Sistem Komunikasi II
(*Digital Communication Systems*)

Lecture #5: **Modulasi & Demodulasi Bandpass**
(*Baseband Modulation & Demodulation*)
- PART I –

Topik:

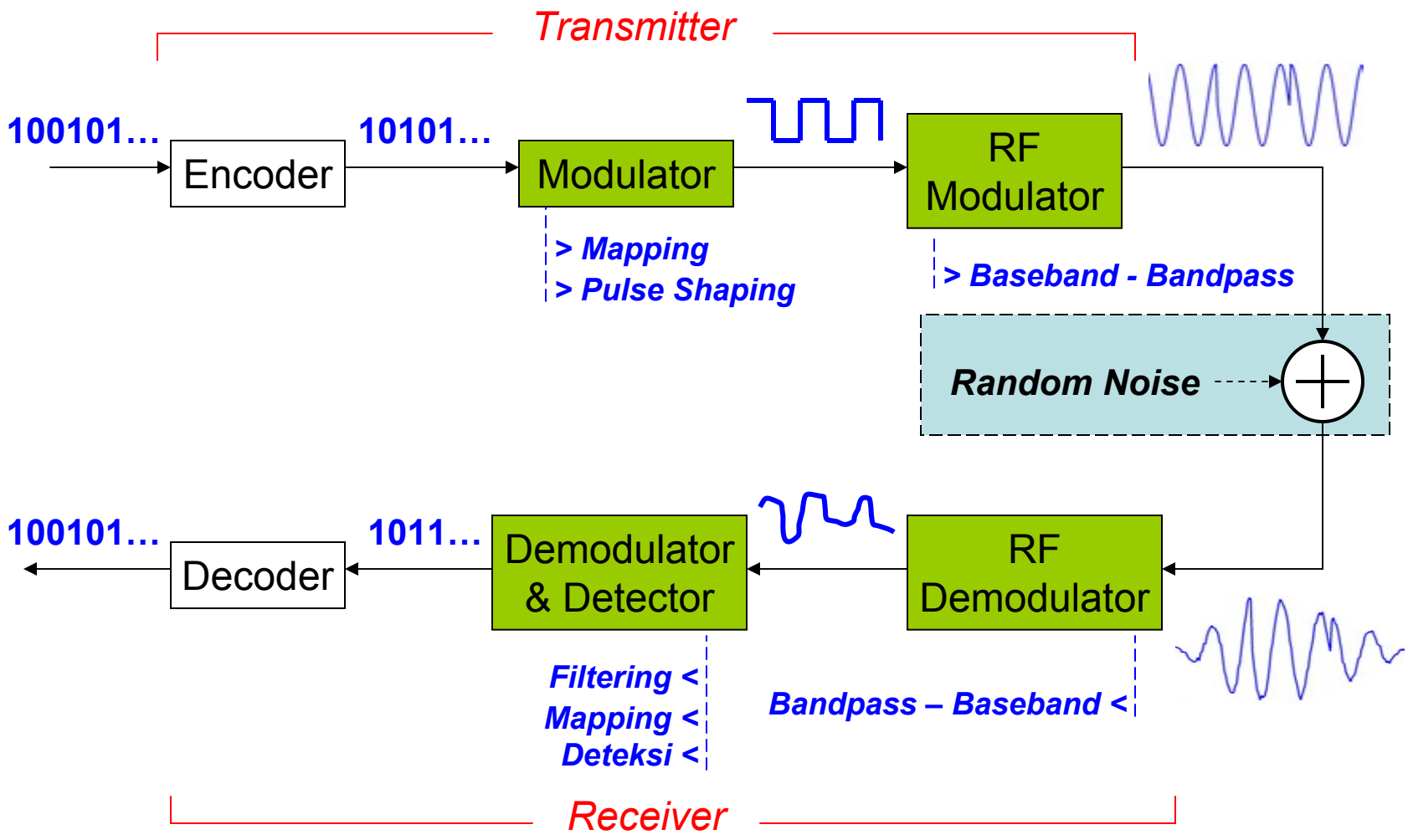
5.1 Pendahuluan.

