软件无线电

一符号同步问题（ch12）

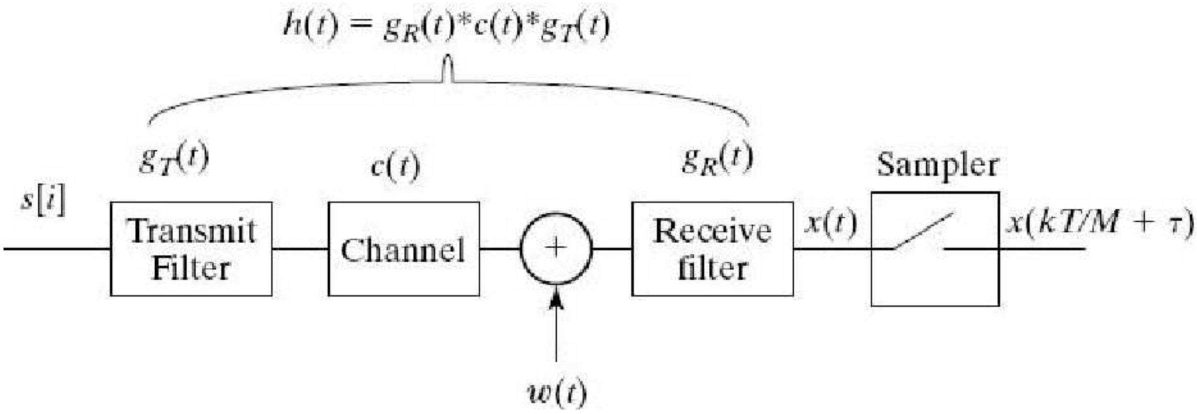
制作人：Wavelet Email：277542550@qq.com

符号同步（ch12）

- ◆符号同步相关问题
- ◆DEMO
- ◆直接判决（方法一）
- ◆输出能量达到最大（方法二）

制作人：Wavelet Email：277542550@qq.com

相关问题—通信系统的建模



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相关问题—符号同步（抽样判决）的本质

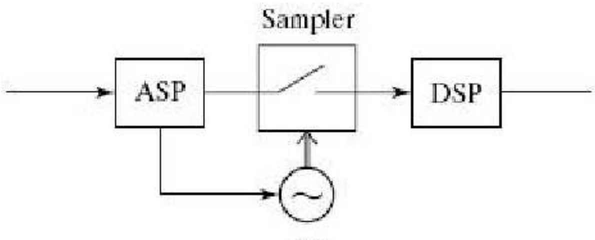
$$x[k] = x(\frac{kT}{M} + \tau)$$

$$= \left(\sum_{i=-\infty}^{\infty} s[i]h(t - iT) + w(t) * g_R(t) \right) |_{t=\frac{kT}{M}+\tau}$$

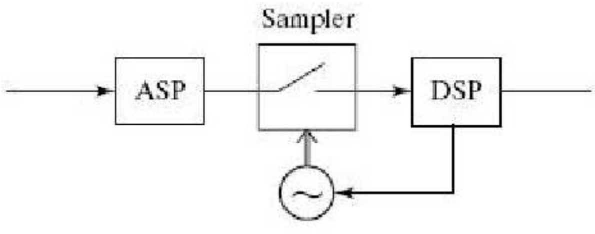
with

$$h(t) = g_T(t) * c(t) * g_R(t)$$

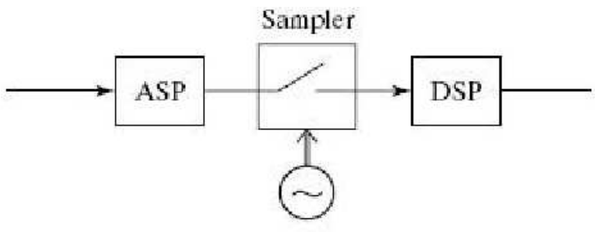
相关问题—符号同步大的三种方法



(a)



(b)



(c)

