

Digital Signal Generation

Air Washington Electronics ~ Introduction to Digital Logic Lab



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Digital Signal Generation

Overview

In this lab, students will simulate and analyze a digital high/low pulse using a mechanical switch. Following this they will reevaluate the signal using a debouncing circuit.

Requirements

To meet all requirements for this lab, you must complete all activities, questions, critical thinking activities and questions, and observations and conclusions.

Course Objectives

- Analyze, construct, and test digital combinational circuits.
- Use manufacturer's data books to determine digital family (TTL, CMOS, ECL) parameters and pin-out configurations.
- Demonstrate proper operating techniques and evaluate for proper operation the following list of test equipment: DC Power Supply, Signal Generator, Frequency Counter, Impedance Meter, Digital Multi-meter, Oscilloscope, Logic Probe / LED

Module Objectives

- Analyze the output of a digital signal using a digital oscilloscope.
- Construct a simple debouncing circuit.

Activities

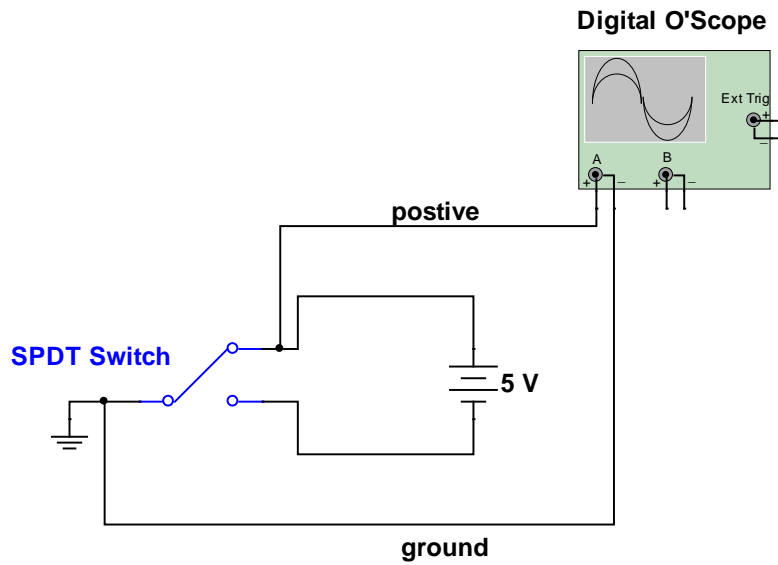
1. Simple Digital Signal
2. A Better Digital Signal

1: A Simple Digital Signal

Components & Equipment Needed

- Simple mechanical SPDT switch
- DC Power Supply
- Digital Oscilloscope with Recording Capability (Fluke Scopemeter 190/196)

Schematic



Procedure

Step 1: Using mini-grabber clips or similar, connect the circuit as shown in the schematic above.

Step 2: Adjust the power supply for 5 Vdc.

Step 3: To view and record the signal using a Fluke Scopemeter 190/196 follow the instructions below.

Note: The F# keys are directly below the screen and correspond to menu choices shown on the screen. To select a specific option, push the corresponding F# key, then use the up/down arrows to scroll through the choices. Select a choice by pressing ENTER key. To exit from a particular menu after making a choice, press ENTER again. To exit without saving, press the Clear Menu button.

A. Turn on the Scopemeter.

B. Set to channel A, push the "A" button and ensure the following menu choices are set:

- Input A = ON
- Coupling = DC
- Probe A = 1:1

- Input A Options = default
- C. Make sure channel B is not engaged by selecting the “B” button and setting “Input B” = OFF.
- D. Set Scope Range (V/DIV) and Time
- Using the RANGE switch located on the “A” side of the scope, adjust until A = 2V (lower left side of screen)
 - Adjust the TIME switch to 50 ms (middle lower screen)
- E. Recorder Set Up
- Push the RECORDER button
 - Select “Scope Record”
 - Press F1 to STOP
 - Press F2 for OPTIONS
 - Reference = From Start
 - Display Glitch
 - Mode = Continuous
 - Enter to exit
 - CONNECT the scope probes to the switch and turn on the power supply
 - Press F1 to START
 - Toggle switch off / on about 1 second per state
 - Toggle – “one one thousand” – Toggle – “one one thousand”
 - Press F1 to STOP
- F. Zoom
- Push the ZOOM button
 - Control of the ZOOM and VIEW:
 - The left / right arrows will move the screen
 - The up / down arrows will adjust the zoom
 - Make sure VIEW ALL is selected
 - Zoom in until ZOOM 2 is shown on upper right of the screen. You will need to use the left / right arrows to scroll the screen to get to the 2nd low to high transition.
 - DRAW this and make any notes about what you observe about its appearance.
 - Scroll to the right until you can see the high to low transition.
 - DRAW this and make any notes about what you observe about its appearance.

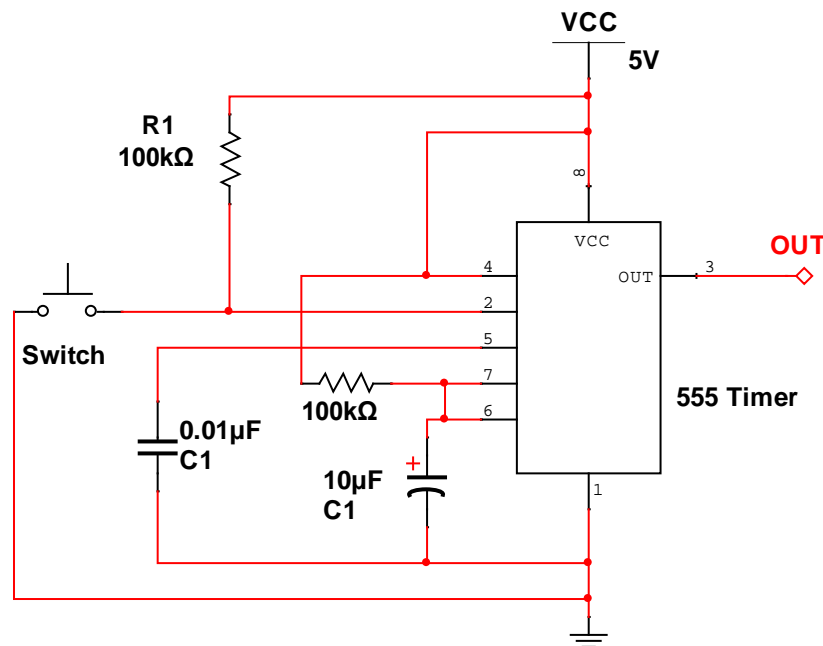
Data requirements After this portion of the experiment, you will have drawn a complete cycle of the digital signal (low to high and then back to low).

