

SYSTEMS ENGINEERING DEPARTMENT
KING FAHD UNIVERSITY OF PETROLUUM AND MINERALS



CISE 313

Automation Devices and Electronics Laboratory Manual

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This laboratory introduces the students to final control elements likes proximity inductive and photoelectric switches, limit and reed switches, valves (solenoid and control valves). It also introduces the students to various power electronics like SCR, FET, DIAC and TRIAC. All these control experiments are first introduced using PLC simulation software and then by physical experimental setup using various modules.

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LAB 1: INTRODUCTION TO AUTOMATION DEVICES AND ELECTRONICS

In automation, mechatronics plays a great role. Suppose we want to use sensor inputs and give outputs to motors to control certain machine or plant as shown in Fig 1. Before electronics becomes popular and cheaper, it has been controlled using pneumatic and/or hydraulic values. Now most of these are replaced by mechatronics systems.

In mechatronics, we use electronics in four different ways.

1. Programmable logic controllers -PLC is a digital electronic device that uses a programmable memory to store instructions for obtaining logic, sequencing, timing, counting and arithmetic in order to control machine and processes. The advantage of using PLC is that it is possible to modify a control system without having the input and output devices rewired and without using new or modified control valves in order to change the required logic. The only requirement being that an operator has to key in a different set of instructions. The result is a flexible system that can be used in control systems that vary quite widely in their nature and complexity.

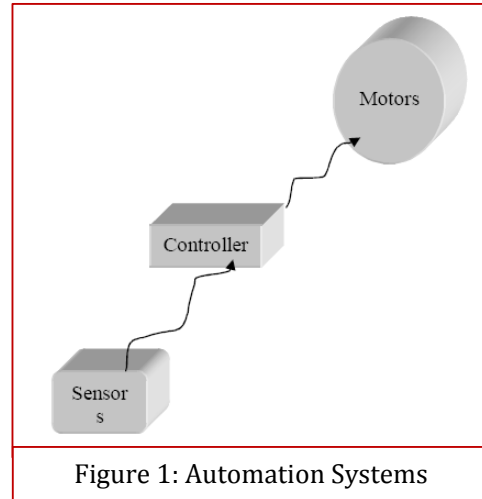


Figure 1: Automation Systems

2. Electronics circuits-This is commonly used in mass products or large batch products since these circuits are especially designed for the purpose. For example Control cards, motor driving circuits.
3. Computer controlled machines-Computer acts as a controller taking inputs from sensors and giving the necessary output signals to the actuators or motors.
4. Micro controllers- it is a programmable integrated circuit (IC). Functions of the micro controllers could be quite similar to PLCs. It is more compact, more flexible in programming and much cheaper, but more programming is required and less number of inputs and outputs in general relative to a PLC.

All these devices have advantages and limitations over each other and hence choice of the controlling method is application dependent. All the above mentioned devices consist of electronic circuits and they consider digital inputs and digital outputs though some PLCs can obtain a kind of analogue inputs and outputs. All the above three mentioned controllers generally consider a digital voltage inputs and a voltage output.

Sensors and Transducers

The term sensor is used for an element that produces a signal relating to the quantity being measured. Transducers are defined as elements that when subject to some physical change experiences a related change. Thus sensors are transducers. However, a measurement system may use transducers, in addition to the sensor, in other part of the system to convert signals from one form to other form.

Signal conditioners

Sensors can give different kinds of output from the sensing devices and these outputs have to be processed or converted as a voltage and the voltage output may have to be converted or processed to

other type of signals in mechatronics systems. This device is known as a signal conditioner. Operational amplifier and A/D converter are two examples of such devices. Signal conditioners act a major role between controller and sensors as well as controller and motor or actuators.

Pneumatic Systems

In early systems, control functions were obtained through pneumatic valves and today replaced by electronic circuits and still pneumatic signals are still popular and used to control final control elements because such signal can be used to actuate large valves and other high power control devices. The main draw back of the pneumatic systems is however the compressibility of air. Pneumatic is not only used as a control mechanism, but also as actuators and in some cases logic is conducted through a PLC or an electronic circuit with electro-pneumatic valves to convert the signals.

Hydraulic Systems

Hydraulic Systems are used basically for actuators and motors consisting high power. In Heavy Machinery equipments hydraulic actuators are used to conduct many tasks. Hydraulic control valves are used to change the direction of the fluid by giving manual, electro-mechanical or/and pneumatic signals. However, there are hazards in using hydraulics due to oil leaks that does not matter in pneumatic systems.

Programmable Logic Controllers

PLC is similar to using a computer but has certain features that are specific to their use as controllers. These are:

1. They are rugged and designed to withstand vibrations, temperature, humidity and noise.
2. The interfacing for inputs and outputs is inside the controller.
3. They are easily programmed and have an easily understood programming language. Programming is primary concerned with logic and switching operations.

PLCs were first conceived in 1968. They are now widely used and extend from self contained units for use with around 20 digital inputs/outputs to modular systems that can be used for large number if inputs/outputs, handle digital or analogue inputs/outputs and also carry out PID control modes.

Architecture of a PLC is given by the figure below.

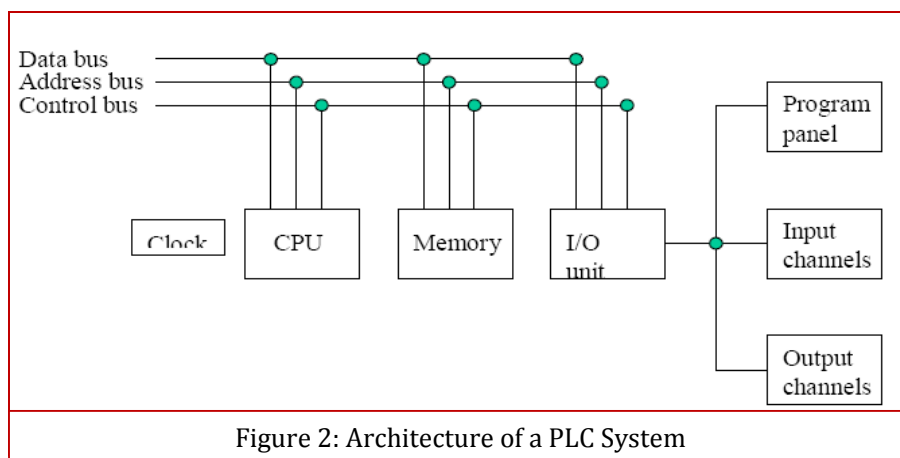


Figure 2: Architecture of a PLC System

Electronic Control Circuits

Basic electronic control circuits consist of two types, namely combinational logic gates and sequential logic gates. The advantage of electronic control circuits is construction is cheaper than pneumatic valves, hydraulic valves or programmable logic controller, but design is quite costly. In this course, we will only look at functions of sequential and combinational logic gates only to understand certain principals of PLC programming. However, electronic circuit design for controllers and for signal conditioning is not expected to be covered during this course and no practical program is conducted to cover the electronics.

PLC for industrial application

PLC is a frequently used in automation at various levels such as small scale automation, medium level automation as well as higher level automation. You will be given hands on experience in programming PLC for small scale automation by the models available in the laboratory. In addition to that you are given programming exercises to simulate your results in different applications. In addition to simulators, there are five models are available for programming. They are as follows.

1. Sorting Mechanism
2. Stamping Mechanism
3. Length sorting Mechanism
4. Sort and Stamping Mechanism
5. Motor Model

All the above models are expected to be programmed with a PLC. You are able to program a small automation application and with practice you can gain the necessary skills to program the medium level as well. Also, you will be exposed to the problems encountered in such programming during practical sessions as well as via lectures conducted by experts in the industry. An introduction about the advance PLC application will be given. However, it is not expected to cover advance application in this course.

Pneumatics

You will be given a basic knowledge about pneumatics and basic pneumatic circuits for you to understand the application models. Most of the above mentioned applications models use pneumatics.

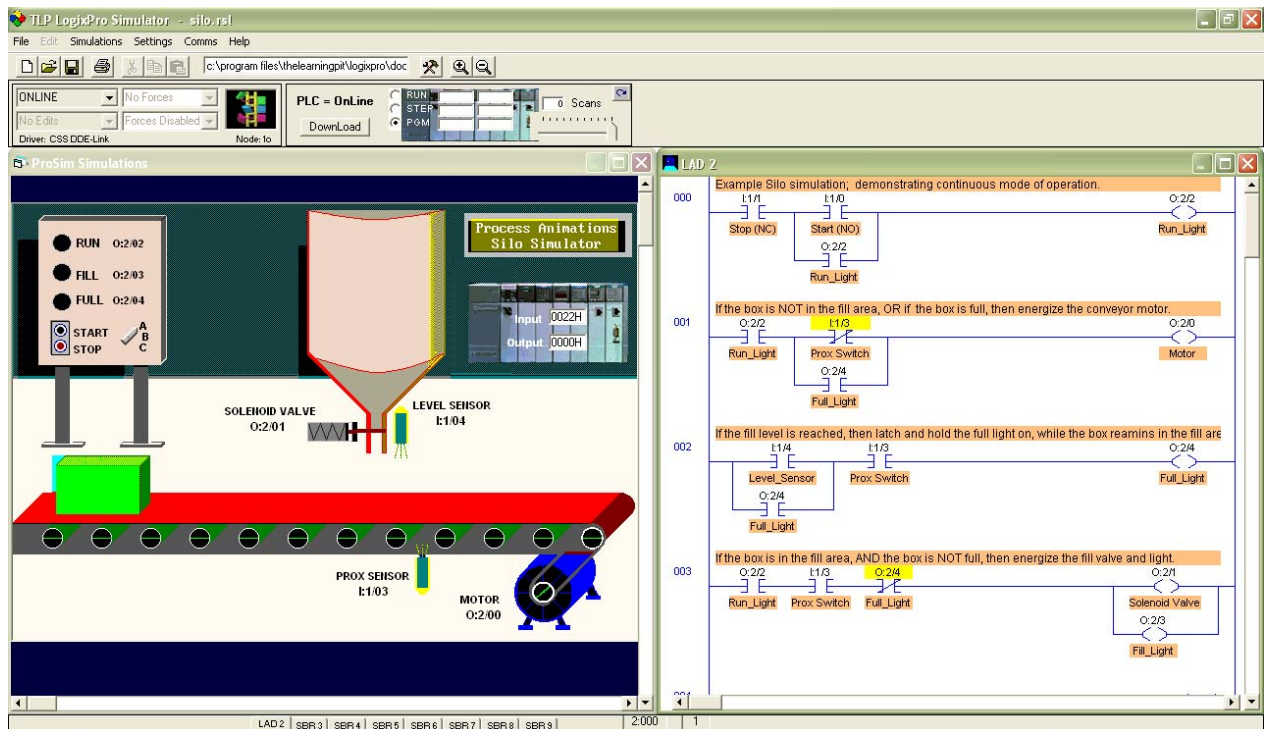
LAB 2: OVERVIEW OF PLC LOGIC SIMULATION & SILO PROCESS EXAMPLE

Overview:

The name of the simulator is “**The logixpro 500 Simulator**”. The Simulator eliminates the dependency on having PLC-Hardware and other Interfacing Components and Hardware Simulators / Sensors – Actuators in learning PLC programming. However, the simulator cannot replace learning quality with Hardware setup (PLC, Sensors, Actuators and Circuits).

