# Digital Communication 23EC2208A

## Spread-Spectrum Communications

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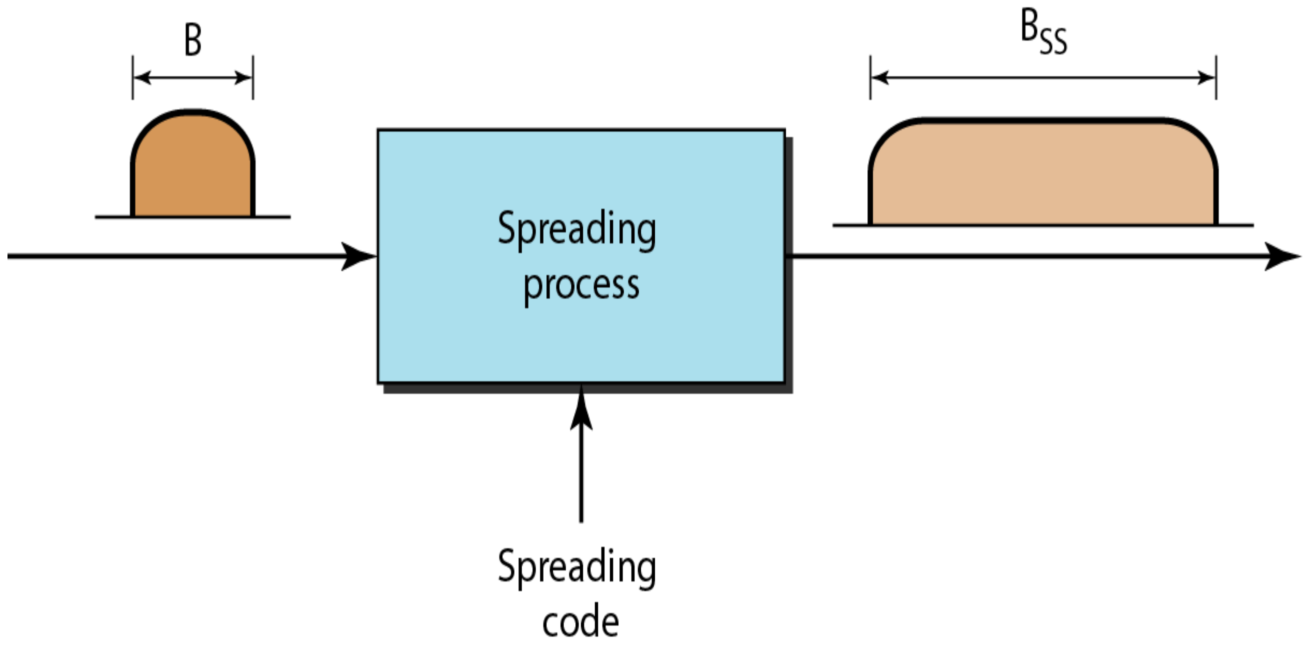
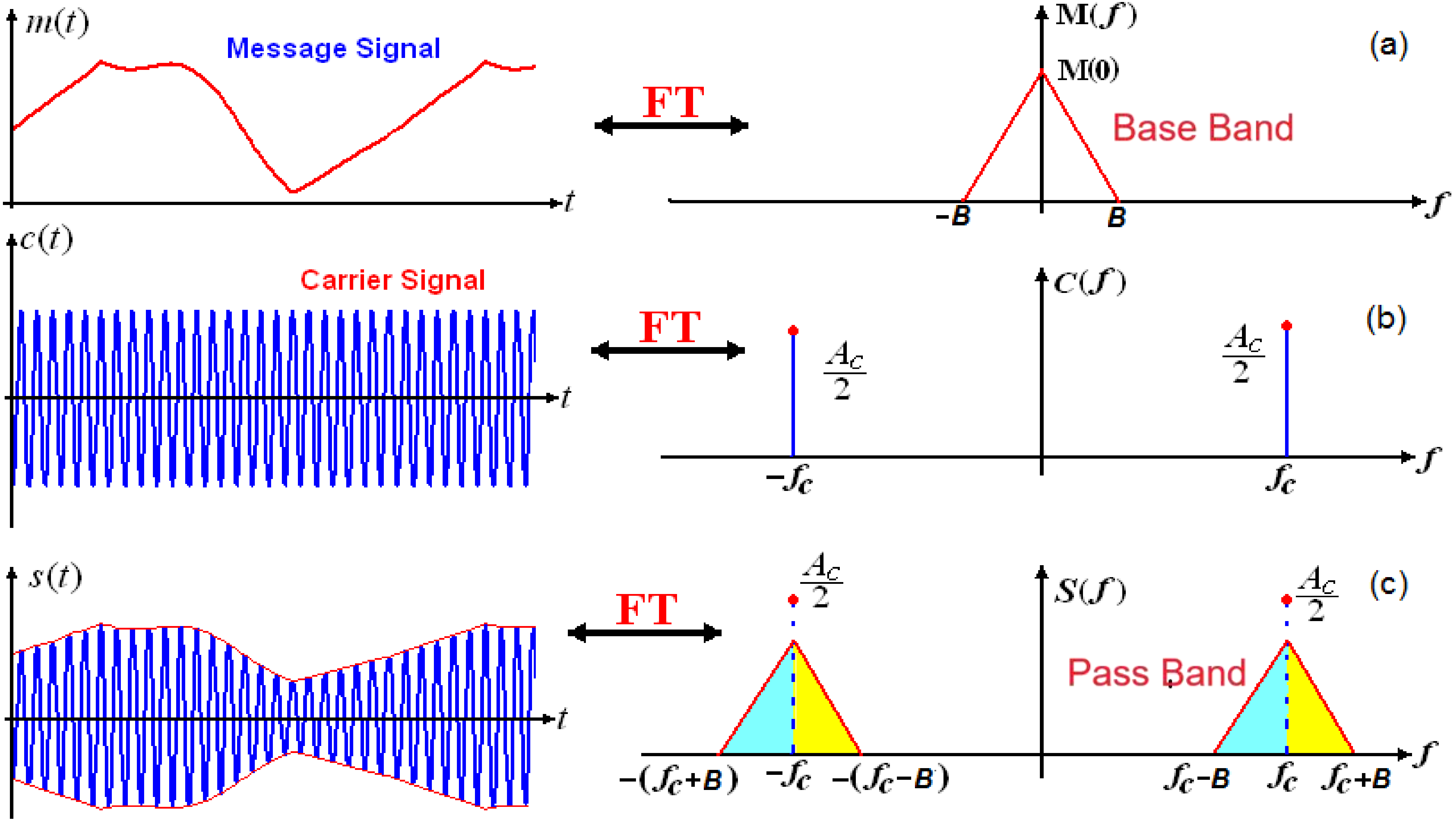
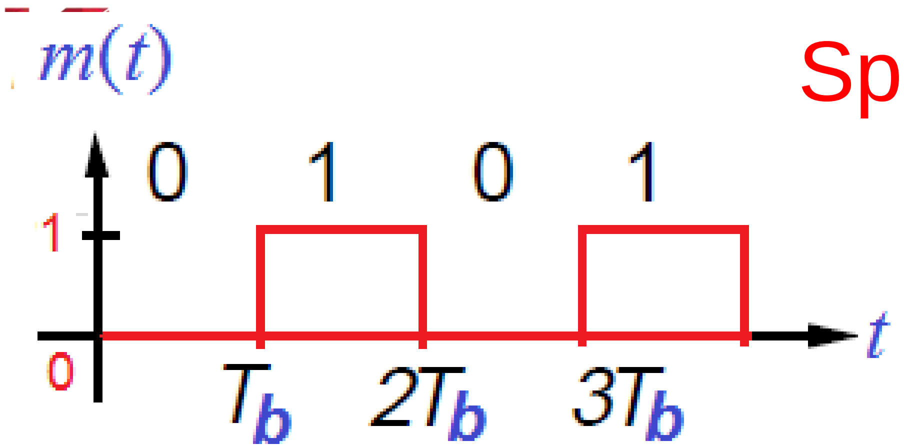
# (Wide band) Spread-Spectrum Communications





m(t)
Message Signal
t
FT
M(f)
M(0)
(a)
Base Band
-B
B
f
c(t)
Carrier Signal
t
FT
C(f)
(b)
$\frac{A_c}{2}$
$\frac{A_c}{2}$
$-f_c$
$f_c$
f
s(t)
t
FT
$\frac{A_c}{2}$
S(f)
$\frac{A_c}{2}$
(c)
Pass Band
$-(f_c+B)$
$-f_c$
$-(f_c-B)$
$f_c-B$
$f_c$
$f_c+B$
f

