



SMART FACTORY

CP7329

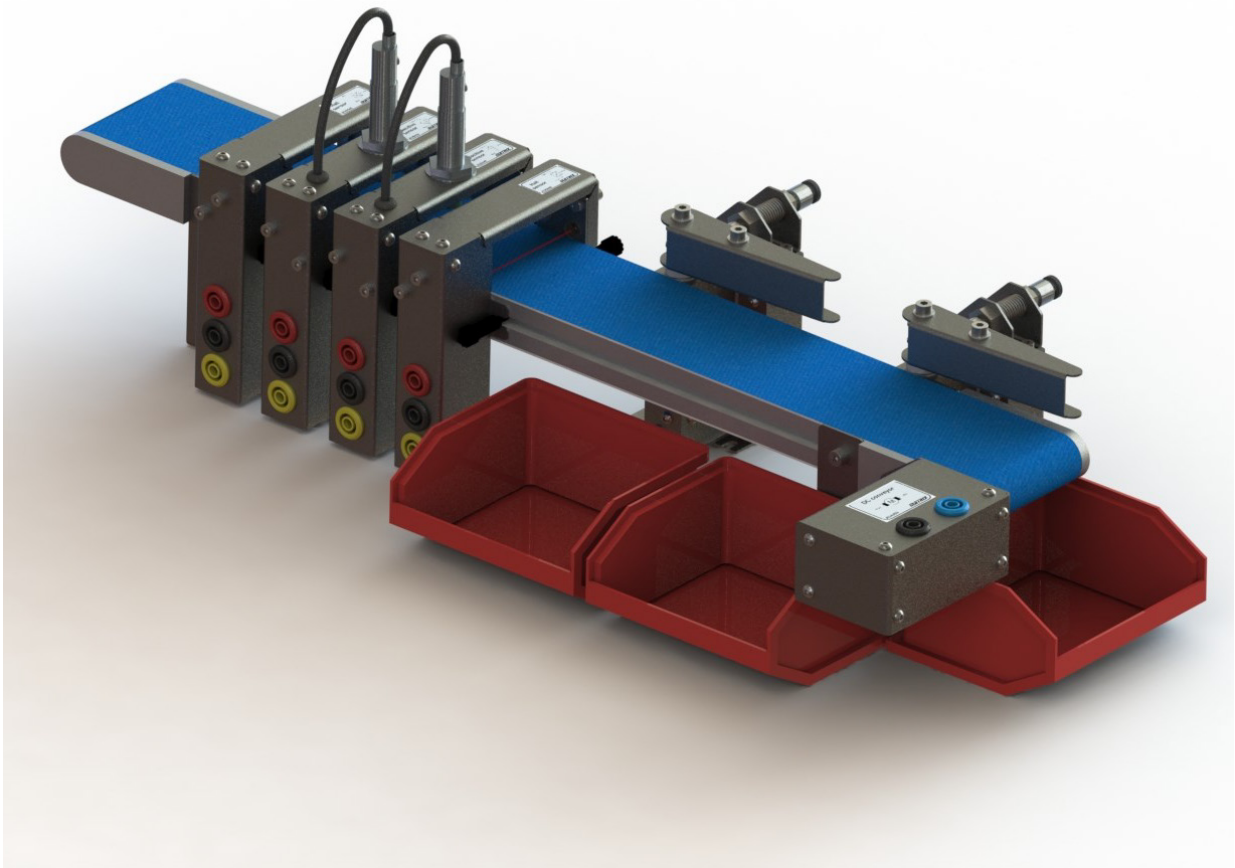
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Conveyer Worksheets





WORKSHEETS



WORKSHEETS

Worksheet 1 - Understanding Sensors

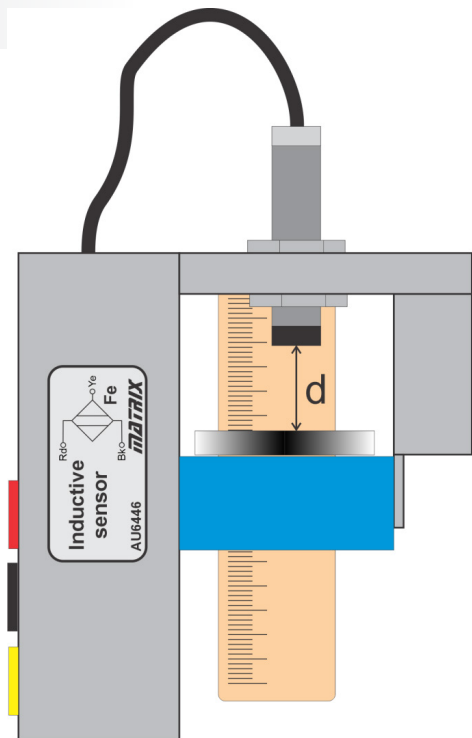


Some digital sensors in machinery can be simple switches like the gantry limit switch in the smart factory. Other digital sensors have some kind of circuit which takes in an analogue signal and converts it into a digital one: the Hall sensor, Capacitance sensor and the infrared beam breakers on the conveyor system are all examples of this.

Over to you:

Inductive sensor

- Take the inductive sensor and apply power and ground to the red and black connectors respectively.
- Referring to the diagram: using a ruler measure the minimum distance, d , from the sensor at which the inductive sensor triggers for each metal counter: aluminium and steel. On some models of sensor there is an LED indicator. On others you will need to use a multimeter on the output to see when the output voltage changes.



	Capacitive sensor	Inductive sensor
Steel counter		
Aluminium counter		

So What?

The inductive sensor allows you to differentiate between different types of metal. So the inductive sensor needs setting up with some precision.

Over to you:

- Add the inductive sensor to the conveyor belt using the t-blots to secure the sensor to the sides of the conveyor. Set up the sensor so that the height of the sensor above the conveyor belt is 5.5 mm more than the height you measured for the aluminium counter. This is 1.5mm plus the height of the counter (4mm). This gives some small margin for error.

WORKSHEETS

Worksheet 1 - Understanding Sensors

- Add power to the conveyor manually so that it runs.
- Place the aluminium and stainless steel on the conveyor and make sure that the sensor reliably detects the steel counter but not the aluminium one.

So What?

- The height of the conveyor varies slightly as it turns: there is a join in the belt that raises the counter slightly. You may need to increase the distance slightly between the sensor and the counter.

Over to you:

Capacitive sensor

- Set up the capacitive sensor so that the height above the conveyor is 2mm more than the trigger height you measured for the steel and aluminium counters. The counter thickness is 4mm so this should give a reliable indication of the presence of a metal counter.
- Add power to the conveyor manually so that it runs.
- Place the aluminium and stainless steel on the conveyor and make sure that the sensor reliably detects the presence of a metal counter beneath it.

So What?

You now have two sensors: the inductive sensor allows you to differentiate between steel and aluminium counters. The capacitive sensor allows you to differentiate between plastic and metal sensors. With a little programming logic you should be able to develop a programme that allows you to sort the counters.

