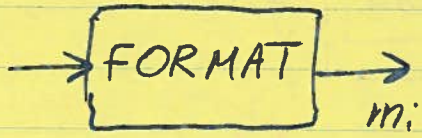
L8 Baseband Demodulation/Detection Basics

8.1 System Review

- Out of TX so far...



- bit stream may have some structural pattern already
  e.g. 3-bit chunks in an 8-level PCM
  7-bit ~~chunk~~ chunks encoding an ASCII character of digital text

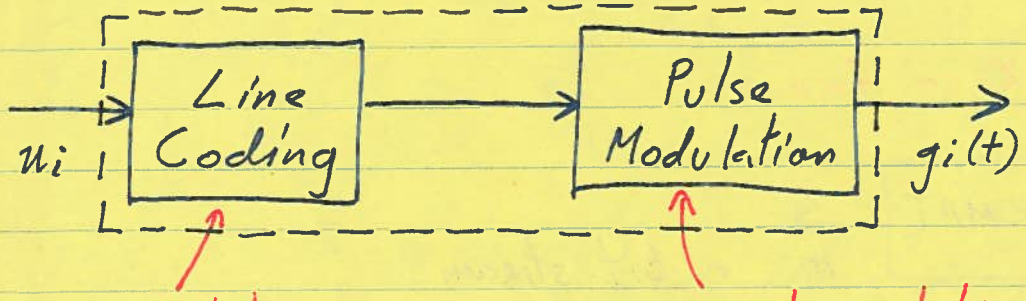
- Then you have...

- adding bits (redundancy) to stream
- e.g. ASCII + even parity

1	2	3	4	5	6	7	8
1	0	0	1	0	1	0	1

- now if receive 00010101 ⇒ ODD parity, detect an error
- practically like boosting signal power
- still from a low-level u_i is still just a stream of bits

- Then you run through the modulator



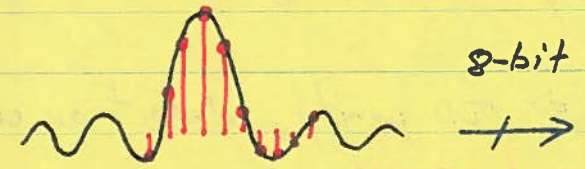
- manipulations of bit patterns # bit representation (still discrete-time) (e.g. 4B5B)

- re-interpretation of bits or collections of bits into continuous waveform representations SYMBOLS

e.g. $g_1(t) = \text{rect}\left(\frac{t}{T}\right)$ $g_2(t) = -\text{rect}\left(\frac{t}{T}\right)$

$g_1(t) = \text{sinc}\left(\frac{t}{T}\right)$ $g_2(t) = -\text{sinc}\left(\frac{t}{T}\right)$

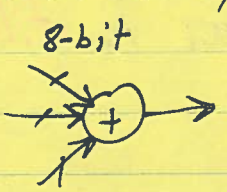
- in practice this may still be a digital signal



at T_s (some oversample period)

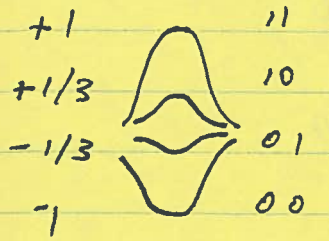
- digital allows us to carry out more complex functions

- e.g.

