

Optimized Low-Pass Filter Architecture with Fast Settling Response

Bhairi Srivani

Department of Electronics and Communication Engineering
Rajiv Gandhi University of Knowledge Technologies, Srikakulam

Abstract

Conventional RC low-pass filters are effective in reducing noise, but they require a significant amount of time to bring the signal back to its original state when it undergoes significant changes. Adding diodes that speed up the charging and discharging of capacitors while maintaining the steady-state frequency response allowed for the creation of a fast-settling low-pass filter architecture, which was used to circumvent this issue. The circuit was built and tested in eSim, and the findings showed that it worked far better than a normal RC filter when it came to settling.

1 Introduction

Low-pass filters are basic parts of analogue signal processing that are often used to clean up signals and reduce noise. The simple RC low-pass filter is the most prevalent because it is easy to make and its frequency response is easy to predict. But one problem with the standard RC filter is that it takes a long time to settle down when the signal changes a lot. This happens because the series resistor only lets the capacitor charge or discharge, which slows down the response time.

In many cases, faster settling is better for system performance without losing filtering properties. To fix this problem, redesigned low-pass filter topologies have been suggested that add nonlinear elements to speed up charging and discharging while keeping the same cutoff frequency. These methods greatly lower the effective time constant for big transients, yet they act like a typical RC filter for small signals. This project is all about designing and building a low-pass filter that settles quickly based on this idea.

2 Purpose of fast settling filter

- To reduce the settling time of a low-pass filter compared to a conventional RC filter.
- To allow the filter capacitor to charge and discharge faster during large signal transitions.
- To maintain the desired low-pass frequency response while improving transient behavior.
- To overcome the limitation of slow response caused by the series resistor in standard RC filters.

- To provide faster and more accurate signal conditioning in systems where rapid response is required.

3 Working Principle

To improve the settling time of a low-pass filter, a nonlinear diode-clamped configuration can be used. In the circuit, the filter capacitor C1 is charged and discharged through the low forward resistance (R_{ON}) of the diode during the initial portion of a large input step change. This allows the capacitor to respond much faster compared to a conventional RC filter where the charging path is restricted only by the series resistor. When the output voltage gets close to the input voltage within the diode's forward voltage drop (around 0.6 V), the diode turns off. At this point, the capacitor c1 only works with the series resistor R1, and the circuit works like a conventional single-pole RC low-pass filter.

This nonlinear action lowers the effective time constant during big changes while keeping the cutoff frequency response the same during steady-state operation. This makes the filter settle faster without losing frequency-domain performance.

4 Proposed System and eSim Realization

When a large step input is applied, the capacitor must charge or discharge only through the resistor. This makes the response slow and increases settling time. In our circuit, a pair of diodes provides an alternate low-resistance charging path for the capacitor. During a large input transition, one diode becomes forward-biased, allowing current to bypass the resistor and quickly charge/discharge the capacitor. The forward resistance of the diode (R_{on}) is very small, so the effective time constant is reduced.

The design is implemented and validated in eSim as shown in Figure 1. The diode IN4148 is the limitation in the circuit because component is present in eSim.

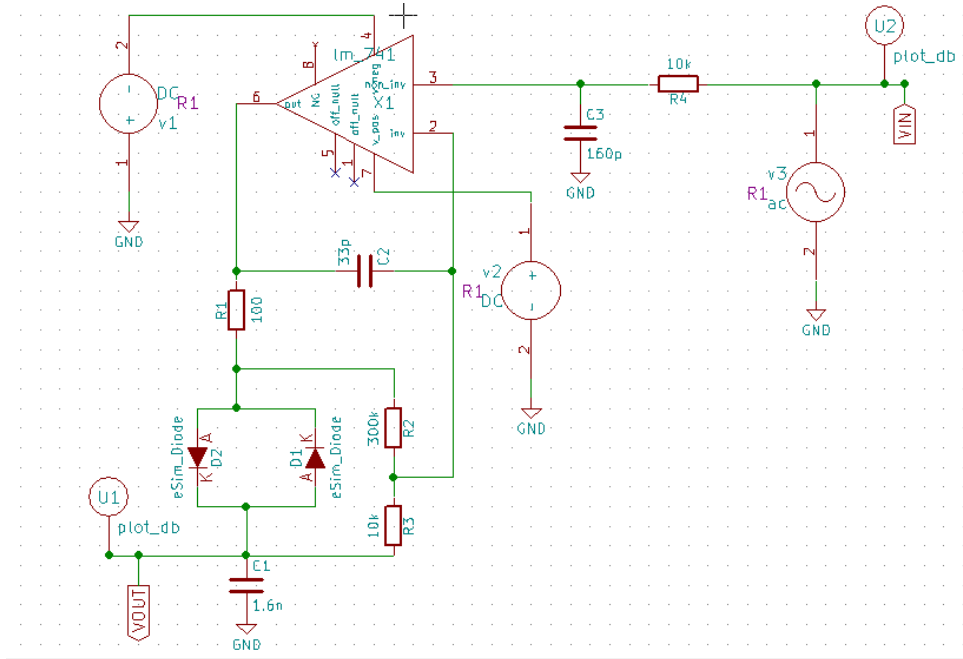


Figure 1: Fast Settling Low pass Filter in eSim

5 Simulation Results

The AC responses fig 2 and fig 3 of the fast-settling filter shows the same response as a conventional RC low-pass filter, confirming that frequency-domain behavior is preserved.

In the transient response fig 4 the fast-settling filter, aided by the diode path, charges and discharges the capacitor much faster. The output reaches steady state much faster. Hence reducing the time constant.

