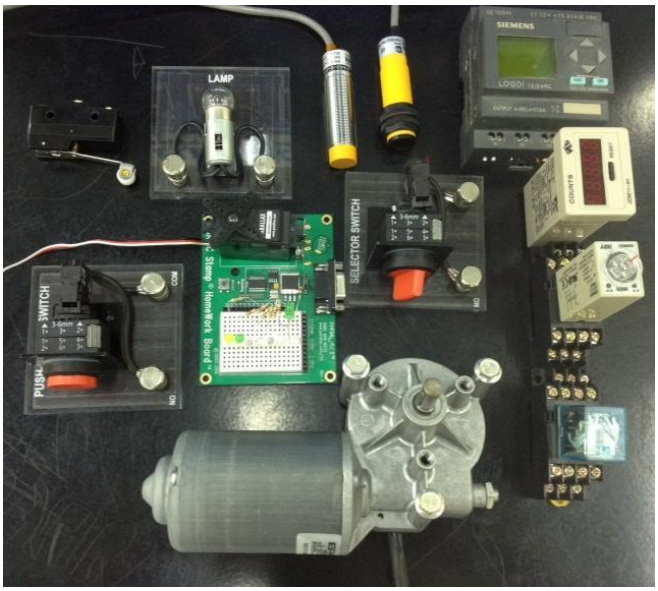
ثانويـة التكنولوجيـا التطبيقيـة
Applied Technology High School

Project Planning

Module 4: Practice Exercises



PREPARED BY

Academic Services Unit

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Module 4: Practice Exercises

Module Objectives

Upon successful completion of this module, students should be able to:

1. Select and utilize the proper input for a certin task.
2. Choose and use different types of actuators and outputs.
3. Draw a simple control diagram.
4. Control a digital output using a digital input and electric relay.
5. Connect a digital input and a digital output to BASIC Stamp microcontroller and operate it.
6. Connect a digital input and a digital output to LOGO! controller and operate it.
7. Compare between LOGO! , BASIC Stamp, NXT brick and relay based control.

Module Contents:

4.1 Introduction

In the previous modules you have selected your project, and as a team with your colleagues you have roughly designed the selected project. This design might not be the best one; you may need to modify it before you start building the prototype. Now in order to do the proper modification and come up with an optimum solution you should be aware of the different types of controllers available, and experiment with different inputs and outputs. In this module, you will explore and experiment with the different types of controllers available in the ATHS labs, and this exercise will help you choose the best controller and appropriate components for your project.

Any engineering system should contain three stages as shown in figure 4.1.

- Input stage: In this stage, the system collects information about the environment including information about actions taken by the operator who is running the system, like pressing pushbuttons or switches or even adjusting the preset value of a counter.
- Processing stage: This is the stage where the system makes decision based on the data received data from the input stage. Decisions made by the processing stage affect the status of the output stage components.
- Output stage: Electrical and mechanical components exist at this stage which can be controlled based on the decisions

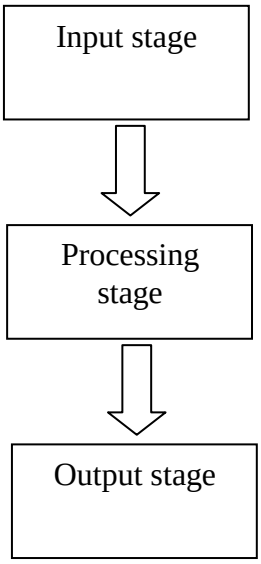


Fig 4.1

made by the processing stage.

4.2 Inputs and Outputs

Inputs

Inputs are devices used to provide information to the processing stage, information might take one of the following forms:

- Triggering one of the switches or pushbuttons that control the system.
- The presence or absence of an object.
- The position of one or more than one component of the operation being controlled.
- Change in environmental conditions like temperature, humidity and pressure.

Figure 4.2 shows different inputs. Try and explain what type of information will be provided by each input.

