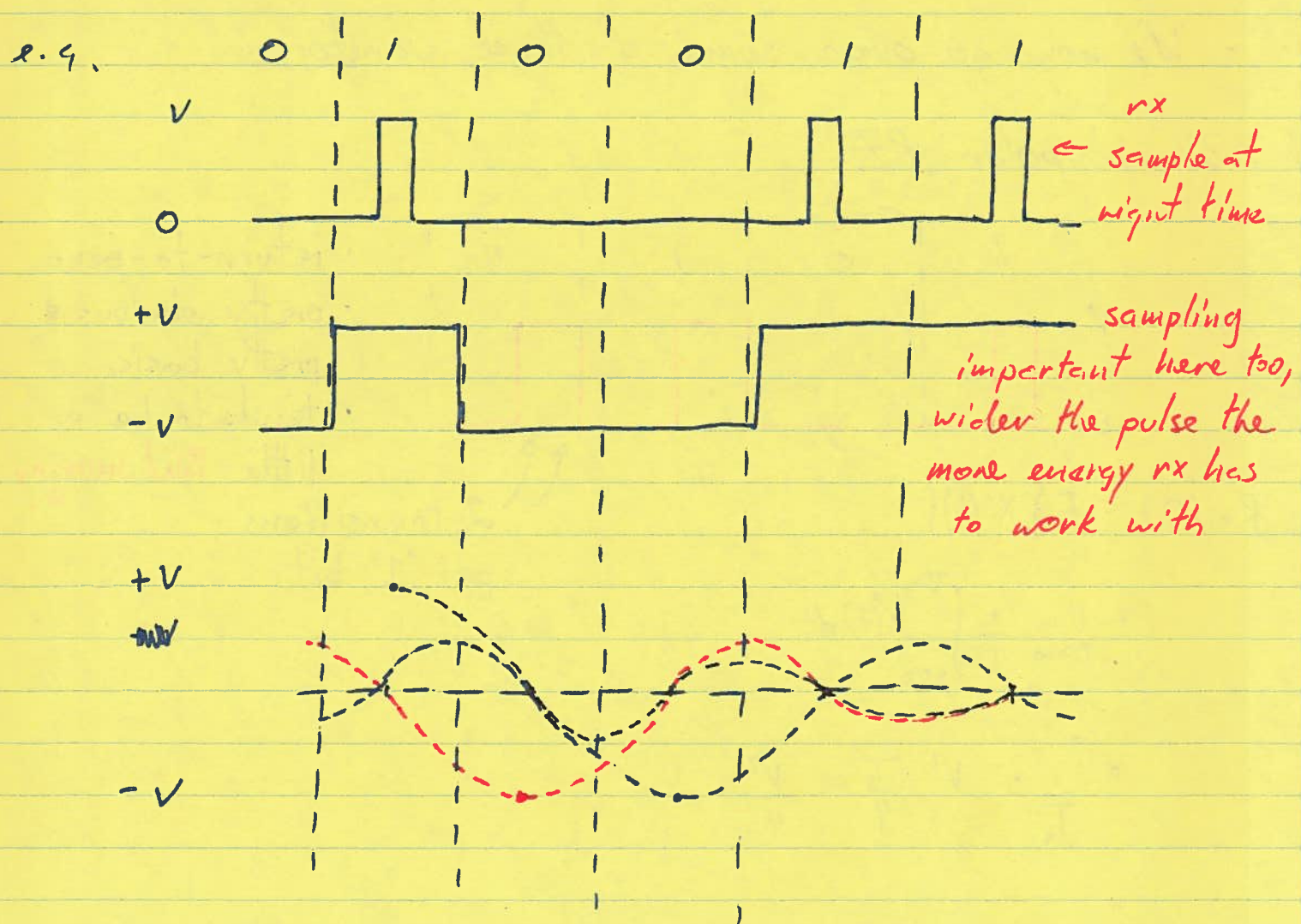


L7 Baseband Transmission (Line Coding)

