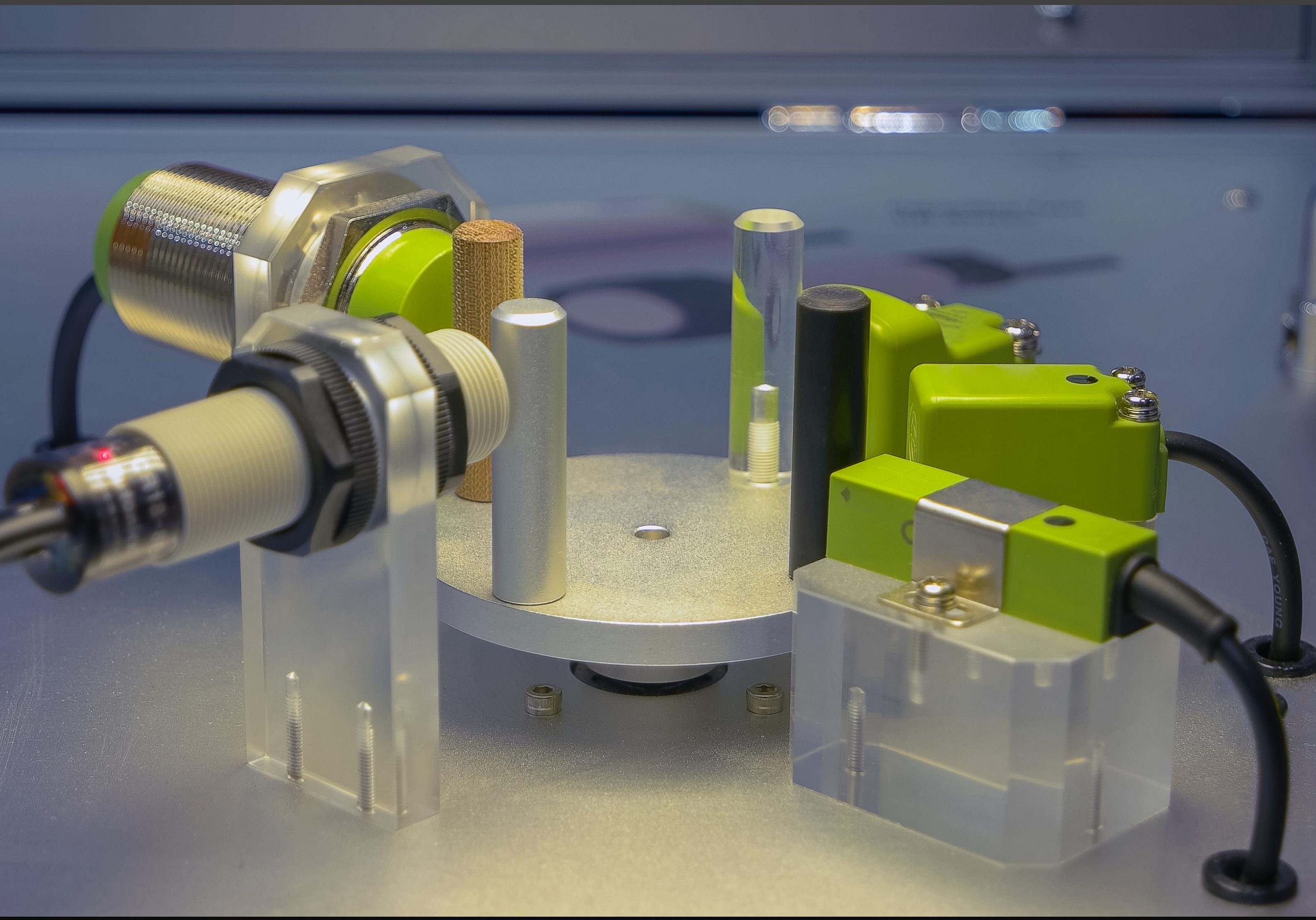
MATRIX | INDUSTRIAL MAINTENANCE

Industrial Maintenance - Sense and Control



Instructors Guide

MATRIX

CP6211

www.matrixtsl.com

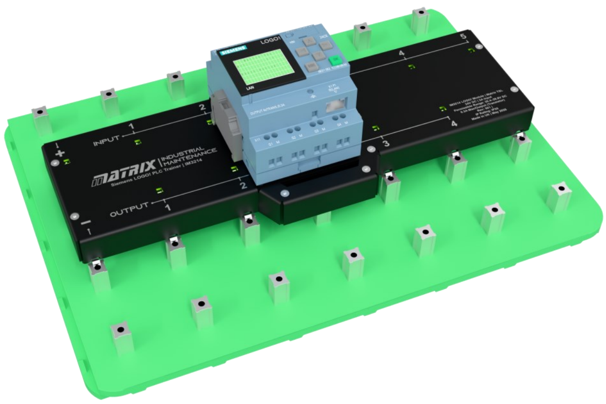
Contents

About this course

Introduction

The course provides a introduction into sensors and actuators in Industrial Automation. It's perfect for beginners learning about Industrial Control Systems. This course provides students with a PLC that has all the software developed by us. Each program needs to be loaded manually onto the SD card of the LOGO! due to limited capabilities of the PLC.

This curriculum is intended to be used with the Matrix PLC LOGO! Module and 4mm Connectors. Our website has all the example programs for this course available for free download. A USB stick is supplied with this kit, with all the example programs. As this product is part of the Industrial Maintenance range, it is intended that students use these example programs as opposed to creating software from scratch. However, you are welcome to download LOGO! Soft Comfort software and have the students write the software themselves.



You can also use any controller of choice.

Locktronics equipment makes it both quick and simple to construct and investigate the electrical circuits used by industrial controllers. When students construct a Locktronics system, the end result can look just like the circuit diagram, thanks to the symbols printed on each component carrier.

The course is designed to work with a 24V power supply.

Aim

The course aims to introduce students to programming industrial controller units, allowing them to interact with the types of sensing and control circuits used in industry.

Prior Knowledge

It is recommended that students have some prior knowledge of the programming languages chosen to complete the course. It is also recommended that the course is completed in a single language and then maybe repeated using a different programming language to reinforce learning.

Learning Objectives:

On successful completion of this course the pupil will have learned:

- to distinguish between analogue and digital sensors;
- that simple digital sensors have a two-state output - either open (off) or closed (on);
- that digital sensors have high resistance when open, and small resistance when closed;
- that simple digital sensors output a signal either at 0V or at the full power supply voltage;
- the circuit symbols for a range of switches, bulbs and sensors;
- that some components are polarised and so work properly only when connected the right way round;