# Spectrum of ASK

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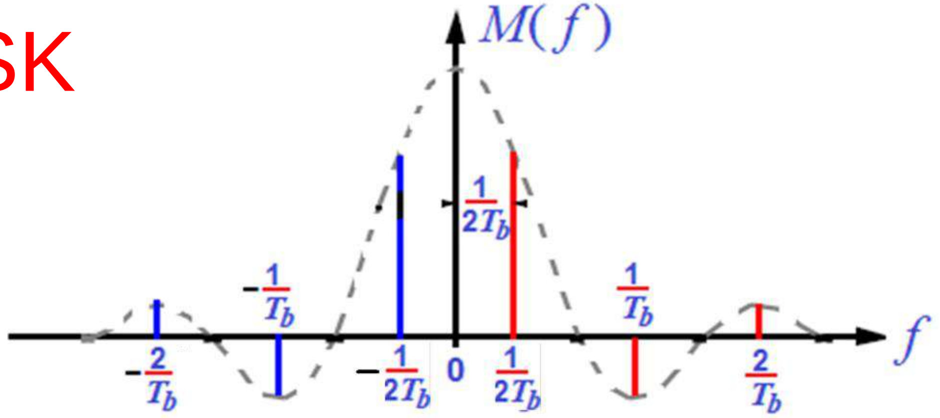


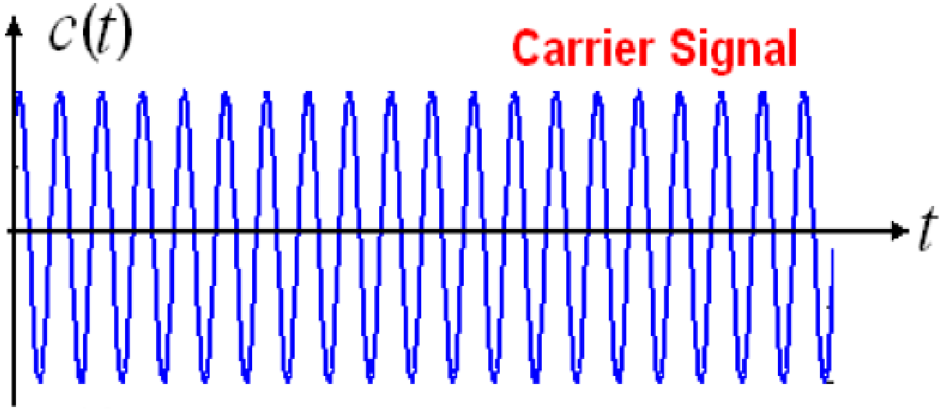


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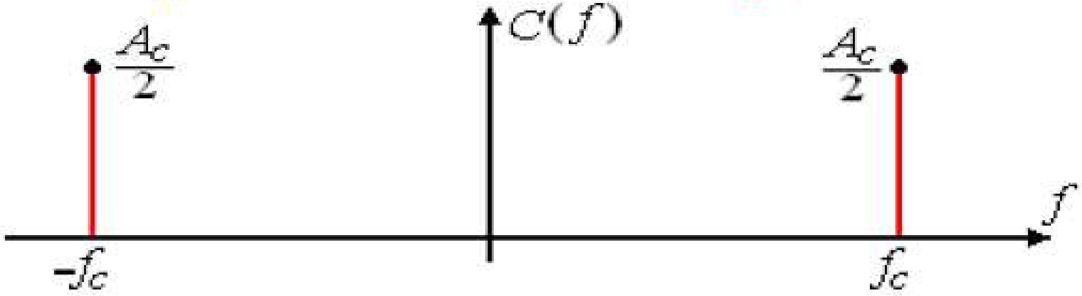
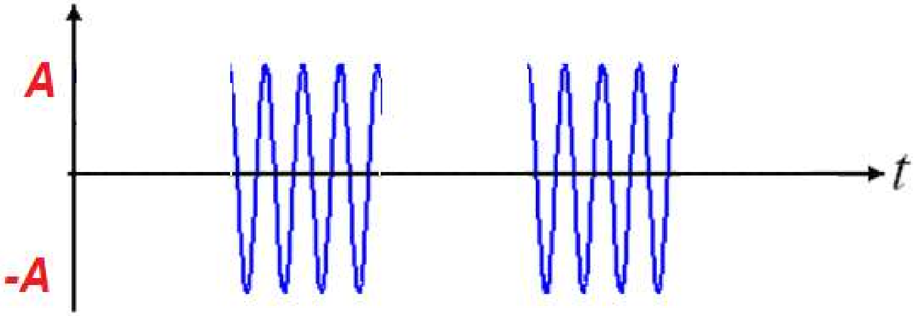
**Spectrum of Carrier Signal**