Over to you:

Light gates

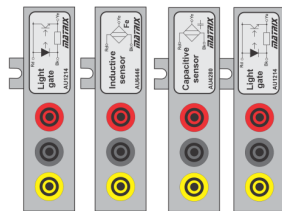
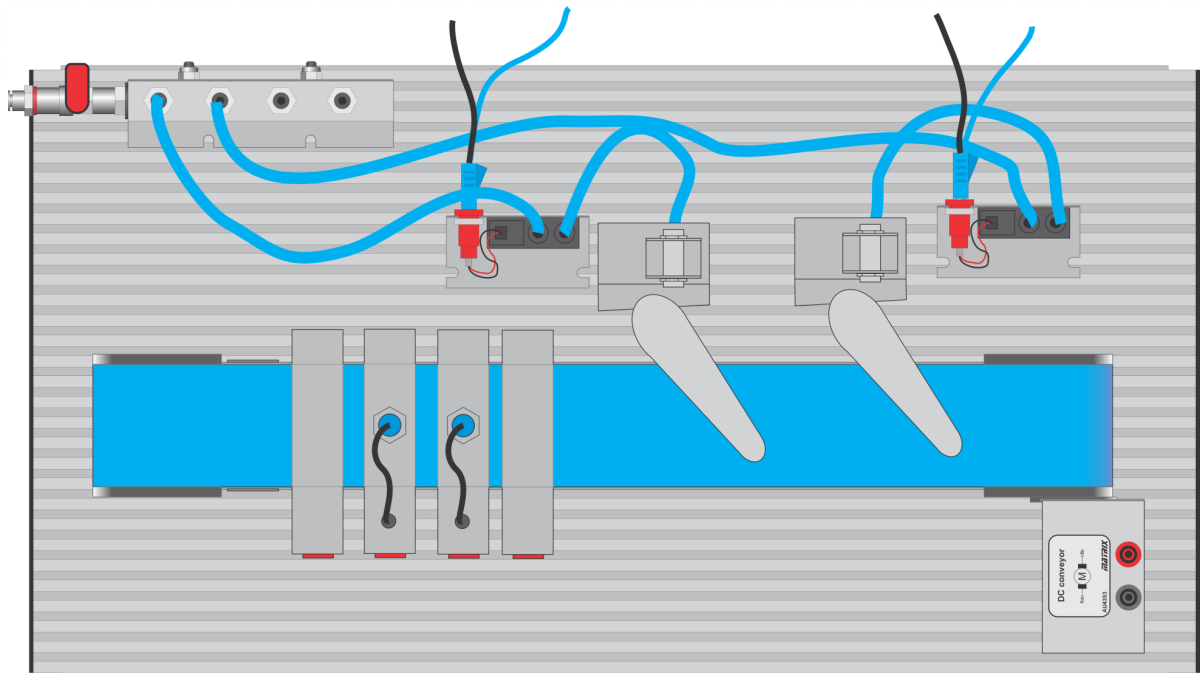
- Add a light gate to the conveyor using the T bolts.
- Add power to the conveyor manually so that it runs.
- Make sure that the light gate is triggered by a counter

So What?

The light gates allow you to detect the presence of a counter reliably. Two light gates allow you to measure the speed of a counter on the conveyor belt. With a little programming you can now predict where a counter is on the conveyor belt once it has been through the sensors. This allows you to effectively programme the rejection mechanisms to direct the counters to the appropriate sorting bins.

WORKSHEETS

Worksheet 1 - Understanding Sensors



Over to you:

Now that you have understood the function of the different types of sensor you can set them up together on the conveyor properly.

Referring to the diagram above set them up as near to the start of the conveyor as you can in the following order:

1. Light gate
2. Inductive sensor
3. Capacitive sensor
4. Light gate

So What?

You are now ready to look at the reject mechanisms.

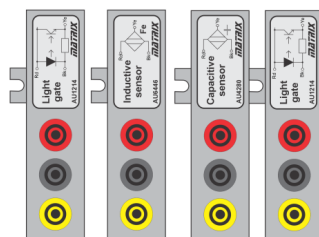
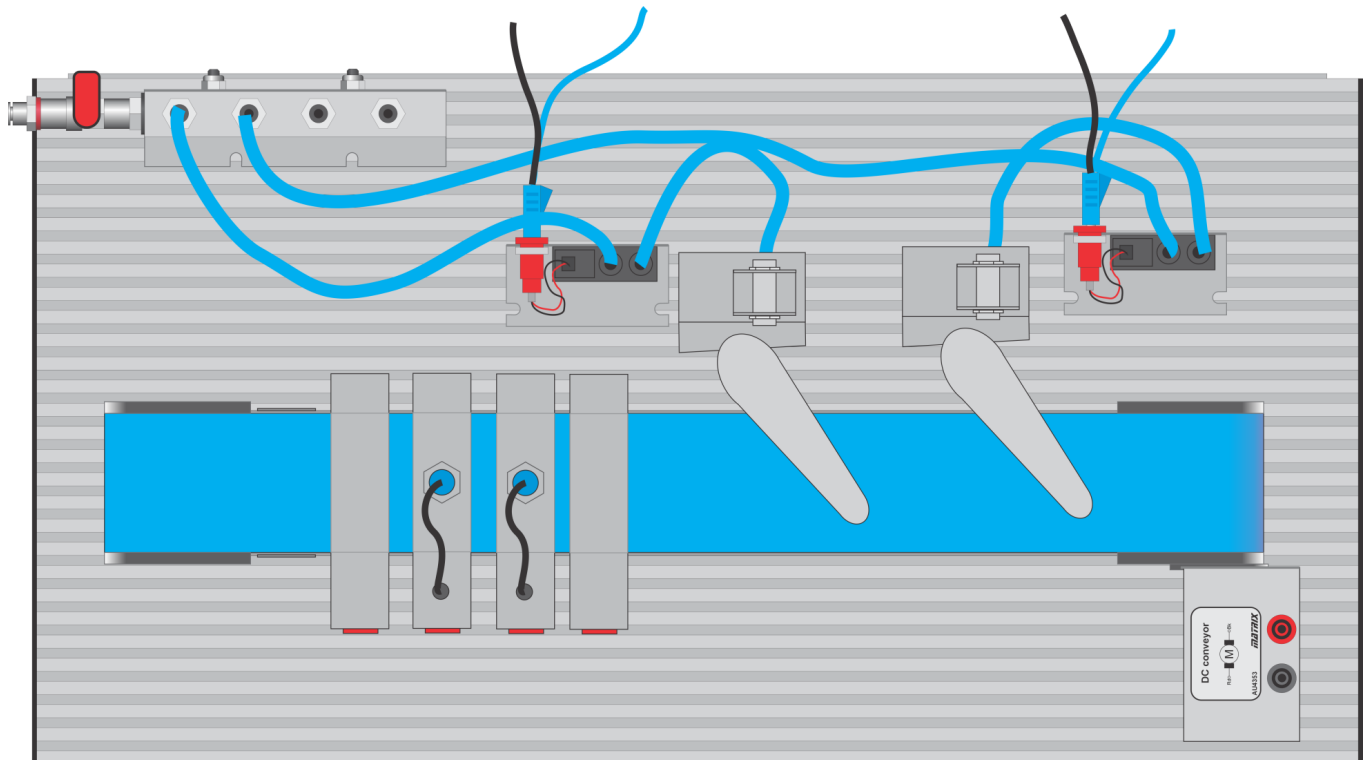
WORKSHEETS

Worksheet 2 - Reject Mechanisms



Rotating machines provide much of the power needed in automation. However pneumatics are often used because of their longevity, their power, their speed of operation and their ability to provide linear movement. The rejection components on the conveyor are a good example of this.

Photograph shows a part on a conveyor belt.

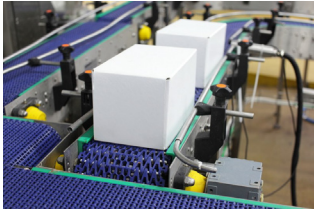


Over to you

- Add the reject mechanisms, the pneumatic manifold, and the two 3/2 electronic valves to your system.
- Connect the 3/2 valves in turn to the 24V line and make sure that the reject mechanisms are working satisfactorily with the metal and plastic counters.

