

# 第八章 多采样率数字信号处理

## *Multirate Digital Signal Processing*

8.1

信号的整数倍抽取

8.2

信号的整数倍内插

8.3

信号的任意有理数倍采样频变换及应用



# 第八章 多采样率数字信号处理

*Multirate Digital Signal Processing*

## 8.3 信号的任意有理数倍采样频变换及应用

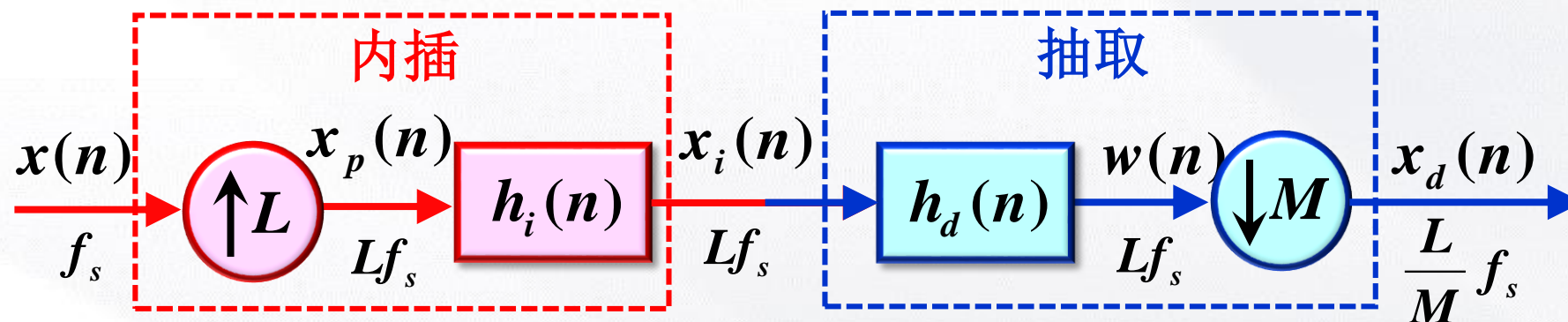
华东理工大学信息科学与工程学院 万永菁



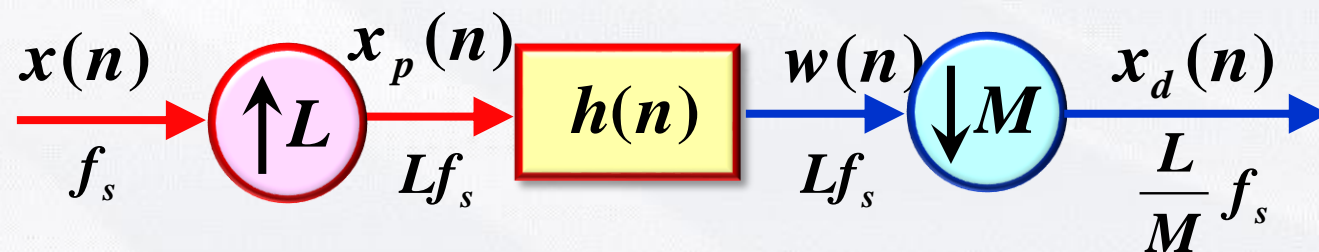
## 8.3 信号的任意有理数倍采样频变换及应用



### 一、单级采样频率变换



$$h(n) = h_i(n) * h_d(n) \iff H(e^{j\omega}) = H_i(e^{j\omega}) \cdot H_d(e^{j\omega})$$



$$H(e^{j\omega}) = \begin{cases} L & 0 \leq |\omega| < \omega_c \\ 0 & \omega_c \leq |\omega| \leq \pi \end{cases}, \quad \text{其中 } \omega_c = \min\left(\frac{\pi}{L}, \frac{\pi}{M}\right)$$

## 8.3 信号的任意有理数倍采样频变换及应用



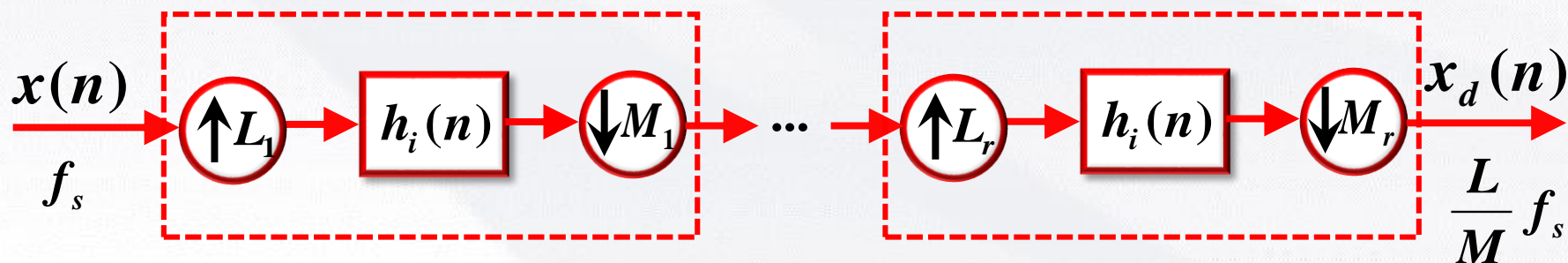
### 二、多级采样频率变换

$$H(e^{j\omega}) = \begin{cases} L & 0 \leq |\omega| < \omega_c \\ 0 & \omega_c \leq |\omega| \leq \pi \end{cases}, \quad \text{其中 } \omega_c = \min\left(\frac{\pi}{L}, \frac{\pi}{M}\right)$$