$$s(t) = A_c\, m(t) \cos 2\pi f_c t, \qquad 0 \le t \le T_b$$

$$S(f) = \frac{A_c}{2} M(f+f_c) + \frac{A_c}{2} M(f-f_c)$$

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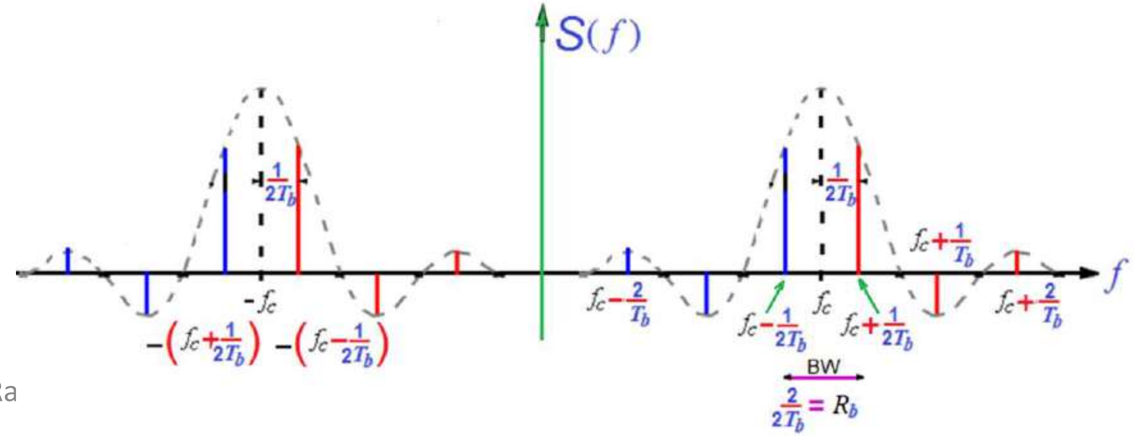
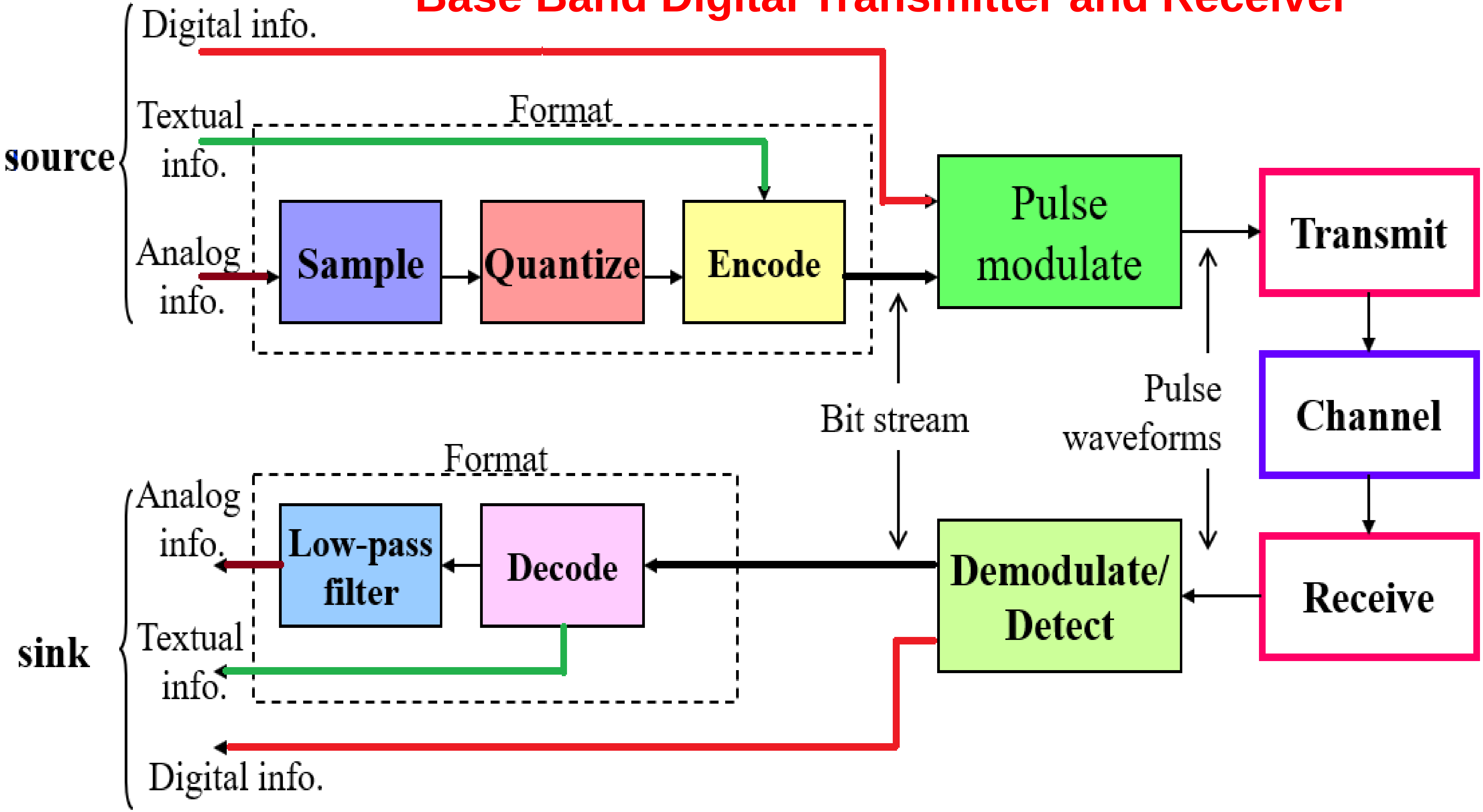
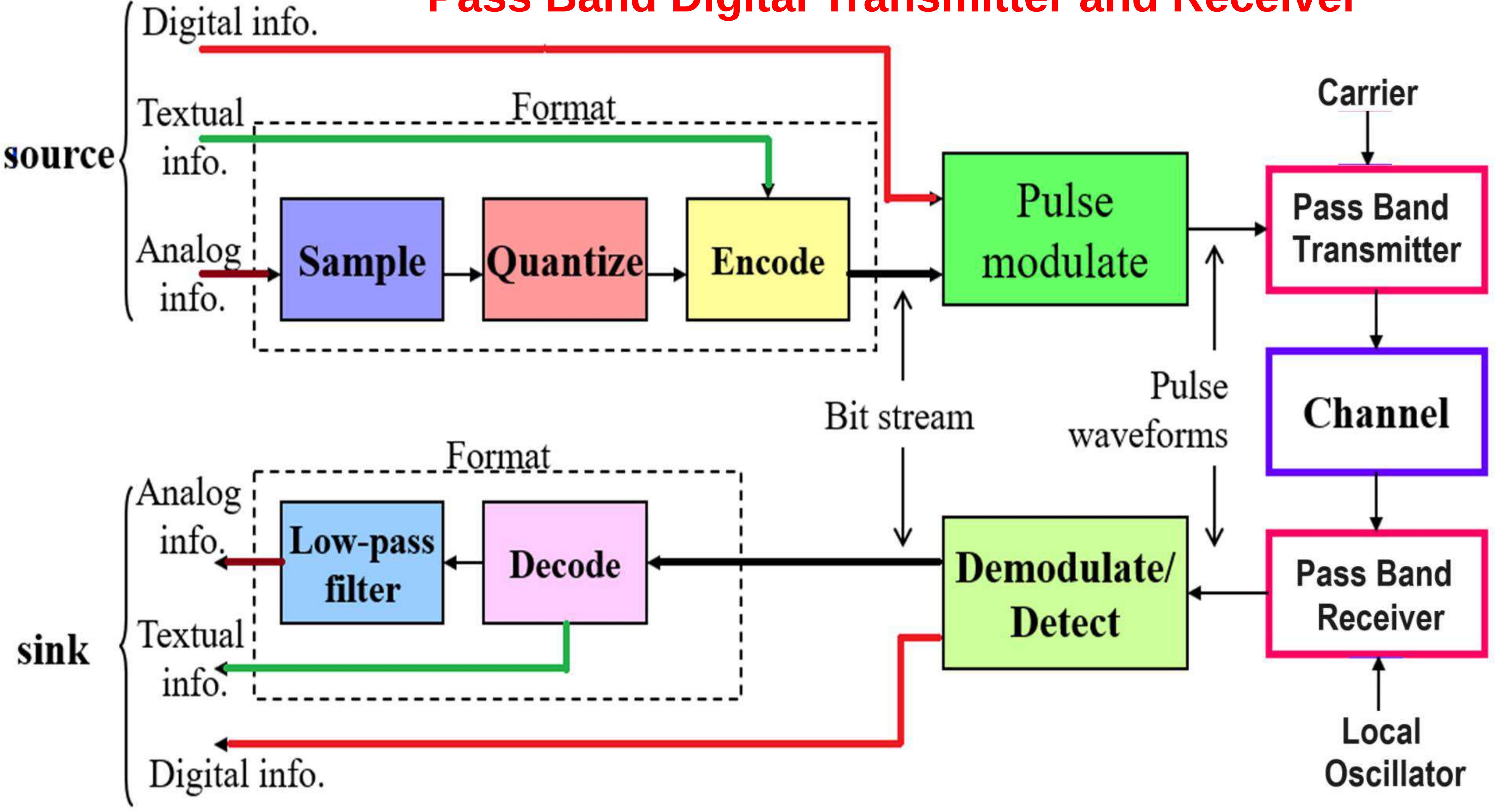


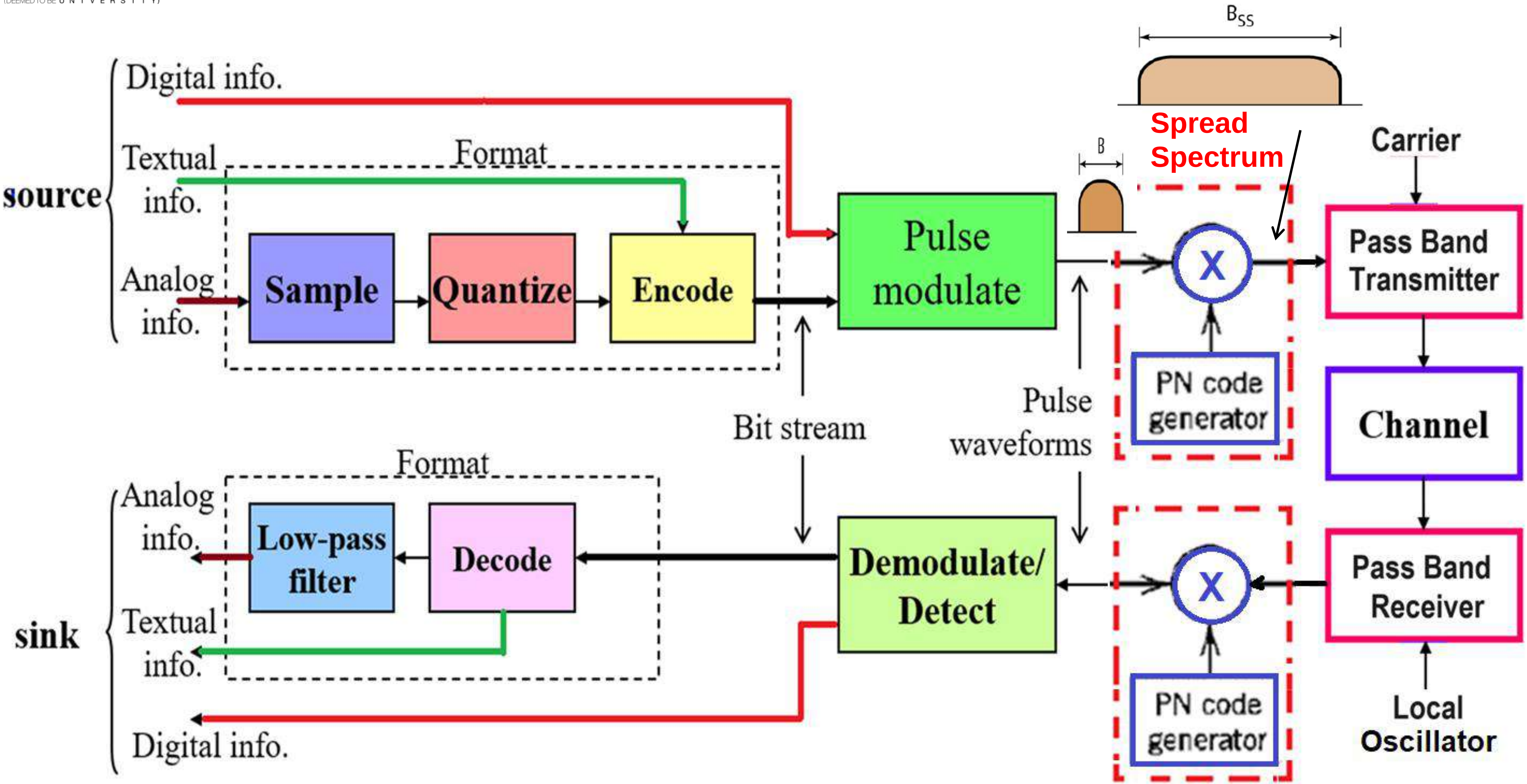
# Base Band Digital Transmitter and Receiver



# Pass Band Digital Transmitter and Receiver



# Spread Spectrum(Wide Band) Transmitter and Receiver



# Introduction

In traditional digital communication systems, the design of baseband pulse-shaping and modulation techniques aim to minimize the amount of bandwidth consumed by the modulated signal during transmission.

