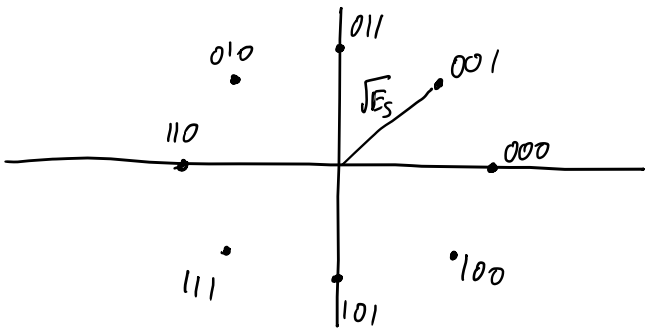
M. Hasyim Abdillah P. 1101191095 TT-43-11

1. a. Modulasi level tinggi : modulasi dimana sinyal informasi yang akan dimodulasi adalah sinyal digital berbentuk 1 dan 0

Jenis - jenis modulasi level tinggi :
- ASK (Amplitude Shift Keying)
- PSK (Phase Shift keying)
- FSK (Frequency Shift keying)
- QAM (Quadrature Amplitude Modulation)

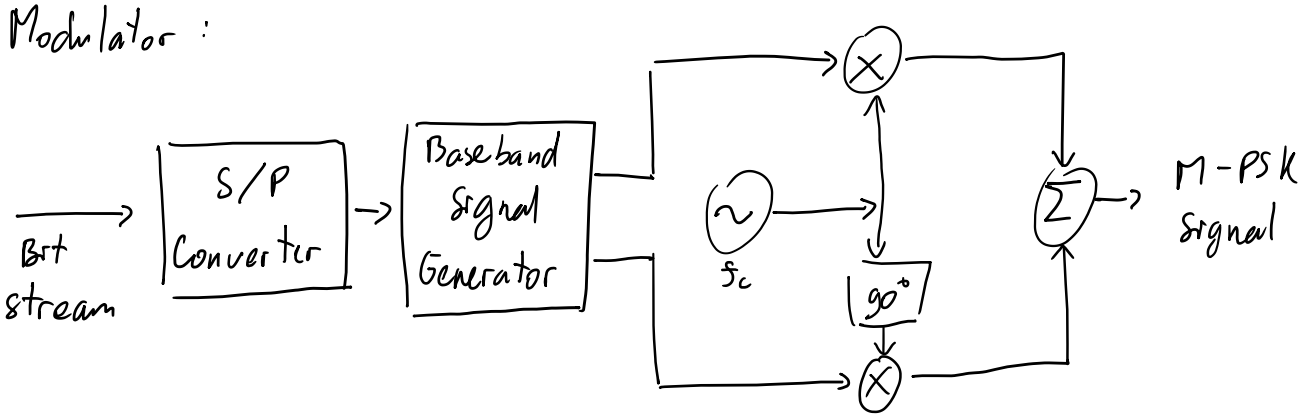
b. M - PSK

Diagram konstelasi :

