SMART FACTORY

Smart Factory

Manual
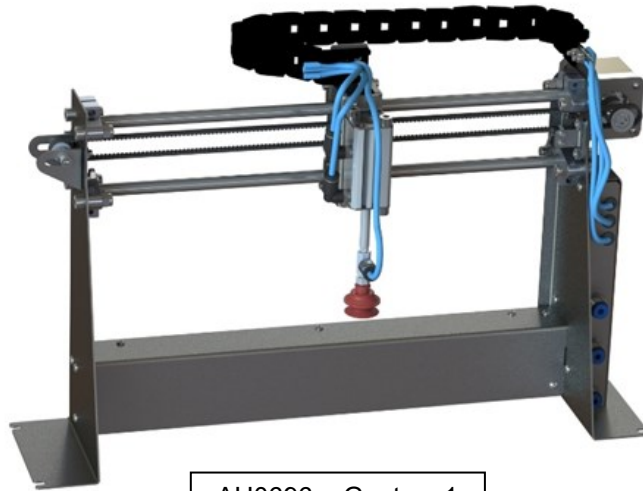
MATRIX

CP5279

www.matrixtsl.com

Contents
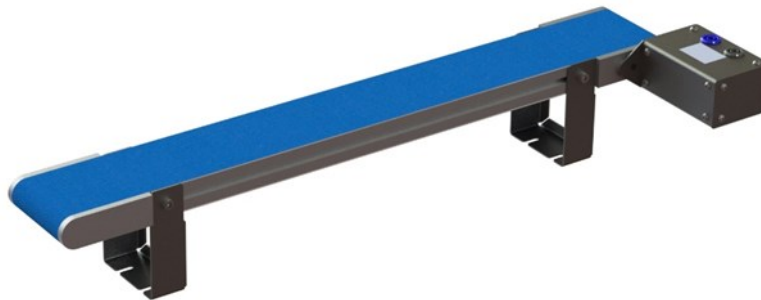
Contents of Product

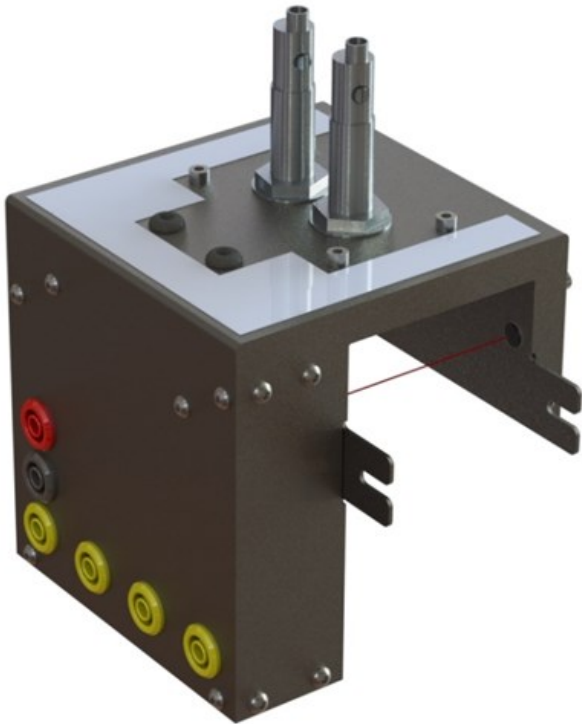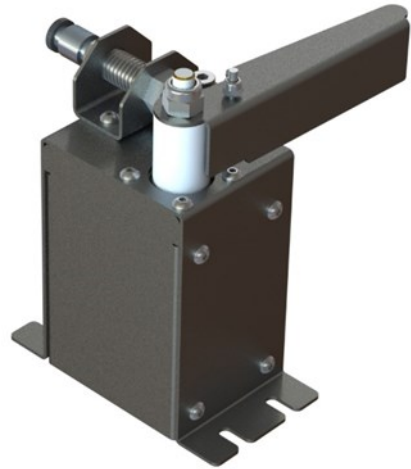## Modules

AU0696 – Gantry x1
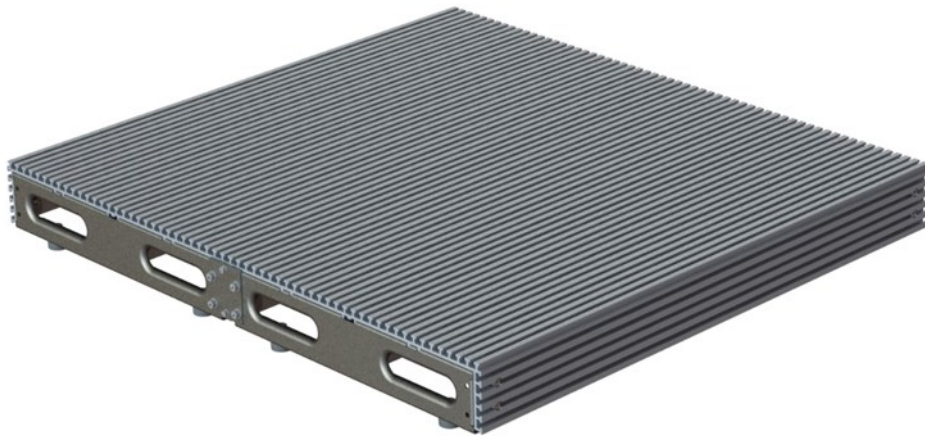
AU9318 – Base x1

AU4353 – Conveyor x1

3

Contents of Product
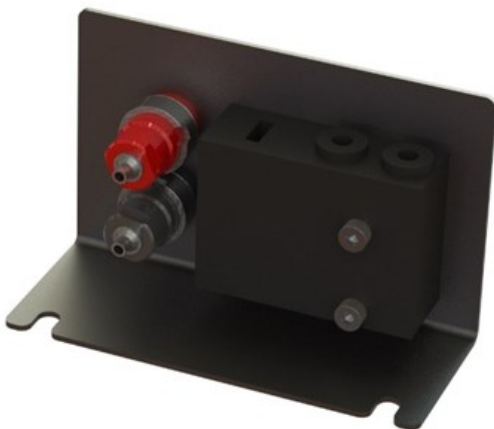
AU6707 – Sensor Unit x1

If you have earlier version of the Smart factory, you will have receiver 4 individual units instead of one. The wiring and the placement is the same.

AU1437 – Paddle x2

AU1443 – Vacuum Generator x1

AU9633 – 3/2 valve x3
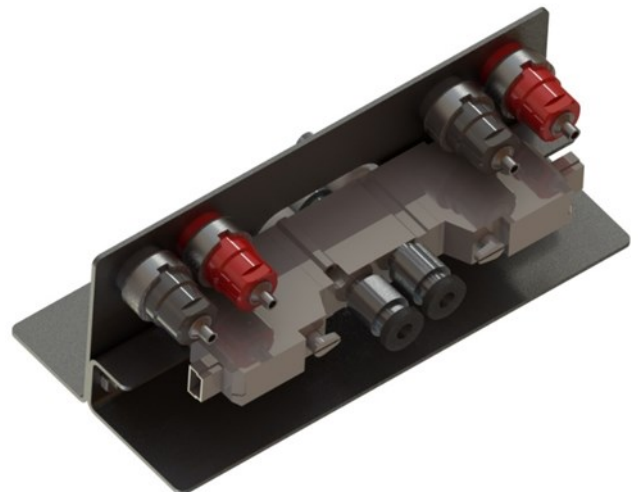
AU2834 – 5/2 valve x1

Contents of Product
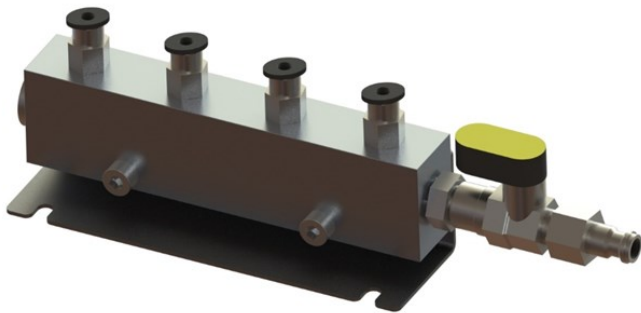
AU6004 – Manifold x1

AU0358 – Counter Rack x1
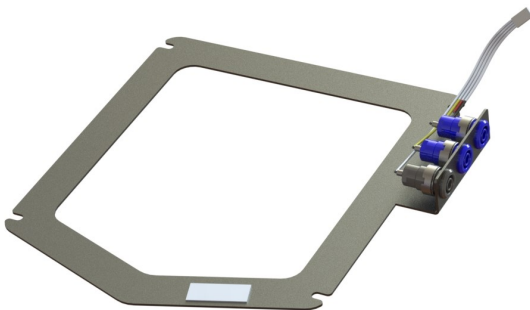
AU5775– Registration Plate x1
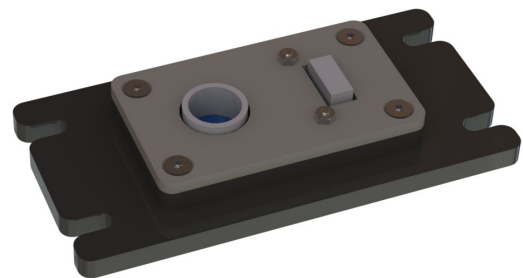
AU4655– Light colour sensor x1

Items

4x Steel counters

4x Aluminium counters

4x White Plastic counters

4x Black Plastic counters

5x AU7654 red bin

1x AU4655 Light sensor PCB holder

5m of pneumatic tubing

10x cable management clips

2x Lead, red. 500mm, 4mm to 4mm stackable

5x Lead, red, 250mm, 4mm to 4mm stackable

5x Lead, red, 1000mm, 4mm to 4mm Stackable

1x Lead black 500mm 4mm to 4mm stackable

3x Lead, black, 1000mm, 4mm to 4mm stackable

4x Lead, black, 250mm, 4mm to 4mm stackable

1x Lead, blue, 500mm, 4mm to 4mm stackable

7x Lead, blue, 1000mm, 4mm to 4mm stackable

9x Lead, yellow, 1000mm 4mm to 4mm stackable

3x Lead, yellow, 250mm 4mm to 4mm stackable

100x tee bolts

1x AU1090 permanent fixing kit

Set Up

Step 1. Adding the Gantry

Add the gantry module to the base board in the top left corner. Use the tee nuts in the four corners of the module to fix it in place.
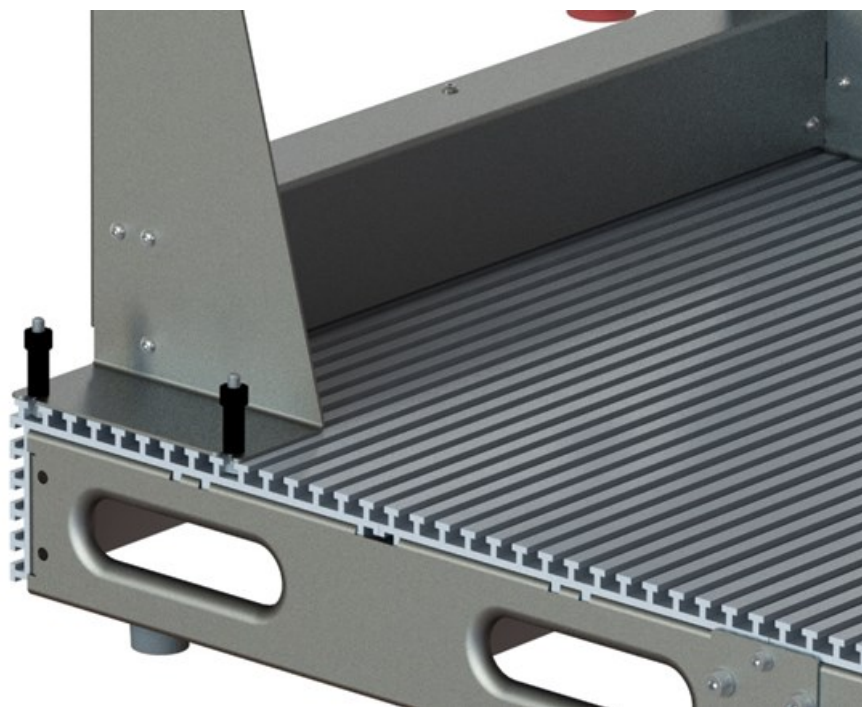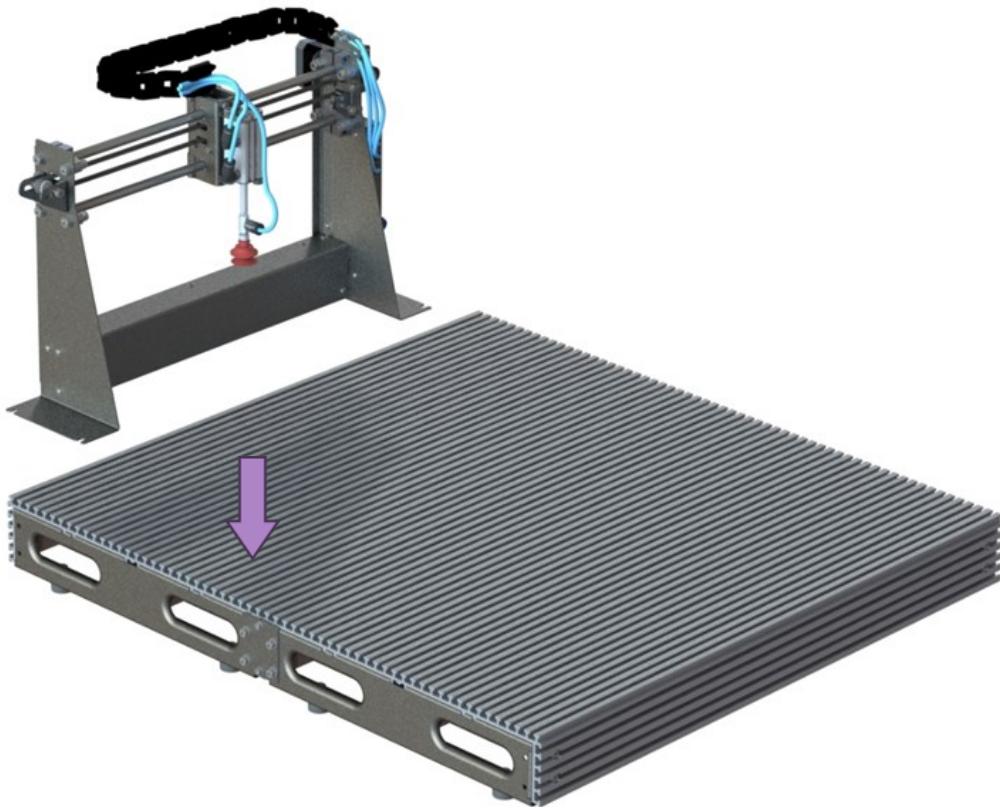
Step 2. Adding the Conveyor

Place the conveyor module to the left side of the base unit. The motor should be in the opposite corner to the gantry unit. The 4 Tee bolts which fix the conveyor down to the base are easier to fix in place, if you place them in the right rung on the base board, and slide the conveyor into them to tighten them in place.