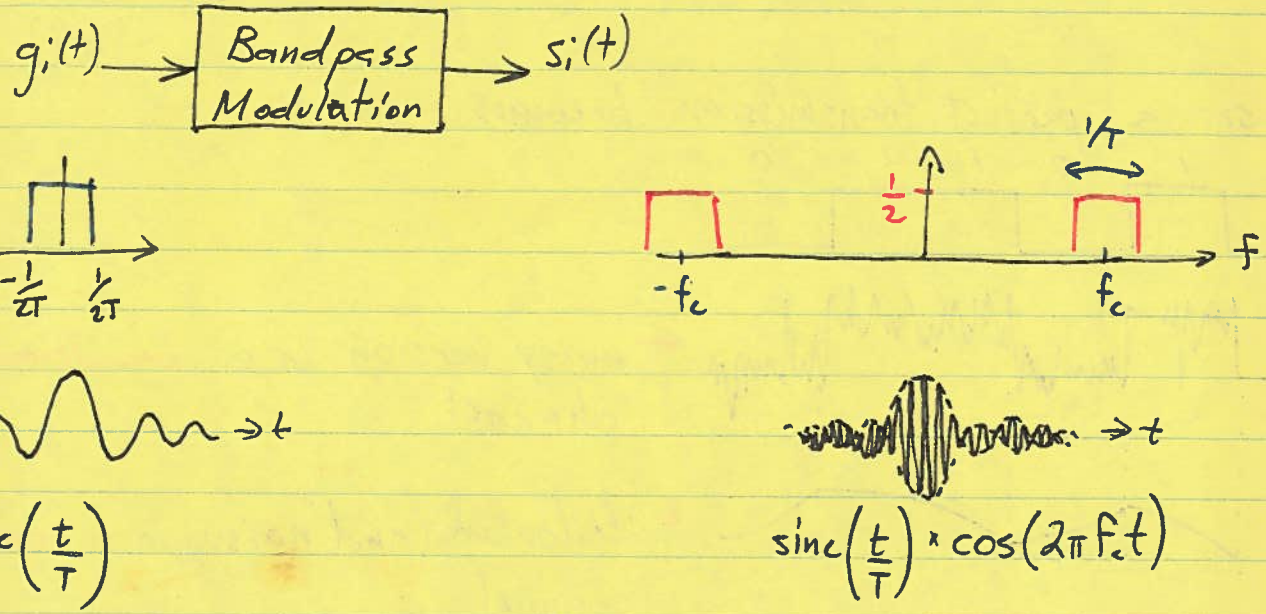


adding up many user waveforms to send from a base station

- you also have the option to encode in amplitude
  M-ary PAM



- you have more freedom... centre frequency bandpass modulation



- how do we get our bits out of these waveforms ???

8.2 The Received Signal

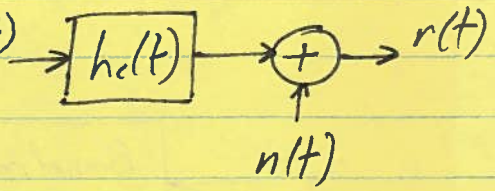
... don't forget the signal we get is changed by the channel

- transmitted digital waveforms (symbols) are

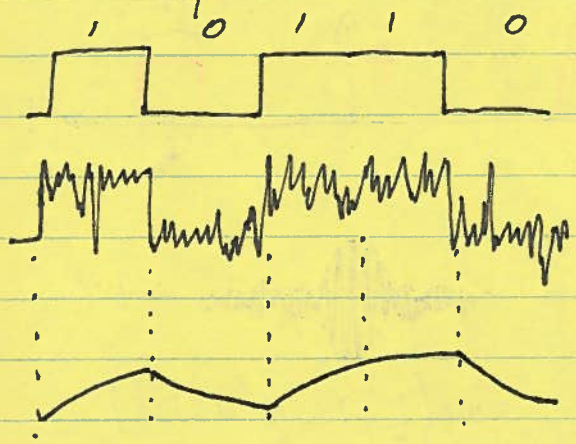
$$s_i(t) = \begin{cases} s_1(t) & 0 \le t \le T \text{ for binary 1} \\ s_2(t) & 0 \le t \le T \text{ for binary 0} \end{cases}$$

