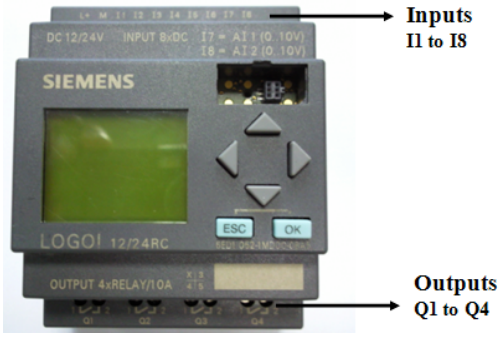
ثانوية التكنولوجيا التطبيقية
Applied Technology High School

PLC Fundamentals

Module 2:
Hardware and Terminology



PREPARED BY

Academic Services Unit

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Module 2:
Hardware and Terminology

Module Objectives

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

1. Demonstrate understanding of the various PLC models and the LOGO! features.
2. Determine the required inputs and outputs for real life problems.
3. Differentiate between Analog and Digital inputs.
4. Identify the major parts of a LOGO! in the Edutrainer Compact and describe their function.
5. Demonstrate understanding of the functions and the parts of the Conveyor Belt Application.
6. Connect input and output devices and program the LOGO! to perform simple tasks.

Module Contents:

2.1 Case Study

Here is a typical situation that you might face in an industry. Our objective is to solve this problem by writing a proper PLC program.

A controller is needed for a hydraulic press. The press uses a 24VDC double actuated solenoid valve to advance and retract the press. This device has three wires: one for common, one to advance and one to retract. A large hydraulic pump should be running as long as the press is ON. Three push buttons are used, one is a NC stop button, the other is a NO manual retract button, and the third is a NO start automatic cycle button. Two limit switches at the top and bottom of the press must also be used.

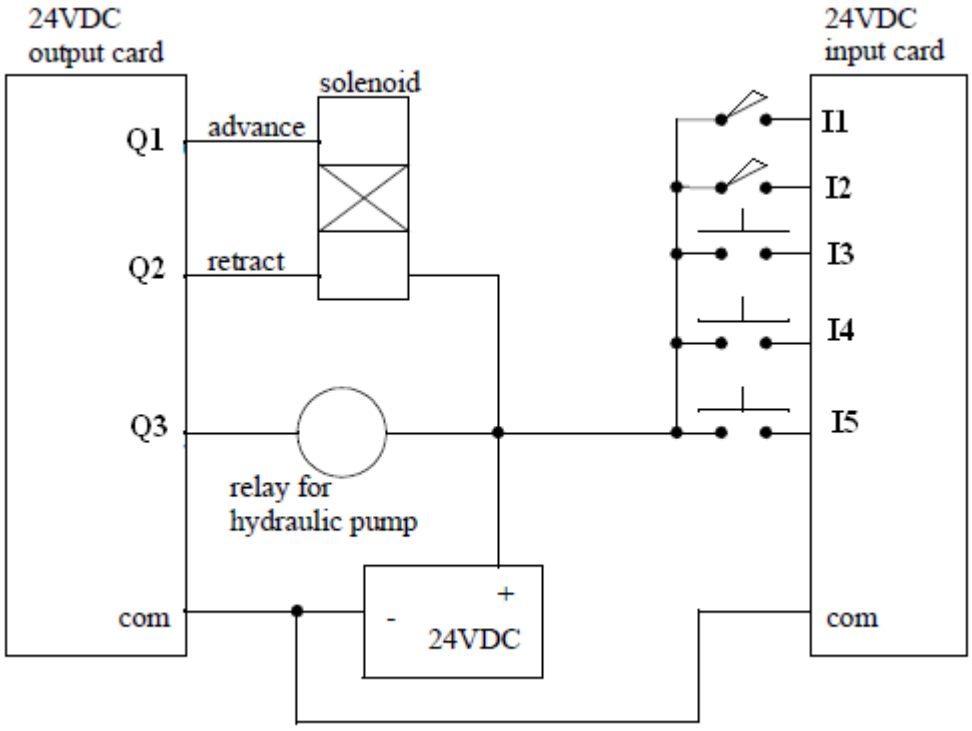


Figure 2.1: Press machine control unit

(For brainstorming and to be discussed throughout the module)

2.2 PLC Inputs and Outputs

Before writing any PLC program you should be familiar with what can be an input and what can be an output for a PLC. As you studied in the first module, the Programmable Logic Controller is a device that can be programmed to perform control functions. Since it is a digital device, it stores information in the form of ON/OFF conditions referred to as binary digits or bits. Even though the PLC uses both digital and analog signals, the CPU can understand only digital signals.

The main parts of a PLC are as shown in figure 2.2.

