L15: Bandpass Detection

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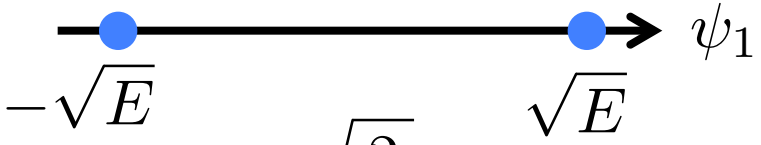
Outline

- 15.1 Coherent Detection of BPSK
- 15.2 Coherent Detection of Multiple PSK
- 15.3 Non-coherent Detection of DPSK
- 15.4 Non-coherent FSK

Bandpass Modulation: BPSK

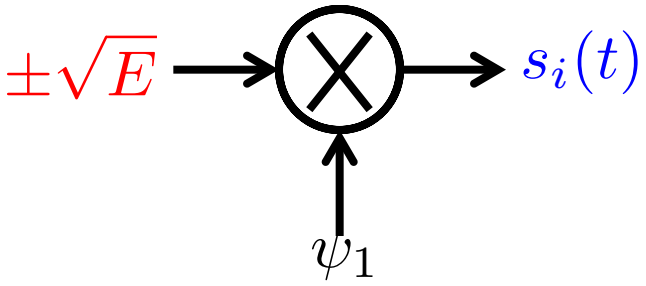
- Recall BPSK

$$-\sqrt{\frac{2E}{T}}\cos(\omega_o t) = s_2(t) \qquad s_1(t) = \sqrt{\frac{2E}{T}}\cos(\omega_o t)$$



