Line Coding

Coding schemes to send a digital signal on a line. (wires, etc.)

Also used for magnetic tape/disc storage, optical storage, optical communication (infrared, fiber optic).

Just sending the serial data is a simple example of line coding.

There are many coding schemes. Only a few are covered here.

HW 7.2-2 a 4 a
Try to evaluate on the 6 properties.

A line coding scheme should have these properties:

1. Transmission bandwidth — as small as possible
2. Power efficiency — For given bandwidth and desired error handling, transmitted power should be as small as possible.
3. Error detection and correction — Some codes can do this, others don't.
4. "Favorable" power spectral density — What is favorable depends on the media. For example, it might block DC.
5. Adequate timing content — it needs a way to synchronize the receiver. Possible to extract timing from the signal
6. Transparency — can send arbitrary patterns without inducing errors.

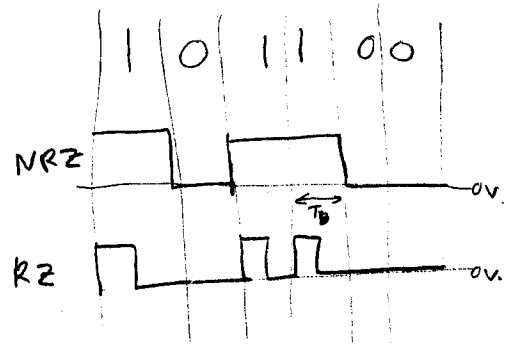
On-off signaling ("Unipolar")

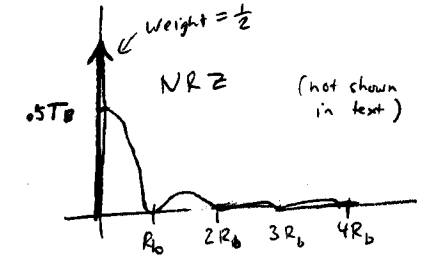
We already mentioned this one.

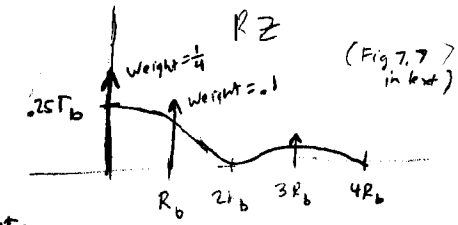
2 variants:

"RZ" — return to zero — signal returns to 0 between pulses

"NRZ" — non-return-to zero — signal does not return to 0 between pulses.







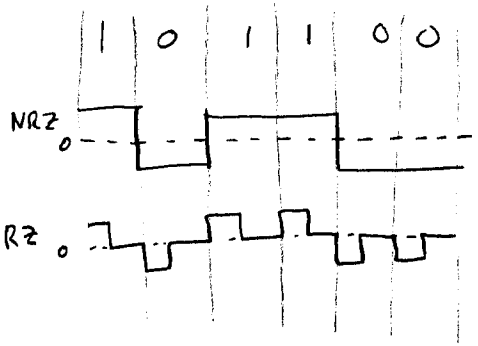
1. BW: ("essential bandwidth" or "first null bandwidth")
   NRZ : R_b (OK)
   RZ : $2R_b$ (bad)
2. Power: Wasted power in DC component. RZ also has wasted power at R_b
3. Error detection: none
   poor noise immunity — depends only on level.
4. PSD has DC component — must use DC coupled amplifiers, no transformers, etc.
5. Timing: NRZ could have none
   RZ has only on 1's
6. Transparency:
   RZ: long string of 0's loses timing
   NRZ: long string of either loses timing
   ] — Not transparent

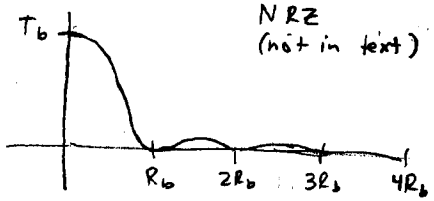
R_b = pulses per second $= \frac{1}{T_b}$

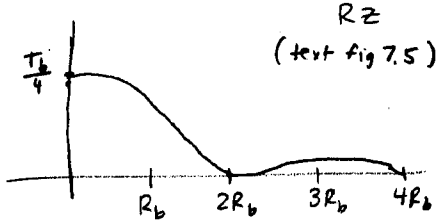
T_b - Time per bit.

Polar signaling

1 = positive
0 = negative
] Same strength, opposite polarity







① BW – NRZ : R_b (ok)
RZ : $2R_b$ (bad)
Same as unipolar.

