EE5801: CSP LAB ASSIGNMENT 1

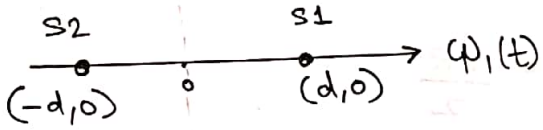
1. Problem Statement

Bit Error Rate (BER) and Symbol Error Rate (SER) performance evaluation of BPSK and QPSK.

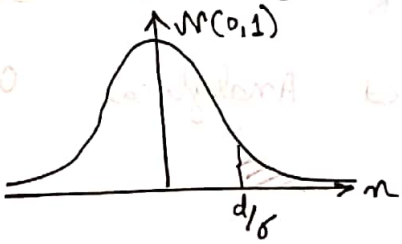
2. Theory

BPSK

The constellation diagram of BPSK can be drawn as



$$P_E(\text{error}|S_2) = P(S_2 + n > 0)$$
$$= P(n > d)$$
$$= P\left(\frac{n}{\sigma} > \frac{d}{\sigma}\right) = Q\left(\frac{d}{\sigma}\right)$$



Similarly $P_E(\text{error}|S_1) = Q\left(\frac{d}{\sigma}\right)$

$$P_E = \frac{1}{2}Q\left(\frac{d}{\sigma}\right) + \frac{1}{2}Q\left(\frac{d}{\sigma}\right) = Q\left(\frac{d}{\sigma}\right)$$

$d = \|S_1\| = \|S_2\| = \sqrt{E_s}$;

$\sigma = \sqrt{\frac{N_0}{2}}$

$$P_E = Q\left(\sqrt{\frac{2E_s}{N_0}}\right) = \frac{1}{2}\text{erfc}\left(\sqrt{\frac{E_s}{N_0}}\right) \quad [\text{here } E_s = E_b]$$

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QPSK

P_E for MPSK is given by,

$$P_E = 2Q\left(\sqrt{\frac{2\log_2 M E_b}{N_0}}\sin\frac{\pi}{M}\right)$$

For QPSK $M=4$

$$P_E = 2Q\left(\sqrt{\frac{4E_b}{N_0}}\frac{1}{\sqrt{2}}\right) = 2Q\left(\sqrt{\frac{2E_b}{N_0}}\right) = 2Q\left(\sqrt{\frac{E_s}{N_0}}\right)$$

$$\Rightarrow P_E = \frac{1}{2}\cdot 2\,\text{erfc}\left(\sqrt{\frac{E_s}{2N_0}}\right) = \text{erfc}\left(\sqrt{\frac{2E_s}{N_0}}/2\right)$$

$$\Rightarrow P_E = \text{erfc}\left(\sqrt{SNR}/2\right) \quad \text{(SER)}$$

BER is given by $P_e = \frac{P_E}{2}$

$$\Rightarrow P_e = \frac{1}{2}\,\text{erfc}\left(\frac{\sqrt{SNR}}{2}\right)$$

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Observation from MATLAB plot

Modulation Scheme	SNR(dB)	SNR	SER		BER	
			Observed	Analytical	Observed	Analytical
BPSK	0	1	0.1587	0.1587	0.1587	0.1587
$P_E = Q(\sqrt{SNR})$	2	1.585	0.104	0.1040	0.104	0.104
$= \frac{1}{2}\text{erfc}(\sqrt{\frac{SNR}{2}})$	5	3.162	0.03768	0.0377	0.03768	0.0377
	10	10	0.000782	0.0007827	0.000782	0.0007827
QPSK	0	1	0.4222	0.4795	0.2395	0.2398
$P_E = \text{erfc}(\sqrt{\frac{SNR}{2}})$	2	1.585	0.3391	0.3173	0.1865	0.1687
$P_e = \frac{1}{2}\text{erfc}(\sqrt{\frac{SNR}{2}})$	5	3.162	0.1933	0.1138	0.105	0.061
	10	10	0.02535	0.0253	0.01325	0.01299

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