ECSE 331
Laboratory No. 6
Design of a BJT Amplifier

Objective:

The student will design a BJT amplifier to realize a voltage gain of magnitude of 50 V/V ± 10% having a 3-dB bandwidth of no less than 10 kHz. This laboratory is much more free-flowing than previous labs, as the student is expected to solve a design problem using their own unique design method, as oppose to follow a set of steps given to them in a linear progression.

Equipment Required:

1. NI Elvis-II$^+$ test instrument
2. PC with ELVIS-II$^+$ software installed
3. Heat Gun
4. Aerosol Freeze Spray to cool diode
5. Hand-held thermal imager
6. Components:
    a. 2N2222A npn transistor
    b. 9 V battery with holder
    c. assorted ¼-W resistors: 100 Ω to 100 kΩ, 10 kΩ
    d. capacitors: 0.22 μF, 1 μF and 10 μF.

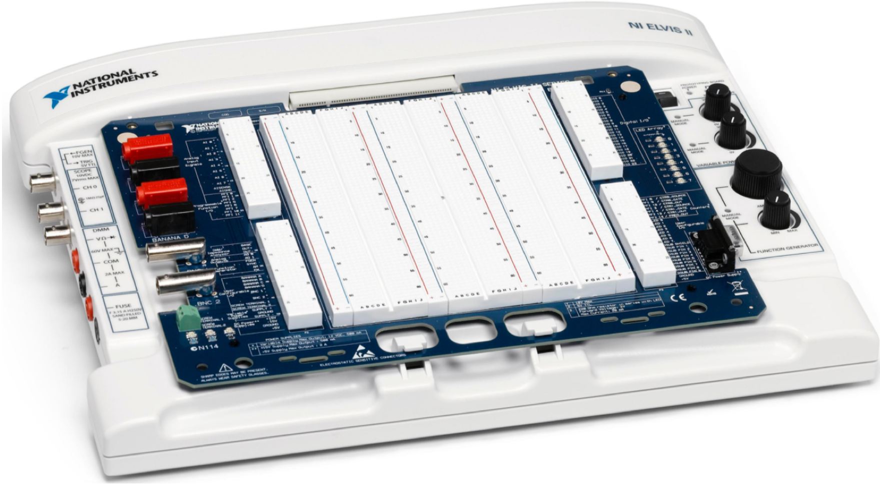
Description of the NI Elvis-II+ Test Instrument:

The National Instruments Educational Laboratory Virtual Instrumentation Suite (NI ELVIS-II$^+$) is a hands-on design and prototyping platform that integrates the 12 most commonly used instruments – including oscilloscope, digital multi-meter, function generator, bode analyzer, and more. It connects to a PC through a USB connection, providing quick and easy acquisition and display of measurements.

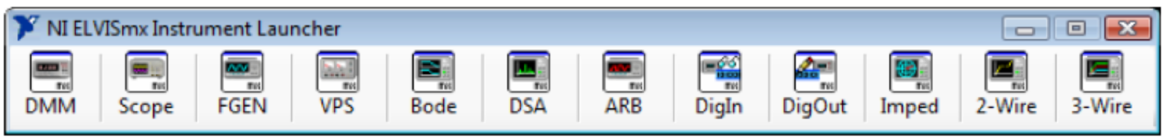
The National Instruments Educational Laboratory Virtual Instrumentation Suite consists of two main components:

1. The bench-top workstation (NI ELVIS-II$^+$), which provides instrumentation hardware and associated connectors, knobs, and LEDs as shown in Fig. 1(a). A prototyping board (breadboard) sits on top of the workstation, plugged into the NI ELVIS-II$^+$ platform, and offers hardware workspace for building circuits and interfacing experiments.
2. NI ELVIS-II$^+$ software, which includes soft front panel (SFP) instruments. Fig. 1(b) illustrates the PC screen view of the oscilloscope interface.

The Elvis-II$^+$ prototype board consists of 5 separate areas: four small prototype areas on the peripheral of the board, and a much larger central prototype area. The boards on the peripheral are used to interface to the internal data acquisition board of the Elvis-II$^+$ system. There are marking along the perimeter of the board indicating the connection. The student was introduced to this test bench back in Laboratory 1. The student should refer back to this lab for a detailed description of the



(a)



(b)

Fig. 1: (a) Elvis-II$^+$ instrumentation hardware with prototyping board, and (b) menu for various virtual instrument.

NI ELVIS-II$^+$ test system.

Practical Information for the Student:

In performing this experiment, you will construct several building blocks of modern transistor circuits. On doing so, keep the following points in mind:

1. In the figures, more positive voltages are always shown closer to the top of the page, so that current flows in the circuit from top to bottom.
2. Keep all connecting leads as short as possible and pushed down to the surface of the circuit board. You want to avoid a "*rat's nest*" of wiring whereby unwanted coupling capacitances and series inductances are created. These parasitics can prevent your circuit from working correctly.
3. Use different color wires in your circuit. The standard convention is red for positive supply voltages, blue for negative supply voltages and black for ground. Use colors that are different than these for signals. If you use a single color for everything, your circuit should still work. However, the debug process will be much more difficult if something goes wrong. It is important for the student to understand that when asked to design a circuit it is not limited to just the arrangement and component selection for the circuit but also to the fact that the design may not work the first time it is assembled. In general, all design will require at least two iterations before one can declare success!
4. In understanding circuits, as well as designing them, keep in mind that that there are two *interleaved* problems: the dc design, which establishes the operating points, and the ac

design, which is responsible for how the circuit responds to signals. The student must design both problems at the same time; if you make a change to one, be sure that you haven't changed the other.

Write-Up Requirements:

A good laboratory report should contain a **brief** description of what the experiment was about, including circuit diagrams, and what you did, your data, your results, and anything else called for in the assignment, such as questions inserted in the laboratory. Answers to these questions require observations that need to be made at the time you do the experiment.

The laboratory report should be written using the IEEE paper style consisting of a double-column single-space format, and must adhere to the following:

1. Title page - Title of the assignment/project, authors' name, and course name.
2. Abstract - Abstract of the assignment/project report.
3. Introduction
4. Main body of the assignment/project report including figures.
6. Conclusions
7. References
8. Appendices

Procedure:

You are required to design a BJT amplifier using the 2N2222A npn transistor that you studied in Lab 5. This amplifier must be capable of operating off a 9 V battery and be fully operational without any additional external components – i.e., bias network.

Your design specifications are to realize an amplifier so that the magnitude of the voltage gain is 50 V/V with a 10% gain tolerance while driving a load of 10 kΩ In other words, the magnitude of the gain can be anywhere between 45 V/V and 55 V/V. In addition, your amplifier must be capable of performing amplification over a 10 kHz bandwidth and have an input resistance of 1 kΩ or greater. Finally, as the amplifier is expected to amplify a wide range of signal levels, demonstrate that your amplifier can operate with a signal having a RMS level of 1 V. Investigate the temperature characteristics of your amplifier.

Follow the general design methodology described in class.

This concludes this lab.