Follow the Steps to get into PLC programming:

1. Launch Simulator and Open the file "silo.rsl" present in LogixPro directory.
2. You will see two windows, one showing Process-Simulation and other showing programming language of PLC known as Ladder Diagram.



3. You first need to download the Software (the ladder program) into the PLC.
4. Steps to Download the Ladder-program into PLC:
 - a. >> File Menu >> Comms >> Go online (this will show the PLC Panel)
 - b. >> Press Download button on the PLC panel
 - c. >> Bring the PLC into RUN mode by clicking appropriately.
5. Note that PLC Panel shows the three modes of PLC.
 - a. RUN Mode
 - b. STEP Mode
 - c. PGM Mode which is the Programming/downloading mode.
6. START the Simulation.
7. While simulation is ON, you are required to answer following questions by carefully observing the process, its components and the Ladder-Logic.

Exercise 1: Understanding Automation from Programming Aspect

1. List the sensors and actuators used in this Automation. Also mention the Input/Output ports of PLC where these devices are connected. (Hint: see the ladder diagram for addresses)

2. Describe the function of sensors and actuators.

3. Which programming language is used?

4. While Simulation is ON, figure out the Logic of the program and write in Sequential Steps.

Exercise 2: How to program in Ladder Logic

Task: How can we automatically STOP the Filling-Process by a fixed number?

(For example, the process fills only the first 10 boxes and then STOPS)

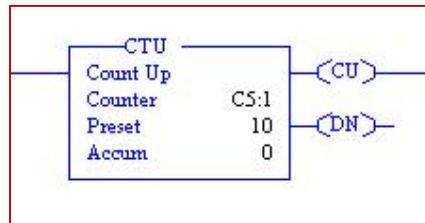
Answer following questions:

1. What devices will be helpful in this task?

2. Suggest a Solution for this task considering you have the ladder-program from the last simulation.

Hint and Help:

1. There are Counters available in the Timer/Counter Tab
2. CTU is a counter used for Count-Up
 - a. Figure of CTU module is:



- b. Observe that it has one input line on left and two outputs on right.
- c. You need to specify the Counter Name. (here it is C5:1)
- d. Preset:- It can be taken as the target value (i.e., the max value we are seeking)
- e. Accum:- This starts from 0 and counts up at every input to the counter

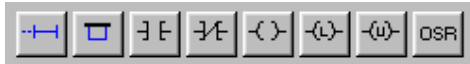
LAB 3: INTRODUCTION TO PLC RELAY LOGIC PROGRAMMING

Objective:

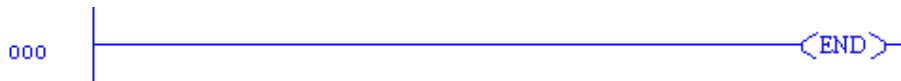
The objective of this exercise is to get familiar with the PLC relay logic programming.

RSLogix Relay Logic Instructions:

This exercise is designed to familiarize you with the operation of LogixPro and to step you through the process of creating, editing and testing simple PLC programs utilizing the Relay Logic Instructions supported by RSLogix. Following are some of the icons that depicts the relay logic.



From the Simulations Menu at the top of the screen, Select the I/O Simulation and ensure that the User Instruction Bar shown above is visible.

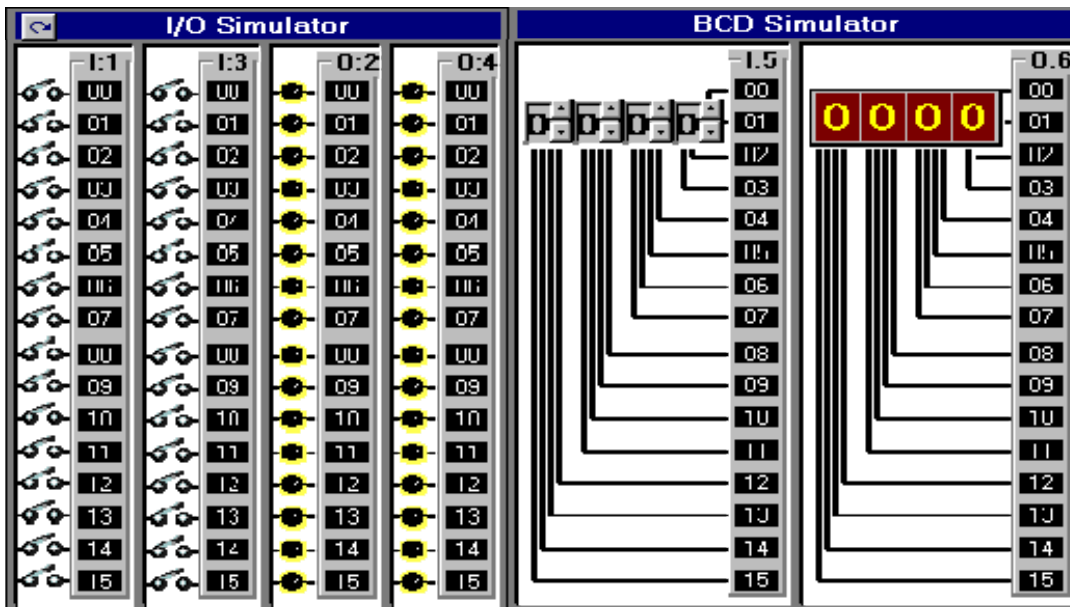


The program editing window should contain a single rung. This is the End of Program rung and is always the last rung in any program. If this is the only rung visible then your program is currently empty.

If your program is not empty, then click on the File menu entry at the top of the screen and select "New" from the drop-down list. A dialog box will appear asking for you to select a Processor Type. Just click on "OK" to accept the default TLP LogixPro selection. Now maximize the ProSim-II Simulation Window



The I/O Simulator:



The simulator screen shown above, should now be in view. For this exercise we will be using the I/O simulator section, which consists of 32 switches and lights. Two groups of 16 toggle switches are shown connected to 2 Input cards of our simulated PLC. Likewise two groups of 16 Lights are connected to two output cards of our PLC. The two input cards are addressed as "I:1" and "I:3" while the output cards are addressed "O:2" and "O:4".


Use your mouse to click on the various switches and note the change in the status color of the terminal that the switch is connected to. Move your mouse slowly over a switch, and the mouse cursor should change to a hand symbol, indicating that the state of switch can be altered by clicking at this location. When you pass the mouse over a switch, a "tool-tip" text box also appears and informs you to "Right Click to Toggle Switch Type". Click your right mouse button on a switch, and note how the switch type may be readily changed.

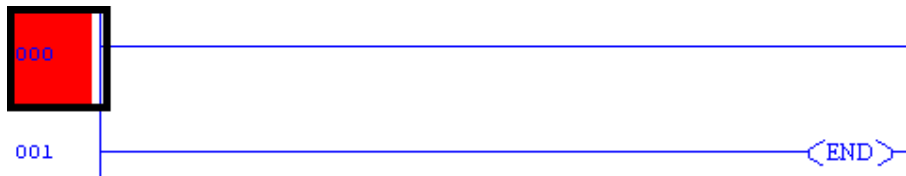
RSLogix Program Creation:

Collapse the I/O simulation screen back to its normal size by clicking on the same (center) button you used to maximize the simulation's window. You should now be able to see both the simulation and program windows again. If you wish, you can adjust the relative size of these windows by dragging the bar that divides them with your mouse.


I want you to now enter the following single run program which consists of a single Input instruction (XIC - Examine If Closed) and a single Output instruction (OTE - Output Energize). There's more than one way to accomplish this task, but for now I will outline what I consider to be the most commonly used approach.




First click on the "New Rung" button  in the User Instruction Bar. It's the first button on the very left end of the Bar. If you hold the mouse pointer over any of these buttons for a second or two, you should see a short "ToolTip" which describes the function or name of the instruction that the button represents.



You should now see a new Rung added to your program as shown above, and the Rung number at the left side of the new rung should be highlighted. Note that the new Rung was inserted above the existing (END) End of Program Rung. Alternatively you could have dragged (left mouse button held down) the Rung button into the program window and dropped it onto one of the locating boxes that would have appeared.

Now click on the XIC instruction  with your left mouse button (Left Click) and it will be added to the right of your highlighted selection. Note that the new XIC instruction is now selected (highlighted). Once again, you could have alternatively dragged and dropped the instruction into the program window.

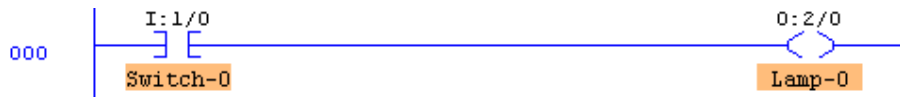
If you accidentally add an instruction which you wish to remove, just Left Click on the instruction to select it, and then press the "Del" key on your keyboard. Alternatively, you may right click on the instruction and then select "Cut" from the drop-down menu that appears.

Left Click on the OTE output instruction  and it will be added to the right of your current selection.



Double Click (2 quick left mousebutton clicks) on the XIC instruction and a textbox should appear which will allow you to enter the address (I:1/0) of the switch we wish to monitor. Use the Backspace key to get rid of the "?" currently in the textbox. Once you type in the address, click anywhere else on the instruction (other than the textbox) and the box should close.

Right Click on the XIC instruction and select "Edit Symbol" from the drop-down menu that appears. Another textbox will appear where you can type in a name (Switch-0) to associate with this address. As before, a click anywhere else will close the box.



Enter the address and symbol for the OTE instruction and your first RSLogix program will now be complete. Before continuing to test your program however, double check that the addresses of your instructions are correct.

Testing your Program:

It's now time to "Download" your program to the PLC. First click on the "Toggle" button at the top right corner of the Edit Panel which will bring the PLC Panel into view.



Click on the "DownLoad" button to initiate the downloading of your program to the PLC. Once the download is complete, click inside the "RUN" option selection circle to start the PLC scanning.

Enlarge the simulation window so that you can see both the Switches and Lamps, by dragging the bar that separates the Simulation and Program windows to the right with your mouse. Now click on Switch I:1/00 in the simulator and if all is well, Lamp O:2/00 should illuminate.

