Multiple Access Techniques

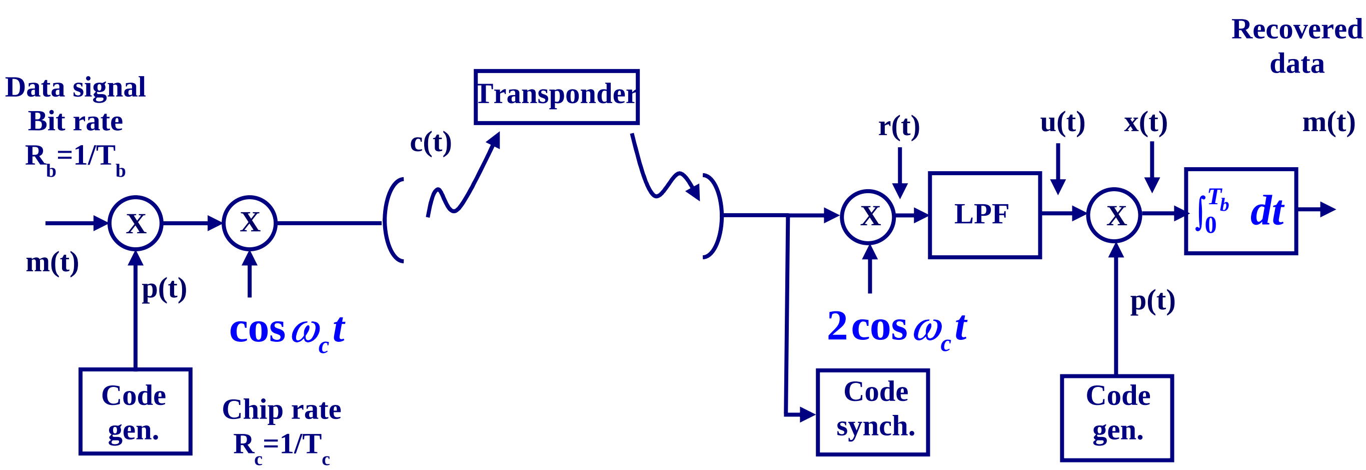
Code Division Multiple Access (CDMA)

- Earth stations transmit continuously and together on the same frequency band.
- Interference exists between the different earth stations. However, this interference is resolved at the receiver, by identifying the signature of each transmitter.
- This signature is a binary sequence called "code". These codes must have the following properties:
  - ⇒ Each code must be easily distinguishable from a replica of itself shifted in time.
  - ⇒ Each code must be easily distinguishable regardless of the other codes used by the network.
- CDMA depends on the availability of greater bandwidth than required to transmit the information alone.
  - ⇒ This is the reason for calling it SPREAD SPECTRUM.

There are two techniques used in CDMA:

1. Direct sequence,
2. Frequency hopping.

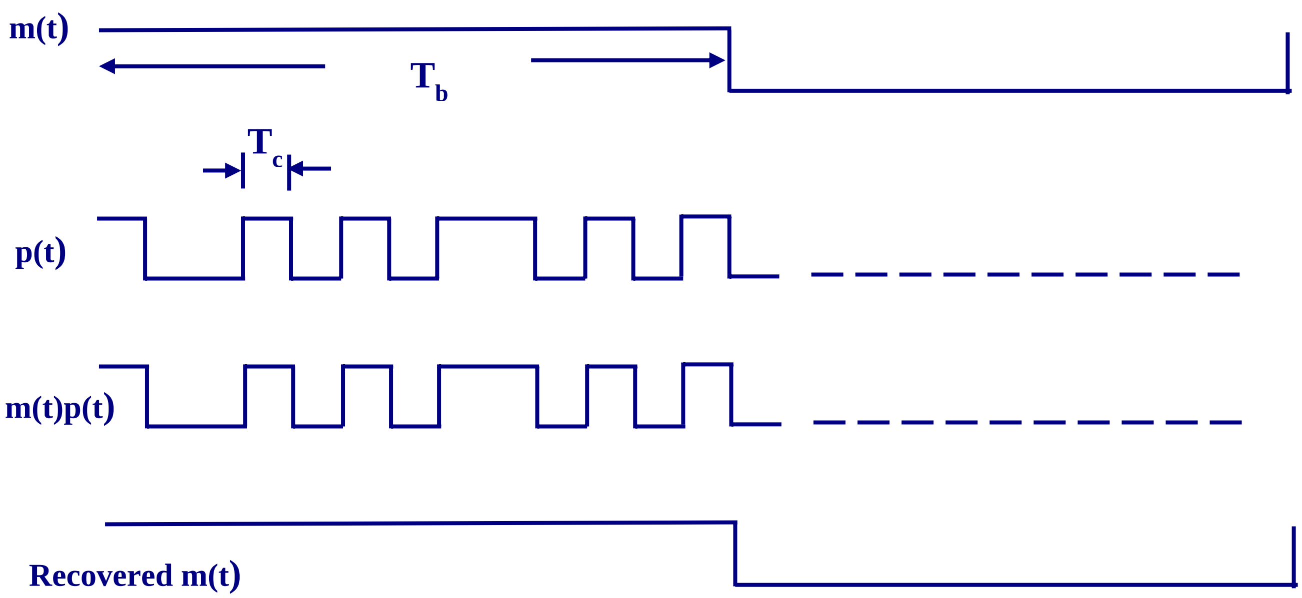
1. Direct Sequence (DS – CDMA):