5.2 M-Phase Shift Keying (M-PSK)

- Modulasi.
- Transmitter.
- Receiver.

5.1. Pendahuluan

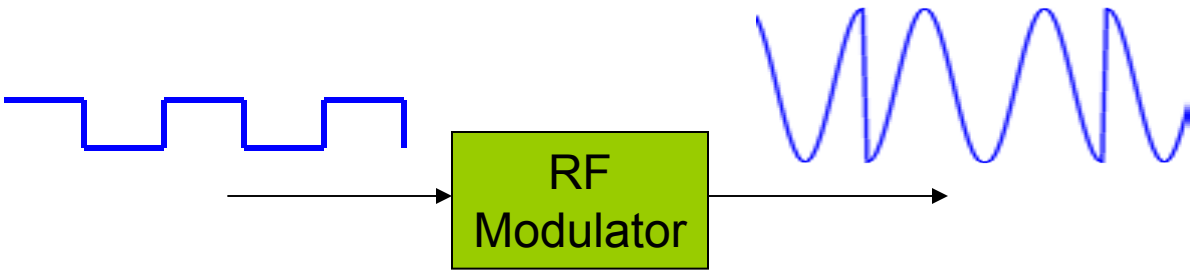
Model Sistem Komunikasi Digital dgn Kanal AWGN:



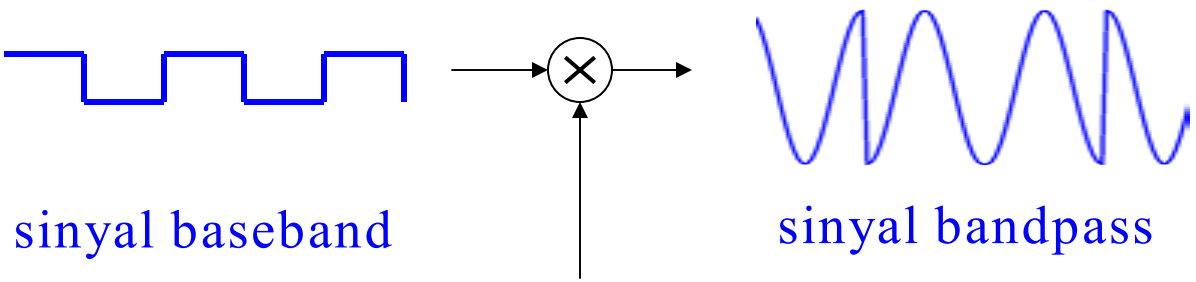
5.1. Pendahuluan – cont.

Baseband → Bandpass - ***gambaran di domain waktu:***

Block Diagram:



Operasi:



