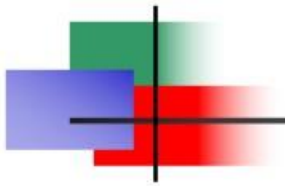
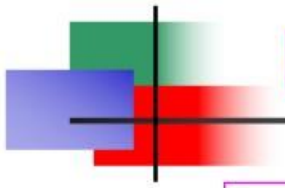


# Chapter 8

# Wireless communications

—— by Prof. XIAOFENG LI

SCIE, UESTC



# Problems

8.14, 8.22

# Contents 4 Hr

- Spread spectrum communication systems

- Brief introduction to mobile communication systems

# 8.4 Spread spectrum communication systems

The **major objective** is often the efficient ultilization of transmission power and BW. Engineers make tradeoff between them.

A spread spectrum (SS) system expands the BW of the signal largely to overcome various interferences. And more, using of the random-like codes in the expansion makes the signal hard to listen for an unintended user.

Rooted in military communications, it was developed to provide resistance to jamming and to hide signals from enemies by transmitting at very low power.

# 8.4 Spread spectrum communication systems

Direct sequence (DS) and freq-hopped (FH) SS are two main types.

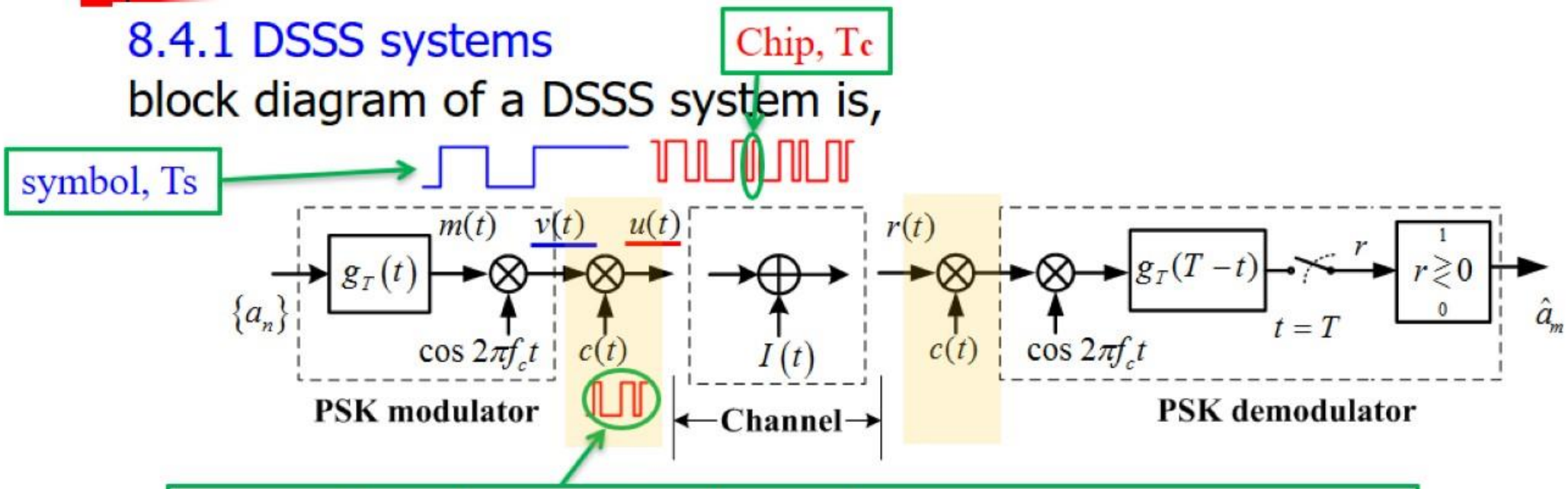
1)The DS system is based on PSK modulation and requires strictly coherent demodulation.

2)The FH system is based on the FSK modulation and often uses non-coherent demodulation.

# 8.4 Spread spectrum communication systems

## 8.4.1 DSSS systems

block diagram of a DSSS system is,




A pseudo-noise or pseudo-random signal is a noise-like signal generated from a noise-like data sequence, called PN code. $c(t)$ is often given by