2: A Better Digital Signal

Components & Equipment Needed

- Simple mechanical switch
- DC Power Supply
- Digital Oscilloscope with Recording Capability
- 2 - 100 k Ω resistors
- 0.01 μ F capacitor
- 10 μ F capacitor
- 555 Timer
- Datasheet for 555 timer

Schematic



Note VCC is used in digital circuit schematics to indicate a dc voltage.

Procedure

Step 1: Obtain the data sheet for the LM555-CN Timer. If you know the manufacturer, you can search their website. Most manufacturers will have a simple search function for their products that will return product specifications and link to a PDF of the data sheet. If you don't know the manufacturer, another place to look is at one of the large vendors such as Digi-Key or Jameco. These companies have extensive inventories and part of the information returned for each product will include specifications and a link to the data sheet. In some cases, you will encounter a component that is obsolete. Usually, these

data sheets can be found doing an Internet search. If you are lucky, there will be information on a replacement or equivalent part. Digi-Key will often list a “comparable parts list” with obsolete parts.

Step 2: Once you have obtained the data sheet, use the information to decipher the pin numbers and the corresponding pin names. You will find that many schematics do not show an accurate representation of a chip. It is important that you become accustomed to this and learn to adapt.

Using the data sheet, list the full name, function and pin number of the LM 555 CN Timer in a table (this would be mentioned in the Results section of your lab report and included, properly labeled, at the end of your report).

Step 3: With this information, build the circuit on a breadboard. Even though 555 timers are notoriously “tough,” do be aware of proper handling techniques for an integrated circuit. Make an effort to conserve space on your breadboard, being mindful of the small footprint in a typical electronic device. Also, keep your wires neat. This is a relatively simple circuit, but digital circuits can become very complicated and unless your wiring is neat and organized, troubleshooting can be very difficult.

Step 4: Connect the scope probe to the output of the timer circuit and repeat the process described in Step 3 in the previous experiment. You will need to draw a complete cycle (low to high and back to low) of this signal at Zoom 2. Make sure you make note of any anomalies that you observe.

3: Critical Thinking

Critical Thinking questions and responses are to be included in the Appendix section of your APA lab report.

1. In a digital circuit, would a gradual (rather than nearly instant) transition from either low to high or high to low cause problems?
2. Describe and explain any anomalies that may appear in the second set of data.

Encoders / Decoders

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Revised: Friday, March 07, 2014

Encoders / Decoders

Overview

In this lab, students will gain practice in wiring digital circuits using both breadboards and circuit simulation software. It is designed to give students a practical application in the functions of encoding and decoding as well as familiarity with different radix systems.

Requirements

To meet all requirements for this lab, you must complete all activities, questions, critical thinking activities and questions, and observations and conclusions. Compile all results into an APA formatted lab report and submit on line.

Course Objectives

- Analyze, construct, and test digital combinational circuits.
- Use software (Multisim) to simulate and analyze digital circuits.
- Use manufacturer's data books to determine digital family (TTL, CMOS, ECL) parameters and pin-out configurations.
- Demonstrate proper operating techniques and evaluate for proper operation the following list of test equipment:
 - DC Power Supply
 - Signal Generator
 - Frequency Counter
 - Impedance Meter
 - Digital Multi-meter
 - Oscilloscope
 - Logic Probe / LED

Module Objectives

- Using the manufacturers' datasheets, read and understand function tables and make decisions based on those tables.
- Familiarize student with both physical and simulated construction of digital circuits.
- Discuss the process of encoding and decoding decimal to BCD to 7-segment (hex).

Activities

1. Encoder
2. Decoder

1: Encoder (Decimal to BCD)

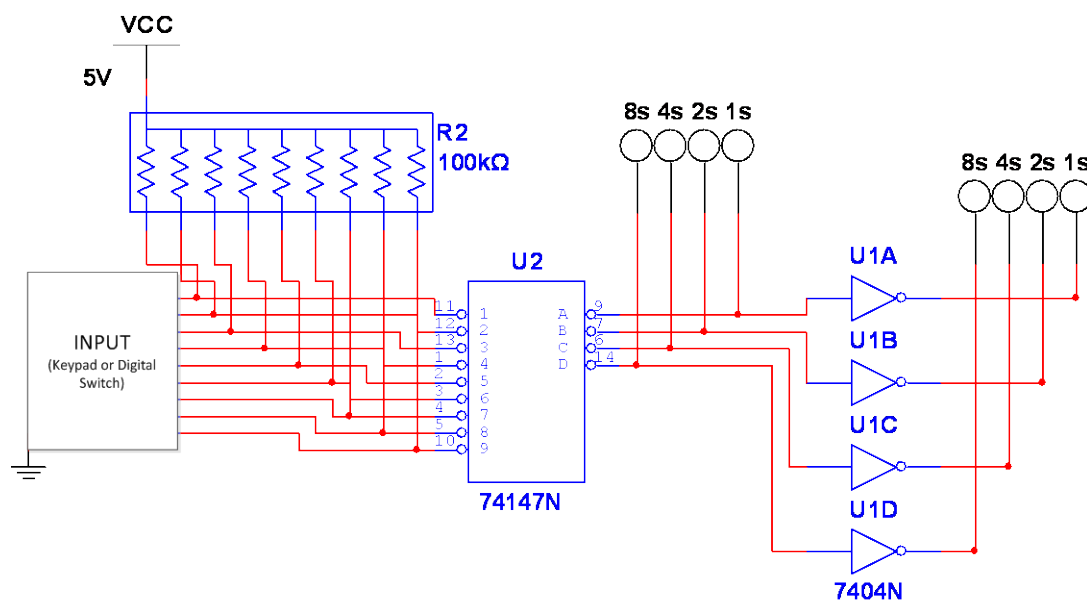
Components & Equipment Needed

- 74147N or 74LS147 10-line Decimal to 4-line BCD Priority Encoder (Texas Instruments, Digi-Key)
- 7404N Hex Inverter (Texas Instruments, Digi-Key)
- 100 k Ω Resistors
- 8 LEDs (any color)
- Breadboard: Keypad (#1700 KP Single Pole Common Bus)
- Multisim: Digital Switch – 9 (DSWPK_9)