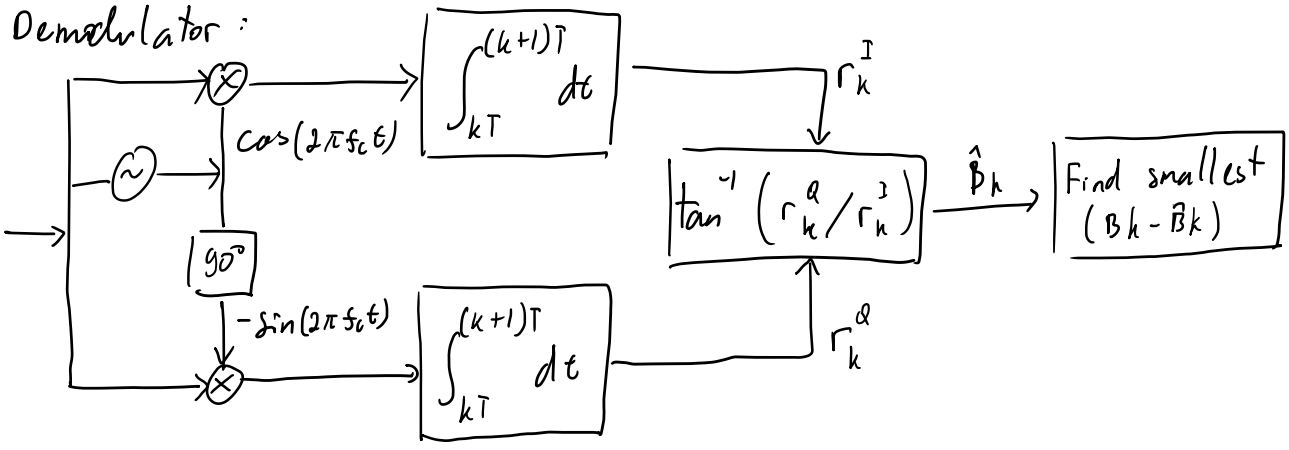


8 - PSK

Modulator :



Demodulator :



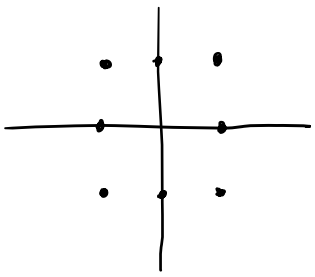
Probabilitas error :

$$P_e = 2Q\left(\sqrt{\frac{2E_s}{N_0}}\,\sin\left(\frac{\pi}{M}\right)\right)$$

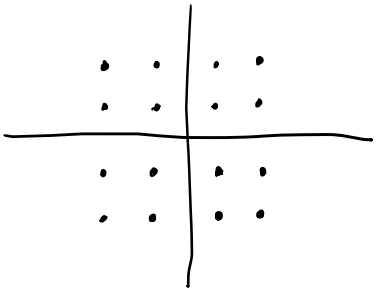
c. QAM

Diagram konstelasi :

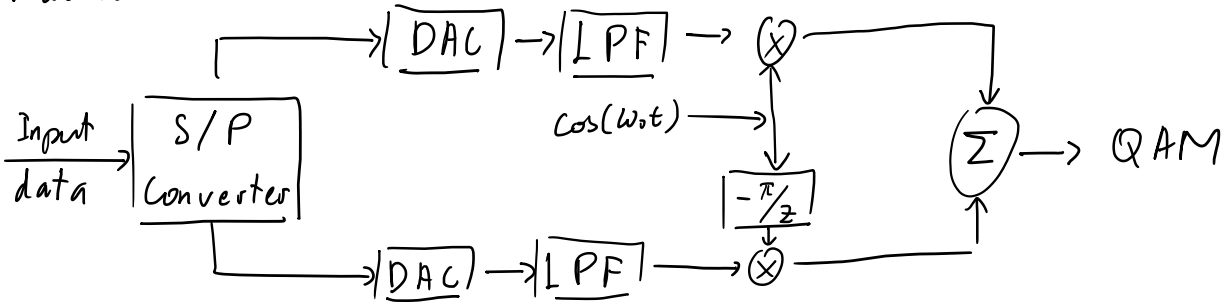
8 QAM



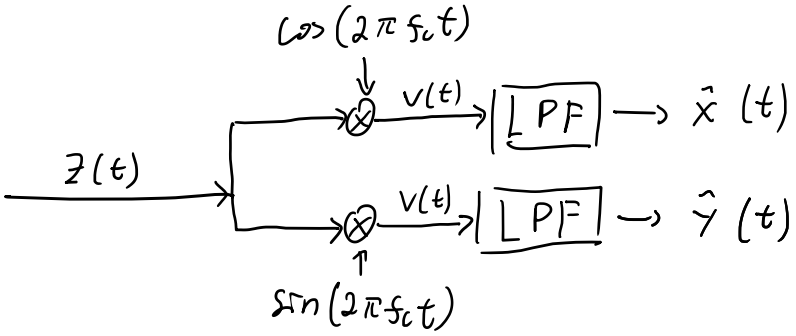
16 QAM



Modulator :



