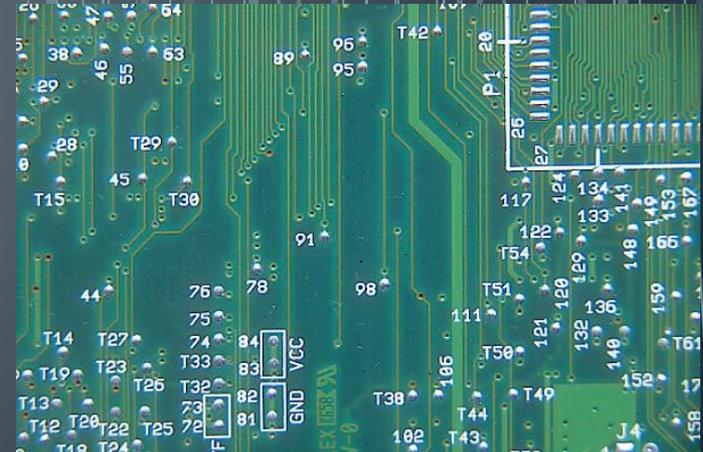
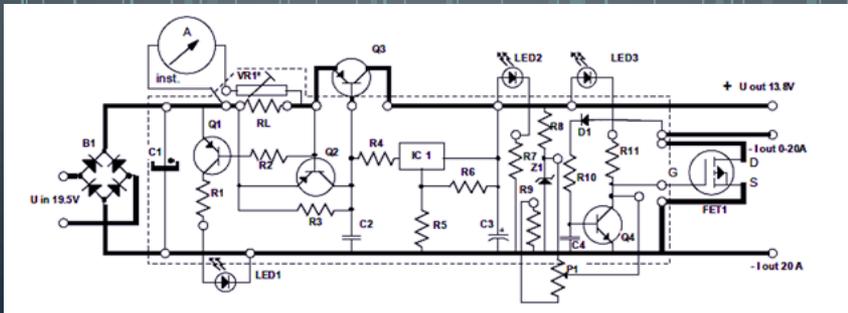


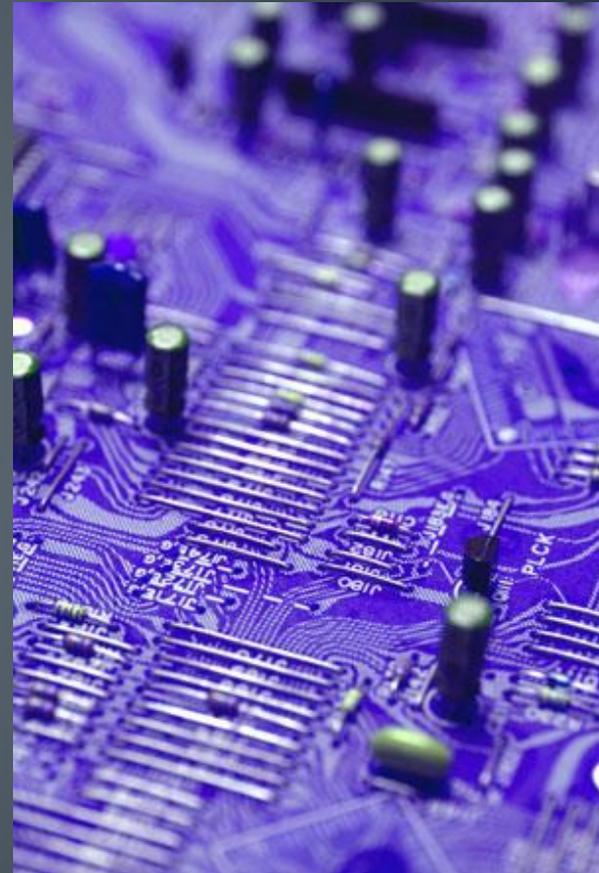
Circuit Design

Circuits, symbols, Binary, Digital Logic, Design, and Troubleshooting



Overview

- Resources
- Introduction to Circuits
- Circuit Design Process
- Electrical Symbols
- Ladder Diagrams
- Latching Circuit Design
- Digital Logic
- Basic Logic Gates
- Sample Circuit Problem
- Digital Logic Circuit Problem Tips



Resources

• For more complete documentation, and more detailed information, the following items are available from:

• <http://mfranzen.ca/index.html>

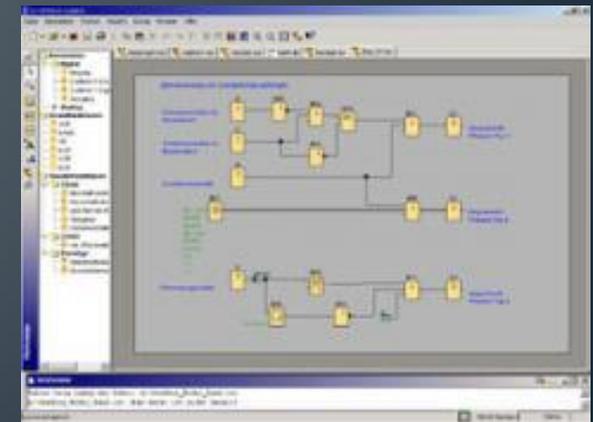
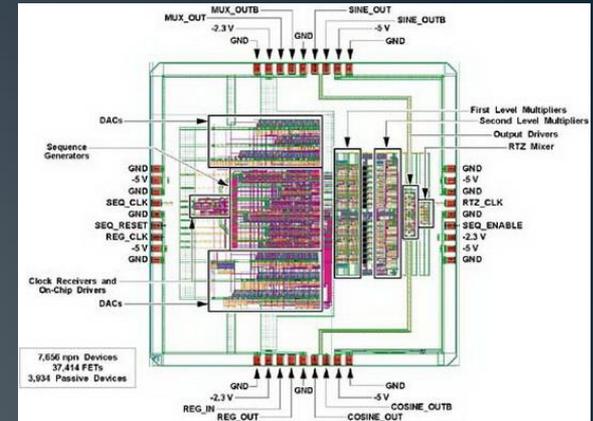
• Handouts

• <http://www.allaboutcircuits.com/>

• Volume IV – Digital Section

• LOGO!Soft Comfort Demo Software, Program Help Files & Tutorials

• <http://www.automation.siemens.com/mcms/programmable-logic-controller/en/logic-module-logo/demo-software/Pages/Default.aspx>