The final position should be that the conveyor is over the line of sight for the pick and place head. While being 70mm from the edge.

70mm
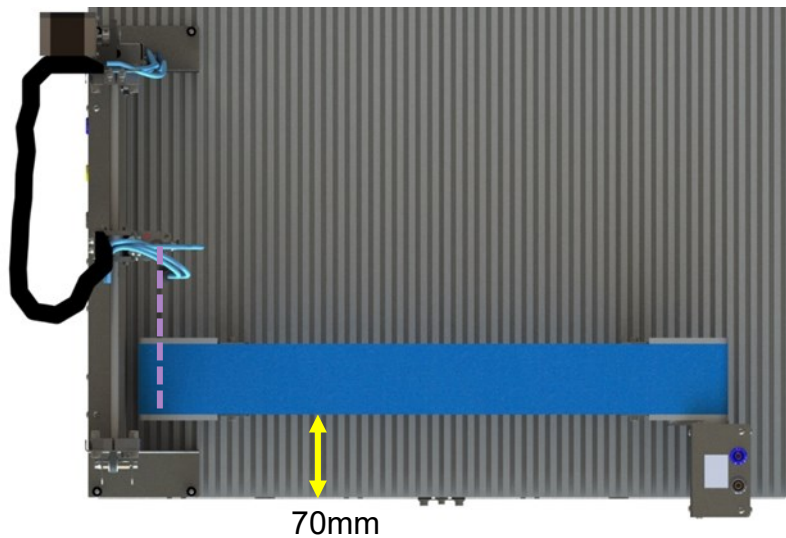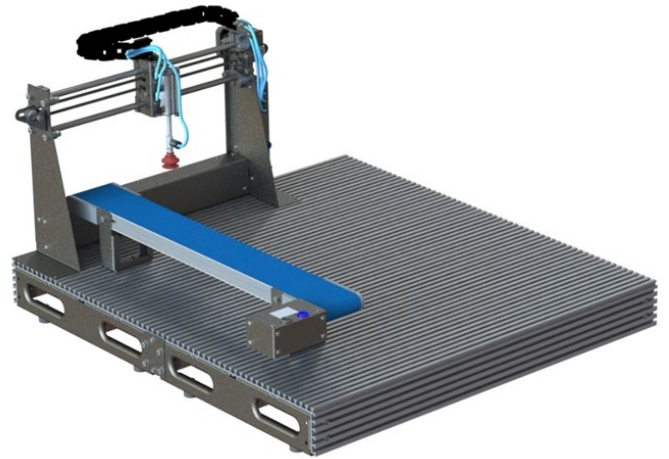
Use 2x Tee bolts in each

Set Up
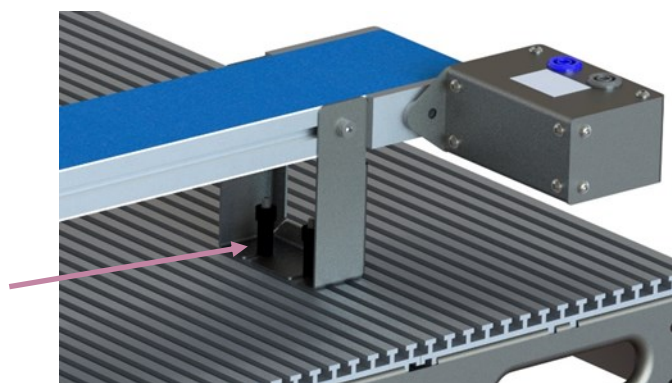
Step 3. Adding the Sensor Unit

The sensor unit sits around the conveyor unit, towards the gantry end.

Insert the Tee nuts into the conveyor extrude slot first.

Slide the sensor unit as far left as possible toward the gantry, and fix down using the fixing tee nuts and M4 bolts. There are 4 positions to fix down.
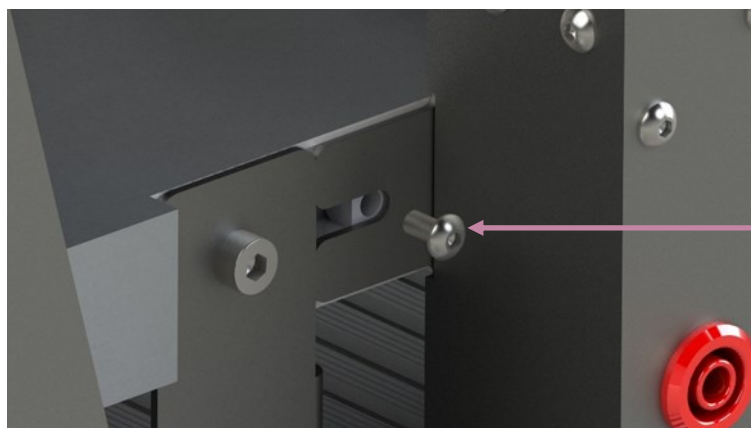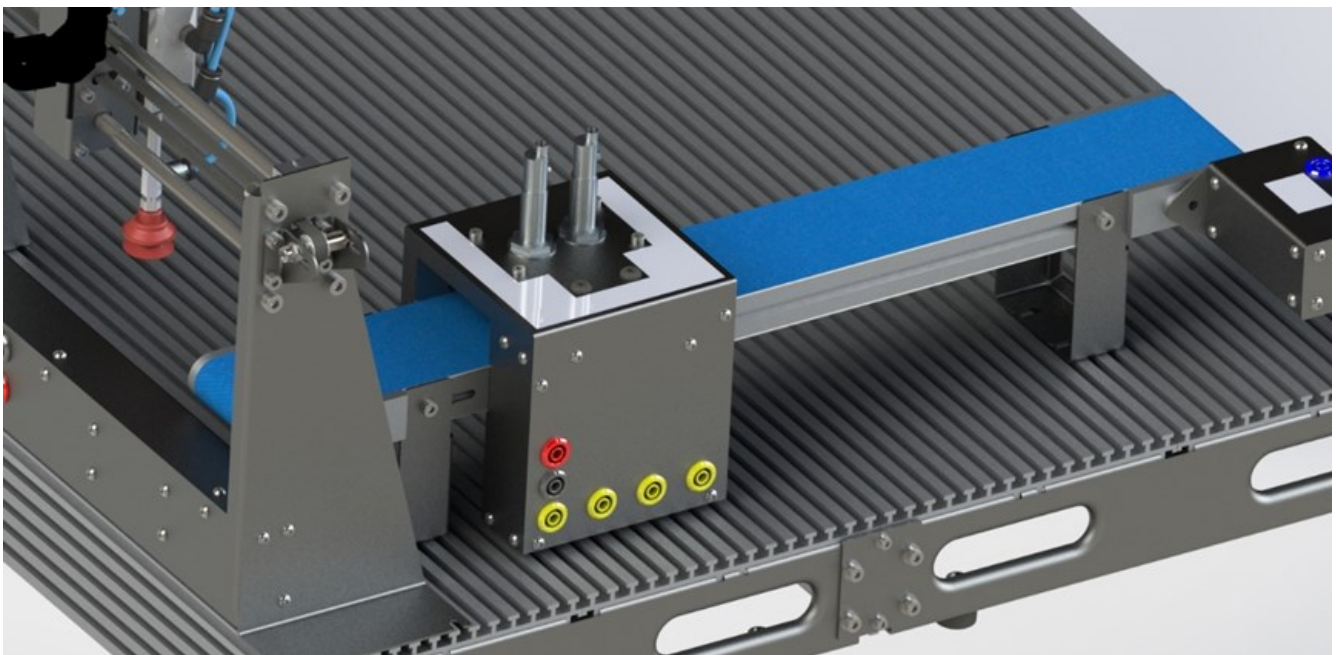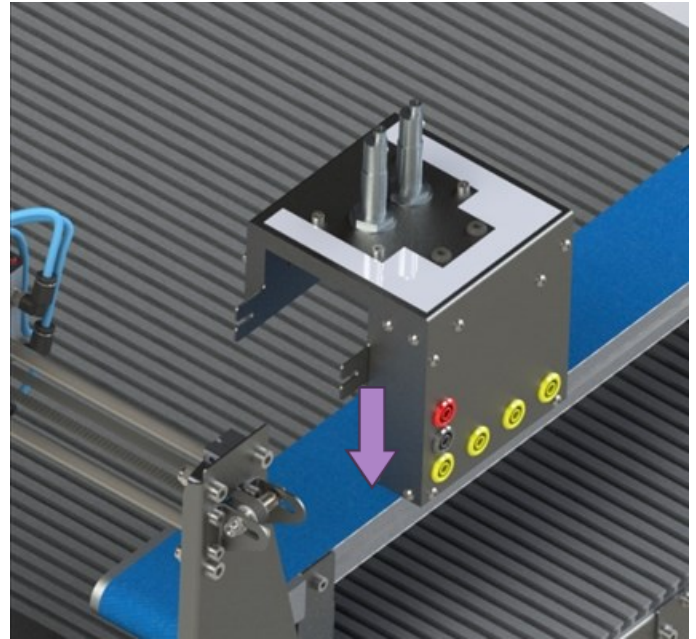
Use Allen Key for this

8

Step 4. Adding the Paddles

Add the 2 paddles to the side of the conveyor. Equally space them out, so there's is clearance for the swing of the paddle. Fix down each paddle with 4x tee bolts.
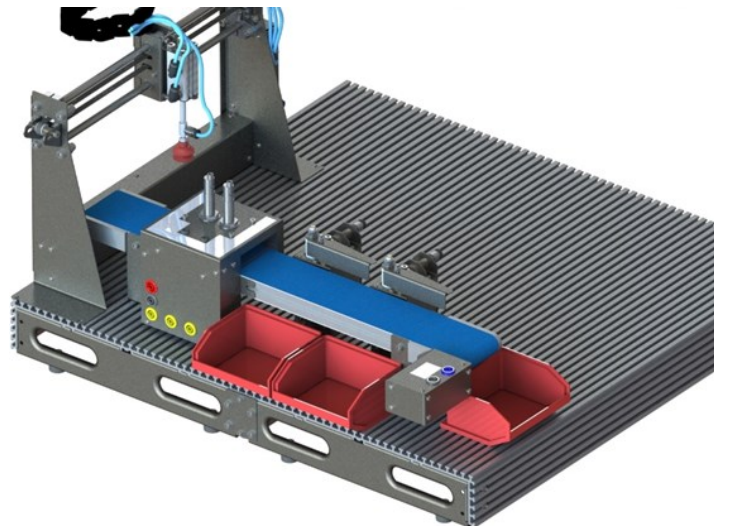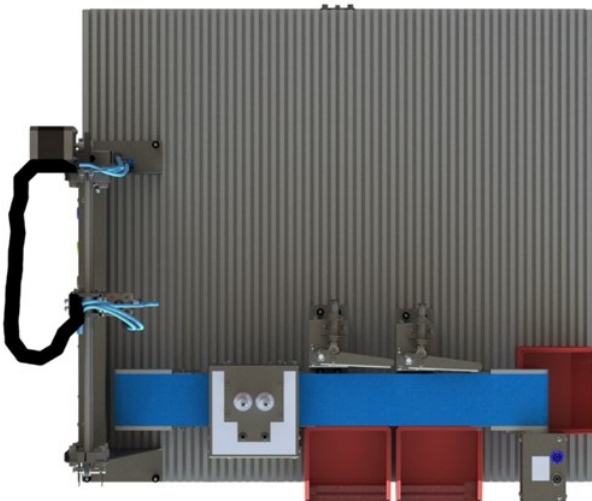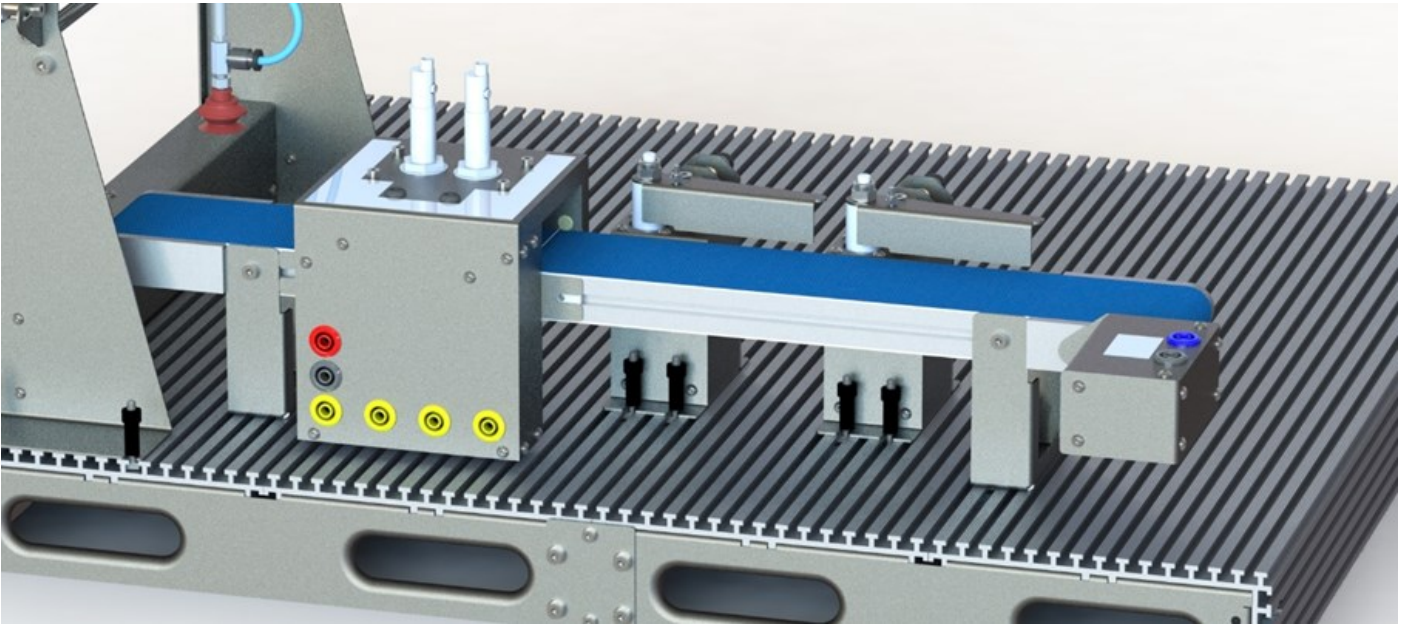
The Paddles should only be 3mm from the edge of the conveyor.