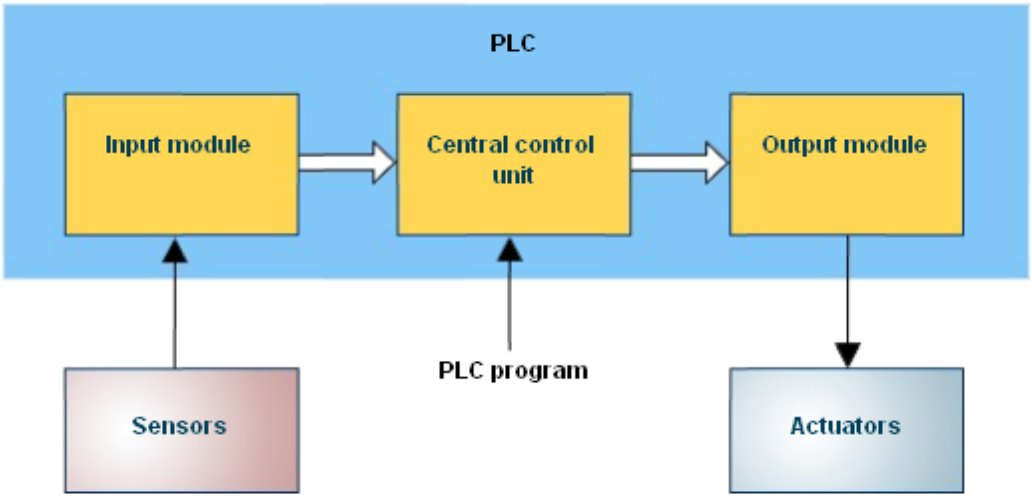


Figure 2.2: Main Parts of a PLC

Input Module

The input module consists of the digital inputs and the analog inputs.

Digital Input

Digital input recognises either the ON or OFF condition like a switch.

Analog Input

It accepts signals that are varying like water level.

Observe figure 2.3. It shows the relation between the logic level and the switch condition. **Logic 1** indicates that a signal is present and the **switch is ON**. **Logic 0** indicates that the signal is absent or the **switch is OFF**. Is the switch a digital input or an analog input? What do you think?

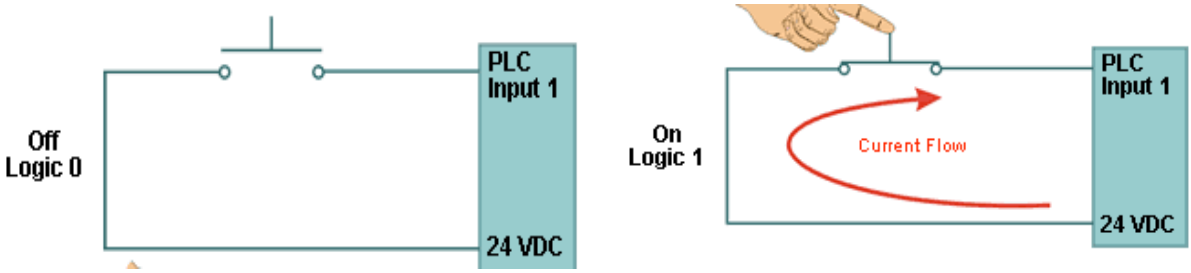


Figure 2.3: Normally Open Pushbutton

A normally open (NO) pushbutton is used in the above example. When the switch is not pressed, no voltage is present at the PLC Input 1 and sets it to OFF state. When the switch is pressed, 24V DC is applied to the PLC input and sets it to ON state. A normally closed (NC) pushbutton acts opposite to the normally open (NO) pushbutton. Figure 2.4 shows the pushbutton symbols.

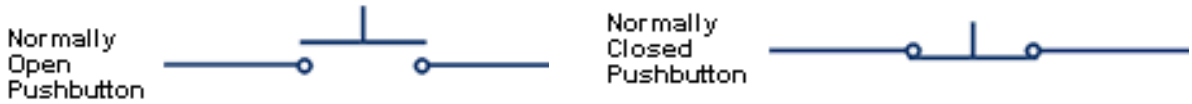


Figure 2.4: Pushbutton Symbols

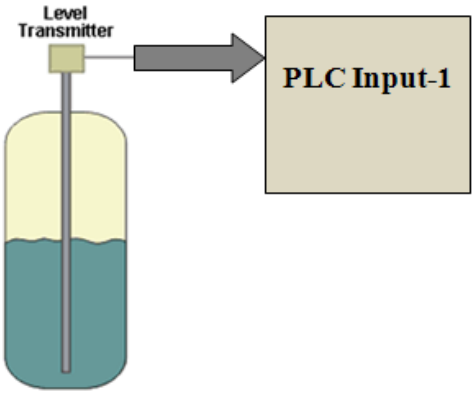


Figure 2.5 : Level transmitter

A **level transmitter** checks the level of liquid in the tank and provides a varying voltage to the PLC input.