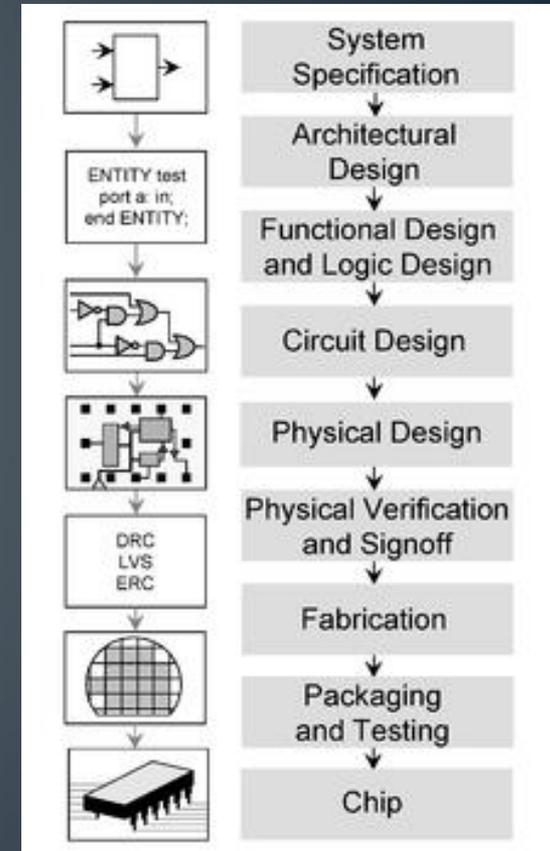


Introduction To Circuits

- *Circuit design is **a process*** that creates electrical/electronic circuits, simple or complex, to complete tasks safely & efficiently
- An **understanding** of how electricity /circuit movement , devices, and loads operate is used in several engineering fields
- **Communicating** those ideas requires a simple communication method using lines and symbols
- Part of this process includes, block troubleshooting, trial and error, step by step methods, and logical analysis
- Circuits should show either:
 - Source, control, and loads found in **hardware mechanical circuits** or
 - Input, function, and output – found in **digital Logic circuits**

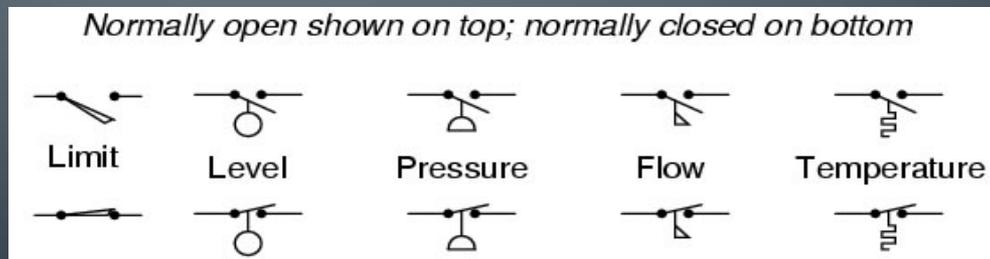
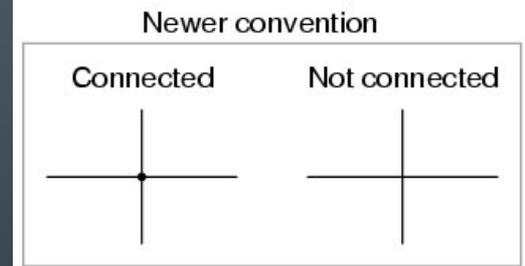
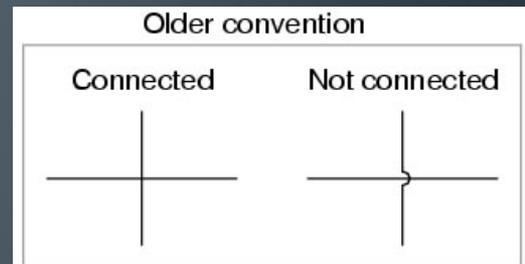
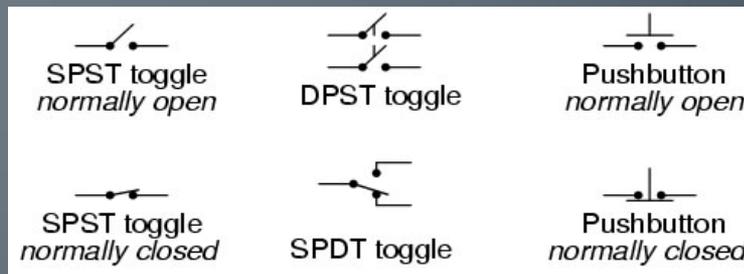
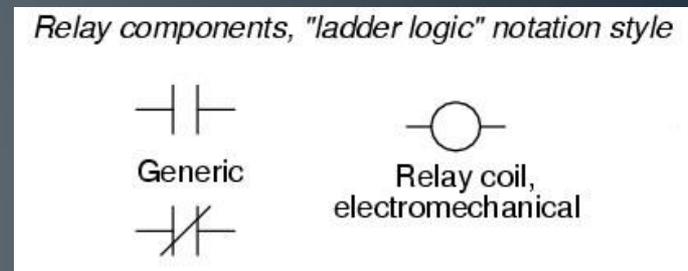
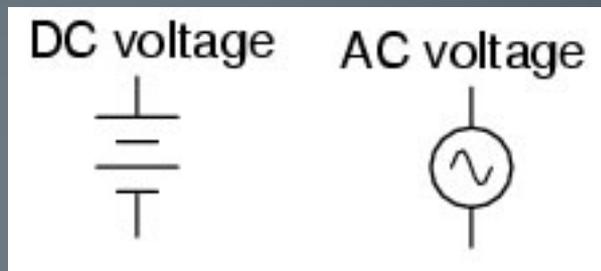
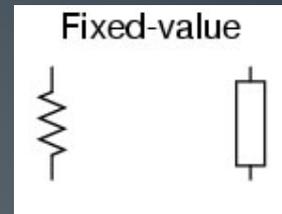
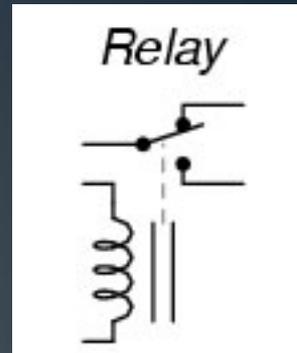
Circuit Design Process

- **SPICE** Process can be applied to Circuit Design
- **SITUATION**
 - Identify the **big picture** – what is the circuit being used for
- **PROBLEM**
 - What is the **challenge** – what circuit needs to do
- **IDEAS**
 - Investigate and **generate ideas** – circuit idea possibilities
- **CREATE**
 - Construct the **best solution** – build your best circuit idea
- **EVALUATION**
 - **Test** and troubleshoot – does it work and solve the circuit problem
 - If not, then go back Ideas step