- after channel we get

$$r(t) = s_i(t) * h_c(t) + n(t)$$



- so a perfect transmission becomes



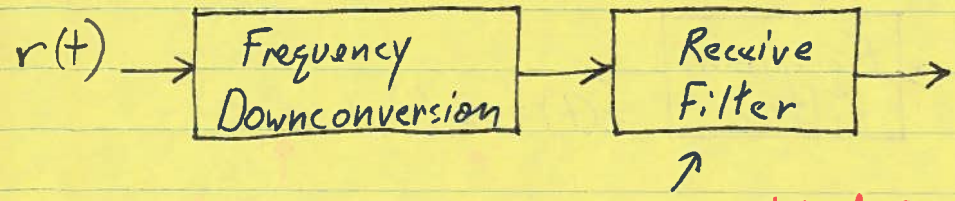
← noisy version in a broadband channel

← distorted (and noisy) in a narrowban channel

- the effect of a symbol leaking out of its designated time period T to interfere with other symbols is ISI

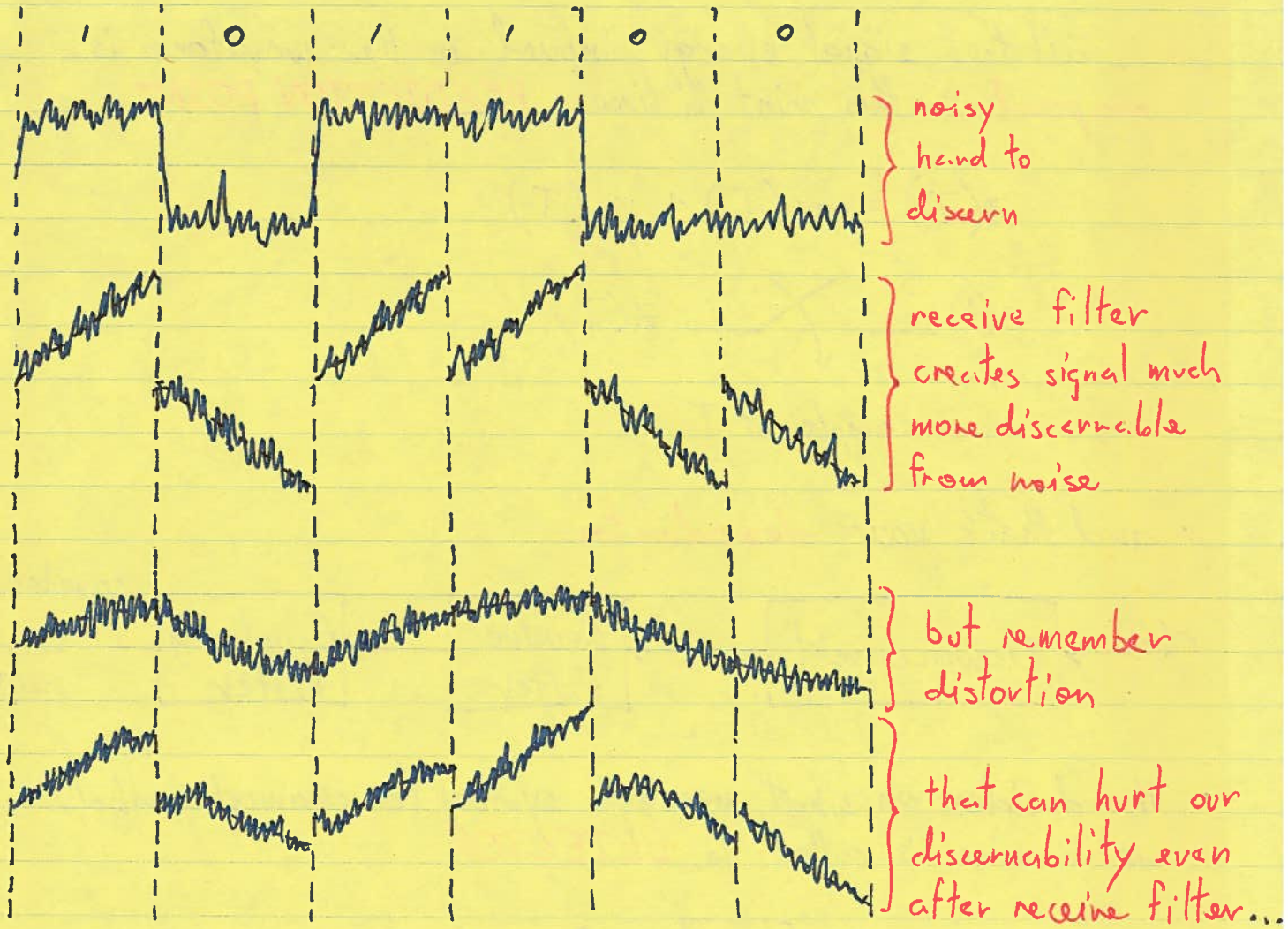
8.3 Demodulation & Detection

- How does a digital comms. RX deal with a signal filtered by the channel?

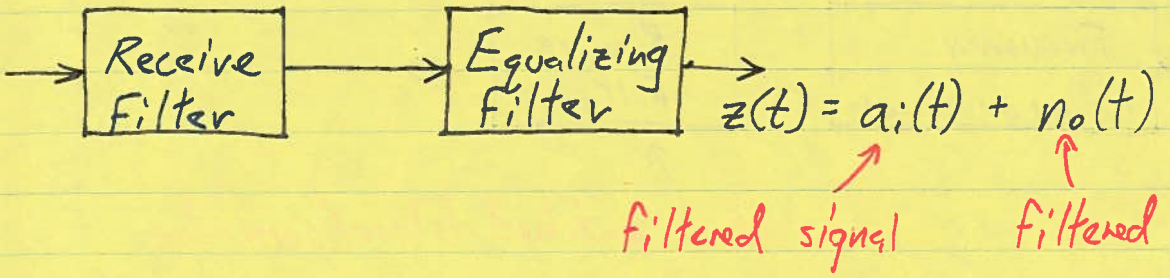


aka matched filter/correlator

- tries to extract as much signal energy as possible while eliminating as much noise as possible



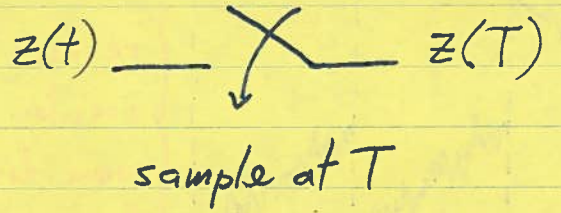
- ... so use an "un-distorter" (equalizer)



... now sample it at the optimal time, T (typically the end of the alloted symbol time)

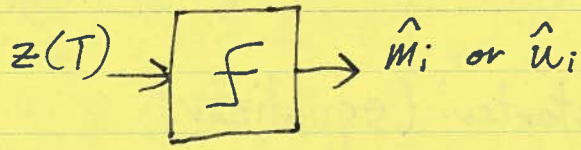
... all the signal energy imbued in the waveform is mapped to this point in time: PREDICTION POINT

$$z(T) = a_i(T) + n_o(T)$$



- and that's your demodulator

- the decider on what message symbol (or channel symbol) we receive is called the DETECTOR



- the detector carries out a statistical hypothesis test
- an "explanation" for an observation that contains probabilistic influences
- obviously the explanation/hypothesis is ... we received this signal because a "0" arrived -OR- we received this signal because a "1" arrived

H_1: Based on $z(T)$ received I hypothesize that a '1' was sent

H_2: " " " " " " " " '0' " "

- These hypotheses are based on a THRESHOLD MEASUREMENT

$$z(T) \underset{H_2}{\overset{H_1}{\gtrless}} \gamma$$

choose H_1 if $z(T) > \gamma$

choose H_2 if $z(T) < \gamma$