当 $L$ 或 $M$ 值较大时， $\omega_c$ 很小，设计 $h(n)$ 的代价太大。因此，可以设计为多级采样率变换系统，避开设计高代价的 $h(n)$ 。

$$\frac{L}{M} = \prod_{i=1}^r \frac{L_i}{M_i}$$

$$\frac{L}{M} = \frac{147}{160} = \frac{7}{8} \cdot \frac{7}{5} \cdot \frac{3}{4}$$

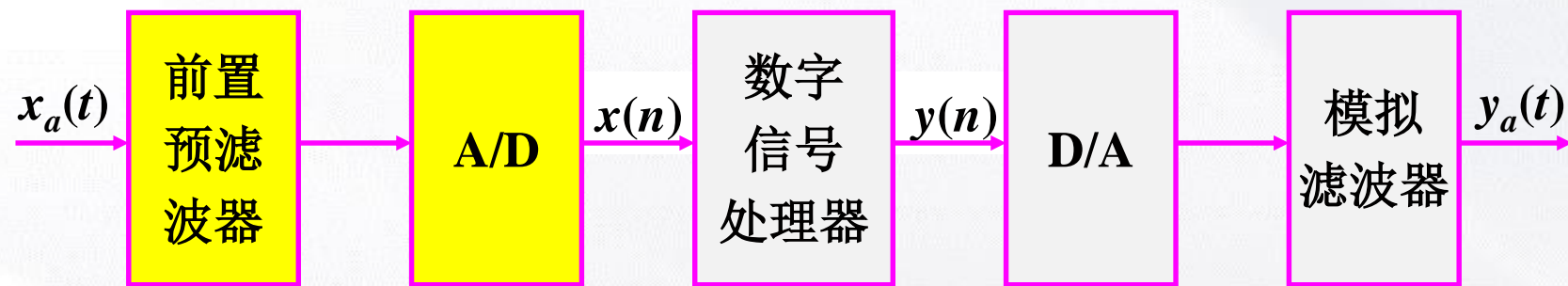




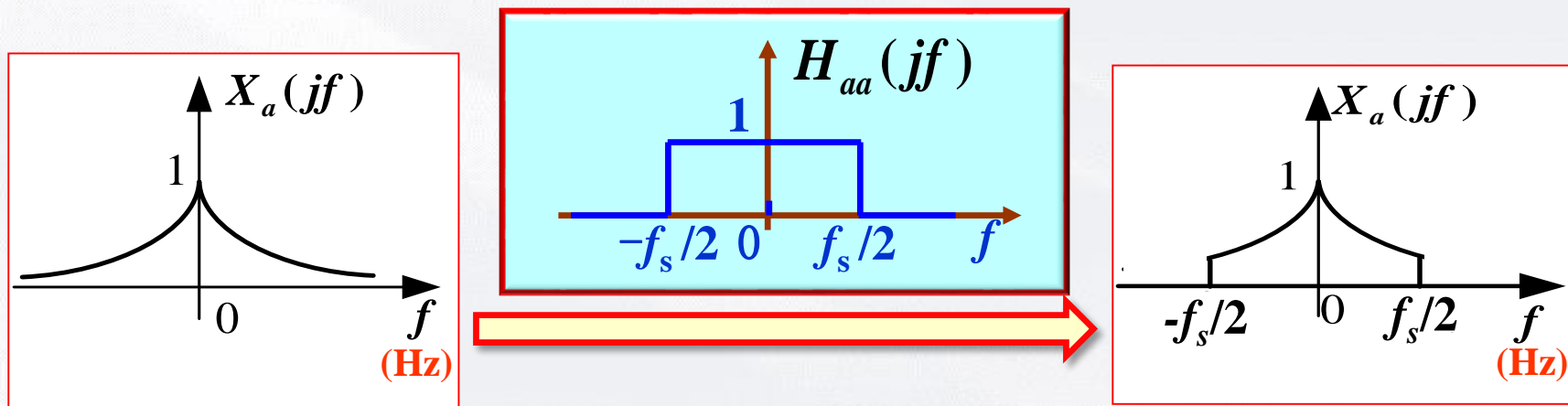
