Chapter 6

Digital transmission through band-limited AWGN channels

—— by Prof. XIAOFENG LI
SCIE, UESTC

Contents 5 Hrs

- ISI and zero-ISI condition

  (Ref p380-381, p393-394)

- Design of BL signals for zero-ISI

  (Ref p396-399)

- OFDM

6.2 Design of BL signals for zero-ISI

Most channels are practically BAND-LIMITED. Examples such as,

- Subscribe-line in a standard telephone system is limited to 4kHz.
- Uplink channel in GSM is for data from mobile user to the base and is a bandpass channel limited to 200kHz.

The freq response of channel, $C(f)$

1. For BB, limited to some w , and $C(f)=0,\ |f|>W$
2. For PB, limited to some w about its central freq f_c , and

$$C(f)=0,\ |f-f_c|\le W/2$$

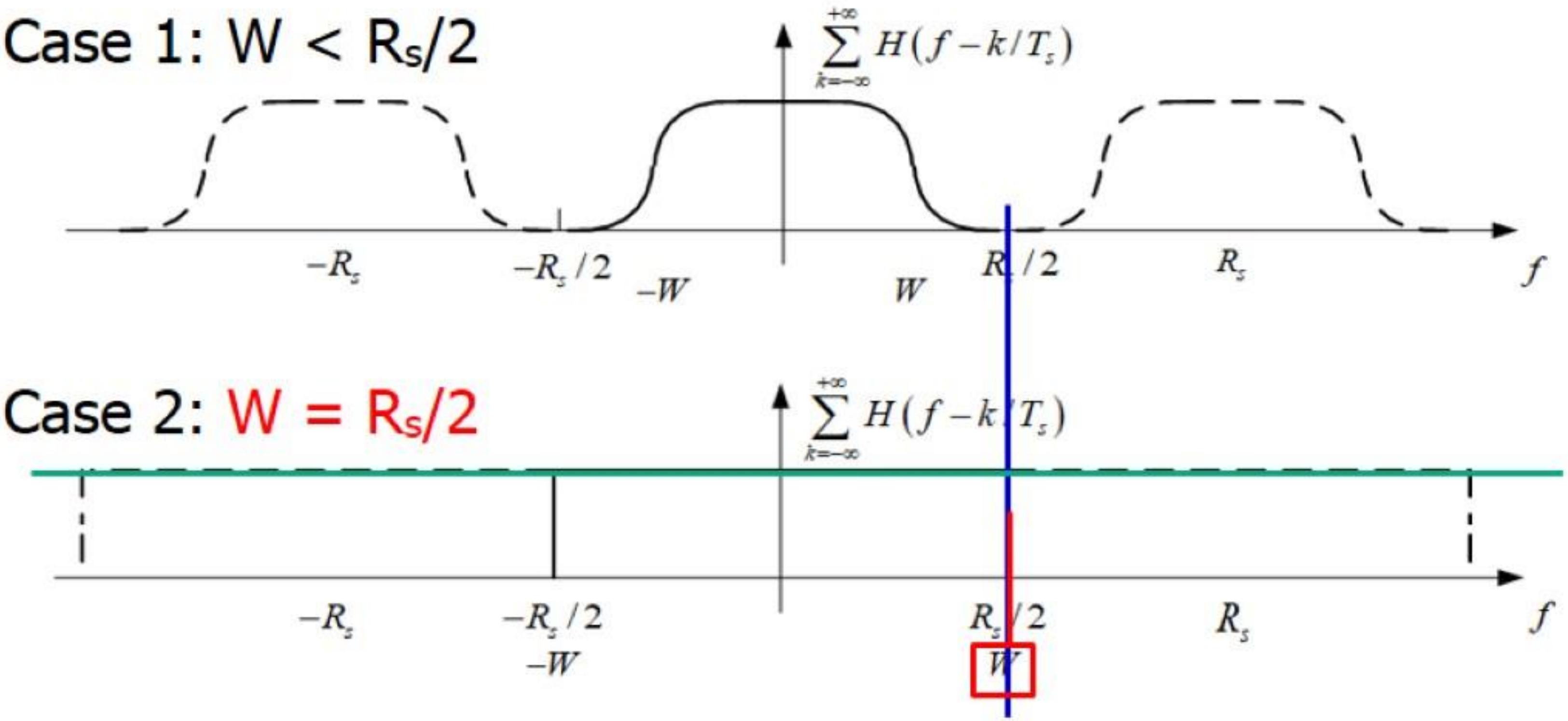
6.2 Design of BL signals for zero-ISI

Think about the channel with BW of WHz.

