

# Differential BPSK: DPSK

EE161: Digital Communication Systems

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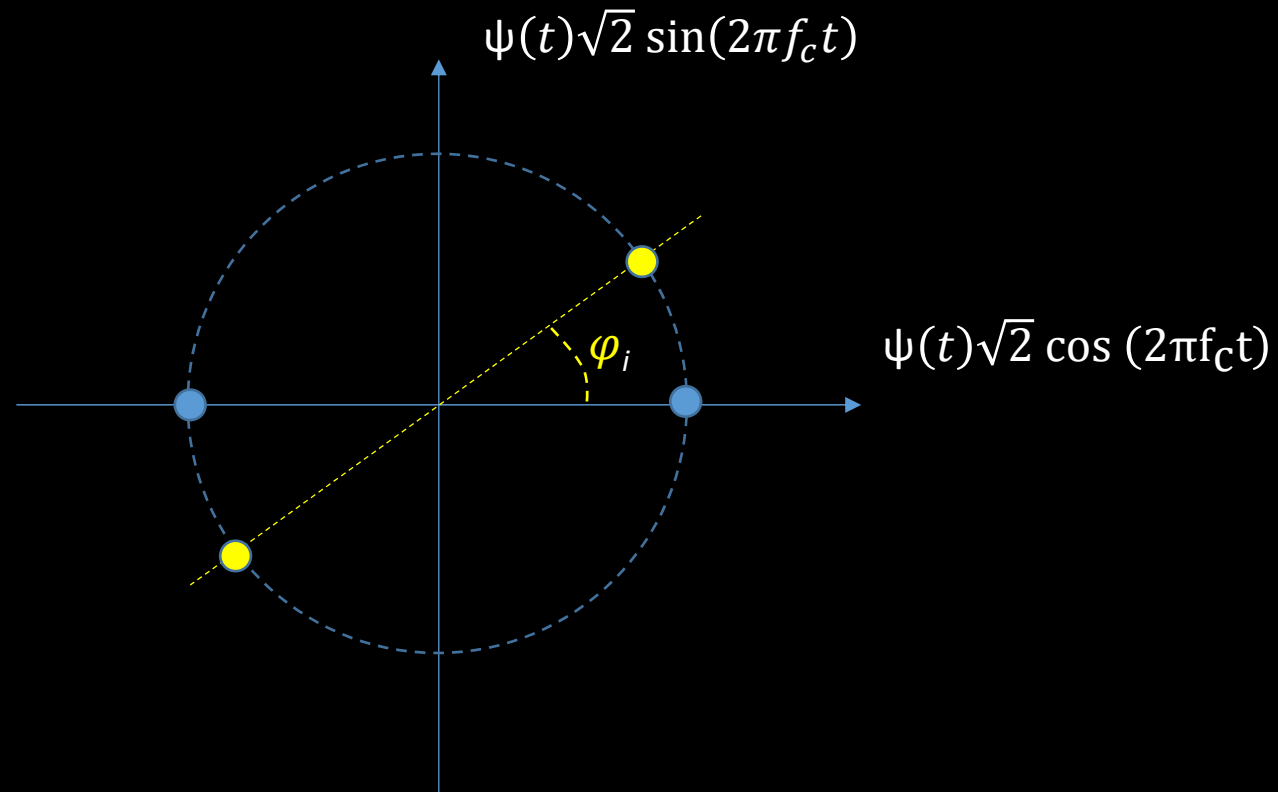
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# Random phase in wireless communications