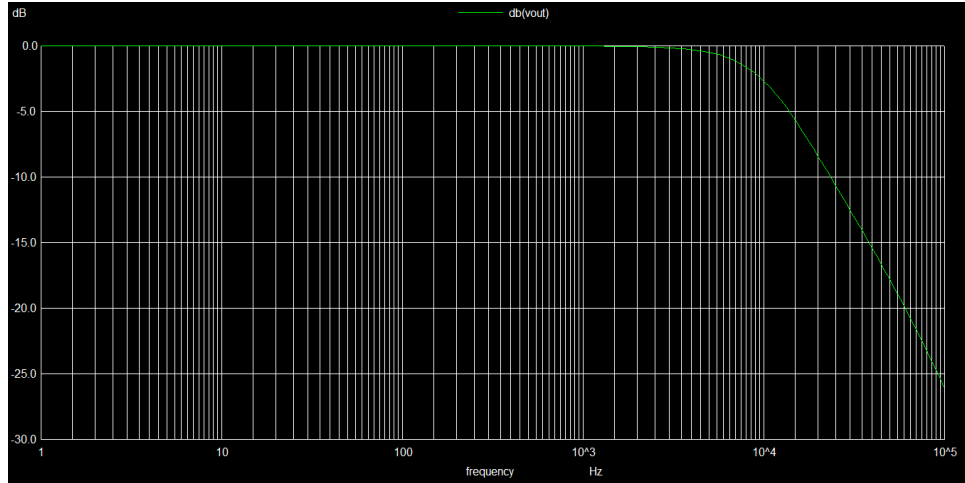


Figure 2: Frequency response

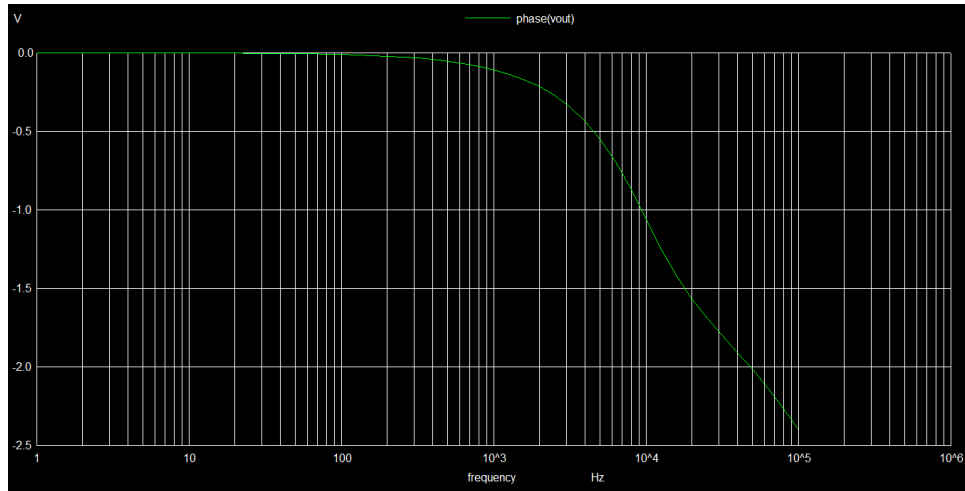


Figure 3: Phase Response

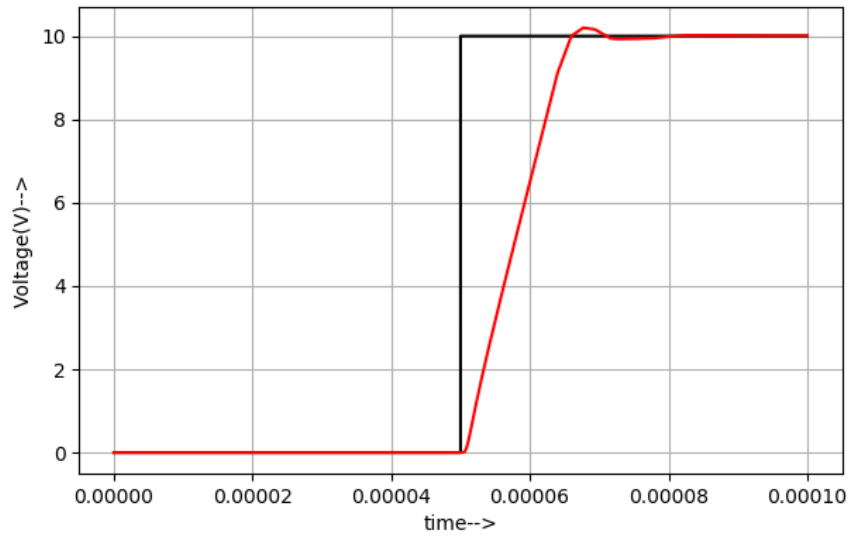


Figure 4: Transient Simulation Result

6 Conclusion

To get around the long settling period of regular RC filters, a fast-setting low-pass filter was designed and built. Adding a diode-assisted technique lets the capacitor charge and discharge faster during big signal changes, which cuts down on settling time while keeping the low-pass characteristics that are wanted. We used eSim to examine and test the circuit, and the results showed that it worked better than the typical RC setup. But because the eSim component library didn't have the commonly used diode 1N4148, a different diode model was used for the simulation. Even so, the proposed filter's practical behavior was clearly shown.

References

1. FAST SETTLING LOW-PASS FILTER By Rod Burt and R. Mark Stitt (602) 746-7445
2. Fast-settling low-pass filter circuit (Rev. A)