$$\psi_1(t) = \sqrt{\frac{2}{T}}\cos(\omega_o t)$$

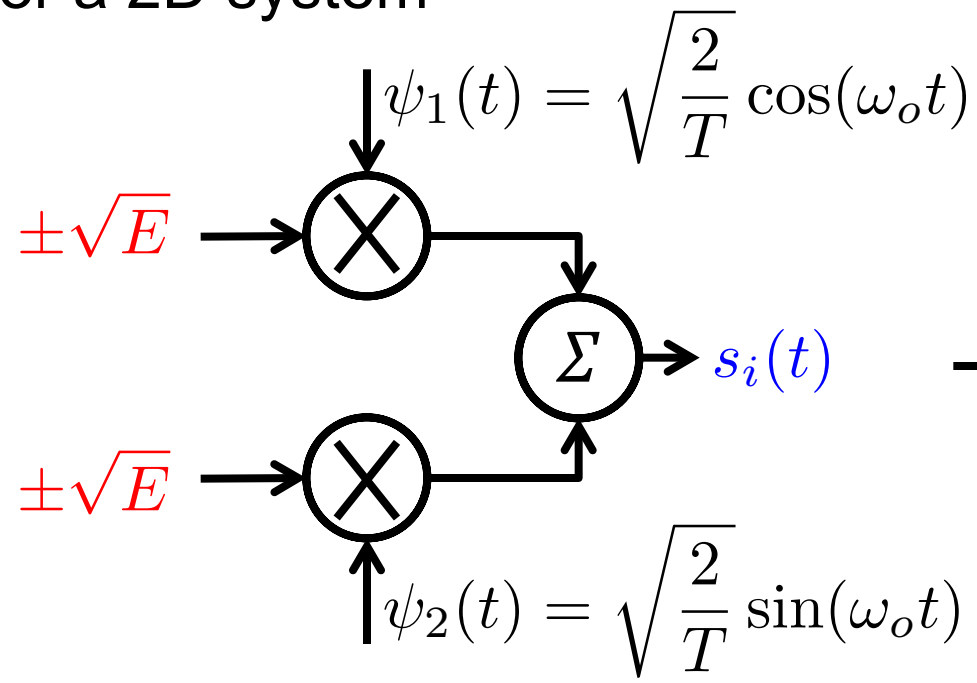
- Modulation-wise

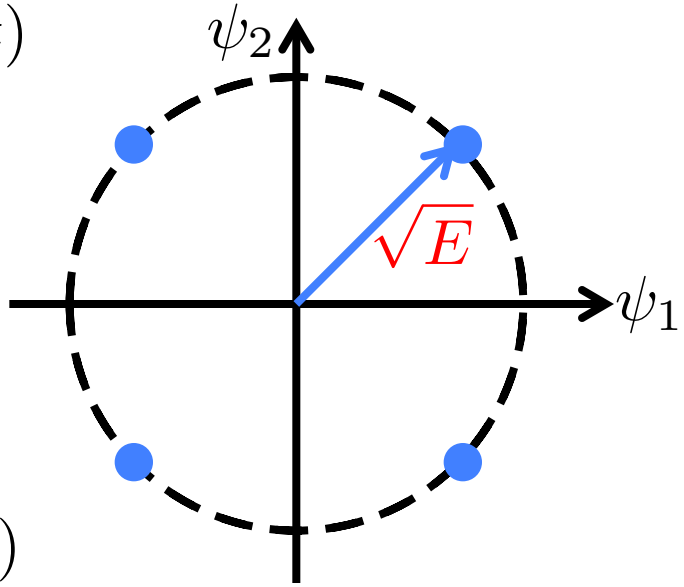


$$s_i(t) = \sum_{j=1}^{N} a_{ij}\psi_j(t)$$

Bandpass Modulation: QPSK

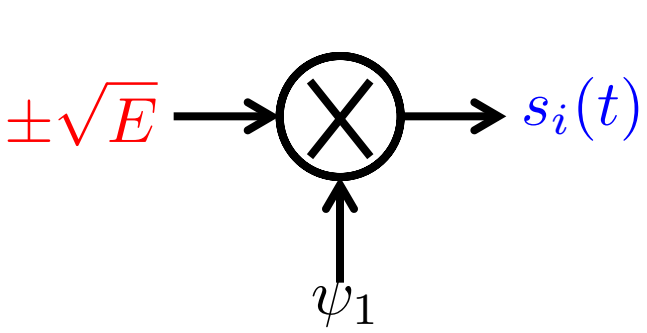
- For a 2D system

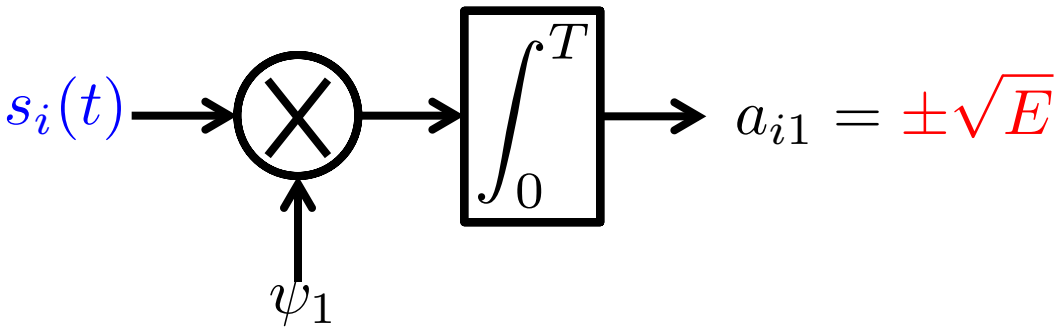




Bandpass Detection: BPSK

- Same idea as with baseband



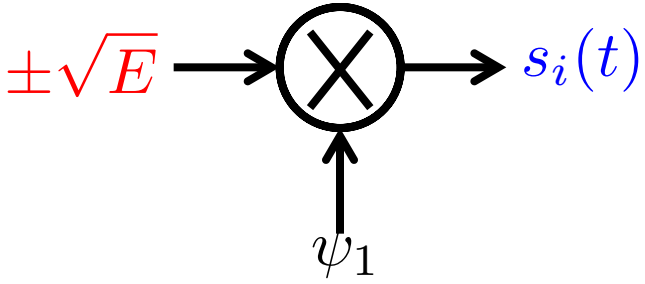


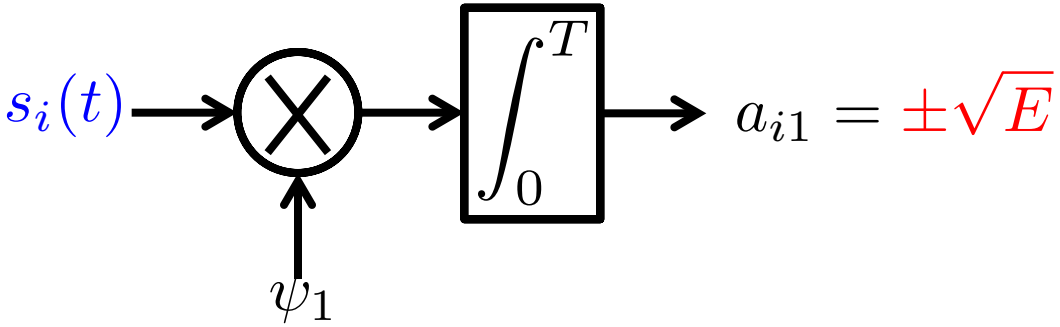
- Send a signal and extract maximum SNR from it
  - Correlator example
- Note how this matches up with our abstract signal-space mapping ideas

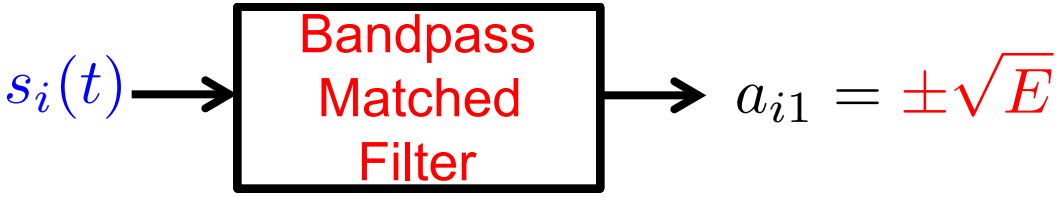
$$s_i(t) = \sum_{j=1}^{N} a_{ij}\psi_j(t) \qquad a_{ij} = \int_{T_i}^{T_f} s_i(t)\psi_j(t)dt$$