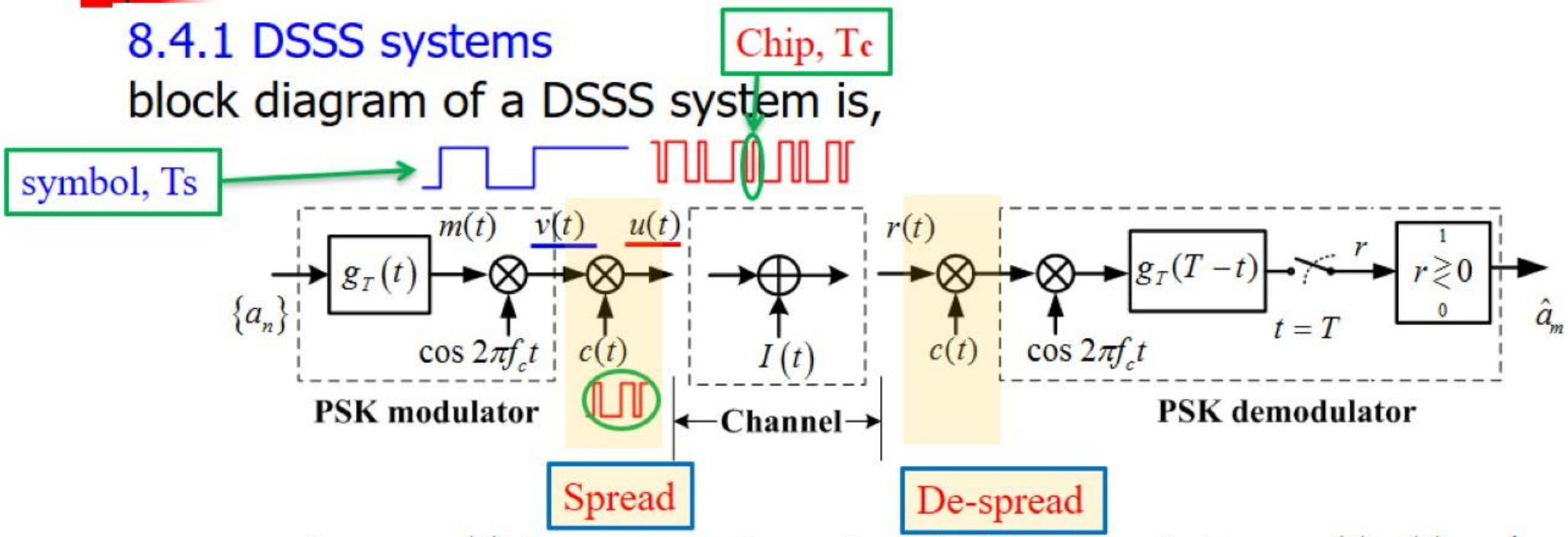
$$c(t) = \sum_n c_n p(t - nT_c)$$

where $\{c_n\}$ is the binary PN codes of $\pm 1$, $p(t)$ is a rect-pulse of duration $T_c$ called a chip.

# 8.4 Spread spectrum communication systems

## 8.4.1 DSSS systems

block diagram of a DSSS system is,

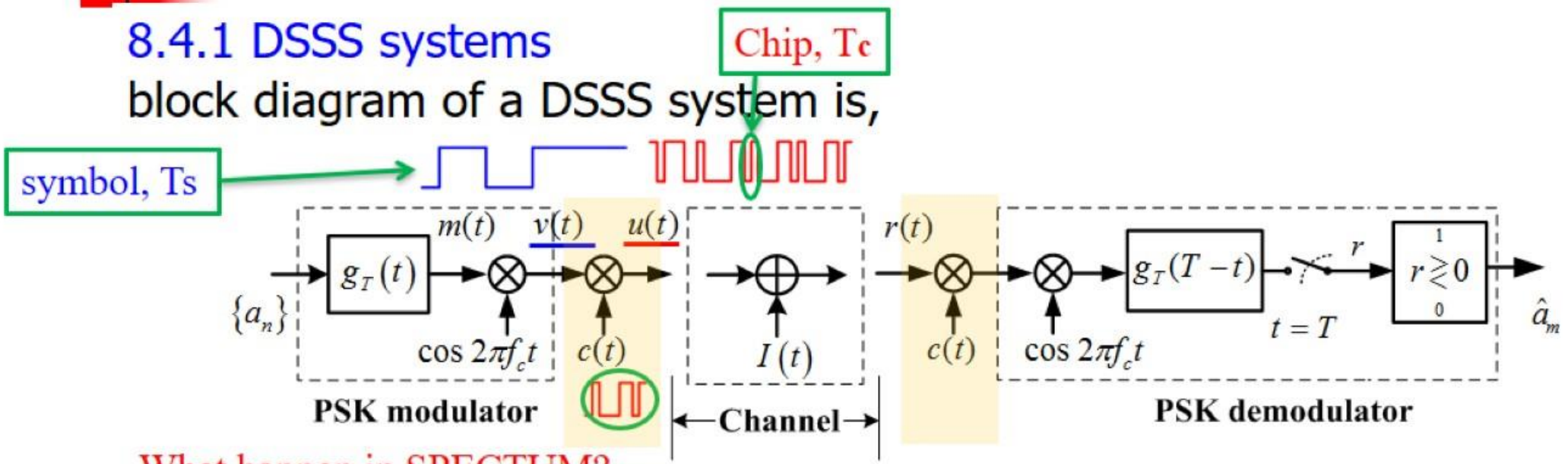



where $c(t)$ is a pseudo-noise (PN) signal. For $c(t)c(t) \equiv 1$, the system works when the receiver is well synchronized.