Add 3 red bins in the positions shown, the can overlap the edge of the base, as long as the base of the bin is fully on. These don't connect down.

Step 5. Adding the Pneumatics

Now to add the pneumatic modules onto the base board. All these modules use tee bolts for fixtures.

Manifold (x1), 5/2 valve (x1), 3/2 valve (x3) and vacuum generator (x1).

1. Start with the manifold in the top right corner, placing it as far into the corner as possible.

2. Next place the 5/2 valve alongside it. With the valve facing outwards.

3. Next place one 3/2 valve and the vacuum generator in front of these, next to side of the gantry.

4. Place two 3/2 valves next to either paddle, one on each side. Face these in opposite direction.

Set Up
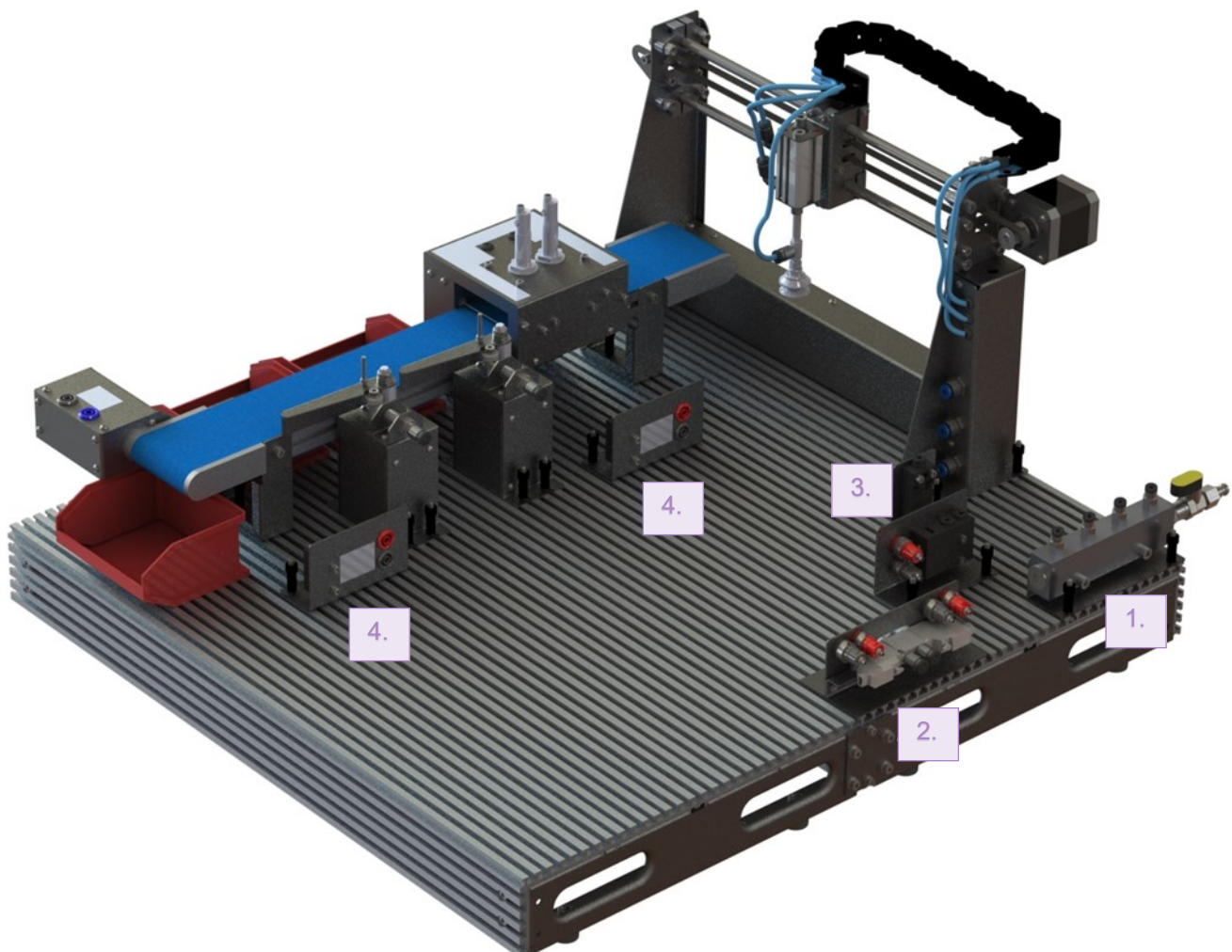
Step 6. Adding the Counter Rack
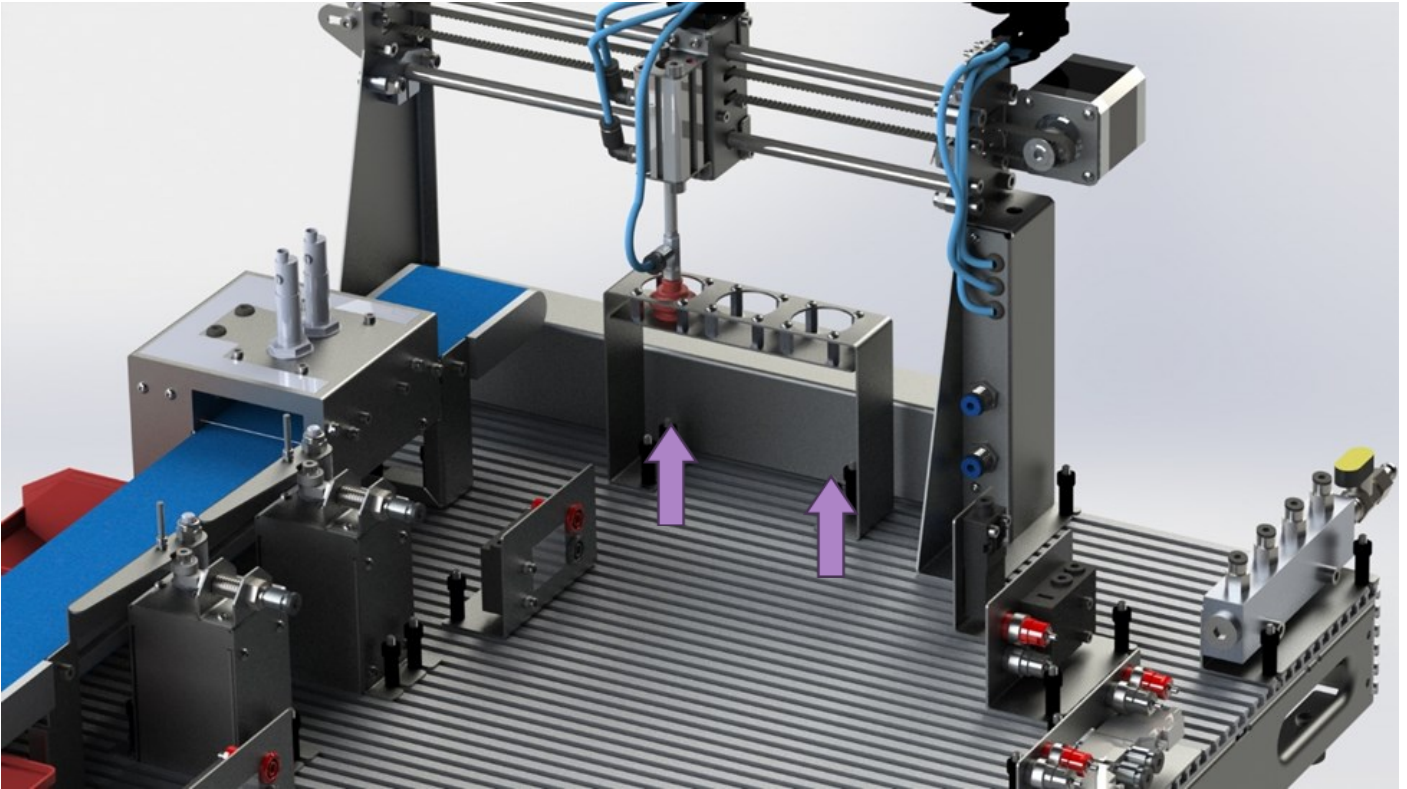
Add the counter rack under the gantry unit. Line up the 3 counter hoppers with the plunger head. The base should have a series of channels that line up for the 4 tee bolts fixings which hold the rack in place.

Place the rack about 40mm from the stepper motor side of the gantry.

Add the counters into the 3 hoppers in any order you'd like. However, by material is sensible.

40mm
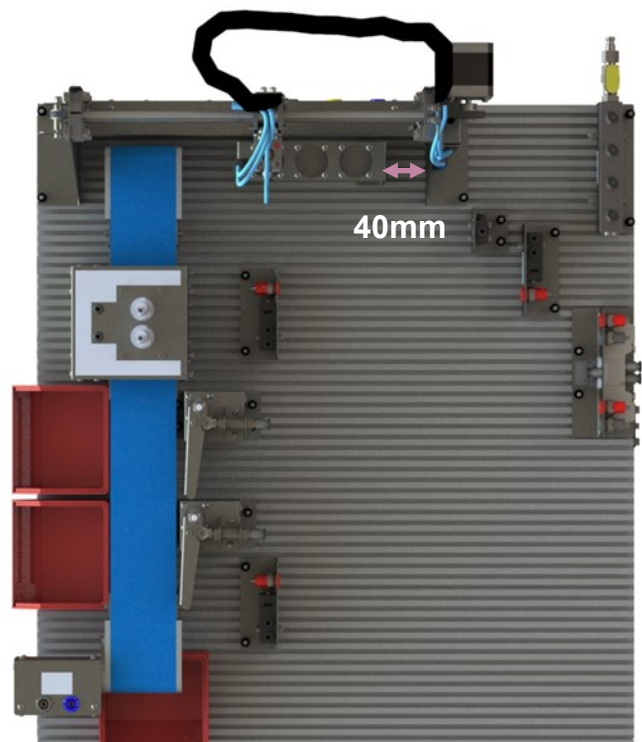
Step 7. Adding the Robot Arm modules
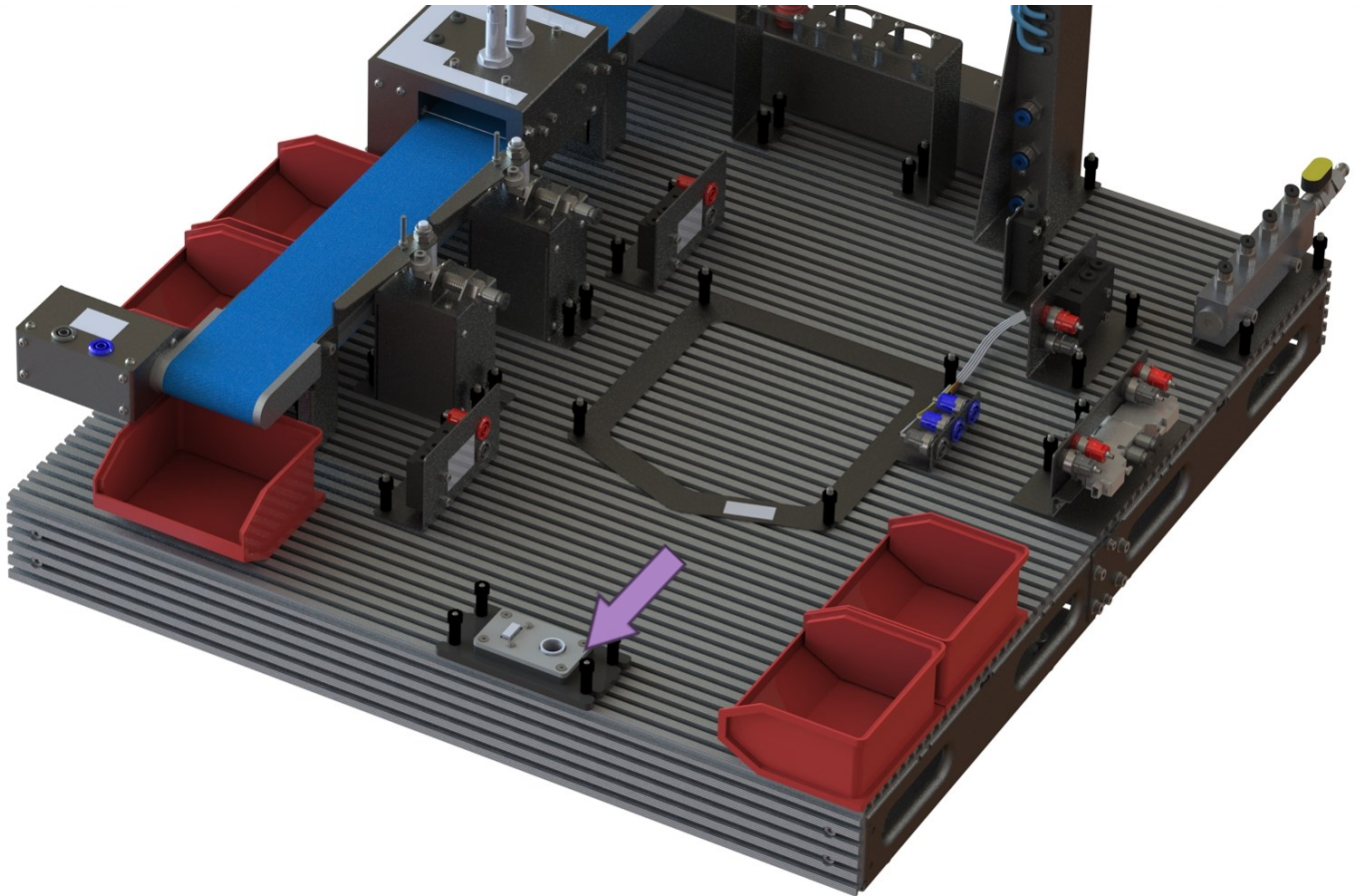
This step is optional if you didn't purchase Matrix's Robot Arm

Add the registration plate for the Robot arm in the middle of the base, with the pointed end facing away from the gantry module.

Add the light colour sensor module at the end of the base, with the middle of the unit lining up with the point of the registration plate.

Use 4 tee bolts to fix down both modules to the base.