Demodulator :



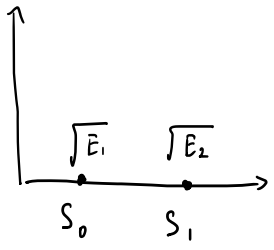
Probabilitas error :

16 QAM

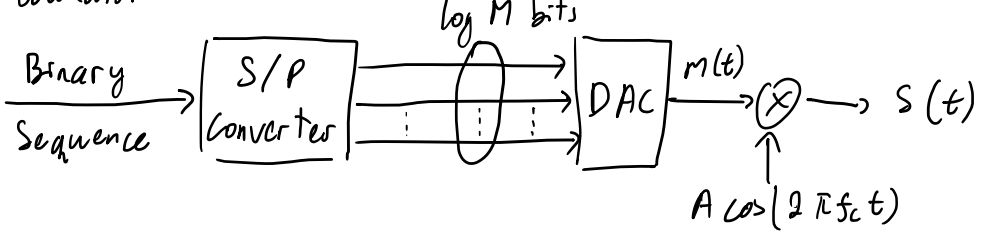
$$P_e = 3Q\left[\sqrt{\frac{4E_b}{5N_0}} - \frac{9}{4}Q^2\left(\sqrt{\frac{4E_b}{5N_0}}\right)\right]$$

d. M - ASK

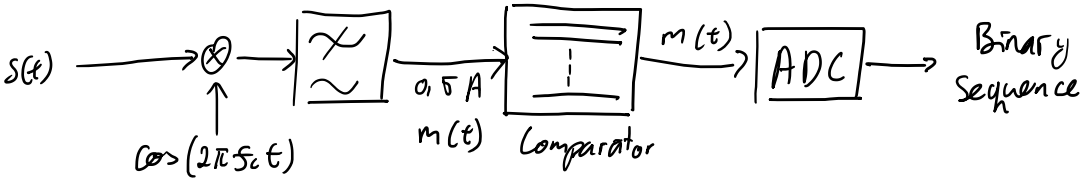
Diagram konstelasi :



Modulator :



Demodulator :

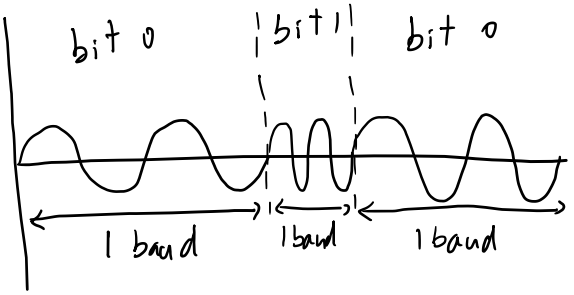


Probabilitas error :

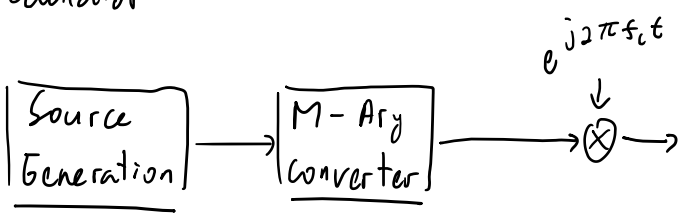
$$P_e(M) = \frac{2(M-1)}{M} Q\left(\sqrt{\frac{6\log_2 M}{M^2-1} \cdot \frac{E_b}{N_0}}\right)$$

e. M - FSK

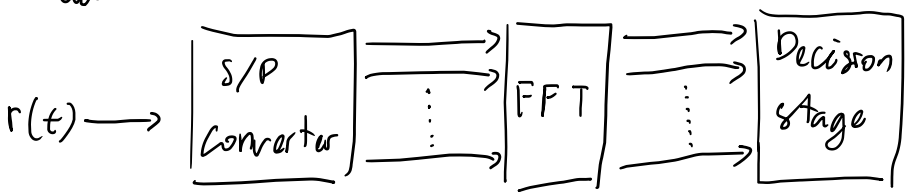
Diagram konstelasi :