- In wireless communications, the phase of the carrier signal is affected by several factors:
  - Propagation delay,  $\tau$
  - Independent oscillators in each device
- Assuming that fading is slow, the received signal over each propagation path is

$$r_i(t) = \alpha_i s(t - \tau_i) \cos(2\pi f_c t + \varphi_i)$$

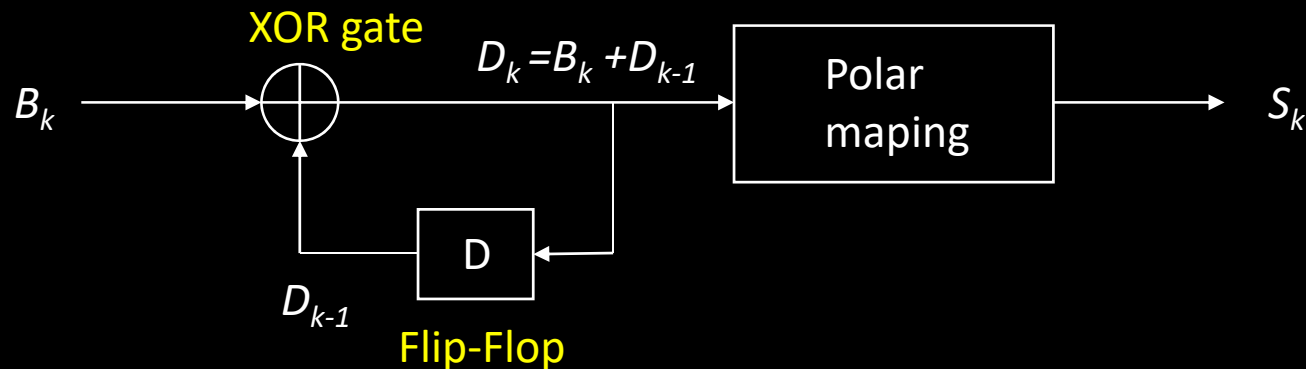
# Phase effect on BPSK constellation



Idea: Encode phase difference, not absolute phase

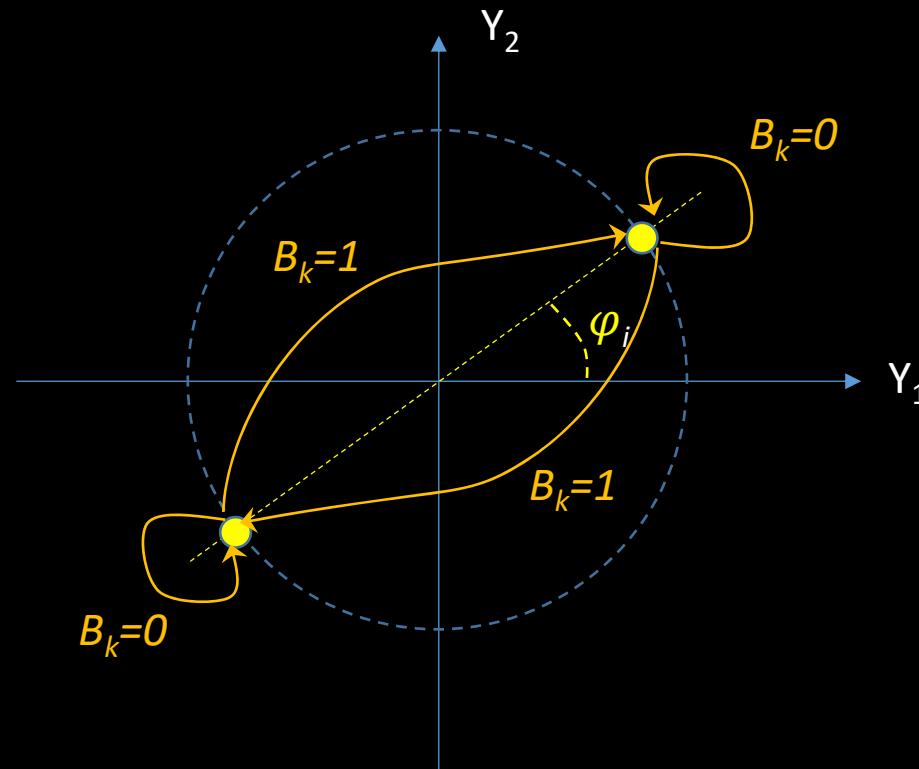
# Differential encoder and mapper

Read “Differential Phase Encoding and Differential Phase Modulation and Demodulation” (sec. 8.6.4 of textbook, 2nd ed.)