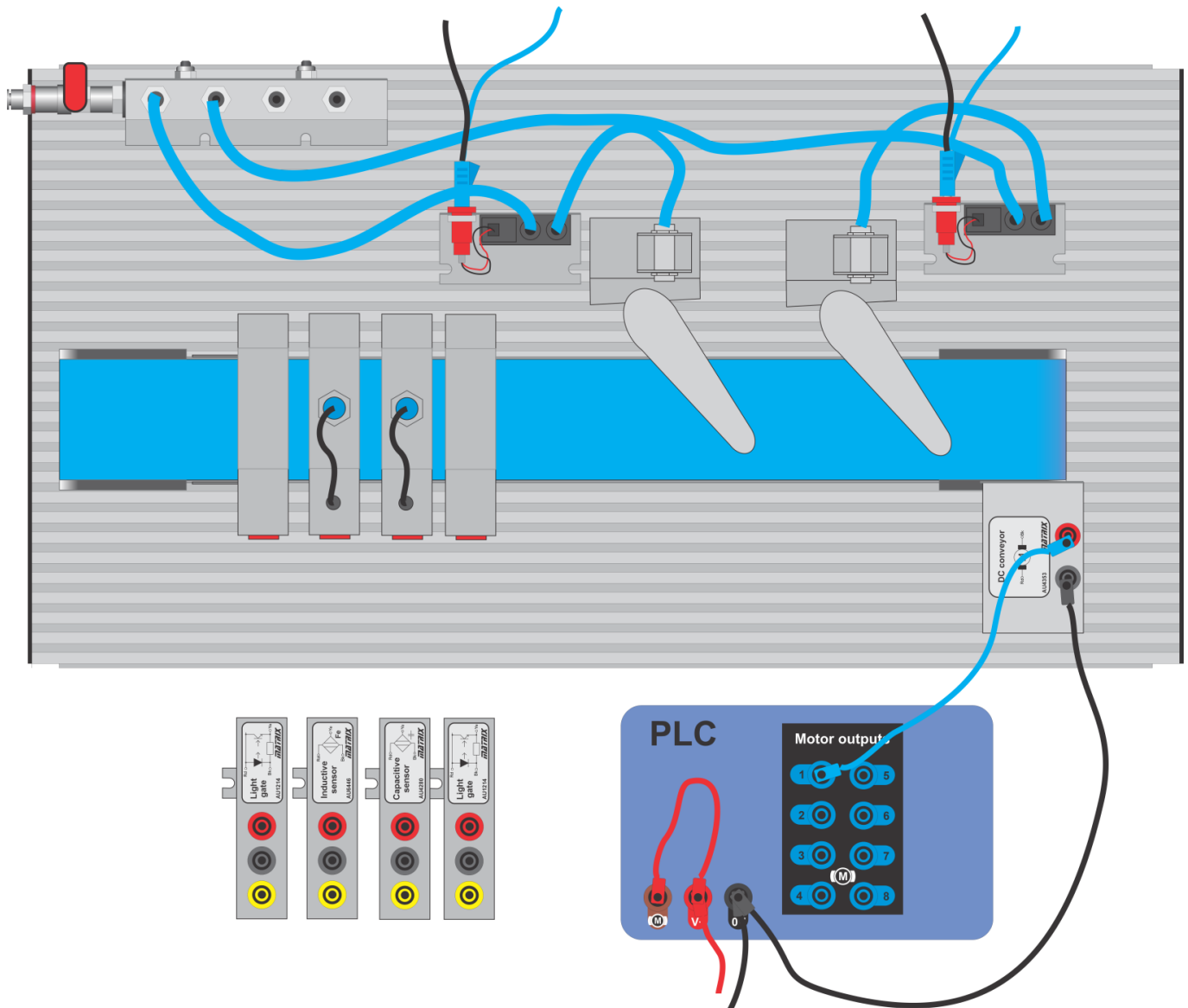
WORKSHEETS

Worksheet 3 - Understanding the Conveyor



Conveyor belts are at the heart of many production lines moving items from one location to another allowing mass production of items from pills to drinks.

Photograph shows boxes on a system of conveyor belts that move and merge goods in a factory.



Over to you

- Wire up the conveyor to your PLC or controller. You will need to use a motor output - these are also sometimes called 'transistor' outputs - for the conveyor.
- On some PLCs the supply line for the transistors is a separate input terminal to the PLC. This allows the transistor outputs to switch a different voltage to the PLC power supply if needed. On the diagram this is labelled as 'M' for motor. You need to put 24V into that terminal - as shown above.

WORKSHEETS

Worksheet 3 - Understanding the Conveyor

- Write a simple program that switches 24V to the conveyor to make sure the conveyor works.
- Vary the mark space output of the transistor output between 10% and 100% in 10% steps and make a note of the speed of the conveyor. To do this you will need to use a ruler to measure the position of a counter and a stopwatch. Make a note of your answers in the table.

PWM%	Speed: m/s
10	
20	
30	
40	
50	
60	
70	
80	
90	
100	

So what?

- Understanding the speed of the conveyor will be useful later on when you use the robot arm to move counters on and off the conveyor. If you understand the speed of the conveyor then you can accurately predict the position of a counter after it leaves the beam interrupter.

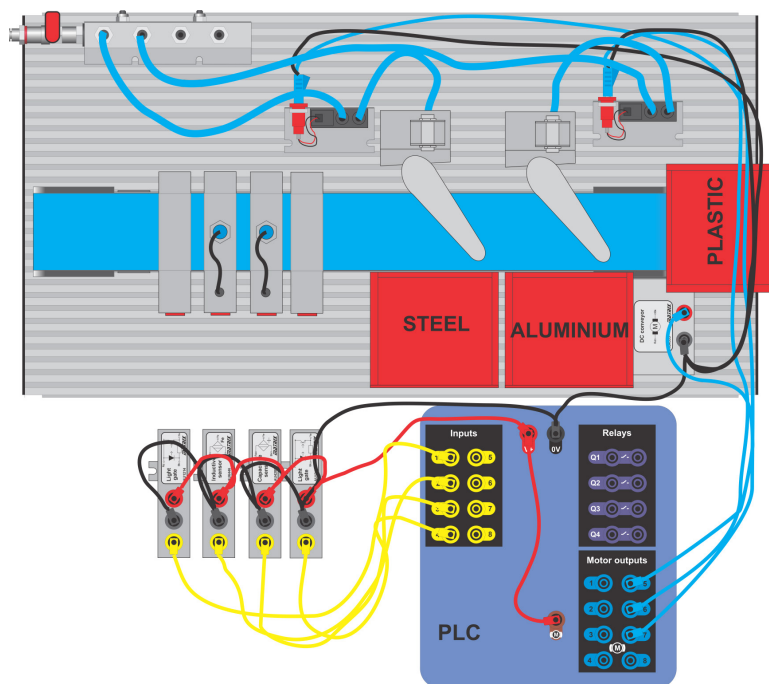
WORKSHEETS

Worksheet 4 - Sorting Counters



Sorting components or products is a key part of many automated production lines. The types of component and sensors vary - but the principles are the same: we take in information from sensors and make decisions about what happens to an item on the production line.

