

EE 230
Experiment 3
Fall 2006

Fundamental Linear Circuit Concepts

Objective: The objective of this lab is to allow the student to investigate the distortion introduced by linear circuits, to enhance the concepts of transfer functions, to develop some reasoning/troubleshooting skills, and to investigate some properties of the audio spectrum.

Equipment:

Computer with SPICE, Signal Express, GP-IB capability, and appropriate IVI drivers
HP E3631A or equivalent power supply (GP-IB Capable)
HP 33120A or equivalent signal generator (GP-IB Capable)
HP 34401A or equivalent multimeter (GP-IB Capable)
HP 54602B or equivalent oscilloscope

Parts:

Assortment of Resistors and Capacitors
Potentiometer
3 Prepared mystery circuits
Amplified speaker

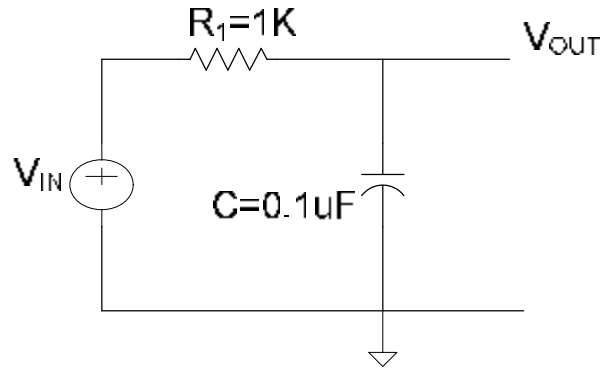
Practical Details: Several fundamental aspects of linear circuits will be investigated in this experiment. In the first problem, the concepts of superposition and harmonic distortion will be investigated. The second will focus on “forensic” skills applied to circuits. These types of skills are often needed when debugging or troubleshooting a circuit either at the design stage or in the laboratory. The third focuses on developing an appreciation for the audio spectrum. The last is a design procedure.

Part 1 Distortion in Passive Circuits

Two kinds of distortion can occur in a circuit. One is frequency distortion and the other is harmonic distortion. Harmonic distortion only occurs in nonlinear networks. Linear networks introduce no harmonic distortion but can introduce frequency distortion.

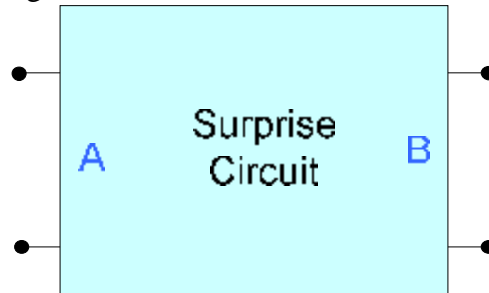
- a) What types of distortion are present in the following network if excited by a 1 kHz square wave? What do you expect to see at the output if a 1 kHz input is applied?
- b) Theoretically determine the magnitude of the fundamental, the second harmonic, the third harmonic, and the fourth harmonics at the input and output of this circuit if a 1KHz square wave is applied.

- c) Use Signal Express to measure $|T(s)|$ from 20Hz to the frequency of the fourth harmonic. Compare the measured output with that predicted by SPICE. Turn on the FFT feature in SPICE and do a simulation. How does the FFT response relate to the harmonic components you determined in Part b).



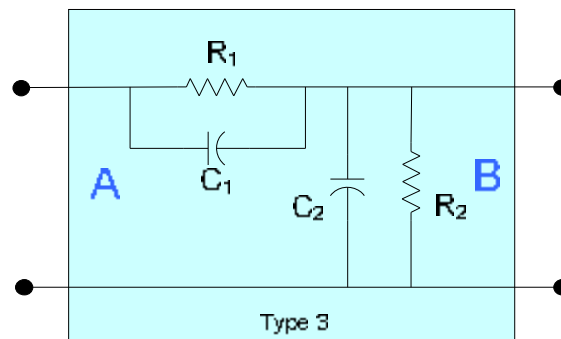
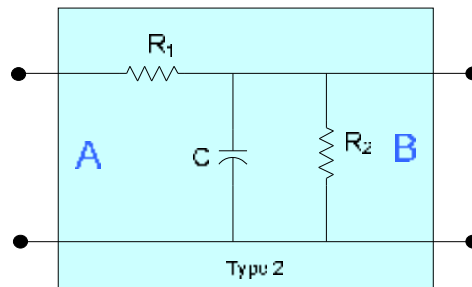
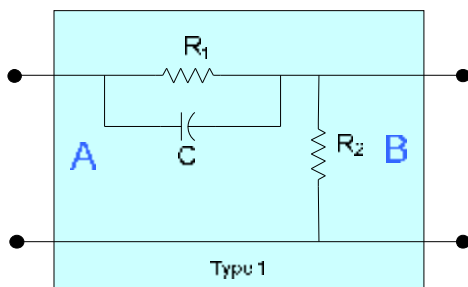
Part 2 Solve the Mystery Circuits

Your TA will give you three “surprise” circuits uniquely labeled. Each is a two-port network with ports designated with an A and a B as shown in the following figure.



Internal to the Surprise Circuits will be one each of the following 3 circuits designated at Type 1, Type 2 and Type 3.

- Identify each of the circuit architectures.
- Determine the components in the circuit.



You may use any of the test equipment available in the laboratory to help you in this determination.

Part 3 Analyze an Audio Signal

- Determine the highest frequency you can hear using a sinusoidal input. Designate this frequency as f_{MAX} .
- Describe the difference in the sound of a square wave signal and a sinusoidal signal that is $0.05 \cdot f_{MAX}$.
- Repeat if the two signals are at $0.5 \cdot f_{MAX}$.
- Comment on why the perceived relationship between the sounds occurs.

Part 4 Design a Treble Control

Many audio systems have what is termed treble and base control. Treble control allows the user to determine how much high frequency component they want to hear and base control allows the user to determine how much low of the low frequency components they want to hear. If a circuit has both treble and base control, the resultant amplifier acts as a bandpass filter in which both the upper and lower 3dB cutoff frequencies are programmable with either a digital control or with a potentiometer.

- a) Design a treble control circuit that will allow you to adjust the upper cutoff frequency with a potentiometer from 2 kHz to 15 kHz.
- b) Verify the bandwidth control experimentally.
- c) Comment on how your treble control circuit affects a square wave and a sinusoidal wave audio signal. Select frequencies so that the effects are apparent.