Is a level transmitter a digital or an analog input?

The table below shows more examples of inputs. Classify them as digital and analog.

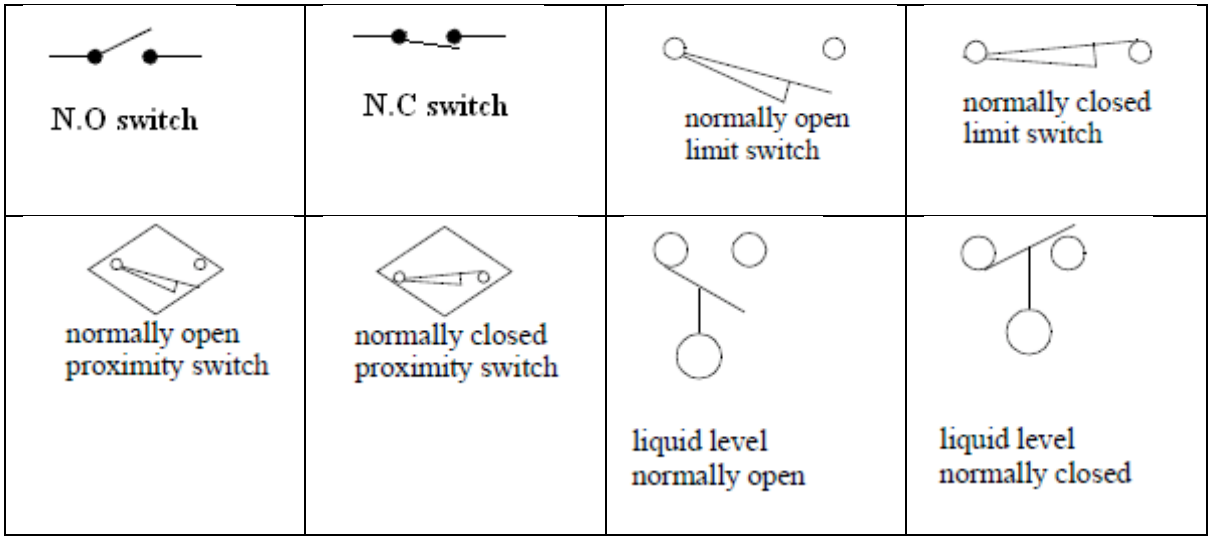


Figure 2.6: Examples of Inputs

All sensors can be connected as inputs to a PLC, some examples are given below:

- Inductive sensor
- Capacitive sensor
- Fiber optic sensor
- Temperature sensor

Class Activity

Refer to the Case Study on page-4, and list all the inputs and outputs and classify them as analog and digital.

Input	Output	Analog/Digital

Output Module

The output module consists of digital outputs and analog outputs.

Digital Output

Digital output can either be ON or OFF. Solenoids, contactor coils and lamps are usually connected to digital outputs. In the example shown in figure 2.7, the lamp can be turned ON or OFF by the PLC output.

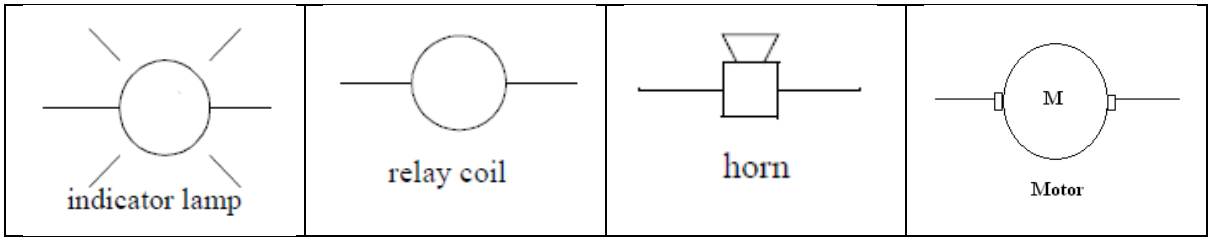


Figure 2.7: Digital Output

Analog Output

The analog output gives a varying signal that could drive an analog meter. Examples of analog meter outputs are speed, weight, and temperature.

Central Control Unit

The Central Control Unit contains the Central Processor which is the brain of the PLC. The CPU monitors the inputs and makes decisions based on instructions in its program memory. It performs counting, timing, data comparison and sequential operations.