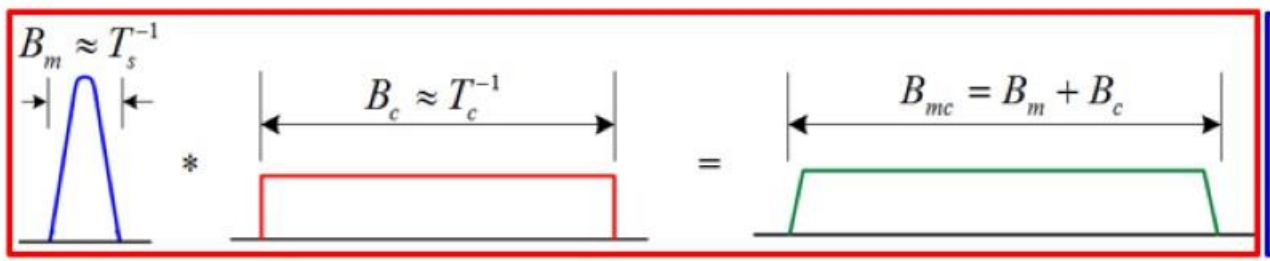
# 8.4 Spread spectrum communication systems

## 8.4.1 DSSS systems

block diagram of a DSSS system is,




What happen in SPECTUM?




Spread-factor:

$$L = \frac{B_{DS}}{B_{PSK}} = \frac{B_{mc}}{B_m} \approx \frac{T_s}{T_c}$$

# 8.4 Spread spectrum communication systems

## 8.4.1 DSSS systems

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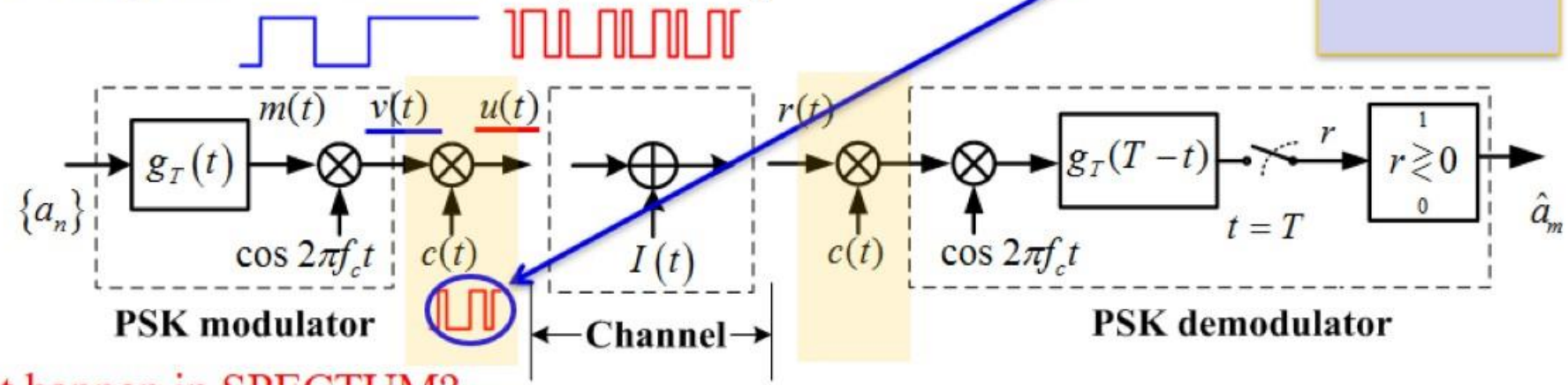


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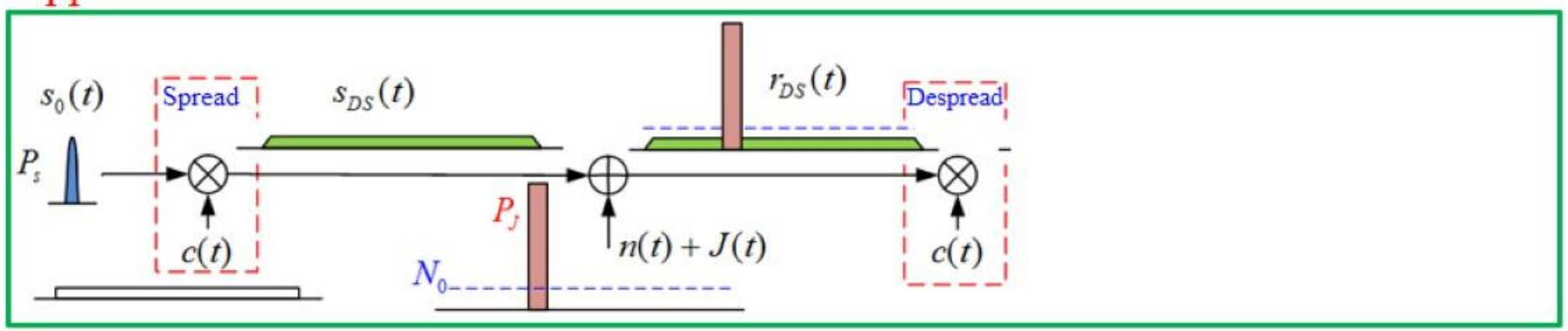