This principal objective is clearly motivated by the desire to achieve high spectral efficiency and thus to conserve bandwidth resource.

However, a narrowband digital communication system exhibits two major weaknesses.

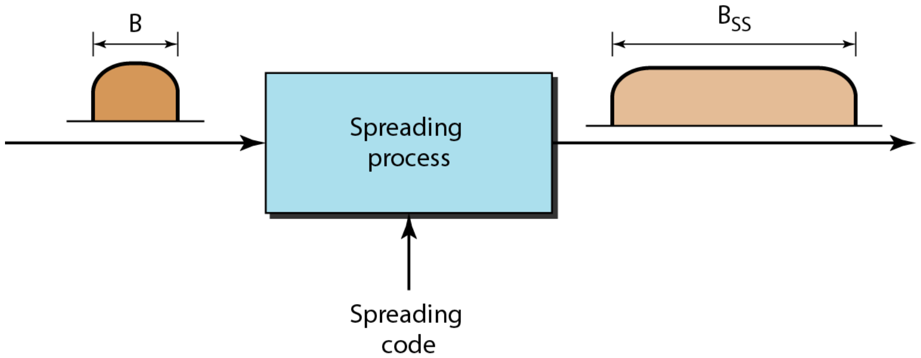
- First, its concentrated spectrum makes it an easy target for detection and interception by unintended users (e.g., battlefield enemies and unauthorized eavesdroppers).(Interception: unauthorizedly capturing or monitoring the transmitted signal).
- Second, its narrow band, having very little redundancy, is more vulnerable to jamming, since even a partial band jamming can jeopardize the signal reception.

(Jamming means deliberate interference intended)

No secure communication.

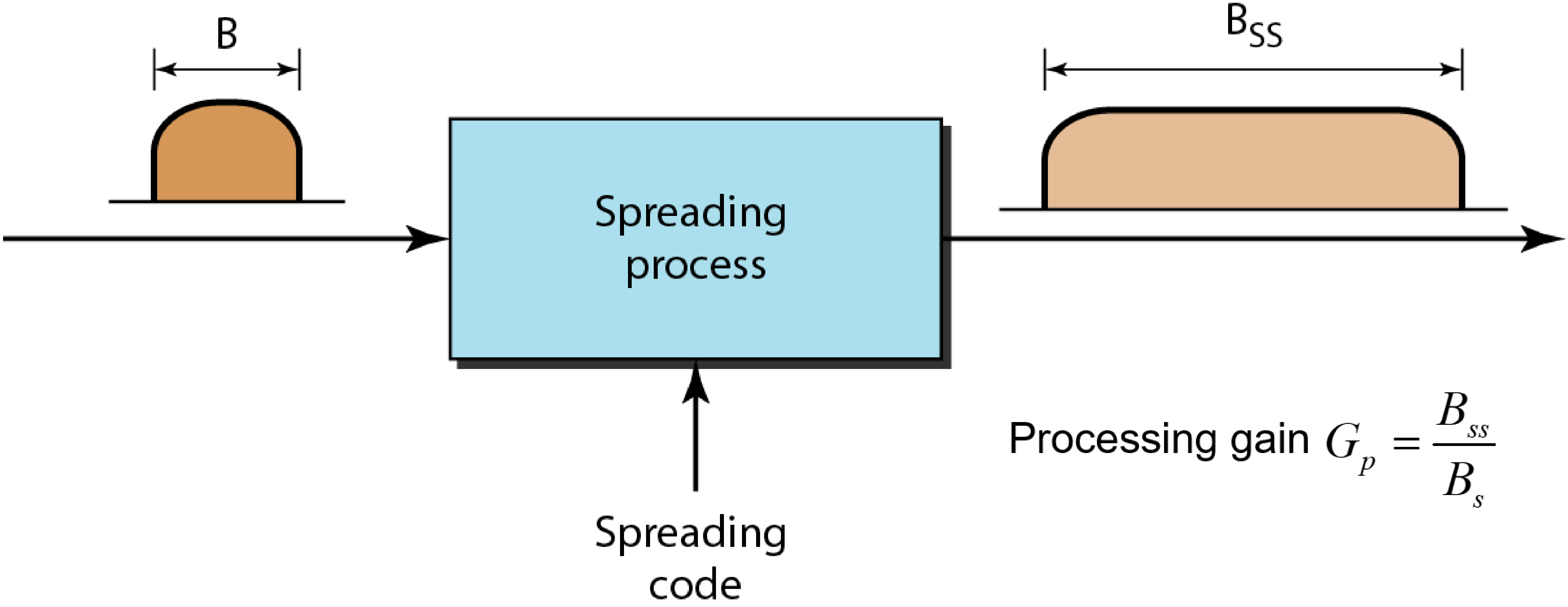
Spread spectrum technologies were initially developed for the military and intelligence communities to overcome the two afore mentioned short comings against interception and jamming.

The basic idea was to expand each user signal to occupy a much broader spectrum than necessary. For fixed transmission power, a broader spectrum means both lower signal power level and higher spectral redundancy.




- The low signal power level makes the communication signals difficult to detect and intercept,
- whereas high spectral redundancy makes the signals more resilient against partial band jamming and interference, whether intentional or unintentional.

# Spreading the input data




Processing gain $G_p = \frac{B_{ss}}{B_s}$

(DEEMED TO BE UNIVERSITY)

## There are many application fields for spreading the spectrum:

- Antijamming,
- Interference rejection,
- Low probability of intercept,
- Multiple access, Multipath reception,
- mobile communications (CDMA)
- Diversity reception,
- High resolution ranging,
- Accurate universal timing

## Advantages of Spread Spectrum:

- Increased tolerance to interferences.
- Low probability of detection and interception.
- Increased tolerance to multipath.
- Increased ranging capabilities.

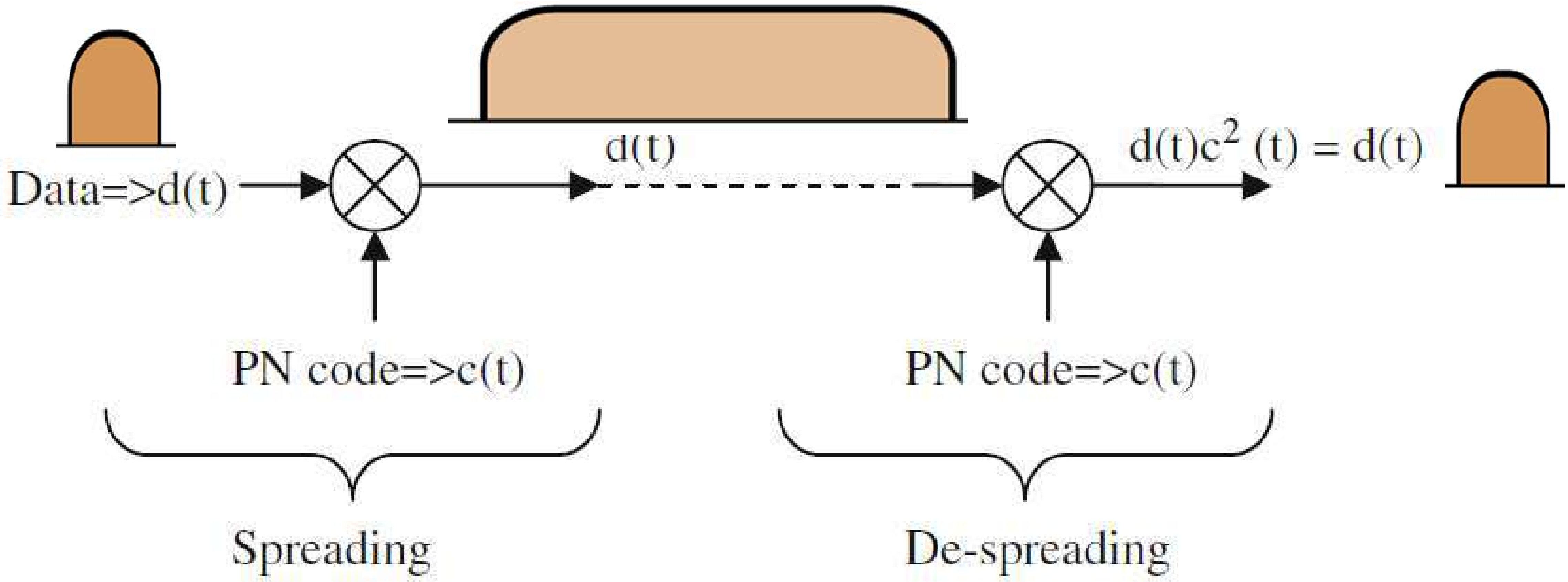
# Types of Spread Spectrum

- Direct Sequence Spread Spectrum (DSSS)
  - DSSS with Base Band data
  - DSSS with Coherent BPSK