Pushbutton

Limit switch

Selector switch

Photoelectric switch


Inductive sensor


Light sensor


Ultrasonic sensor


Temperature sensor

Figure 4.2

Which sensor do you think is the best? Of course, there is no simple answer to this question. Each sensor has certain capabilities and limitations. Selecting a sensor depends on the application for which it is to be used. Bear in mind that you need to consider a few important points while you select a sensor:

- Realistically define what objective the sensor should accomplish.

For example, if you want to sort metallic and non-metallic objects inductive sensor is the best choice.

- Think about the detection range of the sensor.

Touch sensors and limit switches must be in physical contact with an object to operate, while capacitive sensor detects items that are a few millimeters away. On the other hand some optical sensors can detect items that are more than 20 cm away.

- Current and voltage ratings for the sensor.

Most of the sensors need few volts to operate; once they operate they act as a switch that passes exactly the same voltage received.

- Current flow status, does the sensor provide N.O or N.C contact.

It is very important to know the initial condition if the sensor before using it. The current flow status is essential when creating the control circuit.

- Resolution - The smallest increment the sensor can detect.

This is important when analog sensor is to be used, like temperature sensor, pressure sensor, ultrasonic sensor, etc…

- Price, in case two sensors are of the same specifications and quality, selection can be made based on which one is cheaper.

The following table lists different sensors technologies

Sensor	Advantages	Disadvantages	Applications
Limit Switch	•High Current Capability •Low Cost •Familiar "Low-Tech" Sensing	•Requires Physical Contact with Target •Very Slow Response •Contact Bounce	•Interlocking •Basic End-of-Travel Sensing
Photoelectric	•Senses all Kinds of Materials •Long Life •Longest Sensing Range •Very Fast Response Time	•Lens Subject to Contamination •Sensing Range Affected by Color and Reflectivity of Target	•Packaging •Material Handling •Parts Detection
Inductive	•Resistant to Harsh Environments •Very Predictable •Long Life •Easy to Install	•Distance Limitations	•Industrial and Machines •Machine Tool •Senses Metal-Only Targets
Capacitive	•Detects Through Some Containers •Can Detect Non-Metallic Targets	•Very Sensitive to Extreme Environmental Changes	•Level Sensing
Ultrasonic	•Senses all Materials	•Resolution •Repeatability •Sensitive to Temperature Changes	•Anti-Collision •Doors •Web Brake •Level Control

Taken from **S**iemens **T**echnical **E**ducation **P**rogram, Basics of sensors.

Conduct Lab Activity 1

Outputs

Output or Actuators are the component to be switched ON and OFF or simply to be controlled in an electrical circuit. Any of the following components may

be used as outputs:

