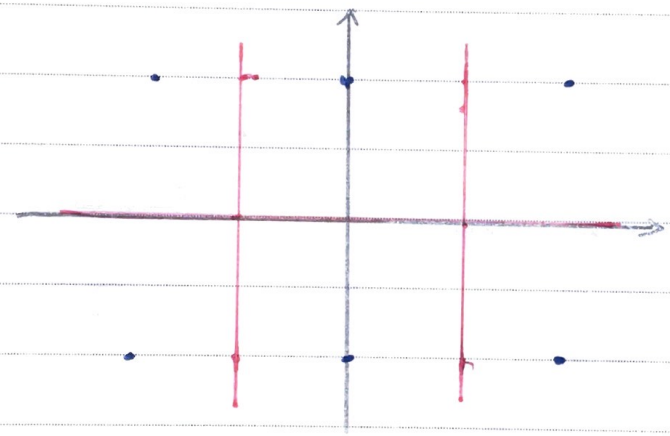
$B = \sqrt{\frac{3}{2} - 3A^2} = \sqrt{\frac{3}{2}(1 - A^2)}$

SUBJECT: Day ..... Month ..... Year (20)

3-



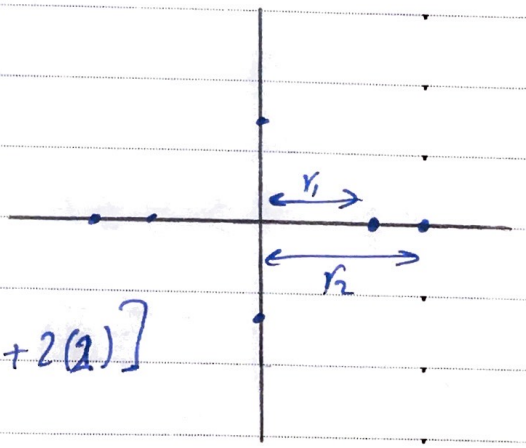
4-



5- $SER = \frac{2k}{M} Q\left(\sqrt{\frac{D_{min}^2}{2N_0}}\right)$;

$r_1 = \sqrt{1/2}$, $r_2 = \sqrt{2}$

$E_{avg} = \frac{1}{M}\sum_{i=1}^{M-1} E_i = \frac{1}{M}\sum_{i=0}^{M-1} |S_i|^2$



$E_{avg} = \frac{1}{6}\left[4r_1^2 + 2r_2^2\right] = \frac{1}{6}\left[4\left(\frac{1}{2}\right) + 2(2)\right]$

$E_{avg} = 1$

$D_1 = r_2 - r_1 = \sqrt{2} - \frac{1}{\sqrt{2}} = \frac{1}{\sqrt{2}}$

$$D_2 = 2r_1 = 2 \cdot \frac{1}{\sqrt{2}} = \sqrt{2}$$

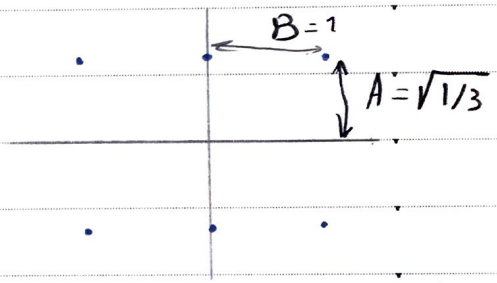
$$D_{min} = \frac{1}{\sqrt{2}} \Rightarrow D_{min}^2 = \frac{1}{2} E_{avg}$$

$M = 6$ $\quad$ $K = 2$ (Pairs bits at min. distance)

$$SER = \frac{2K}{M} Q\left(\sqrt{\frac{D_{min}^2}{2N_0}}\right) = \frac{2 \cdot 2}{6} Q\left(\sqrt{\frac{E_{avg}}{4N_0}}\right)$$

$$SER = \frac{2}{3} Q\left(\sqrt{\frac{E_{avg}}{4N_0}}\right)$$

6- $A = \sqrt{1/3}$, $B = 1$



$$SER = \frac{2K}{M} Q\left(\sqrt{\frac{D_{min}^2}{2N_0}}\right)$$

$$E_{avg} = \frac{1}{M} \sum_{i=0}^{M-1} E_i = \frac{1}{M} \sum_{i=0}^{M-1} |s_i|^2 = \frac{1}{6}\left[4d_1^2 + 2d_2^2\right]$$

$$d_1^2 = A^2 + B^2 = \frac{4}{3} \quad ; \quad d_2^2 = A^2 = \frac{1}{3}$$

$$E_{avg} = \frac{1}{6}\left[4\left(\frac{4}{3}\right) + 2\left(\frac{1}{3}\right)\right] = \frac{18}{18} = 1$$

$M = 6$, $K = 4$ (bits pair at min distance).

~~$D_{min}^2 = 2 E_{avg}$~~

$D_{min}^2 = 1 = E_{avg}$

$$SER = \frac{2K}{M} Q\left(\sqrt{\frac{D_{min}^2}{2N_0}}\right)$$

$$= \frac{2 \cdot 4}{16} Q\left(\sqrt{\frac{E_{avg}}{2N_0}}\right)$$

$$= \frac{4}{3} Q\left(\sqrt{\frac{E_{avg}}{2N_0}}\right)$$

7- Constallation [b] is more power efficient

since $\frac{E_{avg}}{2N_0} > \frac{E_{avg}}{4N_0}$

$SNR > 2SNR$