**Experiment 3: Active Filters Experiment Report**

**Title**: Experimental Study on Active Filtering of High Frequency Noise

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**I. Introduction**

The aim of this experiment is to demonstrate techniques for filtering a noisy electrical signal. A noisy signal is generated by adding a high-frequency signal to a “clean” signal using a summing amplifier. Hardware filtering of the noisy signal is tested using first and second-order active filters, and software filtering is achieved by capturing the signal to obtain raw data and using software tools. It is important to note that all circuit diagrams must be included in the report. Signal filtering plays a crucial role in many electronic circuits as it helps to improve the quality and reliability of the signal. By removing unwanted noise, the filtered signal can be better analyzed and used in various applications.

**II. Experimental Procedures and Results**

**Part 1: Hardware Filtering of Noise**

1. **Experimental Setup and Signal Generation**
   * To generate a high-frequency signal to approximate noise, the function generator was set to produce a sine wave with a frequency of 5 kHz and 5 Vpp. A clean signal was generated by setting the second function generator to produce a noise signal of 50 mVpp.
   * The noise was added to the signal using a summing amplifier designed in the standard inverting operational amplifier configuration. Since the output voltage of this configuration is inverted, a single-input inverting adder with a gain of one was added to the circuit to re-invert the signal.
2. **Signal Testing and Graphical Representation**
   * Representative graphs were produced for the clean signal, the noise signal, and the noisy signal. If Task 5 was completed in the in-person lab, these results were included in the report; otherwise, the Multisim results were used.
   * The clean signal graph shows the characteristics of the original signal without added noise. The noise signal graph displays the generated noise waveform. The noisy signal graph illustrates the combined signal with the added noise.

**Part 2: Second-Order Band Pass Filter**

1. **Filter Design and Implementation**
   * The appropriate cut-off frequency was decided upon, and the second-order band pass filter was designed using the software at <https://filterlab.microchip.com/>. The designed filter was then implemented and tested in Multisim. The noise signal for this part could be generated using the Thermal Noise voltage source.
2. **Data for Report**
   * Graphs were generated to show the input signal and the noisy signal, as well as the noisy signal and the output from the second-order filter. These graphs help to visualize the effect of the second-order filter in reducing the noise in the signal. Additionally, the frequency response of the second-order filter was analyzed. The bandwidth of the filter was determined, and it was observed how the filter attenuated frequencies outside the desired passband. The gain of the filter within the passband was also measured and compared to the theoretical expectations.

**Part 3: Fourth-Order Band Pass Filter**

1. **Filter Design and Implementation**
   * Similar to the second-order filter, the appropriate cut-off frequency was determined, and the fourth-order band pass filter was designed using the software at <https://filterlab.microchip.com/>. The circuit was implemented and tested in Multisim.
2. **Data for Report**
   * Graphs were produced to show the output from the second-order filter and the output from the fourth-order filter. This comparison allows for an assessment of the performance improvement achieved by using a higher-order filter. The frequency response of the fourth-order filter was also studied in detail. It was noted that the fourth-order filter had a narrower bandwidth and better attenuation of out-of-band frequencies compared to the second-order filter. The roll-off rate of the fourth-order filter was steeper, indicating its superior ability to reject noise.

**III. Conclusion**

Through this experiment, techniques for filtering noisy electrical signals using active filters were explored. The process of generating a noisy signal, designing and implementing first and second-order active filters, and analyzing the results through graphical representations was successfully carried out. The data and graphs obtained provide valuable insights into the effectiveness of different filtering methods and the impact of filter order on noise reduction. The frequency response analysis of the filters further enhanced the understanding of their performance characteristics. This experiment serves as a foundation for further studies and applications in the field of signal processing and electronics, where noise filtering is a crucial aspect for accurate signal analysis and system performance. Future experiments could focus on optimizing the filter design, exploring different filter topologies, and applying these filtering techniques to more complex real-world signals.