Block Diagram



Schematic



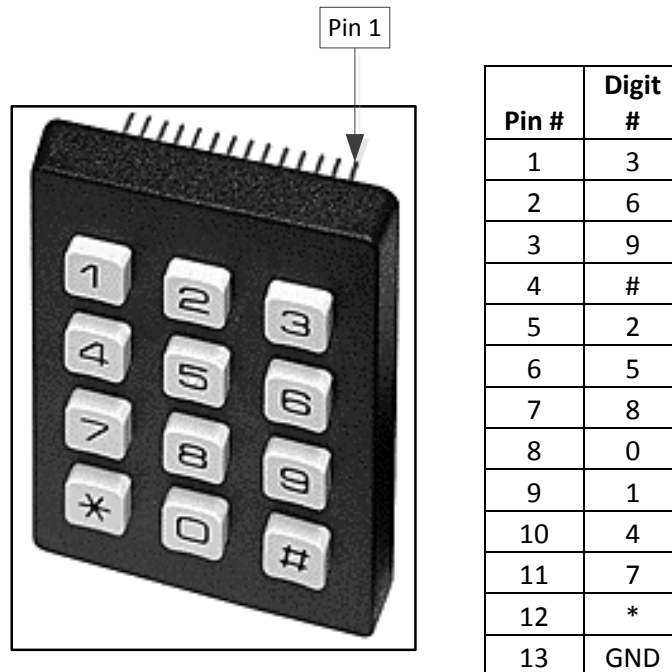
Reading a Digital Wiring Diagram

- Conventions
 - Referring to the 74147N, note that the numbers inside the “box” refer to the input or output function, or label. The numbers outside the “box” refer to the pin number.
 - For ICs such as the 7404 where there are multiple input/output sets, Multisim will refer to each set by letter. The 7404N has six (6) independent inverters available on one chip. This circuit uses only four (4) of them, therefore Multisim shows A, B, C, and D. When using these kinds of chips, it doesn't matter which sets you use, but be sure that you are using the right output for the input.
 - Power and Ground
 - VCC: at term used to indicate the input source for digital voltage. At this time, this will normally be 5 V.
 - Missing the VCC and Ground? For most 5V digital chips, Multisim has “wired” VCC and ground for you. The pins for VCC and GND will not show on the schematic for these types of chips. However, there are some chips where you will need to attach VCC and GND. In these cases, the pins will be visible.
 - Be aware that when you place a VCC on your page, Multisim will return a warning. Ignore this warning.
 - Resistor Packs - The 100 k Ω resistors are shown as a “bussed pack.” This is a useful item when you need a bunch of pull-up or pull-down resistors. These are all attached to VCC (pull-up) and then to each individual pin on the input device. For breadboard circuits, you will need to use individual resistors.
- Input
 - Breadboard: refer to pin-out below for the keypad.
 - Multisim: The 9 switch digi-pack is fairly straightforward. The dot in the upper-right corner indicates “ON,” and will be attached to the 74147 and resistor pack. The other side will all be connected to ground.
- Output
 - Breadboard: Use LEDs (any color) as the output. An LED has two legs, the longer one is the anode (positive) and the shorter one is the cathode (negative). Attach the cathodes to ground and the anodes to the outputs of the 74147 (or 7404).

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- Multisim: Rather than LEDs, digital probes are used. Unlike an LED, they have only a single pin and are attached to whichever output/wire that you would like to test. They are simple to use and light when there is voltage and are unlit when there is not. Perfect for digital circuits. They are found under INDICATORS >> PROBES. Select any of the digital probes for use in this circuit.
- 7 Segment Displays: For Part 2 of this lab, you will need to use a 7-segment display. For now, know that it is constructed from seven LEDs (light emitting diodes) which are either common anode (all anodes are attached to VCC), or common cathode (all cathodes are attached to GND). In this lab, there are both types available. The MAN 72 (or M72) display is the common anode. The MAN 74 (M74) is common cathode. When choosing one from the drawer, ensure you get the correct pin out diagram!!
 - Multisim: 7 Segment Displays are found INDICATORS >> HEX DISPLAYS. Select any color of the SEVEN_SEG_COM_A_* displays. These are all common anode.
- General Advice
 - Breadboard: Keep your wiring NEAT and compact. This circuit (both parts) will fit comfortably on a single breadboard. Start by placing your chips and getting VCC and GND wired first. There are many examples of students wiring up the circuit and forgetting these two basic connections. Keeping your wires neat helps with troubleshooting, too.
 - Multisim: Place all the components first and then wire them. The wire will try to route all over the place, but be aware that you can easily move it after both sides are connected.
 - DO NOT be discouraged if your circuits do not work on the first attempt. Wiring digital circuits takes practice.

Pin-out for Keypad (#1700 KP Single Pole Common Bus)



Procedures

- Step 1: Obtain the datasheets for the 74147 (or 74LS147) and the 7404. The pin-out for the keypad has been provided. For the keys not used (0, #, *), pull them high (attach to resistors) and then leave them.
- Step 2: Review the datasheets, paying particular attention the function table of the 74147. Being able to read and understand function (or truth) tables will be of great use to you as technicians. These valuable tools inform you as to how each output will react given specific inputs.
- Step 3: Breadboard the circuit.

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Step 4: Verify circuit operation. Indicate the state of the probes for both the first and second set.