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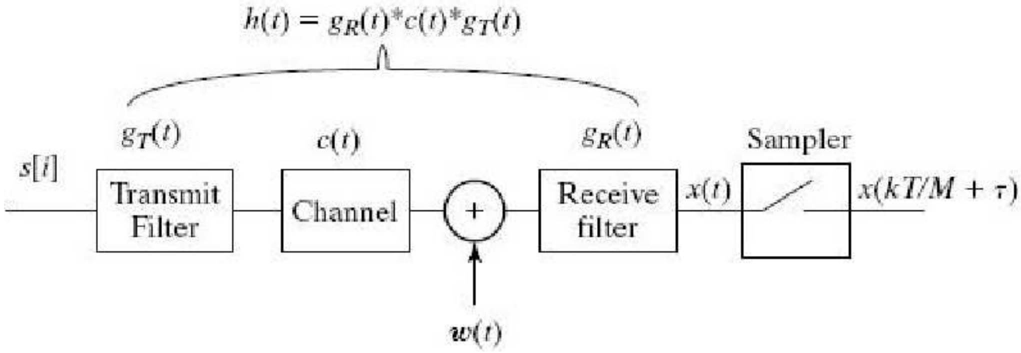
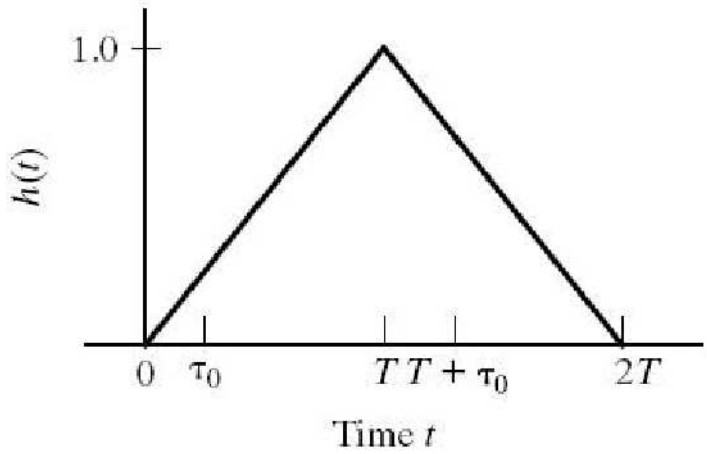
Demo—系统模型


h(t) = g_R(t)*c(t)*g_T(t)
g_T(t)
c(t)
g_R(t)
Sampler
s[i]
Transmit Filter
Channel
+
Receive filter
x(t)
x(kT/M + τ)
w(t)

Demo－系统单位冲击响应（发＋信道＋结）



Demo—准确定时情况下

$$x[k] = \sum_i s[i]h(t - iT)\Big|_{t=kT+\tau}$$

$$h(kT) = \begin{cases} 1, & k = 1 \\ 0, & k \neq 1 \end{cases}$$

Demo－定时准确情况下（续）

$\tau = 0$

- Only one nonzero point in sampled impulse response
- Sampled impulse response

$$
\begin{aligned}
h(t - iT)|_{t=kT+\tau} &= h(kT + \tau - iT) \\
&= h((k-i)T + \tau) \\
&= h((k-i)T) \\
&= \begin{cases} 1, & k - i = 1 \\ & \quad \Rightarrow \; i = k - 1 \\ 0, & \text{otherwise} \end{cases}
\end{aligned}
$$

- $x[k] = s[k-1]$, system is pure delay, and sampler is synchronized with transmitter pulse.

Demo－定时不准确（情况一）

$\tau > 0$

- Two nonzero points in sampled impulse response $h(\tau_0)$ and $h(T + \tau_0)$
- Sampled impulse response

$$h(t - iT)|_{t=kT+\tau_0} = h((k-i)T + \tau_0)$$

$$= \begin{cases} 1 - \frac{\tau_0}{T}, & k - i = 1 \\ \frac{\tau_0}{T}, & k - i = 0 \\ 0, & \text{otherwise} \end{cases}$$

Demo－定时不准确（情况一）

For example, with $\tau > 0$ for $k = 6$

$$x[6] = \sum_i s[i]h((6-i)T + \tau_0)$$

$$= s[6]h(\tau_0) + s[5]h(T + \tau_0)$$

$$= s[6]\frac{\tau_0}{T} + s[5](1 - \frac{\tau_0}{T})$$

Demo－定时不准确（情况一）

For example, with $\tau > 0$ for $k = 6$

- $(s[5], s[6]) = (+1, +1) \Rightarrow$
  $x[6] = \frac{\tau_0}{T} + 1 - \frac{\tau_0}{T} = 1$
- $(s[5], s[6]) = (+1, -1) \Rightarrow$
  $x[6] = \frac{-\tau_0}{T} + 1 - \frac{\tau_0}{T} = 1 - \frac{2\tau_0}{T}$
- $(s[5], s[6]) = (-1, +1) \Rightarrow$
  $x[6] = \frac{\tau_0}{T} - 1 + \frac{\tau_0}{T} = -1 + \frac{2\tau_0}{T}$
- $(s[5], s[6]) = (-1, -1) \Rightarrow$
  $x[6] = \frac{-\tau_0}{T} - 1 + \frac{\tau_0}{T} = -1$