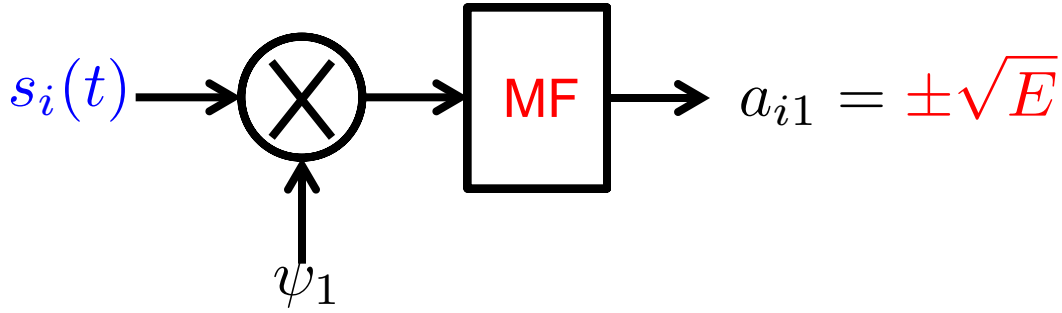
Bandpass Detection: BPSK

- Using related receive architectures gives us the same basic result



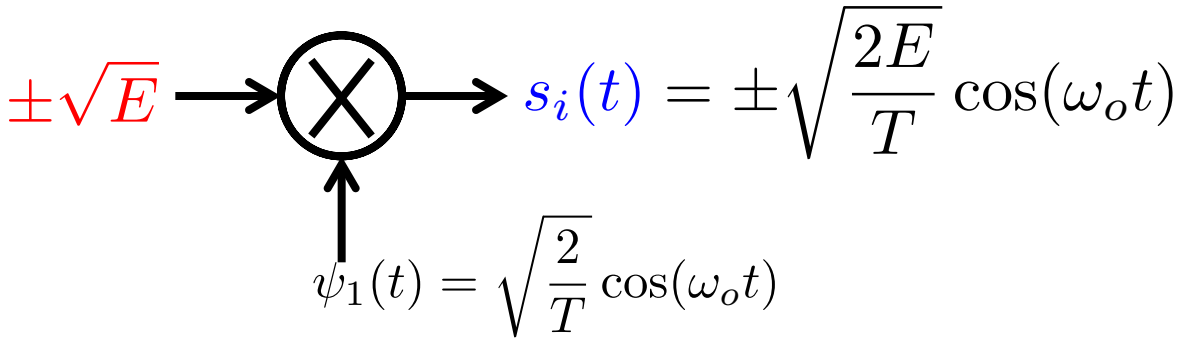




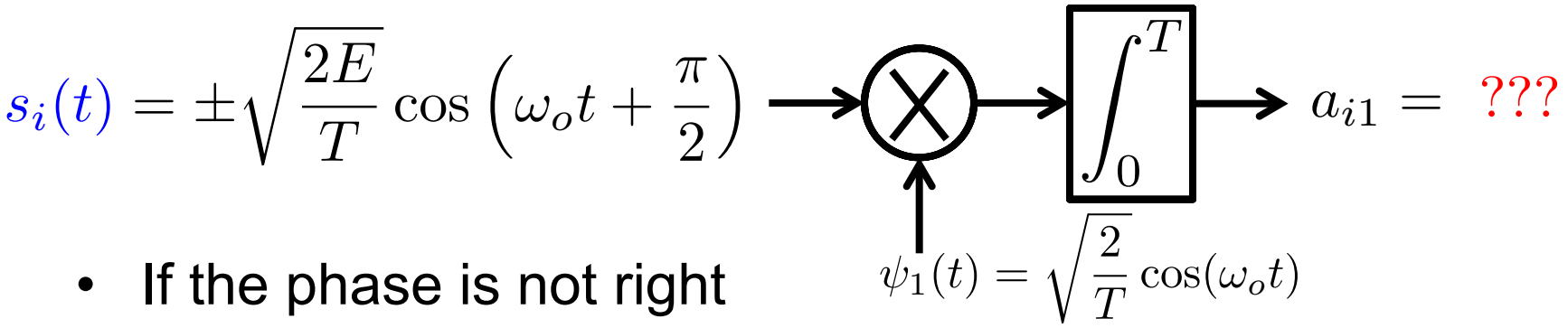


Coherent Detection

- What if we sent…



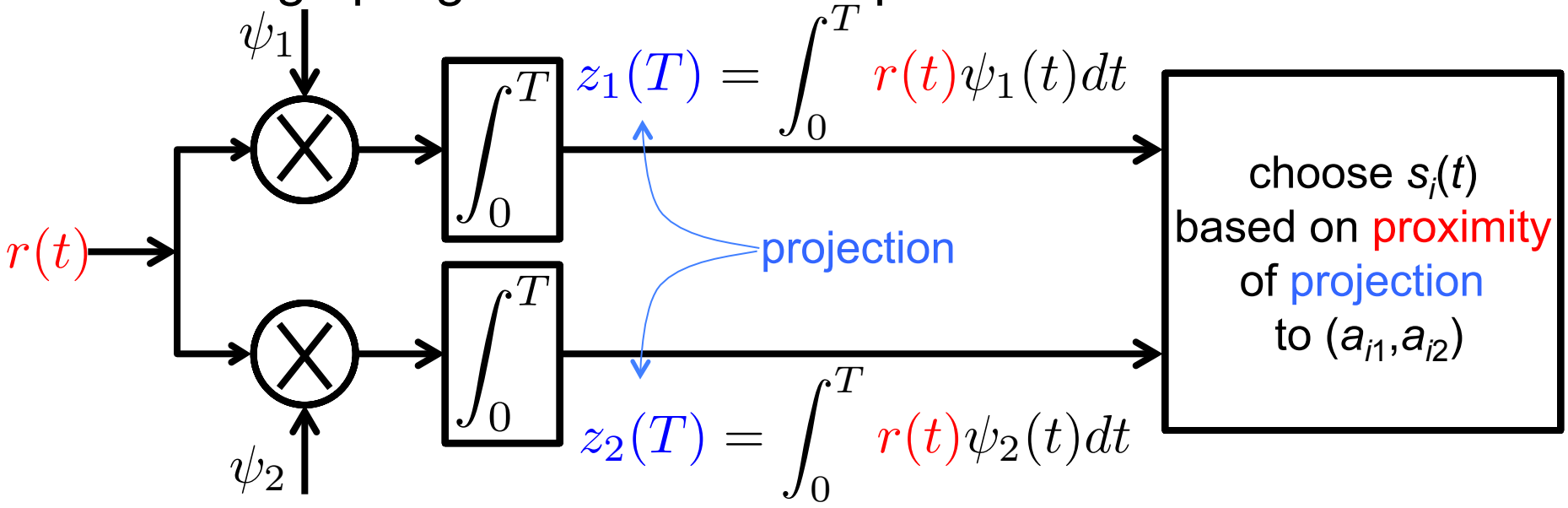
- But received…



- If the phase is not right
  - Easy to get garbage
  - The challenge of coherent detection