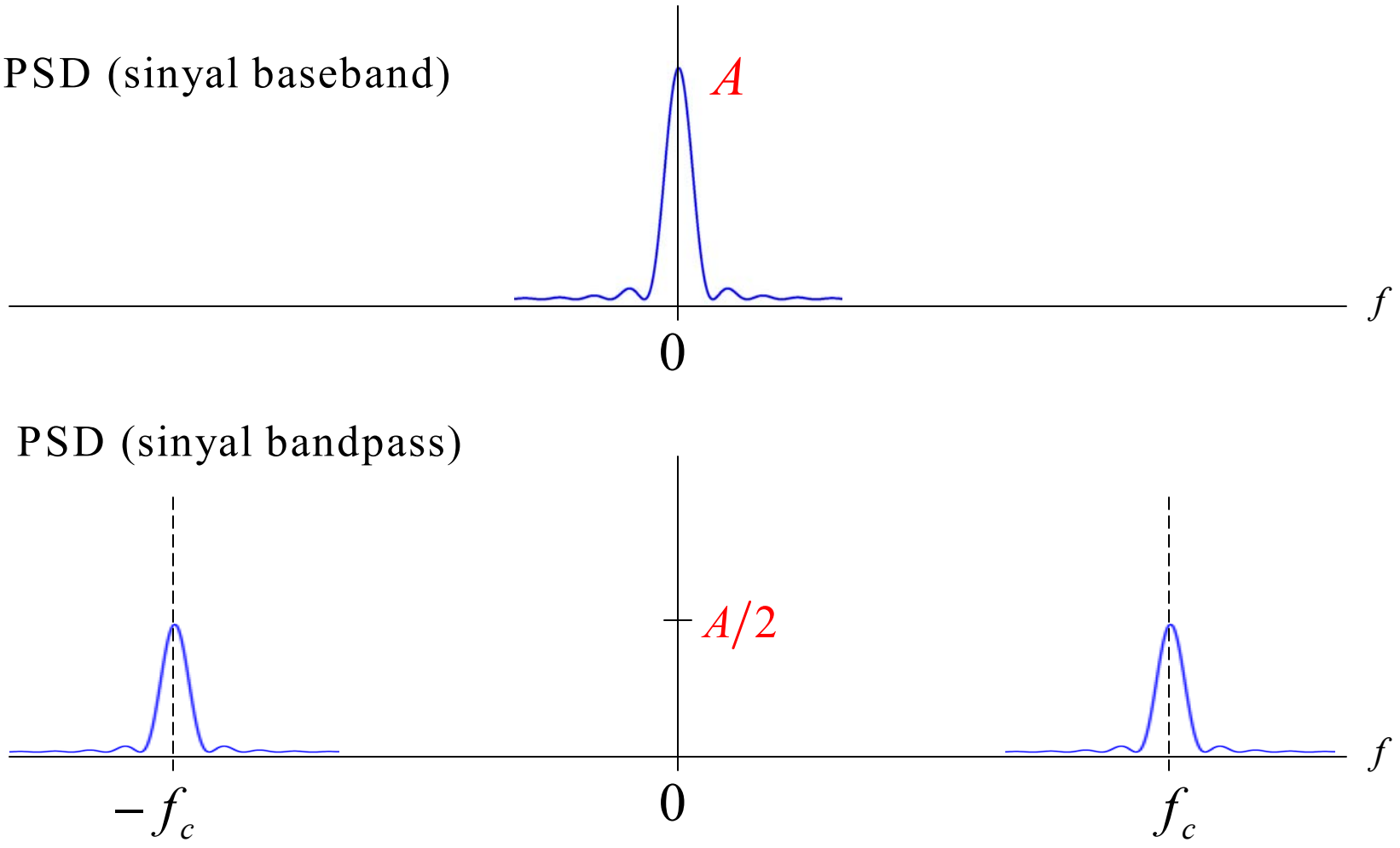
sinyal carrier

$\cos(2\pi f_c t + \theta)$

f_c = frekwensi carrier ($f_c \gg 0 \rightarrow$ frequency tinggi).

5.1. Pendahuluan – cont.

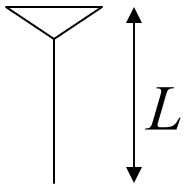
Baseband → Bandpass - ***gambaran di domain frekwensi:***



5.1. Pendahuluan – cont.

Mengapa Bandpass?

1. *Memudahkan pemancaran sinyal melalui antena.*



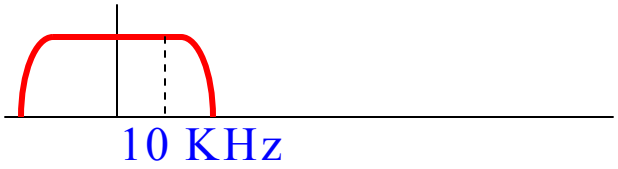
$$L = \frac{\lambda_0}{4} = \frac{c}{4 f_0}$$

λ_0 = panjang gelombang sinyal transmisi (m),

f_0 = frekwensi sinyal transmisi (Hz).

