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Concern

The Use of Filters and Holdoff

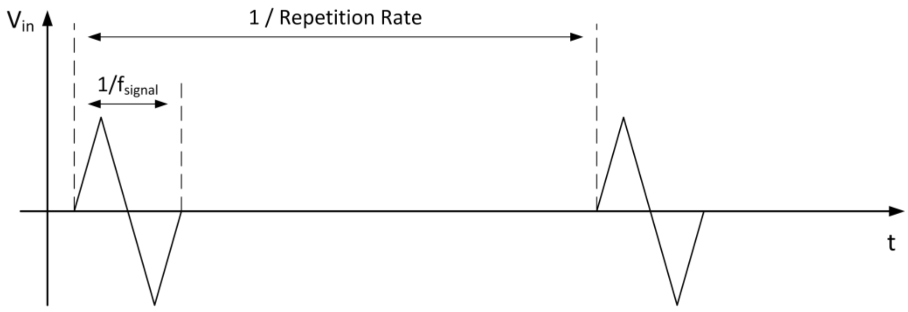
1. Introduction

When a sensor system works in a rough electrical environment, noise or parasitic oscillations can not be avoided some times. Mistriggering can be the result. Limmiting the input bandwidth with a filter may be useful and very effective in some cases. In others one achieves just instability and parasitic triggering by using a low pass filter at the input.

This paper explains the possibilities of filtering and its limmits. It takes a look to the difference between the corner frequency of a filter and the repetition rate of a cyclic pulse signal. And finally filtering is compared to the holdoff function integrated to PI608 Versatile Trigger Unit.

2. Fundamental Frequency and Repetition Rate

One fact that often leads to confusion is that the fundamental frequency of a signal pulse has nothing to do with its repetition rate. The fundamental frequency marked below as f_{signal} just describes how “fast or steep” a signal is. Its repetition rate describes how often the pulse occurs. The knowledge of this difference will be very helpful for the following chapters.



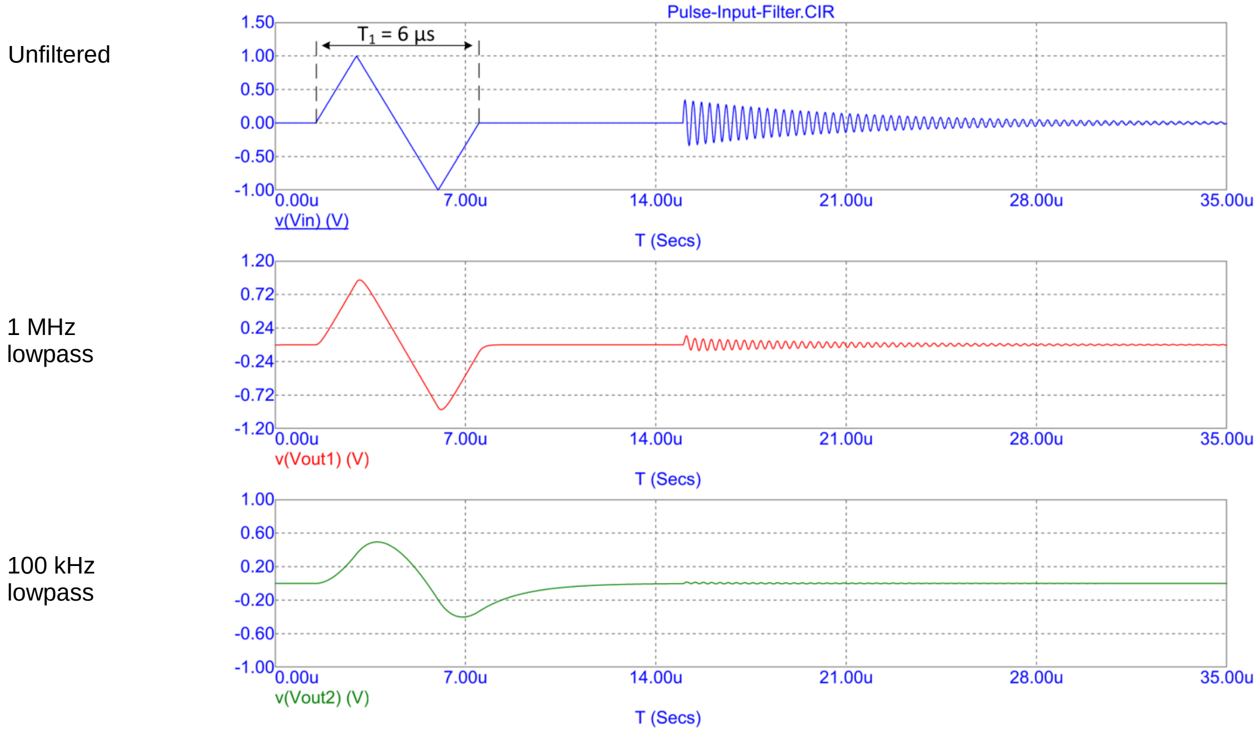
Note: The fundamental frequency of a periodic signal may also be known as first harmonic.