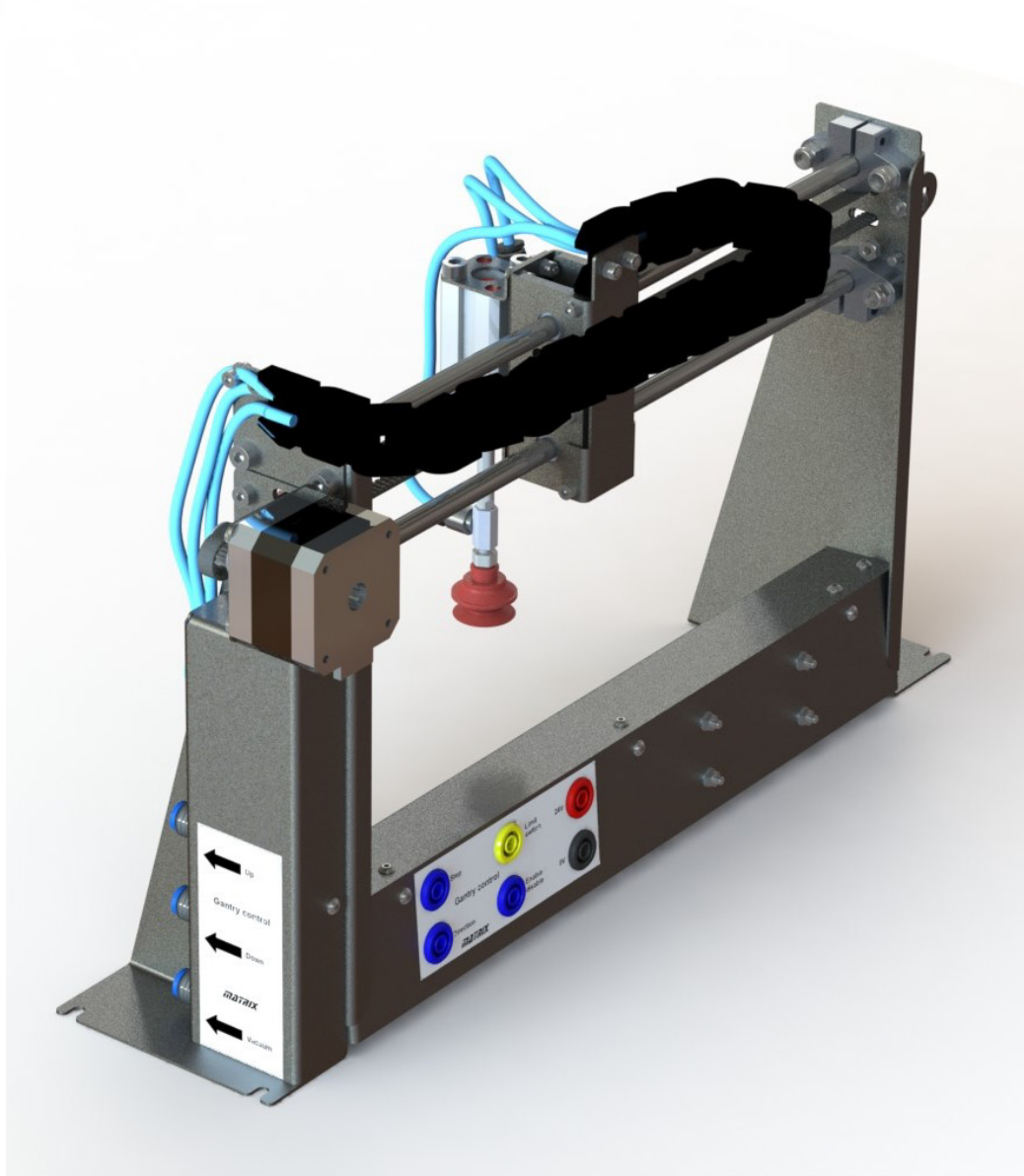
Photograph shows a machine that sorts eggs on their colour.



Over to you

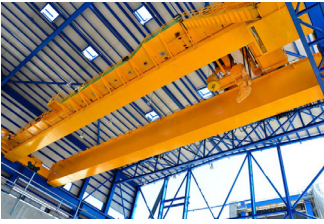
- Build the system you can see in the diagram above.
- The instructions for this task are simple: develop a program on your PLC or controller that can sort the counters into three types: steel, aluminium and plastic.
- The Hall sensor detects the presence of steel. The capacitance sensor detects the presence of a metal.
- The beam interrupters detect the presence of a counter.
- You know the speed of the conveyor and can control it. You can detect when a counter is under each sensor. You know how the rejector mechanisms work. Armed with this knowledge you can develop a program that sorts the counters into the appropriate parts.

Gantry Worksheets

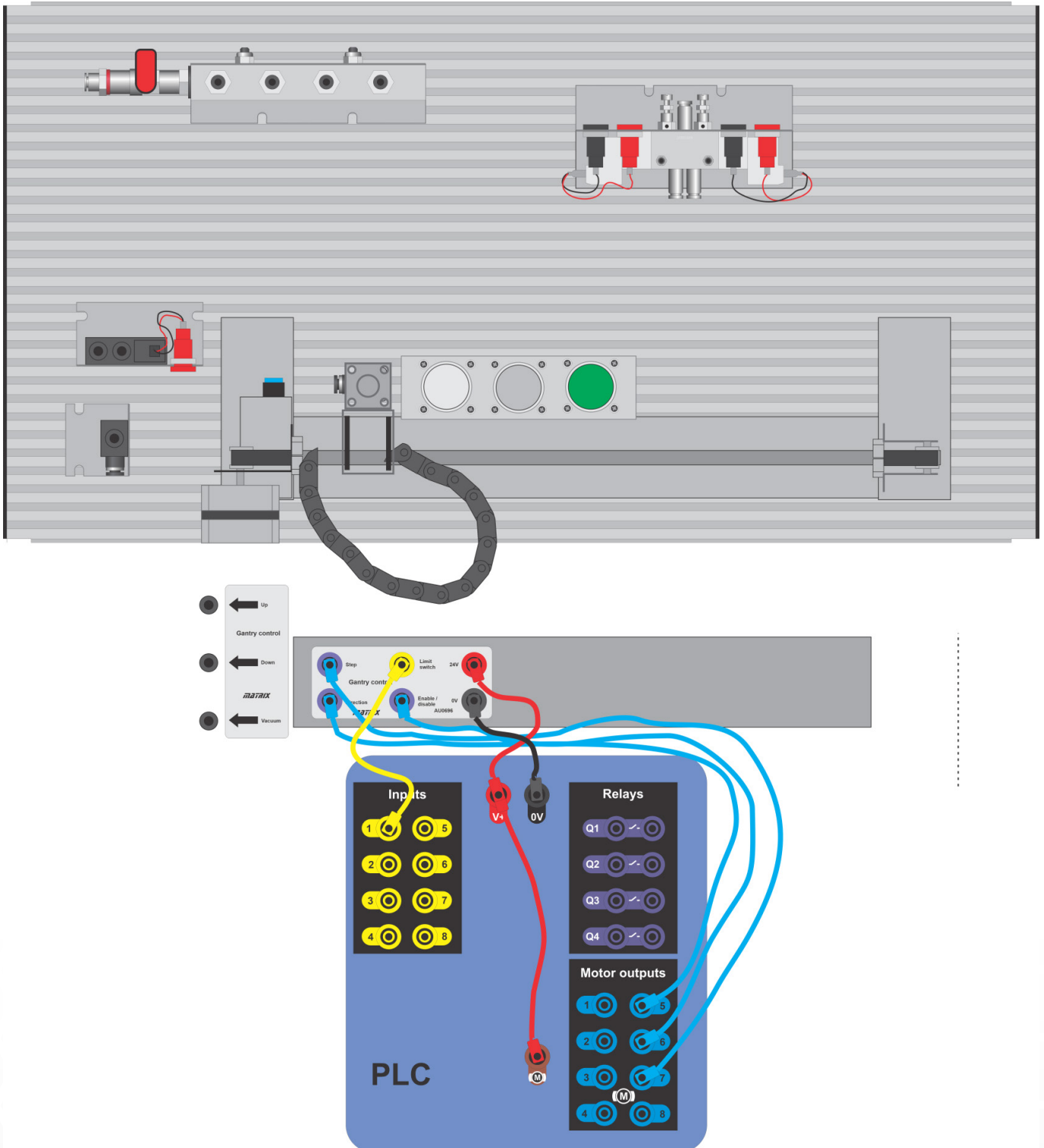


WORKSHEETS

Worksheet 5 - Driving the Stepper Motor



There are many situations in which we need to know the position of a part of a machine in an automated system. The gantry makes use of a limit switch: when the switch is triggered then the mechanism knows that the actuating mechanism has reached a defined position. If movement from that point can be measured then we always know the position of the actuator.