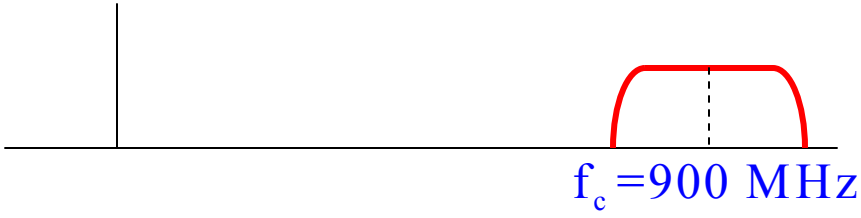
c = kecepatan propagasi gel. elektromagnetik (3×10^8 m/s).

PSD (sinyal baseband)



$$L = \frac{c}{4 f_0} = \frac{3 \times 10^8}{4\left(10^4\right)} = 7500 \text{ m (!)}$$

PSD (sinyal bandpass)

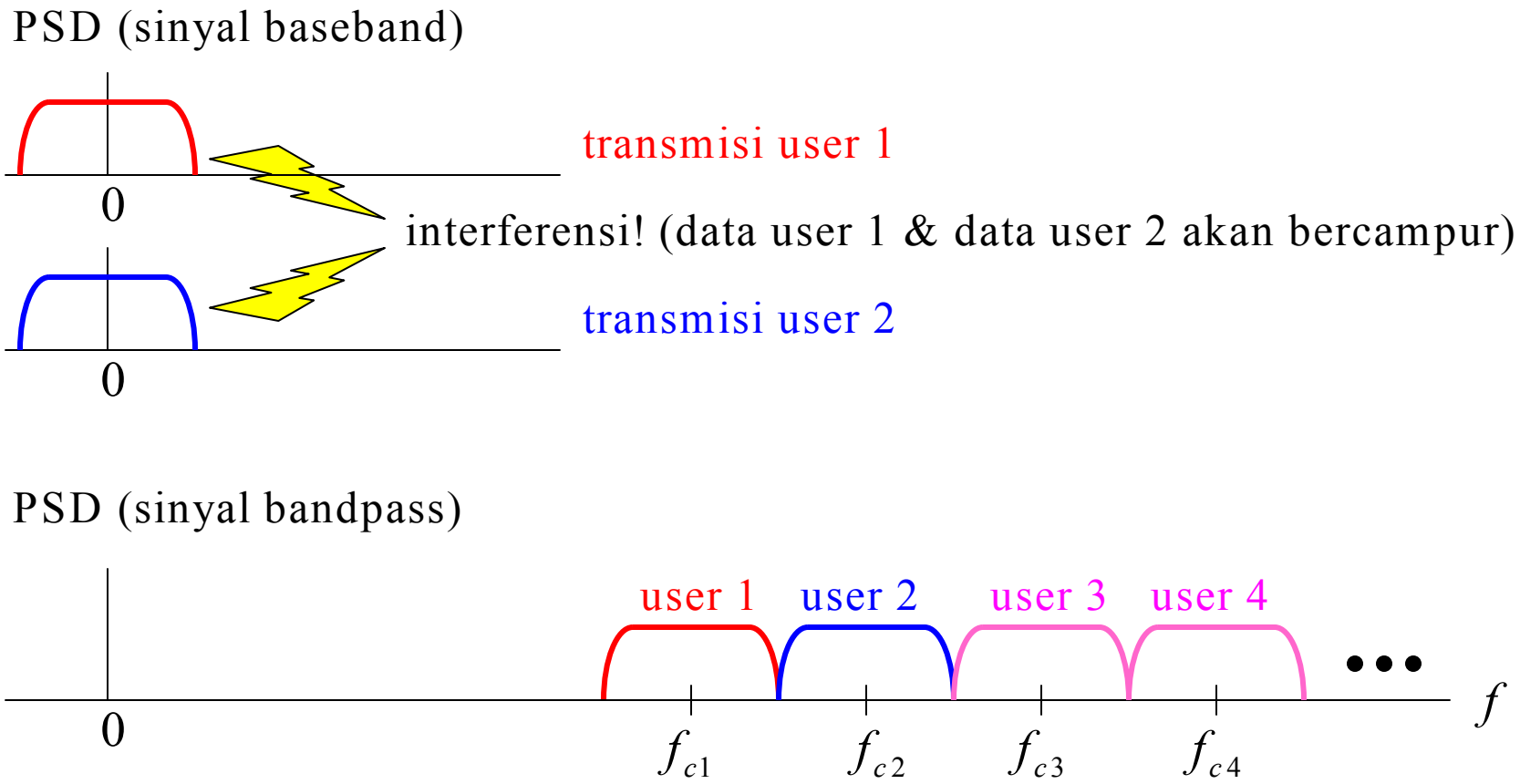


$$L = \frac{3 \times 10^8}{4\left(9 \times 10^8\right)} = 8.3 \text{ cm}$$ ***OK***

5.1. Pendahuluan – cont.

Mengapa Bandpass? – cont.

2. Memungkinkan penggabungan lebih dari 1 transmisi dalam 1 media / kanal (multiple access).

