Illustration of the concepts of system bandwidth and rise time through the analysis of a first order CT low pass filter

Bandwidth and Risetime

Rise time is an easily measured parameter that provides considerable insight into the potential pitfalls in performing a measurement or designing a circuit. Rise time is defined as the time it takes for a signal to rise (or fall for fall time) from 10% to 90% of its final value.

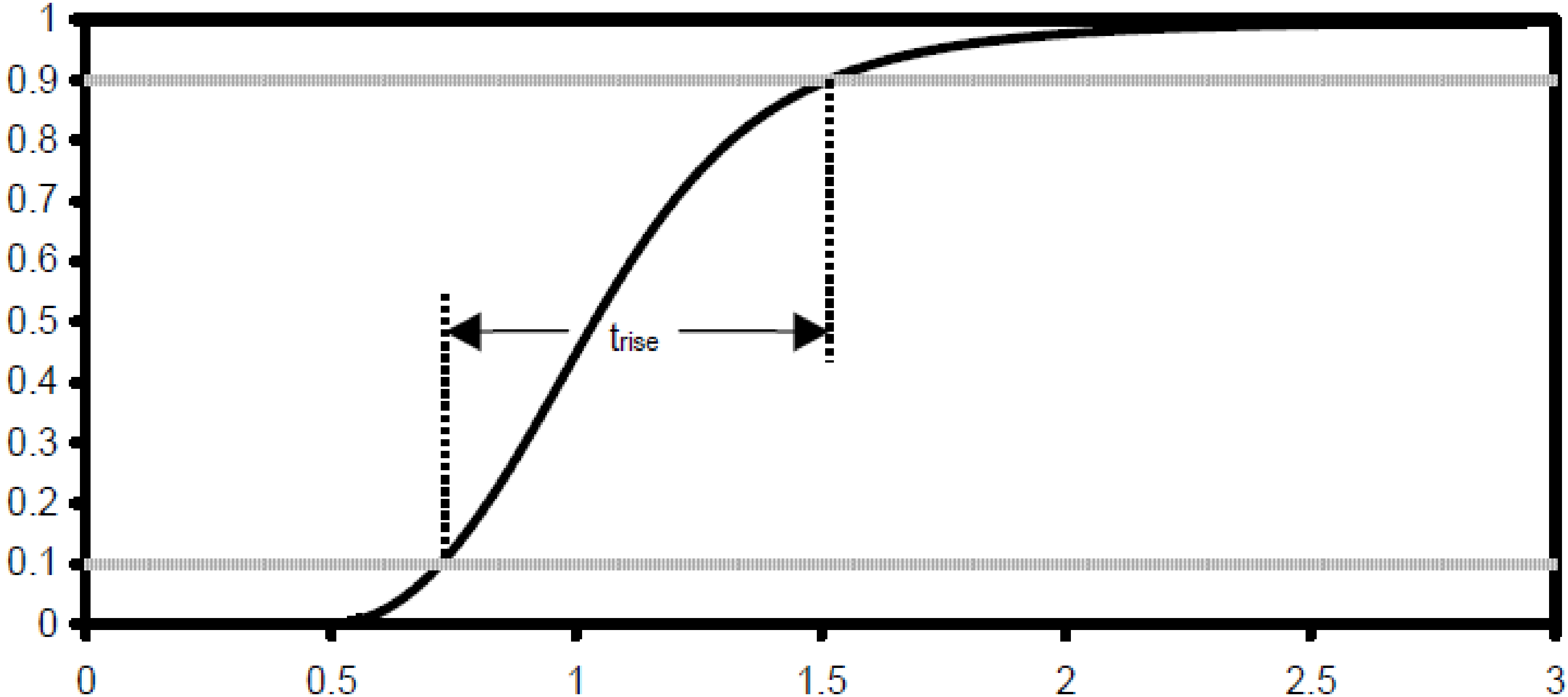


Figure Risetime defined

A useful relationship between rise time and bandwidth is given by

$$t_{rise} = \frac{0.35}{f_{3dB}}$$

Recognizing that for a simple RC circuit f3dB = (2π*RC)-1*, this is equivalent to