Toggle the Switch On and Off a number of times and note the change in value indicated in the PLC Panel's status boxes which are being updated constantly as the PLC Scans. Try placing the PLC back into the "PGM" mode and then toggle the simulator's Switch a few times and note the result. Place the PLC back into the "Run" mode and the Scan should resume.

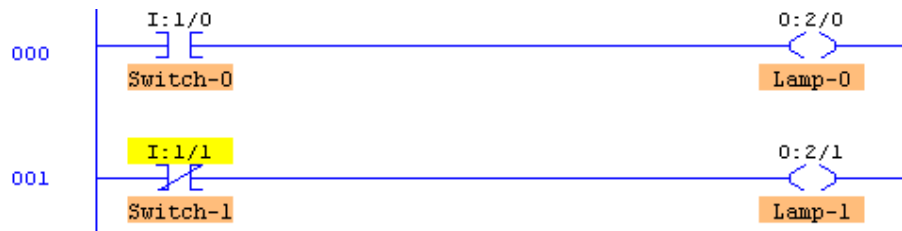
We are usually told to think of the XIC instruction as an electrical contact that allows electrical flow to pass when an external switch is closed. We are then told that the OTE will energize if the flow is allowed to get through to it. In actual fact the XIC is a conditional instruction which tests any bit that we address for Truth or a

Editing your Program:

Click on the "Toggle" button of the PLC Panel which will put the PLC into the PGM mode and bring the Edit Panel back into view.

Now add a second rung to your program as shown below. This time instead of entering the addresses as you did before, try dragging the appropriate address which is displayed in the I/O simulation and dropping it onto the instruction.

Note that the XIO instruction which Tests for Zero or False has its address highlighted in yellow. This indicates that the instruction is True, which in the case of an XIO, means that the bit addressed is currently a Zero or False.

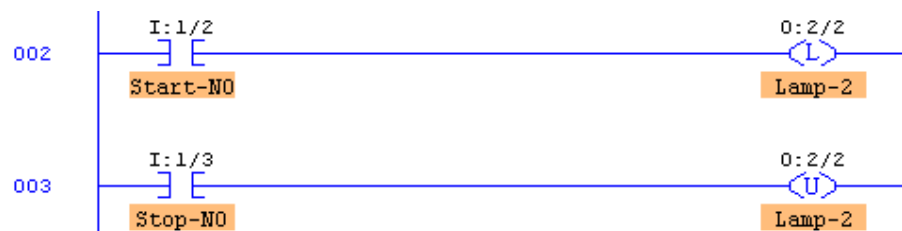


This is probably a good time to practice your dragNdrop skills. Try moving instructions from rung to rung by holding the left mouse button down while over an instruction, and then while keeping the mouse button down, move the mouse (and instruction) to a new location. Try doing the same with complete rungs by dragging the box at the left end of the rung and dropping it in a new location.

Once you feel comfortable with dragNdrop, ensure that your program once again looks like the one pictured above, Now download your program to the PLC and place the PLC into the Run Mode. Toggle both Switch-0 and Switch-1 on and off a number of times and observe the effects this has on the lamps. Ensure that you are satisfied with the operation of your program before proceeding further.

Stop/Start utilizing OTL and OUT:

For this exercise we need two Normally Open momentary switches. Using your right mouse button, click on switch "I:1/2" and "I:1/3", changing them to N.O. pushbuttons. Now add the following two rungs to your program. Once you have the rungs entered correctly, download and run your modified program.

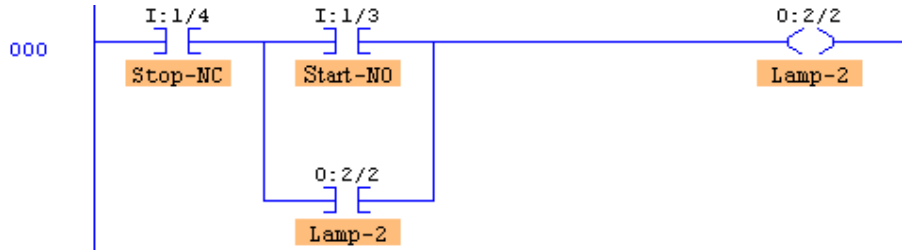


Activate the Start and Stop switches and ensure that the OTL and OTU output instructions are responding as outlined in your text. Once you have the lamp ON, could you turn it off if power was lost in the Stop Switch circuit?

Now modify your program so that it operates correctly when you substitute the N.O. Stop switch (I:1/03) with a Normally Closed Switch. If we now lost power on the N.C. Stop switch circuit, what would happen to the state of Lamp (O:2/02)?

Emulating Standard Stop/Start Control:

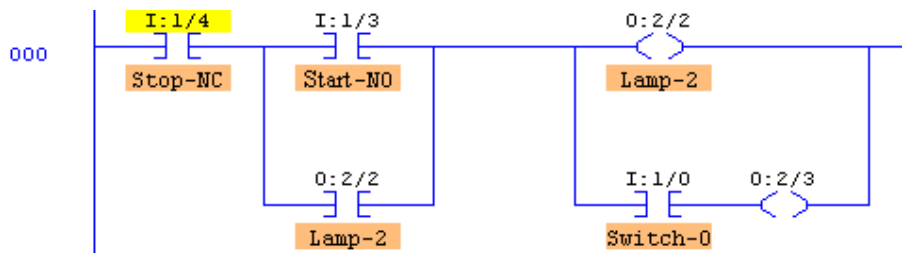
Erase your program by selecting "New" from the "File" menu selection at the top of the screen. When the dialog box appears, just click "OK" to select the default PLC type. Now enter the following program. To enter a branch, just drag the branch (button) onto the rung and then insert or drag instructions into the branch.



Before you download and run this program, take a careful look at our use of a XIC instruction to test the state of the N.C. Stop Switch. When someone presses the Stop Switch, will bit I:1/04 go True or False? Will the XIC instruction go True or False when the Switch is pressed? Is this the logic we are seeking in this case? Run the program and see if you're right! If we lose power in the Stop Switch circuit, what state will the lamp go to? Why do you think that most prefer this method rather than the OTL/OTU method of implementing Stop/Start Control?

Output Branching with RSLogix:

Modify your program so that it matches the following.



Download and Run the program. Operate the Stop and Start switches several times with Switch-0 open, and again with Switch-0 closed. Remove the XIC instruction from the Output branch and note what happens to Lamp-3 when you Start and Stop the circuit. Try moving the Lamp-3 OTE instruction so that it is in series with the Lamp-2 OTE instruction. Download, Run and observe how both lamps still light even with the empty branch (short?) in place. It may look like an electrical circuit but in fact we know that it isn't and therefore obeys a somewhat different set of rules. Remove the empty branch, Download, Run and see if this has any effect on the logic or operation of the rung.

Controlling One Light from two Locations:

Create, enter and test a program which will perform the common electrical function of controlling a light from two different locations. Clear your program and utilize toggle switch (I:1/00) and switch (I:1/01) to control Lamp (O:2/00)... (Hint: If both switches are On or if both switches are Off, then the Lamp should be On! This of course is just one approach to solving this problem)

LAB 4: IMPLEMENTING RELAY LOGIC ON THE DOOR SIMULATION

Objective:

The objective of this exercise is to implement the Relay Logic on the Door Simulation program to open and close the door.

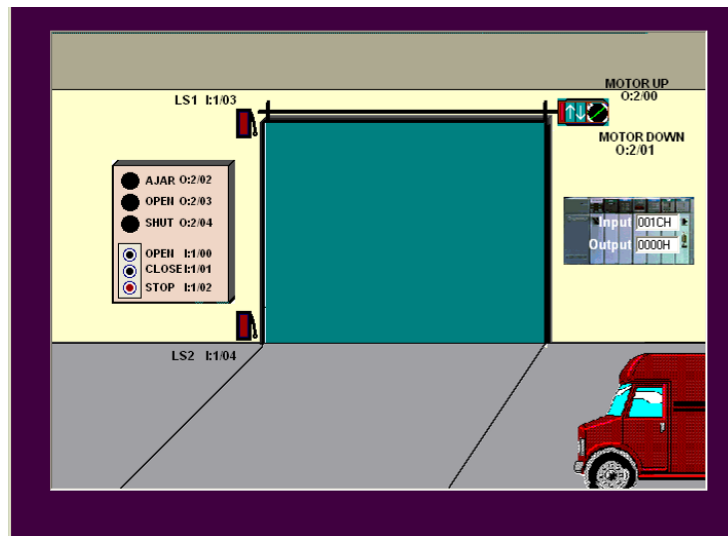
The Door Simulation Introduction:

From the Simulations Menu at the top of the screen, select the Door Simulation.

Take the time to familiarize yourself with the components used in the Door system, and take particular note of the current state of the limit switches. When the door is in the closed position, both limit switches are in their activated state (Not Normal). Run your mouse over each switch, and you should see a tool-tip text box appear, which denotes that the selected switch is wired using a set of Normally Open contacts. With the door fully closed, what signal level would you expect to see at the limit switch inputs I:1/03 and I:1/04?

To confirm your assessment of the current limit switch states, place the PLC into the RUN mode which will initiate scanning. Now open the Data Table display by clicking on the Data Table icon located on the toolbar (3rd from right) at the top of the screen.

When you have the Data Table showing, select the "Input Table" from the drop down Table list box. You should now be able to see the current state of each bit associated with input card I:1. You should also note that bit I:1/02 is also in a High or True state. Use your mouse to press the Stop switch on the Control Panel a few times, and note the results. Don't continue on with the exercise until you are confident that you understand the rationale of the observed results.



Programming Exercise #1:

This exercise will help in applying the knowledge of Relay Logic Instructions to design a program which will control the LogixPro Door Simulation. The door system includes a reversible motor, a pair of Limit Switches and an operator control panel, all connected to your PLC. The program you create will monitor and control this equipment while adhering to the following criteria:

- In this exercise the Open and Close pushbuttons will be used to control the movement of the door. Movement will not be maintained when either switch is released, and therefore the Stop switch is neither required nor used in this exercise. However, all other available Inputs and Outputs are employed in this exercise.
- Pressing the Open Switch will cause the door to move upwards (open) if not already fully open. The opening operation will continue as long as the switch is held down. If the switch is released, or if limit switch LS1 opens, the door movement will halt immediately.
- Pressing the Close Switch will cause the door to move down (close) if not already fully closed. The closing operation will continue as long as the switch is held down. If the switch is released, or if limit switch LS2 closes, the door movement will halt immediately.
- If the door is already fully opened, pressing the Open Switch will NOT energize the motor.
- If the door is already fully closed, pressing the Close Switch will NOT energize the motor.
- Under no circumstance will both motor windings be energized at the same time.
- The Open Lamp will be illuminated if the door is in the Fully Open position.
- The Shut Lamp will be illuminated if the door is in the Fully Closed position.