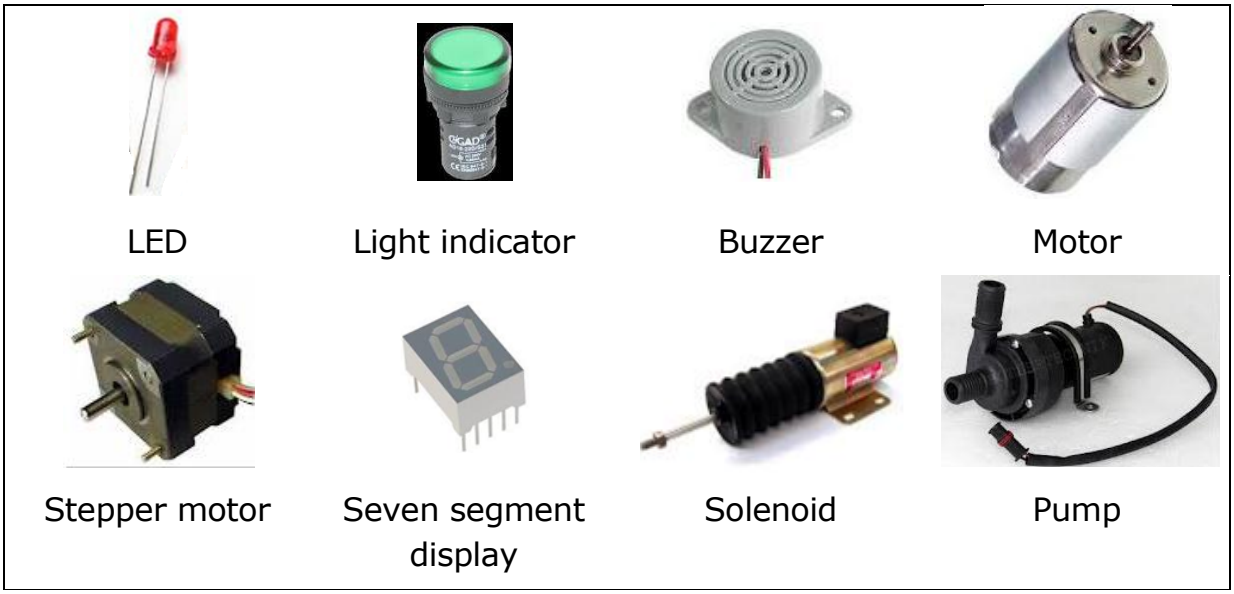


Fig 4.3

Motors

A very wide range of motors are available in the market with different characteristics and specifications.

For continuous rotation, a DC or AC motor can be used, however, proper voltage and current ratings should be considered. For discontinuous rotation, a digital signal can be used to drive either a stepper or servo motor. Every time they receive a digital pulse they rotate through a specific number of degrees.

Stepper motors are digital electromagnetic actuators that can be either ON or OFF, they move in fixed increment in both directions, Stepper motors provide most torque at low speed (RPM).

Servo motors are also digital actuators that move in fixed increment but they are less precise than stepper motor. Steppers simply move incrementally

using pulses [open loop] while servo's read the difference between the motors encoder and the commanded position [closed loop], and adjust the current required to move.

When selecting a motor some factors should be considered like:

- Voltage and current ratings and power signal nature (AC or DC).
- Type of motion (continuous or discontinuous).
- Speed and torque.
- Motor size and cost

Pumps

pumps are used for a wide range of applications that include fire fighting, irrigation, high and low pressure water transfer, agricultural spraying. Pumps are designed in a huge variation of engineering specification to suit different pump applications.

Correct pump selection depends on the application, it is a matter of matching the flow rate and pressure requirements to select the appropriate pump. Not only the capital cost of the pump should be considered but also the running cost, this means voltage and current ratings should also be considered.

Solenoids

A solenoid is a device which converts energy into linear motion. This energy may come from an electromagnetic field, a pneumatic (air-powered) chamber or a hydraulic (fluid-filled) cylinder. When energized solenoids extend to perform a specific task.

4.3 Relay Based Control

Different types of controllers could be used to control engineering systems;

the selection of any controller can be done based on the requirements of the system or the application. **Relays** are simple electromechanical devices that are widely used for controlling a simple manufacturing process. Relays are low current devices that can operate or switch heavy loads.

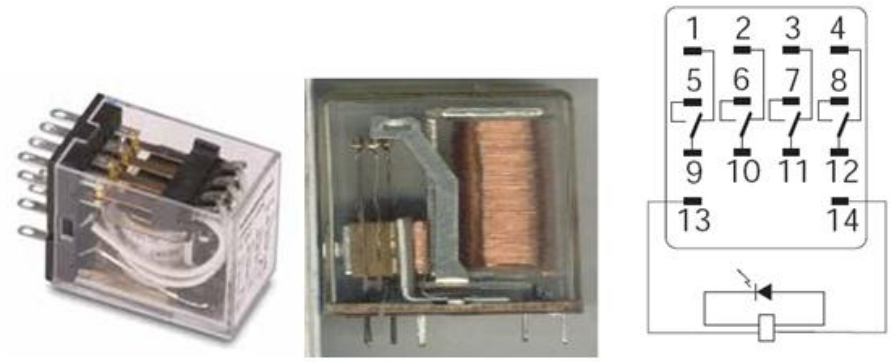


Fig 4.4

Relay operation

When power is applied to the control circuit, this energizes the relay's coil, which then magnetically pulls the armature and movable contacts to the closed position for some contacts and to the open contacts for other contacts. When power is removed the magnetic field is lost and spring tension pushes the armature and movable contacts to the open position .The relay's switch connections are usually labeled COM, NC and NO:

COM = Common; this is the moving part of the switch.