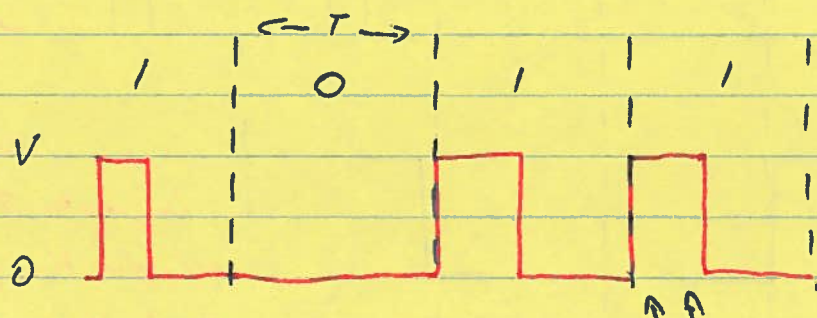
7.1 Waveform Representation of Bits

- PCM is the **binary end-product** of A/D conversion
- The bits could have come directly from some digital source themselves as far as the transmitter is concerned
- But when we **transmit these over a real channel** we need to express them in terms of some **REAL CONTINUOUS WAVEFORM**



- clearly we have some choice in choosing a useful waveform representation
- this is a form of modulation (we multiply our digital levels by some waveform) but without actually introducing a high frequency carrier
- rather the signal largely (not always totally) remains baseband (most of its avg. power lumped around DC)
- this type of modulation is often referred to as LINE CODING
- We now go over some of these waveforms

7.2 Unipolar RZ



- return-to-zero
- pretty obvious & pretty basic
- tends to be a little BW hungry

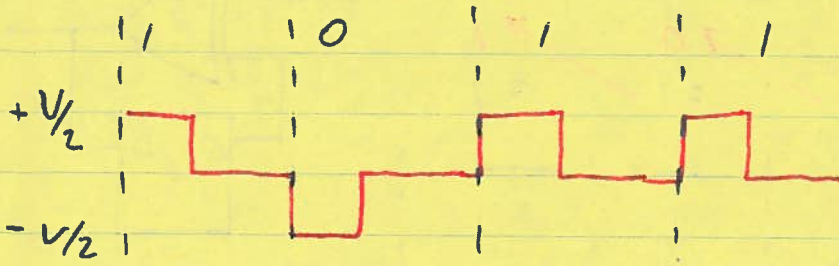
$$R_x(0) = E\{X^2(t)\}$$

$$= \lim_{T \rightarrow \infty} \frac{1}{T} \int_{-T/2}^{T/2} X^2(t) dt$$

$$= \frac{1}{T_s} \cdot V^2 \cdot \frac{T_s}{4} = \frac{V^2}{4}$$

2 transitions per '1' bit

7.3 Bipolar RZ (AMI alternate mark inversion RZ)



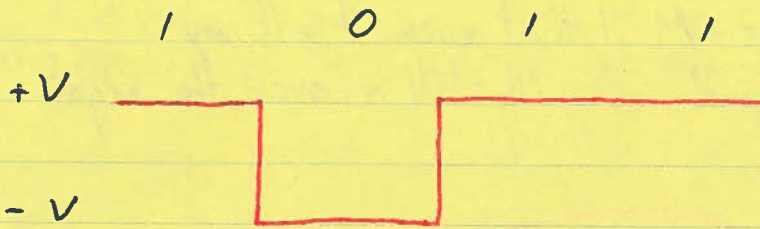
- same basic properties
- can be a little more energy efficient

↓
 varying symmetrically from $+\frac{V}{2}$ to $-\frac{V}{2}$

$$R_x(0) = \lim_{T \rightarrow \infty} \frac{1}{T} \int_{-T/2}^{T/2} x^2(t) dt = \frac{1}{T} \cdot \frac{V^2}{4} \cdot \frac{T}{2} = \frac{V^2}{8}$$