- that a controller can be programmed to recognise a high input voltage as a switch being either 'on' or 'off';
- that output devices require a variety of current levels to make them operate;
- that relays can be used to deliver higher currents;
- that transistors are much faster than relays in switching on and off;
- how to connect a control unit to deliver current through its transistor output terminals;
- how to connect a control unit to deliver current through its relay output terminals;
- that systems typically consist of three basic elements, input, process and output subsystems;
- that analogue sensors output a continuous range of voltages;
- that a potentiometer can be used to set a reference voltage to specify quantities such as temperature;
- that there are two commonly used types of control system, open-loop and closed-loop;
- that varying the duty cycle of a square wave signal simulates an analogue voltage;
- that analogue sensors may require a complex calculation to yield a useful value;
- that control units can be programmed or controlled using a variety of different languages.

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To complete this course the pupil will need the following parts.

LK2101		
1	HP2045	Shallow plastic tray
2	HP4039	Lid for plastic trays
1	HP5540	Deep tray
2	HP7750	Locktronics daughter tray foam insert
1	HP9564	62mm daughter tray
1	LK0123-00	Magnet
1	LK1107	MES bulb, 24V, 0.2A
1	LK6384	Buzzer (24V)
1	LK4025	Resistor - 10 ohm, 1W 5% (DIN)
1	LK5218	Resistor 100k ohm
5	LK5202	Resistor - 1K, 1/4W, 5% (DIN)
2	LK5203	Resistor - 10K, 1/4W, 5% (DIN)
1	LK6238	Resistor - 200K, 1/4W, 5% (DIN)
1	LK5214	Potentiometer, 10K (DIN)
1	LK8011	Power FET
14	LK5250	Connecting Link
1	LK0417	Relay 24V 10A (tranparent case)
2	LK5291	Lampholder carrier
1	LK5402	4.7K thermistor, NTC (DIN)
1	LK5404	Switch, reed
2	LK5603	Lead - red - 500mm, 4mm to 4mm stackable
2	LK5604	Lead - black - 500mm, 4mm to 4mm stackable
4	LK5607	Lead - yellow - 500mm, 4mm to 4mm stackable
4	LK5609	Lead - blue - 500mm, 4mm to 4mm stackable
2	LK6207	Switch Press (morse key-type strip, push to make)
1	LK6209	Switch on/off (stay put, sideways swivel strip)
1	LK2537	LED, red, 24V (DIN)
1	LK2869	LED, yellow, 24V (DIN)
2	LK7945	LED, green, 24V (DIN)
1	LK6634	Microswitch
1	LK1909	DC Motor 24V
1	LK7290	Phototransistor
1	LK0181	Solenoid (24V)
1	LK8275	Power supply carrier with battery symbol
1	LK8900	7 x 5 baseboard with 4mm pillars
1	COM6654	24V power supply
1	COM5825	UK power supply plug
1	COM5826	EU power supply plug
1	COM5827	USA power supply plug