Demo—定时不准确（情况二）

$\tau < 0$

- Two nonzero points in sampled impulse response $h(2T+\tau_0)$ and $h(T+\tau_0)$.
- Sampled impulse response

$$h(t-iT)|_{t=kT+\tau_0} = \begin{cases} 1-\frac{|\tau_0|}{T}, & k-i=1 \\ \frac{|\tau_0|}{T}, & k-i=2 \\ 0, & \text{otherwise} \end{cases}$$

Demo—定时不准确（情况二）

For example, with $\tau < 0$ for $k = 6$

$$x[6] = \sum_i s[i]h((6-i)T + \tau_0)$$

$$= s[5]h(T + \tau_0) + s[4]h(2T + \tau_0)$$

$$= s[4]\frac{|\tau_0|}{T} + s[5](1 - \frac{|\tau_0|}{T})$$

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Demo—定时不准确（情况二）

Similarly, with $\tau < 0$ for $k = 6$, the four equally likely source symbol pairs creating $x[6]$ are $(s[4], s[5])$

- $(s[4], s[5]) = (+1, +1) \Rightarrow$
  $x[6] = \frac{|\tau_0|}{T} + 1 - \frac{|\tau_0|}{T} = 1$
- $(s[4], s[5]) = (+1, -1) \Rightarrow$
  $x[6] = \frac{-|\tau_0|}{T} + 1 - \frac{|\tau_0|}{T} = 1 - \frac{2|\tau_0|}{T}$
- $(s[4], s[5]) = (-1, +1) \Rightarrow$
  $x[6] = \frac{|\tau_0|}{T} - 1 + \frac{|\tau_0|}{T} = -1 + \frac{2|\tau_0|}{T}$
- $(s[4], s[5]) = (-1, -1) \Rightarrow$
  $x[6] = \frac{-|\tau_0|}{T} - 1 + \frac{|\tau_0|}{T} = -1$

Demo—群方差

$$
\begin{aligned}
&\operatorname{avg}\{(\mathrm{Q}(x[6])-x[6])^2\} \\
&= \left\{(1-1)^2+(1-(1-\frac{2|\tau_0|}{T}))^2\right. \\
&\left.+(-1-(-1+\frac{2|\tau_0|}{T}))^2+(-1-(-1))^2\right\} \\
&= \left(\frac{1}{4}\right)\left(\frac{4\tau_0^2}{T^2}+\frac{4\tau_0^2}{T^2}\right)=\frac{2\tau_0^2}{T^2}
\end{aligned}
$$

直接判决（方法一）

- ◆代价函数
- ◆代价函数的导数
- ◆迭代公式
- ◆原理图

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直接判决—代价函数

$$J_{CV}(\tau) = \frac{1}{N} \sum_{k=k_0}^{k_0+N-1} \{(\mathrm{Q}(x[k]) - x[k])^2\}$$

$$= \mathrm{avg}\{(\mathrm{Q}(x[k]) - x[k])^2\}$$

直接判决—代价函数的导数

见教材**171**页

直接判决—迭代公式

$$\tau[k+1] = \tau[k] + \mu(Q(x[k]) - x[k])$$

$$\cdot\left(x(\frac{kT}{M} + \tau[k] + \delta) - x(\frac{kT}{M} + \tau[k] - \delta)\right)$$