Case 1: $W < R_s/2$

Flat? Impossible!

Case 2: $W = R_s/2$



Flat? If and only if H(t) is rect.

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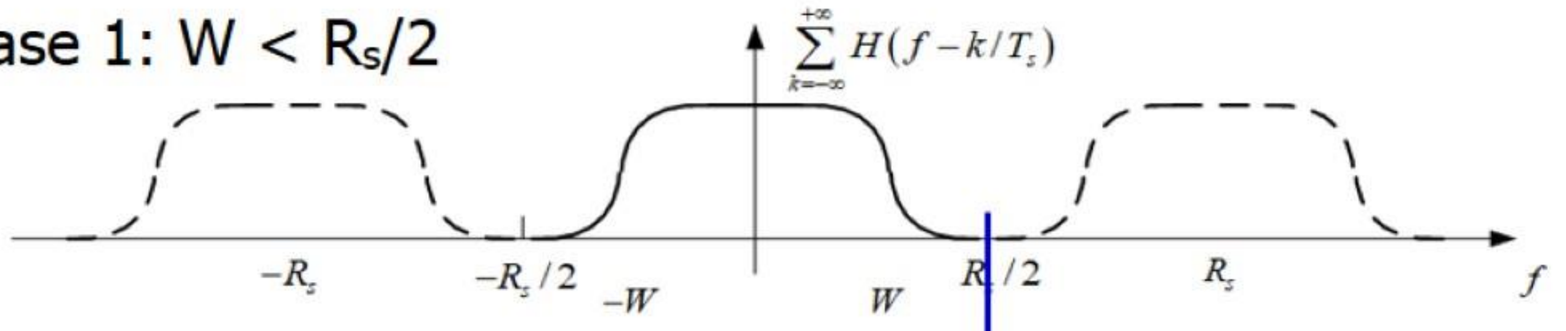

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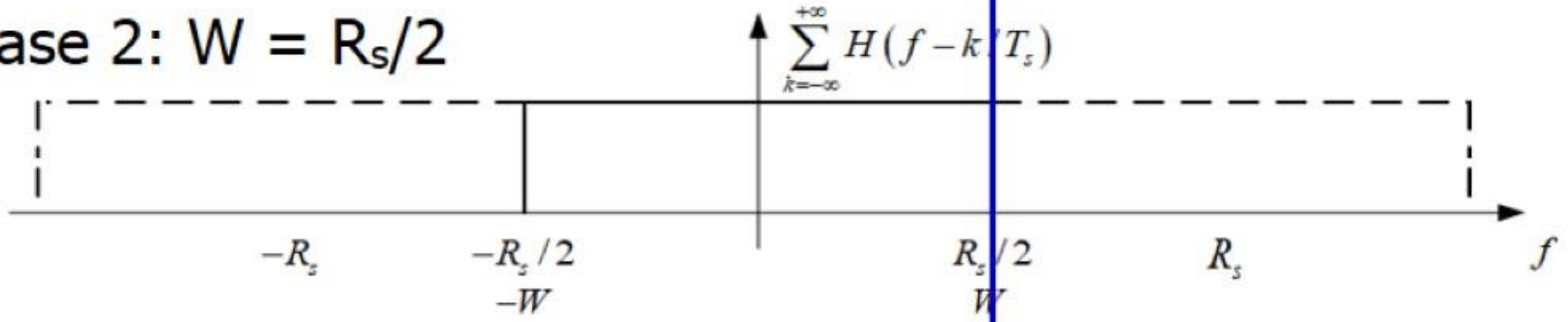
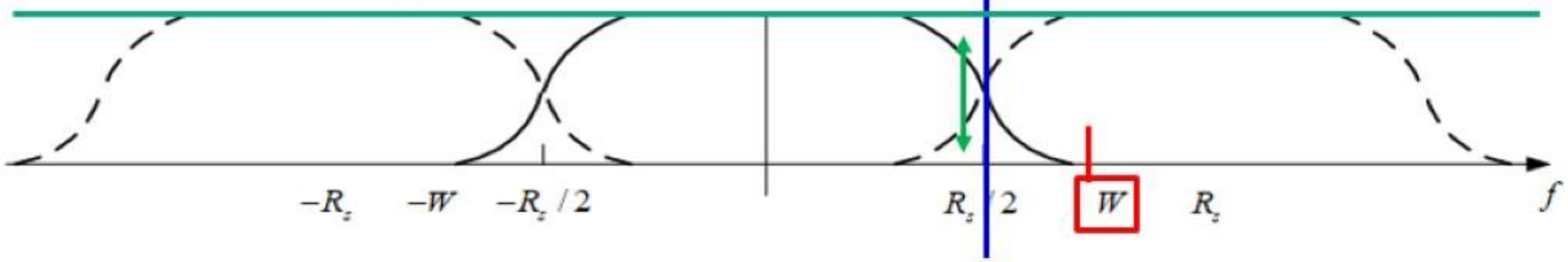


Flat? If and only if H(t) is rect.

