ELEC1323 Communications

11 Baseband Modulation

Baseband vs carrier modulation (CEP 1.5.3)

- We are typically interested in transmitting low frequency signals such as audio (20 Hz – 20 kHz).
- However, low frequencies don't propagate in some channels.
- We can modulate our low frequency onto a high frequency carrier (e.g. 1 Ghz) and transmit that instead.
- In other channels, baseband signals propagate fine and we don't need a carrier.
- Analogue baseband modulation is as simple as amplifying our analogue signal and putting it onto the channel directly, like in intercoms and CCTV.
- However, analogue baseband modulation does not support multiple access - the channel can only carry one signal.

Discrete baseband modulation (CEP 1.5.3.1)

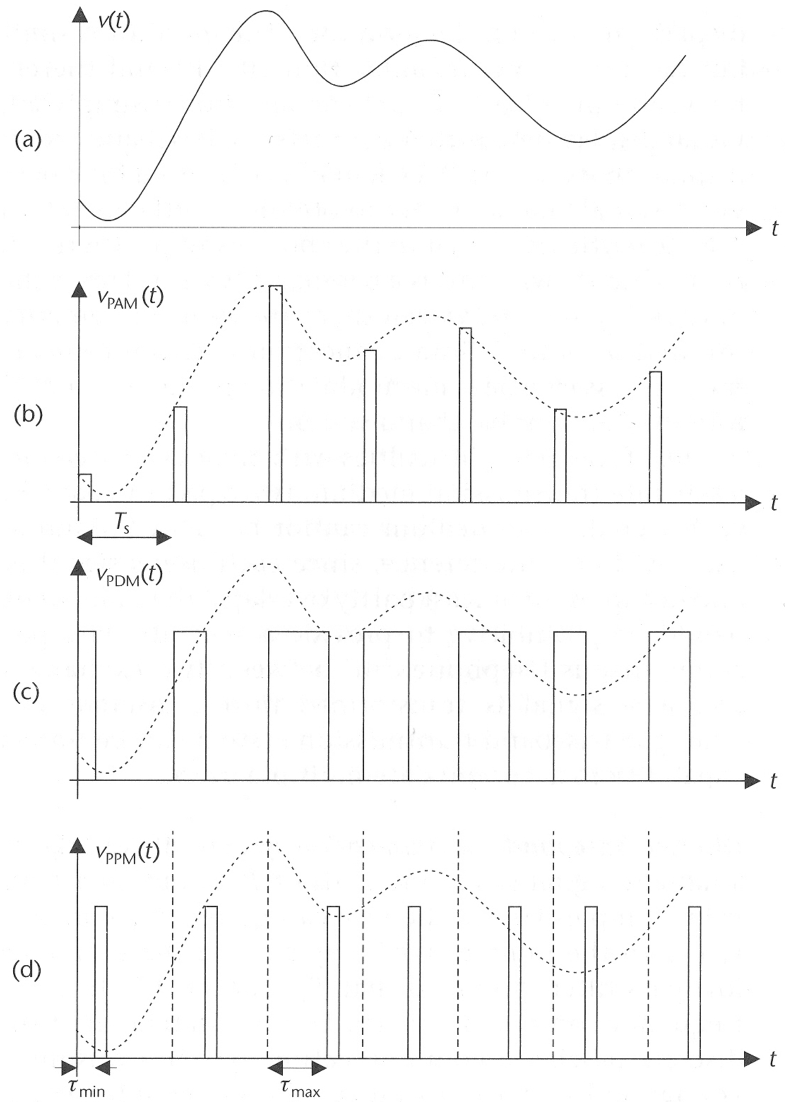


Figure 1.21 Analogue signal and its discrete representation as PAM, PDM and PPM.

- (a) Discrete baseband modulation samples an analogue signal $v(t)$ at time instants t that are integer multiples of the sampling period T_s.
- (b) Pulse Amplitude Modulation represents each sample with a pulse having the same amplitude. The analogue signal can be reconstructed using a LPF. Susceptible to additive noise.
- (c) Pulse Duration Modulation represents the amplitude of each sample with the duration of the corresponding pulse. Wasteful of power. May impose clipping.
- (d) Pulse Position Modulation represents the amplitude of each sample with the position of the corresponding pulse. Susceptible to timing errors. May impose clipping.