NC = Normally Closed, COM is connected to this when the relay coil is OFF.

NO = Normally Open, COM is connected to this when the relay coil is ON.

Selection of an appropriate relay for a particular application requires evaluation of many different factors:

- Number and type of contacts - normally open, normally closed, (double-throw or single throw)
- Rating of contacts.
- Coil current and Coil voltage, typical values 5,12,24,36 VDC 110,220 VAC.

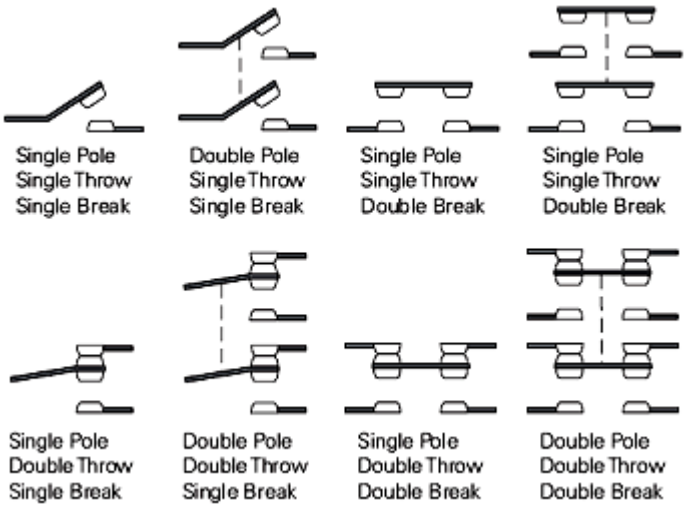


Fig 4.5

Important concepts:

Latching: is to connect a N.O contact across a N.O pushbutton so the current finds another path to flow after releasing the N.O pushbutton.

Electrical interlock: is to prevent two actions or more from taking place at the same time by adding a N.C contacts from all other actions to the desired action.

Conduct Lab activity 2.

4.4 BASIC Stamp Microcontroller

BASIC Stamps are microcontrollers (tiny computers) that are designed to do specific task. Many projects that require an embedded system can use a BASIC Stamp as the controller, it acts as the brain of the system when it is used. Each BASIC Stamp comes with a BASIC CPU chip, internal memory(RAM and EEPROM), a 5-volt regulator, a number of general-purpose I/O pins (0-5 volts), and a set of built-in commands for math and I/O pin operations. BASIC Stamps are capable of running more than thousand instructions per second and are programmed with a simplified, but customized form of the BASIC programming language, called PBASIC.

You are going to study the Basic Stamps in more details in microcontrollers' course. For the time being all you need to know is that any output can be switched ON and OFF using HIGH and LOW commands respectively followed by the pin number to which your output device is connected. You can freeze an action using the command PAUSE followed by the required time in (ms)

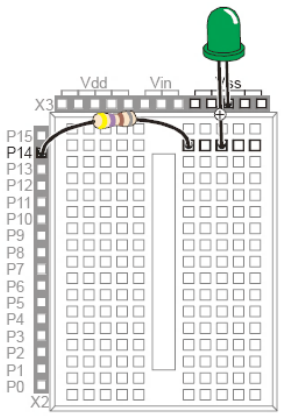


Fig 4.6

```
'{$STAMP BS2}
'{$PBASIC 2.5}

HIGH 14 'Turn ON the green LED
PAUSE 500 'Wait for 0.5 Sec
LOW 14 'Turn OFF the green LED
PAUSE 1000 'Wait for 1 Sec
END
```