Case 3: $W > R_s/2$



Flat? Many chances, once H(t) is complement about $R_s/2$.

6.2 Design of BL signals for zero-ISI

Think about the channel with BW of WHz.

Case 1: $W < R_s/2$

$\sum_{k=-\infty}^{+\infty} H(f - k/T_s)$

Conclusion for BL transmission:
A digital communication system for zero-ISI must meet $R_s<2W$

Flat? Impossible!

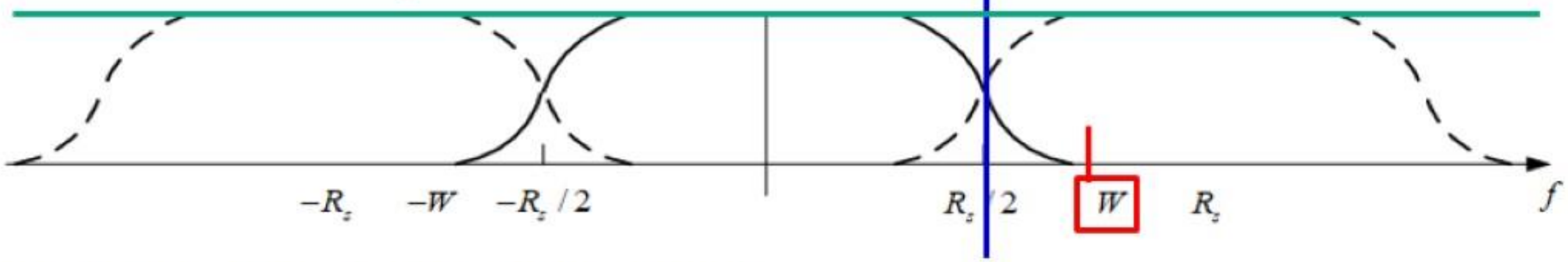
Ca

Nyquist Rate: The maximum symbol rate for zero-ISI transmission over a WHz-channel is 2W baud.

The highest rate can only be reached when the overall system response h(t) is a LPF of WHz.

Flat? If and only if H(t) is rect.

Case 3: $W > R_s/2$



Flat? Many chances, once H(t) is complement about $R_s/2$.

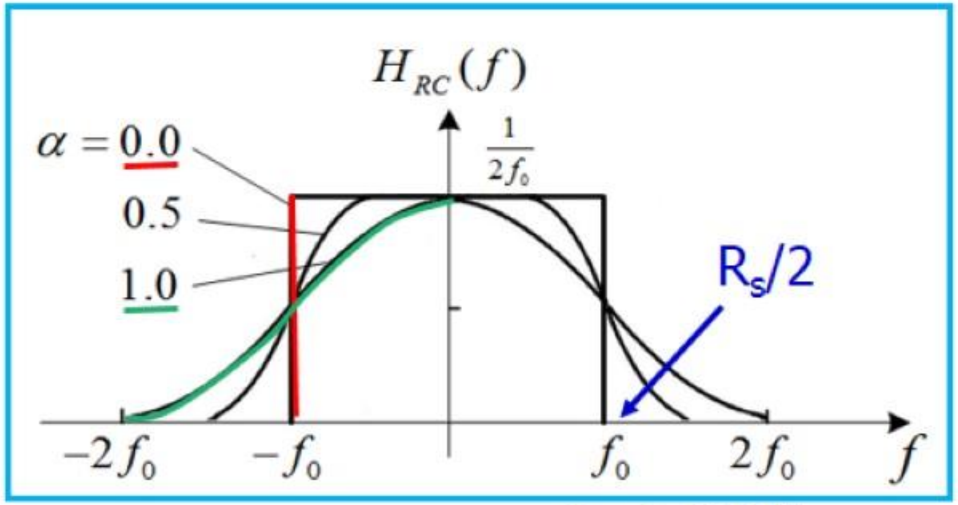
6.2 Design of BL signals for zero-ISI

In the design of BL systems for zero-ISI, Raised-Cosine (RC) spectrum is widely used for $H(f)$.