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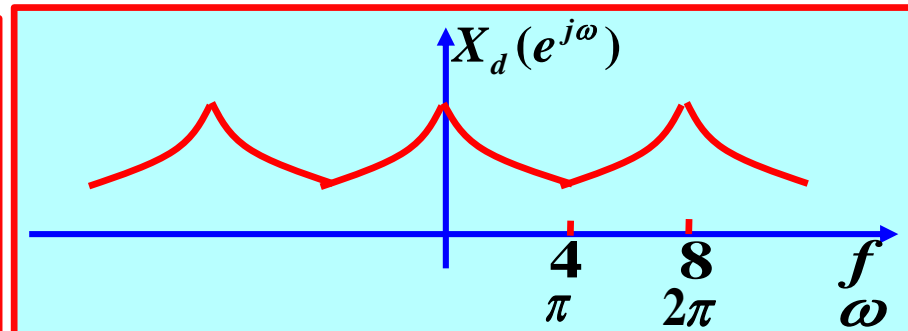
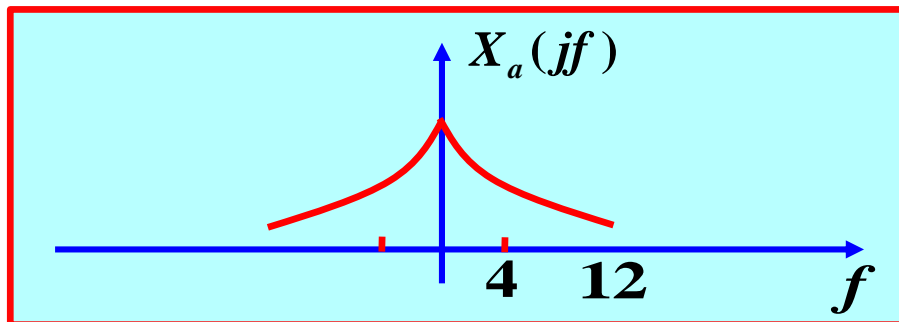
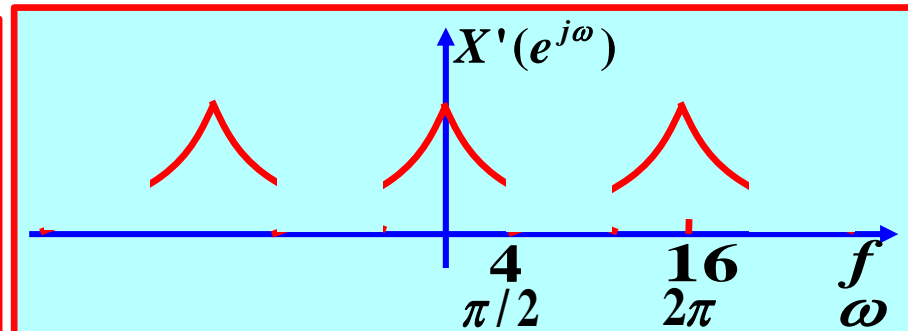
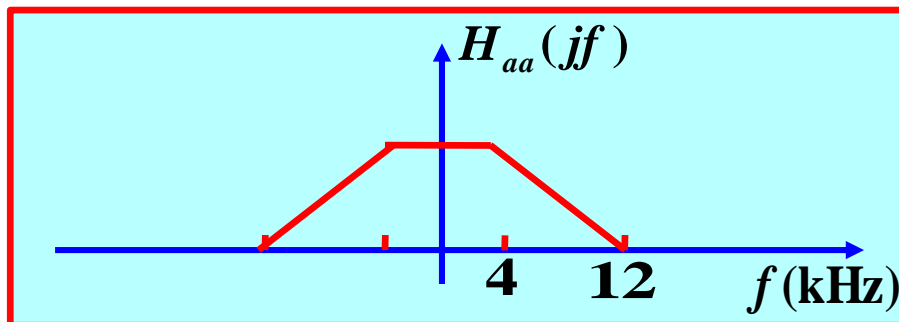
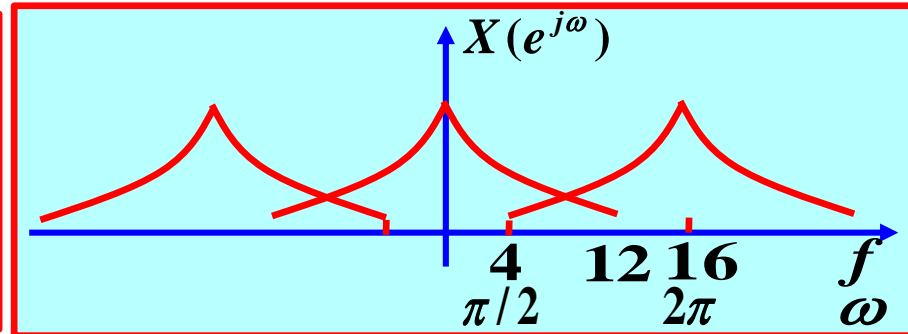
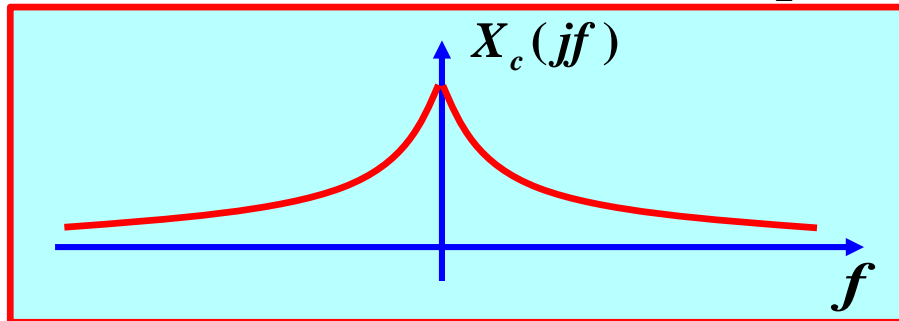
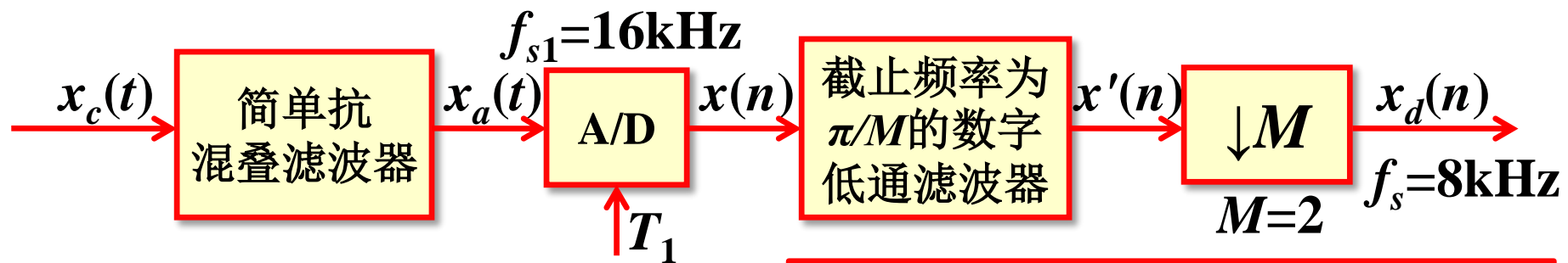
### 三、多采样率系统的应用举例 —— 语音系统中的应用