Basic Stamp microcontrollers provide only 5 volt as an output and very low current, that does not mean loads that need more than 5 V can't controlled using Basic Stamp, but in this case a relay can be used as shown in the circuit below:

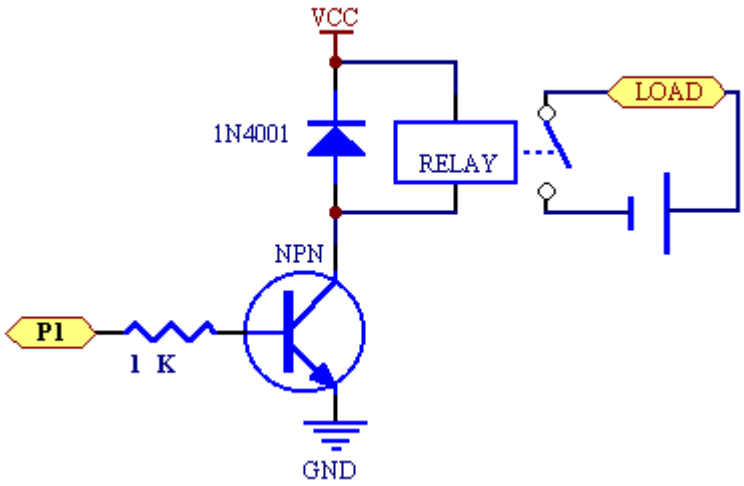


Fig 4.7

Conduct Lab Activity 3

4.5 LOGO! Controller

A Programmable Logic Controller (or PLC) is a specialised digital controller that can control machines and processes. it monitors inputs, makes decisions, and controls outputs.

Fig 4.8

Connecting the power supply

PLC devices need an electrical power supply that can be either an AC, or DC supply. LOGO! 12/24RC needs a DC supply. Fig. 4.9 shows the method of wiring the DC power supply to the LOGO! Module (Fuse is used to protect LOGO! Controller).

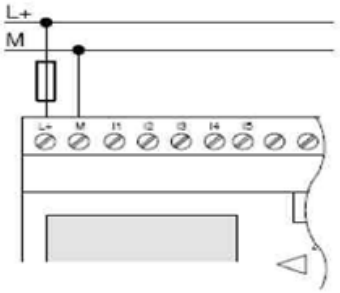


Fig 4.9

LOGO! Controller as a basic module has 8 inputs and 4 outputs. It can be programmed using LOGO! Softcomfort software in two different ways:

- Using Function Block Diagram (FBD)
- Using Ladder Diagram (LAD)

Moreover if LOGO! Has a display unit then simple programs can be created without a need for the software.

Connecting LOGO! Inputs

Figure 4.10 shows the hardware/wiring details of connecting the inputs to the LOGO! Switch S1 is connected to I1 and switch S2 is connected to I2.

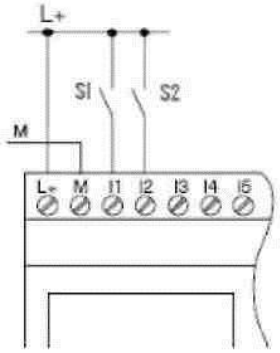


Fig 4.10

Connecting LOGO! Outputs

As shown in fig 4.11, various loads can be connected to the relay outputs, for example, lamps, motors, relays etc.

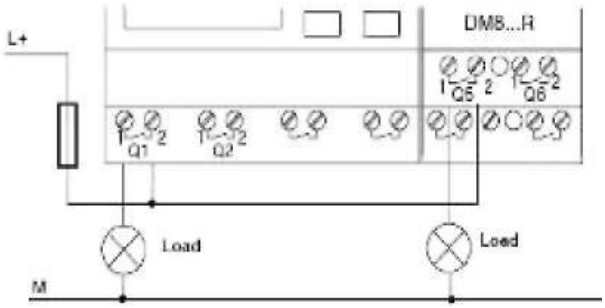


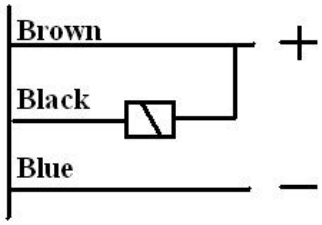
Fig 4.11

Conduct Lab activity 4.