WORKSHEETS

Worksheet 5 - Driving the Stepper Motor

- The stepper motor on the gantry has three inputs: direction, step and enable/disable.
- DIRECTION should be 0V to move towards the home position, +24V to move away from home.
- DISABLE is normally 0V (or disconnected) to enable/power the motor, 24V to disable it. Disable can be left disconnected and the system will function. When DISABLE is high then the current is removed from the stepper motor. This makes it easy to move the gantry by hand. When the motor is enabled there are still holding currents in the windings when it is stopped. This is useful to stop the gantry moving due to pressure from the "pipe-work".
- STEP is normally low (0V). Pulse high and back low to step.
- The 'step size' for this motor is 1.8 degrees. It will require 8 pulses (micro steps) to make a single step.
- The number of teeth on the stepper cog is 20.
- The pitch of the teeth on the drive belt is 2mm. You can now calculate the distance the gantry mechanism moves for each step and microstep (pulse).

Over to you

- Wire up the gantry mechanism to your PLC as shown above.
- Develop a program with your PLC that moves the stepper motor forwards and backwards.
- Refine this program so that on power up, or the first movement, the stepper motor moves left to the point where the gantry hits the limit switch and internally marks this as '0'.
- Lock the counter holder down on the platform. Create a table that shows the position of each counter storage area.

	Column 1	Column 2	Column 3
mm			
Steps from home			

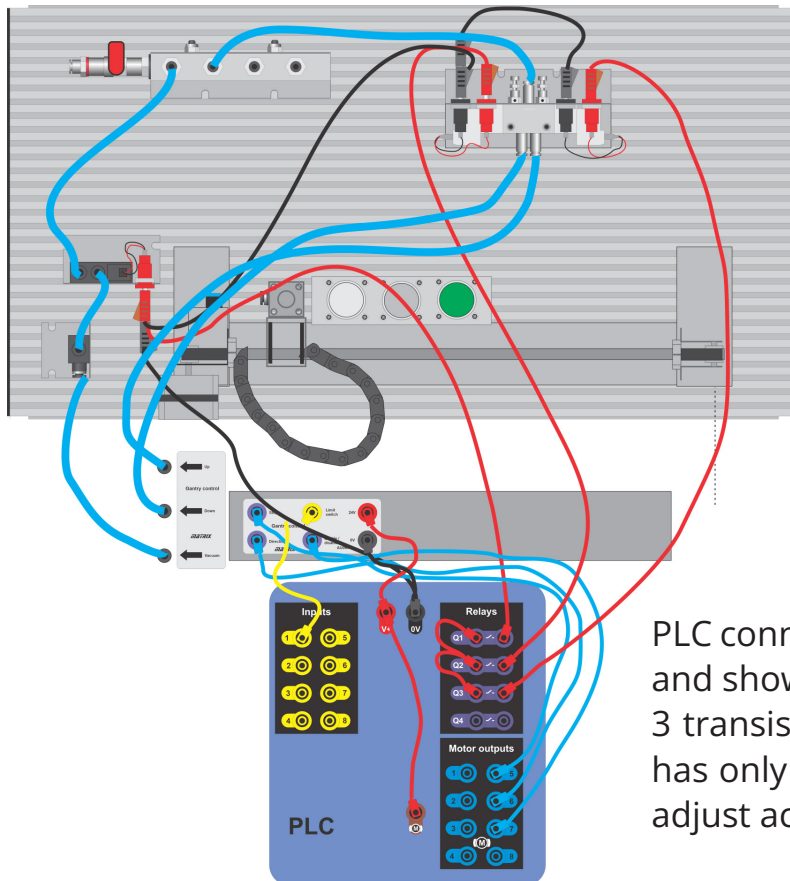
WORKSHEETS

Worksheet 6 - Understanding the Plunger



Pneumatic actuators are great tools for picking and placing objects in production lines. Whilst it takes time to get the part setup accurately at the design stage, they will work for millions of cycles in factories before any maintenance is needed.

Photograph shows a suction device in a production cell.



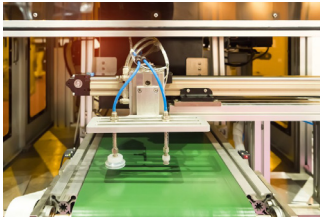
PLC connections are a guide only and show wiring for 3 relays and 3 transistor outputs. If your PLC has only transistor outputs then adjust accordingly.

Over to you:

- Wire up the gantry mechanism to your PLC as shown above.
- The plunger is a simple push out, push in mechanism. The 5/2 valve is used to channel the flow of air pressure to first push the plunger piston out and then to push the piston in.
- In the circuit we have shown relays used to switch 24V to the 5/2 valve for the plunger control. If your PLC has spare transistor outputs then you can use those.
- Develop a simple program to make sure that the default position of the plunger is in and make sure you can push the plunger up and down.
- Vacuum for the suction cup on the end of the plunger is generated by a special vacuum unit. This connects to the plunger via a simple solenoid valve.
- Develop a program that allows you to turn the suction on and off.
- You now have control of the stepper motor, the plunger and the suction cup.