A (More) General BP Detection Scheme

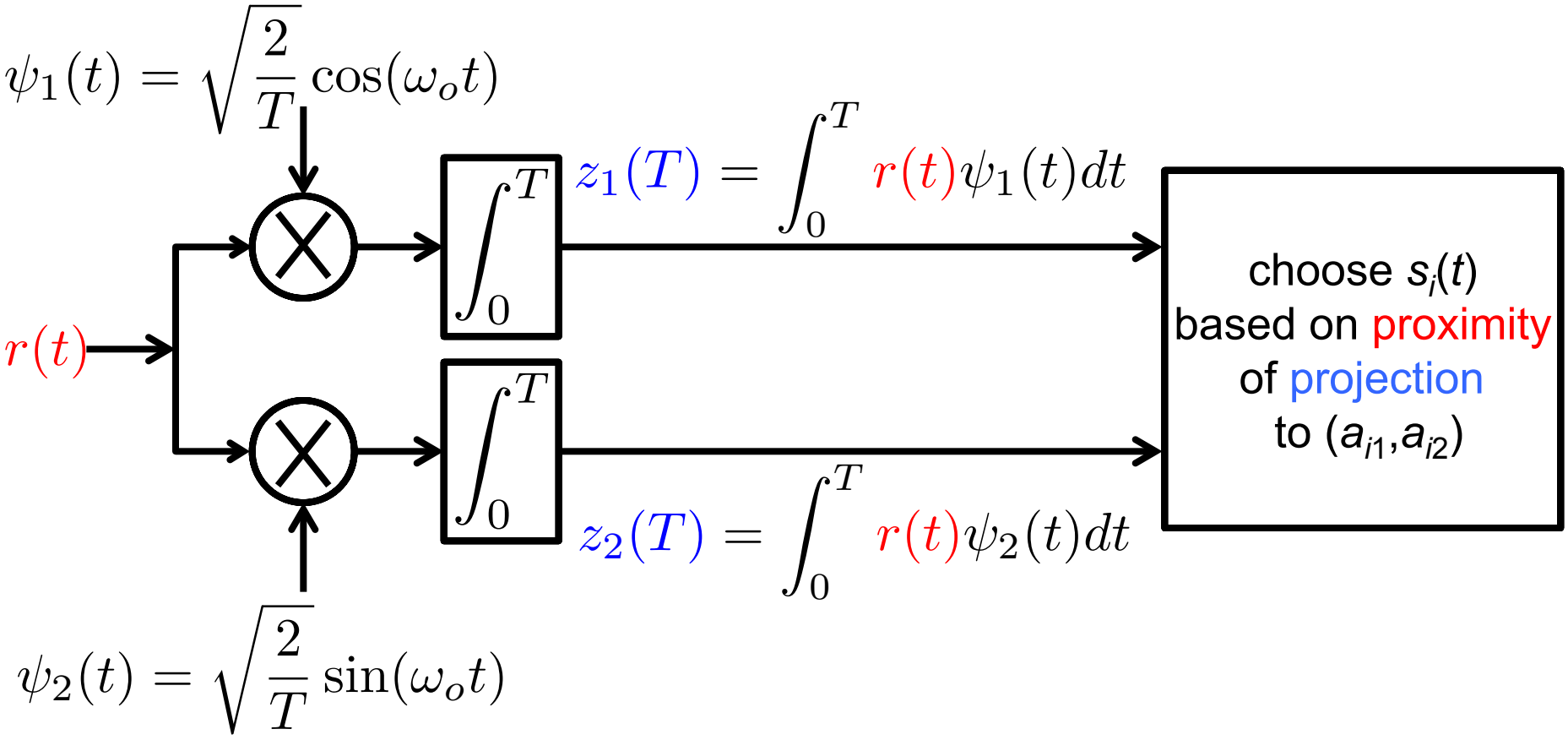
- Picking up signals over a 2-D space



- Formal decision procedure: based on proximity

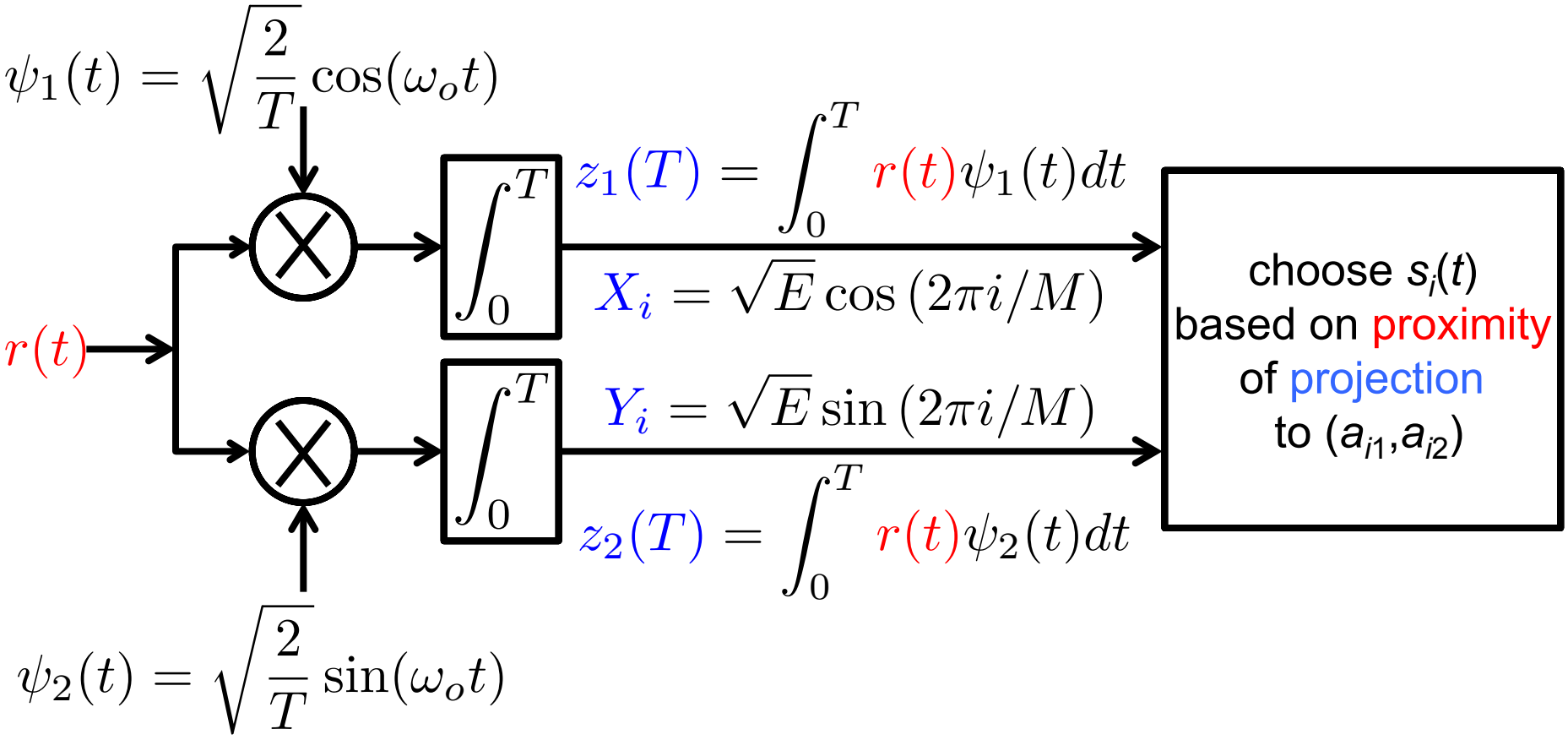
$$\arg\min_{\overline{s}_i}[\overline{s}_i - \overline{z}_i(T)]^2$$

