Equipment List

- A DAQ - we use The National Instruments Educational Laboratory Virtual Instrumentation Suite II (NI ELVIS II)
- Software environment for collecting data - We use National Instruments LabVIEW
- Components for building analog filters (resistors, capacitors, inductors, op-amps, etc.)

Apparatus Pictures

Fig. 1: The National Instrument ELVIS II prototyping board which forms the physical component of the apparatus. Here, a passive low pass filter was constructed on the board for testing with the VNA.
Fig. 2: An example of a LabVIEW block diagram which forms the software component of the VNA.

Fig. 3: An example of the VNA front panel, which is where the user interacts with the apparatus.
Vector Network Analyzer

Vector Network Analyzers (VNAs) are, to a first approximation, instruments that are used to characterize the frequency response of circuits. They do this, by driving a circuit with a known frequency and observing the response. In this lab, we’ll use what we’ve learned from earlier experiments to develop a system that provides a continuous analog output that drives a circuit. The response of the circuit will then be measured and compared to the input. Then we’ll “step” the frequency up and repeat. We’ll do this for frequencies from about 10 Hz to 50 kHz. Your step size need not be uniform, in fact, it’s probably best if it’s not, but should be fine enough to show details of the transfer functions.

Setup your VI to read the computer output that drives the filter as well as the filter output. By reading the output voltage rather than assuming it, you will be able to verify that the output signal is behaving as you expect it to. You want to measure the relative magnitude of each waveform, so that you can determine the gain of the filter as a function of frequency. These tasks will require manipulation of the data in the waveforms (finally we’re doing something with them!). If you have time, also determine the phase shift as a function of frequency. The phase shift will be more challenging than the gain determination. At the end, the gain data should be displayed graphed (i.e. Bode plots). Output of data files to a spreadsheet file is also required. The data files should be submitted with your lab report.

Design and build the following circuits:

1. First order low-pass with cutoff at 1000 Hz.
2. Second order low-pass with cutoff at 1000 Hz.
3. An LRC band-pass filter.
4. Active high-pass with cutoff at 1000 Hz and high freq. gain of 5.
5. Use our TeachSPIN signal processing unit to measure a low-pass filter with a “Q” of 10 and a cutoff of 1000 Hz.
Hints:

- You’ll want to get rid of express VI’s pretty quickly.
- The order of events is critical!
- Break the problem into smaller pieces.
- You’re probably going to have to adjust the waveform sampling data as you go from low frequencies to higher frequencies.
- Try not to collect transient behavior – you’re looking for steady state response of the filters.
- If you feel really lucky, devise a way to measure the phase change introduced by the filter.
Fig. 4: Gain (top) and phase (bottom) for a passive, first-order, low pass RC filter with a cutoff frequency of approximately 1000 Hz (R ≈ 1000 Ω, C ≈ 0.15 μF).

Fig. 5: Gain (top) and phase (bottom) for a passive, second-order, low pass RC filter with a cutoff frequency of approximately 1000 Hz (R ≈ 1000 Ω, C ≈ 0.15 μF).
Fig. 5: Gain (top) and phase (bottom) for a passive RLC band-pass filter (R ≈ 100 Ω, C ≈ 0.15 μF, L ≈ 10 mH).

Fig. 6: Gain (top) and phase (bottom) for an active, first-order, RC high-pass filter with a gain of approximately 5 (R ≈ 1000 Ω, C ≈ 0.15 μF, R_f ≈ 4800 Ω).