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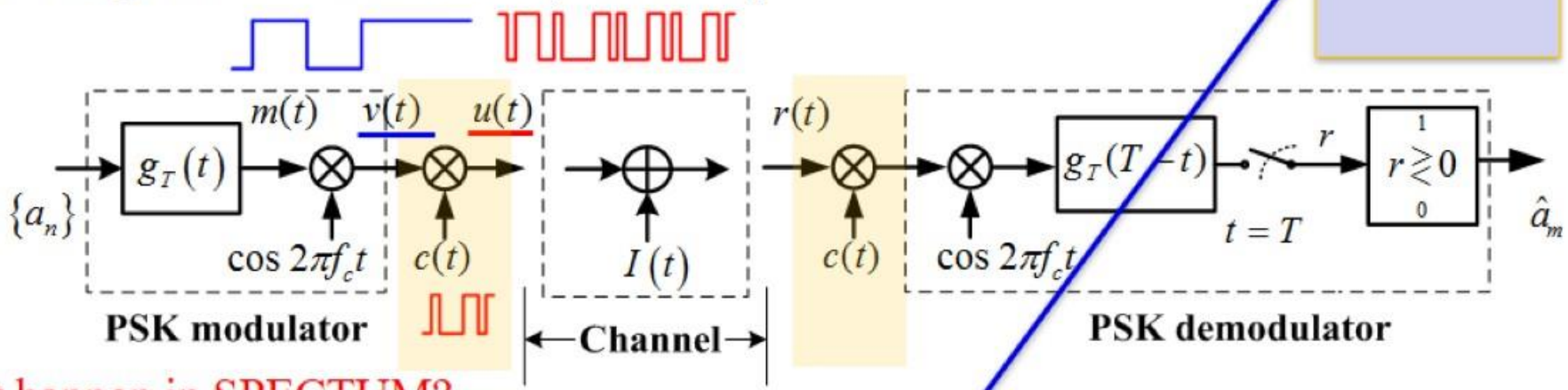
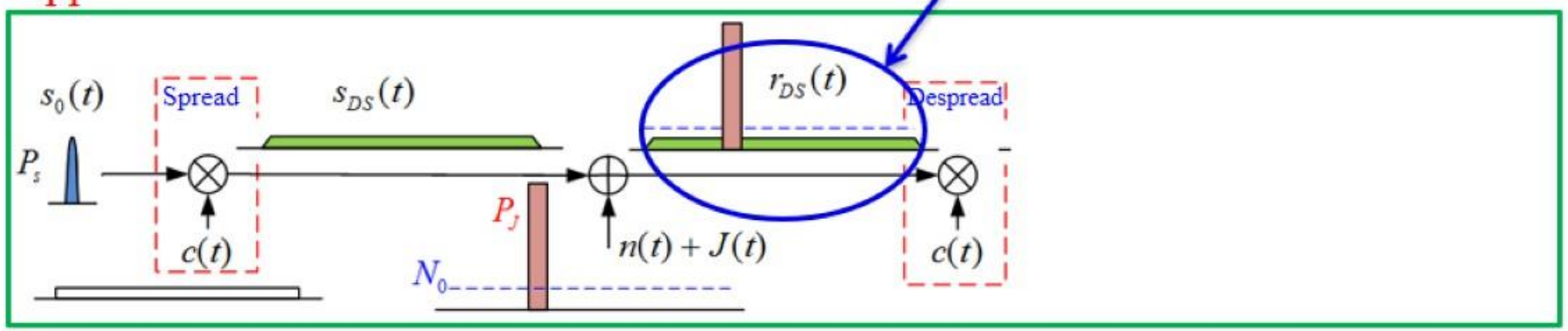



✓ Scramle
✓ Hide

What happen in SPECTUM?

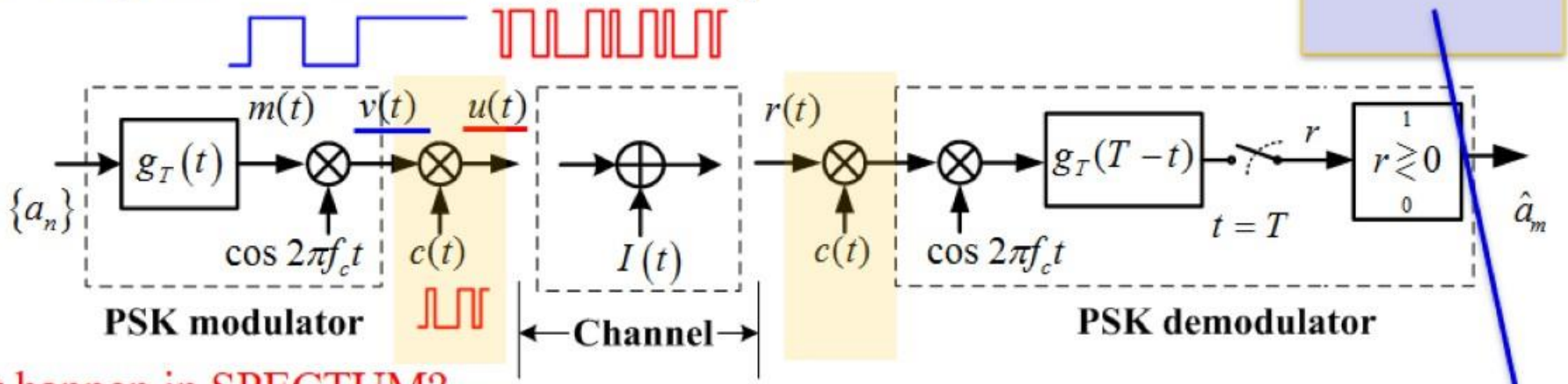


# 8.4 Spread spectrum communication systems

## 8.4.1 DSSS systems

block diagram of a DSSS system is,

- ✓ Scramle
- ✓ Hide
- ✓ Anti-Int.