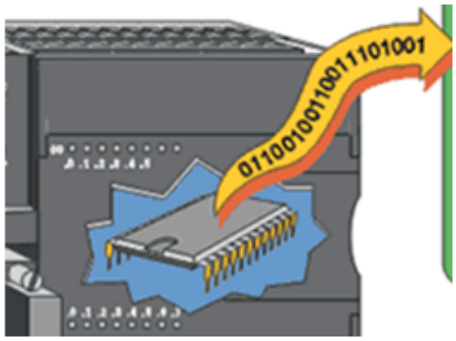


Figure 2.8: CPU

Conduct Lab Activity 1

2.3 LOGO! Hardware

LOGO! Is a universal logic module made by Siemens? The LOGO! Edutrainer Compact includes the following LOGO! parts and accessories:

- LOGO! Basic Module
- LOGO! Expansion modules
- Power supply Unit
- Interface Unit
- Programming Cable
- I/O Data Cable

Figure 2.9: LOGO! Basic & Expansion Modules on Edutrainer Compact

LOGO! Basic Module

LOGO!12/24 RC is the LOGO! Controller that will be used in our applications.

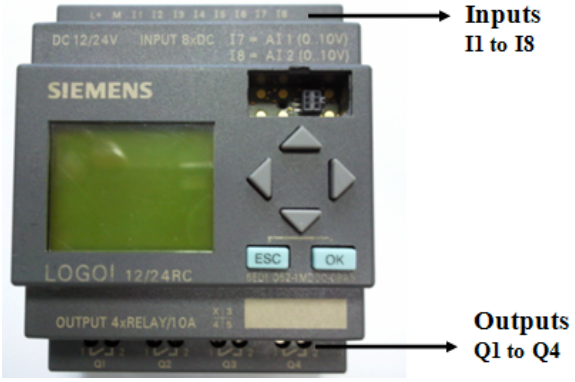


Figure 2.10: LOGO! Basic Module

1. Inputs: The LOGO! Basic Module has 8 inputs and they are designated as I_1, I_2, I_3, …. I_8. Inputs I_1 to I_6 are digital inputs, and the inputs I_7 and I_8 can function as digital or analog.
2. Outputs: The LOGO! has 4 digital outputs Q1, Q2, Q3, Q4.

Expansion Modules

Each LOGO! digital expansion module provides additional 4 digital inputs and 4 digital outputs. Figure 2.11 shows the 2 Digital LOGO! Expansion modules.

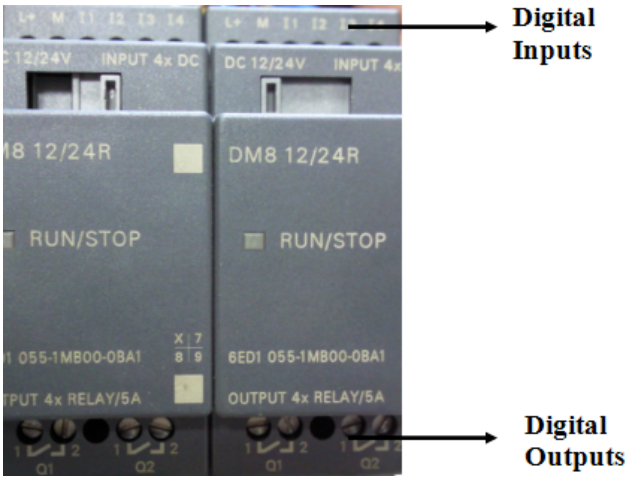


Figure 2.11: LOGO! Digital Expansion Modules

Power Supply

The LOGO! 12/24 RC operates on a 24V power supply.

Figure 2.12: LOGO! Power Supply Unit

Interface Unit

This unit interfaces the LOGO! Controller with the EduTrainer's sensors and one actuator. It receives the control signals from the LOGO! controller through the I/O Data cable. It contains an LED for every input and output that helps visualize the signals, and makes troubleshooting easier.

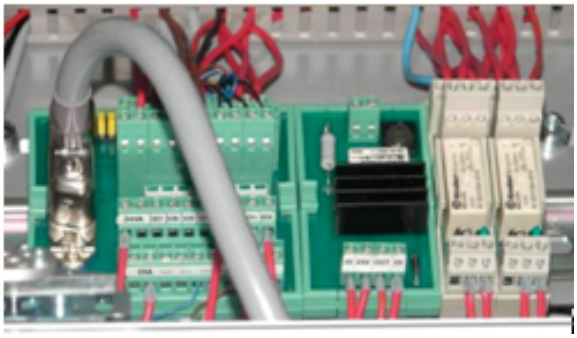


Figure 2.13: Interface Unit

Programming Cable

Figure 2.14: Programming Cable

I/O Data Cable

Figure 2.15: I/O Data Cable

2.4 Sensors and Actuators

A **sensor** is an input device that senses a physical condition and converts it to an electrical signal. The pushbutton shown in figure 2.16 sends an electrical signal to the PLC's input informing the condition of the pushbutton's contacts.