Modulator :



Demodulator



Probabilitas error:

$$P_e(M) \leq (M-1)\, Q\left(\sqrt{\frac{E_s}{N_0}}\right)$$

Ortogonal FSK :

$f_1 - f_0 = \frac{1}{2T}$: memprasentasikan minimum penyebaran f

2.

$$s_i(t) = \sqrt{\frac{2E_s}{T_s}} \cos\left(2\pi f_i t + i\frac{2\pi}{M}\right)$$

QPSK, $T_s = 0{,}001$ s, $A = 2$ V

a. QPSK sama dengan 4-PSK dengan beda fasa 90°

$M = 4$

b.

$$s_0(t) = \sqrt{\frac{2E_s}{T_s}} \cos\left(2\pi f_c t + 0.\frac{2\pi}{4}\right) = \sqrt{\frac{2E_s}{T_s}} \cos(2\pi f_c t)$$

$$s_1(t) = \sqrt{\frac{2E_s}{T_s}} \cos\left(2\pi f_c t + 1.\frac{2\pi}{4}\right) = \sqrt{\frac{2E_s}{T_s}} \cos(2\pi f_c t + 90°)$$

$$s_2(t) = \sqrt{\frac{2E_s}{T_s}} \cos\left(2\pi f_c t + 2.\frac{2\pi}{4}\right) = \sqrt{\frac{2E_s}{T_s}} \cos(2\pi f_c t + 180°)$$

$$s_3(t) = \sqrt{\frac{2E_s}{T_s}} \cos\left(2\pi f_c t + 3.\frac{2\pi}{4}\right) = \sqrt{\frac{2E_s}{T_s}} \cos(2\pi f_c t + 270°)$$

c. $T_s = T_b \, {}^2\log M$

$$T_b = \frac{T_s}{{}^2\log M} = \frac{0{,}001\ s}{{}^2\log 4} = \frac{0{,}001}{2} = 0{,}0005\ s = 0{,}5\ ms$$

$$R_b = \frac{1}{T_b} = \frac{1}{0{,}5\ ms} = 2000\ Hz = 2\ kHz$$

$$R_s = \frac{1}{T_s} = \frac{1}{0{,}001\ s} = 1000\ Hz = 1\ kHz$$

d.

$$A = \sqrt{\frac{2E_s}{T_s}}$$

$$A^2 = \frac{2E_s}{T_s}$$

$$E_s = \frac{A^2 T_s}{2} = \frac{2^2 \cdot 0{,}001}{2} = 0{,}002 \text{ J}$$

$$E_b = \frac{E_s}{^2\log M} = \frac{0{,}002}{^2\log 4} = 0{,}001 \text{ J}$$

$$N_0 = 2 \times 10^{-4} \text{ W/Hz}$$

$$P_e = 2\,Q\left(\sqrt{\frac{2E_b}{N_0}}\right)\left[1 - \frac{1}{2}Q\left(\sqrt{\frac{2E_b}{N_0}}\right)\right]$$

$$= 2\,Q\left(\sqrt{\frac{2 \cdot 0{,}001}{2 \times 10^{-4}}}\right)\left[1 - \frac{1}{2}Q\left(\sqrt{\frac{2 \cdot 0{,}001}{2 \times 10^{-4}}}\right)\right]$$

$$= 2\,Q\left(\sqrt{10}\right)\left[1 - \frac{1}{2}Q\left(\sqrt{10}\right)\right]$$

$$= 2 \cdot 0{,}000078\left(1 - \frac{1}{2} \cdot 0{,}000078\right)$$

$$= 1{,}56 \times 10^{-3}$$

$$= 0{,}156\ \%$$