4.6 Lab Activity 1

Objective: To use different types of inputs, and be familiar with their specifications.

- Connect a three wire optical sensor as shown below:



You need only to connect 12 V DC supply to the sensor.

Observation:

Sensor output voltage:

Output voltage when no object presents in front of the sensor	
Output voltage when an object presents in front of the sensor	

Do you think that this sensor provides N.O or N.C contact?

_____

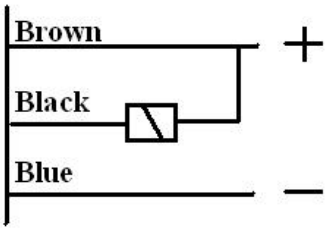
_____

What is the detection range for this sensor?

_____

_____

- Connect a three wire inductive sensor as shown below:



You need only to connect 24 V DC supply to the sensor.

Observation:

Sensor output voltage:

Output voltage when no object presents in front of the sensor	
Output voltage when metallic object presents in front of the sensor	
Output voltage when non-metallic object presents in front of the sensor	

Do you think that this sensor provides N.O or N.C contact?

_____

_____

What is the detection range for this sensor?

_____

_____

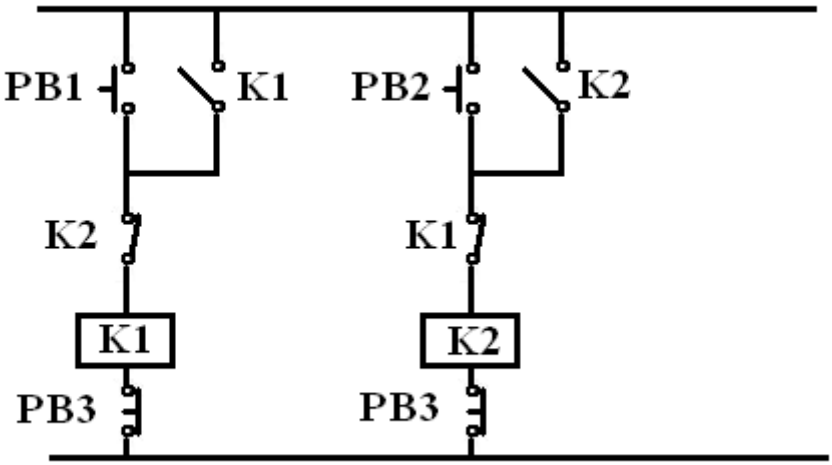
Is it possible to use this sensor to switch ON a load that needs 1 ampere to operate? (Hint: check the current output for this sensor)

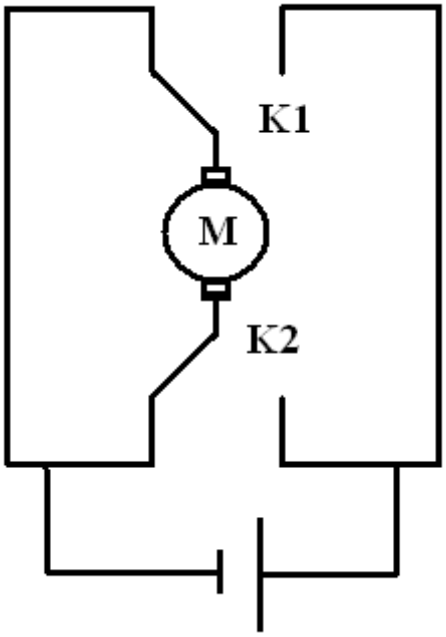
_____

4.7 Lab Activity 2

Objective: To turn a motor in the forward direction and the reverse direction using relay based control circuit.

- Connect both the control circuit and power circuit as shown below:





Observation:

What is the function of each pushbutton in the previous circuit?

Pushbutton	Function
PB1	
PB2	
PB3	

Why do we need to connect a N.O contact cross each N.O pushbutton?