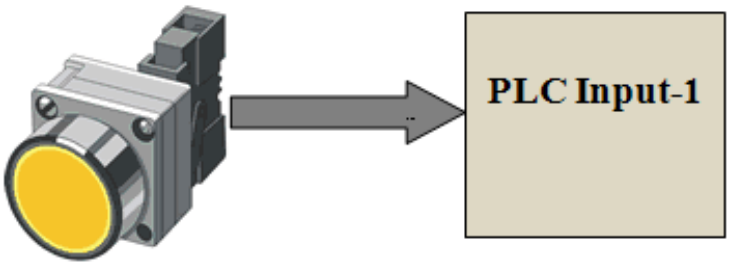


Figure 2.16: Sensor Example

Actuators convert electrical signals from PLC outputs into physical conditions. A motor starter (in fig 2.17) is an example of an actuator. It will either start or stop the motor depending on the state of the PLC output.

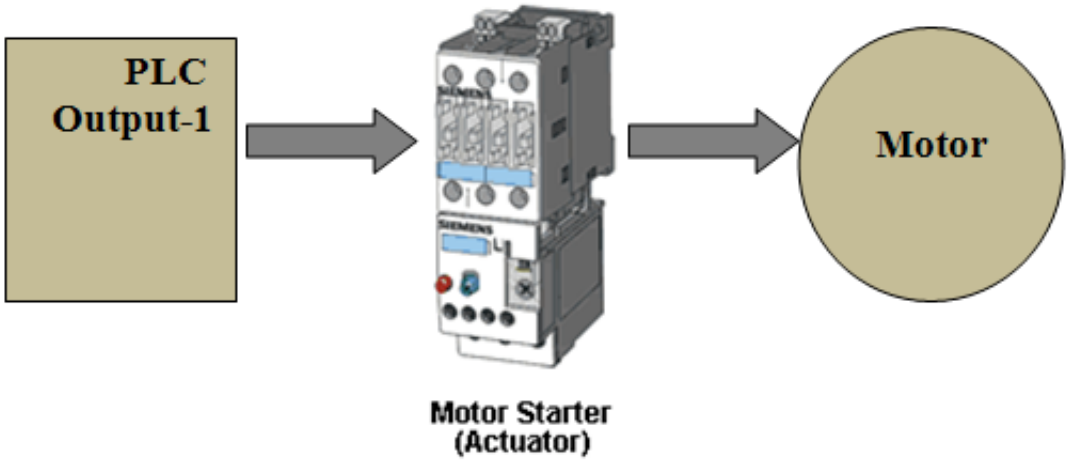


Figure 2.17: Actuator Example

2.5 PLC Wiring

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. 2.18 shows the method of wiring the DC power supply to the LOGO! Module.

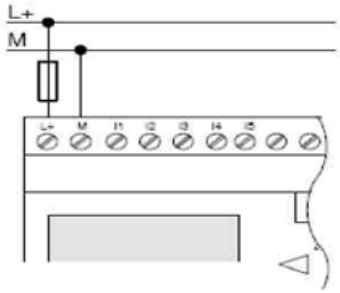


Figure 2.18: Connecting LOGO! to power supply

Connecting LOGO! Inputs

Figure 2.19 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.

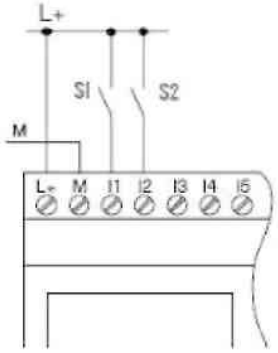


Figure 2.19: Connecting inputs

Connecting sensors to the LOGO!

For two wires sensor the connection can be done easily by taking one wire to the positive terminal of the power supply and the second wire to the LOGO! Input.

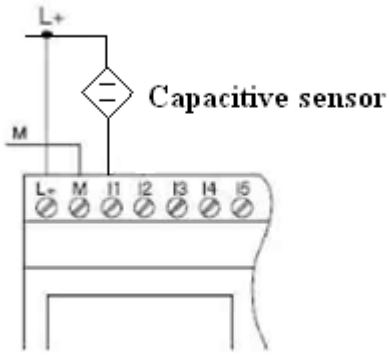


Figure 2.20: Connecting a 2-wire sensor

For three wire sensor, sensor's type must be taken into consideration while programming, PNP sensor can be thought as normally open pushbutton and NPN can be thought as normally close pushbutton.

