Chapter 1

Sequential Logic Design Trainer, Model DL-020

The Sequential Logic Design Trainer that you have contains all of the necessary tools for you to easily implement many combinational and sequential digital logic circuits. Combinational and sequential logic circuits are the two major types of circuits found inside microprocessors. The layout of the trainer is shown in Figure 1.

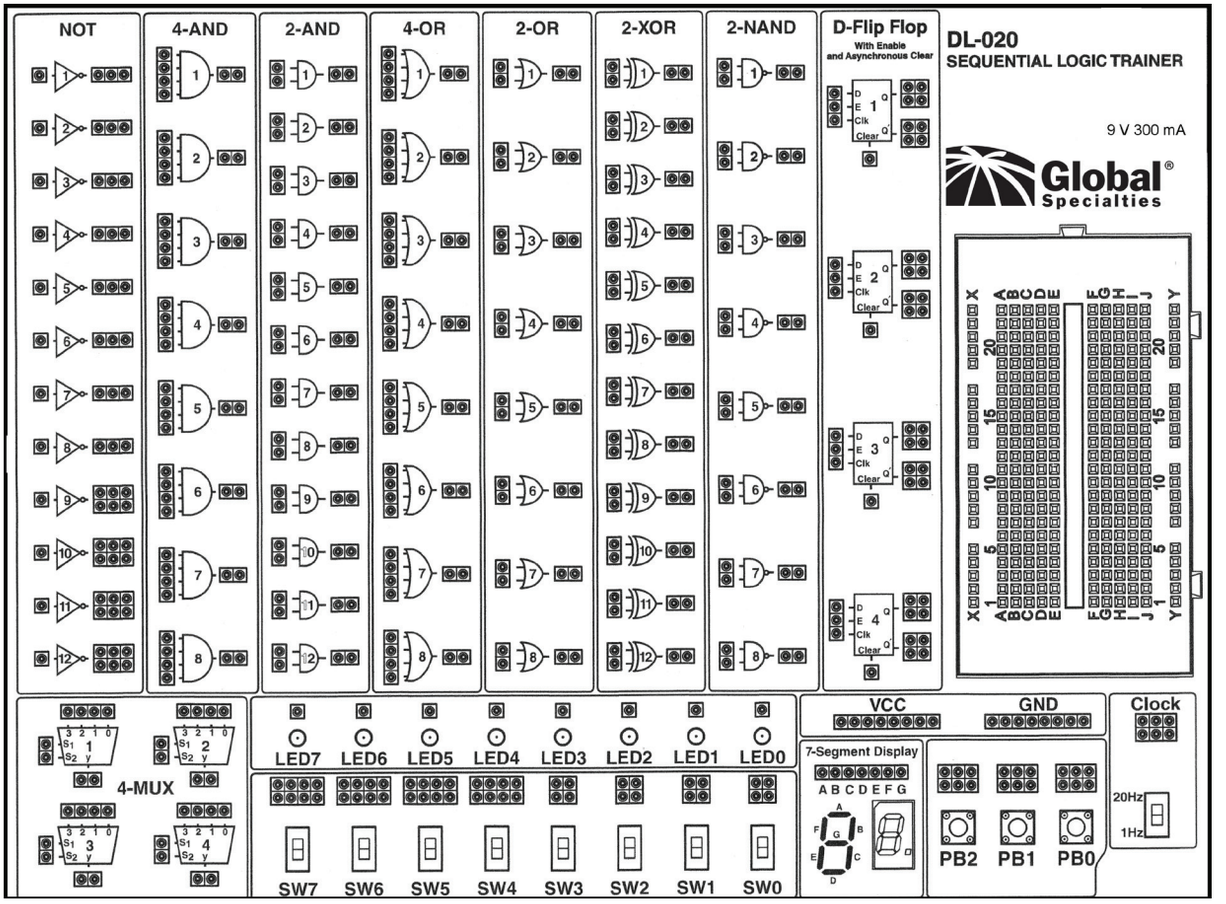


Figure 1: *Sequential Logic Design Trainer layout. All of the logic gates and I / O's are pre-mounted with wire connection points.*

The following is a list of all of the components on the trainer:

- Twelve NOT gates
- Eight 4-input AND gates
- Twelve 2-input AND gates
- Eight 4-input OR gates
- Eight 2-input OR gates

- Twelve 2-input XOR gates
- Eight 2-input NAND gates
- Four D flip-flops with enable and asynchronous clear
- Four 4-to-1 multiplexers
- Selectable 1 Hz/20 Hz clock
- Eight multi-color LEDs
- Two 7-segment LED displays
- Eight toggle switches
- Three push button switches
- VCC and GND connection points
- General bread board area with 270 tie points
- Hook-up wires of various lengths

The eight LEDs and the LED segments of the 7-segment displays are active high, which means that a logic 1 will turn the light on, and a logic 0 will turn the light off. The three push buttons, PB0, PB1 and PB2, are also active high, so pressing the button will produce a logic 1 signal. All of the eight switches, SW0 to SW7, are configured so that when the switch is in the up position the output is a logic 1, and when the switch is in the down position the output is a logic 0.