Discrete baseband modulation continued

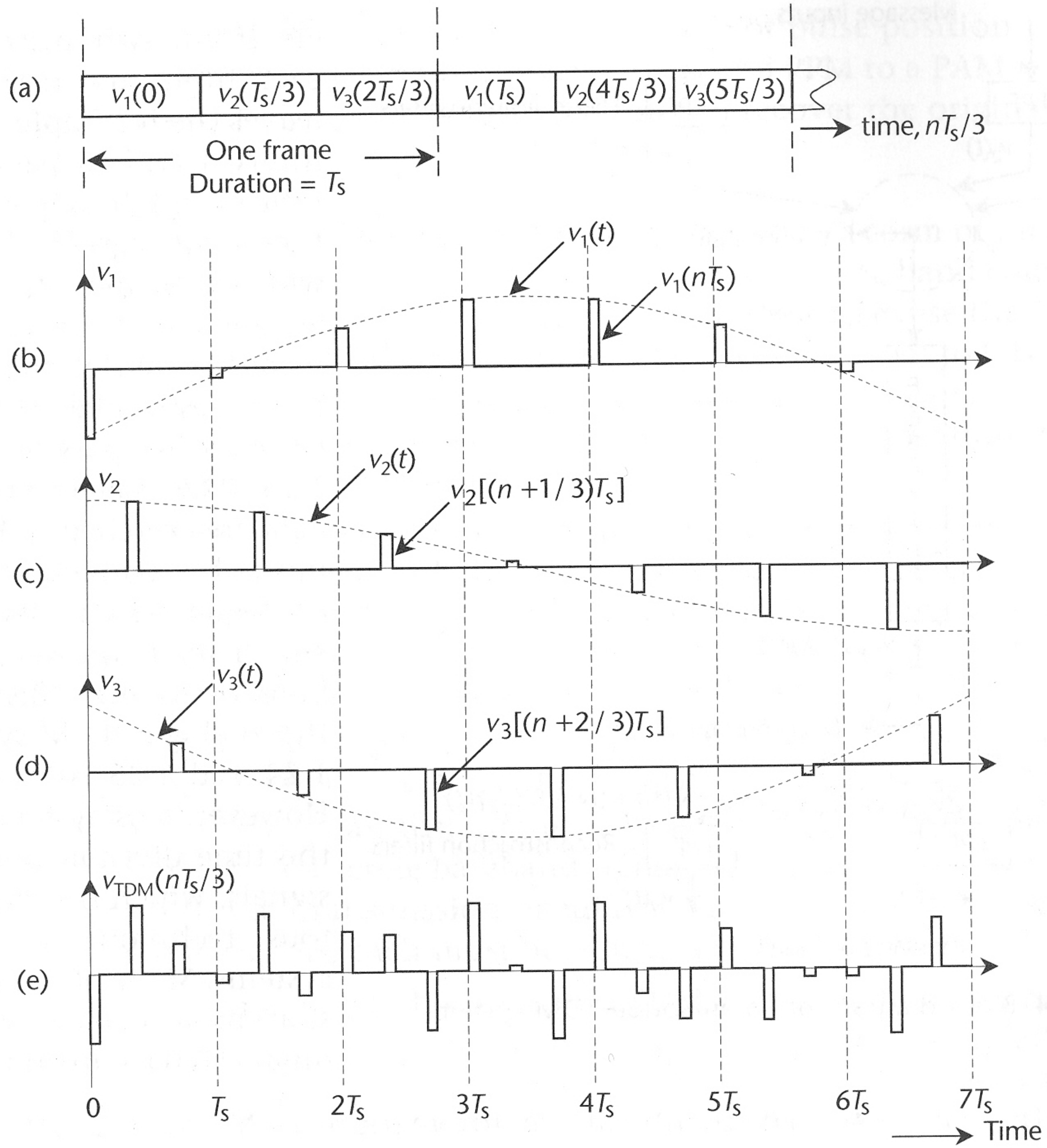


Figure 1.25 Three-channel TDM. n is an integer = 0, 1, 2, 3, ...