$$t_{rise} = 2.2RC$$

First Order Low pass Filter

A **low-pass filter** is a filter that passes signals with a frequency lower than a certain cutoff frequency and attenuates signals with frequencies higher than the cutoff frequency. The amount of attenuation for each frequency depends on the filter design. The filter is sometimes called a **high-cut filter**, or **treble cut filter** in audio applications. A low-pass filter is the opposite of a high-pass filter. A band-pass filter is a combination of a low-pass and a high-pass filter.

Low-pass filters exist in many different forms, including electronic circuits (such as a *hiss filter* used in audio), anti-aliasing filters for conditioning signals prior to analog-to-digital conversion, digital filters for smoothing sets of data, acoustic barriers, blurring of images, and so on.

The moving average operation used in fields such as finance is a particular kind of low-pass filter, and can be analyzed with the same signal processing techniques as are used for other low-pass filters. Low-pass filters provide a smoother form of a signal, removing the short-term fluctuations, and leaving the longer-term trend.

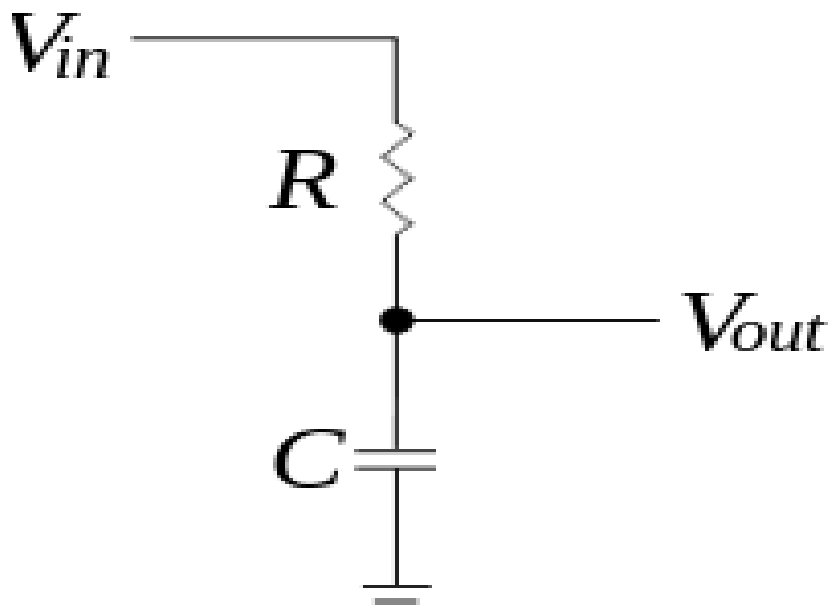
Continuous-time filters can also be described in terms of the Laplace transform of their impulse response, in a way that lets all characteristics of the filter be easily analyzed by considering the pattern of poles and zeros of the Laplace transform in the complex plane. (In discrete time, one can similarly consider the Z-transform of the impulse response.)

For example, a first-order low-pass filter can be described in Laplace notation as:

RC Filter

One simple low-pass filter circuit consists of a resistor in series with a load, and a capacitor in parallel with the load. The capacitor exhibits reactance, and blocks low-frequency signals, forcing them through the load instead. At higher frequencies the reactance drops, and the capacitor effectively functions as a short circuit.

$$\frac{\text{Output}}{\text{Input}} = K\frac{1}{\tau s + 1}$$



The combination of resistance and capacitance gives the time constant of the filter (represented by the Greek letter tau). The break frequency, also called the turnover frequency or cutoff frequency (in hertz), is determined by the time constant:

$$f_c = \frac{1}{2\pi\tau} = \frac{1}{2\pi RC}$$

$$\omega_c = \frac{1}{\tau} = \frac{1}{RC}$$