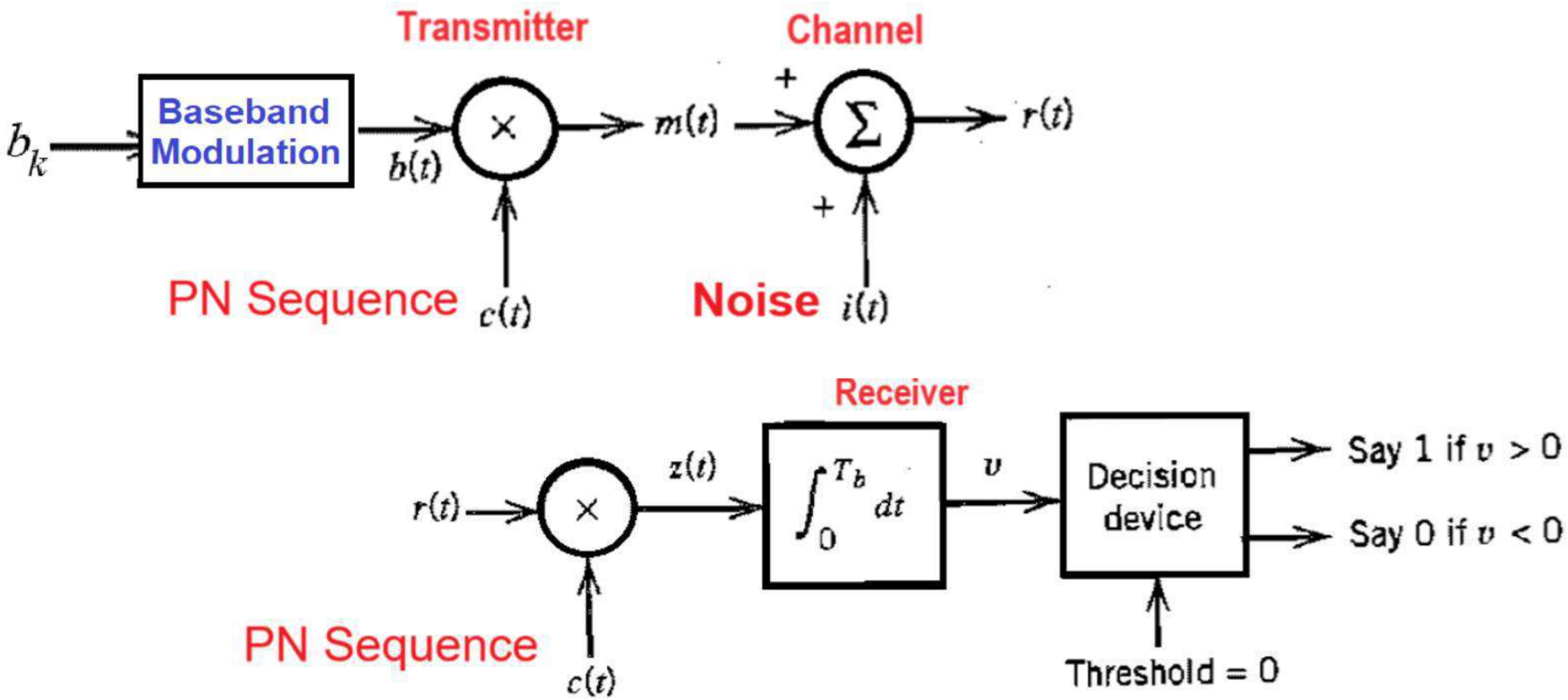
- Frequency Hope Spread Spectrum (FHSS)

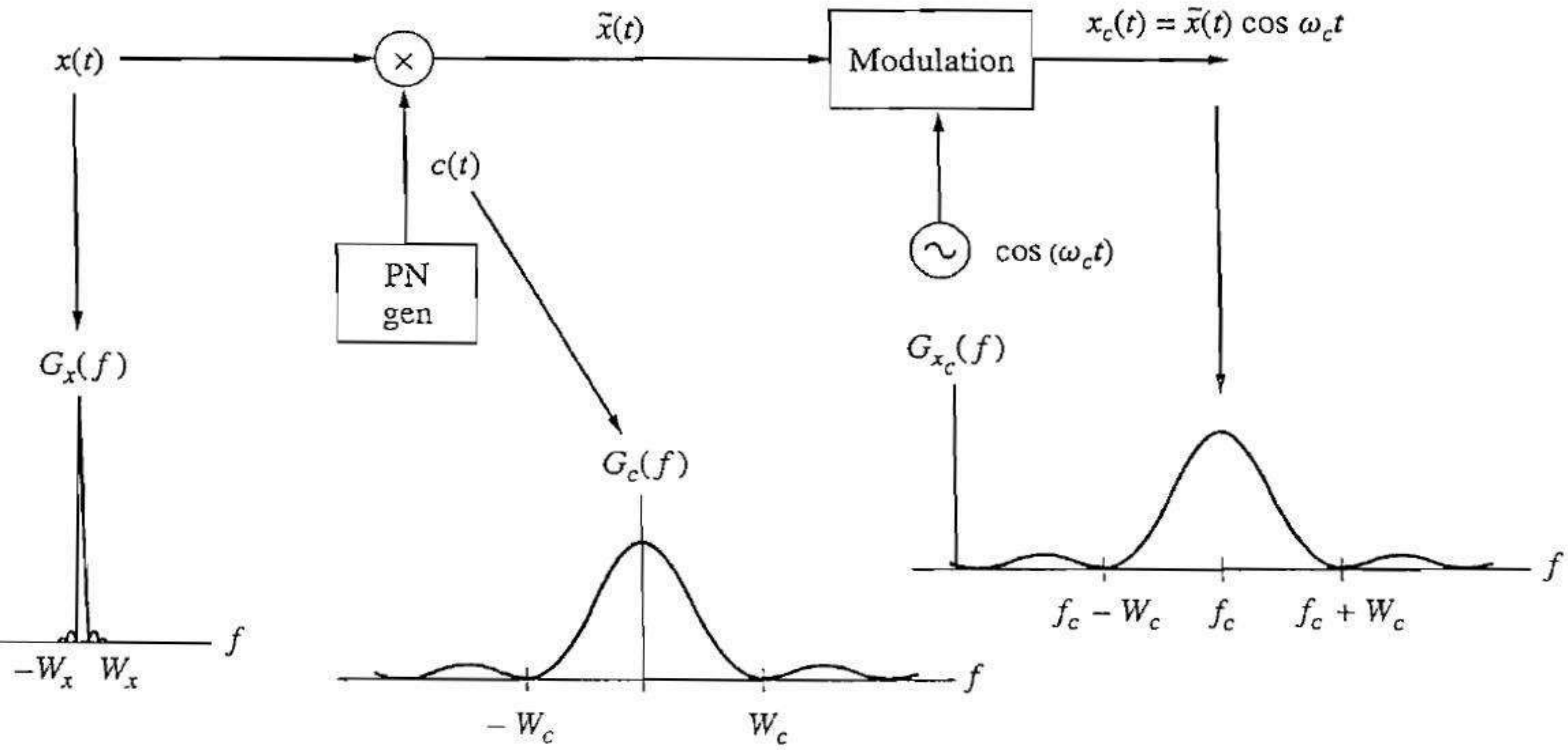
# Direct Sequence Spread Spectrum with Base-Band Data

# Direct Sequence Spread Spectrum



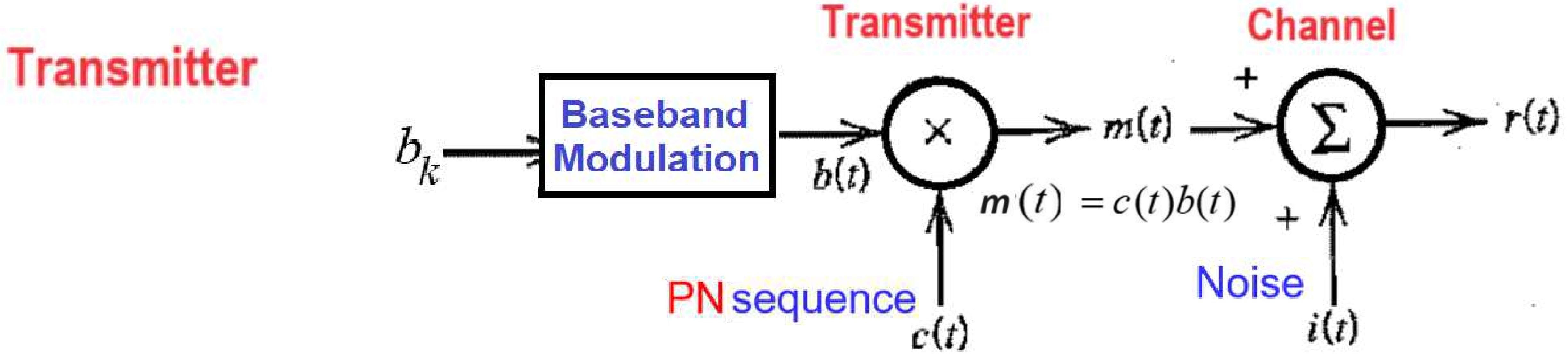
# Idealized model of Baseband Spread Spectrum Communication System






DSS transmitter system and spectra.