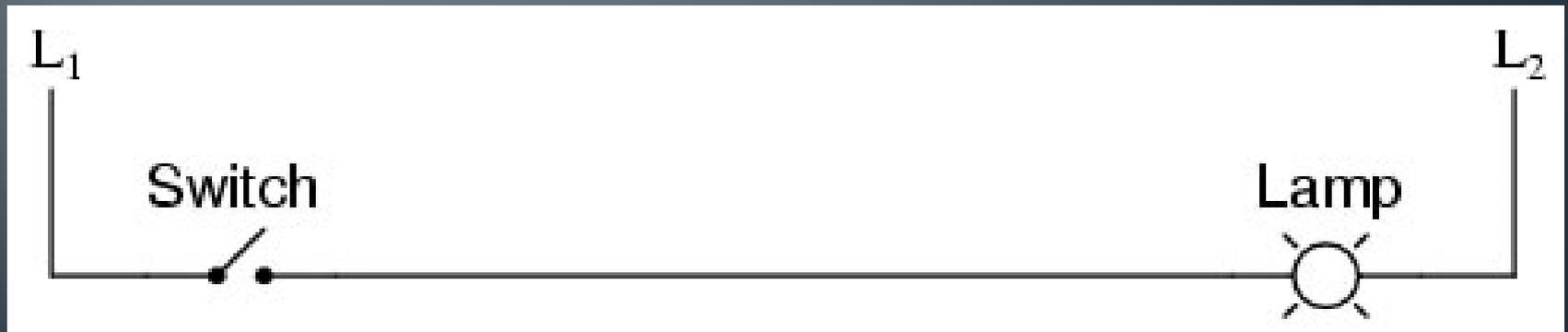
Electrical Symbols

- Some common symbols:
- Loads
- Sources
- Wiring
- Switches
- Contacts
- Relays

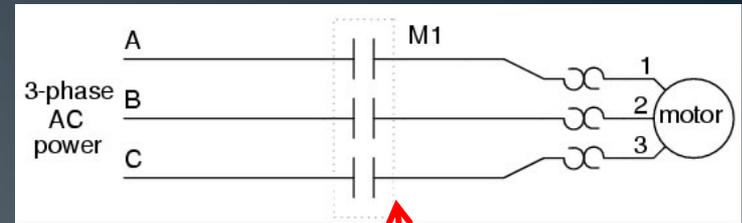


Ladder Diagrams

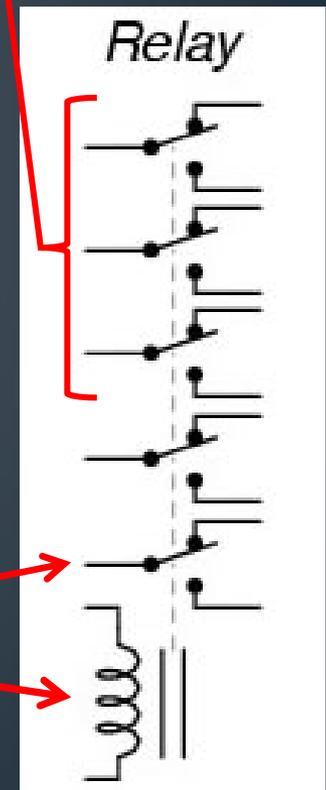
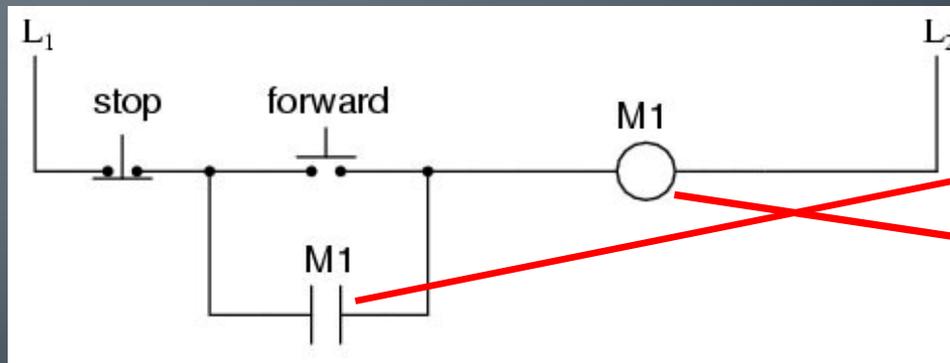
- Used to show circuit **schematics** - a ladder type simple circuit diagram with
 - **vertical rails** representing line power 1 and 2 (feed and return, or +, -)
 - **Rung(s)** representing the circuit components and designed task
- Here is an example of a simple switch and lamp circuit with one rung level in the form of a **hardware mechanical/electrical circuit** :



Latching Circuit Design

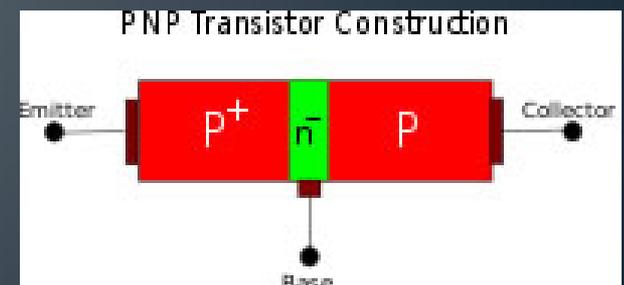
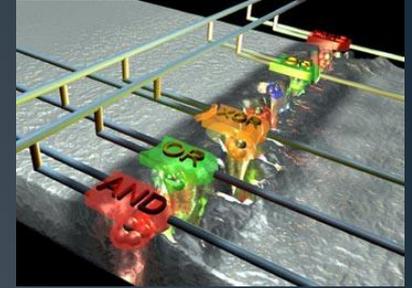


- Industry uses **latched circuit design** to create a safety feature allowing for constant feedback and possible power failure concerns
- This type of circuit uses a **control relay** with momentary **push buttons, control contacts** and - main **power contacts**
- Key to this circuit below is the M1 relay coil and the M1 latch contact
- When the coil is energized by momentary forward push button, it changes the state of all contacts attached including the M1 control contact (below), and the M1 Power contact (above)