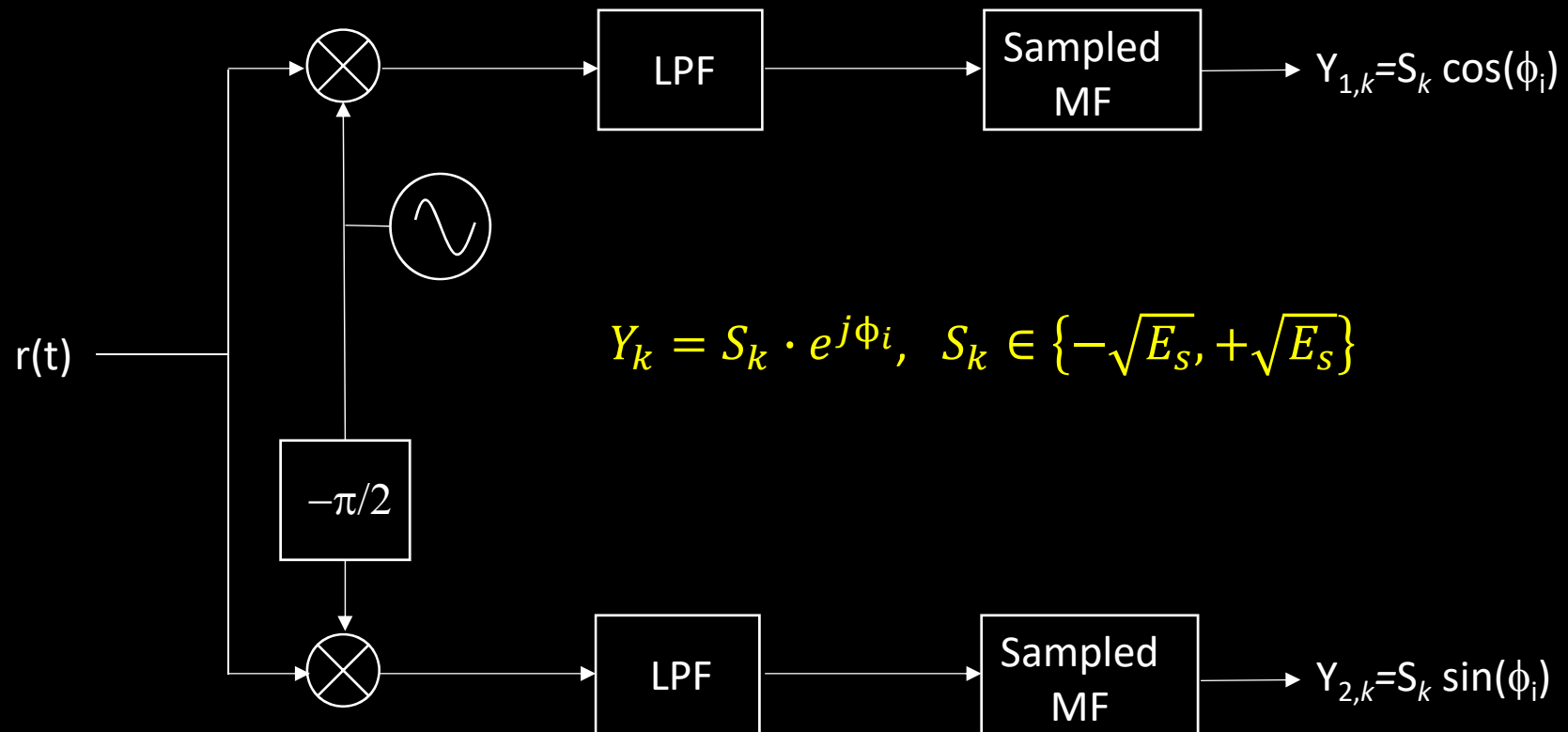
$B_k$	$D_k$	$S_k$	
0	$D_{k-1}$	$S_{k-1}$	No change
1	$\overline{D_{k-1}}$	$-S_{k-1}$	Phase change

