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EE2301/Experiment 5
Operational Amplifiers and Bipolar Junction Transistor Circuits

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Objectives:

- To study the characteristics of the operational amplifier (op-amp) and the behaviour of an inverting and non-inverting amplifier.
- The second objective is to study the experiment on a bipolar transistor (npn) bipolar junction transistor (BJT). The handout introduces the properties and behaviour of BJTs. The output characteristics of the transistor are studied and the transistor is used as a switch and as an amplifier. The transistor is used in the common emitter configuration. The common emitter circuit is used to study the effect of the transistor parameters on the output voltage and current.

Equipment:

- Dual Power Supply (+15 V, 0 V, -15 V) with pilot lamps, Digital Multimeter (DMM) and DMM cables.
- 1 MΩ potentiometer, 1 ceramic capacitor, 1 10-turn resistor, 1 ceramic capacitor, 1 ceramic capacitor, 1 10-turn potentiometer, 1 2N2222 Bipolar Junction Transistor, jumper wires and the breadboard. Use the 10-turn potentiometer to adjust the resistance to the required value.
- Breadboard, Electronic jumper wire, oscilloscope, function generator, multimeter.

The LF411 Op Amp Revisit

- The LF411 is a high speed, JFET input operational amplifier. Since the IC is implemented in complete of op-amp and transistors. The pin-out of the op-amp is shown in Figure 1. Configuration of the op-amp is shown in Figure 2. The internal circuit of the op-amp is shown in Figure 3. The internal circuit of the op-amp is shown in Figure 4. The second op-amp component is a non-inverting amplifier as shown in Figure 5. The non-inverting amplifier is shown in Figure 6. Its output is shown in Figure 7.

Figure 1: Top View of the LF411 Pin-out

Figure 2: Configuration of the op-amp

Figure 3: Internal circuit of the op-amp

Figure 4: Internal circuit of the op-amp

Bipolar Junction Transistors:

- Bipolar junction transistors are semiconductor devices. The main applications of BJTs are analog circuits and switches. BJTs are used in amplifiers, in digital logic and in high speed digital circuits. Bipolar refers to the flights carried as well. There are three operating modes for BJTs: the active mode (amplifying mode), saturation mode (switch on) and cut off mode (switch off). The transistor is a three terminal device. The terminals are the base, collector and emitter. In each BJT, a small current flowing through the base terminal controls a much larger current flowing through the collector terminal.

The BJT can be either implemented as a NPN or a PNP transistor. In both cases, the emitter region has the thin PN-junction, the base is the thin region between the emitter and the collector and the collector is the thicker region. The base is lightly doped, the emitter is heavily doped and the collector is moderately doped. Because transistors are power, which dissipates a lot of heat, the collector is usually the largest of the three. The symbol for the npn transistor is shown in Figure 8. The symbol for the pnp transistor is shown in Figure 9.

Figure 8: Symbol for the npn transistor

Figure 9: Symbol for the pnp transistor

There are three basic ways in which a BJT can be configured. In each case, one terminal is common to the input and output circuit. These configurations are known as common emitter, common base and common collector. The common emitter configuration is used in this experiment.

In most of the cases, the BJT is used as an amplifier or switch. In order to perform these functions, the transistor must be correctly biased. Biasing means that a certain voltage is maintained between the terminals of the BJT. Generally, different modes of operation of the BJT are obtained. The three modes are cut-off, saturation and active.

- Active: Emitter junction is forward biased, collector junction is reverse biased. The BJT operates in the active mode and the BJT can be used as an amplifier.
- Saturation: Both emitter and collector junctions are forward biased.
- Cut-off: Both emitter and collector junctions are reverse biased.

The common-emitter BJT amplifier circuit is shown in the following circuit. The biasing circuit allows defining the operating conditions of transistor.

The transistor is an NPN operating in the active mode with the transistor. There is transistor current flowing through the collector and base. The current through the base is much smaller than the current through the collector. A common-emitter amplifier consists of a bipolar transistor, a base resistor, and a collector resistor, as shown in Figure 1. The DMM connections

Figure 10: Common-emitter circuit

The base current and collector current are related by the equation $I_C = \beta I_B$. In the linear region or normal operation, the base-emitter voltage is approximately 0.7 V. The collector-emitter voltage is given by $V_{CE} = V_{CC} - I_C R_C$. Since the collector-emitter voltage is a function of the collector current, the collector-emitter voltage is also a function of the base current. The base current is controlled by the base resistor R_B. The collector current is controlled by the base current. The collector-emitter voltage is controlled by the collector current. The collector-emitter voltage is also a function of the base current. The base current is controlled by the base resistor