Decimal Input	1 st set of probes (on / off)				2 nd set of probes (on / off)			
	8's	4's	2's	1's	8's	4's	2's	1's
Neutral								
1								
2								
3								
4								
5								
6								
7								
8								
9								

Step 5: Build the circuit in Multisim. You will need to include a screen shot of your schematic with the number 6 activated.

Step 6: Verify circuit operation. Indicate the state of the probes for both the first and second set.

Decimal Input	1 st set of probes (on / off)				2 nd set of probes (on / off)			
	8's	4's	2's	1's	8's	4's	2's	1's
Neutral								
1								
2								
3								
4								
5								
6								
7								
8								
9								

Questions

1. Referring to the function table of the 74147, why are the inputs pulled high rather than low?
2. After testing the circuit, explain the function of the 7404 Hex Inverter and why it is necessary.

1: Decoder

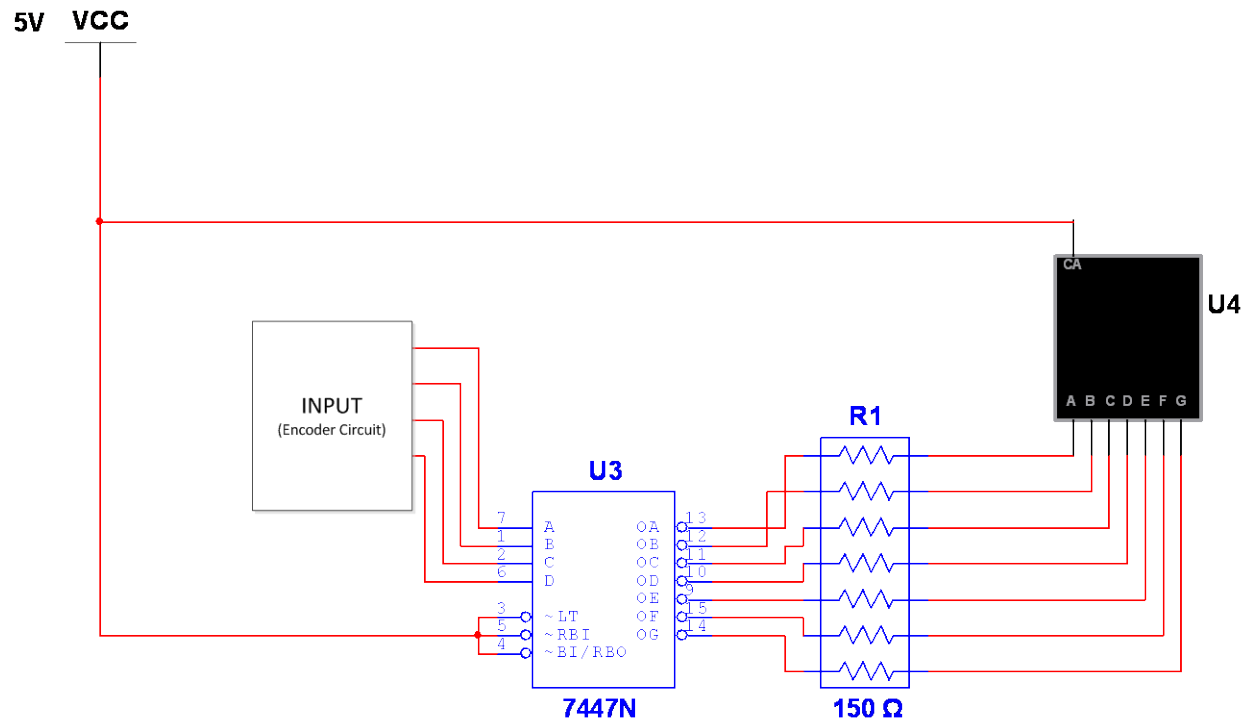
Components & Equipment Needed

- Circuit from Part 1
- 7447 BCD to 7-Segment Decoder (Fairchild, Digi-Key)
- 150 Ω Resistors
- 7-Segment Display (refer to the 7447 data sheet for the type of display necessary – common anode or common cathode)

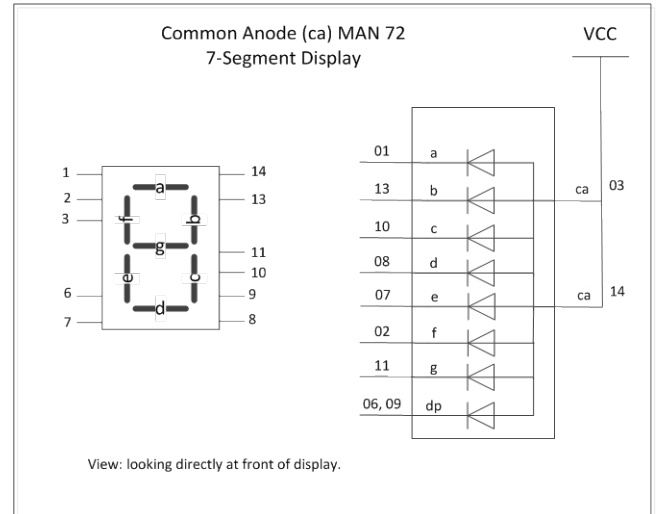
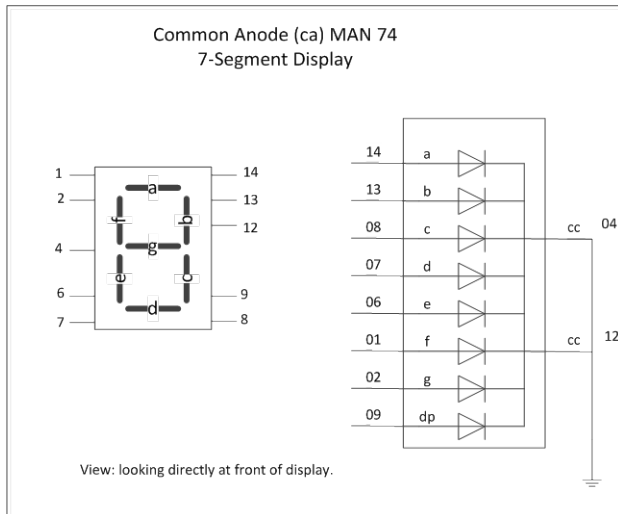
Block Diagram



Schematic



Pin-out for 7-Segment Displays (cc and ca)



Procedures

- Step 1:** Obtain the datasheet for the 7447. The pin-out for both types of 7-Segment display have been provided. You will need to determine which to use for your circuit from information contained in the 7447 datasheet. Leave the pins for the decimal point(s) disconnected when building your circuit (breadboard & Multisim).
- Step 2:** Using the function tables from the ICs of the encoder and of the 7447, determine the insertion point for the decoder.
- Step 3:** Breadboard the circuit.
- Step 4:** Verify circuit operation. Indicate the state of the probes for both the first and second set as well as the number displayed on the 7-segment display.

