

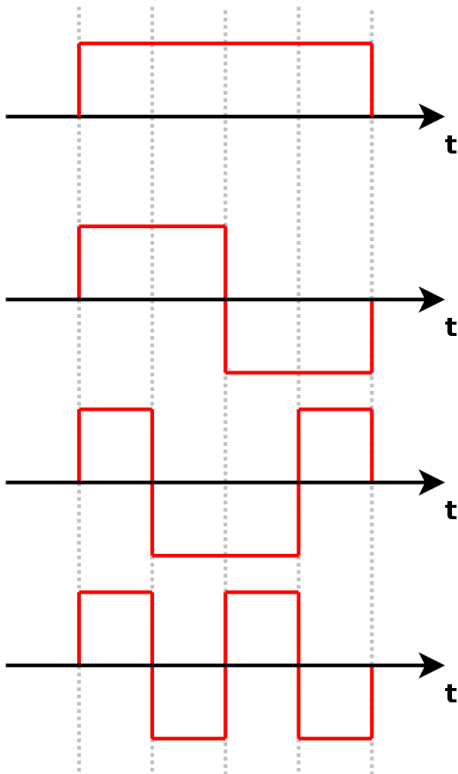
### 1. CDMA - Code division multiple access

Code division multiple access (CDMA) is a channel access method used by various radio communication technologies. CDMA is an example of multiple access, which is where several transmitters can send information simultaneously over a single communication channel. This allows several users to share a band of frequencies. To permit this without undue interference between the users, CDMA employs “spread-spectrum” technology and a special coding scheme (where each transmitter is assigned a code). These codes have special properties:

- Their auto-correlation with offset zero is very high and any other offset is very low.
- The cross-correlation between different codes is very low.

The signal to be transmitted is modulated by the CDMA code (we will cover modulation in detail later, but for now just think of the signal vector being point wise multiplied by the code vector). This modulation lets us differentiate different transmitters from each other and we will see exactly how this is done in this problem.

(a) Show that the “codes” represented by these signals are orthogonal.



(b) Sketch the auto-correlation of each code.

(c) Sketch the cross-correlation between any two pairs of codes.

(d) We now consider two senders and a single receiver. The senders want to talk at the same time.

- Sender 1 uses  $\mathbf{v}_1 = [1 \ -1]$  to represent a 1 and  $-\mathbf{v}_1 = [-1 \ 1]$  to represent a 0.
- Sender 2 uses  $\mathbf{v}_2 = [1 \ 1]$  to represent a 1 and  $-\mathbf{v}_2 = [-1 \ -1]$  to represent a 0.

If sender 1 has data  $[1 \ 0 \ 1 \ 0]$  and sender 2 has data  $[0 \ 1 \ 1 \ 1]$  to send, sketch the encoding process. What would be the raw signal received at the receiver (the signals add up since they were sent at the same time).

(e) If the above coding scheme was used by the senders (and they talked at the same time) and the received signal was  $[0 \ -2 \ -2 \ 0 \ 2 \ 0 \ 2 \ 0]$ , what were the two senders trying to send?

## **2. Applications of least-squares**

List some of the applications where least-squares curve fitting is used.