More Specifics: M-ary PSK Detection



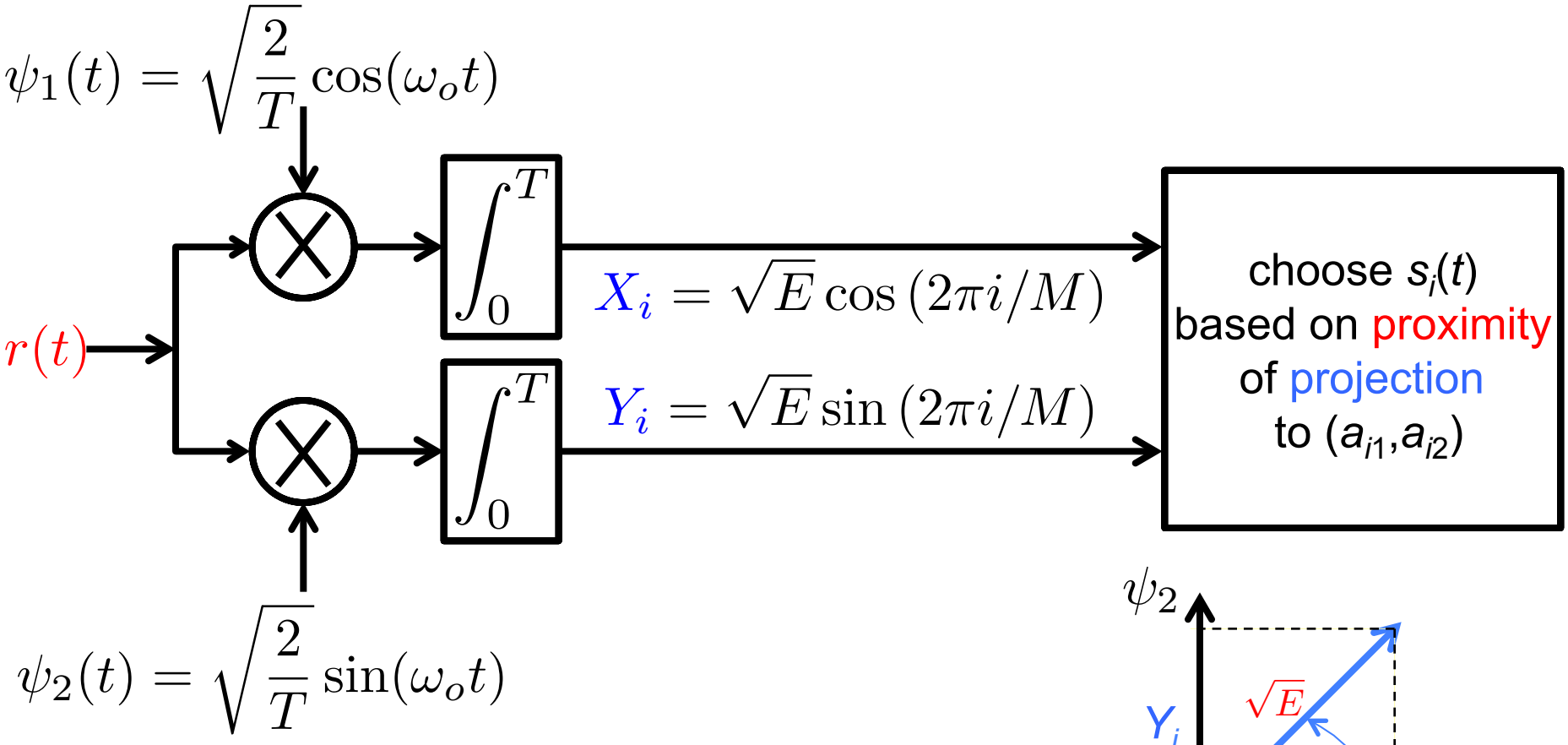
$$r(t) = s_i(t) = \sqrt{\frac{2E}{T}}\cos\left(\omega_o t + \frac{2\pi i}{M}\right), \; i = 0, \ldots, M-1$$

More Specifics: M-ary PSK Detection



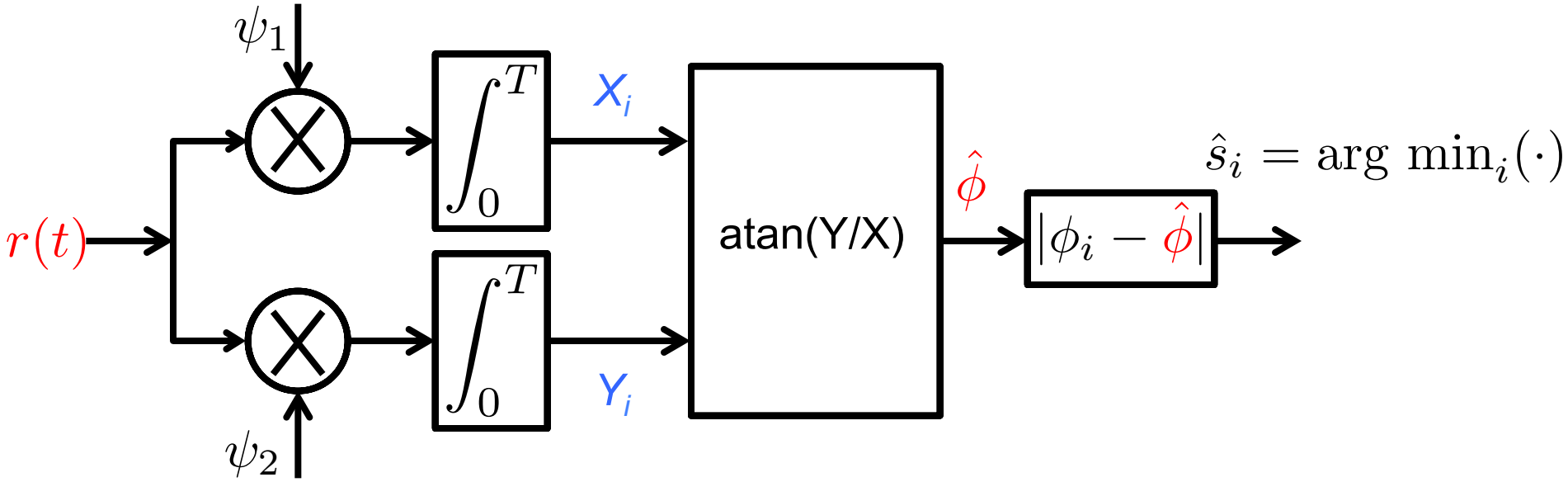
$$r(t) = s_i(t) = \sqrt{E}\cos\left(\frac{2\pi i}{M}\right)\psi_1(t) + \sqrt{E}\sin\left(\frac{2\pi i}{M}\right)\psi_2(t)$$