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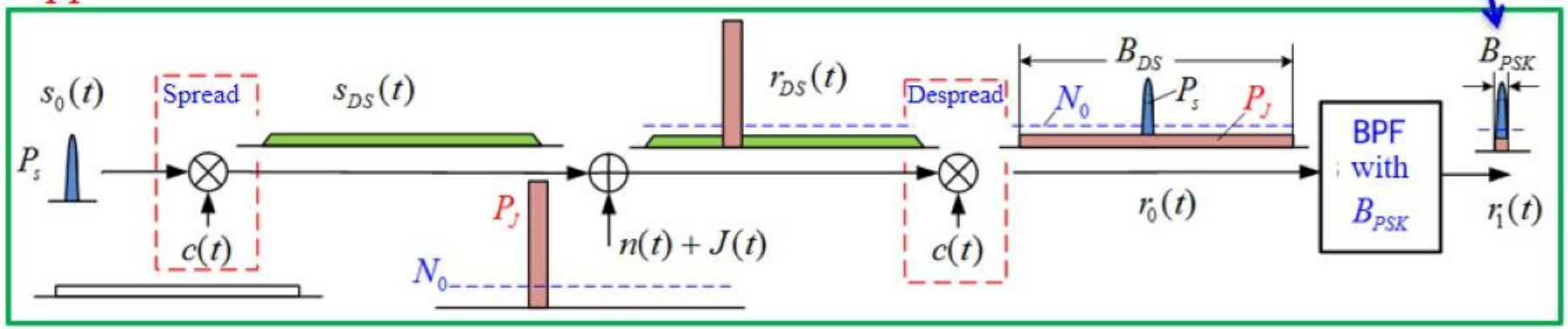


# 8.4 Spread spectrum communication systems

Let $P_s$ be the power of the signal. We have,

$$\frac{E_b}{J_0} = \frac{P_s T_b}{P_I / W} = \frac{P_s}{P_I} \times \frac{W}{R_b} = \frac{P_s}{P_I} \times L_c$$

$$\boxed{\frac{E_b}{J_0} = \frac{P_s}{P_J} \times L}$$

The SNR ($E_b / J_0$) is $L_c$ times of the signal-to-interference ratio (SIR). So we call $L_c$ the processing gain.

More, $$\frac{P_I}{P_s} = L_c \left( \frac{E_b}{J_0} \right)^{-1} \quad or \quad \boxed{\left( \frac{P_I}{P_s} \right)_{dB} = (L_c)_{dB} - \left( \frac{E_b}{J_0} \right)_{dB}}$$

Specifying a required SNR ($E_b / J_0$) for a desired level of reliability, $(P_I / P_s)_{dB}$ tells that how large an interference the system may tolerant. So, $(P_I / P_s)_{dB}$ is called the interference margin.

# 8.4 Spread spectrum com…s

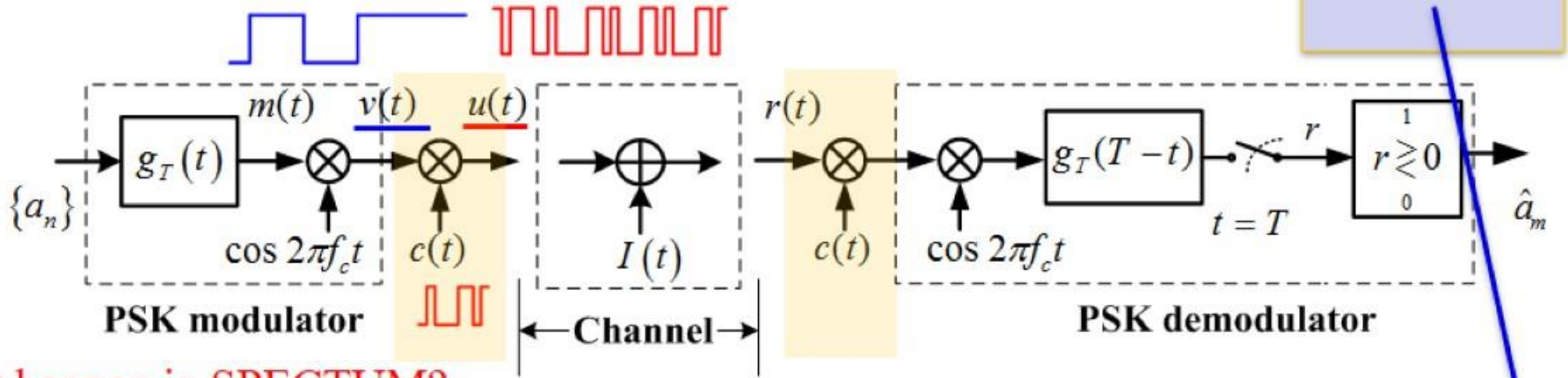
Take $L = 2000$ (Proc. Gain)

$$\frac{P_s}{P_J} = -20\text{dB} \Rightarrow \frac{E_b}{J_0} = 13\text{dB}$$

- ✓ Scramle
- ✓ Hide
- ✓ Anti-Int.