# Idealized model of Baseband Spread Spectrum Communication System

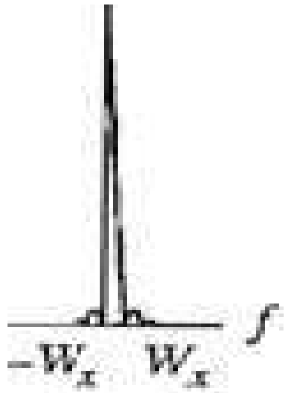



Let $b(t)$ and $c(t)$ denote their respective Polar NRZ representations in amplitude $\pm 1$. we will refer $b(t)$ as an information bearing signal and $c(t)$ as a PN signal.

$$m(t) = c(t)b(t)$$

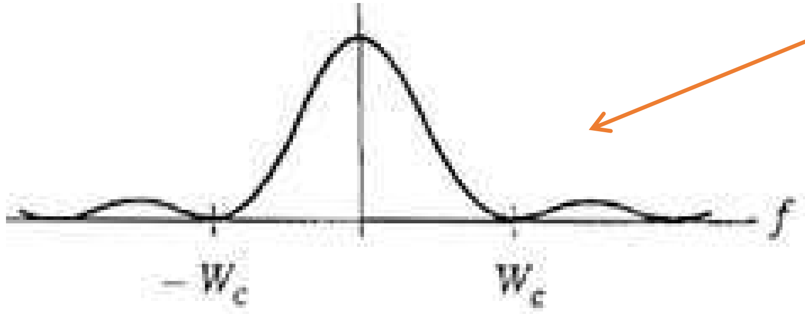
$$r(t) = c(t)b(t) + i(t)$$

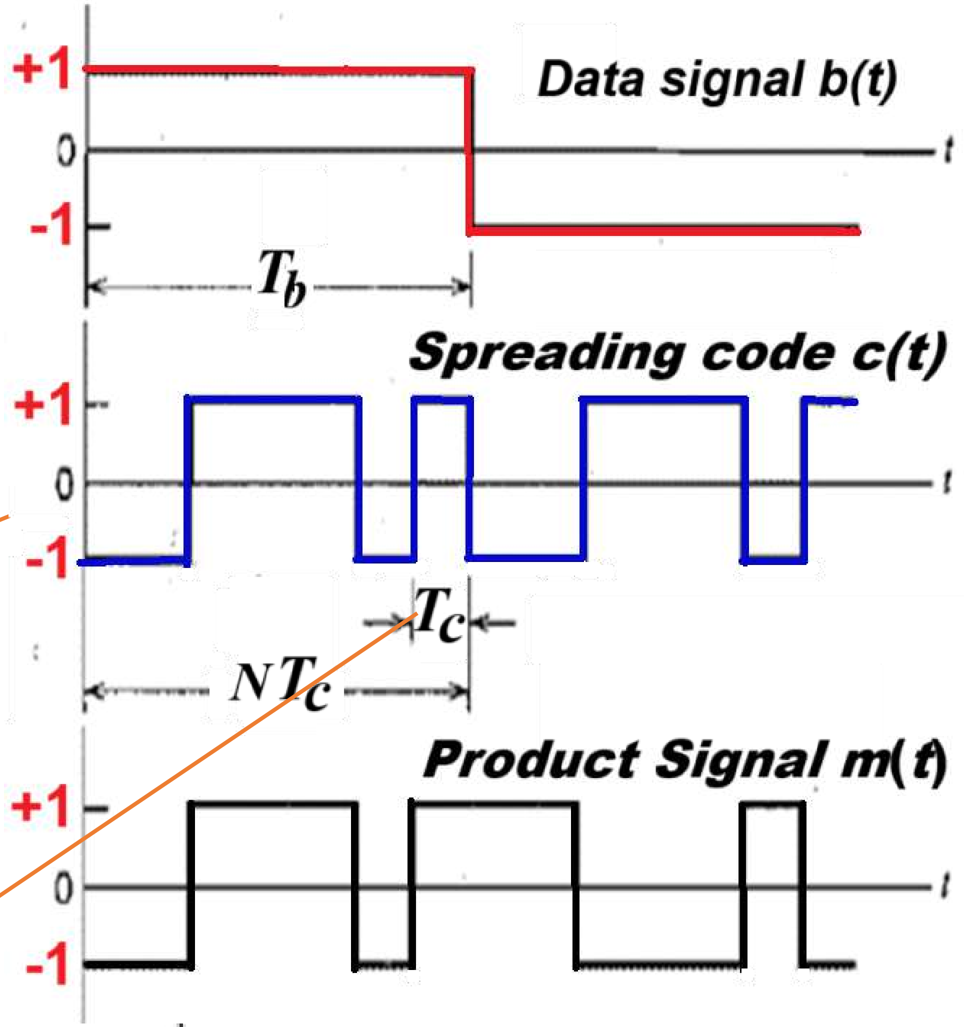
The output of the product modulator is represented by $m(t) = c(t)b(t)$ as illustrated below.



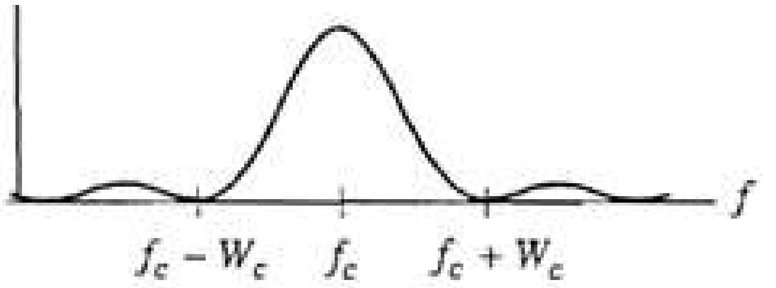

message signal $b(t)$ is narrowband

PN signal $c(t)$ is wideband




By multiplying the information bearing signal $b(t)$ and by the PN signal $c(t)$, each information bit is 'chopped' up into a small time increments is commonly referred to as 'chips'.

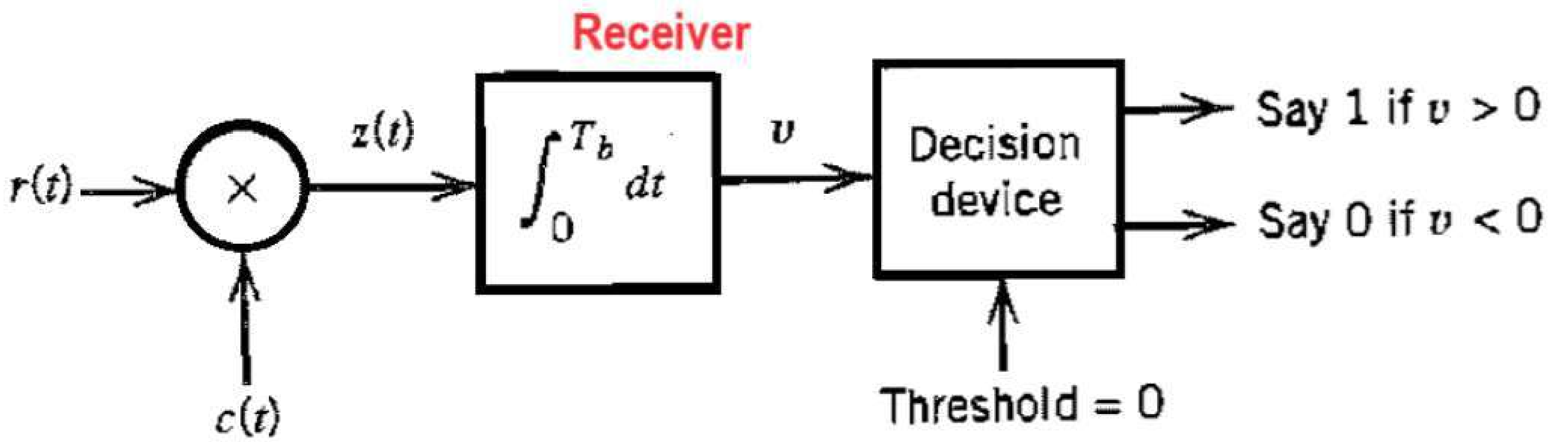


To recover the message signal $b(t)$, the received signal $r(t)$ is applied to a demodulator that consists of a multiplier followed by an integrator and a decision device.