What happens if these N.O contacts are not connected?

_____

_____

_____

_____

Why do we need to connect a N.C contact from relay 2 in series with relay one and vise versa?

_____

_____

Is it possible to have 5 V supply for the control circuit and 24 V for the power circuit? Explain your answer?

_____

_____

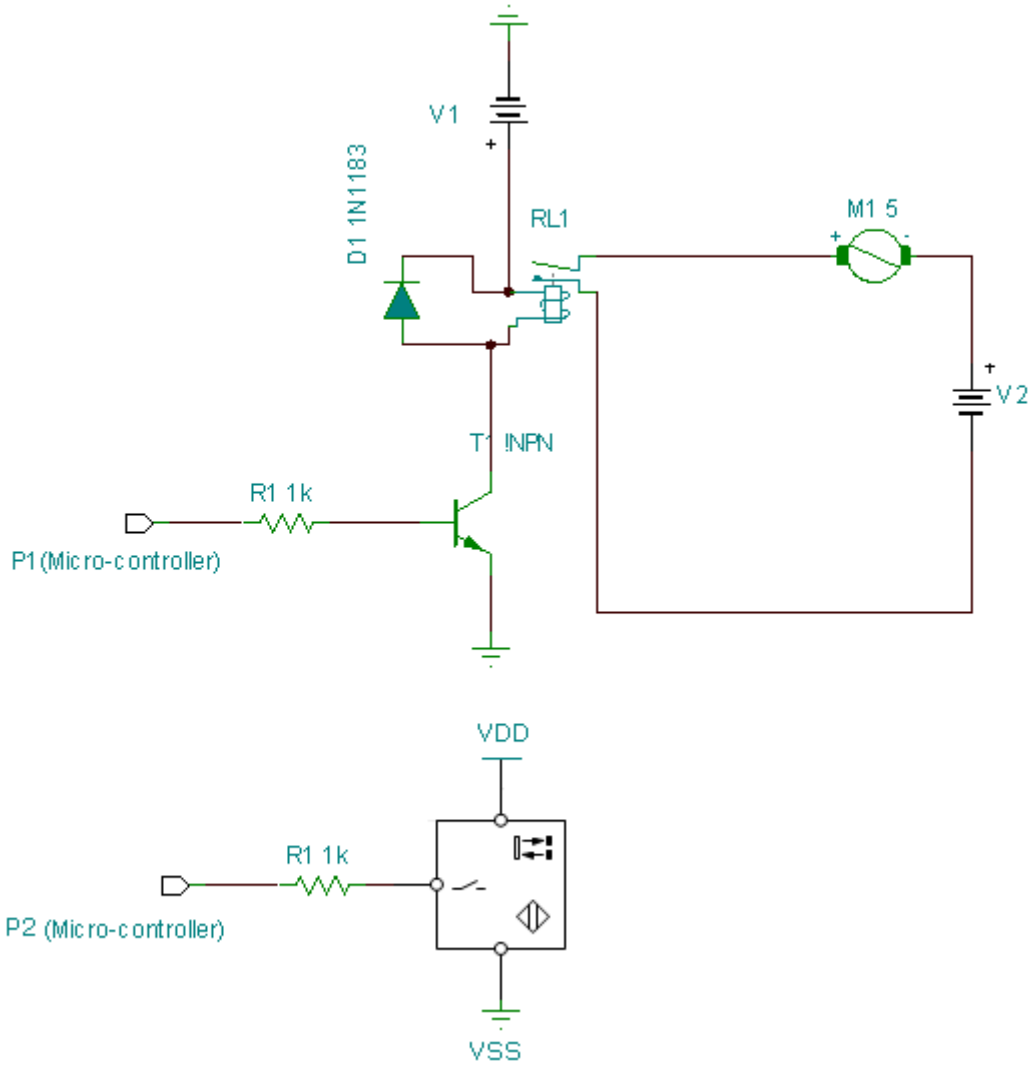
_____

_____

4.8 Lab Activity 3

Objective: To turn a motor ON for a few seconds if a photo electric switch detects an object using BASIC Stamp microcontroller.