It is your responsibility to fully design, document, debug, and test your Program. Avoid the use of OTL or OTU latching instructions, and make a concerted effort to minimize the number of rungs employed.

Ensure that you have made effective use of both instruction and rung comments to clearly document your program. All I/O components referenced within your program should be clearly labeled, and rung comments should be employed to add additional clarity as required.

Programming Exercise #2:

This exercise will apply your knowledge of Relay Logic Instructions to design a program which will maintain the appropriate door movement once initiated by the operator. The Opening or Closing operation of the door will continue to completion even if the operator releases the pushbutton which initiated the movement. The program will adhere to the following criteria:

- Door movement will halt immediately when the Stop Switch is initially pressed, and will remain halted if the switch is released.
- Pressing the Open Switch will cause the door to Open if not already fully open. The opening operation will continue to completion even if the switch is released.
- Pressing the Close Switch will cause the door to Close if not already fully shut. The closing operation will continue to completion even if the Switch is released.
- If the Door is already fully opened, Pressing the Open Switch will Not energize the motor.
- If the Door is already fully closed, Pressing the Close Switch will Not energize the motor.
- Under no circumstance will both motor windings be energized at the same time.
- The Ajar Lamp will be illuminated if the door is NOT in either the fully closed or fully opened position.
- The Open Lamp will be illuminated if the door is in the Fully Open position.
- The Shut Lamp will be illuminated if the door is in the Fully Closed position.

It is your responsibility to fully design, document, debug, and test your Program. Avoid the use of OTL or OTU latching instructions, and make a concerted effort to minimize the number of rungs employed. As before, ensure that you have made effective use of both instruction and rung comments to clearly document your program.

Programming Exercise #3:

In this exercise we want to introduce you to a simple programming technique for adding a bit of "Flash" to your program. We want you to make use of the PLC's Free Running Timer which can be viewed in the Data Table Display at location S2:4. This integer word contains a count which is incremented continuously by the PLC when it is in the Run mode, and it can come in quite handy at times for variety of purposes. In this exercise we want you to utilize this word as follows:

With the PLC in the Run mode, Display word S2:4 utilizing the Data Table display. Ensure that the Radix is set to Binary so that you can view the individual bits within the word. You should see a binary count in progress where the rate of change of each bit is directly related to its position within the word. Bit 0 will have the highest rate, while Bit 1 will be 1/2 as fast as Bit 0, and Bit 2 half as fast as 1 etc. etc.

We want you to add a Lamp Flasher to your program by monitoring the state of one of these bits with an XIC instruction. I'm going to suggest using Bit 4 for this purpose, but depending upon the speed of your computer you may elect to substitute another Bit. With an actual AB PLC, the rate is consistent, but with LogixPro it varies from computer to computer.

Place an XIC instruction addressed to S:4/4 on the rung which controls either the Open or Shut Lamp in your previous program. Now download and Run this modified program to see the flashing effect achieved. The Lamp should flash at a reasonable rate whenever your program energizes the selected Lamp.

Now modify your program so that the following criteria are met:

- If the Door is fully open, the Open lamp will be energized but not flashing as was the case before.
- If the Door is opening, the Open lamp will flash while the door is in motion.
- If the Door is fully closed, the Shut lamp will be energized but not flashing as was the case before.
- If the Door is closing, the Shut lamp will flash while the door is in motion.
- The Ajar Lamp will flash if the door is stationary, and is not in the fully open or fully closed position. The Ajar Lamp will flash at a slower rate (1/4) then the other lamps.
- The Ajar Lamp will be illuminated in a steady state if the door is in motion.

As before, ensure that you have made effective use of both instruction and rung comments to clearly document your program.

Programming Exercise #4:

In this exercise we want you to add one final touch which will possibly extend the life of the door hardware. Starting and stopping the door motion obviously puts a strain on the door hardware, but reversing the direction of the door without giving it a chance to fully stop causes an even greater strain. We want you to modify your program to prevent the possibility of immediate reversal. As we don't need much of a delay, the following additional criteria should suffice:

- If the door is currently opening, pressing the Close Switch will immediately halt movement. Door movement will remain halted when the switch is released.
- If the door is currently closing, pressing the Open Switch will immediately halt movement. Door movement will remain halted when the switch is released.
- Once movement is halted, and all push buttons have been released, then door motion in either direction can once again be initiated by pressing the appropriate Open or Close button.
- The utilization of Binary or Integer Table bits to Flag specific conditions within your program would be appropriate. Also, the retentive OTL and OTU instructions may be utilized freely at your discretion.

Hint: If you review the foregoing criteria carefully, you should note the motor should only be permitted to start after a specific set of conditions have been met. The conditions being that the motor is stopped, and all switches are released.. Since this same set of conditions will apply to both the door opening, and

door closing operations, this may be the ideal time to use flagging.... By flagging, I mean that you will use a bit in the PLC memory (such as B3:0/0) to indicate that a specific condition, or set of conditions exist. Example: You might add a new rung to the beginning of your program, and insert instructions to test that the motor is stopped, and all switches are released... Latch bit B3:0/0 True (ON) if so, and name it something like "Ready-To-Start".... Now you can add an XIC instruction addressed to this "Ready-To-Start" bit to both your existing Motor UP, and Motor Down control rungs, and this will confirm that the motor may be started.. Of course you will need to unlatch the "Ready-To-Start bit once the motor is started.

BTW: Almost any unused bit may be used as a flag, but since RSLogix has set aside the B3: memory area, and this memory area displays in binary format by default, it's commonly used for this purpose.. N7:1/12 would work however, but the N7 area is normally used as place for storing integers as this memory area is displayed in decimal by default.. Additionally, it is sometimes possible to use an Operator Panel lamp as flag if the conditions suit.

For Discussion and/or Research:

The door simulation employs 2 limit switches that have both been wired N.O. (Normally Open). This might not be the best choice in wiring an actual door control installation, but we have learned that simple wiring irregularities such as this can be readily overcome within one's ladder logic program..... But,,, should we do this?... OR,,, should we rewire?

Upper Limit switch wired N.O., Lower limit switch wired N.O. resulting in: Upper limit switch (**door open**) goes **False(0)** when the door reaches the **fully open** position. Lower limit switch (**door closed**) goes **True(1)** when the door reaches the **fully closed** position.

The above truth table may offend one's sense of logic, and many might argue that it would be worthwhile to rewire the upper limit switch so that it is N.C. rather than N.O. The result would be that this switched input would then go **True** rather than **False** when the position it is detecting (**door open**) is reached. This in-turn should make one's final program easier to read, understand, and even troubleshoot.

Upper Limit switch rewired N.C., Lower limit switch wired N.O. resulting in: Upper limit switch (**door open**) goes **True(1)** when Door reaches the **fully open** position. Lower limit switch (**door closed**) goes **True(1)** when door reaches the **fully closed** position.

Sensible!....**But!**.....

Although rewiring the upper switch to N.C. does appear to make greater "logical" sense, it may actually result in an inferior installation. Rewiring one of the limit switches may still be worthwhile, but it's the lower limit switch that we should be concerned with.

Upper Limit switch wired N.O., Lower limit switch rewired N.C. resulting in: Upper limit switch (**door open**) goes **False(0)** when Door reaches the **fully open** position. Lower limit switch (**door closed**) goes **False(0)** when door reaches the **fully closed** position.

Task> Explain why this last rewiring option should result in a safer, more fault tolerant installation.

Hint: All types of control circuits should ideally be designed to be fail-safe. In electrical circuits we must take into account how our installation will react to common electrical faults (short or open) and determine whether the resulting action is the This is of particular concern in Motor Control Stop circuits Which common electrical fault (short or open) is the more likely to go un-noticed, and how should this influence our selection of switch type (N.O. or N.C.) when designing/wiring Motor Control Stop Circuits?

LAB 5: INTRODUCTION TO PROXIMITY SWITCHES

Objective:

The objective of this lab is to introduce different types of switches, and understand their characteristics. We will be using the following switches.

Introduction to Proximity Switches:

Proximity switches open or close an electrical circuit when they make contact with or come within a certain distance of an object. Proximity switches are most commonly used in manufacturing equipment, robotics, and security systems. There are four basic types of proximity switches: infrared, acoustic, capacitive, and inductive.

Proximity switches are used in manufacturing processes: for example, to measure the position of machine components. They are also used in security systems, in applications such as detecting the opening of a door, and in robotics, where they can monitor a robot or its components' nearness to objects and steer it accordingly. (<http://www.wisegeek.com/what-are-proximity-switches.htm>)

Description of different types of proximity switches

Acoustic proximity sensors: Acoustic proximity sensors are similar in principle to infrared models, but use sound instead of light. They use a transducer to transmit inaudible sound waves at various frequencies in a preset sequence, then measure the length of time the sound takes to hit a nearby object and return to a second transducer on the switch. Essentially, acoustic proximity sensors measure the time it takes for sound pulses to "echo" and use this measurement to calculate distance, just like sonar.

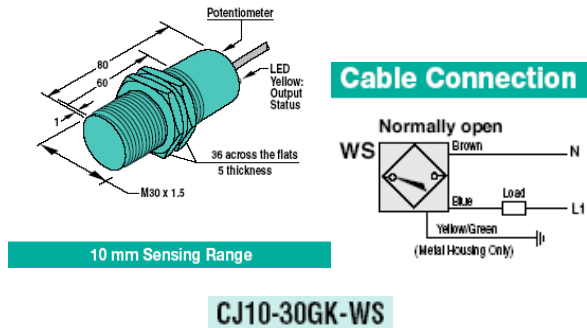
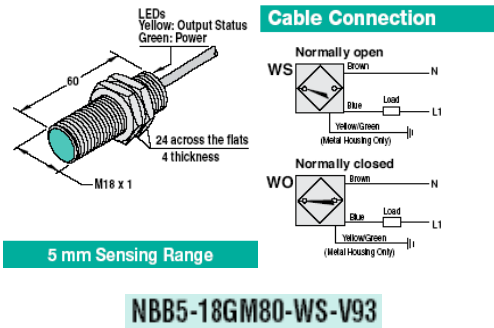
Capacitive proximity switches: Capacitive proximity switches sense distance to objects by detecting changes in capacitance around it. A radio-frequency oscillator is connected to a metal plate. When the plate nears an object, the radio frequency changes, and the frequency detector sends a signal telling the switch to open or close. These proximity switches have the disadvantage of being more sensitive to objects that conduct electricity than to objects that do not.

