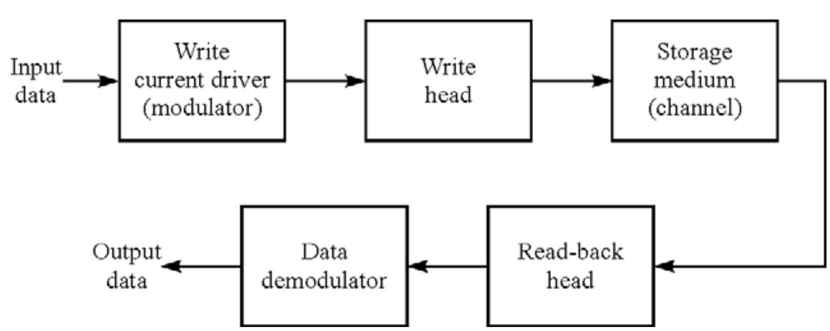
The Magnetic Recording Channels

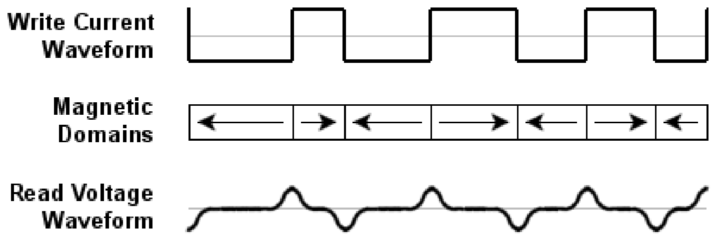
Partial Response Maximum Likelihood

Magnetic Storage Read/Write System

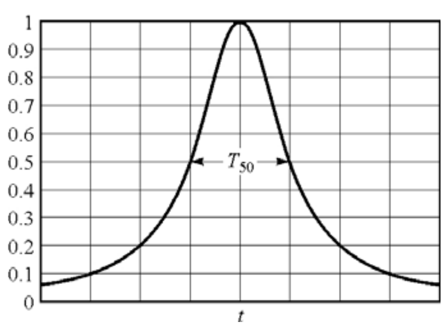


Magnetic Recording Channel (MRC)

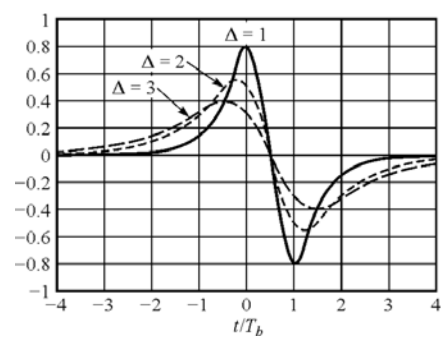
- Flux reversal instead of the absolute field
  - Easy to Measure
  - Easy Synchronization
  - Field Separation



Read Waveform/Readback pulse

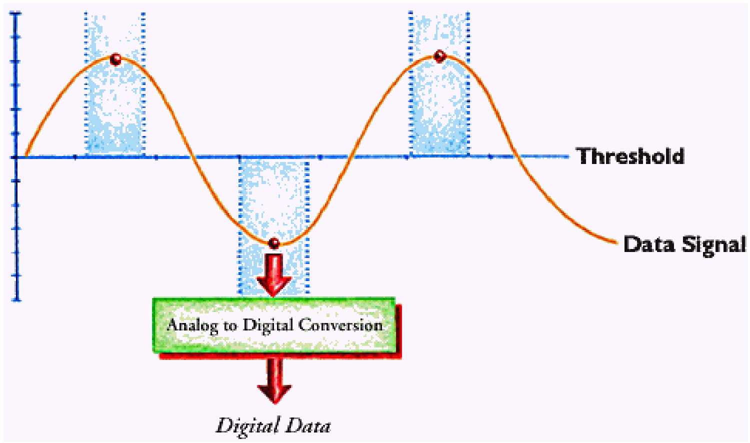


$$g(t) = \frac{1}{1 + (2t/T_{50})^2}$$



$$\Delta = T_{50}/T_b$$

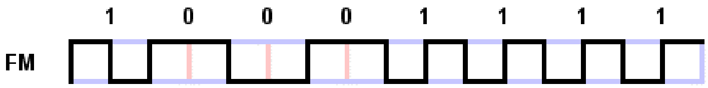
Traditional Peak Detection



Frequency Modulation

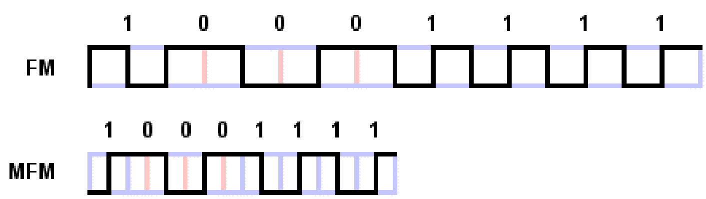
Input Data Bits	Output coded Sequence	# of 1's	Prob. (%)
0	10	1	50
1	11	2	50
	Weight	1.5	100