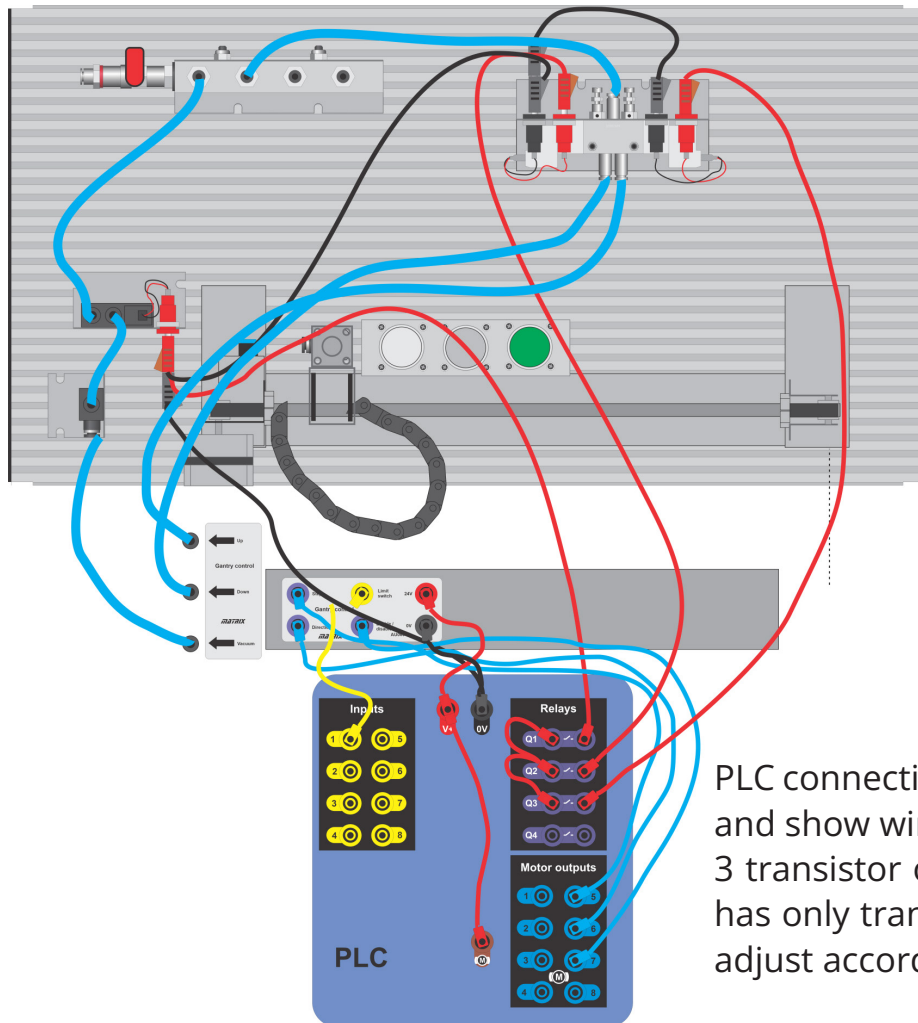
WORKSHEETS

Worksheet 7 - Delivering Counters



XY gantries with suction devices are often used to move a production part from one operation to another. Now that you have understood the movement of the stepper motors, the plunger, and the suction cup you can put all this together to produce a system that picks up counters from the counter storage unit and places them on the Conveyor.

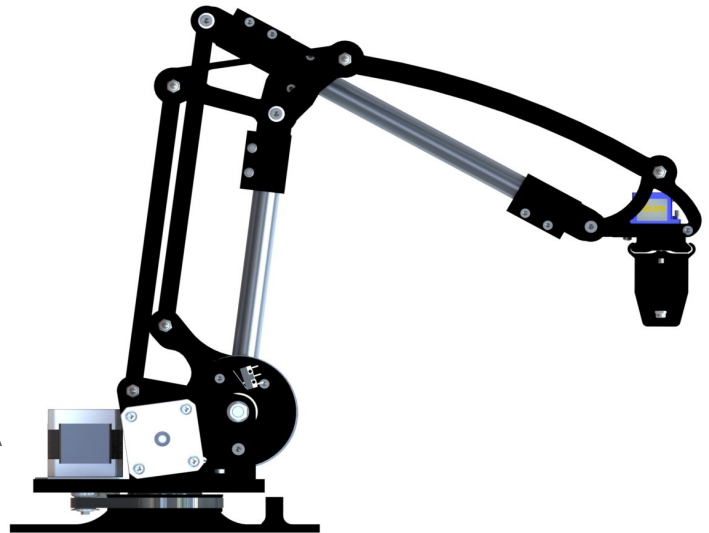
Photograph shows a suction cup and sensor on a production line.



Over to you:

- You are now ready to put the gantry program together.
- Develop a program that can deliver 9 counters - 3 from each storage area - to the 'conveyor belt'. You will have to assume 9 counters are always present as there is no feedback from the plunger mechanism.
- Of course at this stage the gantry is not connected to the conveyor belt so you will simply release the counter at an appropriate point.

Robot Arm Worksheets



Over to you:

- Find the robot arm curriculum pack on our website.
- Go through worksheets 1, to 3 to make sure you can program the robot arm using the pendant programming tool and G code.
- The G code editor will allow you to detect an input and then start a routine. You can use this to allow the PLC to trigger an action on the robot arm.
- If you want to use the colour sorter then you will need to use a proper programming language and the robot arm Application Programming Interface.
- If you are planning a full Industry 4.0 implementation then you will need to use a programming language that has the ability to create internet based communications such as Flowcode App Developer.

NOTE: Remember that the Robot arm runs of 12v system and has its own power supply provided. Please don't run using AU0205 as this is 24v.

WORKSHEETS

Worksheet 8 - Robot Arm I/O



In a robot work cell there will be several programmable robotic modules that need to work together. This can be achieved by sending messages from one module to another, or it can be achieved by a much more simple method of using spare input outputs as 'flags' to indicate certain actions can be taken.

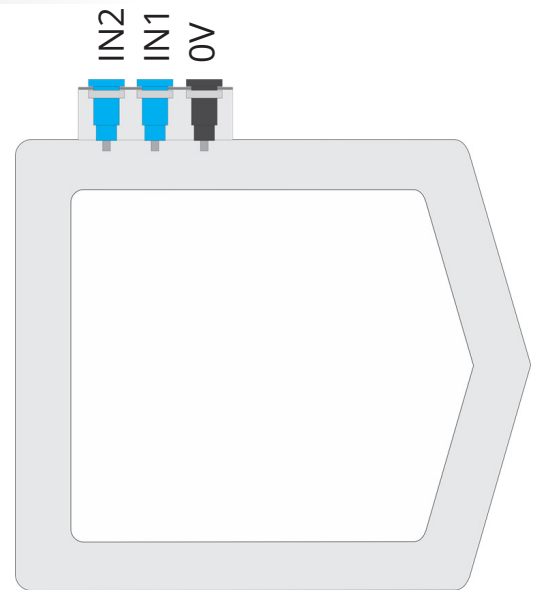
Photograph shows a work cell with a robot arm loading a CNC lathe.

Over to you:

A registration plate is supplied with the robot arm. This allows you to remove the arm easily and yet still know exactly where the arm is with respect to the other parts of the Smart factory.

The registration plate contains three 4mm connectors: 0V, INPUT1 and INPUT2. You can use the INPUT1 and INPUT2 connections to send messages to the arm: for example when to start a routine to go and pick up a counter and put it in a parts bin. The 4mm connectors are soldered to a wire and connector that plugs into the robot arm circuit board.