Step 8. Adding the Robot Arm
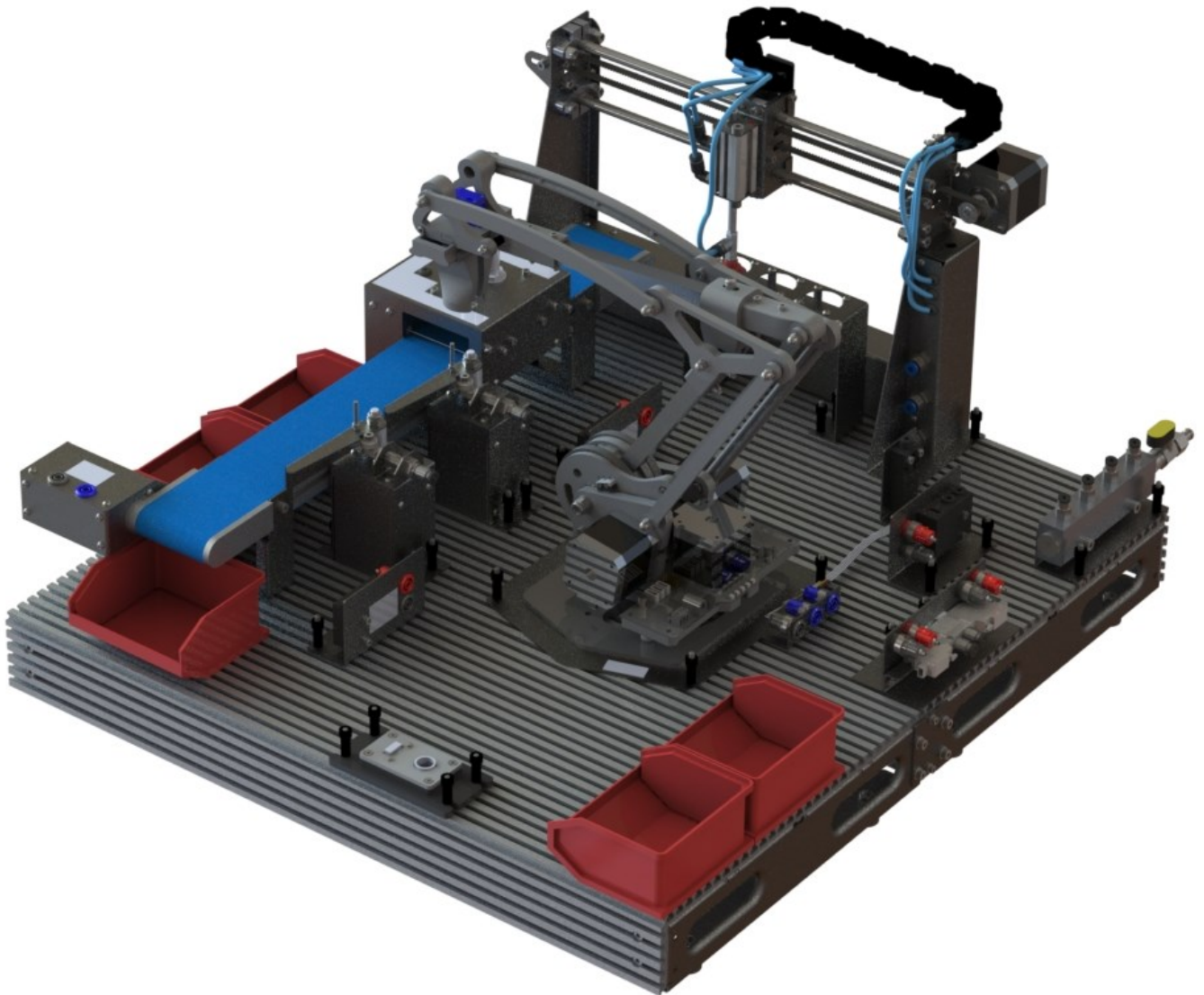
This step is optional if you didn't purchase Matrix's Robot Arm

Add the Robot Arm to the centre of the smart factory, using the shape of the registration plate to guide the orientation of the arm.

PLC Options

Expandable PLC (AU3686)
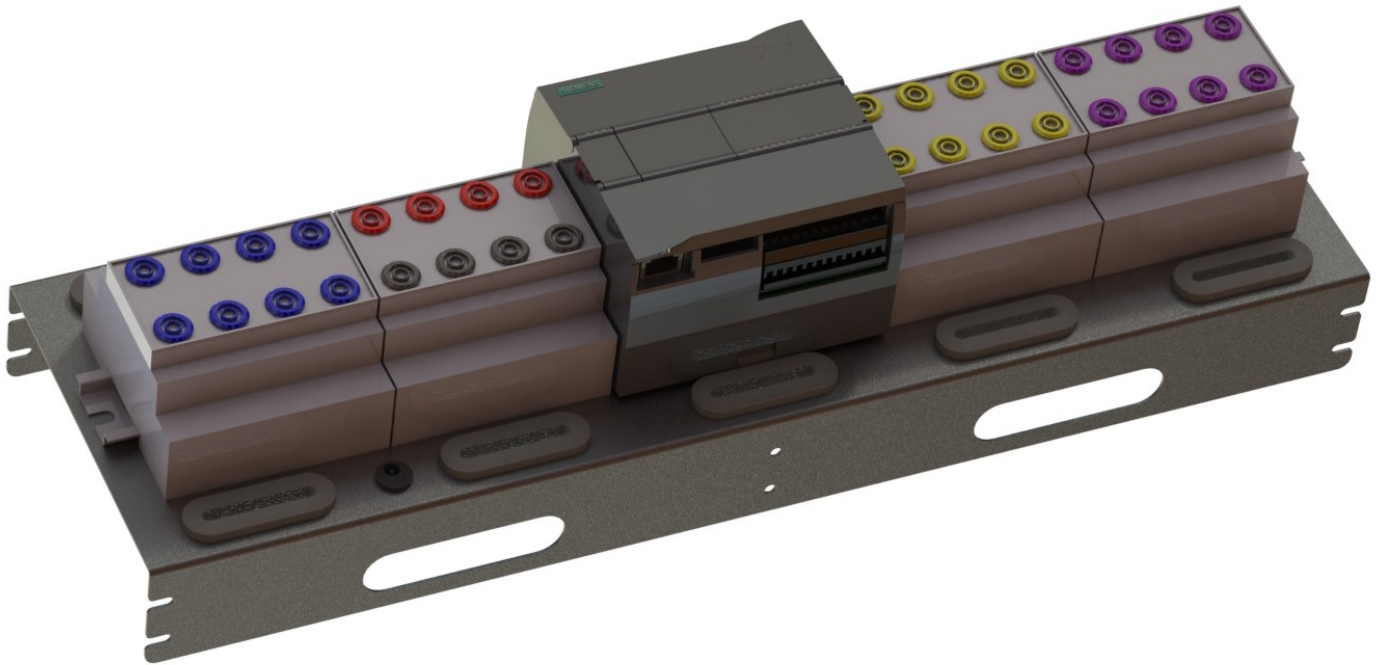
Siemens HMI PLC (AU0205)
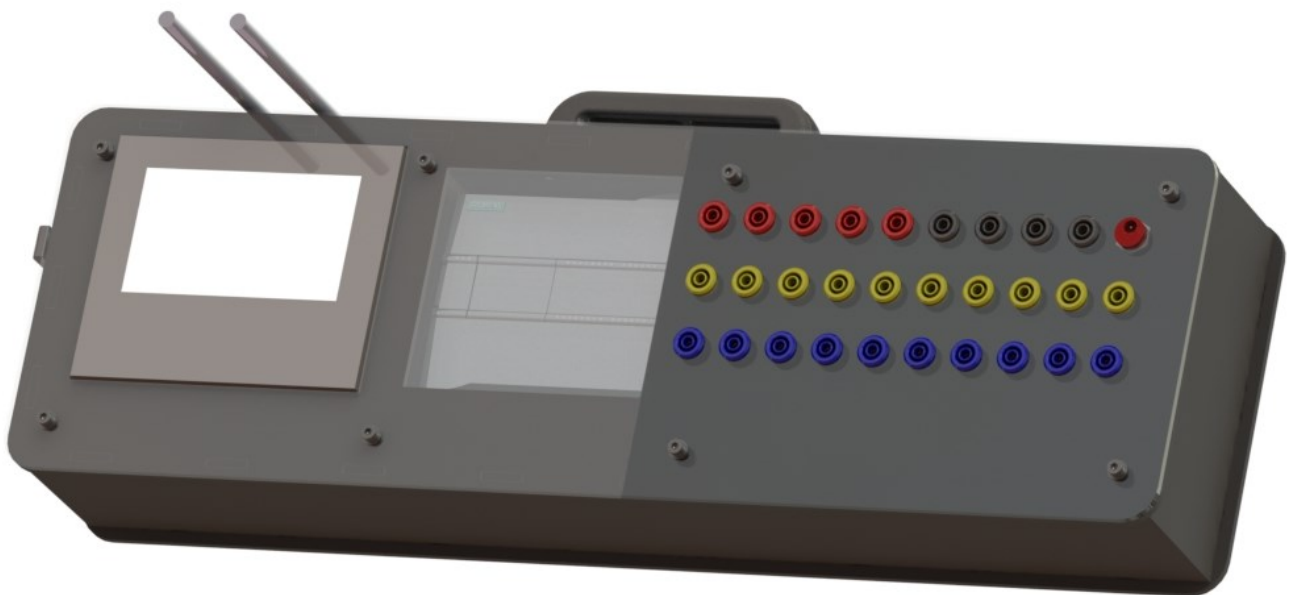
Wiring Diagrams