m(t) has bit rate $R_b = \dfrac{1}{T_b}$ "NRZ" $\rightarrow$ m(t) = ± 1

p(t) has bit rate $R_c = \dfrac{1}{T_c} \gg R_b \quad e.g.\ 10^3 \text{ to } 10^6 \text{ times}$

The binary element of p(t) is called a chip.



$$c(t) = m(t)\, p(t) \cos \omega_c t$$

at the receiver:

$$r(t) = m(t)\, p(t) \cos \omega_c t\, (2 \cos \omega_c t)$$
$$= m(t)\, p(t) + m(t)\, p(t) \cos 2\omega_c t$$

$$u(t) = m(t)\, p(t)$$

and

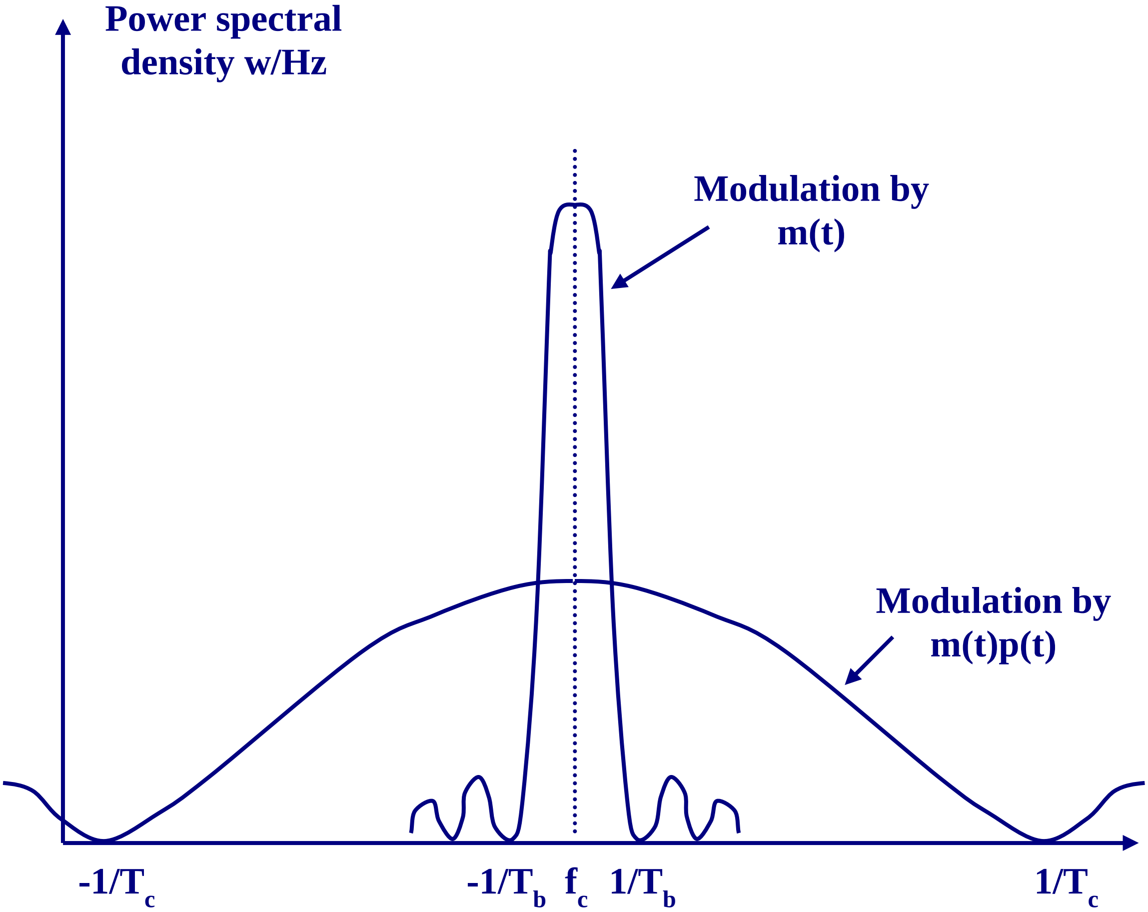
$$x(t) = m(t)\, p^2(t) = m(t)$$

Since $\quad p(t) = \pm 1 \;\rightarrow\; p^2(t) = 1$

Spectral Occupation:

The spectrum of the carrier c(t), of power C and frequency fc is given by:

$$P(f)=\frac{C}{R_c}\left\{\frac{\sin(\pi(f-f_c)T_c)}{\pi(f-f_c)T_c}\right\}^2 \quad w/Hz$$



Spectrum is broadened by the spreading ratio R_c/R_b. This is the result of combining the message with the chip sequence.