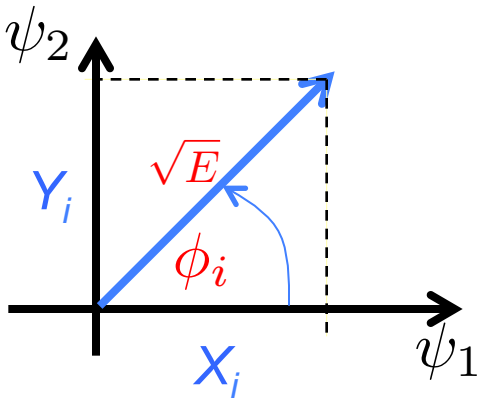
More Specifics: M-ary PSK Detection



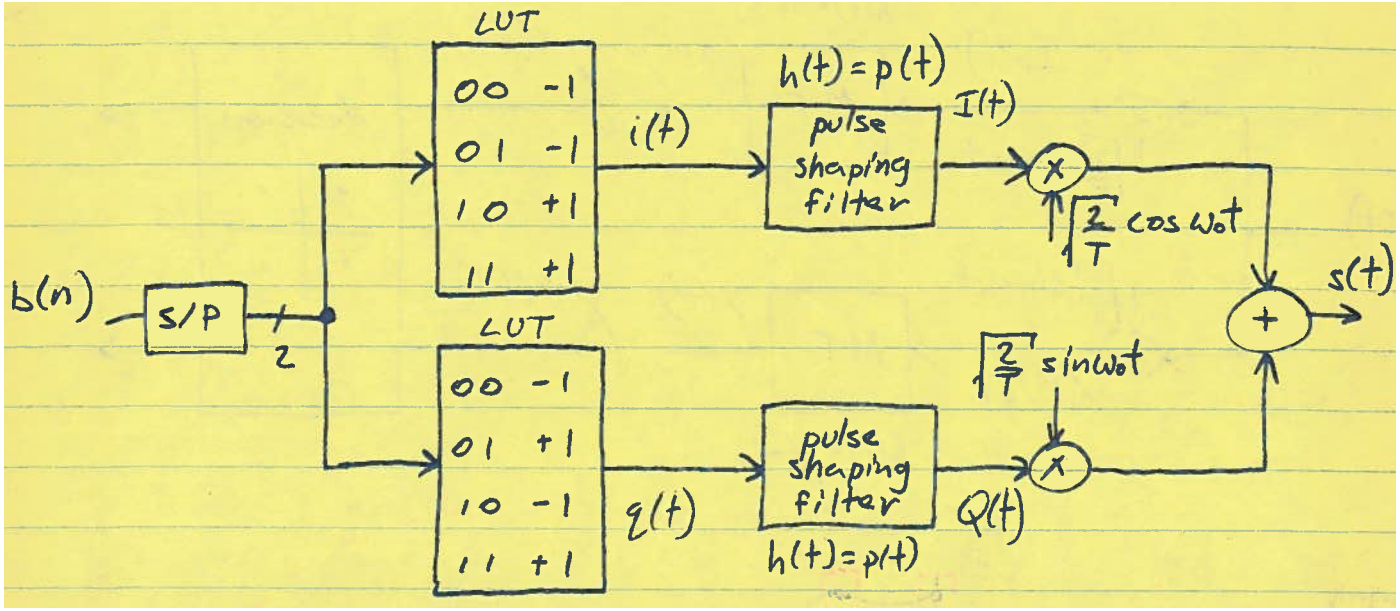
- Detect signals by looking at: ϕ_i

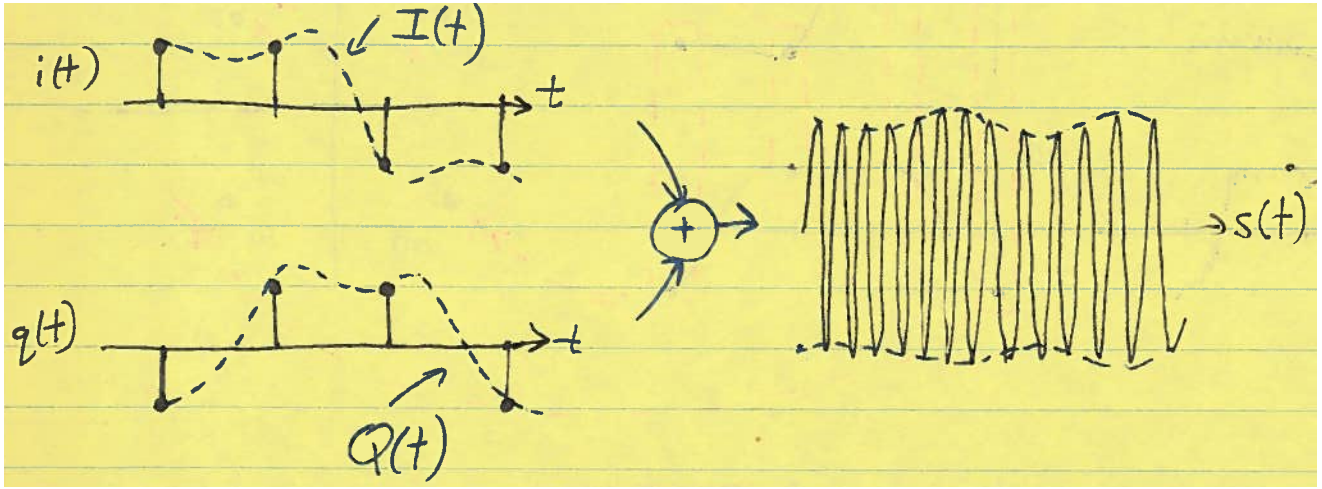
M-ary PSK Receiver



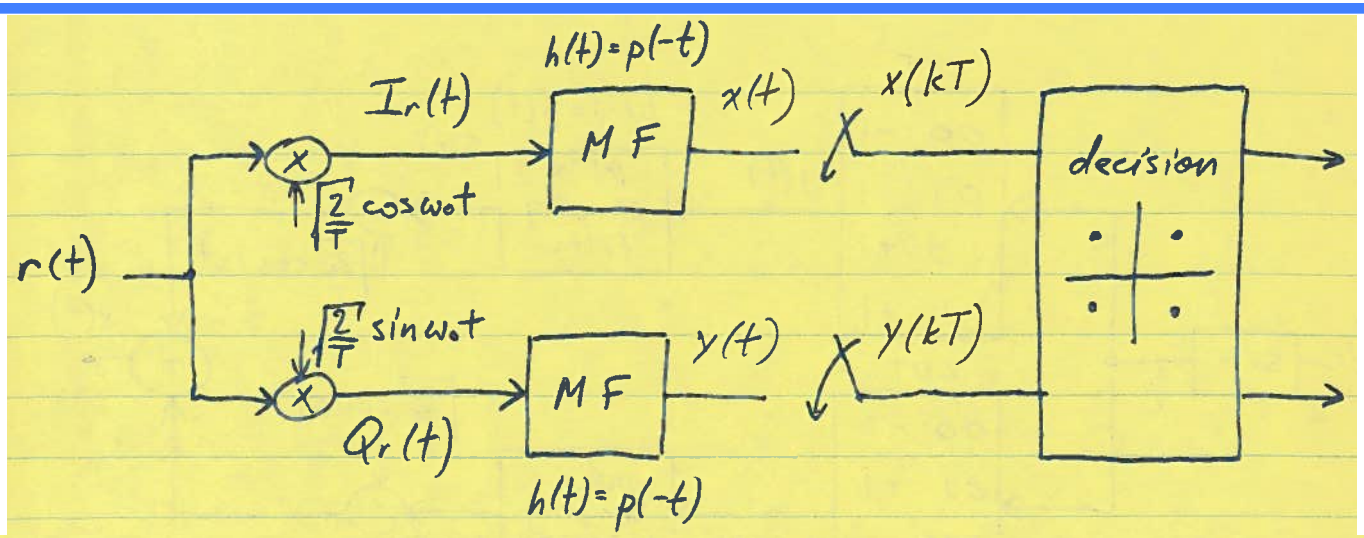


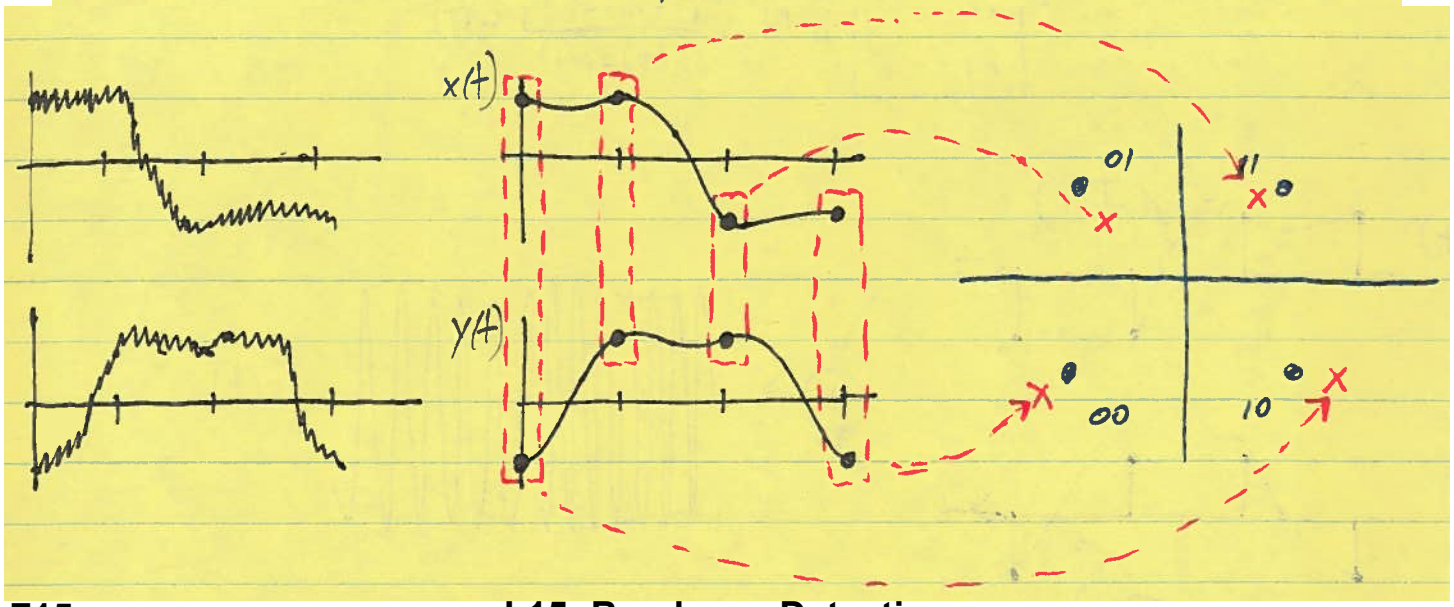
QPSK Transmitter





QPSK Receiver

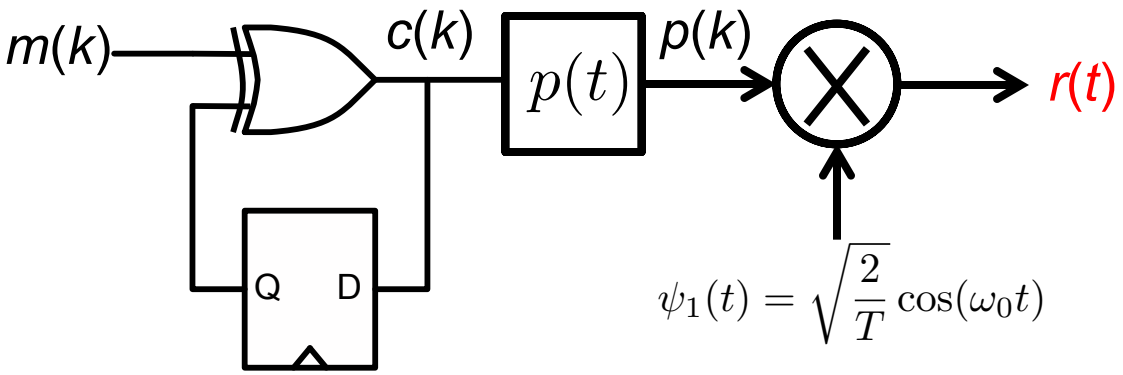