Inductive proximity switches: Inductive proximity switches sense distance to objects by generating magnetic fields. They are similar in principle to metal detectors. A coil of wire is charged with electrical current, and an electronic circuit measures this current. If a metallic part gets close enough to the coil, the current will increase and the proximity switch will open or close accordingly. The chief disadvantage of inductive proximity switches is that they can only detect metallic objects.

Inductive and Capacitive proximity switches:

We shall be using inductive sensor and capacitive proximity switches for our experiments. Some of the specifications of these proximity switches are given as follows:





(Inductive Proximity Switch)	(Capacitive Proximity Switch)
Supply Voltage = 250 VAC, Supply Frequency = 45-65 Hz, Load Current = 5-200 mA, Output = Normally Open (NO), Sensing Range = 5mm	Supply Voltage = 20-250 VAC, Supply Frequency = 45-65 Hz, Load Current = 200 mA, Output = Normally Open (NO), Sensing Range = 10mm



<p>XS1M18MA250 Inductive Proximity Sensor , 24/240VAC - 24/210VDC, 200mA</p>	<p>XS1M30MA250 Inductive Proximity Sensor , 24/240VAC - 24/210VDC, 300mA</p>
<p>Ampere rating = 200mA, LED Indicator = Output=Red, Normally Open=Green, Max Frequency = 25 Hz (AC) / 3kHz (DC), Maximum Voltage = 264 V, Output = AC/DC 2-Wire (Universal) - 1 N.O., Supply Voltage = 24/240VAC - 24/210VDC, Nominal sensing distance = 5mm</p>	<p>Ampere rating = 300mA, LED Indicator = Output=Red, Normally Open=Green, Max Frequency = 25 Hz (AC) / 2kHz (DC), Maximum Voltage = 264 V, Output = AC/DC 2-Wire (Universal) - 1 N.O., Supply Voltage = 24/240VAC - 24/210VDC, Nominal sensing distance = 10mm</p>

Reed and Limit Switches: Switches can be designed to respond to any type of mechanical stimulus: for example, vibration (the trembler switch), tilt, air pressure, fluid level (the float switch), the turning of a key (key switch), linear or rotary movement (the limit switch or microswitch), or presence of a magnetic field (the reed switch).

Reed Switches:

The first reed switch came into being in 1936. It was an invention of W. B. Elwood at Bell Telephone Laboratories. The reed switch is a specialized type of switch that operates magnetically. A reed switch has the ability to trigger a siren when motion is detected as part of a burglar alarm. It is also commonly used with electrical circuit controls and is an important device in the communications industry.

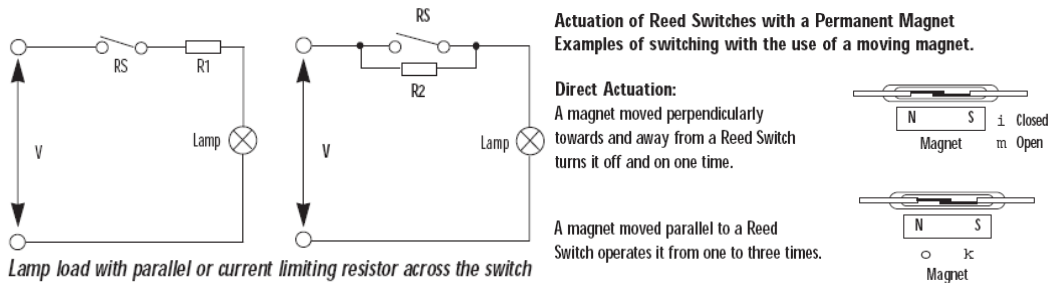
A reed switch consists of a pair of ferrous metal contacts or three springy metal reeds located inside a sealed glass tube. The two-reed switch normally has open contacts that are closed while in operation, referred to as (NO) contacts. The three-reed switch type, on the other hand, has a pair of (NO) and a pair of normally closed contacts, which are referred to as (NC).

The reed switch is enclosed in a small tube, which is controlled by a magnet or magnetic field. It works with the help of an additional magnet, which is placed within close range of the switch. When the

magnets make contact, they pull together and complete an electrical circuit. This results in a change in the contacts to an opposite state.

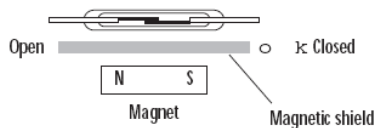
As the magnetic field diminishes in the reed switch, the switch and its contacts immediately return to their original state. A magnetically operated reed switch such as this is commonly mounted on doors and windows to add protection to a home or business. A reed switch is small and discreet enough to mount in a home or office without being noticeable.

While the small size of the reed switch makes it easy to mount and to operate, there are some disadvantages. For instance, because it is small and delicate, a reed switch cannot maintain a large voltage of current. Instead, the current may simply pass right through. In turn, excess voltage can cause the reed switch to spark when in use. The reed switch is also known to overheat when used with a heavy current. This can cause the switch to lose its spring-like form.



Indirect Actuation: Shielding

With the stationary arrangement of a Reed Switch and magnet, the contact Reeds are closed. Should the magnetic field be diverted away from the Reed Switch by a shield of ferro-magnetic material placed between the switch and the magnet, the contacts will open. When the shield is removed, the contact Reeds become magnetically actuated and close.



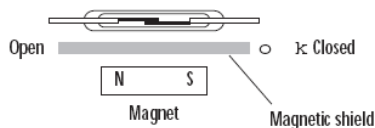
Rotation:

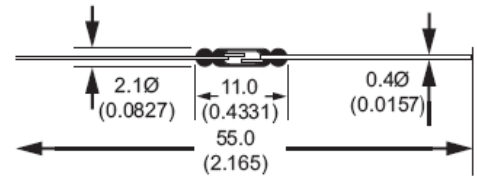
Examples of switching through rotational movement.



Indirect Actuation: Shielding

With the stationary arrangement of a Reed Switch and magnet, the contact Reeds are closed. Should the magnetic field be diverted away from the Reed Switch by a shield of ferro-magnetic material placed between the switch and the magnet, the contacts will open. When the shield is removed, the contact Reeds become magnetically actuated and close.





Different configuration of reed switches that we will be using in our labs are as follows:

Glass Length = 11mm	Glass Length = 15mm	Glass Length = 20.5mm
Switching Voltage = 140 VAC/VDC (Max)	Switching Voltage = 300 VDC	Switching Voltage = 250 VAC
Switching Current = 0.5 A (Max)	Switching Current = 0.5 A (Max)	Switching Current = 1 A (Max)
Pull-in Sensitivity = 10-40 AT	Pull-in Sensitivity = 18-32 AT	Pull-in Sensitivity = 15-28 AT
Drop-out Sensitivity = 5 AT (Min)	Drop-out Sensitivity = 7-27 AT (Min)	Drop-out Sensitivity = 5-16 AT (Min)
Temperature = -40 C to 125 C	Temperature = -55 C to 125 C	Temperature = -40 C to 250 C


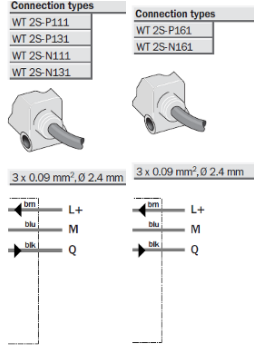
Limit Switches:


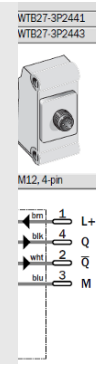
The different configurations of limit switches that will be used are as follows


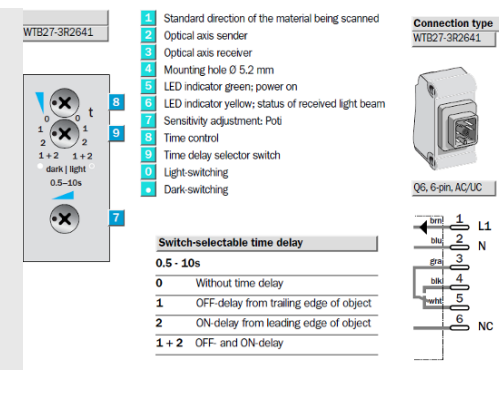
Contact Configuration: 1 NC 1 NO Max Supply Vol: 600 Vac /250 Vdc Actuator Type: Top Pin Plunger Operating Force 17.8N Operating Temp Range: -12 to 93°C IP Rating: IP67	Contact Configuration: 1 NC 1 NO Max Supply Vol: 600 Vac /250 Vdc Actuator Type: Top Roller Plunger Operating Force: 17.8N Operating Temp Range: -12 to 93°C IP Rating: IP67	Contact Configuration: 1 NC 1 NO Max Supply Vol: 600 Vac /250 Vdc Actuator Type: Side Rotary Operating Force: 17.8N Operating Temp Range: -12 to 93°C IP Rating: IP67	Contact Configuration: 1 NC 1 NO Max Supply Vol: 600 Vac /250 Vdc Actuator Type: Adj. Side Rotary Operating Force: 17.8N Operating Temp Range: -12 to +93°C IP Rating: IP67

Photoelectric proximity switch:

Infrared proximity switches work by sending out beams of invisible infrared light. A photodetector on the proximity switch detects any reflections of this light. These reflections allow infrared proximity switches to determine whether there is an object nearby. As proximity switches with just a light source and photodiode are susceptible to false readings due to background light, more complex switches modulate the transmitted light at a specific frequency and have receivers which only respond to that frequency. Even more complex proximity sensors are able to use the light reflected from an object to compute its distance from the sensor.

	<p>Connection types</p> <ul style="list-style-type: none"> WT 2S-P111 WT 2S-P131 WT 2S-N111 WT 2S-N131 	<p>Connection types</p> <ul style="list-style-type: none"> WT 2S-P161 WT 2S-N161 	<p>RS-445-4940 (WT2S-P131)</p>	<p>RS-445-4956(WT2S-P161)</p>
		<p>Scanning Distance: 1-30 mm Supply Voltage: 10-30 VDC Light source, light type: Pin-point LED, Red light Switching Output: PNP, Q Ambient Temperature Operating - -20oC to 50oC Storage - -40oC to 75oC</p>	<p>Scanning Distance: 2-55 mm Supply Voltage: 10-30 VDC Light source, light type: Pin-point LED, Red light Switching Output: PNP, Q Ambient Temperature Operating - -20°C to 50°C Storage - -40°C to 75°C</p>	

	<p>WTB27-3P2441 WTB27-3P2443</p>	<p>530-0888(WTB27-3P2441)</p>
		<p>Scanning Distance 30-1100 mm Operating Distance 100-1100 mm Supply Voltage 10-30 VDC Light source, light type, Pin-point LED, Red light Switching Output PNP, antivalent Ambient Temperature Operating - -40oC to 60oC Storage -40oC to 75oC</p>

	<p>WTB27-3R2641</p>	<p>530-0894(WTB27-3P2641)</p>
		<p>Scanning Distance 30-1100 mm Operating Distance 100-1100 mm Supply Voltage UC 24 ... 240 Vac/dc Light source, light type, Pin-point LED, Red light Switching Output PNP, antivalent Ambient Temperature Operating - -40°C to 60°C Storage - -40°C to 75°C</p>

Exercises:

Connect each and every proximity sensor to a circuit containing a light bulb to mains and study how these switches are activated by different proximity setting like light, magnet, metal, plastic etc.