The multiplier output is represented by

$$z(t) = c(t)r(t)$$

$$= c^2(t)b(t) + c(t)i(t)$$



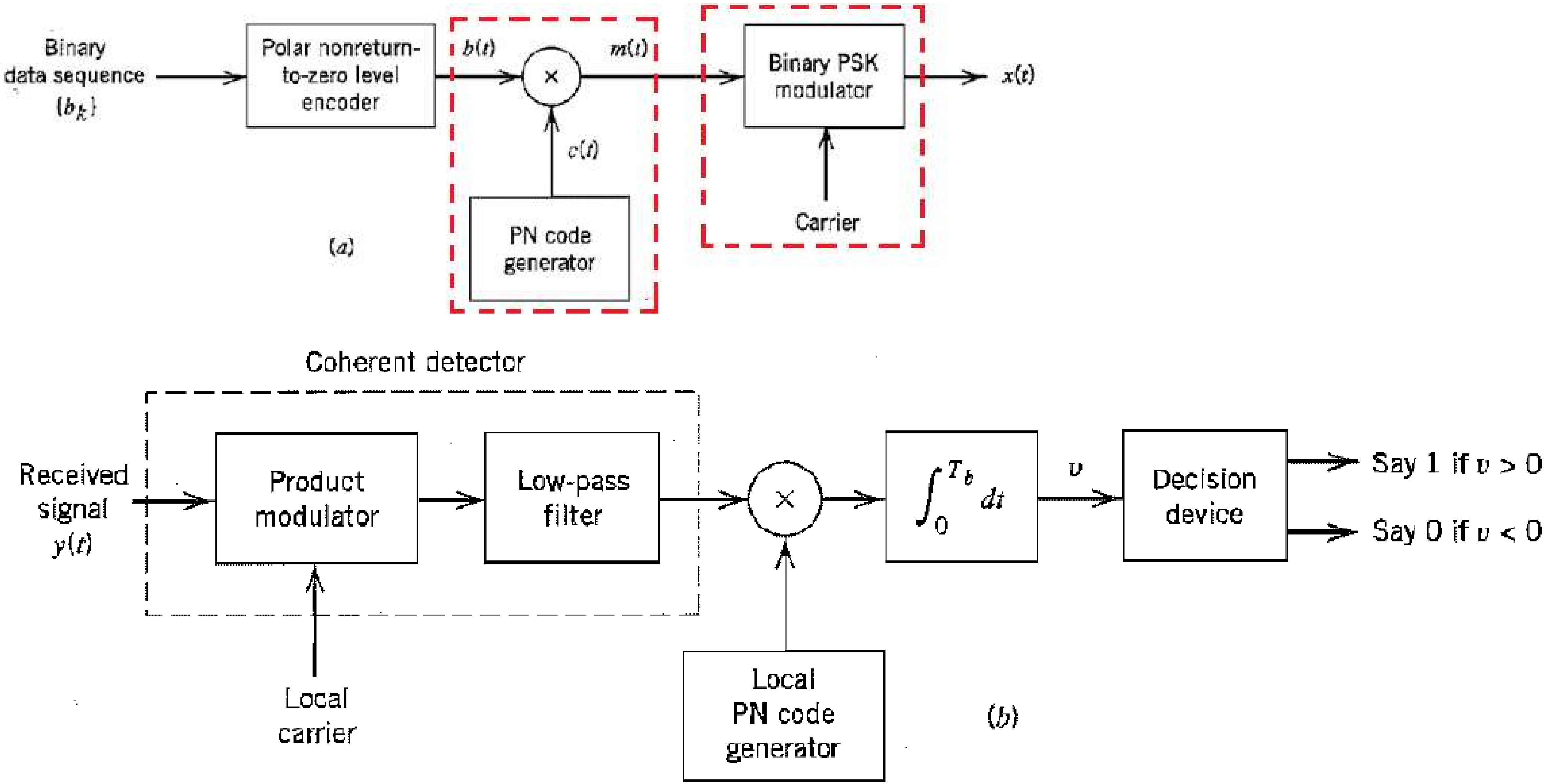

The PN signal $c(t)$ alternates between 1 and -1 and the alternation destroyed when it is squared, i. e., $c^2(t) = 1$, for all '$t$'.

Accordingly, $z(t) = b(t) + c(t)i(t)$.

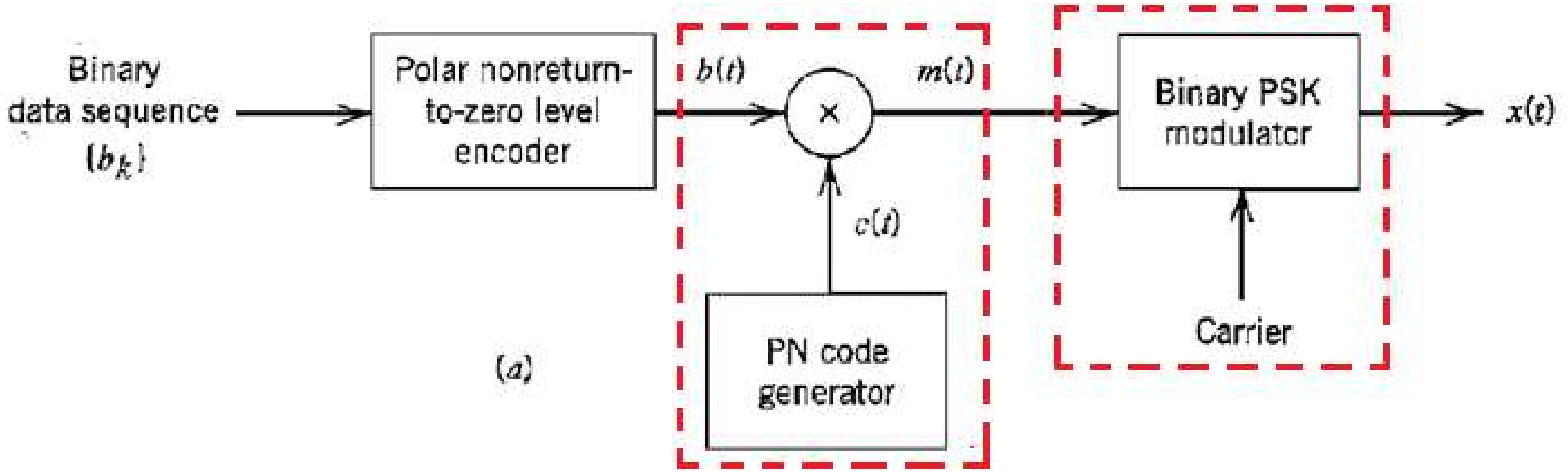
The first term is is the desired signal and the second term is inteference signal can be suppressed by using an integrator (LPF). Finally the decsion made by the decision device with a threshold to get the desired binay data.