A RC spectrum and its time response are defined by,

$$H_{RC}(f) = \begin{cases} \dfrac{1}{2f_0} & 0 \le |f| \le (1-\alpha)f_0 \\ \dfrac{1}{4f_0}\left\{1+\cos\dfrac{\pi\left[|f|-(1-\alpha)f_0\right]}{2\alpha f_0}\right\} & (1-\alpha)f_0 < |f| \le (1+\alpha)f_0 \\ 0 & |f| > (1+\alpha)f_0 \end{cases}$$

respectively, where α is called the roll-off factor and $f_0=R_s/2$ called 6dB-BW.



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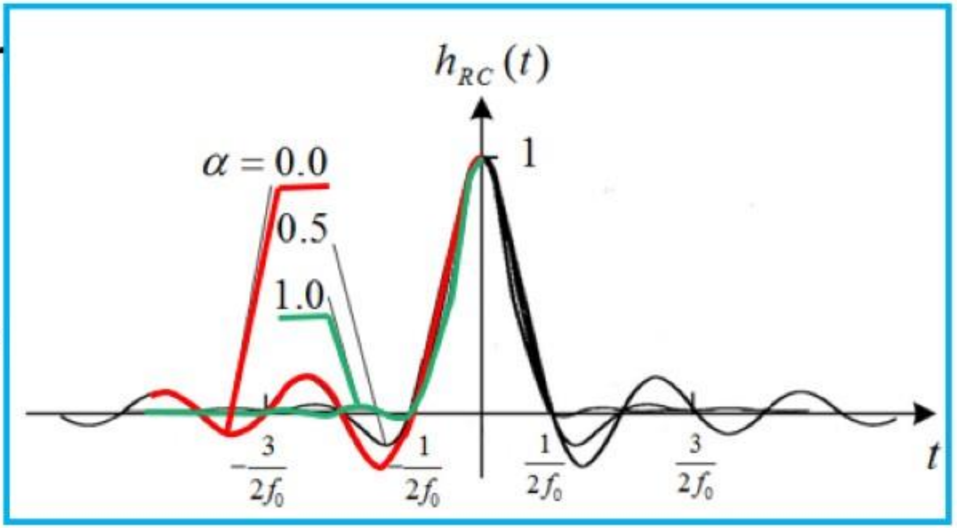

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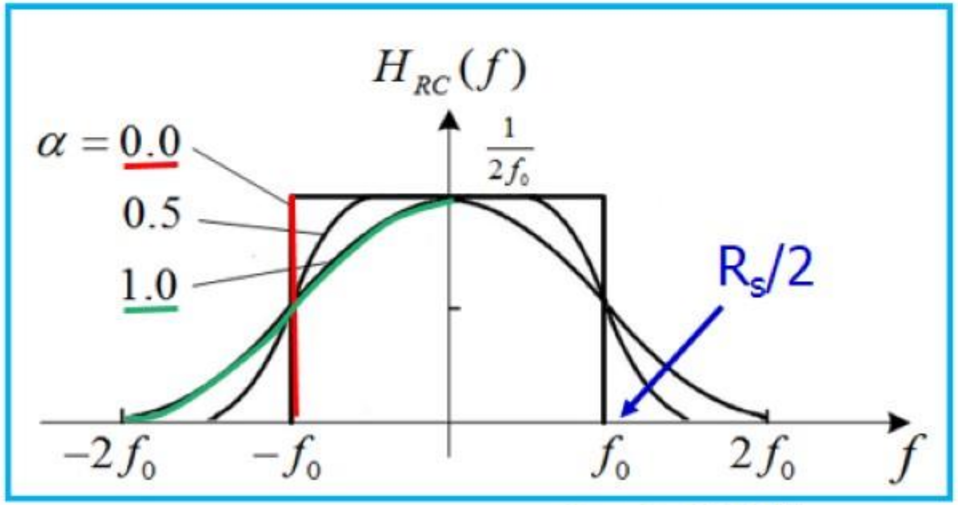
respectively, where α is called the roll-off factor and f_0=$R_s/2$ called 6dB-BW.

and

$$h_{RC}(t) = \frac{\sin(2\pi f_0 t)}{2\pi f_0 t}\cdot\frac{\cos(2\pi\alpha f_0 t)}{1-(4\alpha f_0 t)^2}$$