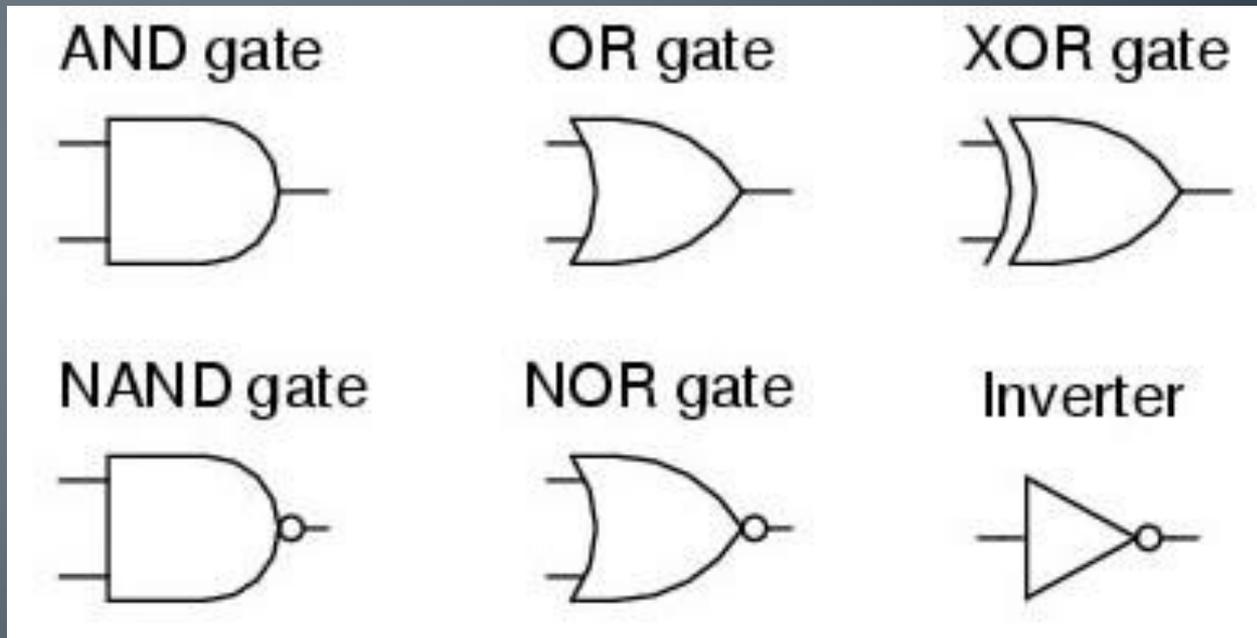
Digital Logic

- Standard electrical circuits use related relays and switches similar to what you find in homes, factories, schools, etc.
- Electronic circuits such as
 - Micro-controllers, computers, robotics, etc. Use a new type of circuit:
 - Digital logic is the basis of digital electronics
 - Formed by the combination of transistors made up of semiconductor materials (electronic switches)
 - Acting similar to standard circuits but use a lot lower voltage/current and extremely small in size
- Boolean logic – bits and bytes
- Logic gates – symbols, truth tables, operators



Basic Logic Gates

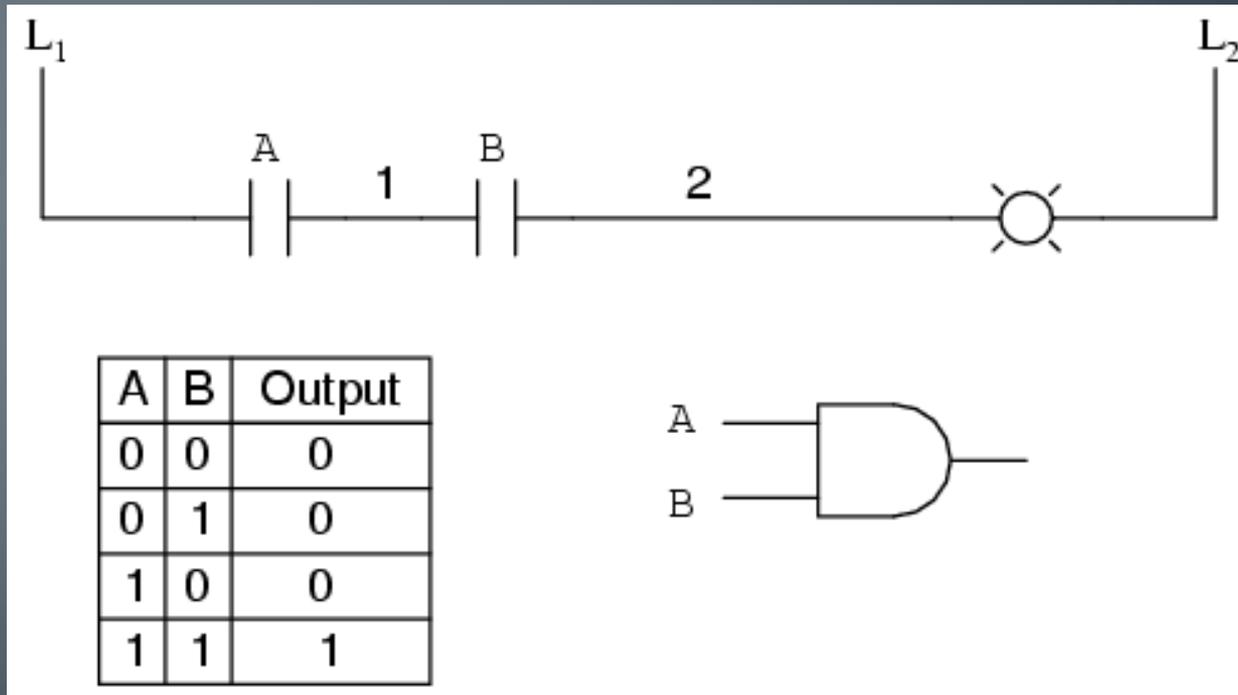
- Here is a quick overview of the symbols used to represent basic digital logic circuit gate



- Lets take a look at these up close in terms a of a equivalent electrical circuit and a truth table