# Differential phase changes (BPSK)

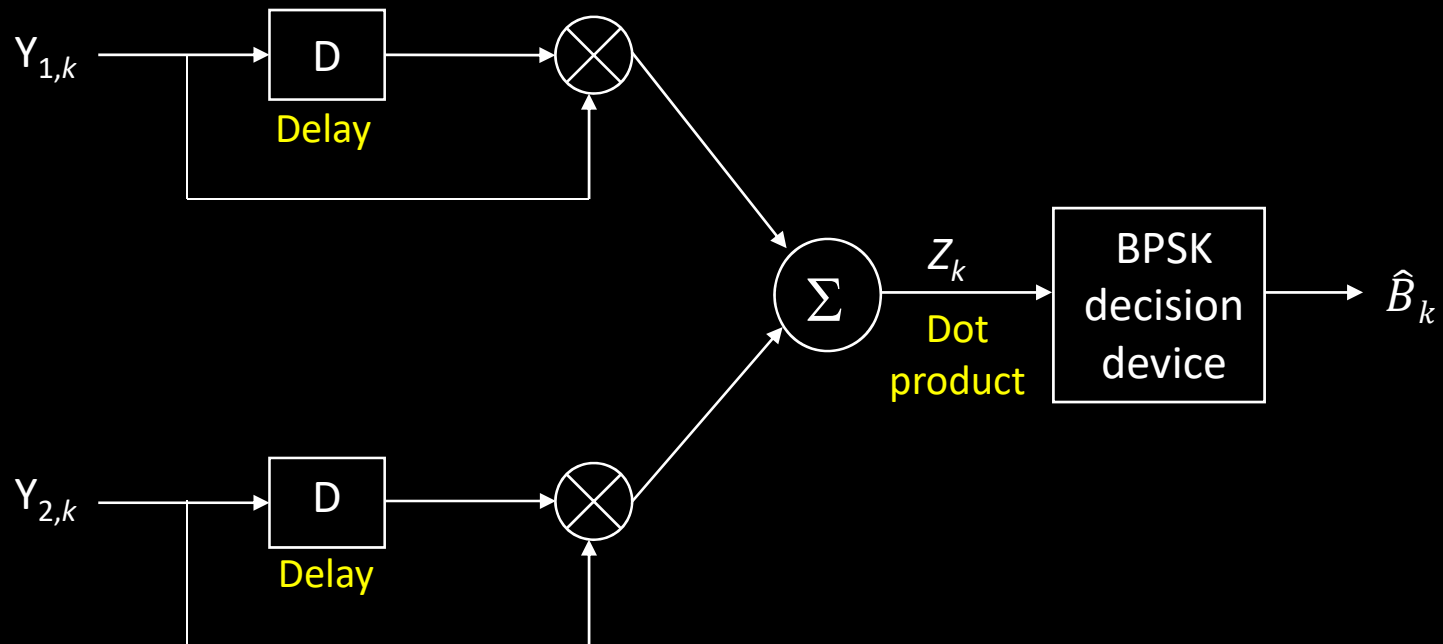


Idea: Compute the dot product  $Z_k$  between two consecutive matched filter output pairs  $(Y_{t,k}, Y_{2,k})$  and  $(Y_{t,k-1}, Y_{2,k-1})$  ---> Need **quadrature demodulator**.

# Quadrature demodulator (DPSK)



# DPSK decision device



$Z_k > 0$ : Same direction ( $B_k=0$ )  
 $Z_k < 0$ : Opposite direction ( $B_k=1$ )

