Introduction to the Cadet II

The Cadet II is a device which makes it easy to build and test simple circuits. It consists of a *breadboard area*, power connections, input sources (logic switches, debounced pushbuttons and function generator) and output sources (logic monitors or LEDs and 7-segment LED display), and input/output connectors (BNC plug). Building a circuit consists of the following steps:

1. Design and check the circuit on paper
2. Choose components and draw a schematic diagram: label all parts and pins
3. Check the circuit using a computer simulation (optional)
4. Connect the Vcc and GND power sources to the power rails of the Cadet II
5. Insert chips into the breadboard
6. Connect power to the chips
7. Connect wires between the gates
8. Connect wires from gates to inputs and outputs
9. Verify wiring is correct
10. Turn on Cadet II power and test circuit

Before building a circuit, you need to become familiar with what the Cadet can do. The Cadet II Trainer description lists eighteen sections of the board that surround the central breadboard area, shown in Figure 1.

![Figure 1](image)

The breadboard area is where the circuits are constructed. Pins from the IC chips fit into the holes on the board, and wires are used to connect the pins to power, ground, inputs and outputs. The holes in the breadboard area are connected underneath, in a regular pattern, by wires. The two rows of holes along...
the top and bottom are connected horizontally, and the two groups of columns in the center are connected vertically. These connections are illustrated in Figure 2. Power and ground are normally connected across the top and bottom rows, so that power and ground "buses" run the length of the breadboard area. The chips are placed to bridge the center gap; this then leaves 4 holes per pin for wire to connect to other ICs.

Figure 2

The Cadet can be used to generate input signals, display output signals in various forms and provide a connection from which to send or receive outside data. The following is a brief description of the most important sections of the Cadet II which are used in the Digital Design Lab.

1. Power connections and On/Off switch

The On/Off switch for the Cadet II is located on the top side next to the power cord. When powered on, the switch will be illuminated. When the 7-segment LED display is not used, you will normally see it display 00. If the switch does not light when turned on, check that it is plugged in and that power is on at your workbench.

For TTL circuits, use the red +5V connection and the black GND connection. Unscrew the tops of the connectors to reveal the inner post. This inner post has a hole into which you slip the stripped end of a wire. Screw the cap back into place in order to hold the wire in place. Place the other end of the wire into your common Power/Gnd strip on your board.

2. Logic Switches

The logic switches, located in the area labeled as Section #8 in Figure 1, can provide input values to test your circuit. When the switch is down, the switch represents a logic 0. There is a column of breadboard connections for each switch at the top of the area.

You will also notice a switch near the logic switches labeled +5/+V. All of the TTL logic designs we will be working with require the +5 setting. Setting this switch to the +V setting causes the logic 1 output of the switch to match the voltage of the V+ knob on the very top of the Cadet II. Since this voltage can vary from +1.3VDC to +15VDC, be sure that it is always set to +5 before turning on power to the Cadet II. Damage can otherwise result to the IC devices.

3. Logic Monitor

The logic monitor (also called the LEDs displays), located in the area labeled as Sections #16 and 17, provide a way to view output values. A logic 0 is shown by the green LOW indicators and a logic 1 by
the red HIGH indicators. As was the case for the logic switches, the +5V switch should always be set to +5. The TTL/CMOS selector switch also needs to be set to TTL.

4. Function Generator

The Cadet has a built-in function generator. A function generator is used to create electrical signals with a particular voltage. The signal repeats continuously, and the frequency at which it repeats can be set by the user. The frequency is measured in cycles per second or Hertz (abbreviated Hz). One Hertz is one cycle per second; 1,000 Hz is 1,000 cycles per second. The shape of the electrical signal (how the voltage changes in each cycle) is also controllable by the user. For digital logic, we are only interested in square wave TTL signals. These signals have only two voltage levels: GND and Vcc. These levels correspond to logic 0 and logic 1, respectively.