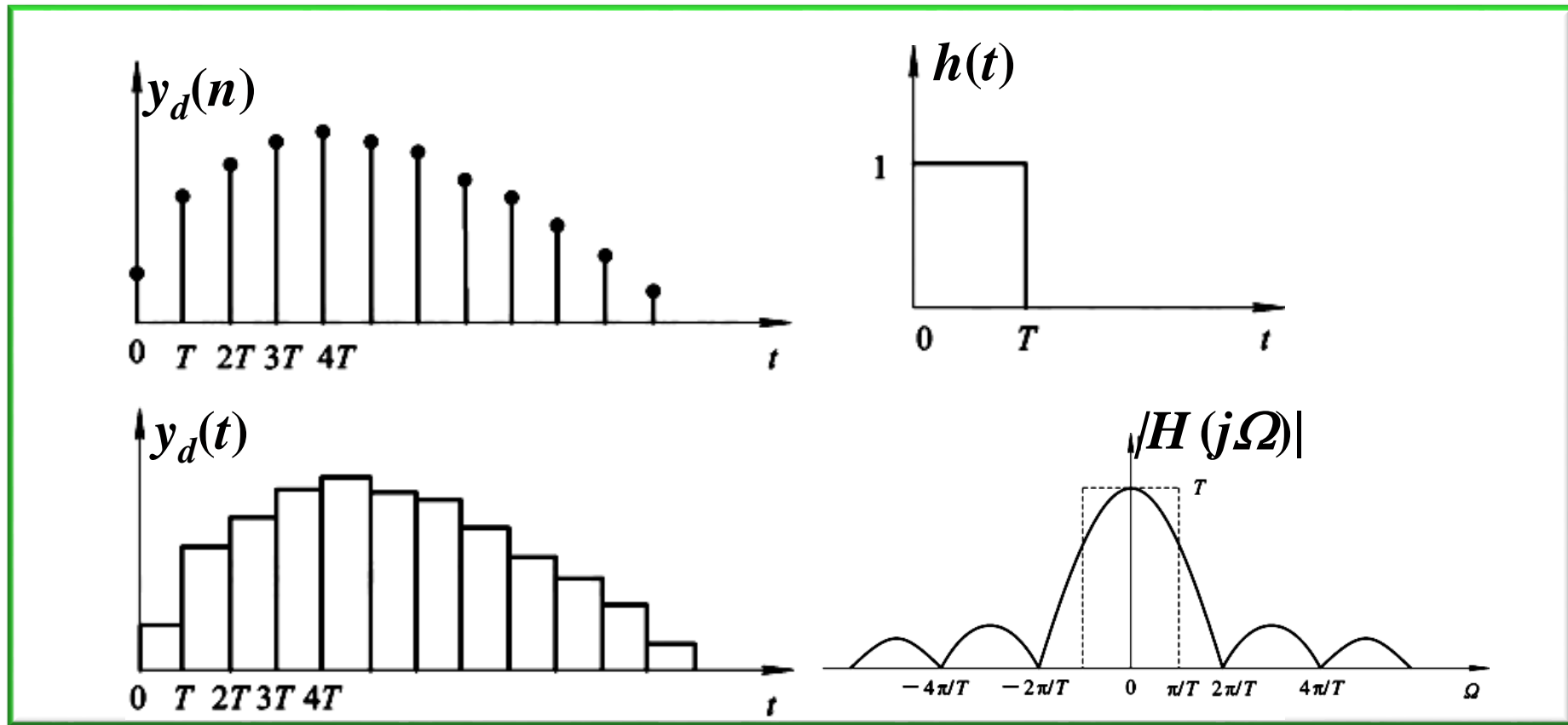
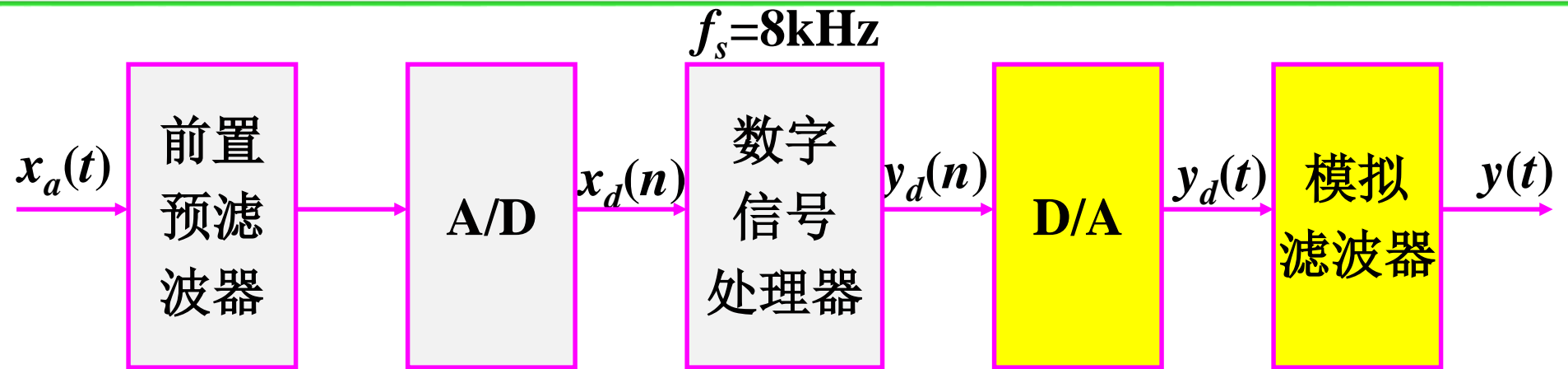