LAB 6: SINGLE SOLENOID VALVES INTRODUCTION & EXPERIMENT

Solenoid valves – Introduction: http://en.wikipedia.org/wiki/Solenoid_valve

A solenoid valve is an electromechanical valve for use with liquid or gas controlled by running or stopping an electric current through a solenoid, which is a coil of wire, thus changing the state of the valve. The operation of a solenoid valve is similar to that of a light switch, but typically controls the flow of air or water, whereas a light switch typically controls the flow of electricity. Solenoid valves may have two or more ports: in the case of a two-port valve the flow is switched on or off; in the case of a three-port valve, the outflow is switched between the two outlet ports. Multiple solenoid valves can be placed together on a manifold.

Solenoid valves are the most frequently used control elements in fluidics. Their tasks are to shut off, release, dose, distribute or mix fluids. They are found in many application areas. Solenoids offer fast and safe switching, high reliability, long service life, good medium compatibility of the materials used, low control power and compact design.

Besides the plunger-type actuator which is used most frequently, pivoted-armature actuators and rocker actuators are also used. An example of a industrially applied solenoid valve is given below:

Technical data	
<p>Orifice: DN 10 - 40 mm</p> <p>Media: Neutral fluids, water, hydraulic oil, oil without additives Per-solutions, hot oils with additives, Oil and fat-free fluids</p> <p>Ambient temperature: Max. +55 °C</p> <p>Media temperature: -10 to +80 °C</p> <p>Voltages: 024/DC, 024/50, 230/50, 024/UC</p> <p>Voltage tolerance: ±10%</p> <p>Duty cycle: 100% continuous rating</p> <p>Electrical connection: Tag connector acc. to DIN EN 175301-803 Form A (previously DIN 43650) for cable plug Type 2508</p> <p>Installation: As required, preferably with actuator upright</p> <p>Circuit function: A Servo-assisted 2/2-way valve; normally closed, with 2-way pilot control</p> <p>1) Measured at valve outlet at 6 bar and +20°C</p> <p><i>Opening:</i> pressure build-up 0 to 90%</p> <p><i>Closing:</i> pressure decay 100 to 10%</p> <p>Response times</p> <p>0.1 - 4 seconds (depending on orifice and differential pressure)</p>	

Exercise 1:

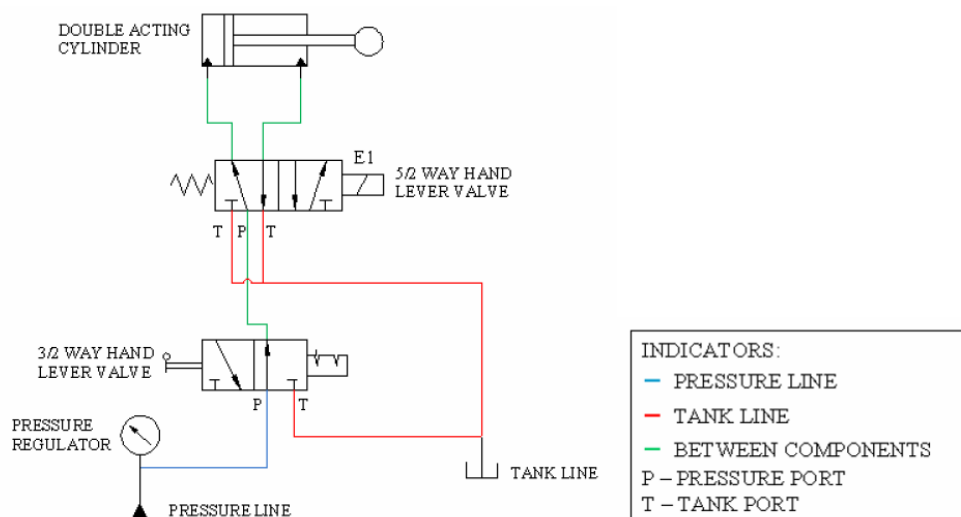
Implement a Directional Control by 5/2 Way Valve using a Single Solenoid

Required components:

- Double acting cylinder (1 unit)
- 3/2 way directional control valve, lever operated (1 unit)
- Pressure reducing / regulating valve with pressure gauge (1 unit)
- 5/2 way valve with single solenoid
- Electrical push button NO + NC
- Set of hoses
- Set of stackable wires

Procedures:

1. Connect the hydraulic power pack unit to the adjustable plug board.
2. Connect the power supply unit to the electrical components according to:
 - a. Terminal 24V (power supply unit) to black terminal (Electrical push button NO + NC).
 - b. Yellow terminal (NO) for the electrical push button NO + NC to the 24V terminal (5/2 way valve with single solenoid).
 - c. 0V terminal (5/2 way valve with single solenoid) to the 0V terminal (power supply unit).
3. Position the double acting cylinder, 3/2 way directional control valve, lever operated, pressure reducing / regulating valve with pressure gauge and 5/2 way valve with single solenoid as illustrated in the diagram.
4. Connect the water supply from the metal quick coupler (pressure line-left) on the adjustable plug board.
5. Connect the water return to the metal quick coupler (tank line-right) on the adjustable plug board.
6. Connect the port next to the solenoid to the tank line with hose.
7. When electrical push button has been pushed, the cylinder will retract and then will extend automatically.

Schematic diagram:

Electrical diagram:

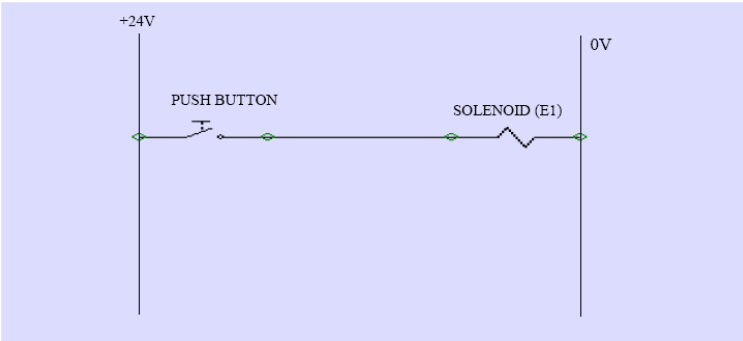
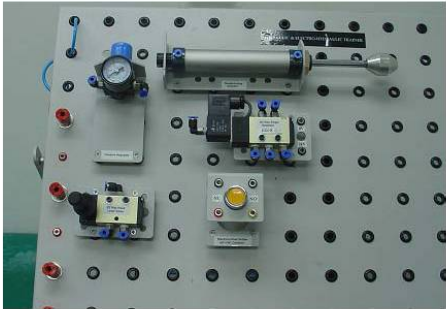
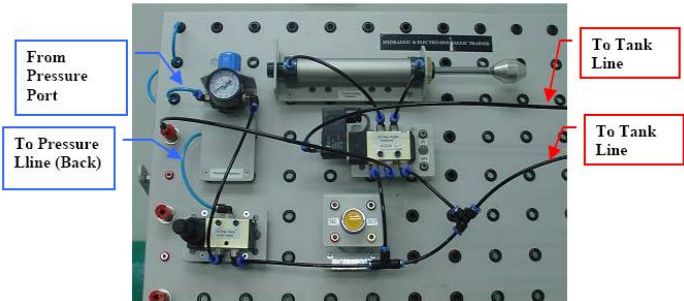


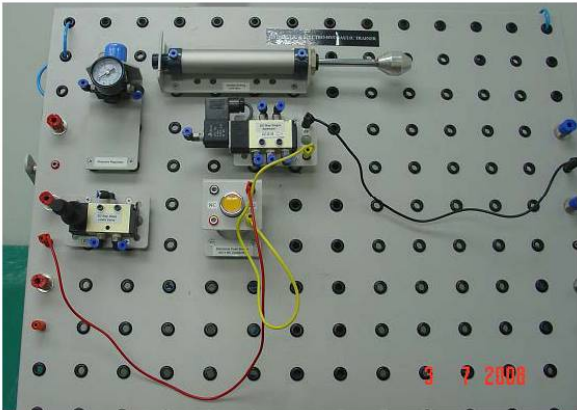
Diagram:



Without Connection



With Hose Connection



With Electrical Connection

Exercise 2:

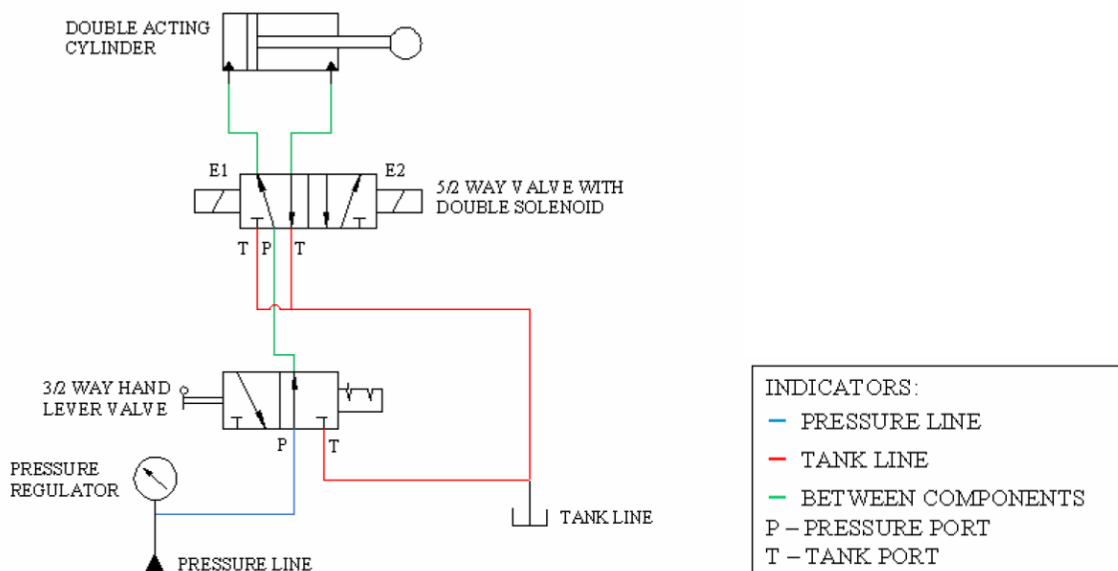
Implement a Directional Control by 5/2 Way Valve using double Solenoid

Required components:

- Double acting cylinder (1 unit)
- 3/2 way directional control valve, lever operated (1 unit)
- Pressure reducing / regulating valve with pressure gauge (1 unit)
- 5/2 way valve with double solenoid (1 unit)
- Electrical selector switch. (1 unit)
- Set of hoses
- Set of stackable wires

Procedures:

1. Connect the hydraulic power pack unit to the adjustable plug board.
2. Connect the power supply unit to the electrical components according to:
 - a. Terminal 24V (power supply unit) to both black terminals (electrical selector switch)
 - b. From Red terminal (NC) to the 24V terminal of the left solenoid
 - c. From Yellow terminal (NO) to the 24V terminal of the right solenoid
3. Both 0V terminals (5/2 way valve with double solenoid) to the 0V terminals (power supply unit)
4. Position the double acting cylinder, 3/2 way directional control valve, lever operated, pressure reducing / regulating valve with pressure gauge and 5/2 way valve with double solenoid and electrical selector switch as illustrated in the diagram.
5. Connect the water supply from the metal quick coupler (pressure line-left) on the adjustable plug board.
6. Connect the water return to the metal quick coupler (tank line-right) on the adjustable plug board.
7. Connect the port next to the solenoid to the tank line with hose.
8. When the selector switch has been selected to ON condition the cylinder will retract and when selector switch has been selected to OFF condition the cylinder will extend.