- (a) Multiple access can be achieved by dividing each sampling period T_s into a number of timeslots.
- (b), (c) and (d) A different PAM signal can be transmitted in each time slot.
- (e) The transmitted signal comprises all of the individual PAM signals. The receiver must be synchronised with the transmitter to tell the signals apart.

Digital baseband modulation (CEP 1.5.3.1 and 6.5)

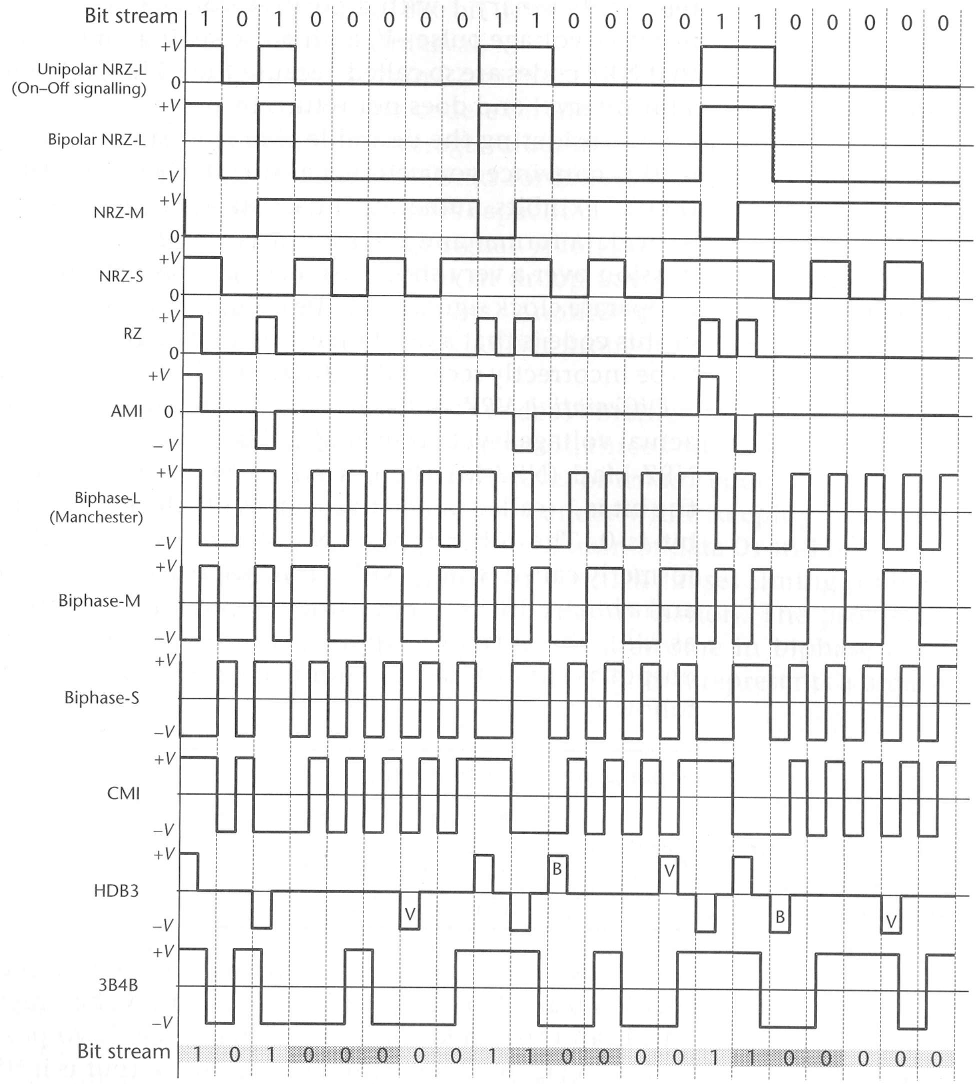
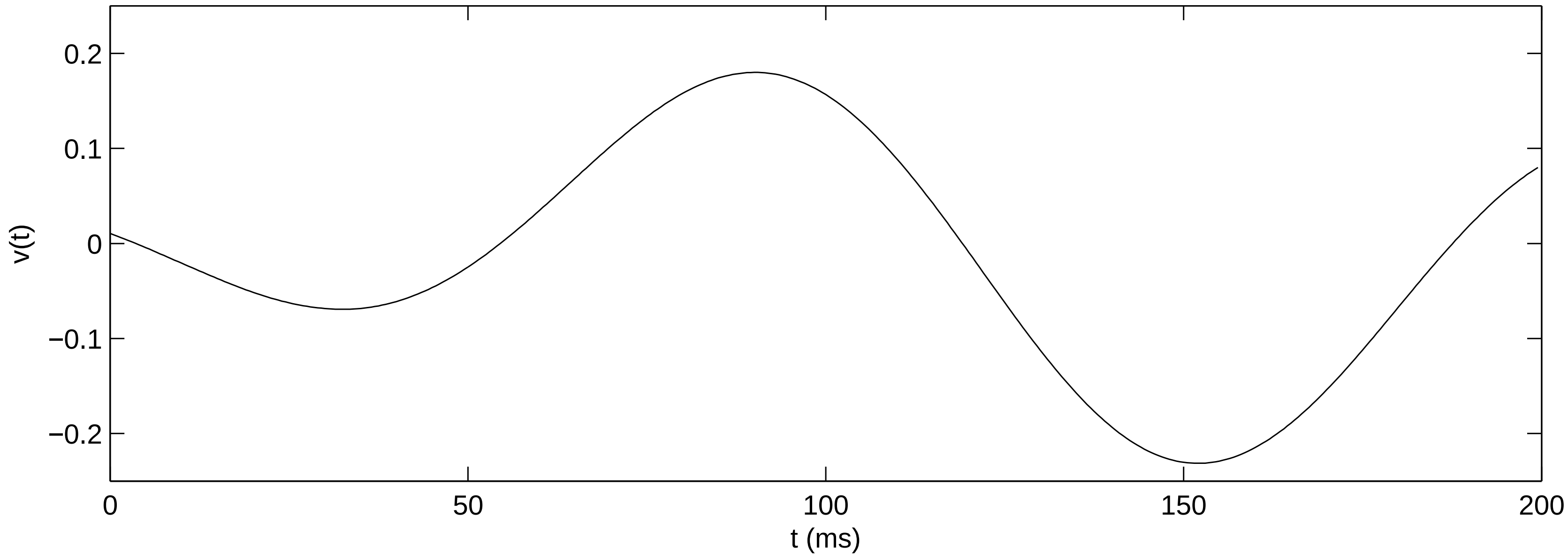


