MATRIX | SMART FACTORY

Smart Factory

Teacher Guide

Teacher’s notes

Introduction

The Smart Factory is a series of practical assignments that students can carry out to learn about and understand the problems that designers of industrial work cells face and how to overcome them. Students have to understand the operation of three distinct modules and bring them together to form a small automation system involving a variety of sensors and actuators.

The three modules are:

- Conveyor system
- Gantry system
- Robot arm system

How this is used in the classroom

A single student could complete all the assignments here. Alternatively this can be run as a group project with 3 students working on individual modules and then coming together to complete the whole task. The tasks are as follows:

Step 1: Pick a variety of workpieces from a storage area using a pick and place gantry. Learning objectives:

- Stepper motor drives
- Limit switches
- Rotational to linear movement with stepper motors
- 3/2 and 5/2 electropneumatic valves
- Vacuum suction systems
- Positional control

Step 2: Use a conveyor system to transport and sort workpieces. Learning objectives:

- DC motor control using Pulse Width Modulation
- Rotational to linear movement with DC drives
- Inductive and capacitive sensors
- Light gates
- Positional control with DC motors using timing
- Reject mechanisms

Step 3: use a robot arm to pick, sort and place workpieces. Learning objectives:

Teacher's notes

- Robot arm workspace and planning
- Robot arm movement
- Pendant and G code programming

If you want to sort workpieces by colour then this work will need to be extended by using the API programming interface.

Timings

The budget times for the activities - assuming a reasonable level of competence - is as follows:

Worksheet 1 - Understanding sensors	1
Worksheet 2 - Reject mechanisms	1
Worksheet 3 - Understanding the conveyor	2
Worksheet 4 - Sorting counters	4
Gantry worksheets	
Worksheet 5 - Driving the stepper motor	2
Worksheet 6 - Understanding the plunger	2
Worksheet 7 - Delivering counters	2
Robotic arm worksheets 1 to 3	**5**
Smart factory	
Worksheet 8 - robot arm I/O	2
Worksheet 9 - commissioning the cell	2
Worksheet 10 - completing the smart factory	4 (not including full handshaking)

So when a single student completes all basic modules it would take around 27 hours. If 3 students are tasked with the problem it would take them around 12 lab hours.

The great advantage of the system is that it can be split into three parts so that all students are really participating in solving the problem.

PLC choice

The system makes use of standard 24V control signals. Nearly all PLCs will be 24V compatible so you have a choice of a wide range of PLCs.

Reference

If 3 students are working on the project you will need up to 3 PLCs for the Conveyor system, the robot arm and the Gantry system.

The robot arm has a full Application Programming Interface in it so that it is compatible with any programming system with an internet connection and the appropriate software. You can use a PLC for this purpose or you can use Matrix Flowcode software which has software components inside it for controlling the robot arm.

The number of PLC inputs and outputs needed is as follows:

	Inputs	Outputs
Conveyor	5	4
Gantry	2	7
Robot Arm	0	0

(Note that this assume that and input and output on each of the Gantry and Conveyor are used for handshaking.)

Using Siemens PLCs

If you don't have a Siemens PLC and want students to work separately on the Conveyor and the Gantry then we suggest you purchase this Siemens PLC:

6ES7212-1AE40-0XB0

If you want a single PLC then we suggest you use this PLC:

6ES7214-1AG40-0XB0

Using Matrix MIACs

Matrix MIAC controllers are ideal for use with the Smart Factory and are Flowcode compatible with Wi-fi built in. The system can be admirably controlled by two dsPIC MIACS product code MI-0007.

Programming language

If you are using an industrial PLC then there will be a choice of programming languages available to you.

<u>Level 1 functionality</u>

Completing the Smart factory to a point where the gantry and conveyor function properly can be done in around 12 hours of lab time. At this point the Gantry will communicate with the Conveyor to notify it of when a counter is on the conveyor and ready, the robot arm will be able to take a plastic workpiece from the end of the conveyor and sort it by colour. However there will be no communication between the Gantry/Conveyor and the robot arm.

Reference

If you are using Matrix MIAC controllers then we would recommend that you use Flowcode. Flowcode is supplied with all necessary software libraries to drive the Conveyor DC motor, the gantry stepper motor and the robot arm.

Level 2 functionality and Industry 4.0

The three parts of the system can be made to work to level 1 with any PLC for the Gantry and conveyor and the Pendant programming software (which uses G code) supplied with the robot arm. At this point there will be no communication between the Conveyor and the Robot arm to notify the arm when a plastic workpiece is ready. Modifying the program slightly and using IN 1 and IN2 of the robot arm will allow the PLC and arm to communicate so that the arm can e integrated with the rest of the Smart Factory.

