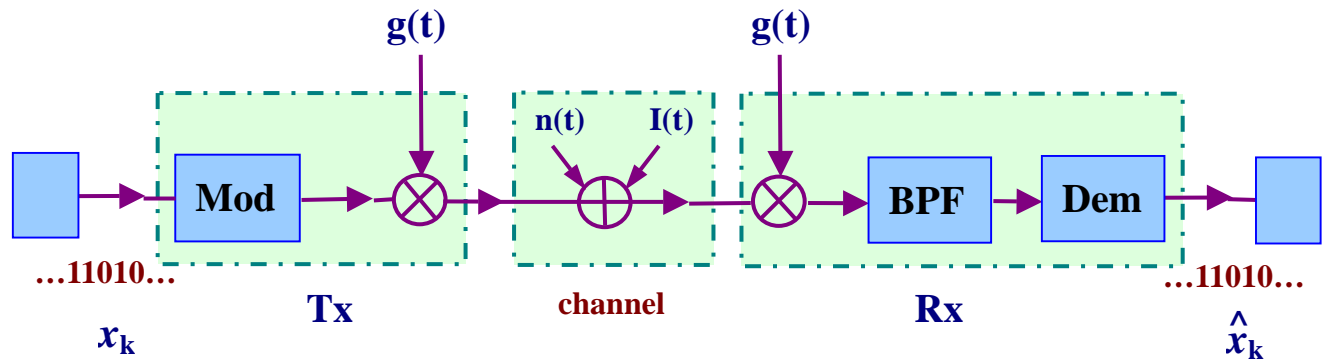


4.3 Code-Division Multiple Access (CDMA) and Spread Spectrum Modulation

Spread Spectrum Concept



- **Transmitter**

Mod : a narrowband modulation

e.g. BPSK, FSK, etc.

$g(t)$: spreading function defined by a code

- **Receiver**

$g(t)$: despreading function exactly the same as used in transmitter

$$[g(t)]^2 = 1$$

BPF : bandpass filter

Dem : demodulator

- **Channel**

$n(t)$: noise

$I(t)$: interference

Spread Spectrum Concept

· **Multiple Access**

- many different signals sharing the same frequency spectrum by different codes in the spreading function

$(x_k)^{(i)}$ spread by $g_i(t)$

$(x_k)^{(j)}$ spread by $g_j(t)$

$g_i(t)g_j(t) \approx 0$ if $i \neq j$

$[g_j(t)]^2 = 1$

- code division multiple access (CDMA)
- low interference among many signals

· **Other Features**

- Secrecy

without the right despreading code, the received signal behaves like white noise

it is even difficult to detect whether communications are taking place

- Interference Rejection

Interference is spread at receiver

$g(t)$ serves as a spreading function in general, except $[g(t)]^2 = 1$

- Low Interference to other narrowband signals behaves like white noise

Direct Sequence (DS) (with BPSK)

$g(t)$: random binary square wave defined by a PN code

$$g(t) = \pm 1$$

Mod : BPSK

Carrier modulated by ± 1 defined by the data code rate of $g(t)$ much higher than data rate, $T_c \ll T_b$

See Fig. 7.6, 7.8, 7.9, p. 489, 492 of Haykin

· PN (Pseudo-Noise) Code

- periodic but noise-like sequence generated by a feedback shift register defined by a Boolean function

See Fig. 7.1, p. 480 of Haykin

- Maximum-length sequence

$$M = 2^m - 1$$

M : period of the code

m : length of shift register

found by selection among the Boolean functions

See examples on Table 7.1, Fig. 7.4, Table 7.2, pp. 484~487 of Haykin

Direct Sequence (DS) (with BPSK)

· Pseudo-Random Properties of PN codes (Maximum-length Sequences)

- in each period number of 1's is one more than number of 0's
- in each period, one half of the runs are of length 1, one-fourth of length 2, one-eighth of length 3, etc., as long as these fractions represent meaningful numbers

Frequency-Hopping (with M-ary FSK) (FH/MFSK)

- spreading sequentially rather than instantaneously
- the carrier frequency hops from one frequency to the other according to a PN code
- slow FH : symbol rate R_s is an integer multiple of hopping rate R_h
- fast FH : hopping rate R_h is an integer multiple of symbol rate R_s

See Fig. 7.11, 7.12, pp. 503, 504 of Haykin

Ref : 7.2, 7.3, 7.4, 7.7 of Haykin