The type of function generated by the Cadet II is controlled by the knobs shown in Section #1, #2 and #3. The Function Generator Magnitude Selection (#1) selects the magnitude of the frequency. It is used in combination with the Function Generator Adjustment Dial (#2). The frequency magnitude can be chosen in six decade ranges. For example, if 100K is chosen, the frequency generated is in the range of 10K-100K. Setting the adjustment to 0.1 will result in an output frequency of 0.1*100K or 10K. The Function Generator Outputs (#4) are the breadboard locations where the signal is available; you connect a wire from one of the two TTL columns on the left side to your circuit to use the signal.

The knob next to the Vernier Adjustment is the Function Generator Amplitude Adjustment; when using a TTL signal this knob has no effect (so, for this class, you can ignore it). Similarly, the Function Generator Signal Shape (Section #3) has no effect on TTL signals. The outputs controlled by these two knobs are available on the Function Generator Output's six right columns. Be careful to avoid using these outputs as they will cause your circuit to behave oddly.

5. BNC connector

The BNC connector (Section #7) is a special connector most often used to connect the Cadet II to another piece of electronic equipment, such as the oscilloscope. There are six rows of connections for the input or output signal. The other two rows are used for grounding.

6. Potentiometers and Debounced pushbuttons

The Cadet II has two potentiometers (Sections #9 and #10) that can be used to set a variable resistance. One has a maximum resistance of 1K ohms and the other 10K ohms. In some labs it might be necessary to use a resistor in a circuit; for example, when using a debounced pushbutton (Sections #5 and #6) we may need a resistor to provide a path to power or ground when the switch is open. You can use these potentiometers to give a specific resistance by connecting a wire to one of the two end columns and another wire to the middle columns, then adjusting the knob to give the desired resistance. You can also use them as fixed 1K or 10K resistors by connecting wires to the opposite ends.

The debounced pushbuttons (Sections #5 and #6) are switches with special circuitry to eliminate what is called switch bounce. Switch bounce is a phenomenon which makes a switch which is closing (or opening) appear to actually alternate between open and closed for a brief period of time, often not more than a millisecond (1/1000 of a second). It's caused by the metal contacts inside the switch actually vibrating. Almost all mechanical switches have switch bounce. This isn't a problem for many electrical devices where time is measured in seconds, but for high-speed electronics it can be a real problem; your
digital circuit can see these bounces, and respond as though you are opening and closing the switch thousands of times a second! Using debounced switches lets you avoid this problem.

Each switch has two sets of connections; normally open (NO) and normally closed (NC). Don't confuse these with meaning normally GND and normally Vcc. Whenever the switch is closed, the switch is connected to ground. If the switch is open, it is not connected to anything. The NC and NO connections let you specify what is the normal position of the switch when you're not pressing it. If you want the switch to behave like the logic switches, you need to use a pull-up resistor to achieve this.

7. SPDT (Single Pole, Double Throw) switches

A single pole, double throw switch (Section #11) is kind of like two switches in one. When the switch is up, one switch is closed and the other open. When the switch is down, one switch is open and the other closed. The center rows of the SPDT switches are the common connection, which is always connected to one switch or the other. These switches are useful for making additional logic switches if needed; simply ground one switch and connect the other to Vcc. Then the common connection becomes either logic 0 or logic 1.

8. 7-Segment LED

The 7-segment LED (Section #13) is used to display numbers from a circuit. There are two 7-segment displays which let you display values between 00 and 99. Each display takes a binary-coded number and displays the corresponding decimal digit. You will discuss binary-coded numbers during class, but in brief a binary-coded number is a four-digit number where each digit is either 0 or 1, and the position of each digit implies the digit's weight. Just a 14 and 41 represent two different numbers -- fourteen and forty-one -- in decimal, 0101 and 0110 represent two different numbers -- five and six -- in binary-coded decimal.

9. Speaker

The speaker (Section #12) can be used to generate sound by a circuit. To do this, you need to pass current through the speaker in some pattern. When you need to do this, you can be sure the instructor will tell you how.