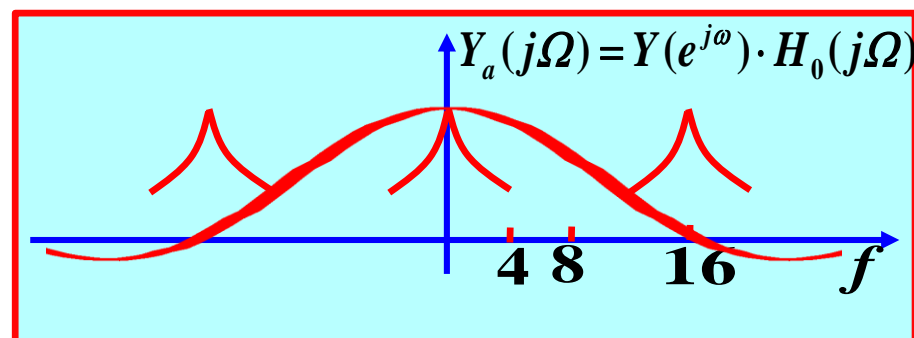
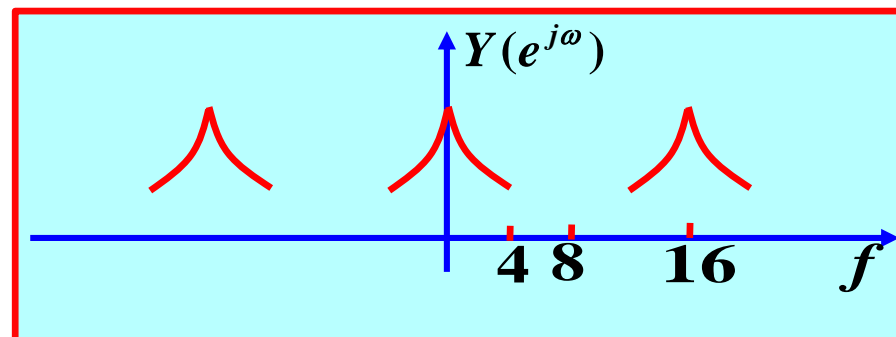
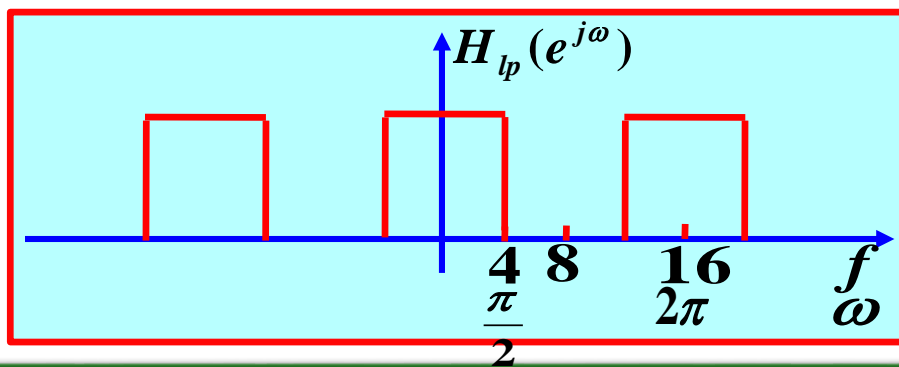
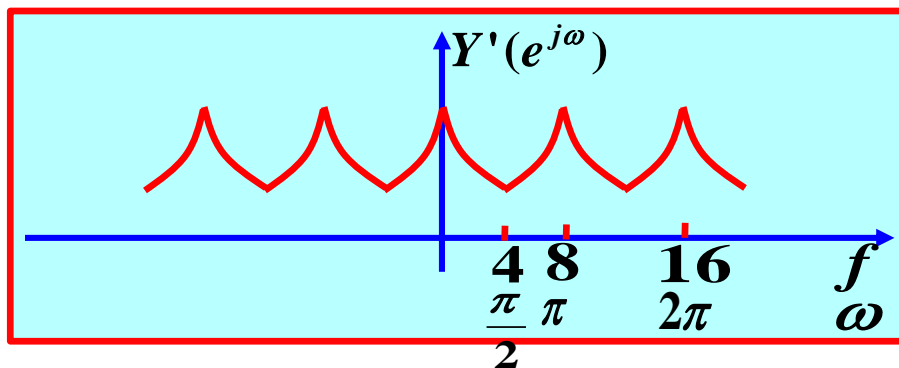
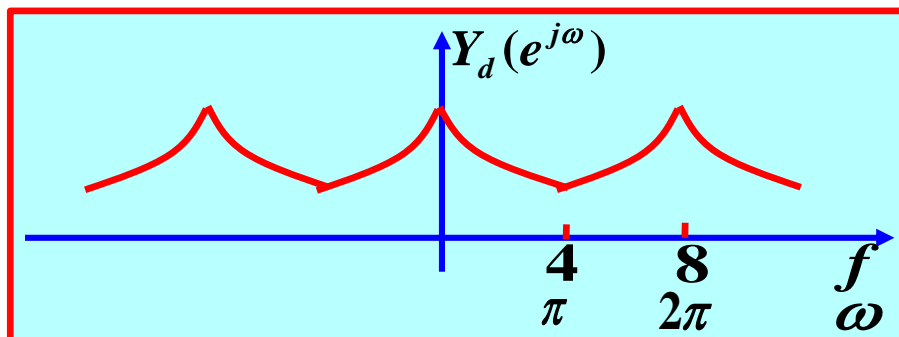
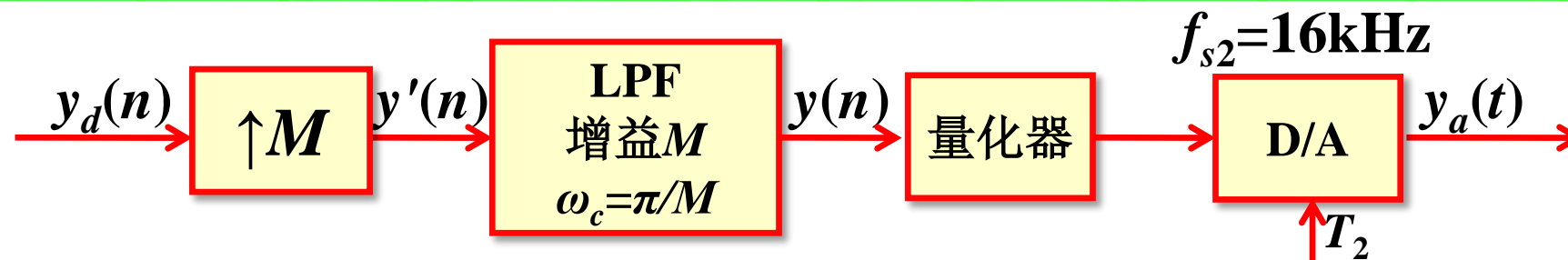
*anti-aliasing*