Control systems Option 1 - MIAC NXT		
1	HPUSB	USB lead
1	MI0550	MIAC NXT
Control systems Option 2 - your own PLC with Matrix 4mm adaptors		
1	XXXX	Your PLC
1	AU3686	PLC mounting platform
1	HP6700	Input module
1	HP6723	Motor module
1	HP6752	Relay module
1	HP6711	Power module
Control systems Option 3 - Siemens industry 4.0 system		
1	AU0205	Siemens S7 + HMI +wifi module with 4mm connectors

Using this course:

Our goal is to help students to understand sensors and control systems in the context of industrial systems and a focus on industrial maintenance & troubleshooting. The aim is for students to understand the behaviour of the components, the circuit diagrams, and the role of the Programmable Logic Controller (PLC).

We do this by asking students, working individually or in pairs, to build a number of circuits typically found in an industrial system that uses an industrial controller. Students generate or select an existing program that makes the circuit work in the desired way and then take measurements, make drawings, or describe what is happening in the circuits, to reinforce learning.

Worksheets:

It is expected that the worksheets are printed / photocopied, preferably in colour, for the students' use. Students will need their own permanent copy, as a record of what they have learned.

Each worksheet has:

- an introduction to the topic under investigation;
- step-by-step instructions for the investigation that follows;
- a summary of the important points of learning

Types of controller

Almost any controller can be used with this product, so long as the controller has digital & analogue inputs and digital outputs, capable of PWM. We do specify that the circuits are limited to 24V, the maximum rating of many of the electronics components.

Programming using Siemens LOGO! PLC

We recommend using the Matrix PLC LOGO! Module and 4mm Connectors.

Time:

It will take students between six and ten hours to complete the worksheets. It is expected that a similar length of time will be needed to support the learning that takes place as a result.

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Scheme of Work

Worksheet	Notes for the Instructor	Timing
1	Basic Outputs: The first worksheet is designed to guide students in using controller outputs. To do this, they are asked to create a small program to switch the motor or transistor outputs on and off, one at a time.	40 - 60 minutes
2	Sequenced Outputs: This worksheet takes output control one step further by explaining the fundamentals of a finite-state machine. This is then reinforced with the practical task of writing a simple traffic-light controller program. The program has four unique states representing the different combinations of traffic-lights that can be active. The movement between the preset states is also another key aspect.	40 - 60 minutes
3	Pulse Width Modulation: Worksheet 3 looks at more advanced outputs, that use Pulse-Width Modulation. This can be achieved by the use of timers to pulse an output, or by programming a controller's internal PWM peripheral where one is included. As reinforcement, students could place a capacitor between the PWM output and ground and use a voltmeter to measure the equivalent analogue voltage as they change the PWM mark/space ratio. Whilst controllers make use of internal transistors, it is useful to explore the role of an FET as a power amplifier.	40 - 60 minutes
4	Basic Inputs: This example tackles the problem of polling digital switches. The students learn that they have to write a loop into their program so that the switch values can be checked periodically. This example also teaches the student how to store values in variables to represent the digital input voltage.	40 - 60 minutes