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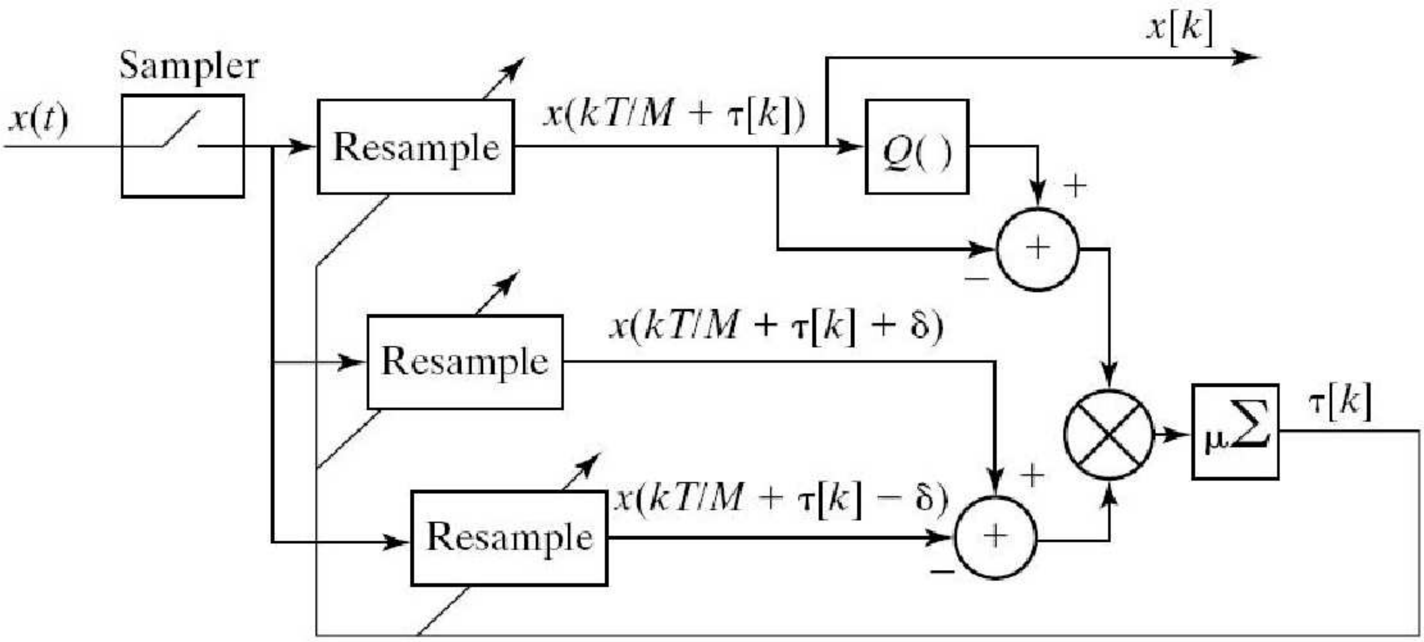
直接判决—原理图



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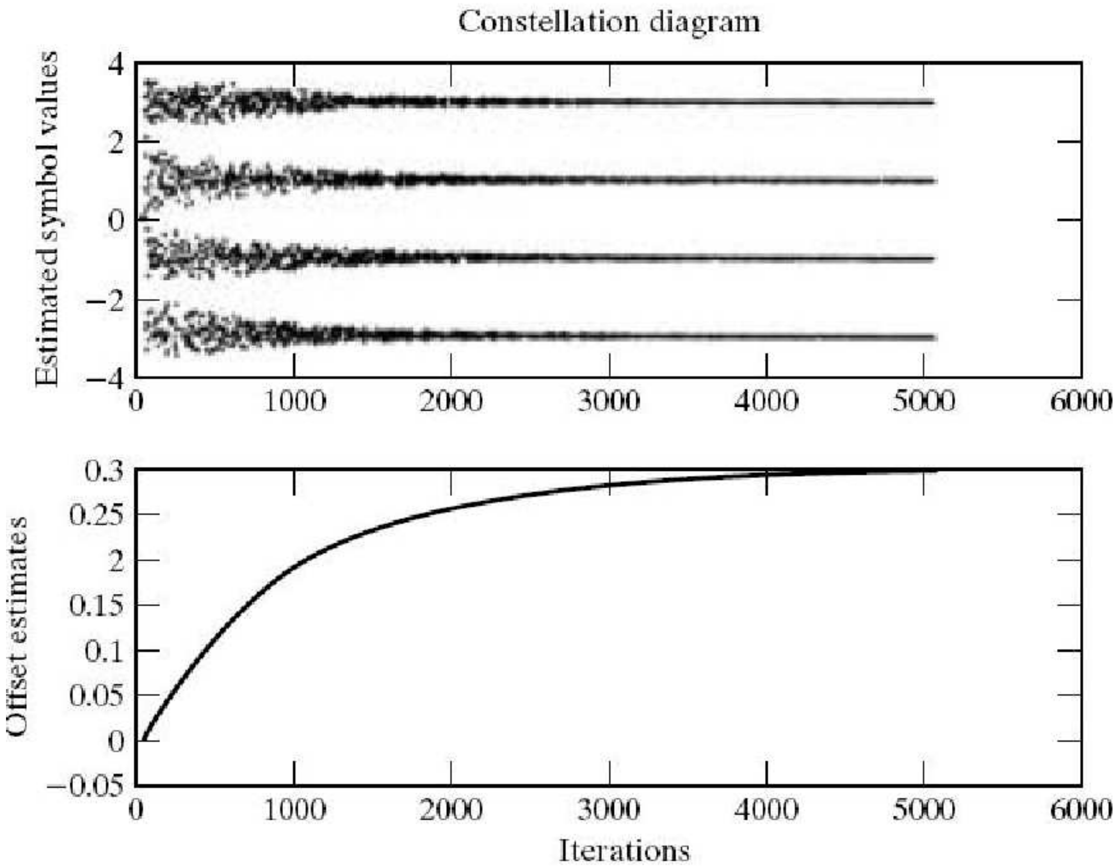
直接判决—效果图