AU3686 Wiring Diagram
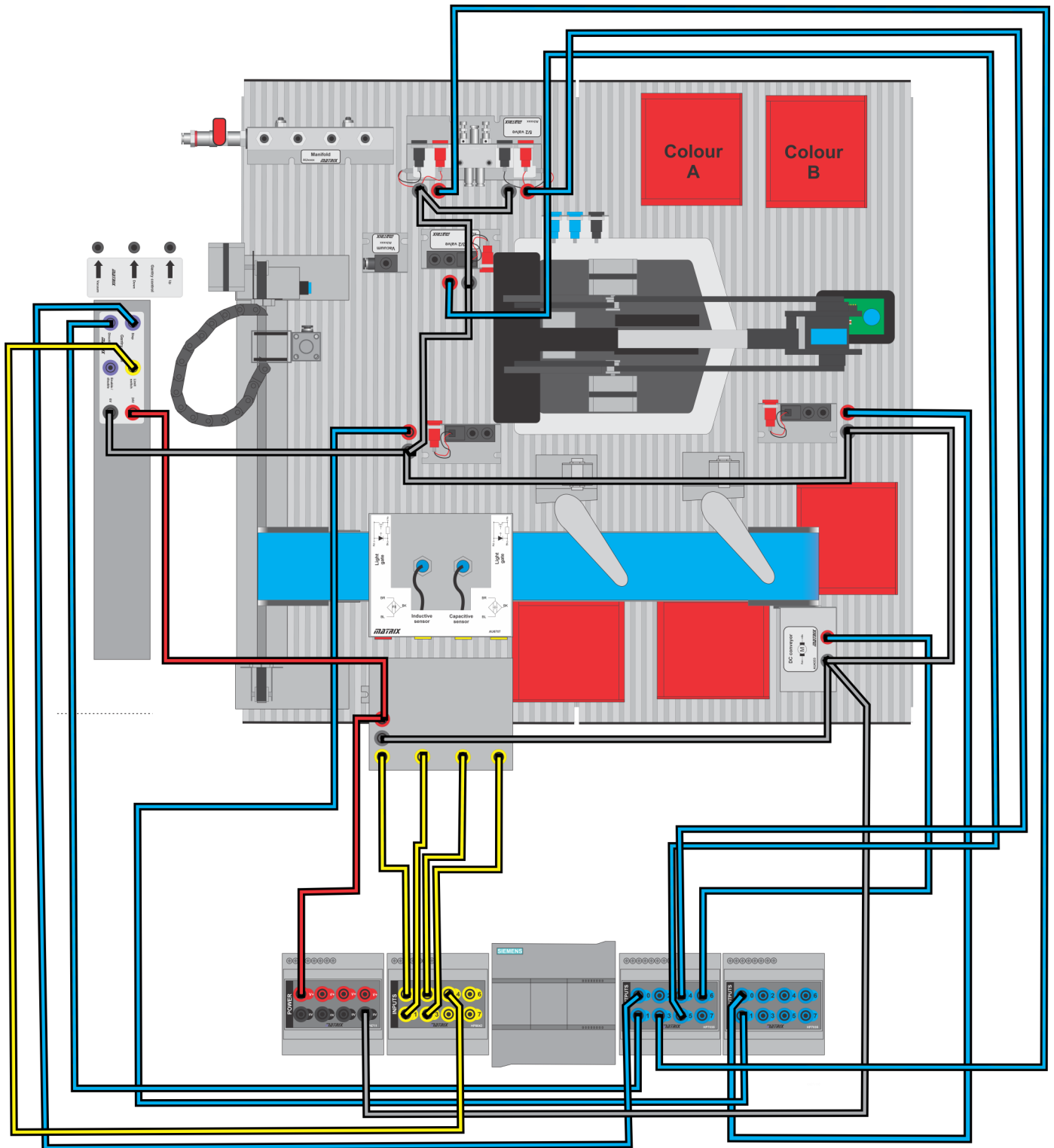
Wiring Diagrams

AU0205 Wiring Diagram
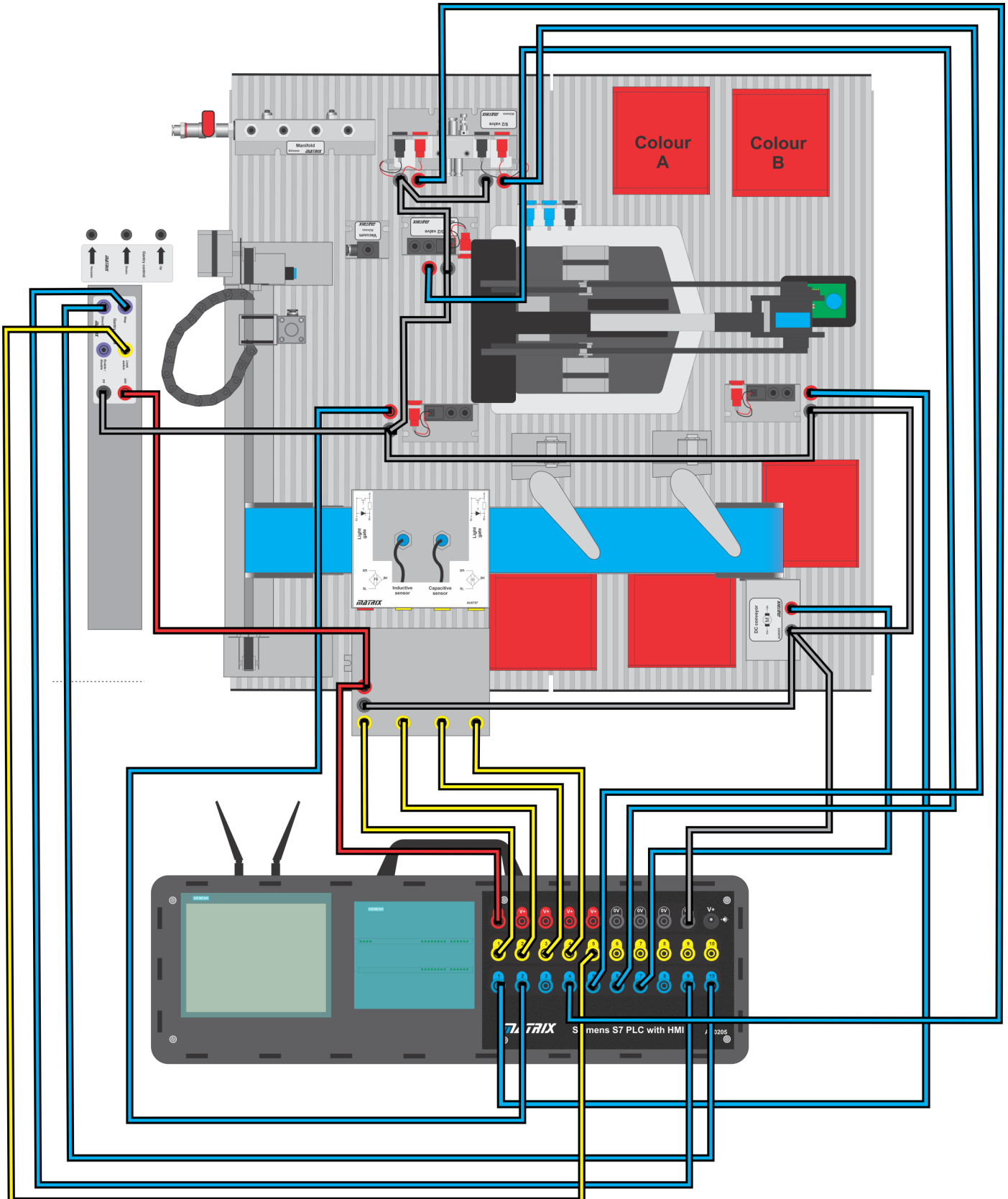
Pneumatic Diagram

Air inlet from compressor

Colour A

Colour B

Robot Arm Setup
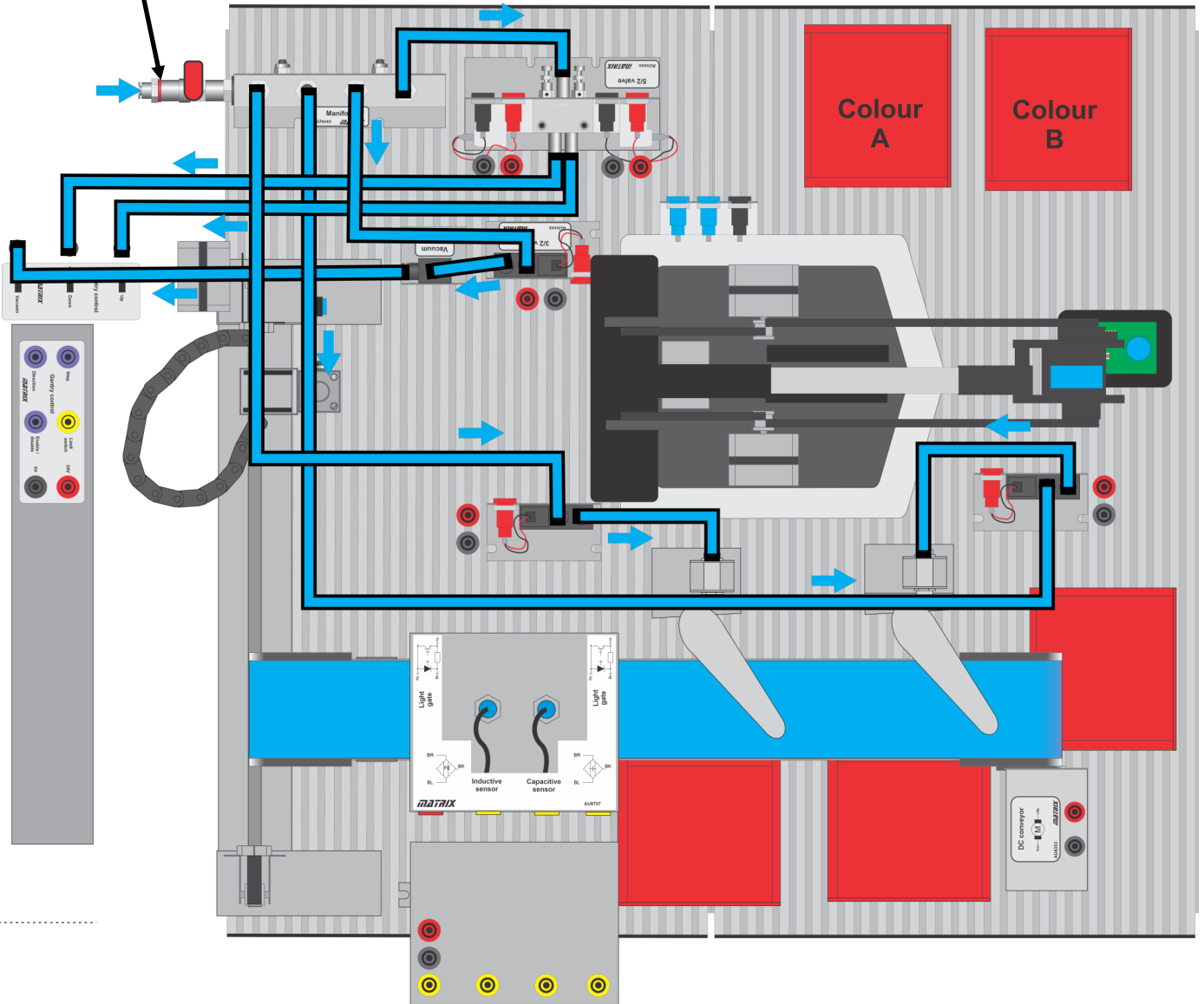
Wiring for the Robot Arm
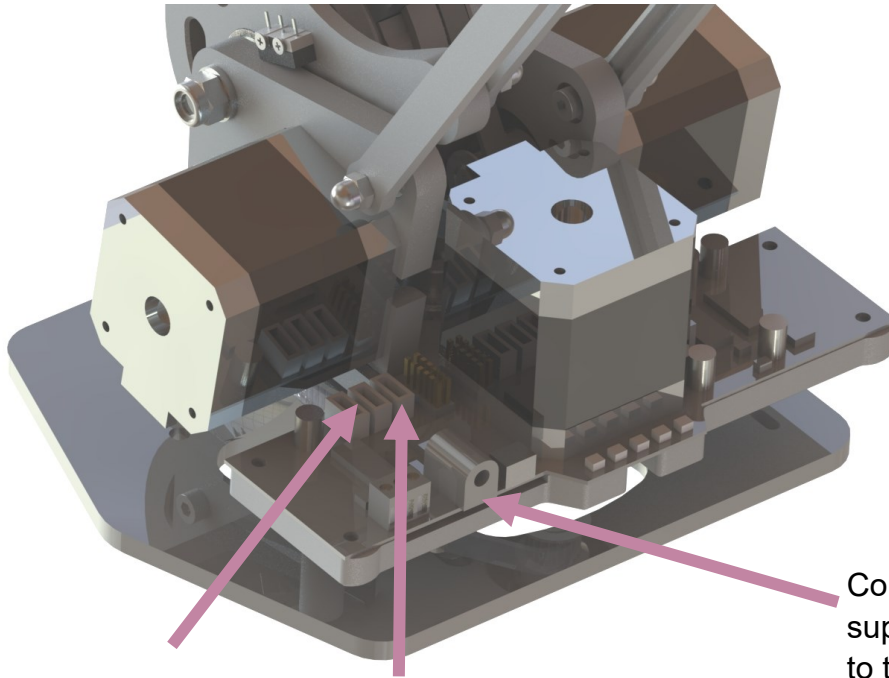
Connect the PLC input from the registration plate to the 2nd port of the 3 on the Robot Arm PCB.

Connect the light sensor ribbon cable from the 4 way JST connector on the light sensor to the 1st port on the Robot Arm PCB.

Connect the power supply for the robot arm to this port.

The USB port is next to this, if you are going to use a wired connection.
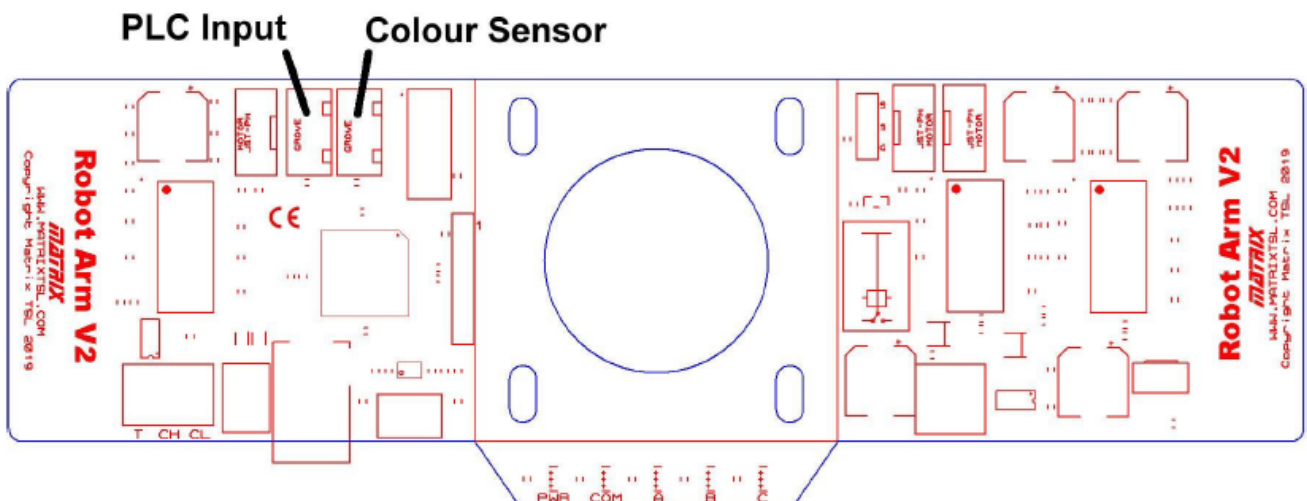
Functionality Test

Step 1. Sensors

There are four sensors mounted above the conveyor, two light gates, an inductive sensor and a capacitive sensor. The PLC has a row of LEDs on the front that will light when each sensor is active. On the top row of LEDs, locate the group of eight that are labelled "DI a" With no counters on the conveyor, all these LEDs should be off. Place a counter on the conveyor and slide it under the first sensor. When the counter breaks the light beam, the LED labelled ".0" should light.

The next sensor is the inductive sensor. The ".1" LED should light when a steel counter passes underneath it. Usually, an LED on the body of the sensor lights at the same time. The sensor should not activate when either aluminium or plastic counters are under the sensor. The sensor is fixed to the mounting bracket with nuts above and below. The sensitivity can be adjusted by moving the sensor closer to the conveyor belt or further away.

Next the capacitive sensor has a tiny pot dial on the barrel, which affects sensitivity. The ".2" LED should light only when a steel or aluminium counter passes underneath it. This sensor can also be adjusted by changing the height of the sensor above the conveyor.

The final sensor is another light gate. The ".3" LED should light as the counter passes through the light beam.
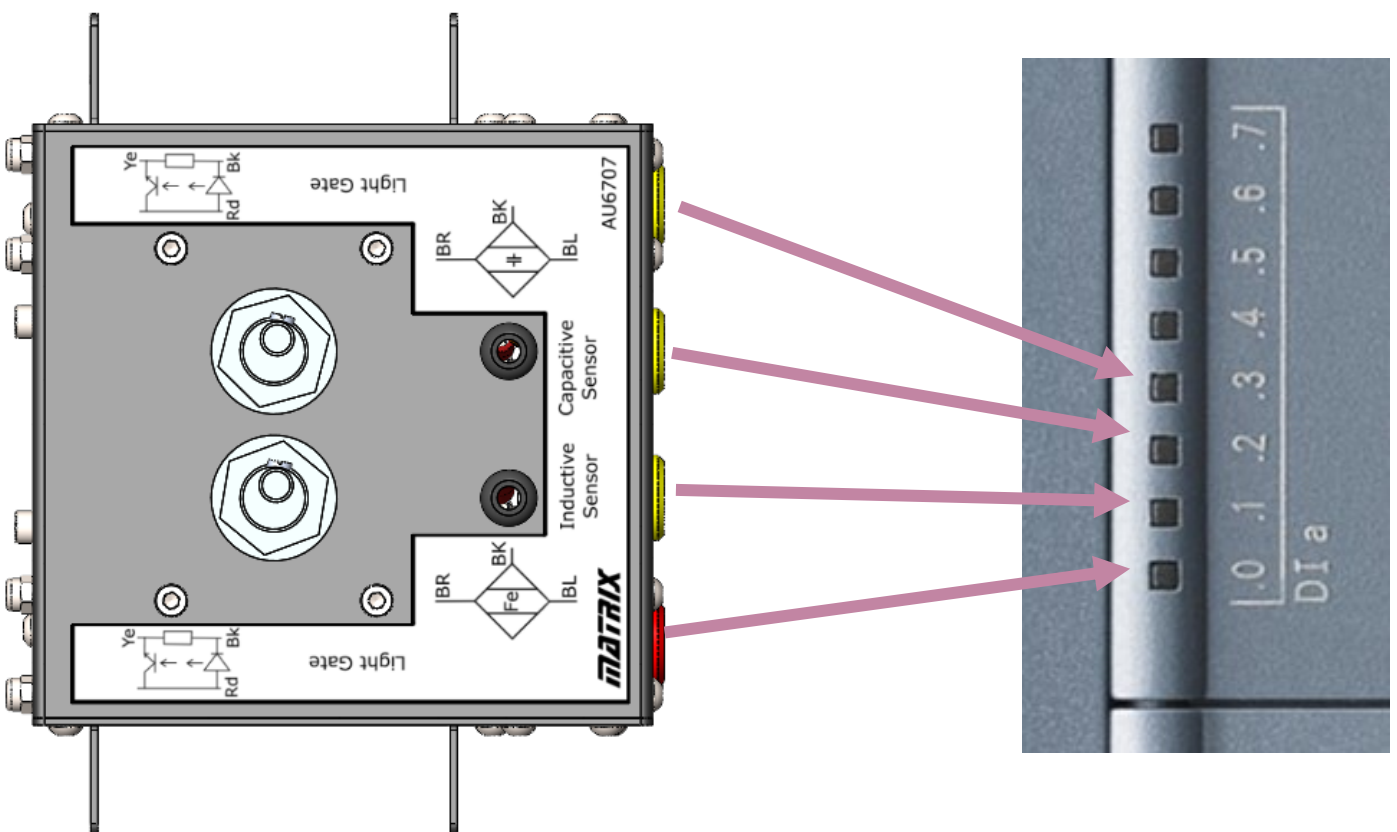
Step 2. Stepper Homing Switch

A small micro-switch is mounted on the gantry close to the stepper motor. The PLC uses this switch to detect the home position of the gantry plunger mechanism. Pushing this switch by hand should cause the "0.4" LED to light.