Decimal Input	1 st set of probes (on / off)				2 nd set of probes (on / off)				7-Segment Display
Neutral	8's	4's	2's	1's	8's	4's	2's	1's	
1									
2									
3									
4									
5									
6									
7									
8									
9									

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Step 5: Build the circuit in Multisim. You will need to include a screen shot of your schematic with the number 5 activated. The number 5 must be clearly visible on the 7-segment display.

Step 6: Verify circuit operation. Indicate the state of the probes for both the first and second set.

Decimal Input	1 st set of probes (on / off)				2 nd set of probes (on / off)				7-Segment Display
Neutral	8's	4's	2's	1's	8's	4's	2's	1's	
1									
2									
3									
4									
5									
6									
7									
8									
9									

Questions

1. Using the data in the function tables of the 74147 and the 7447, discuss your choice of insertion points for the decoder circuit.
2. Referring to the function table of the 7447, explain why pins 3 (Lamp Test), 4 (BI/RBO), and 5 (RBI) are pulled high? In what situation would the Lamp Test pin be held low?
3. In this circuit, the RBI is held high. The function table indicates that for decimals 1 through 15 it doesn't matter (X = Don't Care). By having the RBI held high, what is being accomplished?
4. Critical Thinking: The 7447 is capable of displaying 0 – 15. However, with only one 7-Segment display, how would it display any number greater than 9? Review the function table and discuss how your circuit would be altered to allow the 7-Segment display to count from 0 – 15. Next, build the circuit in Multisim to test your theory. Include a screen shot of your schematic with number 14 displayed on the 7-Segment display.

Intro to Logic & Combinational Logic

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Intro to Logic & Combinational Logic

Overview

In this lab, students will explore the basic functionality of logic gates as well as the use of the universal gate (NAND). For the second part, students will be given a logic statement and asked to implement the necessary steps for simplifying the logic statement and building the final circuit.

Requirements

To meet all requirements for this lab, you must complete all activities, questions, critical thinking activities and questions, and observations and conclusions. Compile all results into an APA formatted lab report and submit on line.

Course Objectives

1. Analyze, construct, and test digital combinational circuits.
2. Use software (Multisim) to simulate and analyze digital circuits.
3. Use manufacturer's data books to determine digital family (TTL, CMOS, ECL) parameters and pin-out configurations.
4. Demonstrate proper operating techniques and evaluate for proper operation the following list of test equipment:
 - DC Power Supply
 - Signal Generator
 - Frequency Counter
 - Impedance Meter
 - Digital Multi-meter
 - Oscilloscope
 - Logic Probe / LED

Module Objectives

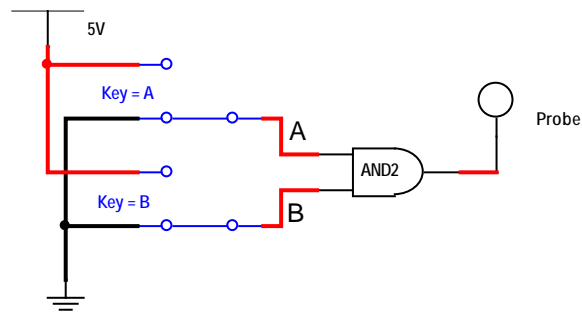
-

Activities

- 1.

1: Basic Logic

Schematic



Procedures

General Instructions

For this experiment, you will be building the above circuit using different logic gate. Using the switches, you will create truth tables for each circuit.

Rather than use specific logic chips, use the named (AND, OR, NOR, etc.) logic gates found under the Group “Misc Digital” and the Family “TTL.”

The probes are located under Group “Indicators” and the Family “Probe.” These probes are very useful when building digital circuits in Multisim in that they merely indicated whether there is a HIGH or a LOW. Unlike LEDs, these do not require additional circuitry. They can be attached wherever in a circuit they are needed.

The switch shown is a SPDT switch which has been flipped horizontally.

When recording your results, use a 1 to indicate a HIGH and a 0 to indicate a LOW.

AND

Build the circuit using an AND gate. Complete the truth table.

AND GATE		
INPUTS		OUTPUT
A	B	Y

NAND

Build the circuit using an NAND gate. Complete the truth table.

NAND GATE		
INPUTS		OUTPUT
A	B	Y

OR

Build the circuit using an OR gate. Complete the truth table.

OR GATE		
INPUTS		OUTPUT
A	B	Y

NOR

Build the circuit using an NOR gate. Complete the truth table.

NOR GATE		
INPUTS		OUTPUT
A	B	Y

XOR

Build the circuit using an XOR gate. Complete the truth table.

XOR GATE		
INPUTS		OUTPUT
A	B	Y

XNOR

Build the circuit using an XNOR gate. Complete the truth table.

XNOR GATE		
INPUTS		OUTPUT
A	B	Y

2: Critical Thinking Universal Logic

Using the information you have compiled, build an XNOR logic circuit using ONLY NAND gates. Prove, using truth tables that this circuit functions as an XNOR. Include your schematic and truth tables in your lab report.

3: Combinational Logic Circuit 1

Expression

$$f(A, B, C) = A'B' + B'C + A'C$$

Procedure

General Instructions: You must include all work, calculations, K-Maps, and schematics with your lab report. Do not use Multisim's Logic Converter except for Step 6.