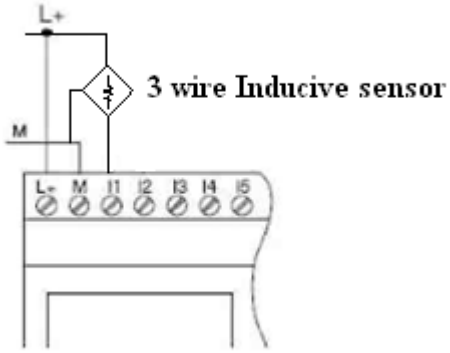


Figure 2.21: Connecting a 3-wire sensor

Connecting LOGO! Outputs

LOGO! …**R**… version is equipped with relay outputs. The potential of the relay contacts is isolated from the power supply and the inputs. As shown in fig 2.22, various loads can be connected to the relay outputs, for example, lamps, motors, relays etc.

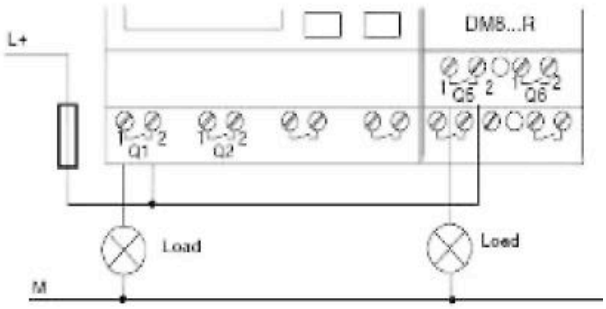


Figure 2.22: Connecting loads to outputs

2.6 Conveyor Belt Application Parts

The parts of the Conveyor Belt application are indicated below along with their functions.

1. **Optoelectronic sensors:**
   Fiber optic barrier
   This sensor is used to detect the presence of a work piece regardless of its color and material.

2. **Inductive Sensor**
   This sensor is used to detect metal parts, and its detection distance is up to 4 mm.

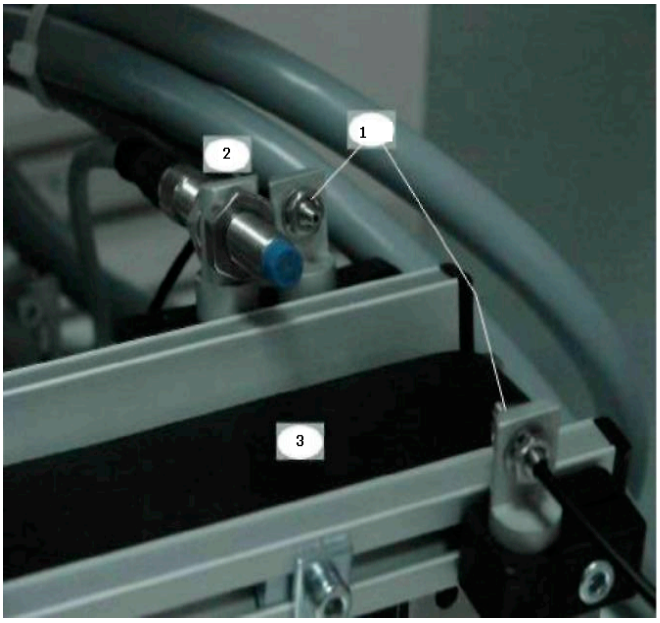


Figure 2.23: Conveyor belt parts

3. **Conveyor Belt**
   This is the transportation media on which the work pieces are transported.

4. **DC Motor**
   It moves the conveyor belt with the aid of the gearbox.

5. **Gear Box**
   It is used to decrease the speed and to increase the torque.

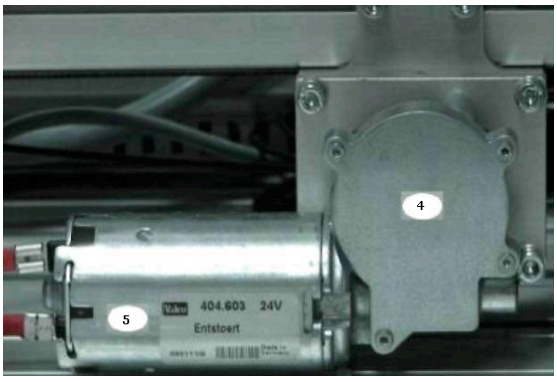


Figure 2.24: DC motor and gear box

6. **Branching Module**

This is a motorized assembly by which branching of the work pieces are done.