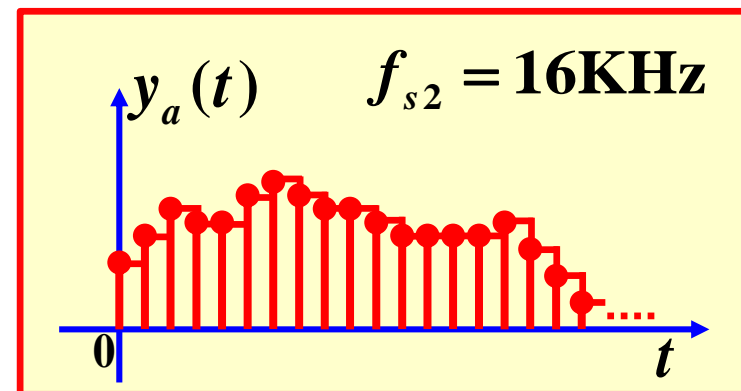
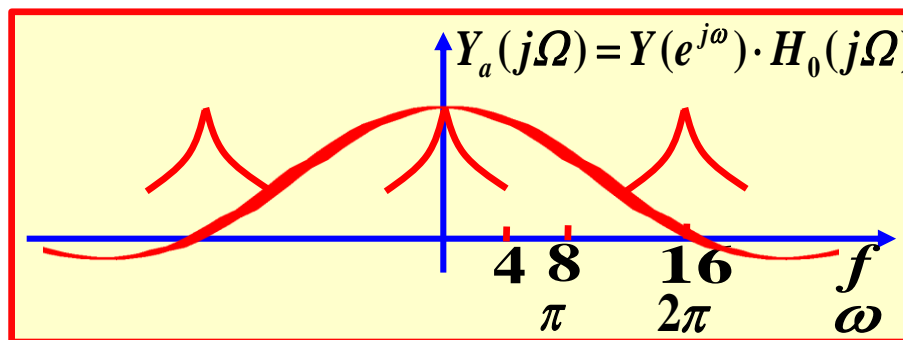
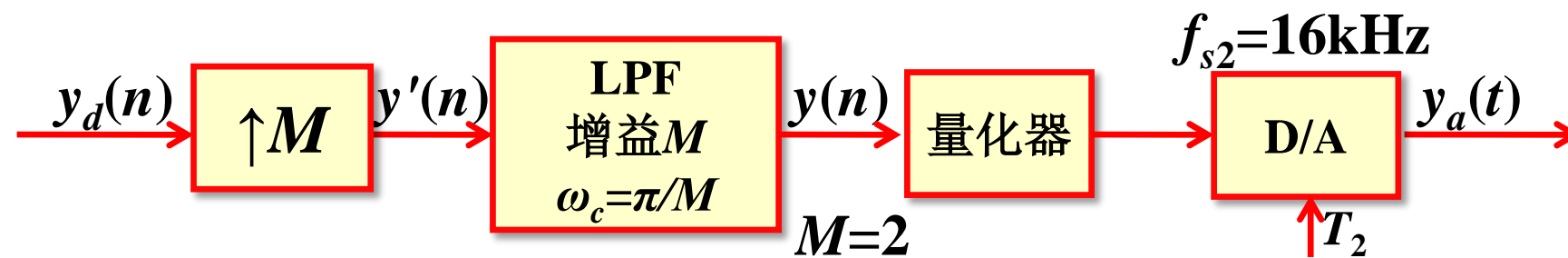
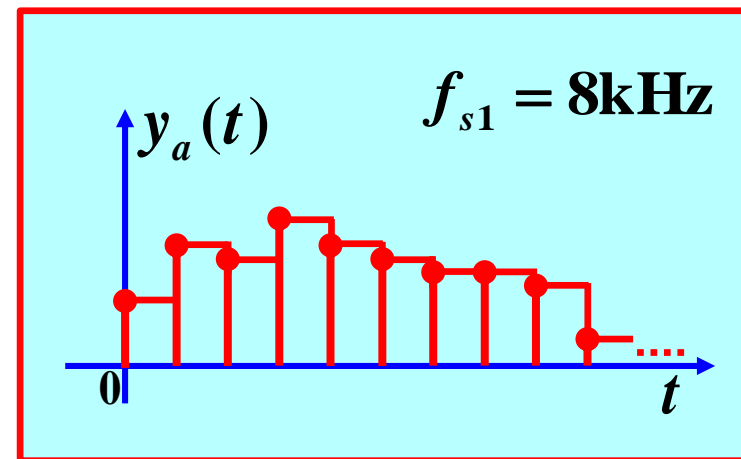
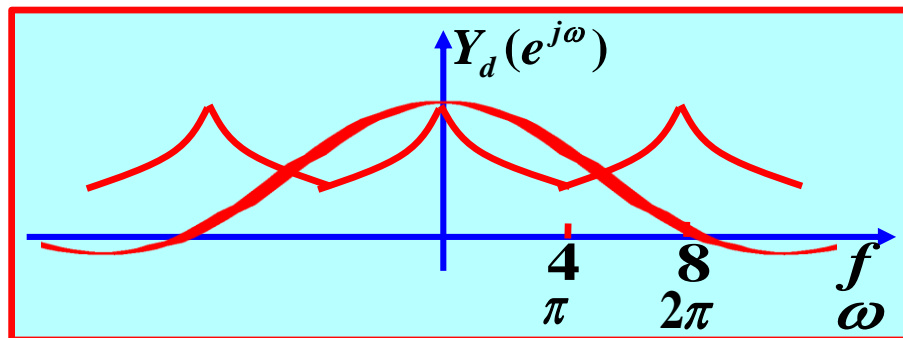
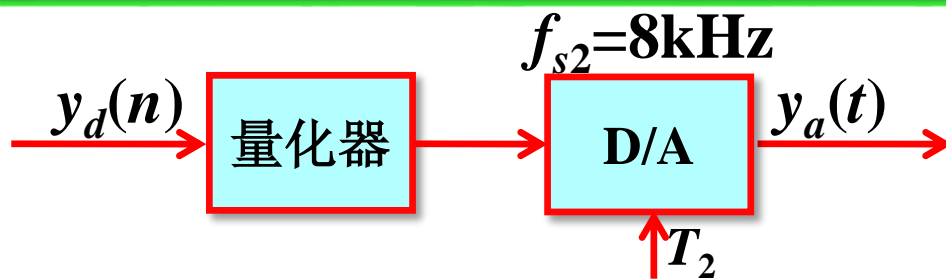
但这个**模拟**抗混叠滤波器很难实现！