1: Reverse the flux
0: Don't reverse the flux



Modified Frequency Modulation (MFM)
Miller code

Input Data Bits	Output coded Sequence	# of 1's	Prob. (%)
0 (preceded by 0)	10	1	25
0 (preceded by 1)	00	0	25
1	01	1	50
	Weight	0.75	100



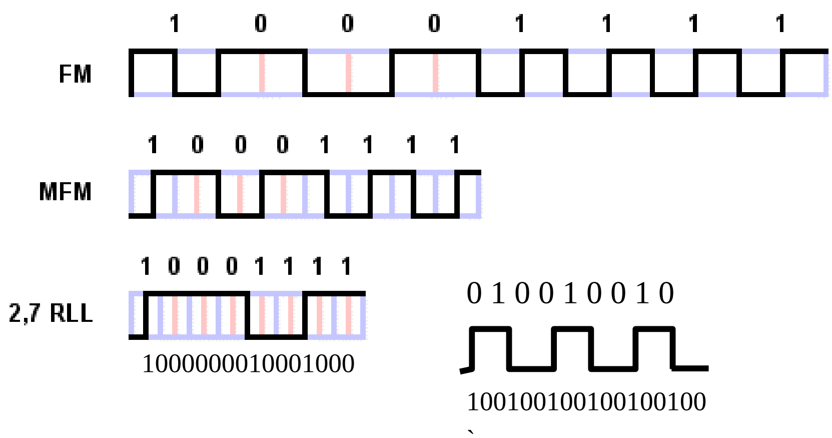
Run-Length Limit (d, κ)

RLL (2, 7)

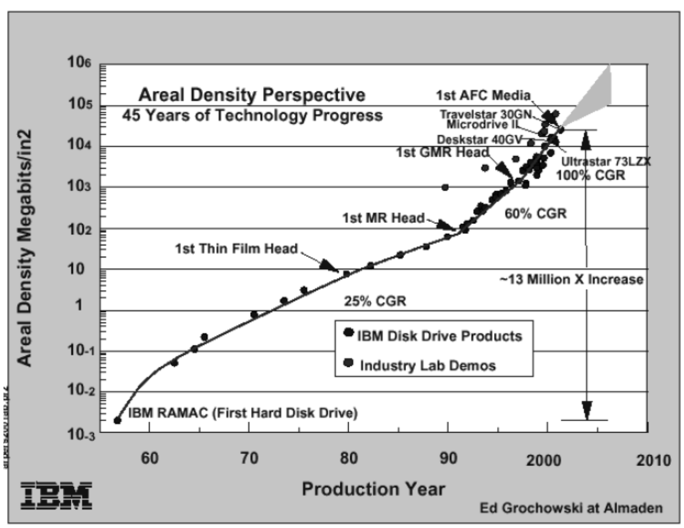
Input Data Bits	Output coded Sequence	# of 1's	Prob. (%)
11	1000	1/2	25
10	0100	1/2	25
011	001000	1/3	12.5
010	100100	2/3	12.5
000	000100	1/3	12.5
0010	00100100	2/4	6.25
0011	00001000	1/4	6.25
	Weight	0.4635	100

(Small difference with the textbook)

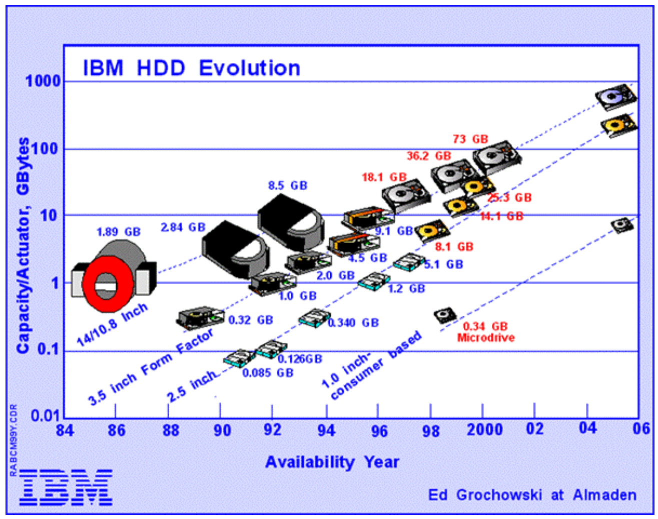
RLL (2, 7)