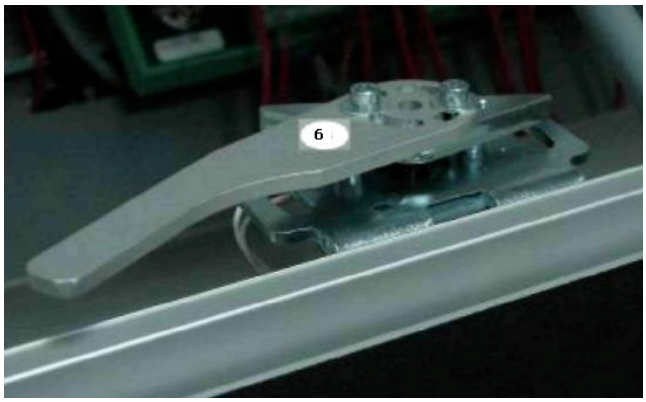
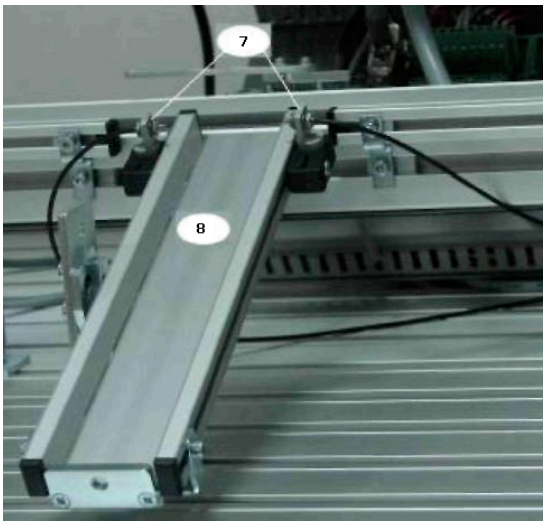


Figure 2.25: Branching arm

7. **Fiber optic barrier**

This sensor is used to detect the passing of a work piece regardless of its color and material.



8. **Slide**

This is the place to hold the branched work pieces.

2.7 Reference table for PLC and Interface Unit

Control Elements	PLC Input/Output	Interface unit
Green pushbutton (N.O)	I1	…
Red pushbutton (N.C)	I2	…
White pushbutton (N.O)	I3	…
Selector Switch	I4	…
Emergency Jumper	I5	…
Fiber optic barrier	I9	I0
Fiber optic barrier	I10	I1
Fiber optic sensor	I11	I2
Inductive sensor	I12	I3
Green Indicator Light	Q1	…
White Indicator light	Q2	…
Table (forward)	Q5	O0
Table (backward)	Q6	O1
Branching arm	Q7	O2
Conveyor belt motor	Q8	O3

2.8 Lab Activity 1

Objective: To identify the Normally Open and Normally Closed pushbuttons on the LOGO! BASIC Control unit.

Figure 2.26: LOGO! Control Unit

The LOGO! Control Unit has three pushbuttons as shown in fig 2.26. Perform this activity to identify the NO and NC pushbuttons.

Procedure:

A. Enter a program to *turn on the white indicator light (Q3) when the green pushbutton (I1) is pressed*. Run the program and observe the result. Has the white light turned ON?

_____

If yes, the green pushbutton is a NO pushbutton.

B. Enter a program to *turn on the white indicator light (Q3) when the red pushbutton (I2) is pressed*. Run the program and observe the result. Has the white light turned ON?

_____

If not, the red pushbutton is a NC pushbutton. It becomes open when pressed.

C. Enter a program to *turn on the white indicator light (Q3) when the white pushbutton (I3) is pressed*. Run the program and observe the result. Has the white light turned ON?

_____

If yes, the white pushbutton is a NO pushbutton.

D. Enter your results in the table below:

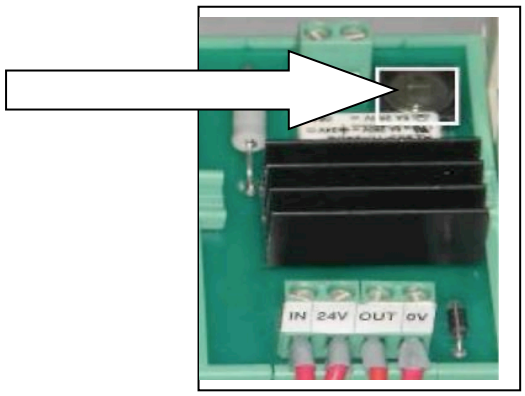
Pushbutton	**Type (**NO/NC?)	**Condition in normal state** (open/close?)
Green		
Red		
White		

2.9 Lab Activity 2

Objective: To familiarize with the LOGO! Interface Unit and the expansion modules.

Procedure:

1. Press the push button found in the conveyor motor control unit, and comment on your observation.



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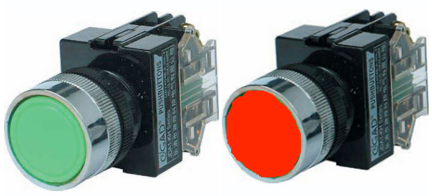
……..

……

……..

2. Connect a *green external push button* to *I0* of the Interface unit and a *red external push button* to *I1* of the Interface unit (see the reference table for PLC and Interface unit).



Note: Green push buttons are Normally Open (NO) while the red ones are Normally Closed(NC).