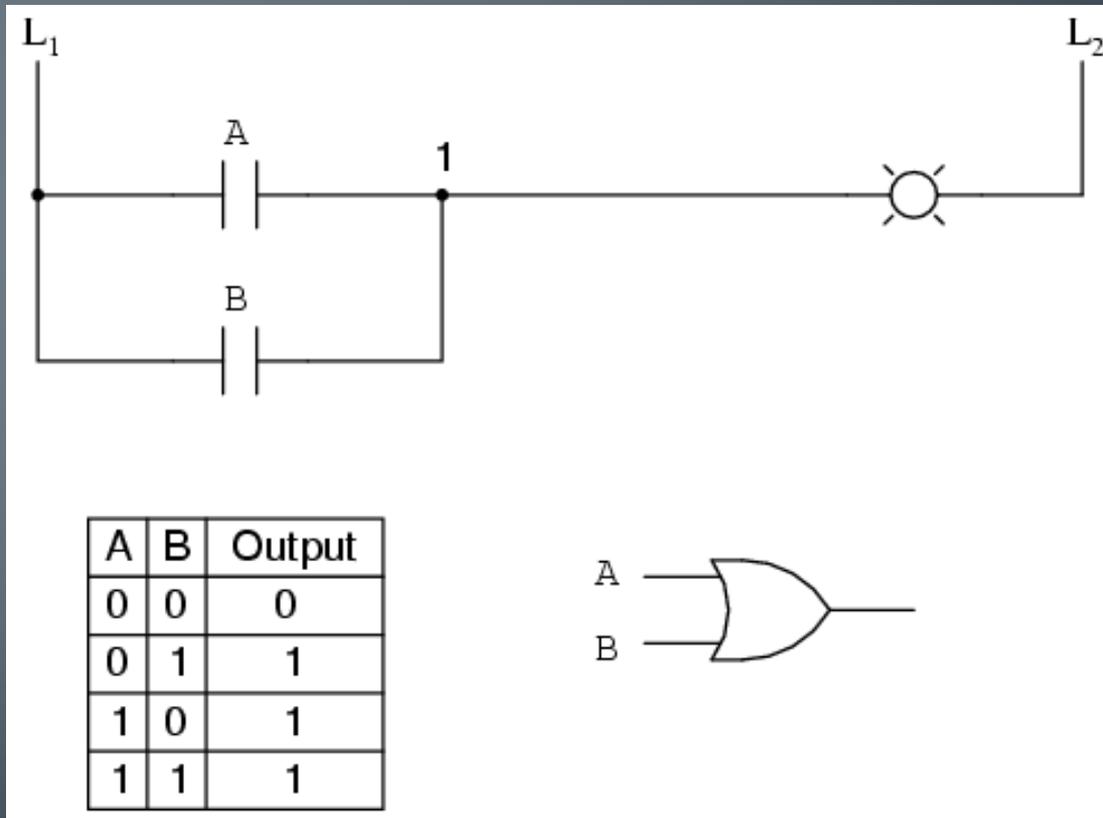
AND Gate

- A and B must both be high/on in order for output to be high/on



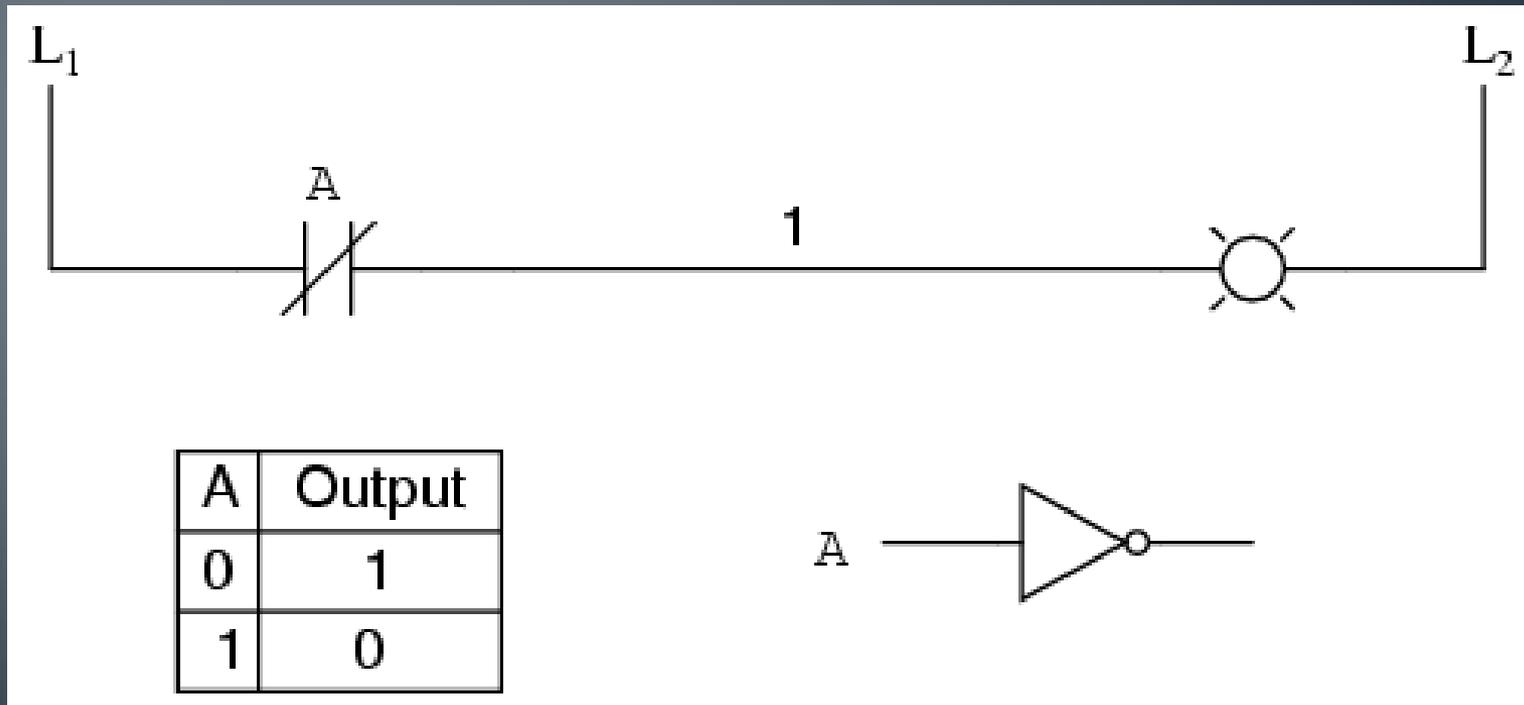
OR Gate

- Either A or B can be high/on to produce a high/on output



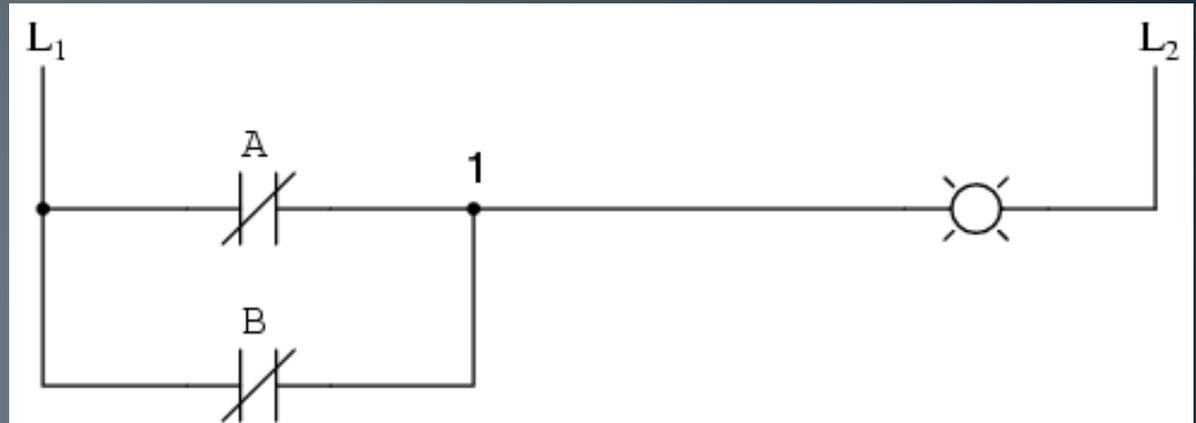
NOT Gate

- The small circle on the end of the triangle represents the inverter, so if A is a high/on, then the output will be Low/off