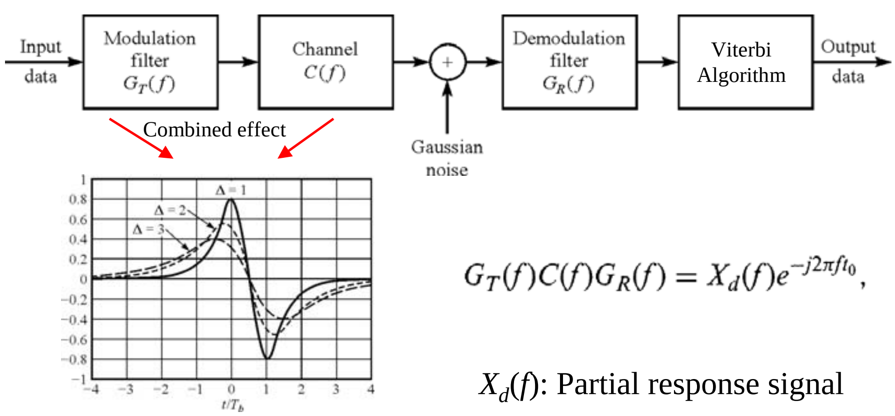
Storage Density vs. time



Hard Disk Evolution



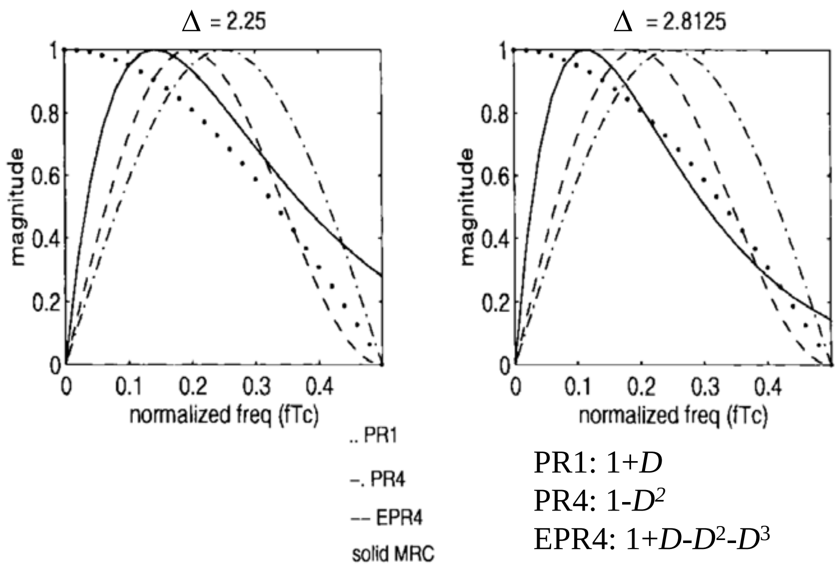
Partial Response Maximum Likelihood



$$G_T(f)C(f)G_R(f) = X_d(f)e^{-j2\pi f t_0},$$

$X_d(f)$: Partial response signal

Partial Response vs. MRC



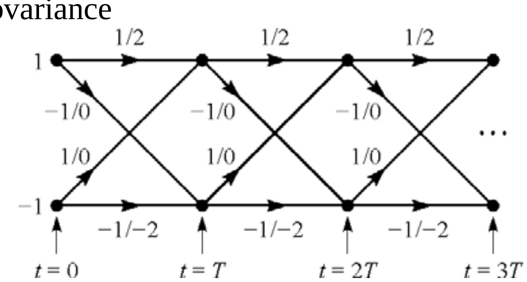
PR1: $1+D$
PR4: $1-D^2$
EPR4: $1+D-D^2-D^3$

Maximum Likelihood Sequence Detection

- pdf of received signal

$$f(\mathbf{y}_N|\mathbf{I}_N) = \frac{1}{(2\pi \det \mathbf{C})^{N/2}} \exp[-\tfrac{1}{2}(\mathbf{y}_N - \mathbf{B}_N)'\mathbf{C}^{-1}(\mathbf{y}_N - \mathbf{B}_N)]$$

y_N: received sequence
B_N: transmitted sequence
I_N: bit (or PAM) sequence
C: Noise covariance



PRML (duobinary PR1 signal)

- Metric

$$\hat{\mathbf{I}}_N = \arg\min_{\mathbf{I}_N}[(\mathbf{y}_N - \mathbf{B}_N)'\mathbf{C}^{-1}(\mathbf{y}_N - \mathbf{B}_N)]$$

Ignore noise correlation:

$$\hat{\mathbf{I}}_N = \arg\min_{\mathbf{I}_N}[(\mathbf{y}_N - \mathbf{B}_N)'(\mathbf{y}_N - \mathbf{B}_N)]$$

$$= \arg\min_{\mathbf{I}_N}\left[\sum_{m=1}^{N}\left(y_m - \sum_{k=0}^{L} x_k I_{m-k}\right)^2\right] \qquad B_m = \sum_{k=0}^{L} x_k I_{m-k}$$

- Viterbi Algorithm

$$DM_m(\mathbf{I}_m) = DM_{m-1}(\mathbf{I}_{m-1}) + \left(y_m - \sum_{k=0}^{L} x_k I_{m-k}\right)^2$$

PRML (PR4 signal)
Modified duobinary (homework)

- PR4: $1-D^2$