First and second order filtering of high frequency noise

Aim

The experiment demonstrates techniques to filter a noisy electrical signal.

Introduction

A noisy signal will be generated by adding a high frequency signal to a “clean” signal using a summing amplifier.
Hardware filtering of the noisy signal will be tested using a number of active filters (first order a second order).
Software filtering is achieved by means of capturing the signal to obtain the raw data which can be filtered then using a number of software tools.

Note: You must include all circuit diagrams in your report.

Hardware filtering of noise

Signal filtering performs an important function in some electronic circuits, simple passive RC and RLC filter circuits are limited and so active filters are generally preferred. The goal of part 1 of the practical is to produce a noisy signal which will be filtered using both a first and second order active filter.

For this lab we need to:

1. Generate a approximate model of high frequency noise
2. Add the noise to a clean signal
3. Filter out the noise.

Task 1: Generate a high frequency signal to approximate noise

Set the function generator to produce a sine wave of frequency 5 kHz and 500 mVpp

Task 2: Generate a clean signal

Set the second function generator to produce a sine wave signal of 1 kHz and 2 Vpp.

Task 3: Add the noise to the signal

Using a summing amplifier design and implement the addition of the noise to the clean signal to produce a noisy signal.

Note: Design the summing amplifier using standard *inverting* operational amplifier configuration i.e.the output voltage will be inverted. To re-invert the signal add a single input inverting adder with a gain of one to your circuit.

***Task 4: Test* the circuit**

Produce representative graphs of

1. The clean signal
2. The noise signal
3. The noisy signal

Task 5: Filter of the noisy signal using a first order filter

- Decide on an appropriate cut-off frequency for the filter.
- Design an active first order filter with the required cut-off frequency, choose a cut-off frequency is slightly higher than the frequency of the clean signal i.e. chose a cut-off frequency of 1200 Hz.
- Explain how the passive component values were determined.
- Implement and test the filter.

Task 6: Filter of the noisy signal using a second order filter

- Decide on the appropriate cut-off frequency (as above)
- Design the filter using *online software as described below*

From the mircropchip home page (www.microchip.com) search for and install FilterLab® V2.0 Use the software to design the second order filter.

- Show how the passive component values are determined using the coefficient method.

- Implement and test the circuit.

Task 7:

Using a digital oscilloscope:

1. Show the two input signals
2. Show the input signal and noisy signal
3. Show noisy signal and output from 1st order filter
4. Show noisy signal and output from 1st order filter
5. Show output from 1st order filter and 2nd order filter
6. Comment on the results.

Task 8: Filtering using NI LabVIEW

- Connect your noisy circuit to LabVIEW using an **NI DAQ**
- Construct a LabVIEW VI to first and second order filter the undesired frequencies from the signal, using the **Filter Express VI** to configure the required filter

Additional work:

1. ***Explain why a cut-off frequency of 1200 Hz was chosen.***
2. ***Produce a Bode plot for the 1st and 2nd order filter in Multisim Live.***
3. ***Using FilterLab 2 design a second order Chebyshev Filter with the same cut-off frequency as the Butterworth Filter. Using this design produce a Bode plot for this filter in Multisim Live.***
4. ***Explain how the frequency response of the Butterworth filter differs from the frequency response of the Chebyshev filter.***
5. ***Explain when might you choose one filter over the other.***