Schematic diagram:

Electrical diagram:

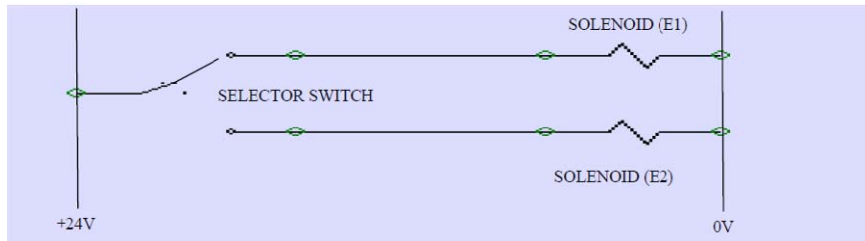
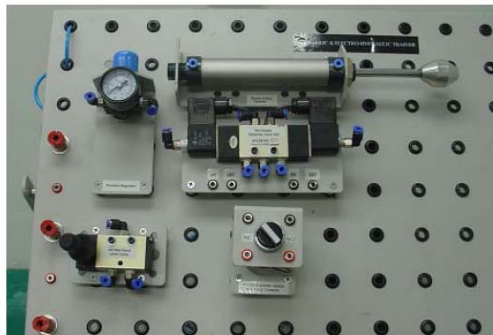
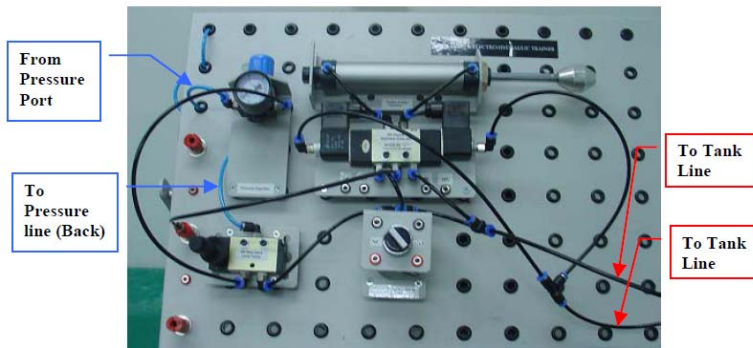


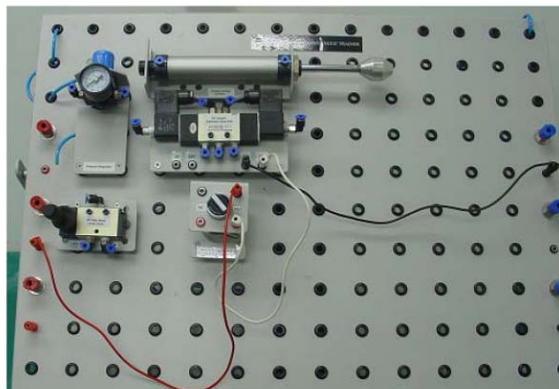
Diagram:



Without Connection



With Hose Connection



With Electrical Connection

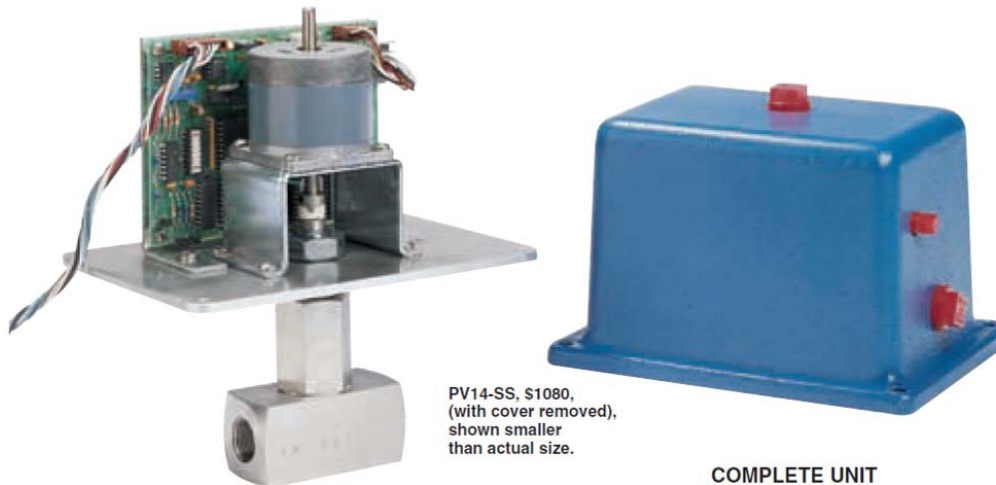
LAB 7: SPEED CONTROL BY USING ONE WAY FLOW CONTROL VALVE

Control Valves - Introductions

Control valves are valves used to control conditions such as flow, pressure, temperature, and liquid level by fully or partially opening or closing in response to signals received from controllers that compare a "setpoint" to a "process variable" whose value is provided by sensors that monitor changes in such conditions.

The opening or closing of control valves is done by means of electrical, hydraulic or pneumatic systems. Positioners are used to control the opening or closing of the actuator based on Electric, or Pneumatic Signals. These control signals, traditionally based on 3-15psi (0.2-1.0bar), more common now are 4-20mA signals for industry, 0-10V for HVAC systems, & the introduction of "Smart" systems, HART, Fieldbus Foundation, & Profibus being the more common protocols.

One of the control valve and its technical specifications are mentioned below:



SPECIFICATIONS

ELECTRONICS

Power Supply: 12 to 24 Vdc @ 5 A (10 W typical, 23 W max) (2.5 A for $\frac{3}{4}$ " valve, 38 W max)

Inputs: 4 to 20 mA control signal (250 Ω impedance) and dual external switch contact sensing via 5 Vdc signal

Control Modes: Direct or reverse, full or split range, high or low range, fail condition open or closed

Adjustments: Zero offset ± 0.5 mA

Operating Temperature: 0 to 49°C (32 to 120°F)

Connections: $\frac{1}{2}$ NPT conduit (16" 22 AWG pigtail leads)

ACTUATOR

Type: DC step motor, 200 steps/rev, 4 rev travel

Resolution: 200:1 (0.5%) (4 steps increment)

Speed: 18 rpm

Torque: 57.5 in-oz (188 in-oz $\frac{3}{4}$ " valve)

VALVE**Type:** In-line globe**Temp.:** -18 to 121°C (0 to 250°F)**Pressure:** 120 psi max (70 psi on 3/4" valve)**Max Flow:** GPM = Cv (ΔP/SG)^{1/2} liquids; for gases use standard equation found in solenoid valve section**Wetted Parts:** Ethylene propylene rubber O-ring, PTFE washer, and valve body (Brass models have 303 SS internal trim)**COMPLETE UNIT****Dimensions:** 216 H x 185 W x 137 mm D (8.5 x 7.3 x 5.4")**1/2" Valve:** 229 H x 185 W x 137 mm D (9 x 7.3 x 5.4")**3/4" Valve:** 305 H x 203 W x 191 mm D (12 x 8 x 7.5")**Weight:** 3.2 kg (7 lb)**1/2" Valve:** 4.5 kg (10 lb)**3/4" Valve:** 8.2 kg (18 lb)

SPECIFICATIONS	
ELECTRONICS	ACTUATOR
Power Supply: 12 to 24 Vdc @ 5 A (10 W typical, 23 W max) (2.5 A for 3/4" valve, 38 W max) Inputs: 4 to 20 mA control signal (250 Ω impedance) and dual external switch contact sensing via 5 Vdc signal Control Modes: Direct or reverse, full or split range, high or low range, fail condition open or closed Adjustments: Zero offset ±0.5 mA Operating Temperature: 0 to 49°C (32 to 120°F) Connections: 1/2 NPT conduit (16" 22 AWG pigtail leads)	Type: DC step motor, 200 steps/rev, 4 rev travel Resolution: 200:1 (0.5%) (4 steps increment) Speed: 18 rpm Torque: 57.5 in-oz (188 in-oz 3/4" valve)
VALVE	COMPLETE UNIT
Type: In-line globe Temp.: -18 to 121°C (0 to 250°F) Pressure: 120 psi max (70 psi on 3/4" valve) Max Flow: GPM = Cv (ΔP/SG) ^{1/2} liquids; for gases use standard equation found in solenoid valve section Wetted Parts: Ethylene propylene rubber O-ring, PTFE washer, and valve body (Brass models have 303 SS internal trim)	1/2" Valve: 229 H x 185 W x 137 mm D (9 x 7.3 x 5.4") 3/4" Valve: 305 H x 203 W x 191 mm D (12 x 8 x 7.5") Weight: 3.2 kg (7 lb) 1/2" Valve: 4.5 kg (10 lb) 3/4" Valve: 8.2 kg (18 lb) Dimensions: 216 H x 185 W x 137 mm D (8.5 x 7.3 x 5.4")

Exercise:

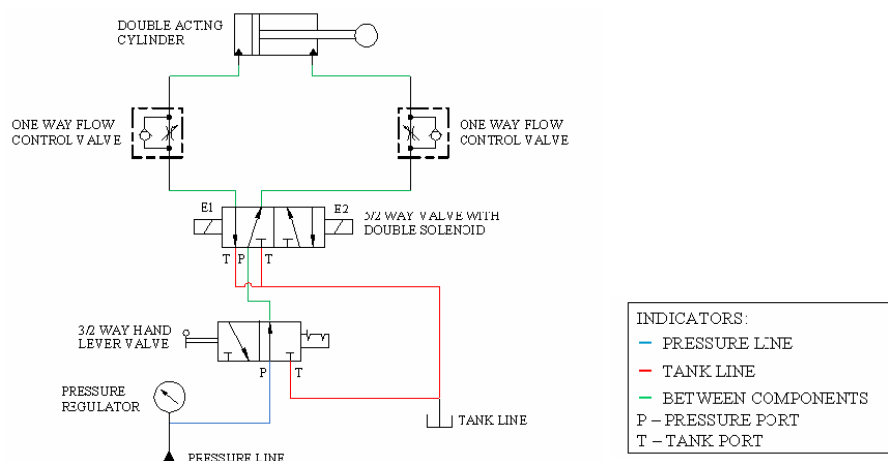
Speed Control by Using flow Control Valve

Required components:-

- Double acting cylinder (1 unit)
- 3/2 way directional control valve, lever operated (1 unit)
- Pressure reducing / regulating valve with pressure gauge (1 unit)
- 5/2 way valve with double acting cylinder (1 unit)
- Flow control valve (2 units)
- Electrical selector switch (1 unit)
- Set of hoses
- Set of stackable wires

Procedure:

1. Connect the hydraulic power pack unit to the adjustable plug board.
2. Connect the power supply unit to the electrical components according to:
 - a. Terminal 24V (power supply unit) to both black terminals (electrical selector switch)
 - b. From Red terminal (NC) to the 24V terminal of the left solenoid
 - c. From Yellow terminal (NO) to the 24V terminal of the right solenoid
 - d. Both 0V terminals (5/2 way valve with double solenoid) to the 0V terminals (power supply unit)
3. Position the double acting cylinder, 3/2 way directional control valve, lever operated, pressure reducing / regulating valve with pressure gauge, 5/2 way valve with double solenoid, one way flow controls and electrical selector switch as illustrated in the diagram.
4. Connect the water supply from the metal quick coupler (pressure line-left) on the adjustable plug board.
5. Connect the water return to the metal quick coupler (tank line-right) on the adjustable plug board.
6. Connect the port next to the solenoid to the tank line with hose.
7. Turn on the water pump and see the movement of the cylinder when the electrical selector switch in ON and OFF condition.
8. Set a one way flow control valve and see the movement of the cylinder. Observe the result.

Schematic diagram:

Electrical diagram:

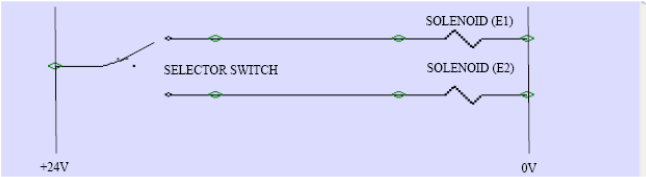
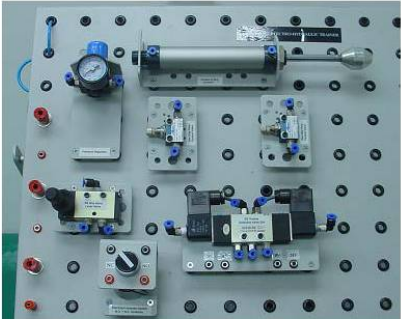
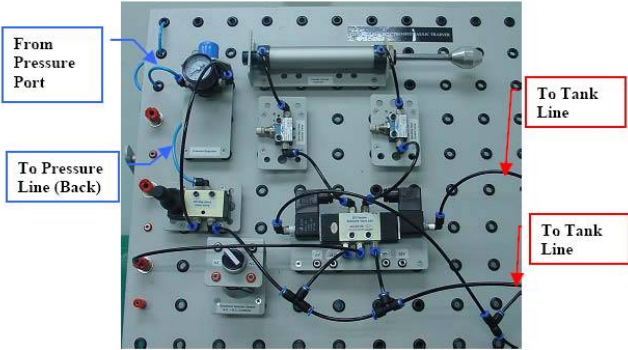


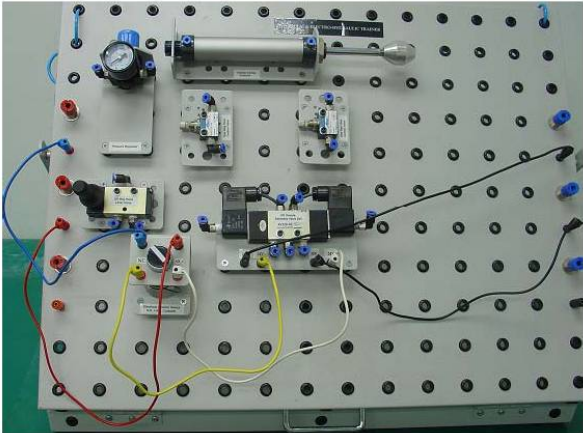
Diagram:



Without Connection



With Hose Connection



With Electrical Connection

LAB 8: AUTOMATIC FORWARD AND BACKWARD

Exercise:

In this exercise automatic flow control is achieved using limit switches

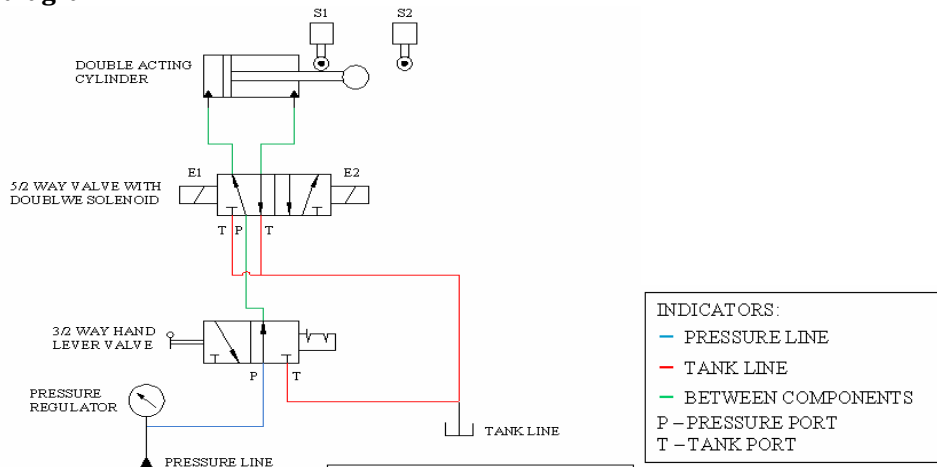
Required components:

- Double acting cylinder (1 unit)
- 3/2 way directional control valve, lever operated (1 unit)
- Pressure reducing / regulating valve with pressure gauge (1 unit)
- 5/2 way valve with double solenoid (1 unit)
- Electrical roller limit switch (1 units)
- Set of hoses
- Set of stackable wires

Procedures:

1. Connect the hydraulic power pack unit to the adjustable plug board.
2. Connect the power supply unit to the electrical components according to:
 - a. Terminal 24V (power supply unit) to both black terminals (COM) of the electrical roller limit switch
 - b. From Yellow terminal (NO) of the left switch to the 24V terminal of the left solenoid
 - c. From Yellow terminal (NO) of the right switch to the 24V terminal of the right solenoid
 - d. Both 0V terminals (5/2 way valve with double solenoid) to the 0V terminals (power supply unit)
3. Position the double acting cylinder, 3/2 Way Directional Control Valve, lever operated, Pressure reducing / regulating valve with pressure gauge, 5/2 way valve with double solenoid and electrical limit switch as illustrated in the diagram.
4. Connect the water supply from the metal quick coupler (pressure line-left) on the adjustable plug board.
5. Connect the water return to the metal quick coupler (tank line-right) on the adjustable plug board.
6. Connect the port next to the solenoid to the tank line with hose.
7. In this experiment, electrical limit switch is functioning as a sensor to make the cylinder automatically moving.
8. The cylinder will extend & retract repeatedly until the pressure line or power supply is turn off.

Schematic diagram:



Electrical diagram:

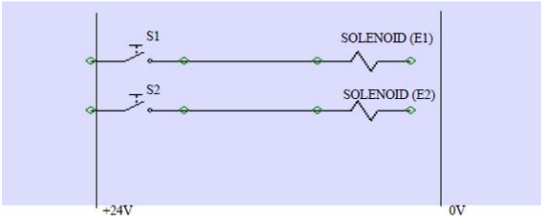
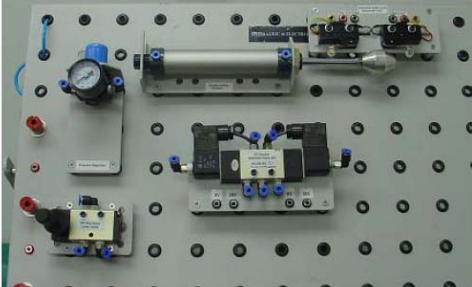
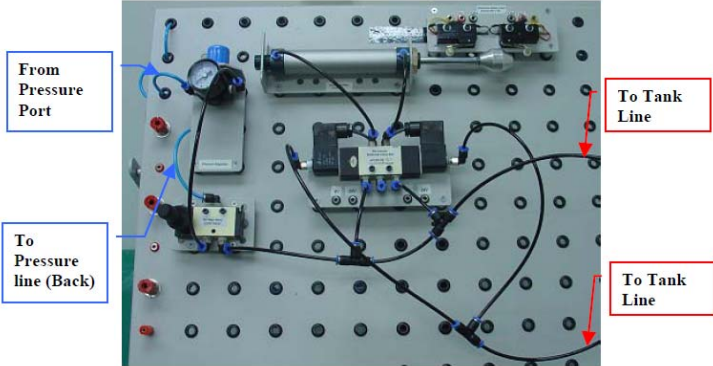


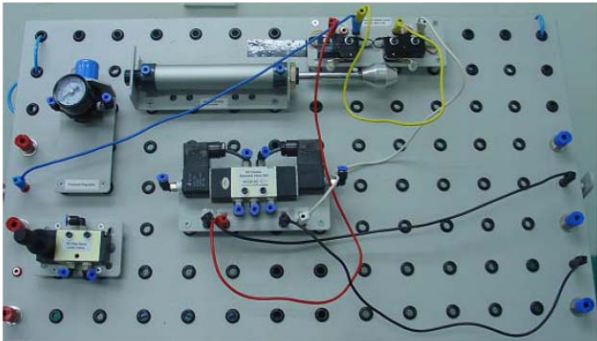
Diagram:



Without Connection



With Hose Connection



With Electrical Connection