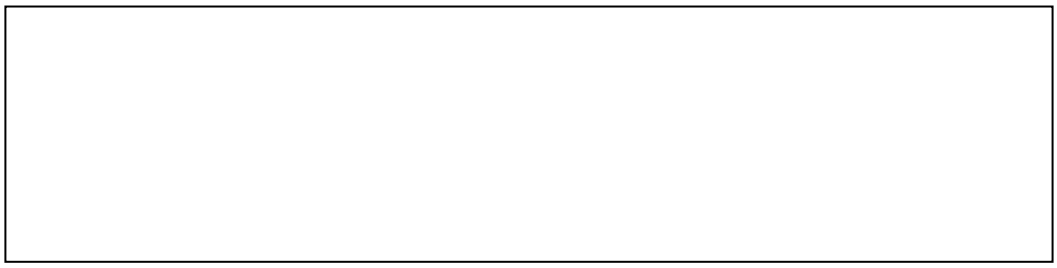
3. Press each of the pushbuttons, and observe the LEDs of the Interface unit. Comment on your observation.

……

……

of erfaunit and a *red external push button* to *I1* of the Interface unit (see the reference table for PLC and Interface unit).

4. Draw the function block diagram for the following action:
   - Switch ON the conveyor belt (connected to output O3-Interface Unit) when the green push button is pressed, and
   - Switch it OFF when the red push button is pressed.



Run the program and complete the statements below:

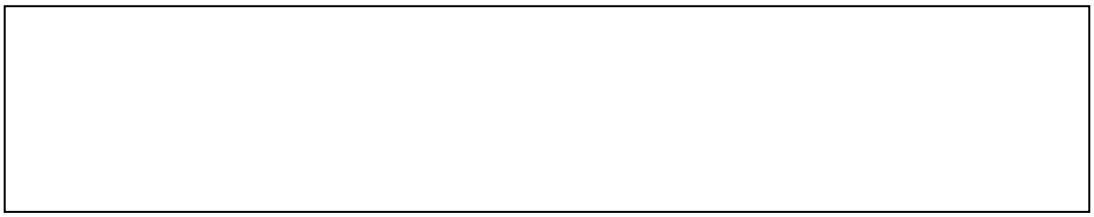
The conveyor belt starts when ……

……

The conveyor belt stops when ……

……

5. Use the **memory function block** (RS-Latch) to implement the same operation and observe the result. Draw the function block diagram



6. Replace the output from O3 to O5 and modify your program to run the conveyor belt. Draw the function block diagram with the changes done:

2.10 Lab Activity 3

Objective: To test the function of the optical sensor and inductive sensor connected to the Interface Unit.

Procedure:

1. Connect the optical sensor shown to Input I3 of Interface unit.

2. Notice the status of LEDs of the Interfacing unit when there is no object in front of the sensor; write your observation below:

   ……

   ……

3. Move your hand forward and backward in front of the same sensor and observe the status of LEDs of the Interfacing unit. Comment on your observation.

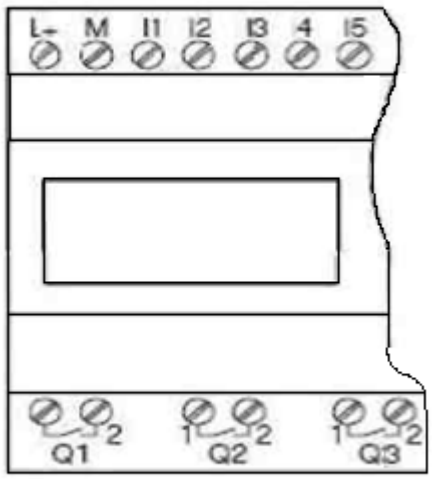
   ……

   ……

4. Create a program that turns ON the conveyor belt when the selector switch is switched ON, the branching arm should move when the inductive sensor detects a metallic piece.

2.11 Review Exercise

1. Read the case study at the beginning of this module, and then draw all the inputs and outputs and connect them to the LOGO! PLC given below.



2. Write T for the correct statement and F for the wrong statement.

No	Statement	T/F
a	The control panel of LOGO PLC consists of 4 pushbuttons, 1 Selector switch, and 2 Lamps.	
b	The output voltage of the Power Supply Unit is 24VDC.	
c	The inductive sensor is used to detect metals only.	
d	I1 is the first output for LOGO! PLC and Q1 is the first input.	

3. Give three examples for each one of the following :

Digital Input	Analog Input
Digital Output	Analog Output

4. A normally open pushbutton is used to turn ON an automatic filling system. When the normally closed liquid level detector is activated, a pump starts filling the tank. Once the tank is full a normally open liquid level detector sends a signal to the PLC and the PLC turns the pump OFF.

   Complete the wiring diagram below.