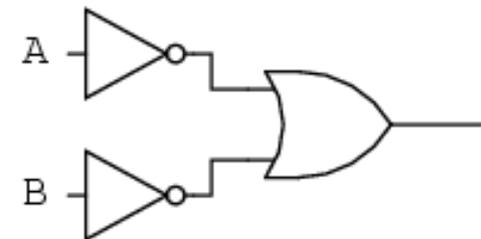


NAND Gate

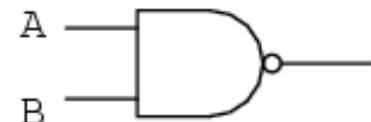
- Opposite of an AND gate because of the inverter.
- Both A and B must be High/on to get a output of Low/off



A	B	Output
0	0	1
0	1	1
1	0	1
1	1	0

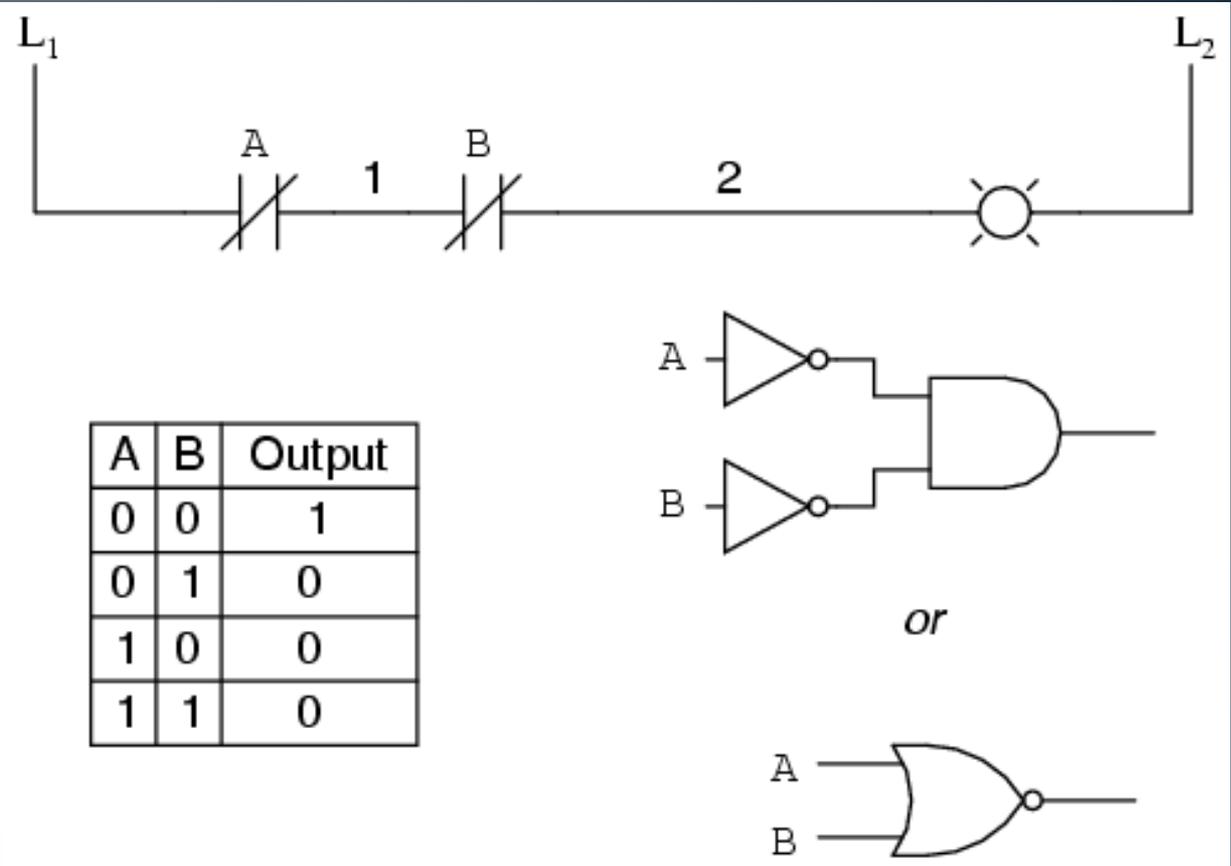


or



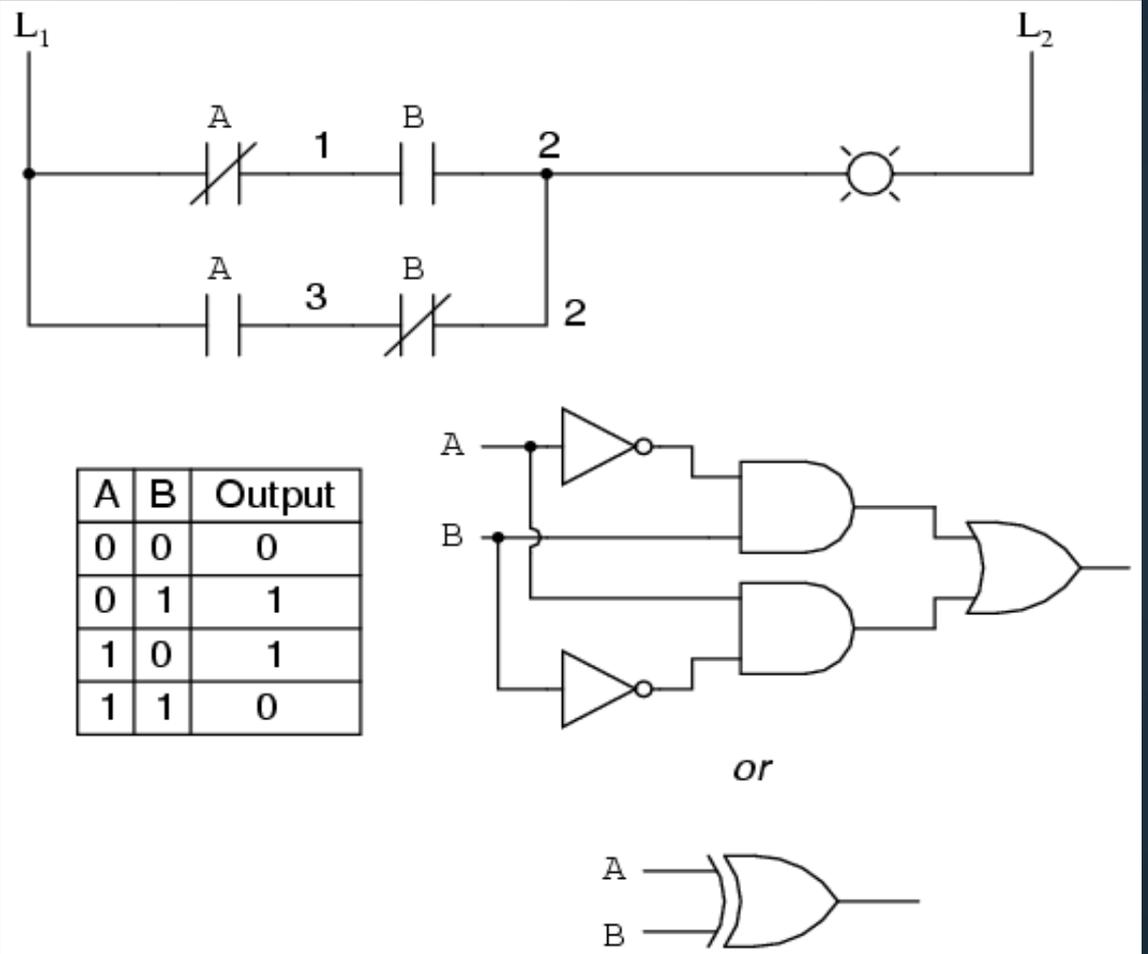
NOR Gate

- Opposite of an OR gate because of the inverter.
- Both A and B must be Low/off to get a output of High/on