- Connect the circuit as shown below:



- Use the BASIC Stamp editor to write the following code:

```
' {$STAMP BS2}
' {$PBASIC 2.5}

OUTPUT 1
INPUT 2

DO
IF IN2=1
HIGH 1
PAUSE 5000
LOW 1
ENDIF
LOOP
```

Observation:

Why do you think we used the command OUTPUT with pin number 1 and the command INPUT with pin number 2?

_____

_____

For how long does the motor go ON after the sensor detects an object?

_____

_____

Is it possible to connect the motor direct to the microcontroller without relay? Explain your answer.

_____

_____

What happens if the DO … LOOP command is deleted?

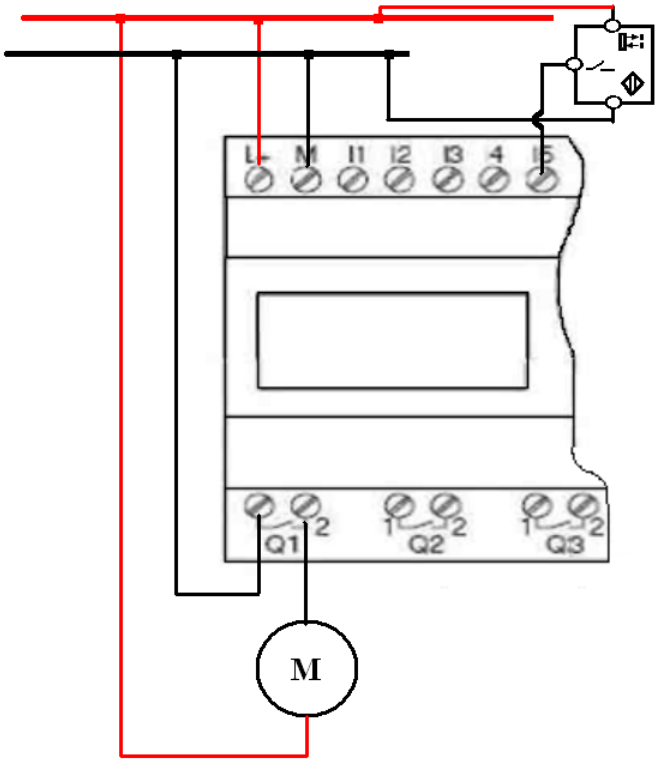
_____

_____

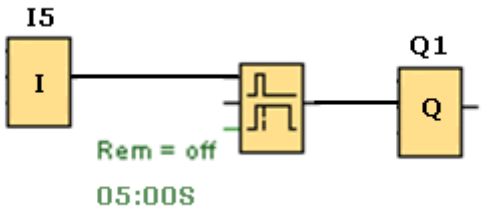
4.9 Lab Activity 4

Objective: To turn a motor ON for a few seconds if a photo electric switch detects an object using LOGO! Controller.

- Connect the circuit as shown below:



- Use the LOGO! Softcomfort software to drag and drop the following programming block:



Observation:

Why do you think we used I block with the sensor and Q block with the motor?

_____

_____

What is the function of the second programming block?

_____

_____

For how long does the motor go ON after the sensor detects an object?

_____

_____

What happens if an object stays in front of the sensor will the motor go ON? Explain your answer.

_____

_____

What are the advantages of the LOGO! Controller over the microcontroller?

_____

_____

Compare between the LOGO controller and microcontroller in terms of size, price, working conditions, number of inputs and outputs.

_____

_____

4.10 Lab Activity 5

Objective: To use LEGO! NXT brick in a simple control system.

Repeat lab activity 3 and lab activity 4 using NXT brick, and LEGO Mindstorm software.

Observation:

Compare between all the controllers Relay based, LOGO controller, microcontroller and NXT brick in terms of size, price, working conditions, number of inputs and outputs, ease of use, programming and system modification.