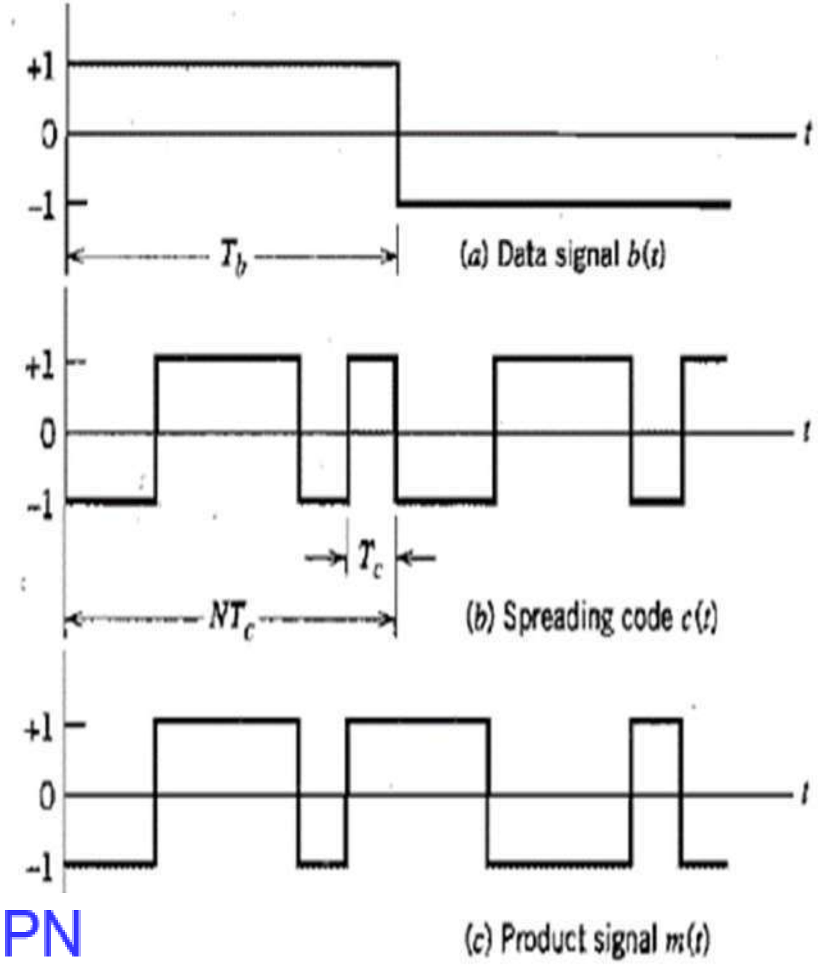
# Direct Sequence Spread Spectrum with Coherent BPSK

# Direct Sequence Spread Spectrum with Coherent BPSK



# DSSS with Coherent BPSK




- Binary data sequence $b_k$ is converted into polar NRZ waveform $b(t)$.
- Two stages of Modulation:

Stage1: Product modulator or multiplier with data signal b(t) and PN sequence $c(t)$ as Inputs resulting $m(t)$ referred to as spreaded signal

Stage2: The second stage consists of BPSK modulator.

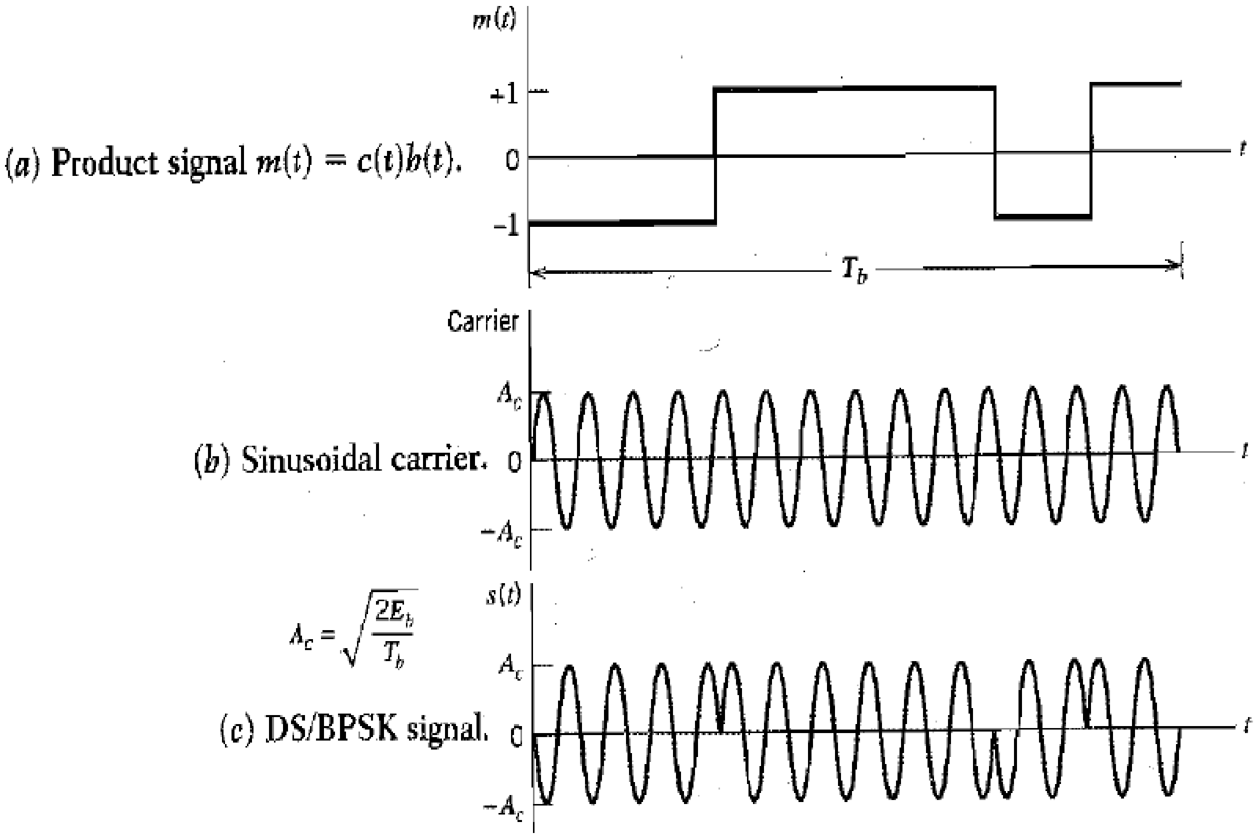
**Stage2**: The second stage consists of BPSK modulator.

- The transmitted signal $x(t)$ is referred to as direct sequence spread binary phase shift keying (DS/BPSK).

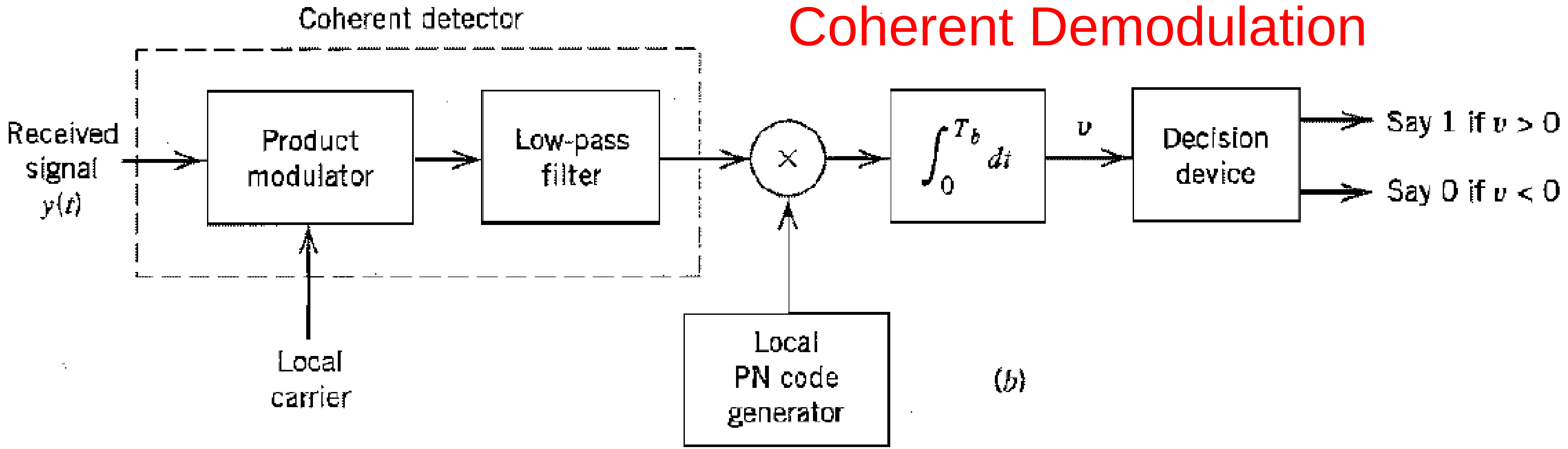
The phase modulation $\theta(t)$ of $x(t)$ has one of two values '0' and '$\pi$', depending upon the polarity of message signal $b(t)$ and PN sequence at time '' in accordance with the truth table given below.

**Truth table for phase modulation $\theta(t)$ radians**

| | | Polarity of Data Sequence b(t) at Time t | |
|---|---|---|---|
| | | + | − |
| Polarity of PN sequence c(t) at time t | + | 0 | $\pi$ |
| | − | $\pi$ | 0 |



# Coherent Demodulation




Two stages of demodulation:

Stage1: This stage of demodulation is the reverses the phase shift keying applied to the transmitted to the signal. The received signal y(t) and locally generated carrier are applied to the product modulator followed by a LPF with cut-off frequency of m(t).

Stage2: The second stage of demodulation performs spectrum dispreading by multiplying LPF output by locally generated replica of PN signal c(t) followed by integration over a bit interval and finally decision making device performs thresholding produce detected data.

# End