- good for timing, always get a transition

7.4 NRZ-L (Level) (Polar NRZ) / (NRZ change)



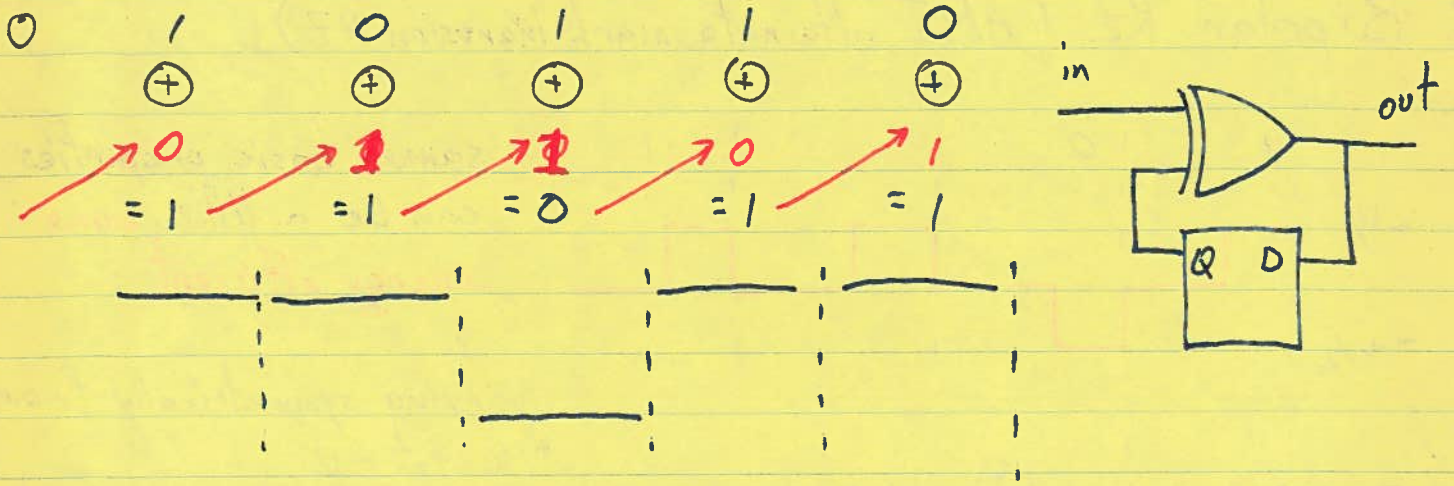
- less BW needs
- timing problems

7.5 Differential NRZ NRZ-M (Mark) (Differential Encoding)

~~'Hi' (mark) represents change in bits 'Lo' (space)~~

a scheme with memory

- if bit to send differs from last bit sent → send a 1 (mark)
- " " " " same as " " " → send a 0 (space)



• NRZ-M decoder?



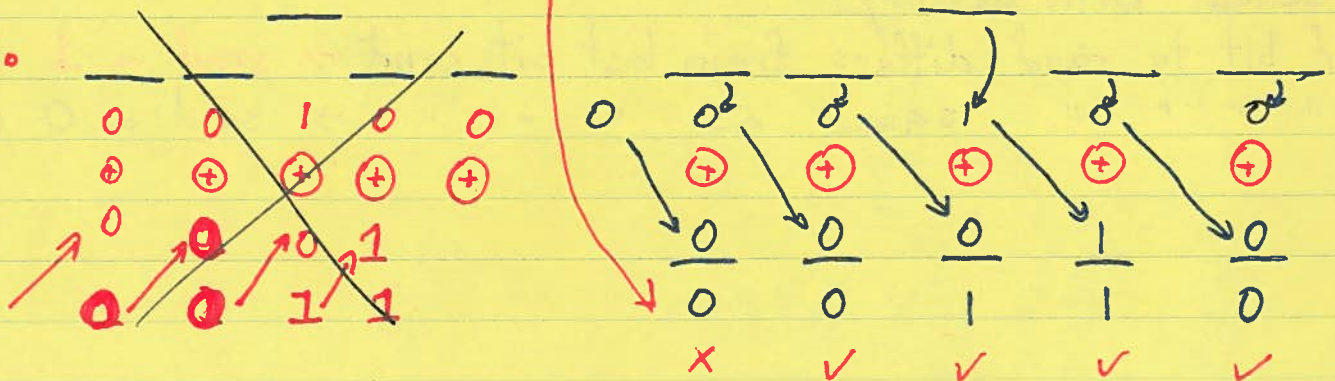
• again comparing current + previous

• nice property of NRZ-M it that even if all my received bits are flipped, I will still recover the right sequence