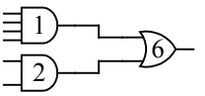
You can also connect a wire to one of the VCC connection points to directly get a logic 1 signal. Similarly, connecting a wire to one of the GND connection points will get a logic 0 signal.

In addition to the standard logic gates and I/O's, the trainer also provides four D flip-flops with enable and asynchronous clear for building larger sequential circuits. Sequential circuits in a computer system also require precise timing, and this is accomplished by using a clock signal which is a square-wave of a fixed frequency. The trainer has a square wave clock generator for two different frequencies, 1 Hz and 20 Hz, selectable using a toggle switch. The use of the flip-flops and the clock will be explained in detail in later sections of this manual. Finally, the trainer also includes four 4-to-1 multiplexers for building larger circuits.

All of the logic gates, flip-flops, multiplexers and I/O's are pre-mounted for easy wiring of a circuit. All component inputs are connected to one wire connection point, and all component outputs have multiple wire connection points. To connect from the output of a component to the input of another component, simply use a hook-up wire to connect between the two wire connection points. For example, push button PB0 has six common wire connection points, so to use PB0 you can connect a wire to any one of these six connection points. Connect the other end of the hook-up wire to the one connection point for LED0. When you press the push button, the LED should turn on. Try this simple connection now to see that it works.

The logic gates on the trainer are also numbered for easy reference for when connecting a circuit up. For instance, the eight 4-input AND gates are numbered from 1 to 8. There are also eight 4-input OR gates, and they are also numbered from 1 to 8. So be careful when a circuit diagram says gate number 1 that you know which type of gate it is referring to, i.e., whether it is the 4-input AND gate,

the 4-input OR gate or even one of the other gates. For example, the following circuit diagram uses the number-1 4-input AND gate, the number-2 2-input AND gate and the number-6 2-input OR gate. In this courseware, we will use the notation 4-AND#1, 2-AND#2 and 2-OR#6 to refer to these three gates respectively.



The general breadboard area allows you to connect other components that are not available on the trainer together with your circuit. The breadboard consists of many holes for you to connect hook-up wires and integrated circuit (IC) chips. All of the holes are already connected together in groups. This way, you can connect two wires together (or connect a wire to an IC pin) simply by plugging the two wires into two holes that are already connected together. The layout of the breadboard is shown in Figure 2.

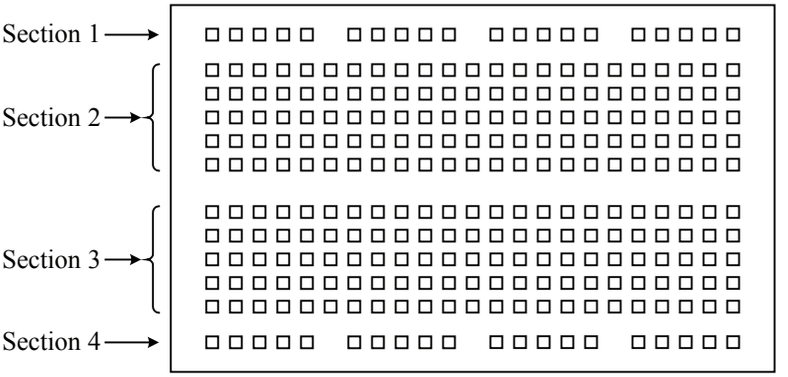


Figure 2: *Breadboard layout. The holes in section 1 are connected horizontally. The holes in section 2 are connected vertically. The holes in section 3 are connected vertically. The holes in section 4 are connected horizontally. Holes in any two different sections are not connected.*

There are four general sections on the breadboard. All of the holes in section 1 are connected in common horizontally. The holes in this section are usually connected to VCC to provide power or the logic 1 signal to your circuit on the breadboard. Like section 1, all of the holes in section 4 are also connected in common horizontally. The holes in this section are usually connected to GND to provide a common ground or the logic 0 signal to your circuit. The holes in section 2 are connected vertically, so the five holes in each column are connected in common, but the vertical columns are not connected together. The holes in section 3 are also connected vertically like those in section 2, so the five holes in each column are connected in common, but the vertical columns between section 2 and section 3 are not connected together. Finally, holes in any two different sections are not connected together.

