Experiment 1

• Objectives
  – Become familiar with the Digiac 4010 logic trainer
  – Introduce concept of logic conventions

• Topics
  – Binary Logic System
  – Logic Conventions
  – Switches
  – Indicators
  – Inverters
  – Connecting a Circuit
Digiac 4010 Logic Trainer Board

- Flip-Flops
- Logic Gates
- Numerical Display
- Power/Clock Switches
- Display Interface
- Switches
The Binary Logic System

A system with only two possible states: the 2 states may be

- **on** or **off**
- **true** or **false**
- **0** or **1**
- **open** or **closed**, etc.

A Boolean variable $C$, for example, may be either 0 or 1.

On the Digiac 4010 the two possible states are two voltage levels:

- **0 volts** and **+5 volts**
- (LOW) and (HIGH)
**Boolean Values on the Digiac**

It seems very natural, then, to let

- $0 \text{ volts}$ represent a *Boolean 0*
- $+5 \text{ volts}$ represent a *Boolean 1*

The symbols on the Digiac are drawn with this representation in mind.

For example, for an OR gate:

```
        (0 volts) 0
  (5 volts) 1
```

However, this is **not** the only way to relate the voltage levels to the Boolean values!
Logic Conventions

Positive Active Logic Convention (also called Active High):

- (Low) $0 \iff 0$
- (High) $5 \iff 1$

Negative Active Logic Convention (also called Active Low):

- (Low) $0 \iff 1$
- (High) $5 \iff 0$

Logic conventions can be very useful for building AND/OR circuits using only NAND gates, for example.
Switches

Switches are sources whose value can be controlled.

On the Digiac 4010 the switches are toggle switches that appear somewhat as shown below:

Switch down

Switch up
Simplified Circuit for Toggle Switch and Indicator

DPDT Switch (Switch up)

Connecting Wire

0 volts

"0"

5 volts

"1"

Ground

Light Bulb

Ground
Switch Voltages

In the *Laboratory Manual* a switch is represented more simply by the block diagram at the right.

The voltage output of a switch is illustrated by the following:

- **Switch down**
  - 5 volts
  - 0 volts

- **Switch up**
  - 0 volts
  - 5 volts
A convenient interpretation:
call the output labeled “1” the *positive active output*
and the output labeled “0” the *negative active output*
PA and NA Switch Outputs

The Boolean values of the switch outputs are then as shown below:

0 (NA) = 5 volts
0 (PA) = 0 volts
1 (NA) = 0 volts
1 (PA) = 5 volts

Switch down

Switch up
Indicators

Red LED’s (light emitting diodes) in the Display section of the Digiac 4010 are used to monitor the voltage level of a signal (hence the Boolean value also)

**Simplified Indicator circuit:**

- 5 volt input ⇒ LED is *on* (indicates PA “1”)
- 0 volt input ⇒ LED is *off* (indicates PA “0”)

![Simplified Indicator circuit diagram]
Indicators

The *Positive Active Indicator*: The LED’s are ready-made Positive Active Indicators (PAI’s). They are represented in the Lab Manual by the symbol at the right.

The *Negative Active Indicator*: There is no ready-made Negative Active Indicator (NAI) on the Digiac. You must *construct* the NAI.

For the NAI, you want the LED to be

- *on* for a NA “1” input (0 volts input)
- *off* for a NA “0” input (5 volts input)
The Inverter

To construct the NAI you need a device to change the voltage level of the signal before it is sent to the LED.

The device that will do this is called an *inverter*.

<table>
<thead>
<tr>
<th>input</th>
<th>output</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 volts</td>
<td>0 volts</td>
</tr>
<tr>
<td>0 volts</td>
<td>5 volts</td>
</tr>
</tbody>
</table>
Constructing the NAI

To construct the Negative Active Indicator, we connect an inverter to an LED (a PAI):

<table>
<thead>
<tr>
<th>NA input signal</th>
<th>NAI output</th>
</tr>
</thead>
<tbody>
<tr>
<td>NA 0 (5 volts)</td>
<td>off</td>
</tr>
<tr>
<td>NA 1 (0 volts)</td>
<td>on</td>
</tr>
</tbody>
</table>
Switches: Digiac vs. LogicWorks

Digiac Toggle Switch

LogicWorks Binary Switch (with inverted output added)
LogicWorks: “Physical” Switch with Indicators

- **Switch**
  - +5V
  - +5 Volts
  - Ground
  - SPDT Switch

- **Indicator**
  - 0
  - Binary Probe
  - 1
  - LED
  - Ground

- **Digiac switch**
- **Digiac PAI (an LED)**
## Experiment Procedures

### No. 1

<table>
<thead>
<tr>
<th>Switch position</th>
<th>Output voltage at the terminal of the switch</th>
<th>Boolean value of the switch output [0,1], [PA,NA]</th>
<th>Input voltage at the terminal of the LED</th>
<th>LED output [on,off]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Down</td>
<td></td>
<td></td>
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