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# **Root-raised-cosine filter**

In <u>signal processing</u>, a **root-raised-cosine filter** (**RRC**), sometimes known as **square-root-raised-cosine filter** (**SRRC**), is frequently used as the transmit and receive filter in a <u>digital communication</u> system to perform <u>matched filtering</u>. This helps in minimizing <u>intersymbol interference</u> (ISI). The combined response of two such filters is that of the <u>raised-cosine filter</u>. It obtains its name from the fact that its frequency response,  $H_{rrc}(f)$ , is the square root of the frequency response of the raised-cosine filter,  $H_{rc}(f)$ :

$$H_{rc}(f) = H_{rrc}(f) \cdot H_{rrc}(f)$$

or:

$$|H_{rrc}(f)| = \sqrt{|H_{rc}(f)|}$$

# Why it is required

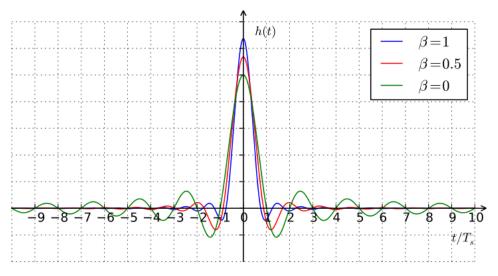
To have minimum ISI (<u>Intersymbol interference</u>), the overall response of transmit filter, channel response and receive filter has to satisfy <u>Nyquist ISI criterion</u>. <u>Raised-cosine filter</u> is the most popular filter response satisfying this criterion. Half of this filtering is done on the transmit side and half is done on the receive side. On the receive side, the channel response, if it can be accurately estimated, can also be taken into account so that the overall response is <u>Raised-cosine</u> filter.

## **Mathematical Description**

The RRC filter is characterised by two values;  $\beta$ , the *roll-off factor*, and  $T_s$  the reciprocal of the symbol-rate.

The <u>impulse response</u> of such a filter can be given as:

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The impulse response of a root-raised cosine filter multiplied by T<sub>s</sub>, for three values of  $\beta$ : 1.0 (blue), 0.5 (red) and 0 (green).

$$h(t) = egin{dcases} rac{1}{T_s} \left(1 + eta(rac{4}{\pi} - 1)
ight), & t = 0 \ rac{eta}{T_s \sqrt{2}} \left[ \left(1 + rac{2}{\pi}
ight) \sin\left(rac{\pi}{4eta}
ight) + \left(1 - rac{2}{\pi}
ight) \cos\left(rac{\pi}{4eta}
ight) 
ight], & t = \pm rac{T_s}{4eta} \ rac{1}{T_s} rac{\sin\left[\pirac{t}{T_s}\left(1 - eta
ight)
ight] + 4etarac{t}{T_s}\cos\left[\pirac{t}{T_s}\left(1 + eta
ight)
ight]}{\pirac{t}{T_s} \left[1 - \left(4etarac{t}{T_s}
ight)^2
ight]}, & ext{otherwise} \end{cases}$$
 otherwise ough there are other forms as well.

though there are other forms as well.

Unlike the raised-cosine filter, the impulse response is not zero at the intervals of  $\pm T_s$ . However, the combined transmit and receive filters form a raised-cosine filter which does have zero at the intervals of  $\pm T_s$ . Only in the case of  $\beta$ =0 does the root raised-cosine have zeros at  $\pm T_s$ .

## References

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