## 8.4.1 DSSS systems

block diagram of a DSSS system is,

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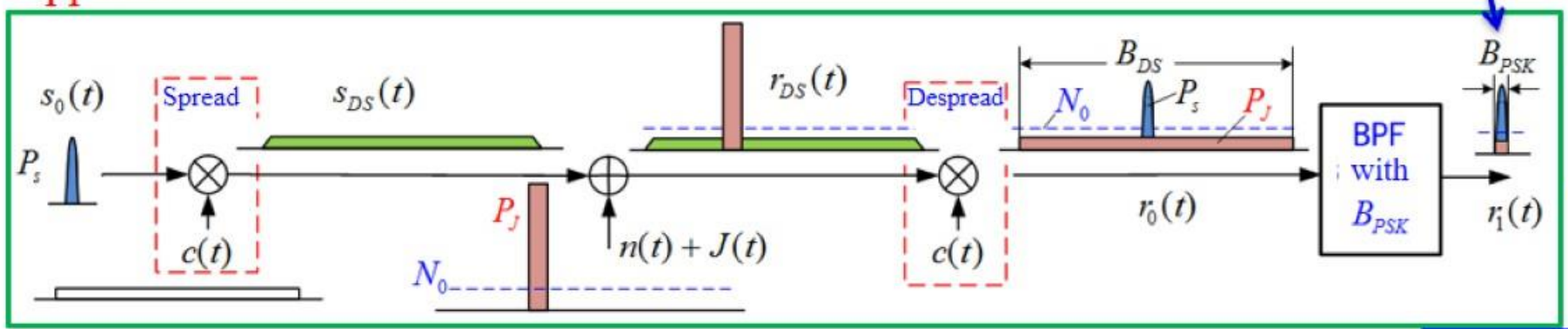
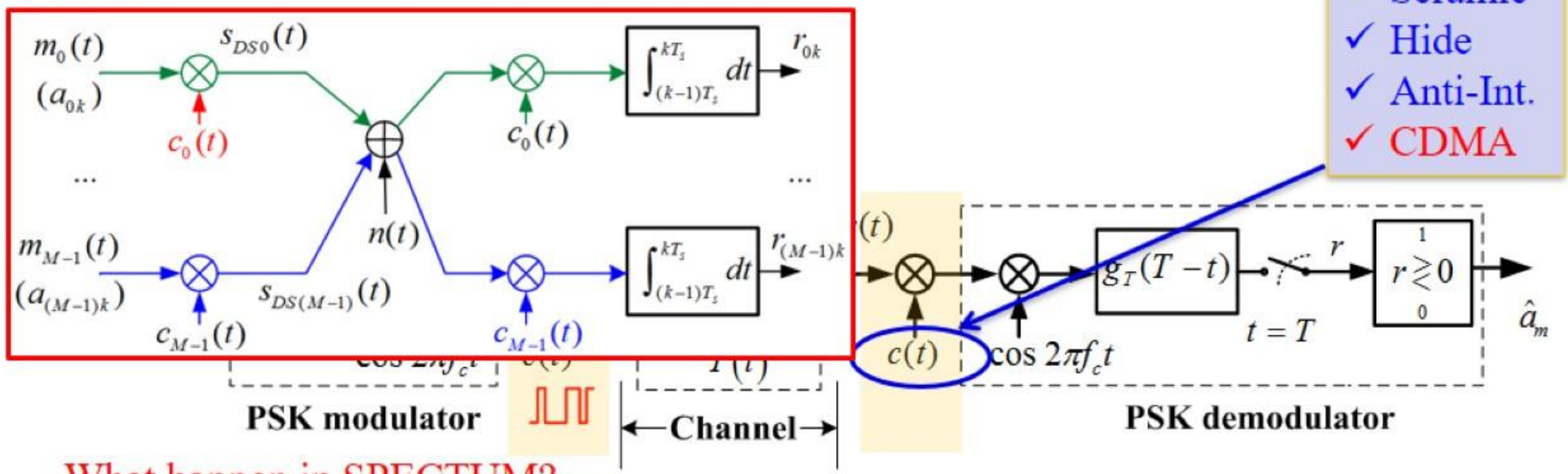



$$\frac{E_b}{J_0} = \frac{P_s}{P_J} \times L$$

Interference margin

$$\left(\frac{P_I}{P_s}\right)_{dB} = (L_c)_{dB} - \left(\frac{E_b}{J_0}\right)_{dB}$$