Step 3. Reject Mechanisms

Before testing the reject mechanisms, check that all the pneumatic tubing is correctly installed and pushed fully into each connection point. Set the air compressor to a pressure of 3 bar and turn on the inlet tap of the manifold.

For each reject mechanism in turn, unplug its cable from the PLC output and connect it instead to one of the red +24VDC outputs. As soon as the cable is plugged in, the paddle should extend across the conveyor. Unplug the cable from the +24VDC output and the paddle should return to its home position. After this test, replace the cable back into the PLC output.

Functionality Test

Step 4. Plunger

Check the pneumatic tubing and turn on the air supply to test the plunger. The plunger that is mounted on the gantry is controlled by a 3/2 valve and a 5/2 valve.

To test the vacuum, unplug the cable of the 3/2 valve from the PLC output and connect it to +24VDC. The 3/2 valve should operate and a flow of air will be heard exhausting from the vacuum generator. A counter placed under the rubber cup of the plunger should be held in place by the vacuum. When the cable is removed from +24VDC and replaced in the PLC output, this counter should fall.

The 5/2 valve has restrictors on its exhaust ports. As air is admitted into one side of the cylinder, air from the other side is expelled through the restrictor. To begin with these should be adjusted almost fully in, this will slow down the operation of the cylinder.

Slide the plunger along the gantry so that it is above the conveyor. It will be necessary to remove the +24VDC connection from the stepper input of the gantry so that the gantry can be moved by hand. Replace the +24VDC connection once it is positioned.

Remove the cable of the 'down' of the 5/2 valve from the PLC output to +24VDC and then back to the PLC output. The plunger should move down. Repeat this with the cable of the 'up' side and check that the plunger moves up.

With the restrictors wound fully in, the movement of the plunger will be sluggish and may not come down far enough to reach the counter rack. Adjust the restrictors by small increments and repeat the test until the movement is smooth but not too fast. There are lock nuts on the restrictors, tighten these once adjustment is complete.

Step 5. Conveyor

To test the conveyor, unplug its cable from the PLC output and connect it to one of the +24VDC outputs. The belt should run smoothly, traveling away from the gantry towards the reject mechanisms. After this test, replace the cable back into the PLC output.

Step 6. Gantry

The stepper driver requires a pulse to move the motor. This is not easy to do without using the PLC. For this reason, testing of the gantry is limited to visually checking the connections. Check that the plunger can be moved by hand when the power is off and that it moves smoothly.

Loading Software on AU3686

PLC I/O	Connector	Function
%I0.0	Yellow 0	First Light Gate
%I0.1	Yellow 1	Inductive Sensor (Detect Steel)
%I0.2	Yellow 2	Capacitive Sensor (Detect Aluminium)
%I0.3	Yellow 3	Final Light Gate
%I0.4	Yellow 4	Gantry Home Switch
%I0.5	Yellow 5	Trigger program, Bin 1
%I0.6	Yellow 6	Trigger program, Bin 2
%I0.7	Yellow 7	Trigger program, Bin 3
%Q0.0	Left-Hand Blue 0	Gantry Step
%Q0.1	Left-Hand Blue 1	Gantry Direction
%Q0.3	Left-Hand Blue 3	Plunger Down
%Q0.4	Left-Hand Blue 4	Plunger Up
%Q0.5	Left-Hand Blue 5	Plunger Vacuum
%Q0.6	Left-Hand Blue 6	Conveyor Motor
%Q1.0	Right-Hand Blue 0	Steel Reject Paddle
%Q1.1	Right-Hand Blue 1	Aluminium Reject Paddle

Use an Ethernet cable to connect the PLC to the computer that will be used for programming. Either connect the PLC directly to the Ethernet port of the computer or connect both devices to an Ethernet hub. It is best to use an authentic Ethernet port on the computer rather than a USB-to-Ethernet convertor because many convertors do not fully implement all the features that are needed for connecting to the PLC.

Programming the PLC is performed using the TIA portal software. This is available from Matrix or from a local Siemens distributer. The demo programs are written using TIA Portal V15 and are compatible with any version above this.

Demonstration programs are available from the Matrix website: -

https://www.matrixtsl.com/automatics/resources/

The appropriate program for the stand alone PLC is "Smart Factory Siemens S7-1200.zap15" Download the programs from the website and unzip them into a folder on the local computer.

Start TIA Portal, it will open in "Portal View", click on the label "Project View" at the bottom left of the window.

Select "Retrieve…" from the Project menu and browse to the location of the project archive. Once the file is selected, you will be prompted to choose a folder for the archive to be expanded into. Any folder on the local hard disk will work.

Loading Software on AU3686

Find the device "PLC_1" in the Project tree. Expand the device to examine the Program blocks. Right-click to download the project to the device. Both hardware configuration and software should be downloaded.
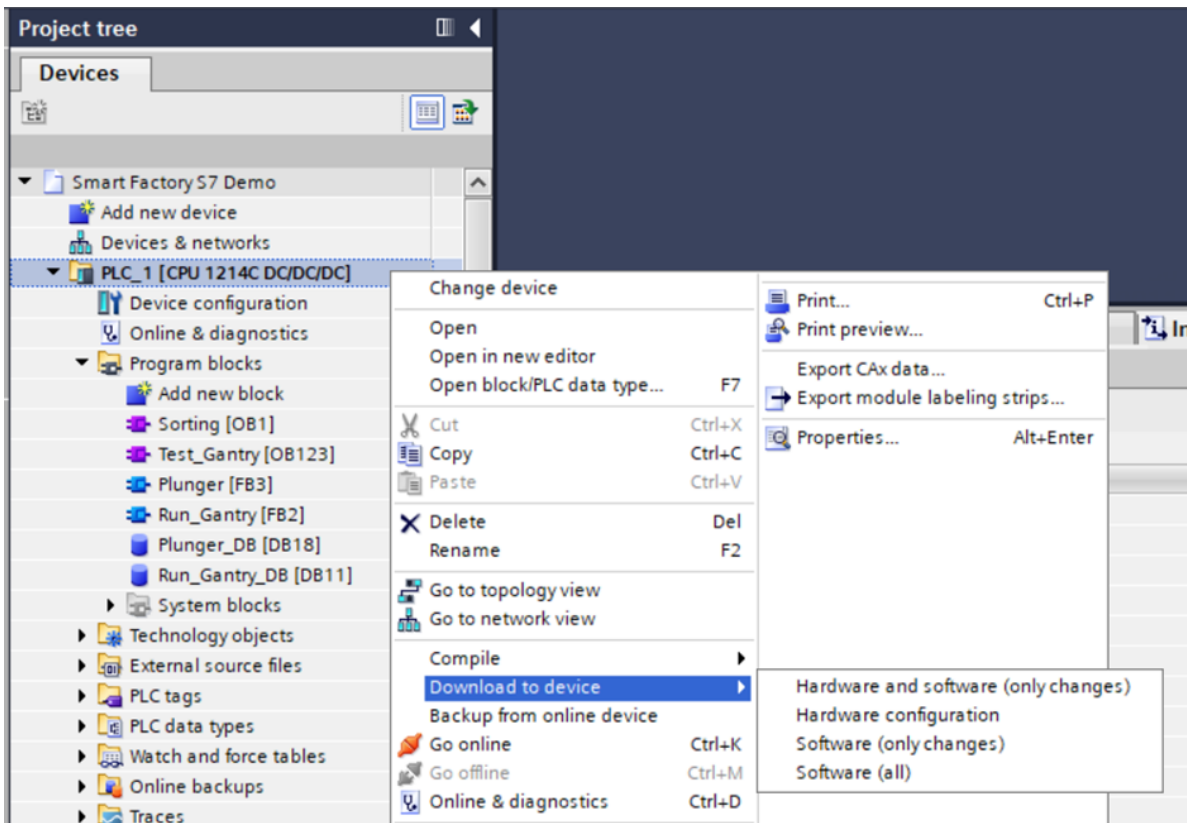
In the download window, check that the type of interface is "PN/IE", the selected interface is the Ethernet interface of the local computer and the search option is "Show all compatible devices. Click "Start Search" to begin connecting to the PLC.
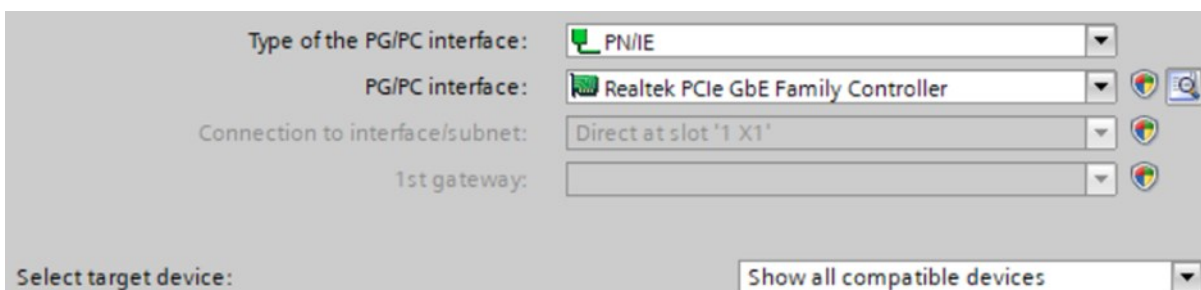
Once the PLC is found, click "Load" to download the configuration and software to the device. A dialog box will give options for what the PLC will do on completion of download. Change the option from 'No Action' to 'Start'.

Operation with AU3686

The program is triggered by applying 24VDC to one of yellow inputs 5 thru 7. Briefly connect a cable from +24VDC to the input. It is also possible to install a momentary push button with one terminal connected to the input and the other to +24VDC.

When the input is triggered, the stepper motor will drive the plunger to the home position of the gantry. The PLC will hit the limit switch, back off and then hit the switch again to provide a precise home position.

The plunger will then be positioned over one of the bins in the hopper depending upon which input triggered the sequence. 5 being bin 1, 6 being bin 2 and 7 being bin 3. The plunger will extend, pick up a counter by vacuum and then retract. The counter will then be carried to the conveyor. The plunger will extend and drop the counter onto the conveyor by switching off the vacuum. The plunger then returns to the other end of the gantry.

The conveyor carries the counter under the rack of four sensors. All counters will trigger the first light gate. A steel counter will trigger the inductive sensor. Either steel or aluminium will trigger the second sensor. As the counters are identified, steel and aluminium counters are sorted into one of the two red bins by the reject paddles. Plastic counters are allowed to fall off the end of the conveyor into a red bin positioned at the end.

Loading Software on AU0205

PLC I/O	Connector	Function
%I0.0	Yellow 0	First Light Gate
%I0.1	Yellow 1	Inductive Sensor (Detect Steel)
%I0.2	Yellow 2	Capacitive Sensor (Detect Aluminium)
%I0.3	Yellow 3	Final Light Gate
%I0.4	Yellow 4	Gantry Home Switch
%I0.5	Yellow 5	Trigger pick from each bin in turn
%Q0.0	Blue 1	Steel Reject Paddle
%Q0.1	Blue 2	Aluminium Reject Paddle
%Q0.3	Blue 4	Plunger Down
%Q0.4	Blue 5	Plunger Up
%Q0.5	Blue 6	Plunger Vacuum
%Q0.6	Blue 7	Conveyor Motor
%Q1.0	Blue 9	Gantry Step
%Q1.1	Blue 10	Gantry Direction

The AU0205 product is supplied with demonstration software preloaded. If it is necessary to restore the demonstration software then it can be downloaded from: -

https://www.matrixtsl.com/automatics/resources/

The appropriate program for AU0205 is "AU0205 Smart Factory Demo_1.zap15" Download the programs from the website and unzip them into a folder on the local computer.

Start TIA Portal, it will open in "Portal View", click on the label "Project View" at the bottom left of the window.

Select "Retrieve…" from the Project menu and browse to the location of the project archive. Once the file is selected, you will be prompted to choose a folder for the archive to be expanded into. Any folder on the local hard disk will work.

Connect the Ethernet cable of the controller to the computer that will be used for programming. Either connect the cable directly to the Ethernet port of the computer or connect both devices to an Ethernet hub. It is best to use an authentic Ethernet port on the computer rather than a USB-to-Ethernet convertor because many convertors do not fully implement all the features that are needed for connecting to the PLC.

Find the devices "PLC_1" and "HMI_1"in the Project tree. Expand them to examine the demonstration program. Right-click PLC_1 to download the project to the device. Both hardware configuration and software should be downloaded. Right-click HMI_1 to download the software to the device. The instructions for downloading are described in the section on AU3686 above.