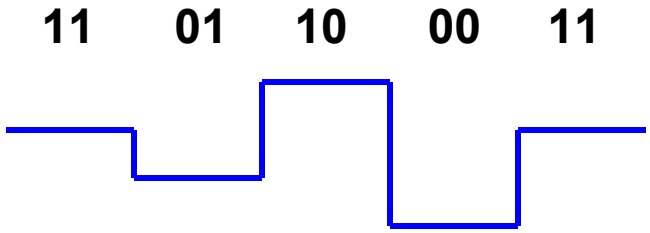


5.1. Pendahuluan – cont.

Modulasi Baseband:

Pulse Amplitude Modulation (PAM):

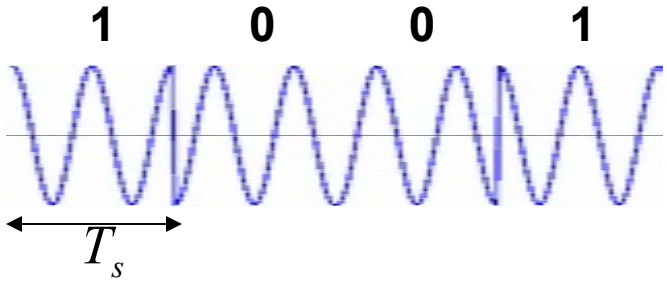
Informasi ‘dibawa’ oleh amplitudo sinyal.



Modulasi Bandpass:

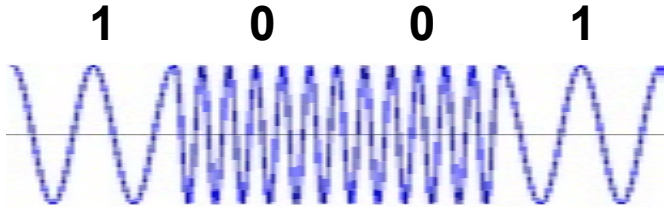
Phase Shift Keying (PSK):

Informasi ‘dibawa’ oleh fasa sinyal.



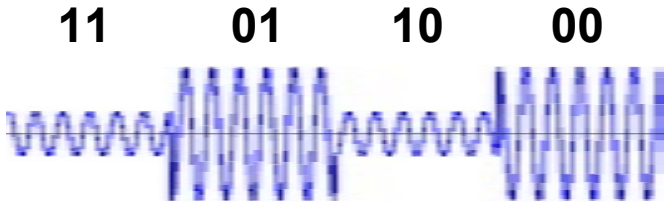
Frequency Shift Keying (FSK):

Informasi ‘dibawa’ oleh frekwensi sinyal.