Figure 6.22 Common line codes.

- Line codes can be used to transmit a bit sequence. They combine data and timing information into a single signal. They may allow error detection, by having some illegal sequences (e.g. in the sign of bipolar signals).

Exercise



1. This analogue signal is already suitable for analogue baseband modulation. However, in order to use discrete baseband modulation, we need to sample it. Sketch the impulses that would be obtained if a sampling period of $T_s = 100$ ms was used. What is the problem here? Draw the corresponding sketch for a sampling frequency of $f_s = 40$ Hz. Is this okay? Given that the maximum frequency in this signal is $f_{max} = 10$ Hz, what is the lowest acceptable sampling frequency?

Exercise continued

2. Sketch PAM, PDM and PPM representations of the analogue signal for a sampling period of $T_s = 25$ ms.

3. In order to use digital baseband modulation, we need to quantise our sampled signal. Choose $N = 4$ appropriate quantisation levels and sketch the result of applying these to the signal after it has been sampled with a period of $T_s = 25$ ms.

4. Choose a mapping from quantisation levels to bits and convert your quantised signal into a bit sequence. What is the bit rate?

5. Sketch Non-Return to Zero (NRZ), Non-Return to Zero Mark (NRZ-M) and Manchester representations of your quantised signal, remembering to annotate the time axes.