The robot arm is fitted with a Wi-fi module and a full Application Programming Interface. Details of this interface are documented in the Robot Arm manual.

Handshaking between the robot arm and the Gantry / Conveyor will also be possible using Internet based communications between the robot arm and the other modules.

The PLC or programming system you use will need a LAN/ Wi-fi connection and the robot arm programming language you use will need to have the capability to issue internet based API calls.

Matrix PLC adaptors

Matrix makes available a number of adaptors for PLCs to allow them to be used with 4mm ‘banana’ connectors. We supply two types of adaptors which have slightly different numbering conventions and slightly different connection systems. The adaptors have a number of screw terminals which connect to the 4mm connectors differently. The tables below show you the connections so that you can decide which are best for you.

HP6711 Power module

General controllers - including Matrix MIAC

Part	Description	Numbering	Screw Terminals	Comments
HP6700	Input Module	1-8	I1, I2, I3, I4, I5, I6, I7, I8	
HP6723	Motor Module	A, B, C, D	A, G, B, G, C, G, D, G	G = common

Reference

Other controllers

Part	Description	Numbering	Screw Terminals	Comments
HP8042	Input Module	0-7	I0, I1, I2, I3, I4, I5, I6, I7	
HP7035	Motor Module	0-7	Q0, Q1, Q2, Q3, Q4, Q5, Q6, Q7	

These parts are needed for Siemens , Omron and other controllers that start output numbering with 0.

Reference

Sensor settings

Setting up the inductive sensor

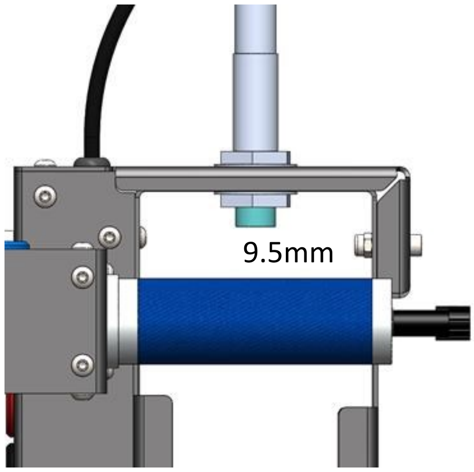
The inductive sensor can detect different types of metal due to the difference in the magnetic field changes between materials.

This sensor has a scaling factor to the distance of detection depending on material.

- Steel – 1
- Stainless steel – approx. 0.8
- Aluminium - approx. 0.45
- Copper – approx. 0.4
- Brass – approx. 0.4

This will vary slightly from one sensor to the other. In our experiments the trigger distance for different types of metals is:

Aluminium:	4mm
Stainless steel	6mm
Mild steel	8mm



Adjusting the height of the sensors

Use the M12 nuts on the top and bottom of the sensor to adjust the height of the sensor. This will move the sensor up and down relative to the conveyor.

Adjust the height of the inductive sensor to the conveyor so that it is roughly '9.5'mm distance away from the conveyor belt.