Non-Coherent Detection: DPSK

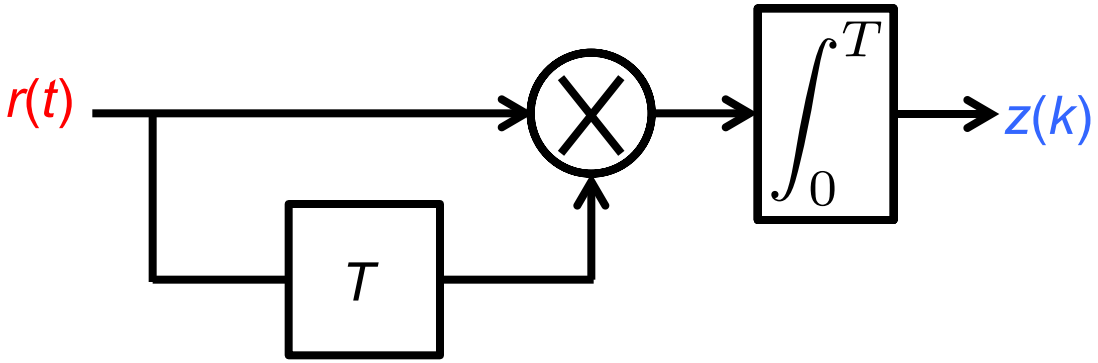
- Instead of mapping data to phase: θ_k
  - BPSK: $\theta_k = 0, \pi$
  - QPSK: $\theta_k = \pi/4, 3\pi/4, 5\pi/4, 7\pi/4$
- Map it to phase shift: $\theta_k = \theta_{k-1} + \Delta\theta_k$
  - DPSK: $\Delta\theta_k = 0, \pi$
  - DQPSK: $\Delta\theta_k = 0, \pi/2, \pi, 3\pi/2$