3. RF Rejection – a Job for a Lowpass Filter

Here the sensor signal (V_{in}) is disturbed by an external interference whose frequency is far higher than the fundamental frequency of the signal. The repetition rate is far lower than the fundamental frequency of the signal. In other words, repetition rate, signal frequency and interference frequency are in different frequency bands.

In the example below the input signal is a triangle with $f_1 = 1/T_1 = 1 / 6\ \mu s = 166$ kHz. See in the plot below the blue graph marked as "unfiltered".

When using a lowpass filter with fc = 1 MHz, the interference is significantly attenuated, while the signal pulse remains almost unaffected. See the red graph. That's the case where filtering is a good choice.



PI608 Versatile Trigger Unit has a maximum bandwidth limit of 1MHz. In general that's a good setting for most industrial applications. RF rejection is provided, while the sensor signal remains unaffected.

4. Where Filtering fails

In the graph below, the sensor signal has very steep edges. That can be necessary to get a high time accuracy.
The output signal of an optical sensor could look like that. As in the example above in chapter 3, the cable connected to the sensor is disturbed by interference such as capacitive coupling.
The interference can be attenuated by a lowpass filter. But as the interference suppression becomes effective, the signal slew rate is dramatically reduced. See Vout2 (green) and Vout3 (pink). That can cause several problems like loss of timing accuracy. In some cases it may even lead to missing trigger pulses. That may occur when the signal amplitude is decreased dramatically by the filter, as it is shown in the example Vout4 (blue). As we see it is almost possible to filter the pulse completely away.

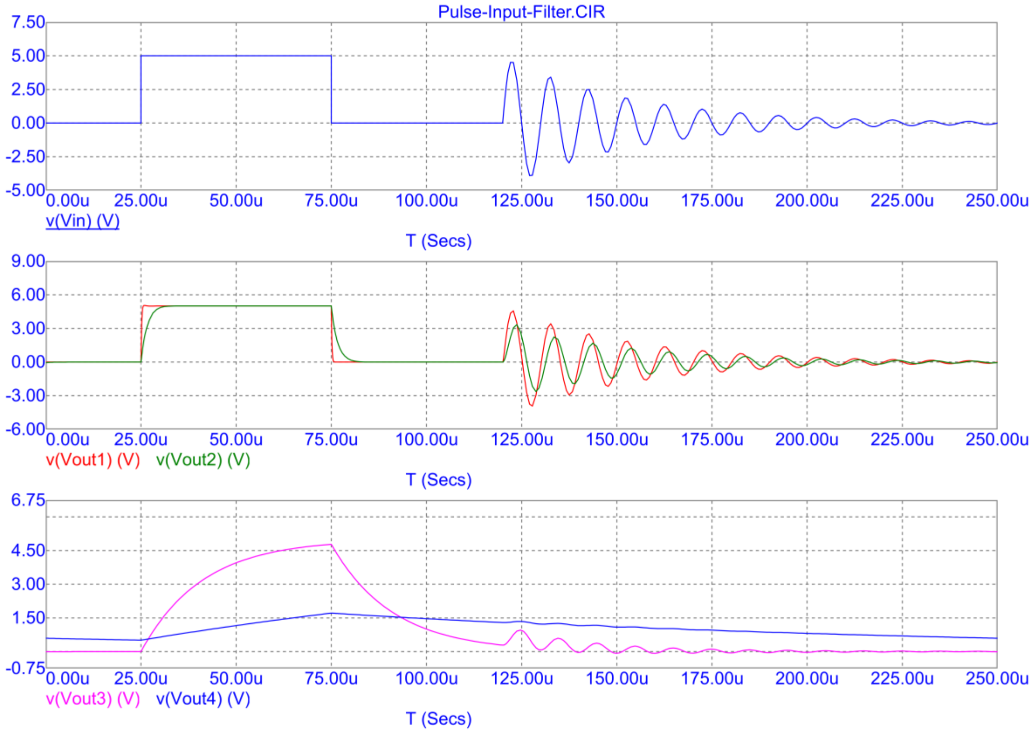
Unfiltered:

red:
fc = 1 MHz

green:
fc = 100 kHz

pink:
fc = 10 kHz

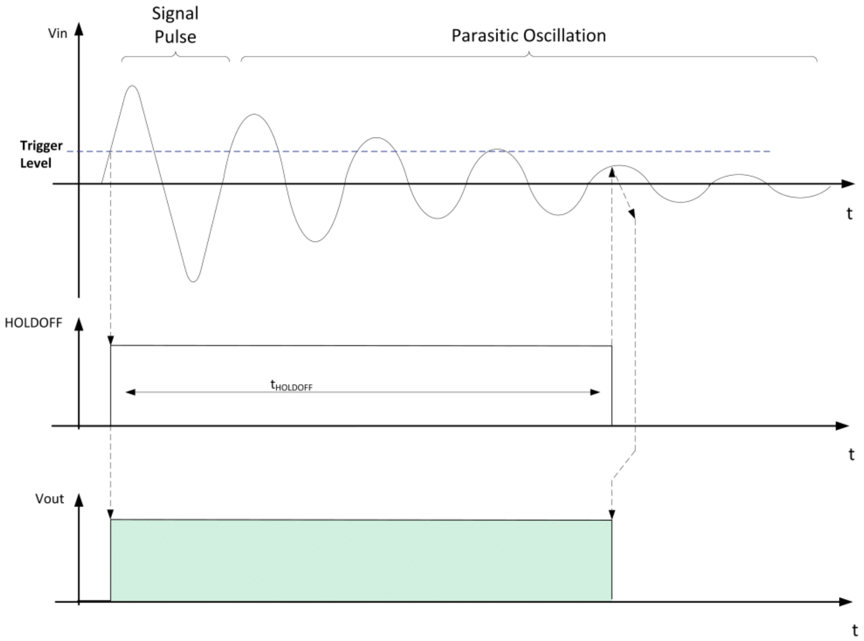
blue:
fc = 1 kHz



5. The Holdoff Function – a Solution in the Time Domain

The main advantage of the holdoff function is, that it does not matter what noise or interference frequencies are superposed to the signal (V_{in}). That means the input signal can be processed with a high bandwidth like lowpass filter set to fc = 1 MHz. A high slew rate or slope steepness and with that a high timing accuracy remains.

Activating the holdoff function in PI608 Versatile Trigger unit is like locking the output for a specified time after a trigger event. In other words for positive edge triggering: When the input signal crosses the set trigger level ascending, the output goes high and remains high until $t_{holdoff}$ is elapsed. Then it is unlocked again. See the graph below.



The holdoff function is a powerful feature to suppress parasitic triggering. To get further information about it, please see "TN608-02 Blocking parasitic triggering with the HOLDOFF function".

6. Conclusion

The advantage of filtering is, that it does not matter at which instant of time the input signal is disturbed. Use it to block high frequency noise. Check if it does not flatten your signal too much.

A rough rule of choice to calculate the uncritical corner frequency is described below:

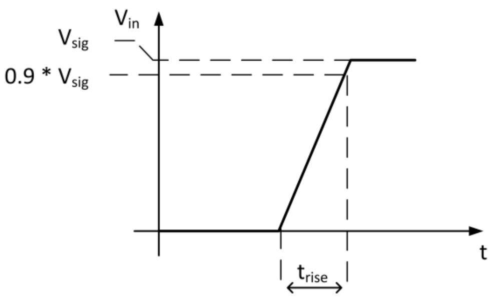
$$0.9 * t_{rise} > 2.2 * \frac{1}{2 * \pi * f_{c\,filter}}$$

Means that:

$$f_{c\,filter} > 2.2 * \frac{1}{2 * \pi * 0.9 * t_{rise}}$$

Simplified:

$$f_{c\,filter} > \frac{0.389}{t_{rise}}$$



If your system tends to oscillate caused by your trigger pulse, the HOLDOFF function is the first choice. In general we recommend using the HOLDOFF function, as cases where it disturbs a proper triggering are very rare.