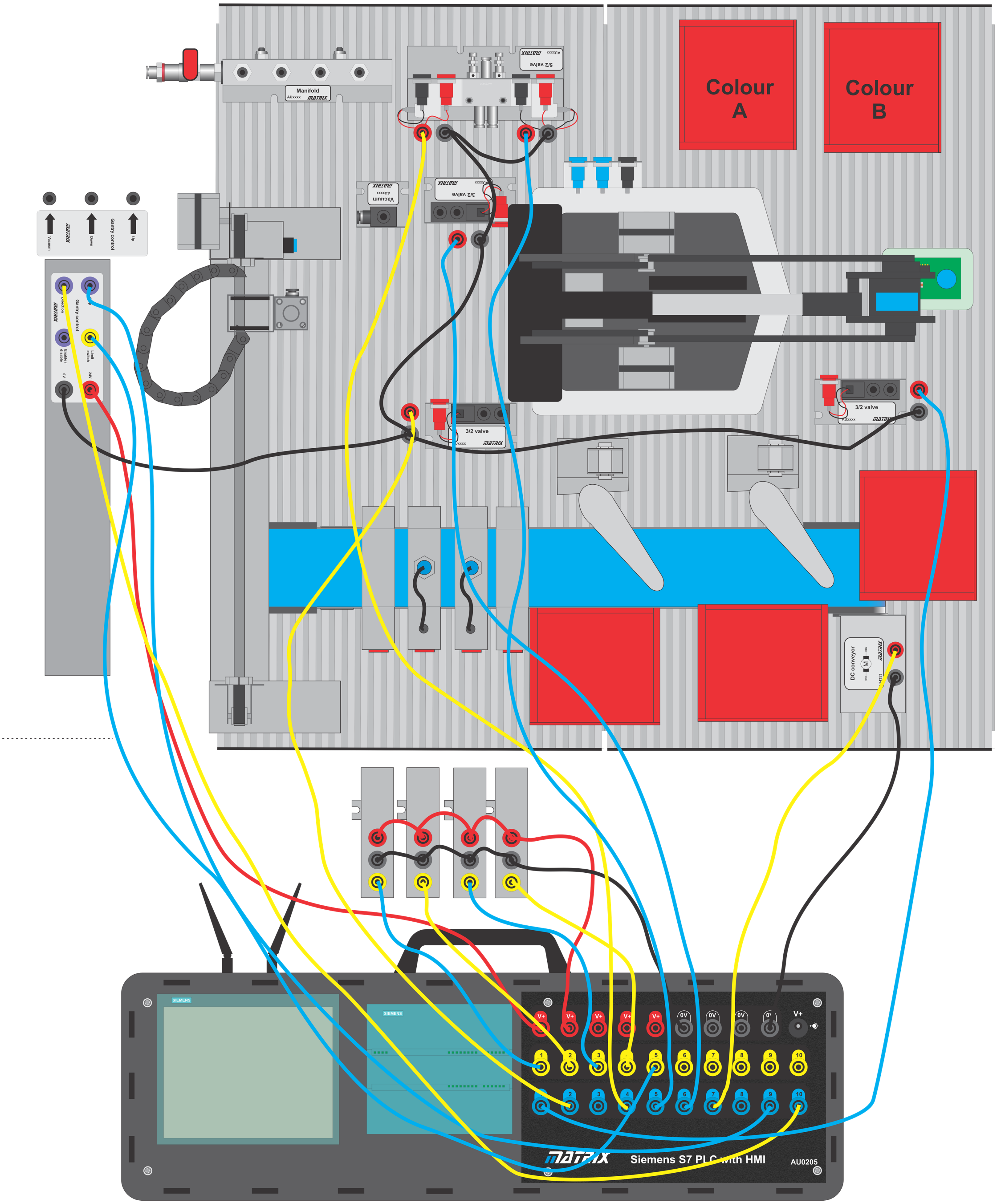
This should mean that when a stainless steel counter passes under the sensor it activates, but when the aluminium counter passes, it does not.

This is due to the scaling factor distance of the two materials.

Setting up the capacitive sensor

The capacitive sensor needs to be around 6mm away from the surface of the counter under test. It should activate when a metal counter is underneath it but not with a plastic one. The capacitive sensor is fitted with a potentiometer for sensitivity adjustment. The distance from the sensor surface to the counter can be adjusted with the M12nut.

Smart factory Siemens S7 wiring diagram



Bill of Materials

Code	Description	Qty
AU9318	Automatics platform	2
AU0696	Gantry mechanism	1
AU4353	DC conveyor	1
AU6004	Manifold	2
AU2834	5/2 Valve	1
AU9633	3/2 valve	3
AU1443	Vacuum generator	1
AU6446	inductive sensor	1
AU4280	Capacitance sensor	1
AU1214	Light gate	2
AU8046	Reject mechanism	2
AU7654	Red plastic bin	4
AU0358	Workpiece holder	1
RB6231-3	Robot arm	1
COM6654	24V DC power supply	2
COM5825	UK 24V PSU adaptor	2
AU3052	Steel counter	4
AU5694	Aluminium counter	4
AU7482	Plastic counter red	5
AU9925	Plastic counter green	5
LK5604	Lead - black 4mm to 4mm unshrouded	10
LK5603	Lead - red 4mm to 4mm unshrouded	12
LK5609	Lead - blue 4mm to 4mm unshrouded	8
LK5607	Lead - yellow 4mm to 4mm unshrouded	8
AU1072	Plastic tubing - blue	1
AU1070	Plastic tubing - red	1
AU1080	Tubing cutter	1
AU1060	Pack 50 T bolts	1
AU5775	Registration plate	1
AU0847	Pneumatic pipe tidy	10
	Control option 1 - MIAC	
MI3494	dsPIC cased MIAC with wi-fi	2
	Control option 2 - PLC generic - numbering from 1	
HP6700	PLC adaptor - inputs	1
HP6723	PLC adaptor - transistor module	2
HP6711	PLC adaptor power module	1
HP6822	PLC bracket for the smart factory	1
	Control option 3 - Siemens etc - numbering from 0	
HP8042	PLC adaptor - inputs	1
HP7035	PLC adaptor - transistor module	2
HP6711	PLC adaptor power module	1
HP6822	PLC bracket for the smart factory	1
	Non UK options	
COM5826	EU 24V PSU adaptor	2
COM5827	US 24V PSU adaptor	2