② Power:
More efficient –
No constant DC and R_b terms.
that carry no information.

③ Error detection:
None but better noise immunity

④ PSD – still has DC component.
Most power is low frequency

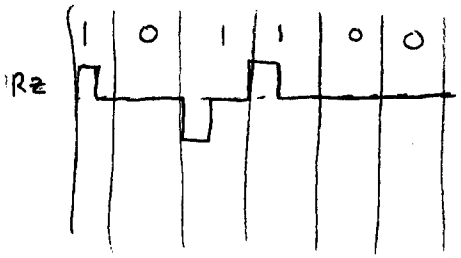
⑤ Timing: NRZ could have none if all 1 or all 0.
RZ has timing.

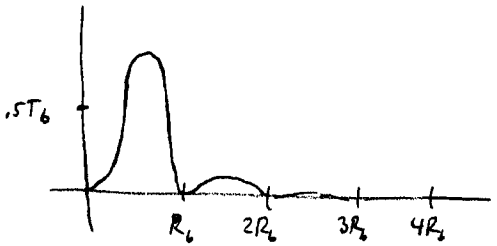
⑥ Transparency:
NRZ: long string of either loses timing – Not transparent
RZ: is transparent.

"Bipolar" signaling

(Also known as "AMI" (alternate-mark-inverted))

Like unipolar, except that 1 alternates between + and –





Really a ternary system – There are 3 possibilities.

① BW: = R_b (good)

② Power – No DC component,
but otherwise like on-off.
→ poor. 3dB worse than polar

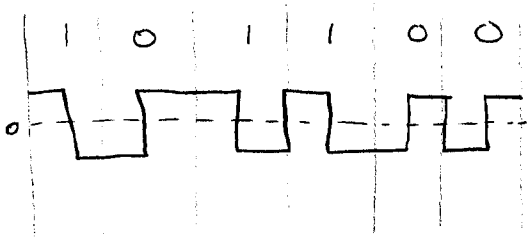
③ Error detection –
Can detect single error
because 1's alternate polarity.
Any error would result in violation of alternating pulse rule

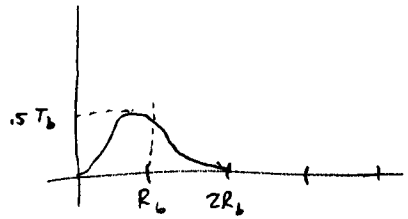
④ PSD: No DC.
can use AC coupled amplifier.

⑤ Timing:
String of 0's could lose timing

⑥ Transparency:
NO – string of 0's could lose timing

"Manchester" or "split-phase" or "twinned-binary"





Instead of returning to zero, send the opposite polarity.

① BW: $2R_b$ -- Twice bipolar

② Power: ?

③ Error detection: No.

④ PSD: NO DC (can use AC coupled amplifier) but wider bandwidth

⑤ Timing:
Both 1 and 0 send timing info

⑥ Transparency
long string of 0's looks like long string of 1's except for phase shift.

"High Density Bipolar" (HDB)

A patch on bipolar...
If there are more than a certain number (N) of 0's, substitute a pattern for them, send with a deliberate violation so it can be identified.

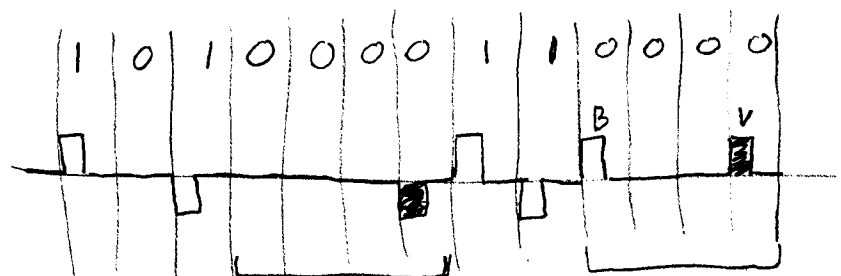
"HDB3" → N = 3
Replace sequences of 4 zeros with a pattern:

Either B 0 0 V
or 0 0 0 V

B is a bipolar fake data bit

V is a violation bit —
Always send a bit (1) but send it in opposite polarity.

Pick B00V or 000V
so V's alternate



4 0 sequence. Need negative V it is already a violation, so 1st bit is 0.

4 0 sequence Need positive V. It wouldn't be a violation, so add an extra 1 to make it one