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输出能量达到最大（方法二）

◆代价函数

◆代价函数的导数

◆迭代公式

◆原理图

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输出能量达到最大—代价函数

$$J_{OP}(\tau) = \frac{1}{N} \sum_{k=k_0}^{k_0+N-1} \{x^2[k]\} = \text{avg}\{x^2[k]\}$$

输出能量达到最大—代价函数的导数

见教材175页

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输出能量达到最大—迭代公式

$$\tau[k+1] = \tau[k] + \mu x[k] \cdot \left(x(\frac{kT}{M} + \tau[k] + \delta) - x(\frac{kT}{M} + \tau[k] - \delta) \right)$$

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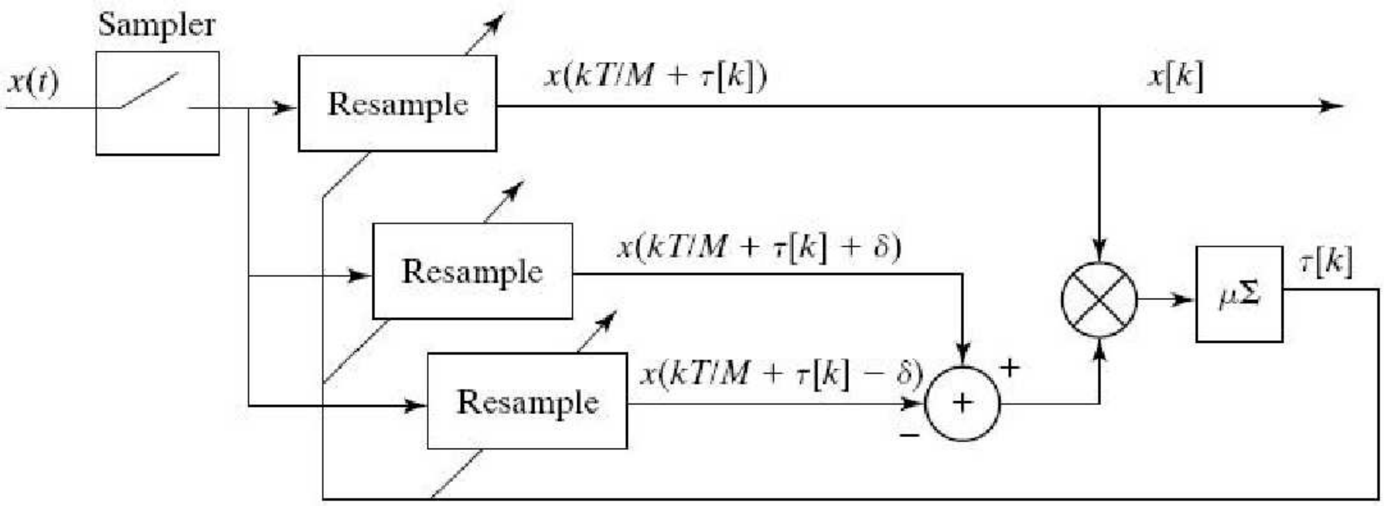
输出能量达到最大－原理图



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输出能量达到最大—效果图