Amplitude Phase Keying (APK):

Informasi ‘dibawa’ oleh amplitudo & fasa sinyal.



5.2. M-Phase Shift Keying (M-PSK)

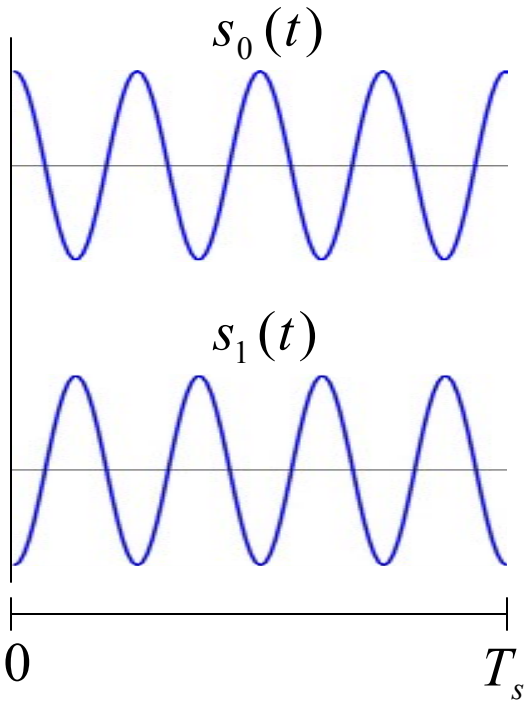
Modulasi M-PSK:

$$m_i \longrightarrow s_i(t) = \sqrt{\frac{2E_s}{T_s}} \cos\left(w_c t + i\frac{2\pi}{M} \right) \quad ; \text{i} = 0, 2, \ldots, \text{M-1}$$

M = 2 (Binary PSK - BPSK)

$$m_0 = 1 \longrightarrow s_0(t) = \sqrt{\frac{2E_s}{T_s}} \cos\left(w_c t \right)$$

$$m_1 = 0 \longrightarrow s_1(t) = \sqrt{\frac{2E_s}{T_s}} \cos\left(w_c t + \pi \right)$$



5.2. M-Phase Shift Keying (M-PSK) – cont.

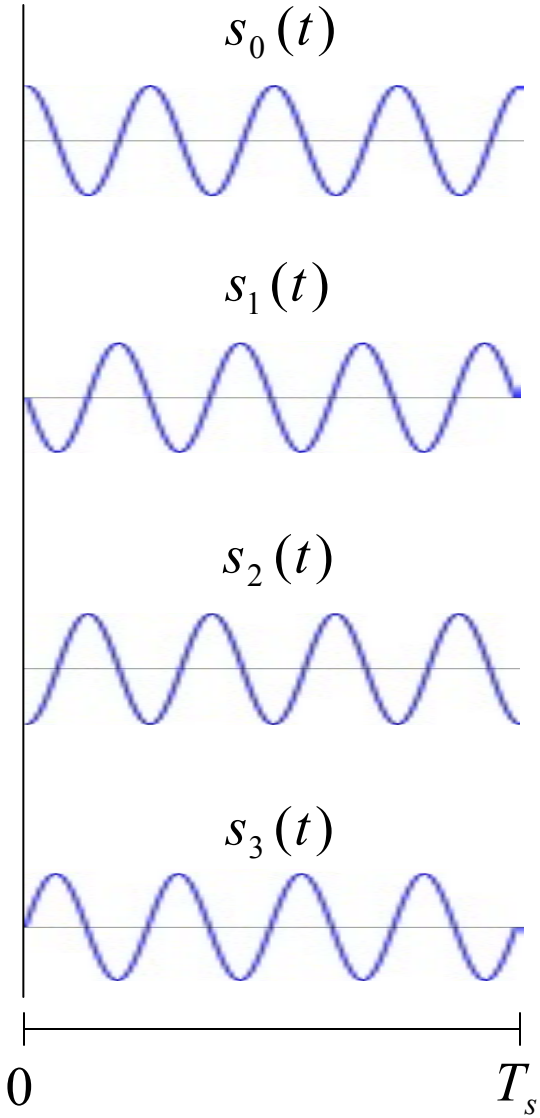
M = 4 (Quarternary PSK - QPSK)