DPSK Transmitter



k	0	1	2	3	4	5	6	7	8
m		1	1	0	1	0	1	1	0
c	0	1	0	0	1	1	0	1	1
p	-1	1	-1	-1	1	1	-1	1	1
θ	π	0	π	π	0	0	π	0	0

DPSK Receiver



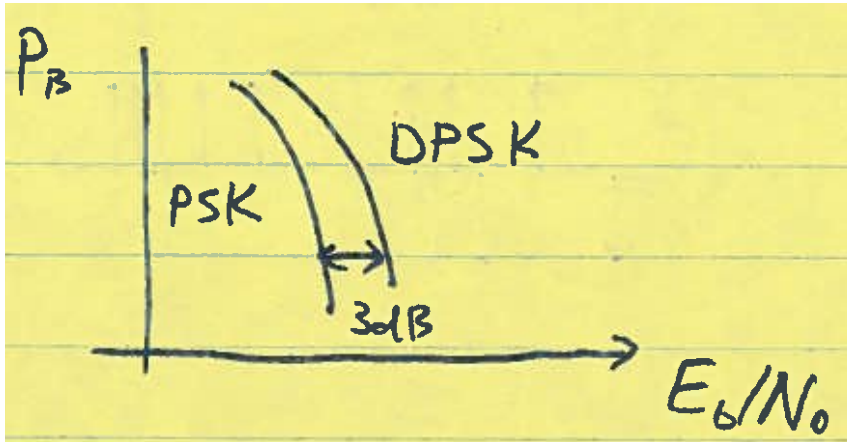
k	0	1	2	3	4	5	6	7	8
m		1	1	0	1	0	1	1	0
c	0	1	0	0	1	1	0	1	1
p	-1	1	-1	-1	1	1	-1	1	1
θ	π	0	π	π	0	0	π	0	0
z		-1	-1	1	-1	1	-1	-1	1

Differential Drawback

- Higher noise
- In coherent reception
  - Demodulate with clean reference signal

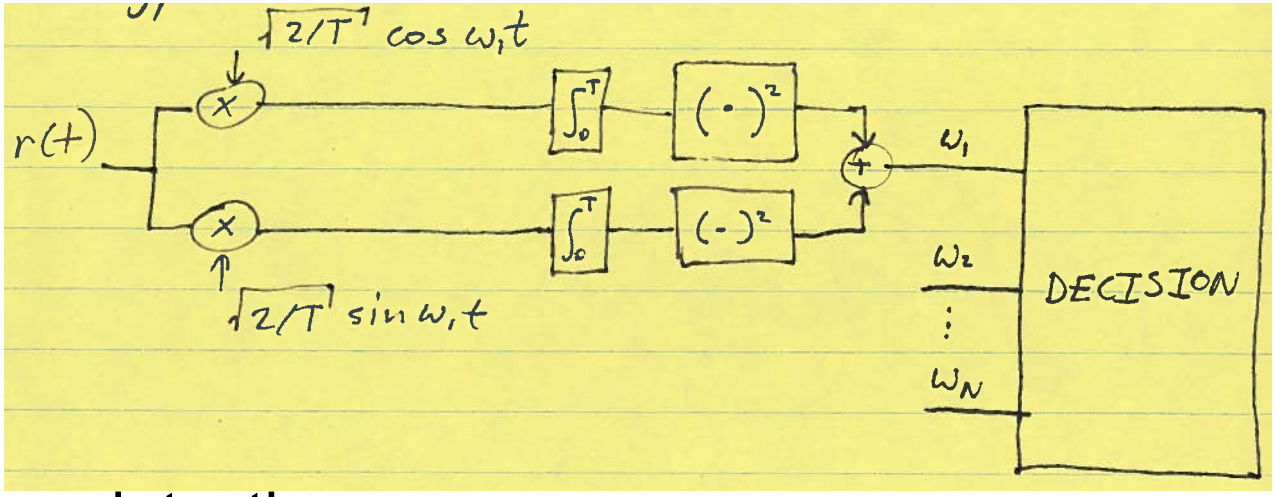
$$\psi_1(t) = \sqrt{\frac{2}{T}}\cos(\omega_0 t)$$

- In non-coherent reception
  - Demodulate using a noisy reference (the previously received signal)
  - 2X the noise

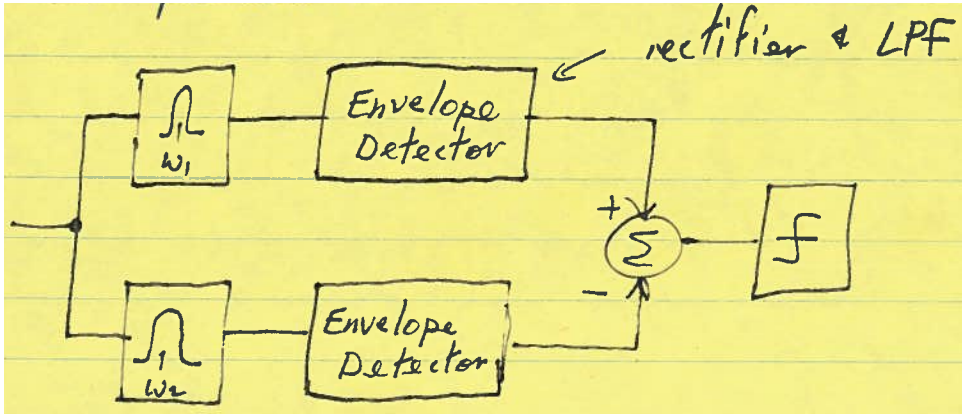


Non-Coherent FSK

- Energy detection method



- Envelope detection



Non-Coherent FSK

- Another receiver example