# 8.4 Spread spectrum communication systems

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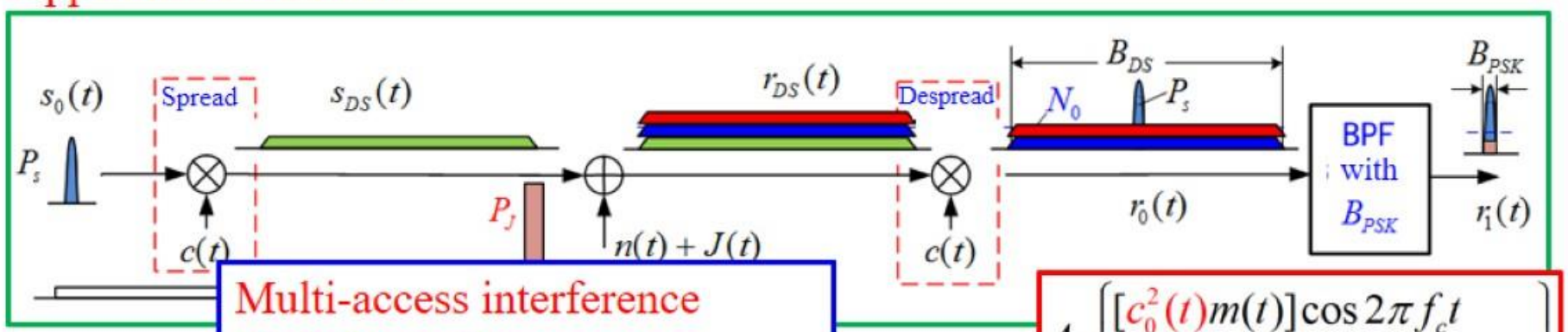


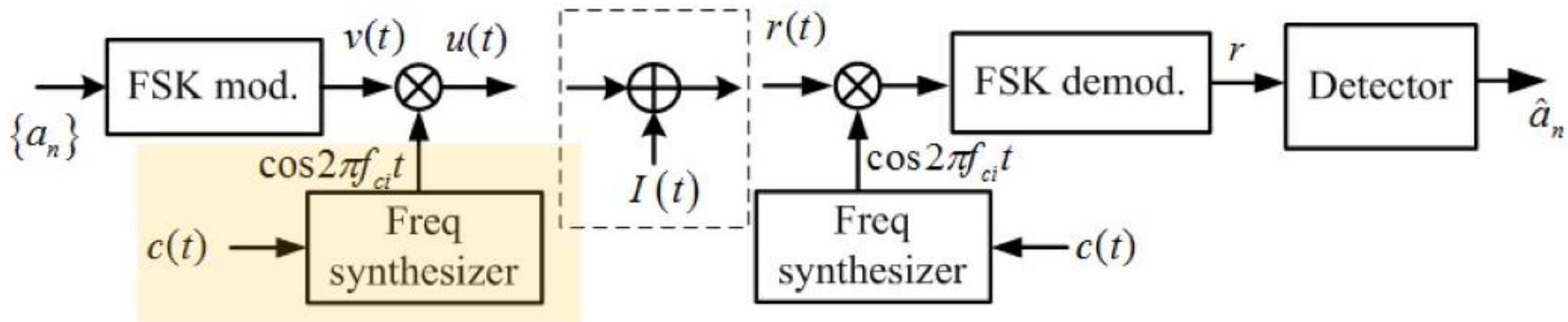

Multi-access interference
- ✓ Ortho.codes
- ✓ "Far-near-effects" and wireless power control

$$A_c\begin{Bmatrix}[c_0^2(t)m(t)]\cos 2\pi f_c t \\ [c_0(t)c_1(t)m(t)]\cos 2\pi f_c t\end{Bmatrix}$$

$$N_0 + N_1 + \ldots + N_{M-1}$$

## 8.4.2 DSSS systems

The block diagram of a FHSS system is,




The primary modulation is FSK. The modulated signal is mixed with a freq $f_{ci}$ which is selected by the synthesizer under the control of a PN sequence. In this way, the resultant signal hops "randomly" in the whole available BW of the channel and behaves as a wideband signal.

## 8.4.2 DSSS systems

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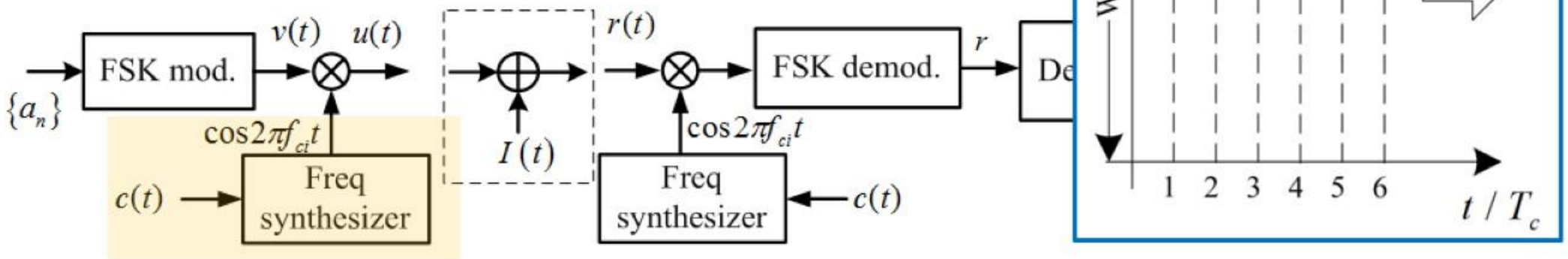