In the case where you might need more connection points for a component on the trainer, you can use the breadboard to give you extra connection points. Typically, you use a breadboard to connect wires to an IC chip. A standard dual-in-line (DIP) IC chip would be plugged into the breadboard with one row of pins in section 2 and the second row of pins in section 3.

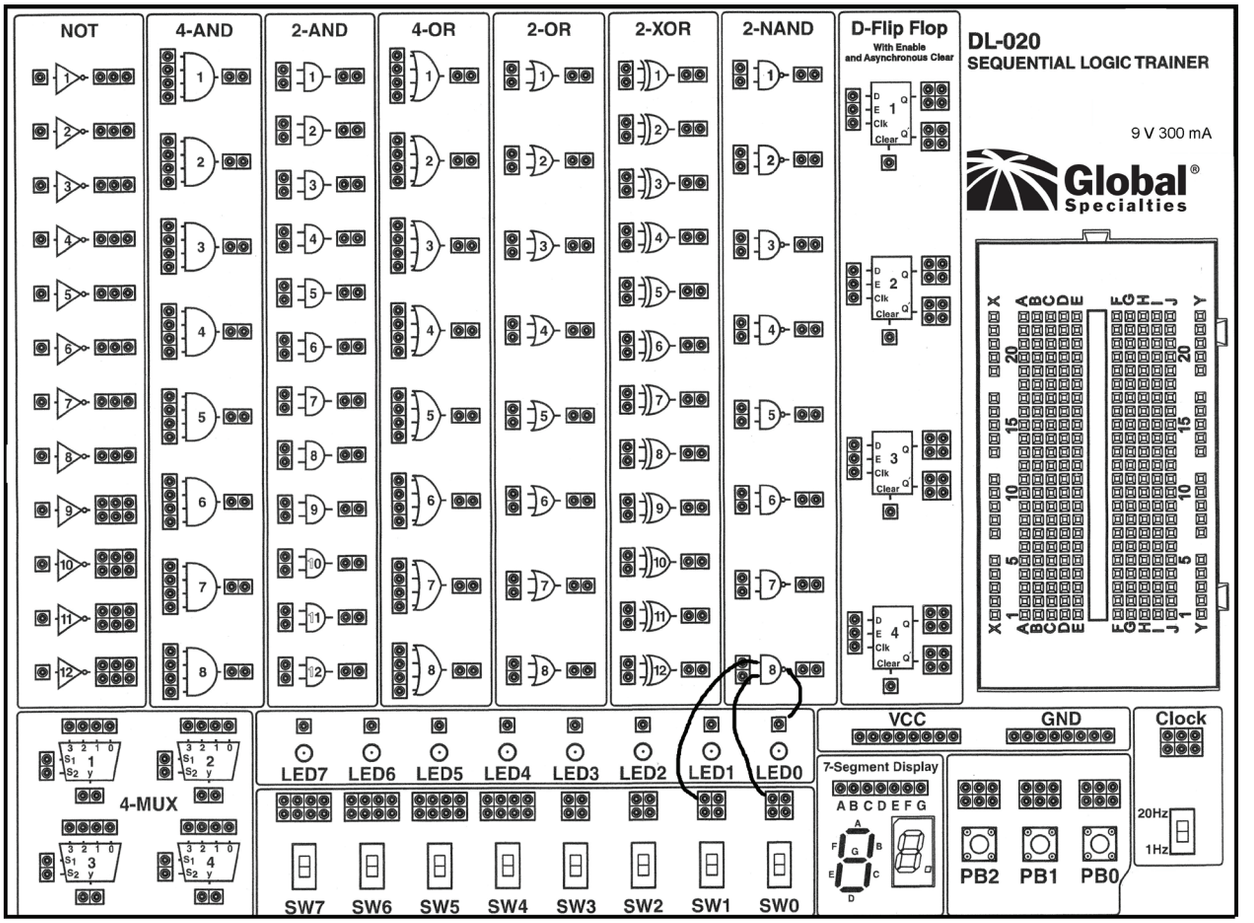
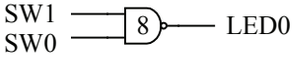


Figure 1A: *DL-020 trainer with three jumper wires.*

Let us now test out the trainer. The three thick lines in **Figure 1A** show three wires connected from the two switches, SW0 and SW1, to the inputs of the number-8 2-input NAND gate, and the output of this NAND gate is connected to LED0. In a schematic circuit drawing, this circuit would be shown as follows



Using three pieces of hook-up wires, make these same connections now on your trainer. Slide the two switches up and down and see how the LED turns on and off. At this point you may not understand why the LED turns on and off the way it does. Just keep reading and you will find out very quickly, and you will be well on your way to designing your very own microprocessors.