XOR Gate

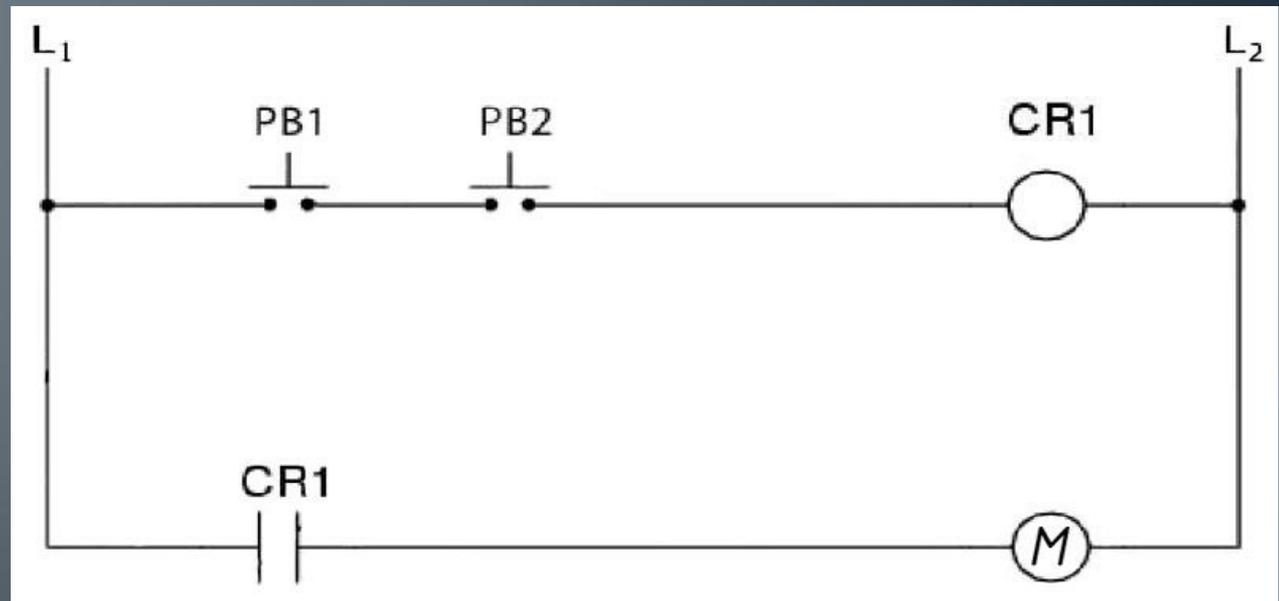
- Exclusive OR will only have a High/on output if either A or B only have a High/on



Sample Circuit Problem

- **Given:** Create an equivalent logic circuit that forces an operator to push two buttons at the same time in order to energize control relay 1 that will activate the load/machine to start. If one or both buttons are released the load/machine will stop.

- **Step 1:** Draw the standard hardware/electrical circuit required



Sample Circuit LogoSoft Familiarization

Step 2: If this is the first time to using this software, familiarize yourself with this programs interface, toolbars, and logic gates needed

Start up LOGOSoft Comfort and insert title, name, given information, and Sub titles for Inputs, Functions, and outputs using the text tool

User interface - Overview
User interface and programming interface

LOGOSoft Comfort starts with the empty user interface of LOGOSoft Comfort. Click on this icon.

Result: LOGOSoft Comfort creates a new, empty circuit program.
You now see the complete user interface of LOGOSoft Comfort. The programming interface for creating your circuit programs occupies the greater part of the screen. The icons and logical links of the circuit program are arranged on this programming interface.
To help you to maintain an overview of large circuit programs, the right side and the bottom of the programming interface contain scroll bars, which you can use for vertical and horizontal scrolling of the circuit program.

1
2
3
4
5
6
7

① Menu bar
② Standard toolbar
③ Programming interface
④ Info box
⑤ Status bar

⑥ Programming toolbar

Menu bar
The menu bar is located at the top of the LOGOSoft Comfort window. Here, you can find various commands for editing and managing your circuit programs, as well as functions for defining your default settings and for transferring of the circuit program to and from LOGO!

Toolbars
LOGOSoft Comfort provides the following three toolbars:

- Standard toolbar
- Programming toolbar
- Simulation toolbar

Standard toolbar
The standard toolbar is located above the programming interface. After its start, LOGOSoft Comfort shows you a reduced standard toolbar that provides only the essential functions.
The standard toolbar provides direct access to the essential functions of LOGOSoft Comfort.
After you have opened a circuit program for editing on the programming interface, you can see the complete standard toolbar.
You can use the icons to create a new circuit program or to download, save and print out an existing program, cutcopy and paste objects, or initiate data transfer to and from LOGO! devices.
You can use the mouse to select and move the standard toolbar. The toolbar is always snapped onto the top of the menu bar when you close it.

Programming toolbar
The programming toolbar is located at the left of the screen. Its icons can be used to change to other editing modes, or for quick and easy creation or editing of a circuit program.
You can drag and drop the programming toolbar to another location with the mouse. The toolbar is always snapped onto the top of the menu bar when you close it.

Simulation toolbar
The LAD Editor no longer contains the Basic function (SF) icon, because you create logical "AND" and "OR" links by interconnecting individual blocks.
This toolbar is only relevant for the simulation of circuit programs.

Info box
The info window, located at the bottom of the programming interface, displays information and notes, as well as the LOGO! devices recommended by the Tools -> Determine LOGO! function for use in your circuit program.

Status bar
The status bar is located at the bottom of the program window. It shows the currently active tool, the program status, the zoom factor, the page number of the circuit diagram and the selected LOGO! device.