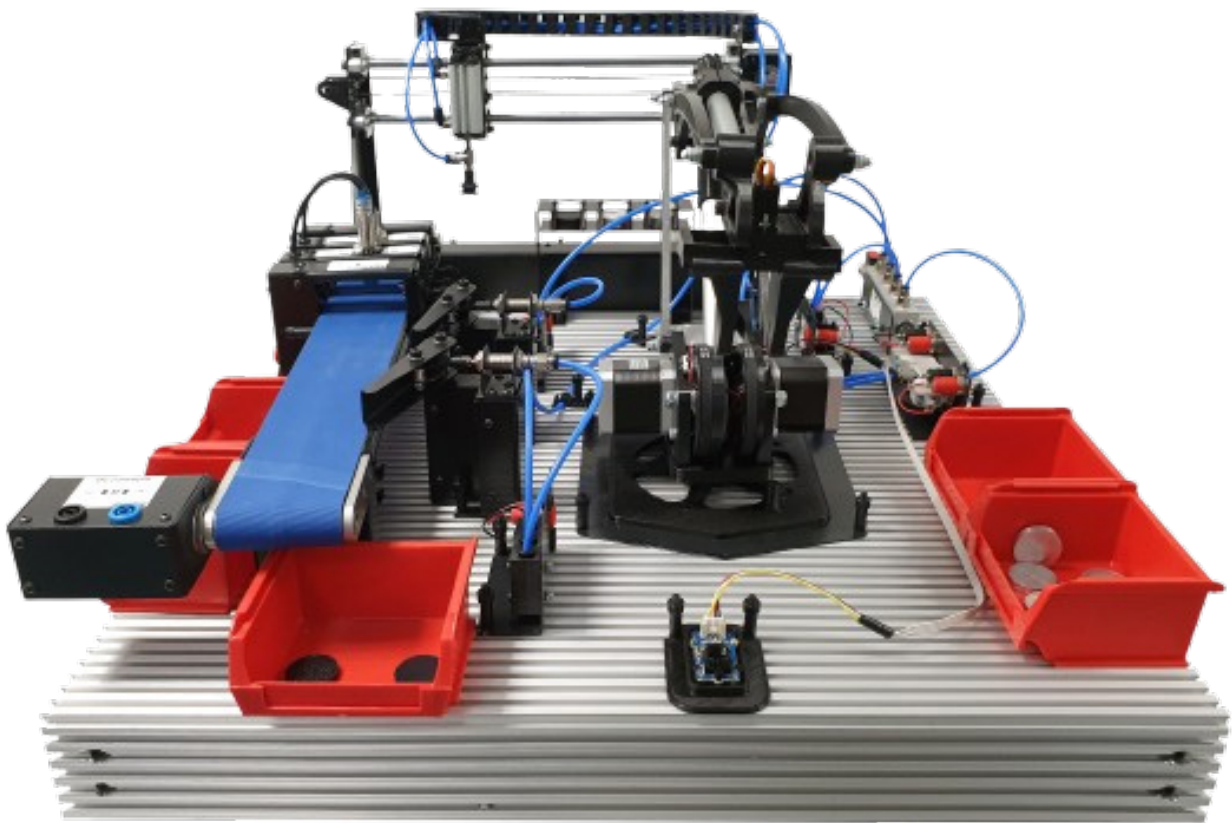
1. Connect the robot arm up to the registration plate using the connector provided.
2. Using the G code editor write some test programs that interface with INPUT1 and INPUT2. For example write a program that waits for INPUT1 or INPUT2 to go high and then moves in a different sequence depending on whether INPUT1 or INPUT2 goes high.



So what?

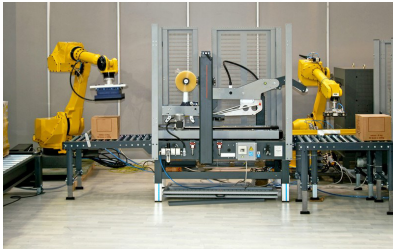
Next you will develop a program that will get the arm to pick up a counter at the end of the conveyor and place it into a bin. The PLC you program will need an extra output which will be used to tell the robot arm what to do using INPUT1 and INPUT2.

Complete Smart Factory



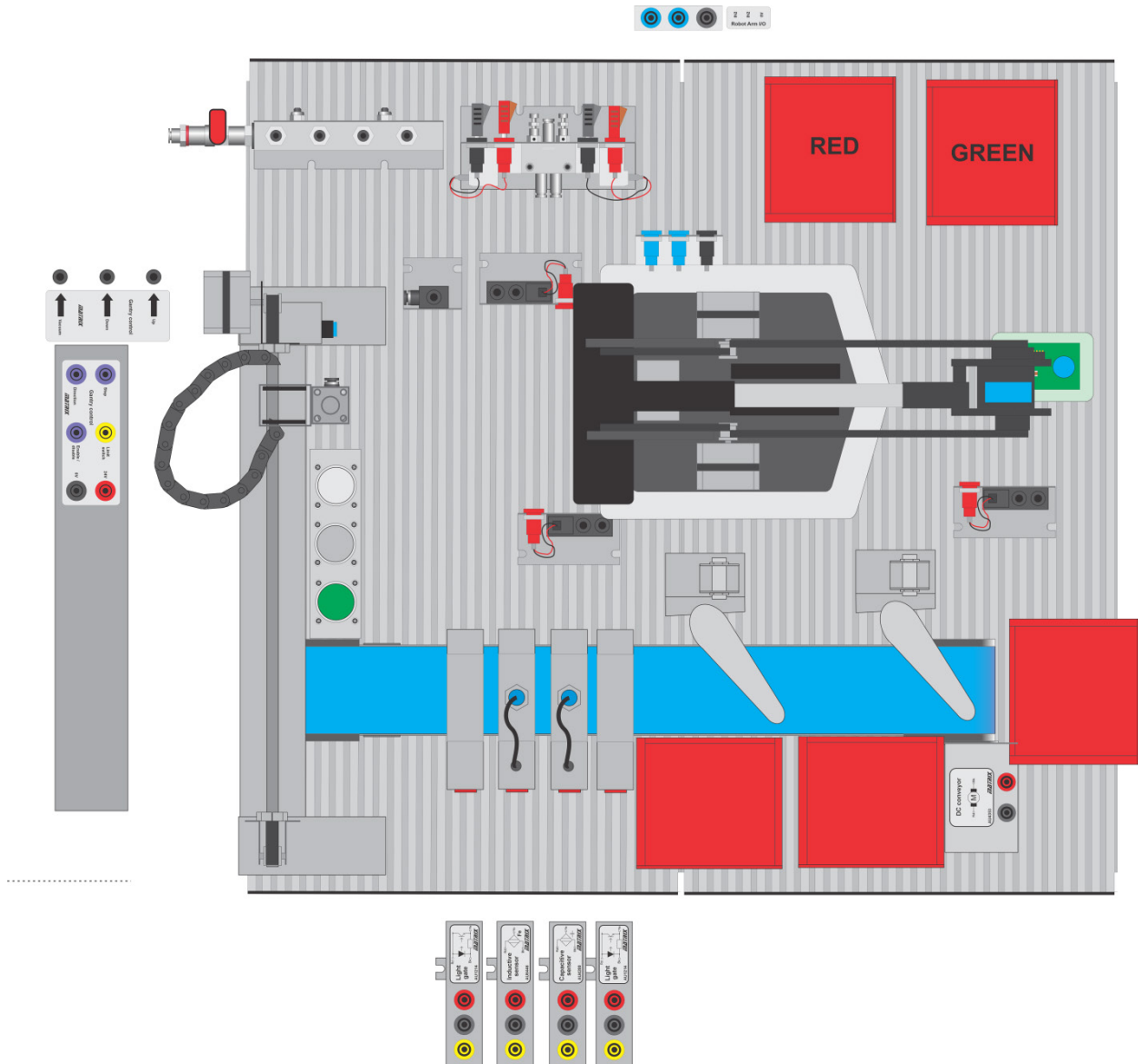
WORKSHEETS

Worksheet 9 - Commissioning the Cell



The development of a production line will involve many engineers and many sets of technology. Now that the individual parts of the smart factory have been commissioned individually its time to bring all the parts together.

Photograph shows two robots in a packaging work cell.