$$m_0 = 00 \rightarrow s_0(t) = A\cos(w_c t)$$

$$m_1 = 01 \rightarrow s_1(t) = A\cos\left(w_c t + \frac{\pi}{2}\right)$$

$$m_2 = 11 \rightarrow s_2(t) = A\cos(w_c t + \pi)$$

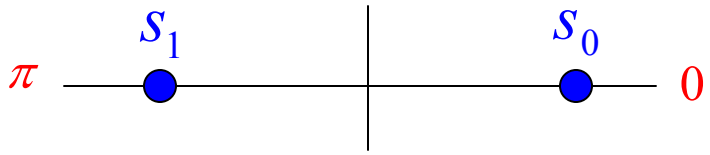
$$m_3 = 10 \rightarrow s_3(t) = A\cos\left(w_c t + \frac{3\pi}{2}\right)$$



5.2. M-Phase Shift Keying (M-PSK) – cont.

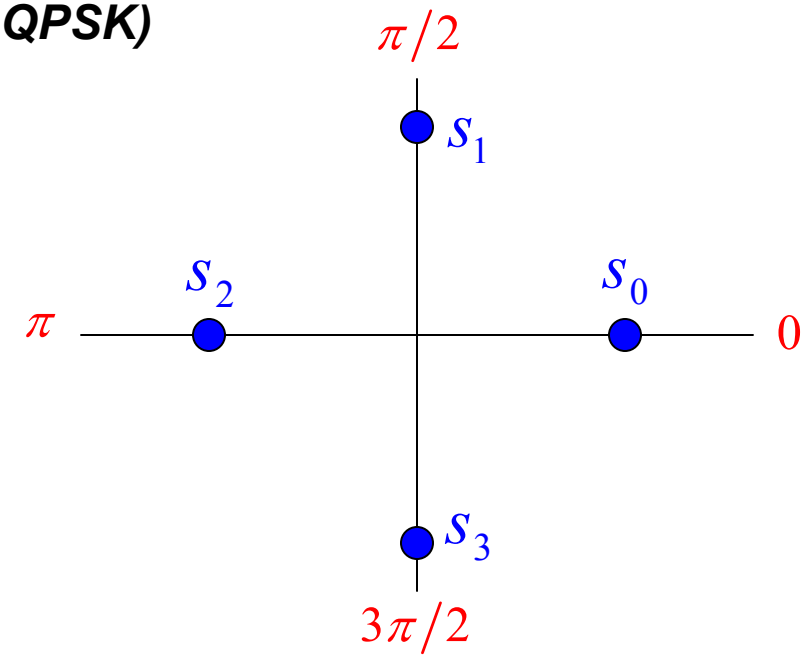
M = 2 (Binary PSK - BPSK)

Konstelasi Sinyal:



M = 4 (Quartenary PSK - QPSK)

Konstelasi Sinyal:

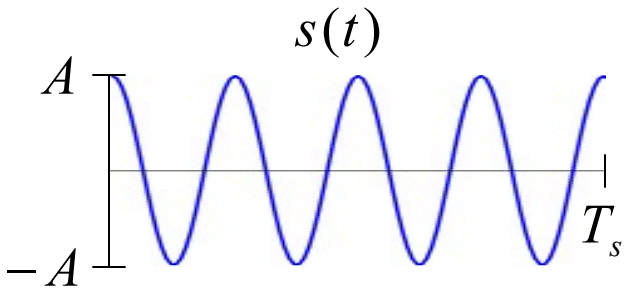


5.2. M-Phase Shift Keying (M-PSK) – cont.

Modulasi M-PSK – cont.