Realization of Multiple Access:

Received signal at the earth station is the wanted carrier together with all other carriers ci(t) of the (N-1) other users (i= 1, 2, ….. (N-1))

$$\therefore r(t) = c(t) + \sum c_i(t)$$

where $c(t) = m(t)\,p(t)\cos\omega_c t$

and $\sum c_i(t) = \sum m_i(t)\,p_i(t)\cos\omega_c t$

$$\begin{aligned}\therefore x(t) &= m(t)\,p^2(t) + \sum m_i(t)\,p_i(t)\,p(t)\\ &= m(t) + \sum m_i(t)\,p_i(t)\,p(t)\end{aligned}$$

If the codes have low cross-correlation function, then the second term (which is like noise) will be very small and can be neglected.

Example:

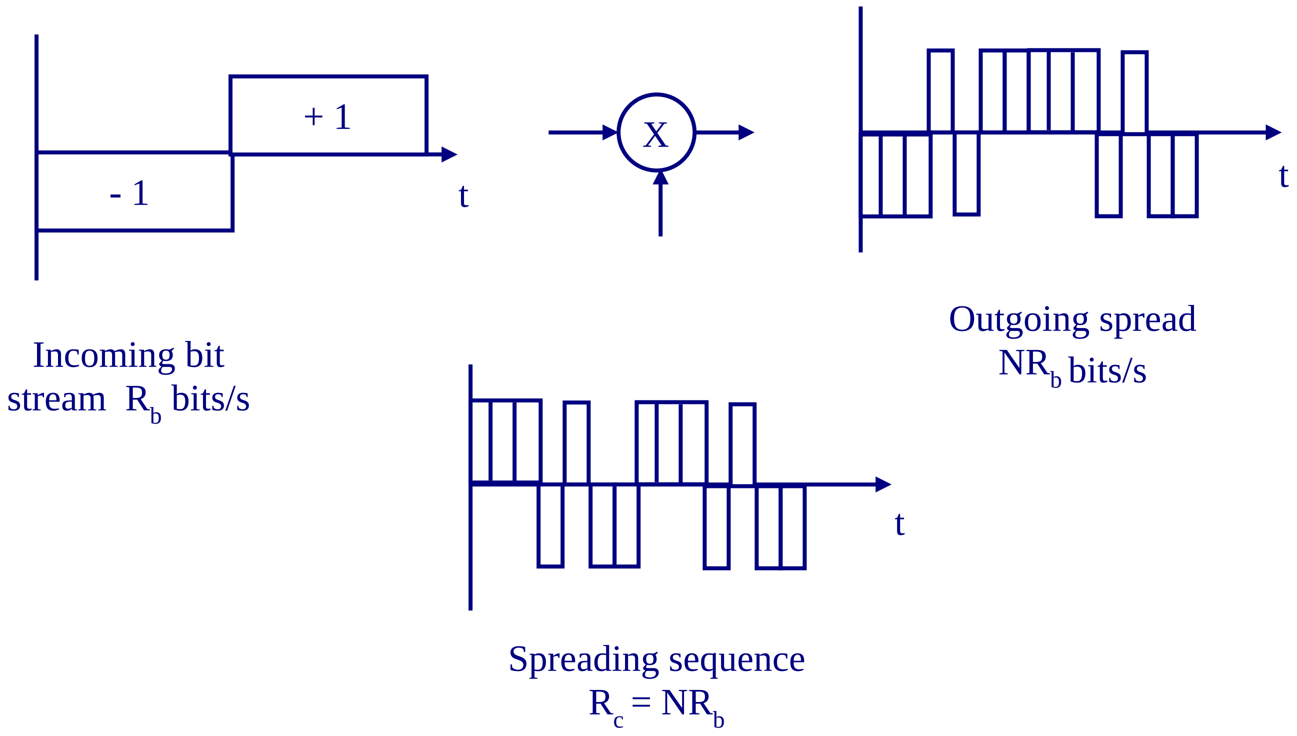
PN sequence +1, +1, +1, -1, +1, -1, -1 is used to spread the incoming bits -1 and +1.

∴ +1 in the original bit stream would be transmitted by the chip stream:

+1, +1, +1, -1, +1, -1, -1

and -1 in the original stream is transmitted by the chip stream:

-1, -1, -1, +1, -1, +1, +1



The original bit stream can be recovered at the receiver if we multiply the received stream by a synchronized copy of the PN (Pseudo-random) sequence, which was used at the transmitter.