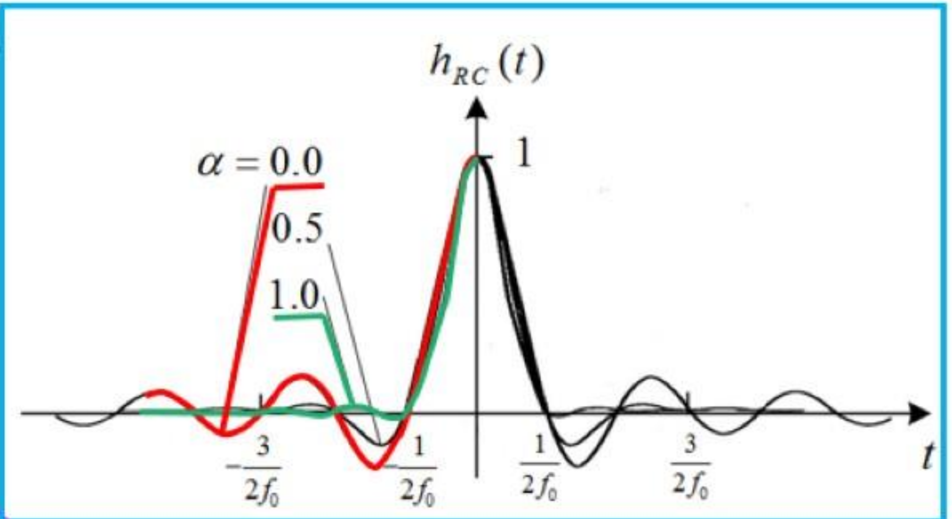
In the design of BL systems for zero-ISI, Raised-Cosine (RC) spectrum is widely used for $H(f)$.

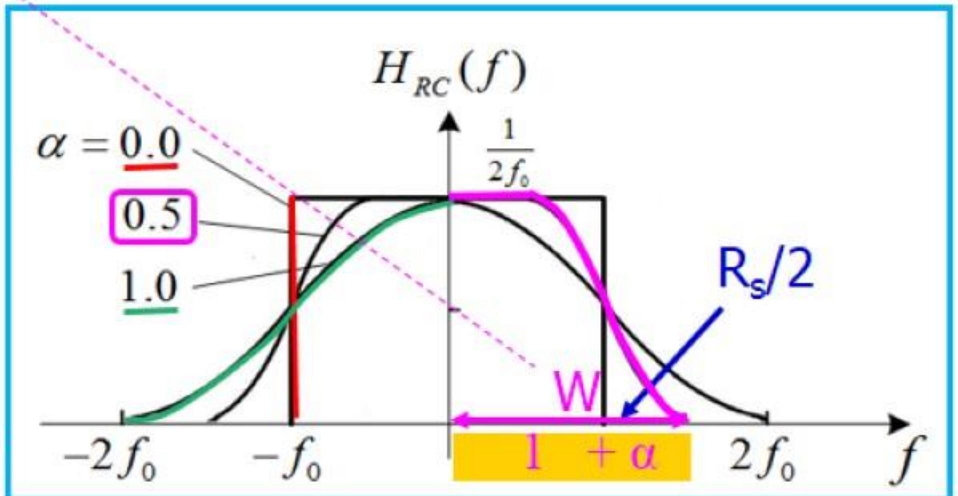
From the figure, we read $W=(1+\alpha)R_s/2$. α controls the transition of the band. We note that:

1) Large α gives a smooth transition and requires large BW, while small α sharp transition and small BW.

2) The RC spectrum for $\alpha=0$ is exactly the LPF and BW reaches the minimum.

3) The smoothness of transition band with non-zero α is very important in practical implementation of filters.





Example: a **passband** channel of 600<f<3600Hz, for 7200kbps transmission.

Analysis:

1. fc=(3600+600)/2=2100(Hz)
2. **W/2**=3600-2100=1500

   Make W/2>=Rs/2=[7200/log2(M)]/2

   log2(M)>=7200/(2*1500)=2.4,

   Take M=8, and 8PSK. Rs=2400 Baud
3. Take W/2>=(1+ α)Rs/2, that is 1500>=1200(1+ α),

   α <=1500/1200-1=5/4-1=1/4, Take a RC filter with α =0.25
4. The spectral efficiency is: Rb/**W**=7200bps/3000Hz=2.4bps/Hz