Operation with AU0205

When the device powers on the touchscreen HMI will show a start menu; touch the "Start" button to begin. At the next menu touch the "Smart Factory" button to start the demonstration. The first screen of the Smart Factory program shows tallies for the three categories of counters: Al = Aluminium, Fe = Steel and Plastic. These will normally show the numbers of counters since power on but they can be zeroed by touching the "Reset" button.
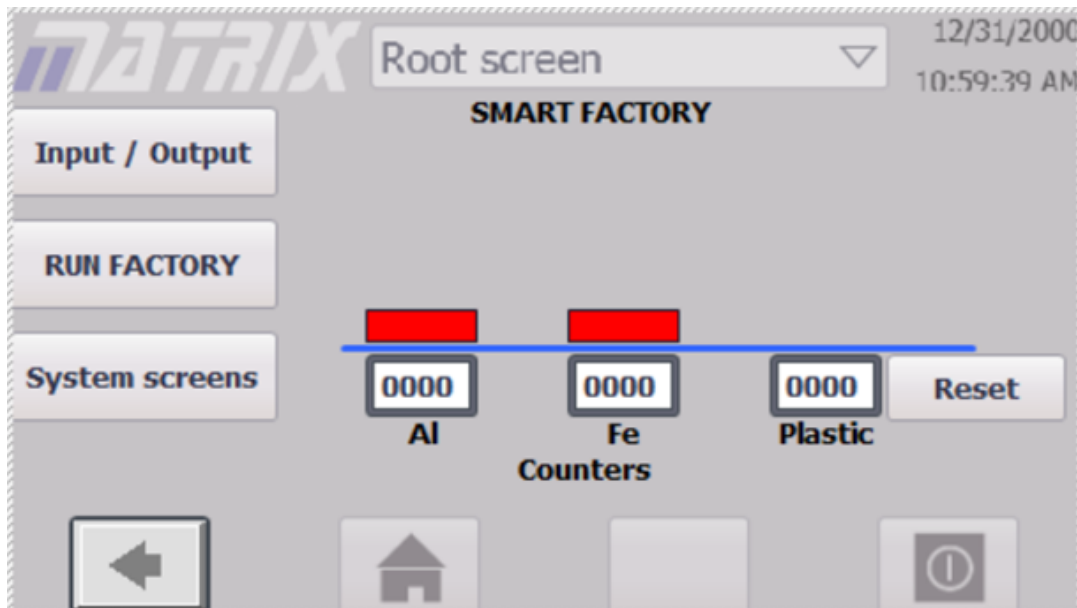
Touch the "Input/Output" button to see a display of the states of the PLC inputs and outputs. On this screen, the inputs and outputs of the PLC are represented as animations of LEDs. They will be coloured bright green when they are in the on state and dull green when in the off state.
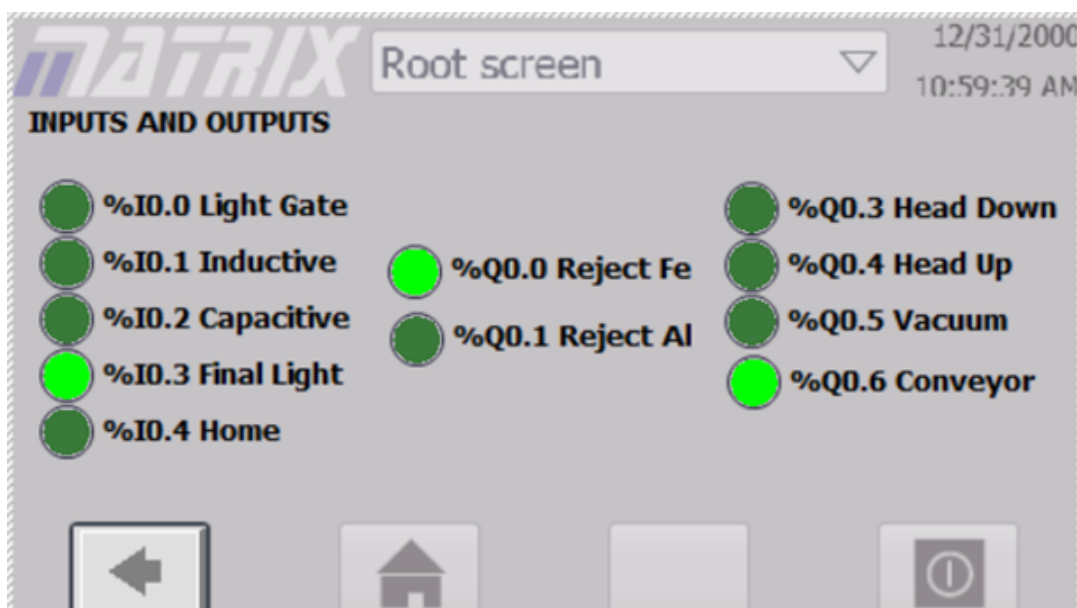
Operation with AU0205

Touch the back arrow at the bottom-left of the screen to return to the main screen and touch the "RUN FACTORY" button to load a screen that provides control over the Smart Factory. The buttons labelled Bin 1 thru Bin 3 will trigger the PLC to pick up a counter from the appropriate bin of the hopper and then deposit it on the conveyor for sorting.

On the right hand side of the screen is a switch that controls the behaviour of the PLC with respect to the robot arm. If a robot arm is installed with the factory, the switch should be in the "WAIT" state. In this state, the PLC will trigger the robot am to pick up any plastic counters, hold them to the colour sensor and then place them into the black and white sorting bins. If another counter is picked up by the gantry before the arm has completed its operation then the gantry will wait with the counter above the conveyor until the robot returns to its home position.

As well as being triggered automatically when a plastic counter is detected, the robot arm can be triggered by touching the "Start Arm" button.

If no robot arm is present, then the switch should be in the 'IGNORE' state.

Webserver Connection

The S7 PLC contains a built in webserver that can be used for maintenance, diagnostics and user defined pages. The demonstration software includes webpages that can be used to see tallies of the counters and to trigger the pick and sort routine. The router in the AU0205 provides a wireless network that can be connected to a mobile phone or laptop computer. Find the network named "Matrix_AU0205" and log on with the password "Matrix123" Alternatively, a computer can be connected using the Ethernet cable.

To connect to the PLC, start a web browser and type in the address: -

> http://192.168.7.2

This is the IP address of the PLC on the local network that the router is producing. Note that not all web browsers will recognise an IP address. In some cases the web browser will misinterpret the address as a search term. If this happens, try a different browser application.

When the front page of the PLC appears, click or touch the "ENTER" link.

Operation with AU0205

On the next page click on the "User-defined-pages" and then "Homepage of the application" links.
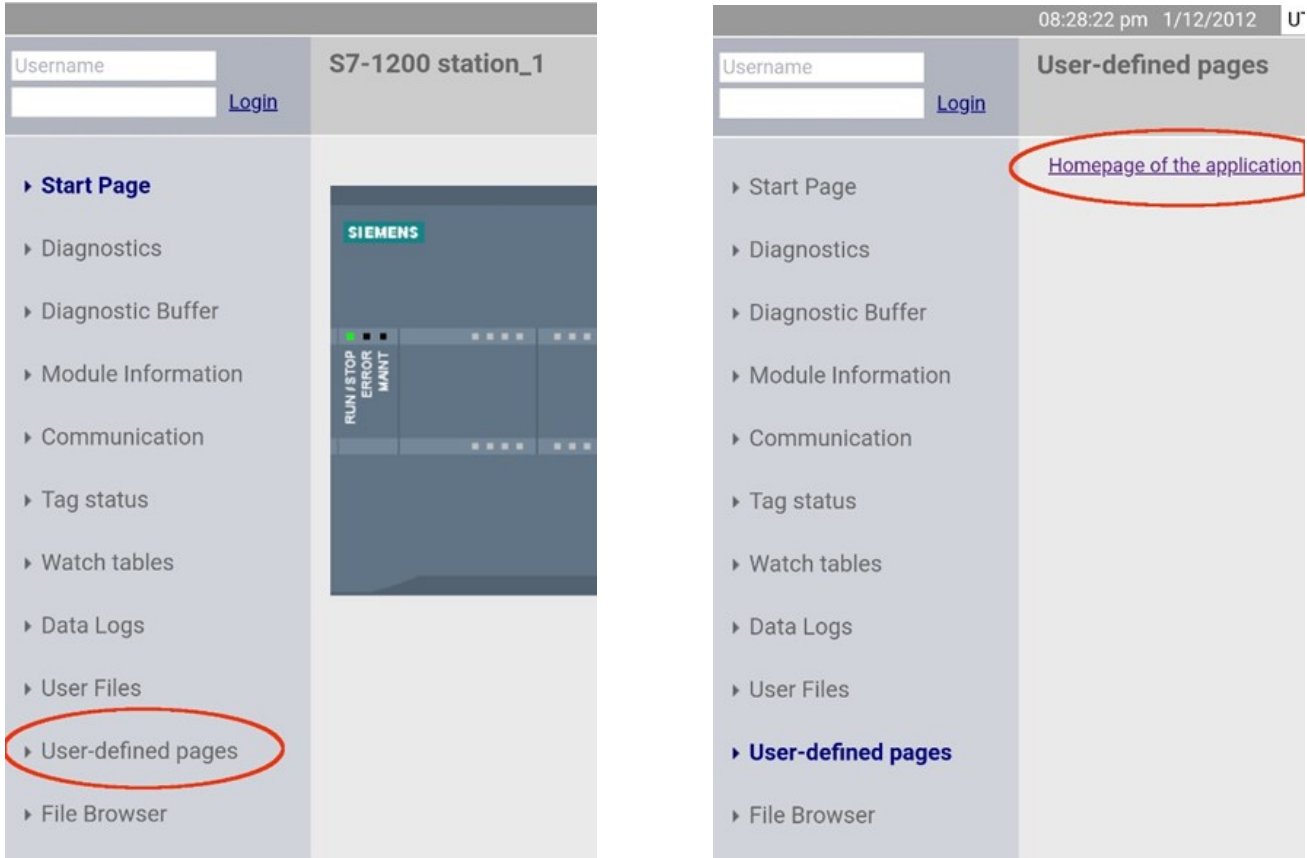
The user defined page for the Smart Factory application shows tallies of the three categories of counters. It also splits the plastic category into black and white. The "Pick 1" thru "Pick 3" buttons will trigger the pick and sort routine in the same way as the HMI buttons and the "Reset Counters" button will zero the tallies.
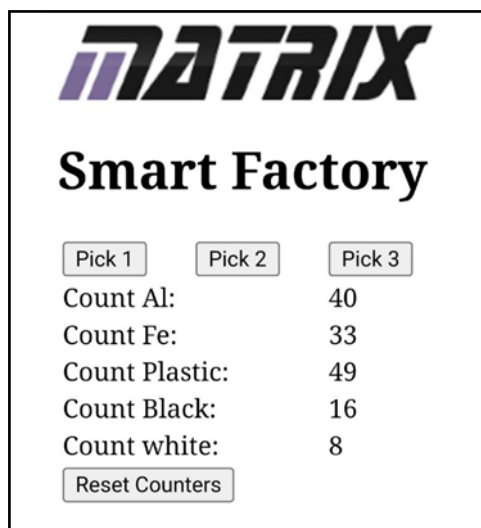
Getting Started with Robot Arm

The AU0205 product contains a built in router that connects to the PLC by Ethernet and can connect to the robot arm by Wi-Fi. There are two steps to creating a connection. The first is to configure the robot to connect to the router and the second is to configure the router to assign a fixed address to the robot.

Configure Robot Arm Wi-Fi

To configure the robot, download the Robot Arm V2 Control Apps applications from:

https://www.matrixtsl.com/allcode/resources/

Connect the robot arm to the computer using a USB cable and apply power to the robot. Run the Configure.exe program. Press F5 or click on the run button at the top left of the screen and the "Connected" LED should turn green. Click on the "Configure WiFi" button to begin the configuration.
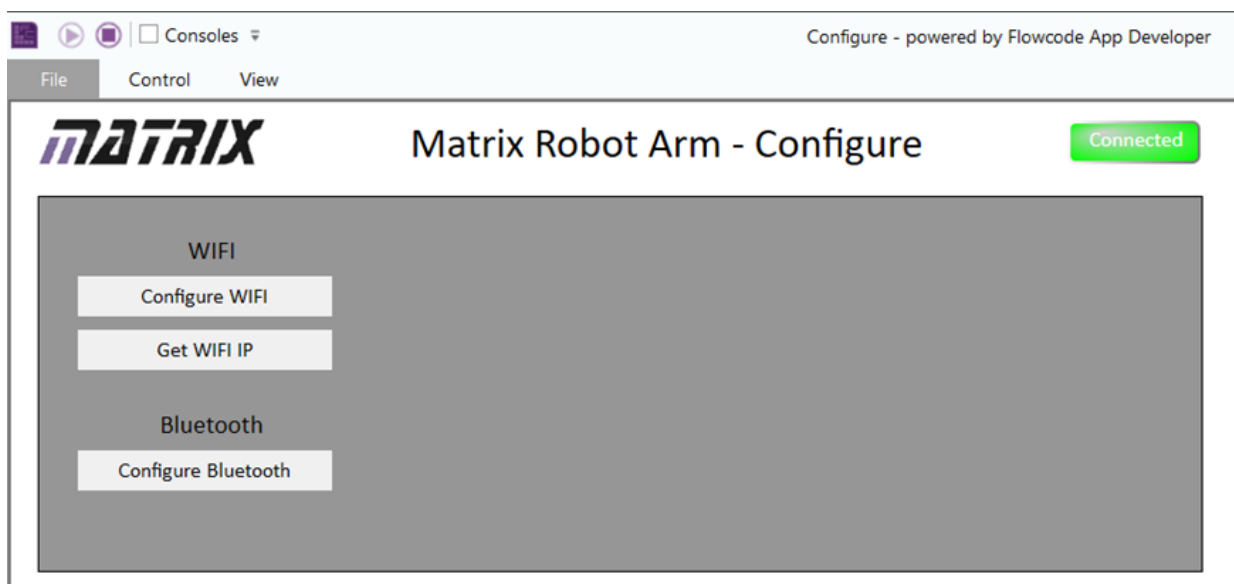
The application will prompt with a series of dialog boxes. Choose the following responses: -

WiFi Enabled? – Yes

Host Network? – No

WIFI SSID – "Matrix_AU0205"

WIFI Password – "Matrix123"

WIFI Port – 1245

After entering the responses, the software will ask you to power cycle the robot arm for the changes to take effect.

Getting Started with Robot Arm

Configure Robot Arm IP Address

The router in the AU0205 contains a DHCP server that assigns addresses to components on the network.

Connect a computer to the router using either the Ethernet cable or the Wi Fi connection. Open a web browser and enter the address: -

http://192.168.7.1

Login to the router using the username "admin" and the password "Admin123"

Look at the Wireless Clients section of the status page. If the robot has been configured correctly according to the previous section, it should appear in the list of clients. Make a note of the MAC address as this will be needed later.

Select the Network page by clicking on the icon on the left hand side of the screen. Select interfaces and click on the edit icon for the LAN interface.

Getting Started with Robot Arm

In the properties for the LAN interface, edit the DHCP server and add a new static lease. Name the new instance "Robot", enter the MAC address that was noted earlier and give it the IP address "192.168.7.7" This is the address that the demonstration software in the PLC uses to communicate with the robot arm.

Once the robot arm and the router are configured, power cycle the robot arm in order for the robot to obtain the new IP address from the router.

Connecting the Robot Arm to AU3686

There is a demonstration program available for the AU3686 that connects to and controls the robot arm. Since the AU3686 product is not supplied with a router, it is necessary for customers to have a locally available router connecting to the PLC by Ethernet and the robot arm by Wi-Fi. Some networking expertise may be required to set this up. Follow the same steps as for configuring AU0205 but substitute the details of the local network.

The demonstration software is "Smart Factory with Robot Demo.zap15" The software can be downloaded using TIA Portal using the procedure described in the section on AU3686. The IP address is coded in the function block "Robot_Arm_Comms" The default is 192.168.1.63 but it can be changed to suit the local network. The program will begin a sequence of picking three counters, one from each bin of the hopper, when input 5 is connected to +24VDC.