Step 1: Reduce the expression to its simplest form using Boolean algebra.

Step 2: Use a Karnaugh Map to confirm your reduction.

Step 3: Build a truth table for the circuit.

Step 4: Build the circuit using Multisim.

Step 5: Test your truth table and provide a table of your results.

Step 6: Using the Multisim Logic Converter, provide a schematic of this circuit using ONLY NAND gates.

4: Combinational Logic Circuit 2 (Multisim Logic Converter)

Expression

$$f(A, B, C, D, E) = B'C'E' + B'CE + CD'E + A'BCD' + ABC'DE'$$

Procedure

General Instructions: This experiment is to be done with Multisim's Logic Converter

- Step 1:** Reduce this expression to its simplest term using a Karnaugh Map.
- Step 2:** Using the Logic Converter simplify the expression.
- Step 4:** Build the circuit using Multisim.
- Step 5:** Test your truth table and provide a table of your results. Also, include a screen shot of your truth table.

Questions

Using the results of your experiments above and the following information, please answer the questions.

All chips are of the same brand, foot print size, and quality

Logic	AND chip	OR chip	NOT chip	NAND chip	NOR chip	XOR chip	XNOR chip
Part #	7408	7432	7404	7400	7402	7486	74266
# of Gates	4	4	4	4	4	4	4
Cost Each	\$0.63	\$0.68	\$0.63	\$0.63	\$0.63	\$0.69	\$1.28

1. For Combinational Logic Circuit 1, is there any advantage to using NAND gates instead of mixed logic gates (AND/OR)? Keep in mind that a Please explain your answer.
2. For Combinational Logic Circuit 2, is there any advantage to using NAND gates instead of mixed logic gates (AND/OR)? Please explain your answer.

Interfacing with ICs

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Interfacing with IC's

Overview

In this lab, students are asked to build a moderately complicated circuit in both Multisim and on a bread board. This will give students practice in wiring digital circuits and also in interfacing multiple integrated circuit chips with buzzers and LEDs. In addition, they will be asked to “clean up” the design and to include a logic circuit allowing the selection of either or both outputs.

Requirements

To meet all requirements for this lab, you must complete all activities, questions, critical thinking activities and questions, and observations and conclusions. Compile all results into an APA formatted lab report and submit on line.

Course Objectives

- Analyze, construct, and test digital combinational circuits.
- Use software (Multisim) to simulate and analyze digital circuits.
- Use manufacturer's data books to determine digital family (TTL, CMOS, ECL) parameters and pin-out configurations.
- Demonstrate proper operating techniques and evaluate for proper operation the following list of test equipment:
 - DC Power Supply
 - Signal Generator
 - Frequency Counter
 - Impedance Meter
 - Digital Multi-meter
 - Oscilloscope
 - Logic Probe / LED

Module Objectives

- Follow a complicated schematic to build a digital circuit.
- Test functions of a digital circuit.
- Understand the challenges of interfacing various components with ICs.
- Design a logic circuit that uses a keypad to select functions.
- Discuss the differences between real world (bench) circuits and Multisim.

Activities

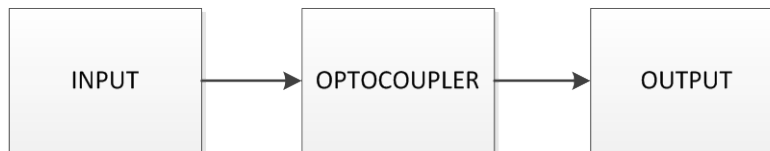
1. Interfacing with IC's.

Components & Equipment Needed

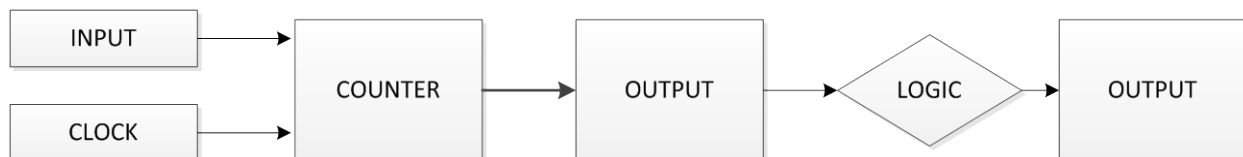
- **ONLY ONE** breadboard
- Function Generator
- DC Power Supply (5 V)
- Switches (2)
- 4n25 Optocoupler
- 150 Ω Resistors (about 11)
- 2.4 k Ω Resistor (1)
- Potentiometer (any size)
- Piezo Buzzer
- 74xx393 Dual 4-bit Decade and Binary Counter
- 7408 Quad 2-Input AND chips (2)
- 7404 Inverter (NOT)
- LEDs (8) plus 1 green, 1 red, and 1 yellow
- NO Keypad
- Other components to be determined