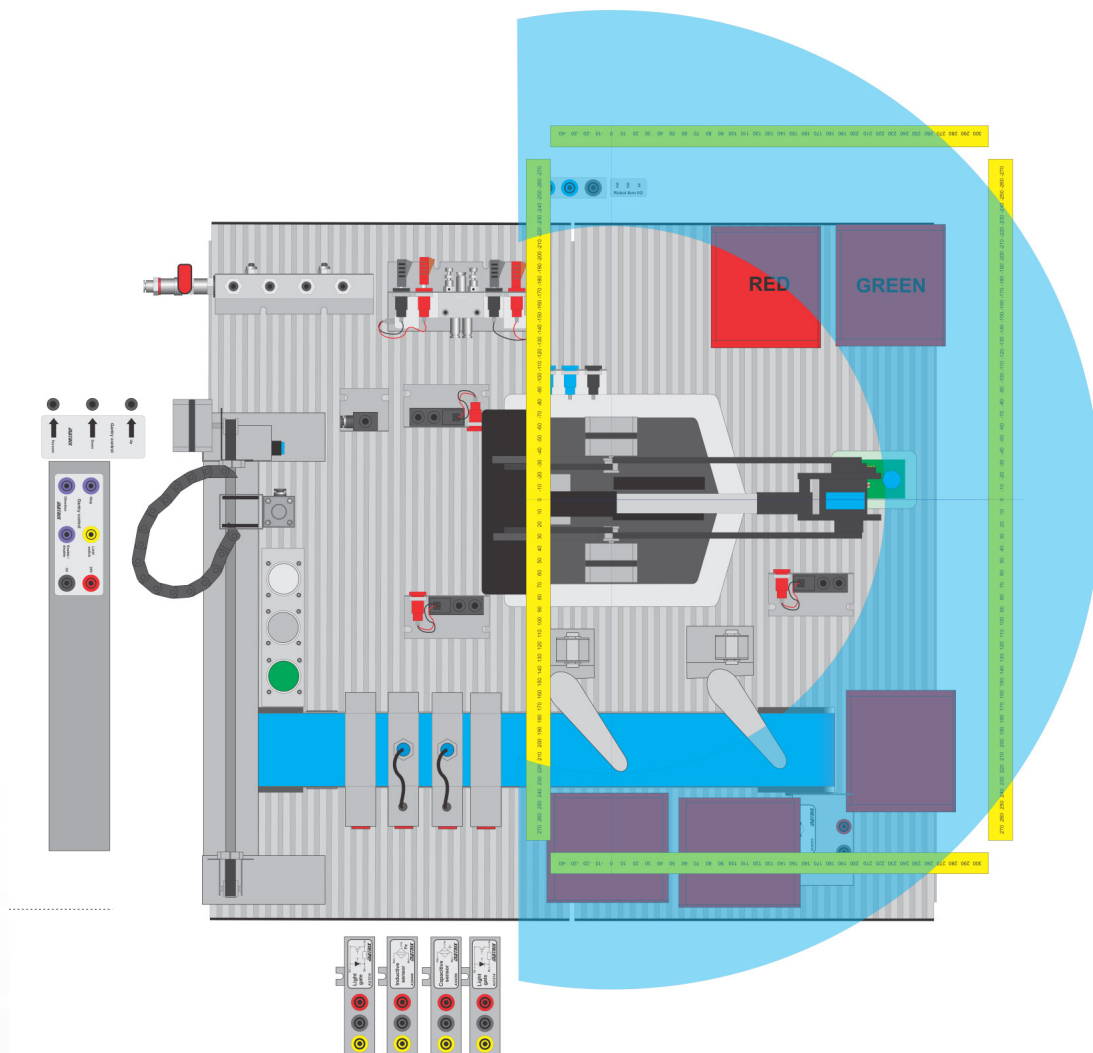
Over to you:

- Bolt the two platforms together.
- Rearrange the Gantry and the Conveyor onto the platforms as shown above.
- Position the robot arm onto the centre of the two platforms. You can use the registration plate to mark the position of the arm so that it can be removed from the system and easily put back in the right place.

WORKSHEETS

Worksheet 9 - Commissioning the Cell

- Gantry: fine tune the program you wrote earlier to deliver 9 counters in succession to the conveyor.
- Gantry and Conveyor: make sure that the Gantry and Conveyor programs work together to delivery and sort 9 counters of varying types. For now there is no communication between the conveyor and the gantry: just use appropriate timing. You can use an extra input and output on your controller to develop communications between the Gantry and the Conveyor.
- Robot arm: Alter the counter sorting program you wrote earlier to pick up a plastic counter from the end of the conveyor, test its colour with the colour sensor, and deposit it into the 'RED' or 'GREEN' bin on the workspace. You can see the workspace plan in the image below. You can do this with the G code editor program. If you want to use the colour sorter to differentiate between colours then you will need to use a more sophisticated programming language (like Flowcode App Developer). To make your programming task easier you will need to develop a measuring system so that you know the locations of the conveyor, colour sensor and bins.

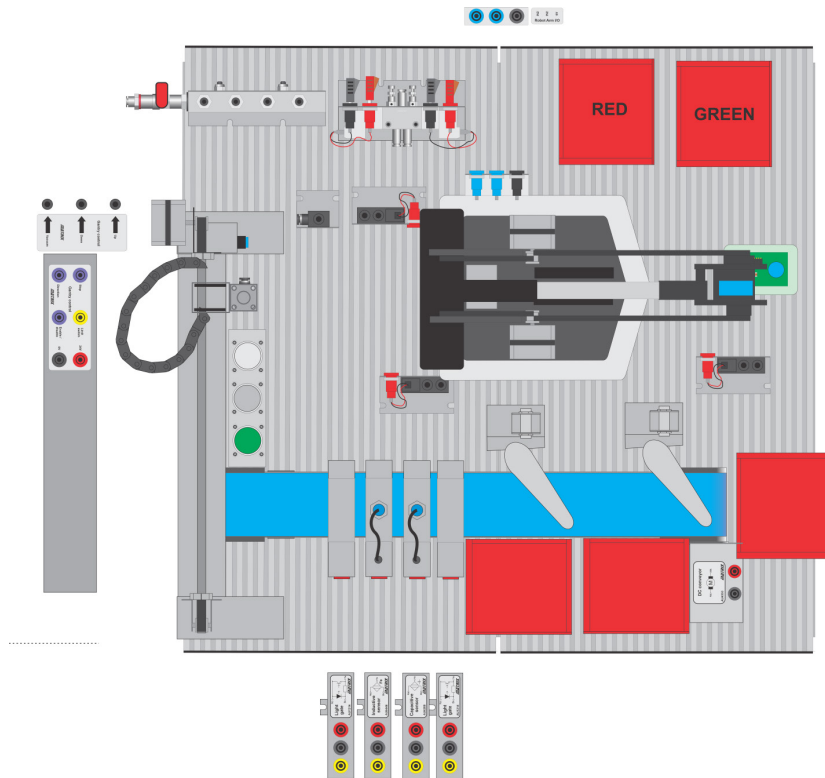


WORKSHEETS

Worksheet 10 - Completing the Smart Factory



Many factories now make use of web based control systems. This offers lots of benefits including remote system monitoring, maintenance and even programming - allowing technicians to work on systems without being there. Because IP technology is so widespread the boundaries between building based and world based systems is becoming more indistinguishable.



Over to you:

- You now need to bring all the parts of your Smart Factory together. You can do this locally with a number of PLCs or a single large PLC. Or you can use web based communications to communicate between the three parts of the Smart Factory.
- First develop communication between the Gantry and the Conveyor so that when the Gantry has delivered a counter it notifies the Conveyor which can move the counter through the sensors.
- Next develop your Conveyor program so that when a plastic counter is detected it stops at an appropriate point so that the robot arm can pick up the counter and sort it. You will need to connect an output of your PLC to the IN1 or IN2 input on the robot arm.
- Develop a robot arm program to pick the counter, pass it over the colour sensor and sort it by red/green colour. You will need to initialise this manually as there is no communication between the arm and the other parts of the system.
- The robot arm is fitted with Wi-fi connectivity and has a full Application Programming Interface that allows it to communicate with other LAN/Wi-fi connected products. Develop communications between the arm and the other parts of the system so that the Smart factory works in a fully automatic mode to sort the workpieces.

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