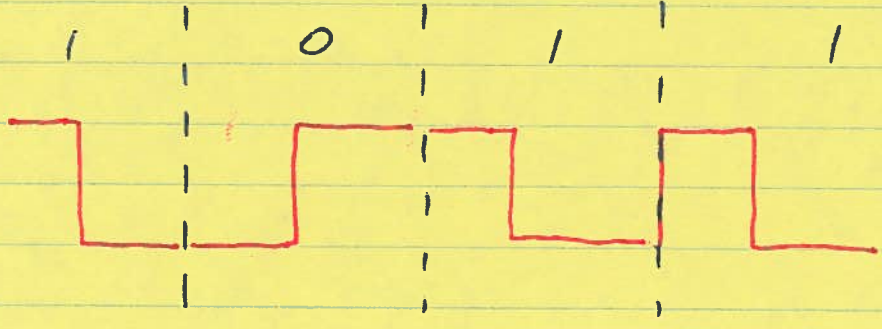
(maybe after brief initial error) since I'm comparing the difference between adjacent bits in time

• flipped twisted pair
• 180° flip in wireless

e.g. if receive



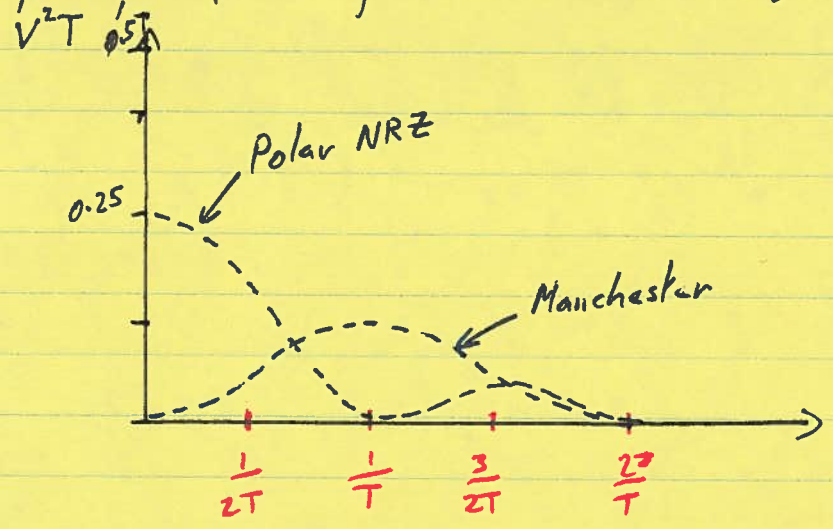
7.6 Phase Encoded / Bi-φ-L / Manchester Coding



- good for synch since guarantees transition

- a form of 1B2B coding... send 2 pulses for every bit
- other than techniques like 4B5B
 - ≤ 5 consecutive 1's & 0's
 - balances 1's & 0's such that no more than 2 apart over any stream (better DC removal)
 - 8B10B
 - 64B66B (10G Ethernet)

7.7 Spectra (for sigs with variation of V: 0 → V -V/2 → +V/2)



2

1. The first part of the paper is devoted to a study of the

properties of the function $f(x)$ defined by the equation

$$f(x) = \int_0^x (1-t)^n dt$$

where n is a positive integer. It is shown that the function

is continuous and differentiable on the interval $[0, 1]$.

The derivative of the function is given by the formula

$$f'(x) = (1-x)^n$$

which is valid for all x in the interval $[0, 1]$.

It is also shown that the function satisfies the differential equation

$$x f'(x) + f(x) = x^n$$

with the initial condition $f(0) = 0$.

The function $f(x)$ is also shown to be concave down on the interval

$[0, 1]$ and to have a maximum value of $\frac{1}{n+1}$ at $x = 1$.

The function $f(x)$ is also shown to be a solution of the differential equation

$$x^2 f''(x) + 2x f'(x) + f(x) = x^{n+1}$$