Functional Diagrams

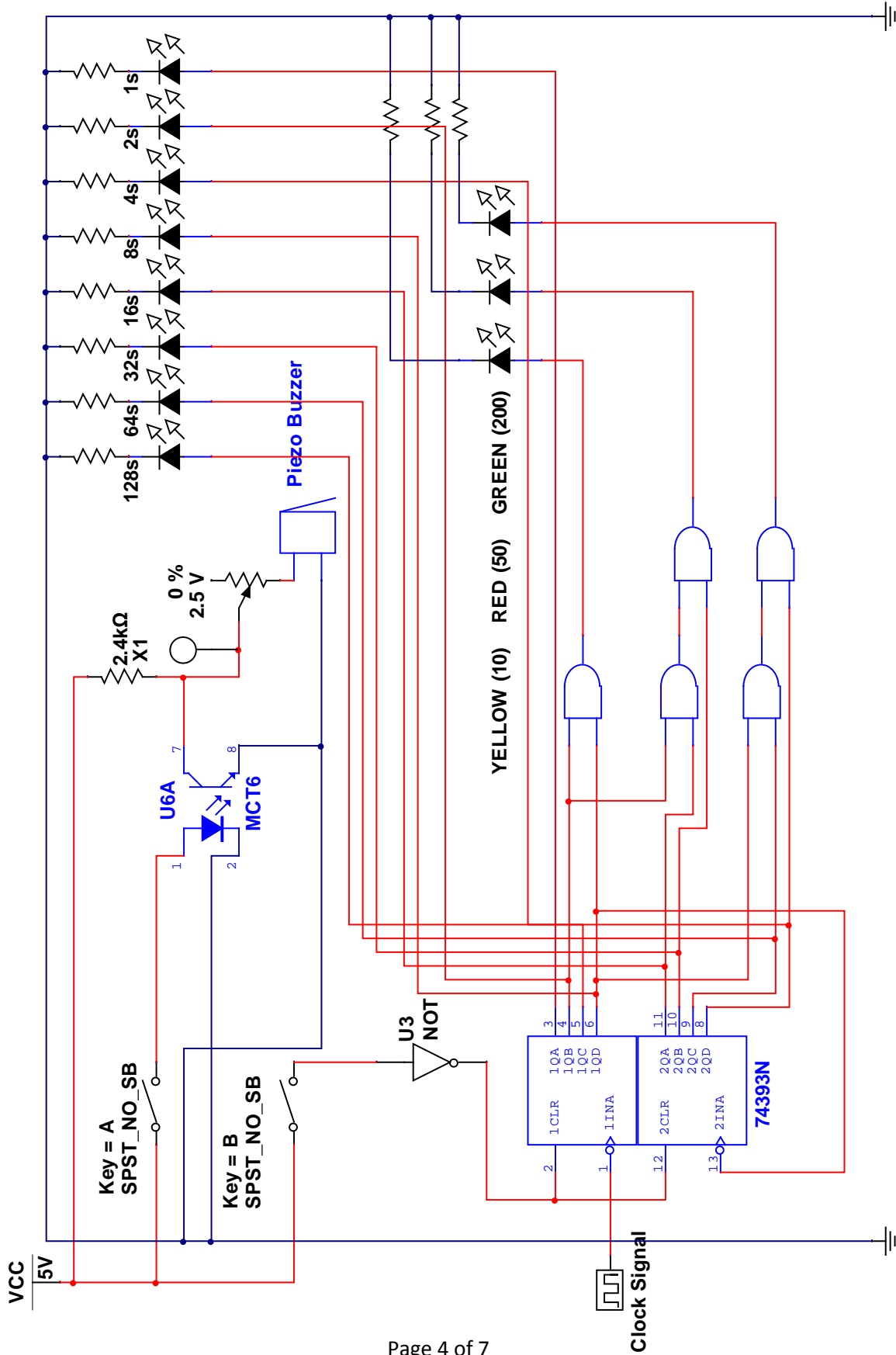
Buzzer



Counter



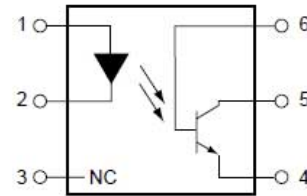
Schematic



4N25 Optocoupler

Pins 3 and 6 are not used. The internal LED is connected like any LED – the cathode is pulled to ground with a 150 Ω resistor and the anode is connected to the switch. For the transistor, the emitter (4) is pulled to ground and the collector (5) is the output. In Multisim, there is no 4N25; however, there is a MCT6 Optocoupler which is compatible.

Functional Block Diagram



PIN 1. ANODE
2. CATHODE
3. NO CONNECTION
4. EMITTER
5. COLLECTOR
6. BASE

Clock Signal

For the clock signal, set the function generator to provide a square wave at about 2.5Vpp. Experiment with the voltage to see what happens. It can be set to be any frequency, such as 60 Hz. One nice thing about using the function generator is that the frequency can be adjusted to slow down or speed up the counting.

74xx393 Dual 4-Bit Decade and Binary Counter

There are two types of this chip available: HC or LS. These are interchangeable. On the datasheet, there is more than one pin out diagram for the DIP (dual inline package) format. Make sure you are referring to the correct one. Hint: one format has 16 pins and the other has 14 pins. In Multisim, the chip is presented in two parts (A and B). You will need both.

This is a fairly straightforward chip with no special set up required. It does have D as the MSB (most significant bit) and A as the LSB (least significant bit). This makes a difference when attaching the LEDs.

Switches & Keypads

The keypads in the lab are NO (normally open). When replacing the keypad with switches in Multisim, be sure to use NO switches, such as the SPST_NO_SB (Single Pull Single Throw-Normally Open-Single Break).

Wiring Tips

It is recommended that the circuit be built in stages. For the counter section, ensure that the counter is working and lighting up the LEDs before setting up the logic. Be mindful of the need for pull up (or pull down) resistors if needed. Also, this entire circuit (both Buzzer and Counter) must be built on a single bread board. Plan accordingly.

REQUIREMENTS

There are several functions that the circuit must perform BEFORE it can be altered or experimented with:

1. The entire circuit (both buzzer and counter) must be on a single breadboard.
2. Must count from 1 – 255.
3. A yellow LED must light when the counter reaches 10. The LED does not have to stay on.
4. A red LED must light when the counter reaches 50. The LED does not have to stay on.
5. A green LED must light when the counter reaches 200. The LED does not have to stay on.
6. The buzzer must buzz and be adjustable using a potentiometer.

Procedure

Question

1. Before building the circuit, please describe how you expect the circuit will function. Be specific.

Step 1: MULTISIM: Build the circuit as shown in the schematic. Be sure to save your circuit.

Questions

2. Does it function as required? If not, please describe what is not working and discuss your troubleshooting procedures.
3. Does it function as you expected? If not, please describe the differences.

Step 2: BREADBOARD: Build the circuit as shown in the schematic.

Questions

4. Does it function as required? If not, please describe what is not working and discuss your troubleshooting procedures.
5. Does it function as you expected? If not, please describe the differences.