# Error performance of DPSK

- AWGN channel

$$P_b = \frac{1}{2} e^{-E_s/N_0}$$

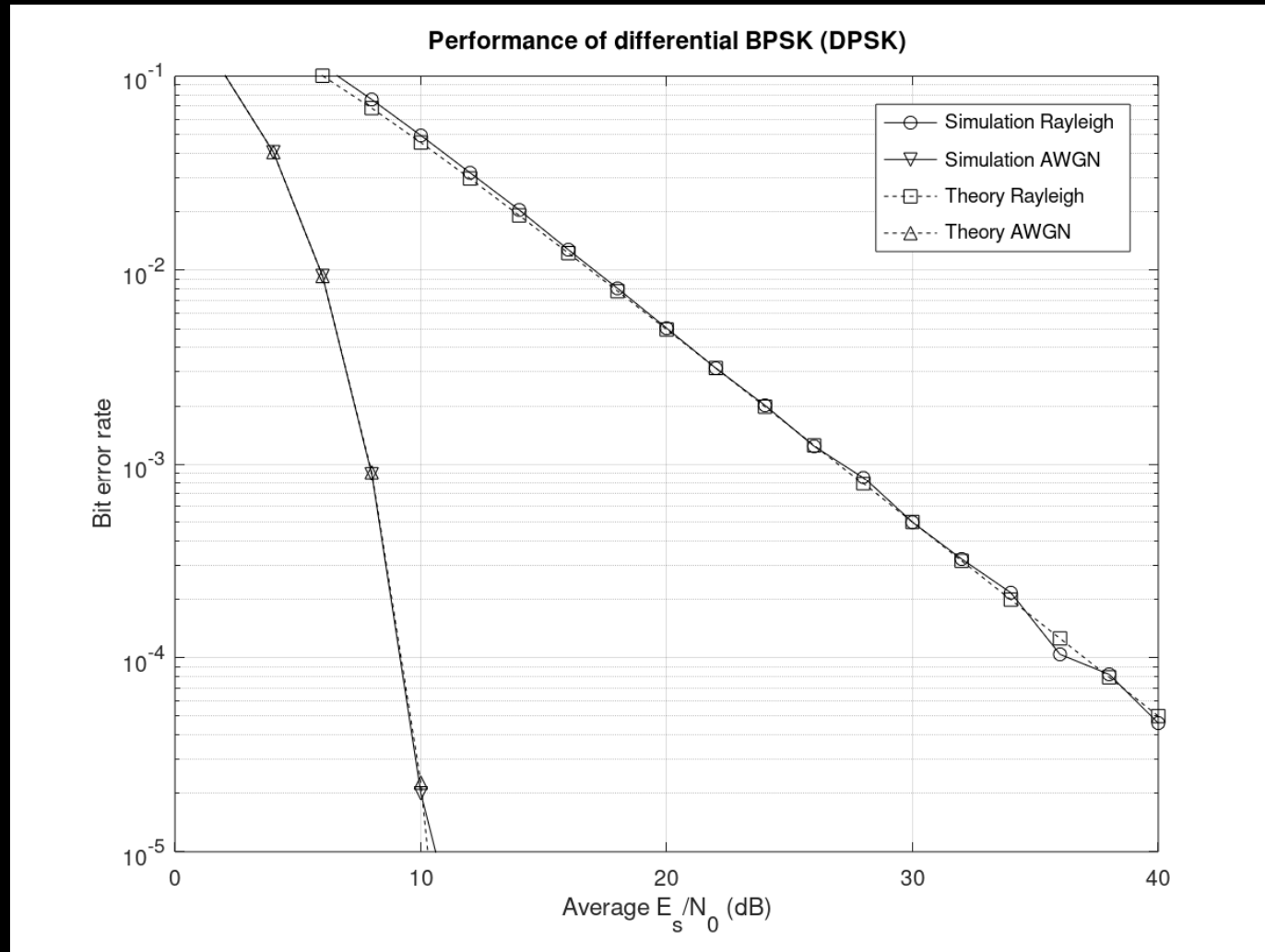
- Rayleigh fading channel,  $\rho_0 = \frac{E_s}{N_0} E\{A^2\}$

$$P_b = \frac{1}{2(1 + \rho_0)}$$

See MATLAB script “dpsk\_AWGN\_rayleigh.m” and results shown next.



# DPSK simulation results



# Differential modulation

- The same ideas used in DPSK (differential encoding) can be extended to other linear modulation, such as *M*-PAM, *M*-PSK and *M*-QAM