Apa itu $\sqrt{\frac{2E_s}{T_s}}$?

$$s(t) = A\cos\left(w_c t + \theta\right)$$



$$E_s = \int_0^{T_s} s^2(t)\,dt$$

$$= A^2 \int_0^{T_s} \cos^2(w_c t + \theta)\,dt$$

$$= \frac{A^2}{2}\int_0^{T_s} \cos(2\left[w_c t + \theta\right])\,dt + \frac{A^2}{2}\int_0^{T_s} dt$$

0

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

Amplitudo sinyal carrier

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

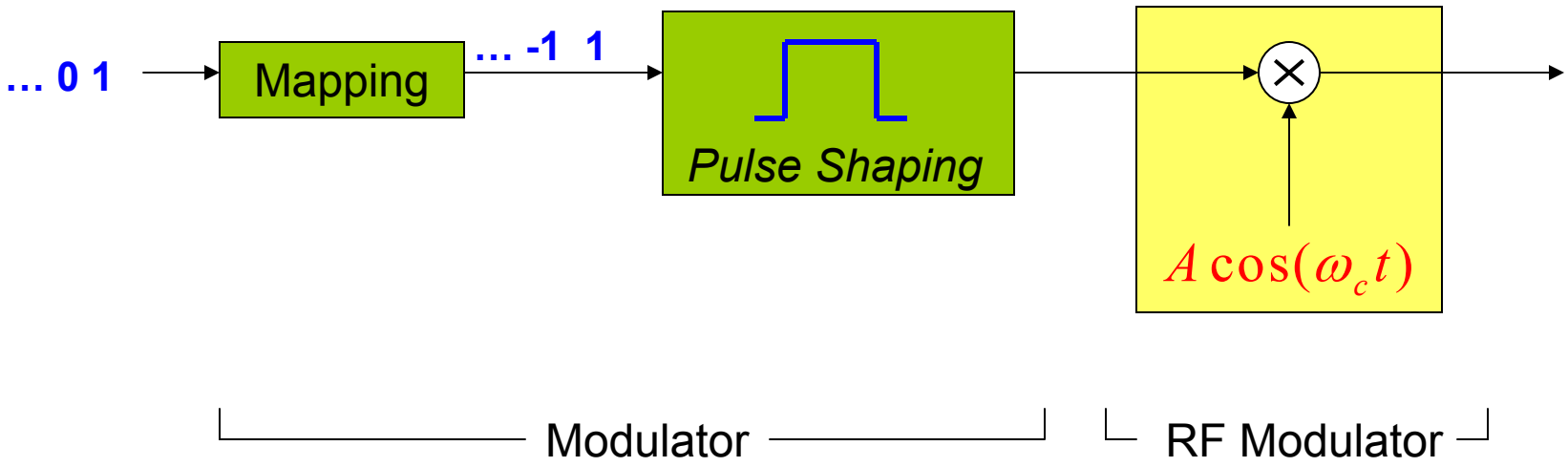
5.2. M-Phase Shift Keying (M-PSK) – cont.

Transmitter M-PSK:

M = 2 (Binary PSK - BPSK)

$$m_0 = 1 \longrightarrow s_0(t) = A\cos\left(w_c t\right)$$

$$m_1 = 0 \longrightarrow s_1(t) = A\cos\left(w_c t + \pi\right) = -A\cos\left(w_c t\right)$$



5.2. M-Phase Shift Keying (M-PSK) – cont.

Transmitter M-PSK: *M = 4 (Quartenary PSK - QPSK)*

$$m_0 = 00 \rightarrow s_0(t) = A\cos(w_c t)$$

$$m_1 = 01 \rightarrow s_1(t) = A\cos(w_c t + \pi/2) = -A\sin(w_c t)$$

$$m_2 = 11 \rightarrow s_2(t) = A\cos(w_c t + \pi) = -A\cos(w_c t)$$

$$m_3 = 10 \rightarrow s_3(t) = A\cos(w_c t + 3\pi/2) = A\sin(w_c t)$$