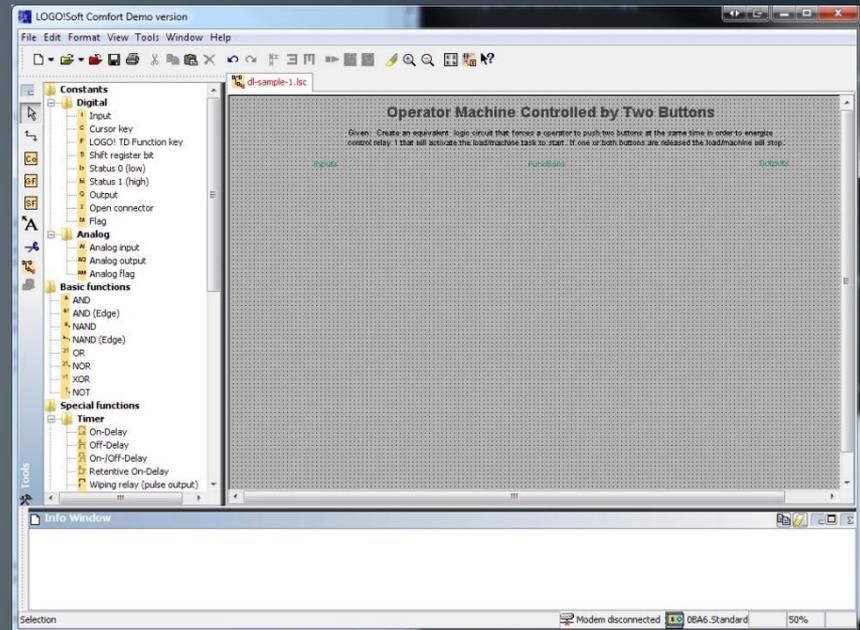
Sample Circuit Problem Setup

Step 3: Neatly insert a title, description of circuit operation, and sub titles; Inputs, Functions, and Outputs spread out on page at top

Step 4: Insert your known inputs and outputs in appropriate locations, then figure out what is needed for you functions –drag and drop

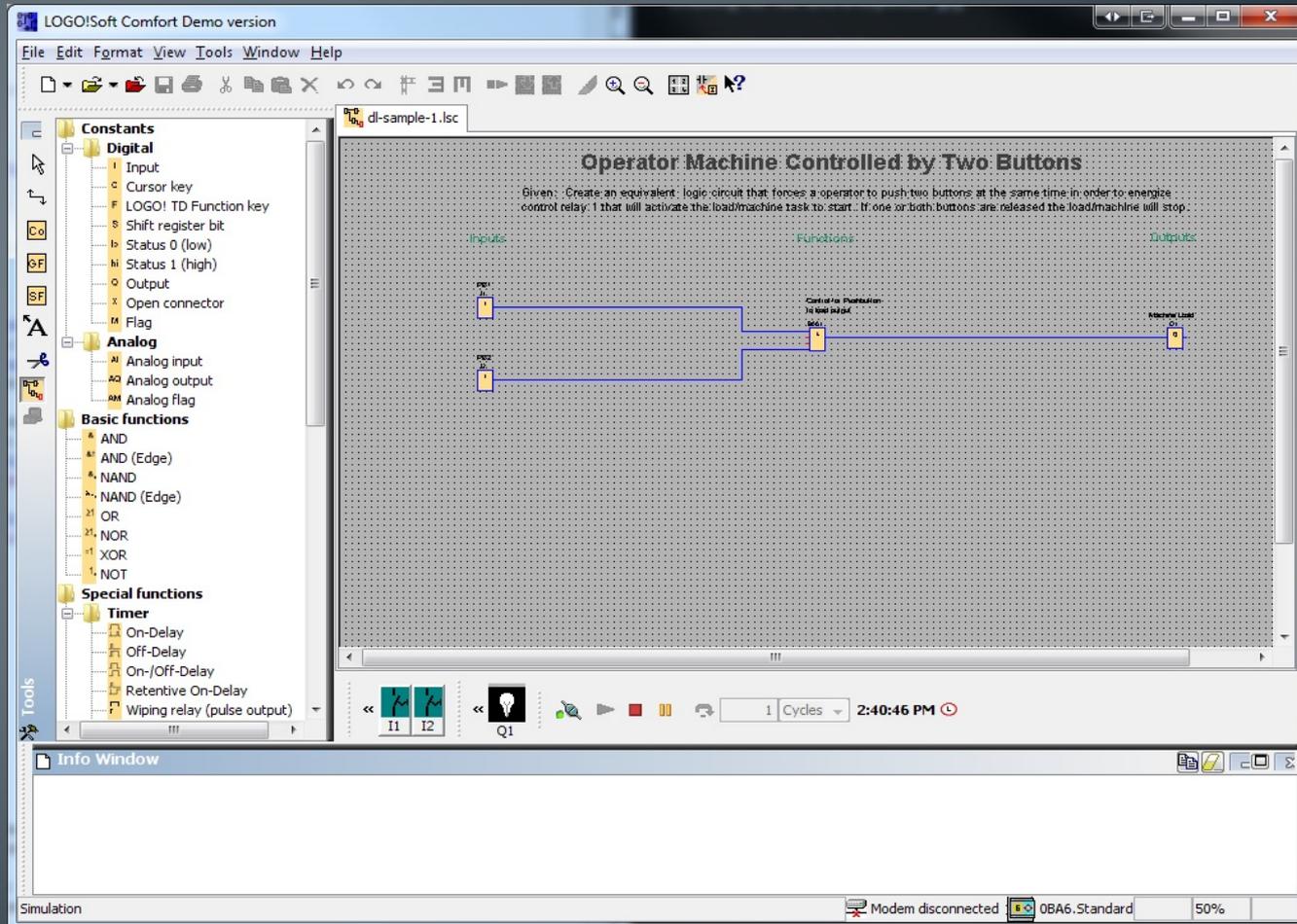
Step 5: Label and set configurations for all inputs, functions, and outputs using comment command in the actual object's menu

Step 6: Connect all your wiring, organize placement of objects using alignment tools and make sure wiring is not crossing and is easy to follow



Sample Circuit Simulation Testing

Step 7: Simulate circuit using F3 to test if circuit is working properly



Digital Logic Circuit Design Creation Tips

- Know your basic logic gates
- Use SPICE to guide you through circuit design process
- Break down circuit requirements into blocks/sections and work on one section at a time
- Think series or parallel circuit operation to ensure proper connections and operation
- Use LOGO!Soft Comfort Demo Software :
 - <http://www.automation.siemens.com/mcms/programmable-logic-controller/en/logic-module-logo/demo-software/Pages/Default.aspx>
 - ...to create, test, modify, and troubleshoot your circuit design idea
- Ensure components are neat, organized, and labelled
- Show your Inputs, Functions, and Outputs titles and ensure your circuit is in this order across the horizontal of the page
- Fit your diagram on a single page
- Do not cross wires unless absolutely unavoidable