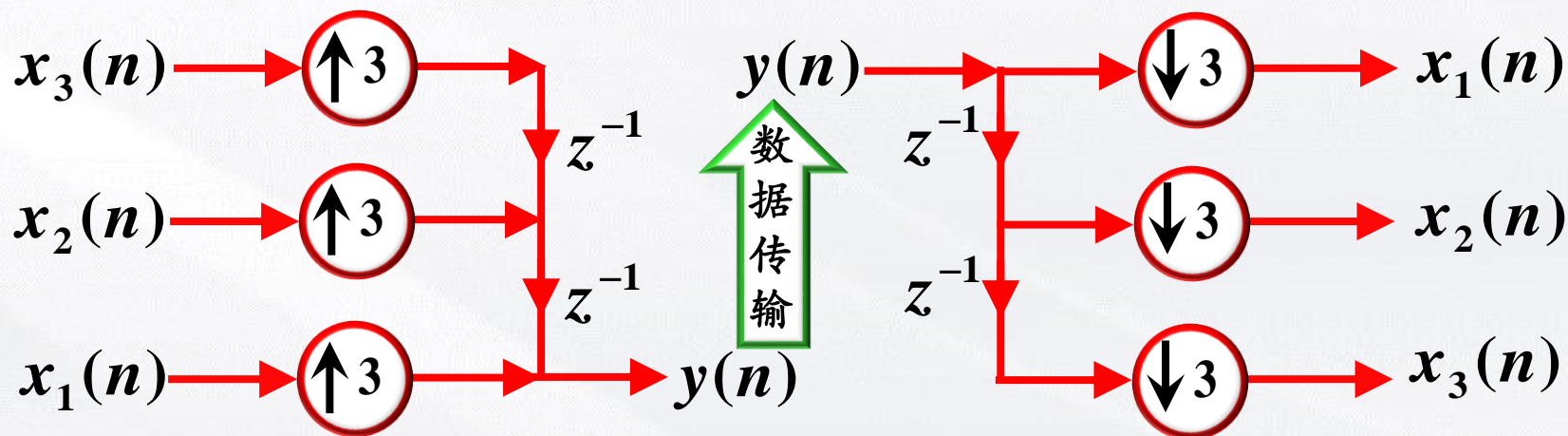






### 三、多采样率系统的应用举例——时分复用和频分复用

#### ◆ 时分复用 (*time division multiplexed*, **TDM**)



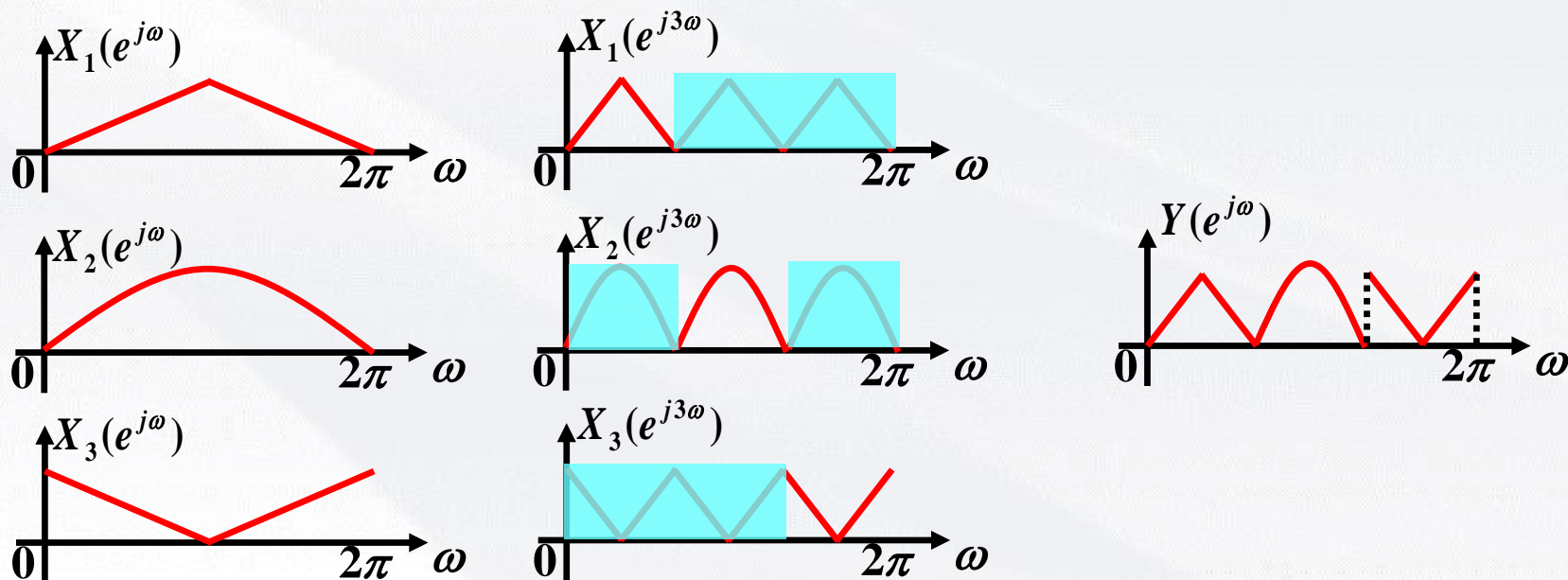
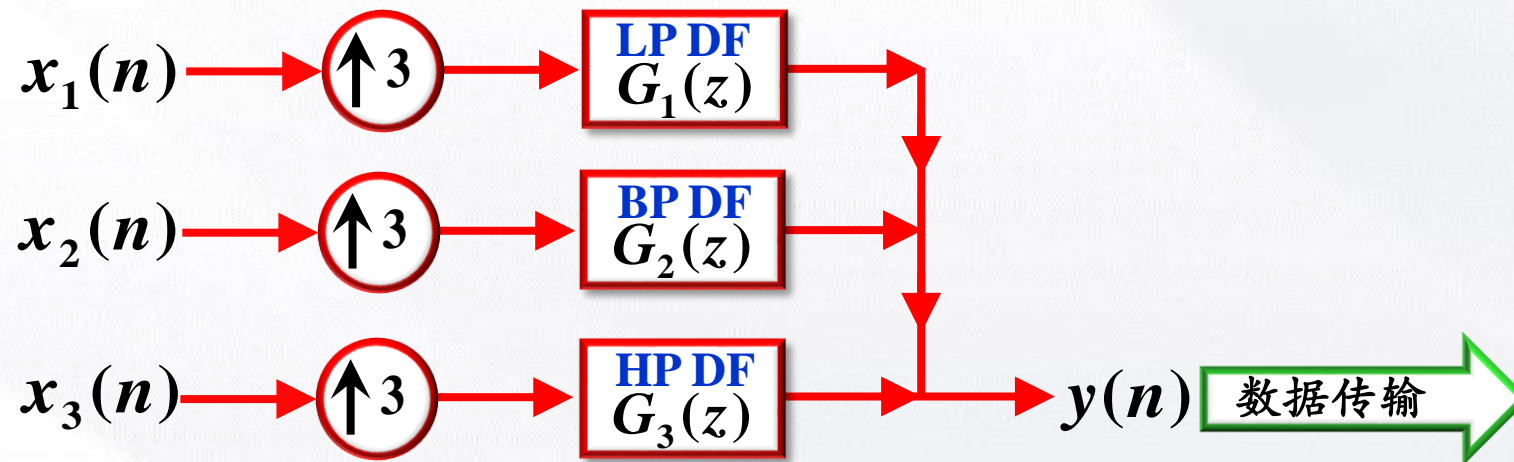
$y(n)$  是  $x_1(n)$ 、 $x_2(n)$  和  $x_3(n)$  按时间分开后的组合

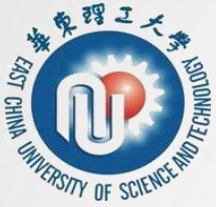
$$y(n) = \{ \dots \dots \underline{x_1(0)}, \underline{x_2(0)}, \underline{x_3(0)}, \underline{x_1(1)}, \underline{x_2(1)}, \underline{x_3(1)}, \dots \dots \}$$

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### ◆ 频分复用 (*Frequency division multiplexed*, **FDM**)





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