Worksheet	Notes for the Instructor	Timing
5	Pedestrian Crossing: This worksheet combines outputs and inputs to create a fully-operational pelican-crossing system. The worksheet does not detail a specific method here. You may wish to introduce the concept of using state machines to manage programme flow.	40 - 60 minutes
6	Potentiometers: This worksheet introduces students the use of potentiometers as analogue controls in electronic systems. Students create a variable for the input voltage and make decisions as to go/no go values. An issue that arises is the specification of the inputs on your controller or PLC. The MIAC controller has eight inputs which are either analogue or digital, dictated by the software. PLCs such as those made by Siemens have separate analogue and digital inputs and you may need to brief your students accordingly.	40 - 60 minutes
7	Using sensors: This worksheet introduces students to analogue sensors and to the data manipulation often required to obtain a meaningful result from them. Students need to understand the NTC thermistor characteristics given in the reference section on 'Using thermistors' and use them to calculate the voltage at the input pin at a given temperature. If your controller has a low input resistance, it will affect the circuit. You may need to leave out the balancing resistor in the voltage divider chain and recalculate. The thermistor used is an EPCOS B57164K0472J000. Students will probably want to use a look up table in their program.	40 - 60 minutes

Worksheet	Notes for the Instructor	Timing
8	Detecting Faults 1: This worksheet introduces automatic fault-sensing to the industrial controller. By detecting if an output has switched on as expected, the students' programs can determine whether an output such as a bulb has become damaged or missing. This allows students to see for themselves how to design and create a fault tolerant system.	40 - 60 minutes
9	Detecting Faults 2: This worksheet moves on from the first fault-finding worksheet to include analogue sensors and how to make these tolerant to faults such as electrical breaks or shorts. The programs can then detect these faults and inform the user of the problem.	40 - 60 minutes
10	Open-Loop Control: This worksheet details the basics of an open-loop control system. An analogue voltage created from a potentiometer is used as the input to a DC motor speed controller. Students should note that the motor is simply being told what to do and has no control over any aspect of the system.	40 - 60 minutes
11	Closed-Loop Control: This worksheet details the basics of an closed-loop control system. A bulb is driven directly from an input analogue voltage provided by a potentiometer. The light level produced is then fed back into the system to create a 'error signal' or difference between what is expected and what is sensed. This error signal is then used to adjust the control signal to allow the bulb to behave as expected. The changing output can be seen by removing and replacing the paper 'roof' over the bulb and sensor circuitry. When that is present, the light from the bulb will be dim, as the sensor is detecting the correct amount of light. When the paper is removed the bulb will become brighter to try and raise the amount of light sensed by the sensor.	40 - 60 minutes

Using thermistors

The thermistor used in this module is a EPCOS B57164K0472J000 4k7 NTC thermistor.

Its characteristics are shown in the table below.

This should enable you to calculate the output voltage from a voltage divider chain consisting of the NTC thermistor and a 10kΩ resistor from a given supply voltage.

R/T No.	4001	
T (°C)	$B_{25/100}$ = 3950 K	
	R_T/R_{25}	α (%/K)
−55.0	88.052	7.3
−50.0	61.65	7.0
−45.0	43.727	6.8
−40.0	31.395	6.5
−35.0	22.802	6.3
−30.0	16.742	6.2
−25.0	12.367	6.0
−20.0	9.2353	5.6
−15.0	7.0079	5.4
−10.0	5.3654	5.4
−5.0	4.126	5.2
0.0	3.2	5.0
5.0	2.4986	4.9
10.0	1.9662	4.7
15.0	1.5596	4.6
20.0	1.2457	4.5
25.0	1.0000	4.4
30.0	0.80355	4.2
35.0	0.65346	4.1
40.0	0.53456	4.0
45.0	0.43966	3.9
50.0	0.36357	3.8
55.0	0.30183	3.7
60.0	0.25189	3.6
65.0	0.21136	3.5
70.0	0.17819	3.4
75.0	0.15089	3.3
80.0	0.12833	3.2
85.0	0.10948	3.1
90.0	0.093748	3.0
95.0	0.080764	2.9
100.0	0.069842	2.9
105.0	0.060455	2.9
110.0	0.052498	2.8
115.0	0.04574	2.7
120.0	0.039972	2.7
125.0	0.034984	2.6
130.0	–	–
135.0	–	–
140.0	–	–
145.0	–	–
150.0	–	–
155.0	–	–

Version control

04 04 25	New curriculum created from CP7718