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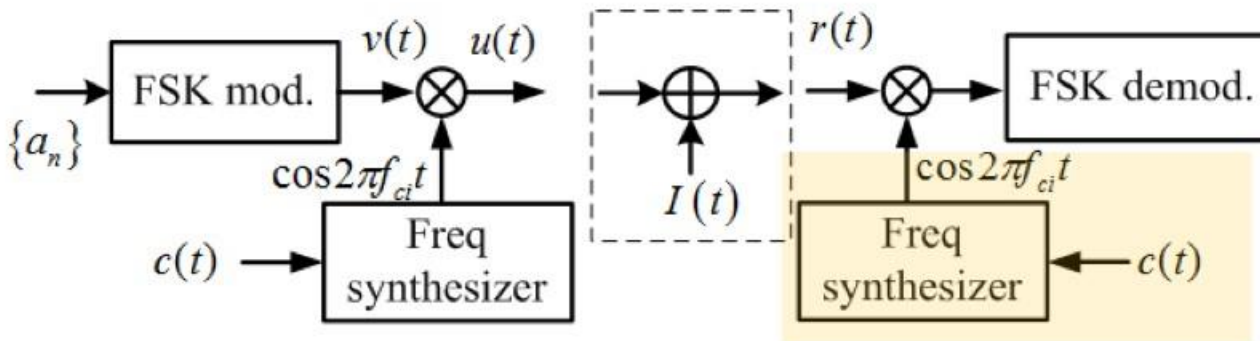
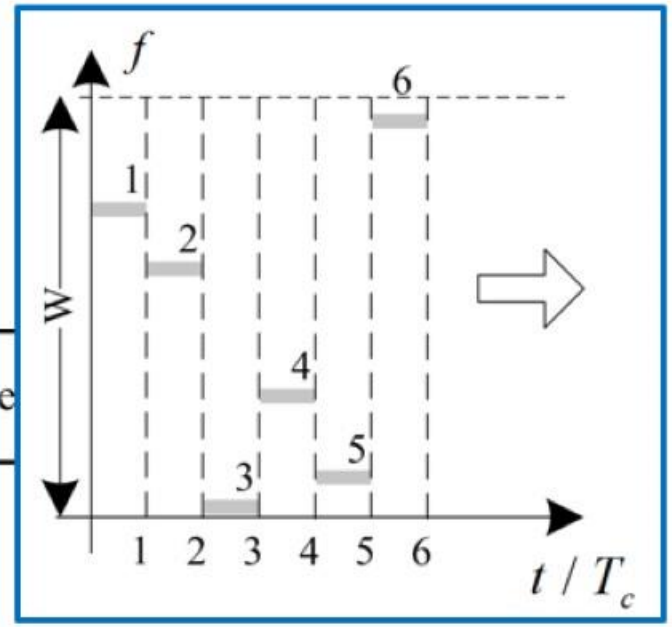
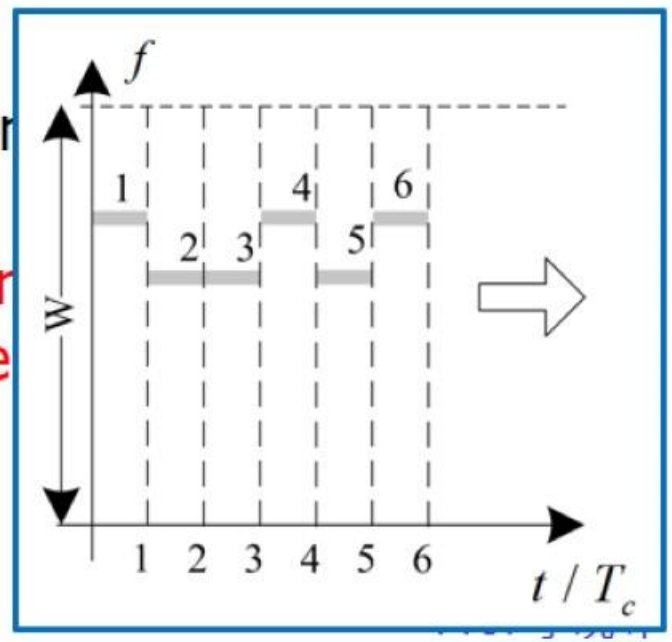
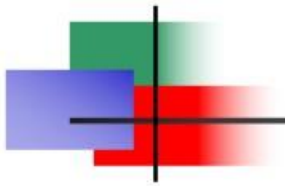



In the receiver, the synthesizer and PN code are synchronized with the received signal, and the conventional FSK signal is restored.





End of this chapter

# Thank you