- Step 3:** Make a copy of your Multisim circuit. You will be making modifications to the original and both the original and modified circuits must be included in your lab report.
- Step 4:** Modify the circuit (starting in Multisim) so that the following conditions are met:
1. The yellow LED lights ONLY when the counter reaches 10. It doesn't have to stay lit.
 2. The red LED lights ONLY when the counter reaches 50. It doesn't have to stay lit.
 3. The green LED lights ONLY when the counter reaches 200. It doesn't have to stay lit.
 4. Design and implement logic using a keypad for a switch. It should have the following functions:
 - a. 1: Buzzer
 - b. 2: Counter Starts
 - c. 3: Both Buzzer and Counter
 5. Note: Since Multisim does not have a keypad, you will need to use 3 switches instead.
 6. For your lab report include the following:
 - a. Truth tables and Boolean logic equations as well as screen shots of the Multisim Logic Analyzer if used.
 - b. Schematics (both before and after modifications).
- Step 5:** Add the keypad circuit and other modifications to the circuit you have already bread boarded. You may need an additional breadboard for the keypad if there was not enough room on the first one. (It does all fit on a single breadboard, though). Be aware that circuit may not work due to differences between Multisim and "bench" (real world).

Questions

6. Document any difficulties encountered between bread boarding and Multisim.

7-Segment Displays

Air Washington Electronics ~ Introduction to Digital Logic



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Revised: Friday, March 07, 2014

7-Segment Displays

Overview

In this lab, students will build a seven segment display that will serve as the output to a simple up-down counter circuit. The type of seven segment display, whether common anode or common cathode will need to be determined from data sheets.

Requirements

To meet all requirements for this lab, you must complete all activities, questions, critical thinking activities and questions, and observations and conclusions. Compile all results into an APA formatted lab report and submit on line.

Course Objectives

- Analyze, construct, and test digital combinational circuits.
- Use software (Multisim) to simulate and analyze digital circuits.
- Use manufacturer's data books to determine digital family (TTL, CMOS, ECL) parameters and pin-out configurations.
- Demonstrate proper operating techniques and evaluate for proper operation the following list of test equipment:
 - DC Power Supply
 - Signal Generator
 - Frequency Counter
 - Impedance Meter
 - Digital Multi-meter
 - Oscilloscope
 - Logic Probe / LED

Module Objectives

- Use datasheets to choose appropriate parts.
- Assemble a 7-Segment display using LEDs.
- Build and operate an up/down counter

Activities

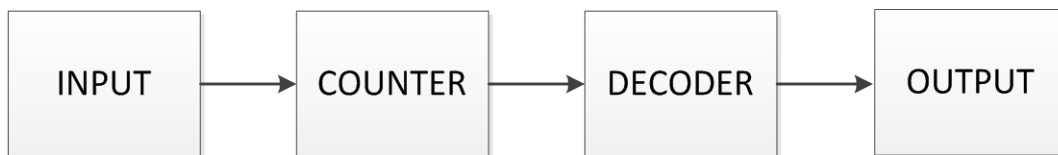
1. Up/Down Counter with 7-Segment Display
2. Carrying On

1: Up/Down Counter with 7-Segment Display

Components & Equipment Needed

- Function Generator (Clock Signal)
- DC Power Supply (5 V)
- 150 Ω Resistors
- 74xx192 Synchronous 4-bit Up/Down Counter
- 74xx47 BCD-to-Seven-Segment Decoder/Driver
- LEDs

Functional Diagrams



Special Instructions

74xx192 Synchronous 4-bit Up/Down Counter

- Inputs “D-C-B-A”
 - D is most-significant bit
 - A is least-significant bit
 - For this circuit, pull all inputs low
- Outputs (QA, QB, QC, QD)
 - Connect to the corresponding inputs on 74xx47
- Count Up
 - Pull Down Pin (#4) High
 - Pulse Up Pin (#5) with clock
- Count Down
 - Pull Up Pin (#5) High
 - Pulse Down Pin (#4) with clock

- Borrow (\sim BO), Carry (\sim CO), Clear (CLR) Pins (#12, #13, #14)
 - Borrow and Carry are used with counting with more than 4-bits
 - CLR resets the count when taken high
 - Pull them all low for this circuit
- Load Pin (#11)
 - Load allows for a preset starting number
 - Pull pin high

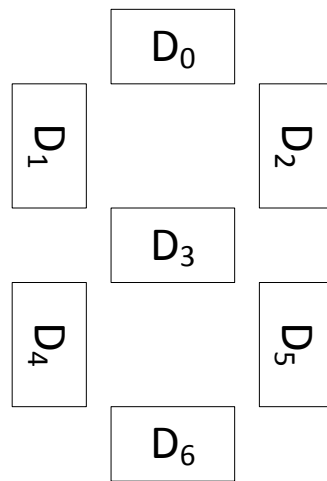
74xx47 BCD-to-Seven-Segment Decoder/Driver

- \sim LT, \sim RBI, and \sim BI/RBO Pins (#3, #4, #5)
 - Pull them all high for this circuit
- Outputs (A-G)
 - Correspond to the LEDs a-g on the 7-Segment Display

Procedure

- Step 1:** After reviewing the requirements for the 7-segment display in the 74xx47 datasheet, breadboard a 7-segment display using LEDs in your choice of color.
- Step 2:** Using the special instructions given and the datasheets, breadboard the Up/Down Counter Circuit.
- Step 3:** Verify the operation of the circuit.

2: Critical Thinking



- A. Complete the truth table for a 7-Segment display counting from 0 through 9. All inputs over 9 are considered “Don’t Care.”

Inputs				Outputs						
I ₃	I ₂	I ₁	I ₀	D ₆	D ₅	D ₄	D ₃	D ₂	D ₁	D ₀
0	0	0	0	1	1	1	0	1	1	1
0	0	0	1	0	1	0	0	1	0	0

- B. Using the truth table, write the Boolean equations for each diode.

Example: Given the two lines of information filled out in the truth table, the Boolean equation for D₅ is:

$$D_5 = \overline{I_3 I_2 I_1} I_0 + I_0$$

- C. Using the Logic Converter in Multisim, enter the truth table (remembering that all inputs over 9 are “don’t care”) and generate the logic circuit. Copy and paste your logic circuit into your lab report.