Getting Started with Robot Arm

In the demonstration programs, the robot arm is commanded to progress through a sequence of moves. These carry the plastic counter from the conveyor to the colour sensor. After reading the colour sensor, the counter is placed in either the white or black sorting bin and the robot returns to its home position.

The exact positions that the robot arm moves through are dependent on the layout of the Smart Factory. For the robot to work as intended in the demonstration programs, it will be necessary to make fine adjustments. There are two approaches that can be used. One is to carefully move the robot arm base, the colour sensor and the sorting bins until the program works as written. The better approach is the Robot Arm V2 Control Apps that were downloaded earlier and use the BasicControl application to find the appropriate positions. The step counts for each motor can then be edited in the demonstration programs before re-downloading them to the PLC.

Stopping the plastic counter on the conveyor relies on timing how long the conveyor motor is run. This leads to small variations in the exact stopping position. The program is designed to bring the robot arm down so that one jaw of the gripper lands over the centre of the counter. The robot then scoots sideways so that the jaw of the gripper slips of the edge of the counter before closing the gripper.

Robot Gripper

Counter

Conveyor Belt

The gripper jaw lands on the counter.
As the robot scoots, the leading jaw drops over the edge of the counter.
When the movement stops, the jaws close around the counter.
This allows a tolerance for the position of the counter on the conveyor.
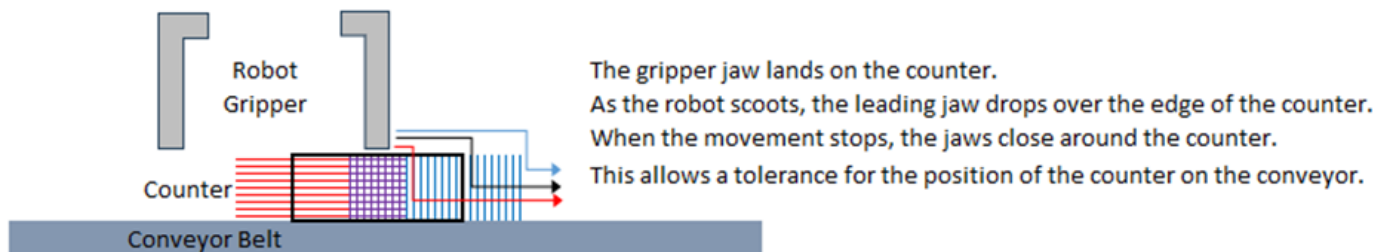
Getting Started with Robot Arm

The positions of the robot that are programmed into the demonstration programs are listed in the following table.

Instruction Number	Description	Step Counts		
		Motor 0	Motor 1	Motor 2
		Base	Shoulder	Elbow
0	Home all motors			
1	Position above conveyor	260	700	200
2	Land one jaw on counter	260	860	900
3	Scoot across counter	360	860	900
4	Close gripper			
5	Lift above conveyor	360	700	200
6	Rotate above sensor	2625	700	200
7	Lower onto sensor	2625	1360	1520
8	Read colour sensor			
9	Lift above sensor	2625	700	200
10-A	In mouth of black bin	3120	1200	1000
10-B	In mouth of white bin	3600	900	1000
11	Open gripper to drop			
12	Position above bins	3200	700	200
13	Home all motors			

Introduction to Programming

In order for the PLC to interact with the robot arm, they must both be part of a local area network with the robot connected by Wi-Fi and the PLC by Ethernet. An alternative way to control the robot arm is to write a FlowCode program to control the robot. Documentation for FlowCode and Robot Arm programming can be found on the Matrix website.

The blue sockets on the base of the robot arm can be connected to outputs of the PLC. The PLC program could be modified to use one of its outputs to signal that a plastic counter is ready to be collected. A FlowCode program could be written to wait for an input before running through the sequence of picking up and sorting a counter.

Getting Started with TIA Portal

A major goal of the Smart Factory is to provide a platform for teaching PLC programming. The PLC in the AU3686 and AU0205 products is made by Siemens and can be programmed using the TIA Portal software. This package incudes all the tools needed to configure and program the PLC and to design screens for the HMI if included.

Framework

The demonstration programs available on the Matrix website include "Smart Factory Framework.zap15" This is a project framework that includes the target PLC and has most of the low level configuration completed along with some low level functions for communicating with the robot arm. The user can add higher level control functions to the framework without needing to spend time on the lower level parts.

To use the framework, start TIA Portal, it will open in "Portal View", click on the label "Project View" at the bottom left of the window. Select "Retrieve…" from the Project menu and browse to the location of the project archive. Once the file is selected, you will be prompted to choose a folder for the archive to be expanded into. Any folder on the local hard disk will work. Save the retrieved framework as the project name of your choice.
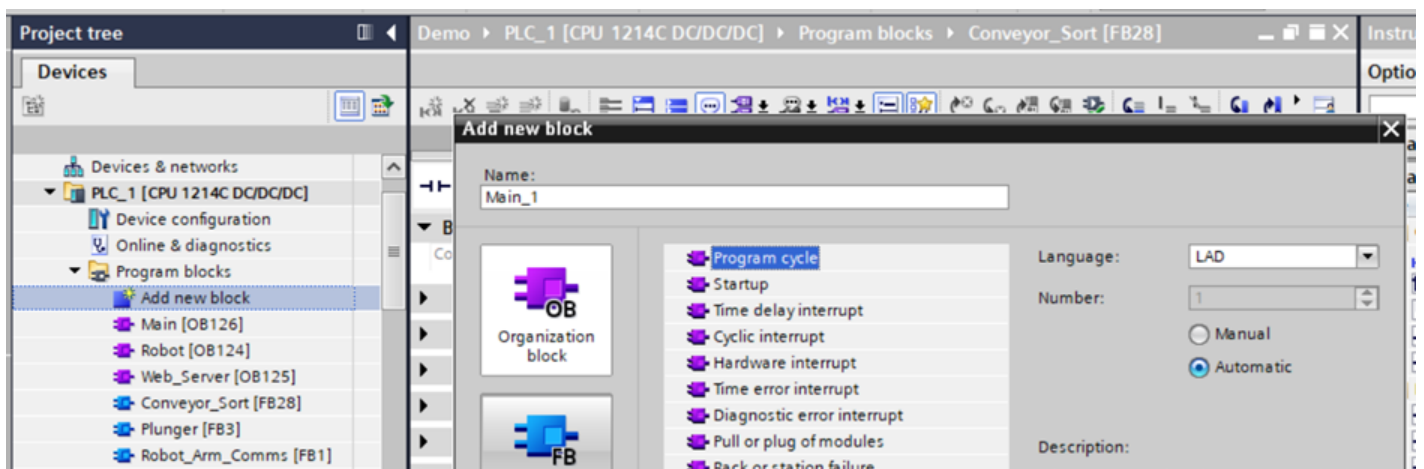
Introduction to Programming

Project

If not using the framework, create a new project in TIA portal. When the software opens in the portal view, click on "Create New Project." Fill in details of the project and choose a location on the local hard drive to save the files, then click "Create." Click on "Configure a Device" and then "Add new Device."

Add a controller from the SIMATIC S7-1200 family. The device is CPU 1214C DC/DC/DC and its article number is 6ES7 214-1AG40-0XB0. If using the AU0205 then return to the portal view and add an HMI from the SIMATIC Basic family. The device is a 4" Display, type KTP400 Basic and its article number is 6AV2 123-2DB03-0AX0.

The added devices will appear in the Project tree on the left hand side of the Project View screen.

Basic I/O

The PLC in the Project tree contains a folder named "Program Blocks." Click on "Add new block" to create a new program. The simplest type of program is an "Organization block" that runs on the program cycle. Such a program will run continuously.

Set the language to "LAD" to write the program in ladder logic.

With the new program open, click on the "Instructions" tab to open a toolbox of ladder logic instructions. The toolbox is context specific so it will contain items that are relevant to whatever editor window is active.

The PLC inputs are connected to yellow 4 mm sockets. They can be used as contacts in a program by using the addresses %I0.0 thru %I0.7. The AU0205 product has two more inputs that are accessed by addresses %I1.0 and%I1.1.

The PLC outputs are connected to blue 4 mm sockets. They can be accessed in a program by using the addresses %Q0.0 thru %Q0.7, %Q1.0 and %Q1.1. For example; to cause output number six to switch on whenever input number six is asserted, connect a normally open contact to an assignment. Give the two elements the addresses %I0.6 and %Q0.6.
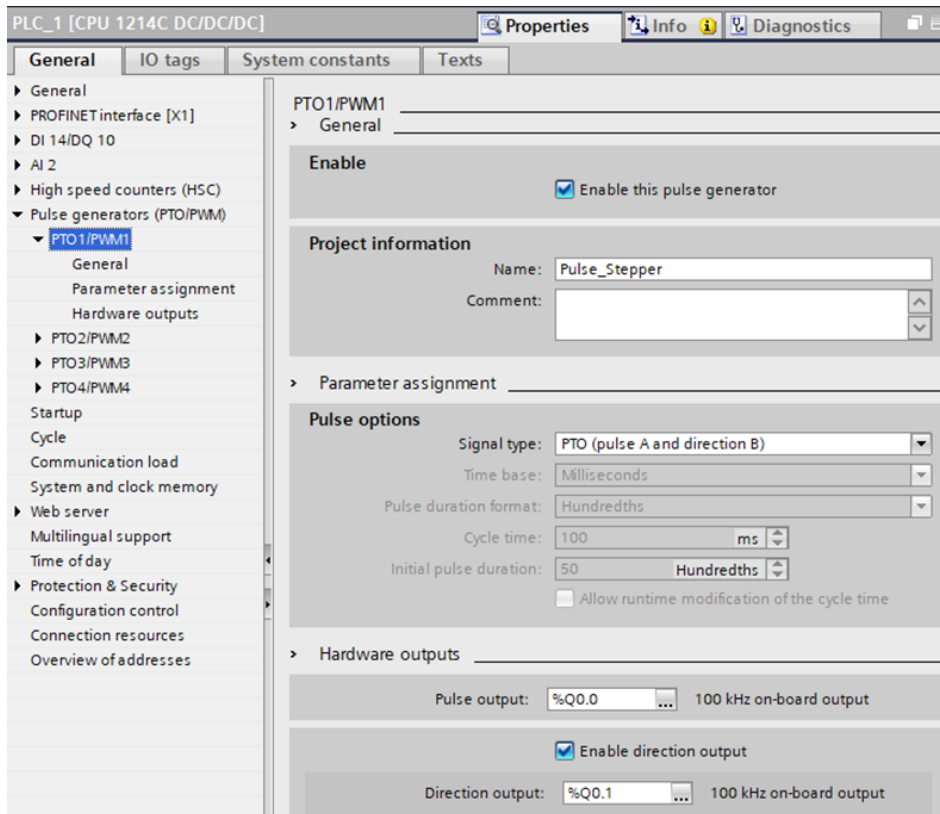

Motion Control

The stepper driver in the gantry is controlled by a pulse input and a level input. The stepper motor advances one step every time the "Step" input pulses. It moves towards its home position when the "Direction" input is not asserted and moves away from home the input is asserted.

While it would be possible to write a program that switched the step output on and off a number of times, there is a better way. The PLC contains a pulse generator that can be configured in its properties. Outputs of the PLC can be dedicated as pulse and direction outputs. Refer to the example projects and framework to see how to configure this.

Introduction to Programming

Once configured, the pulse generator can be assigned to a Motion Control Object. In the Project tree, the PLC contains a folder named Technology objects. Click on "Add new object" and choose "TO_PositioningAxis"
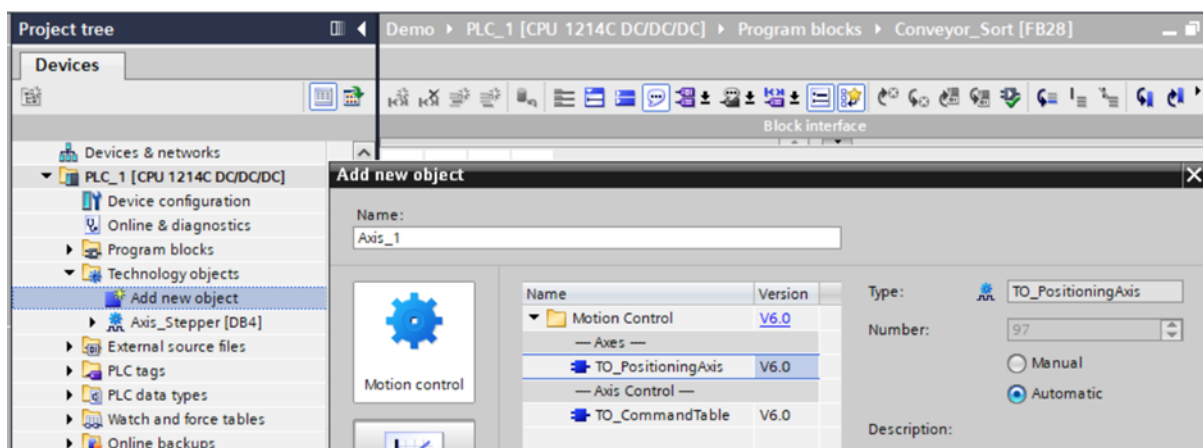
Refer to the example projects and framework to see how to configure the object. Once configured, motion control commands will be available in the Instructions toolbox under the heading Technology.

Introduction to Programming

Robot Arm

The robot arm is commanded using TCP communication. The instruction blocks that are used for this are found in the Communication section of the instruction toolbox under the Open user communication section. Refer to the example programs to see how these blocks are used. The robot arm has an application programming interface. Refer to the documentation of the robot arm product for details.

HMI Screens

Once added to the project, the HMI screen will appear in the Project tree. It will contain a folder named Screens and this folder includes the action "Add new screen." When editing a screen, the toolbox will contain Basic objects and elements that can be added to the screen. The first screen to be shown when the system starts up can be chosen by right clicking that screen and choosing "Define as start screen." The start screen is highlighted in the project tree by a small green arrow overlayed on its icon.

The properties of an object can include "Animations" that indicate the conditions of tags. These tags can be linked to tags in the PLC so that information about the running program is conveyed to the user.

The properties of an element can include events that change tags when the user interacts with the element on the screen. These tags can be linked to tags in the PLC so that the user can control the running program.

To add an indicator, drag a shape from the Basic objects toolbox onto a screen. Adjust the position of the object and resize it as required. In the properties for the shape, select the Animations tab. Click on "Add new animation" and select Appearance. Click on the ellipsis next to the tag name box to choose a tag to base the animation on. If a tag from the PLC is chosen then TIA Portal will automatically set up the required communication between the HMI and the PLC so that the tag is available in the HMI. A binary tag can be represented as a simple range type with different Background color for the zero and one states. If it is dull in the zero state and bright in the one state then it will appear to behave like an LED.

Introduction to Programming
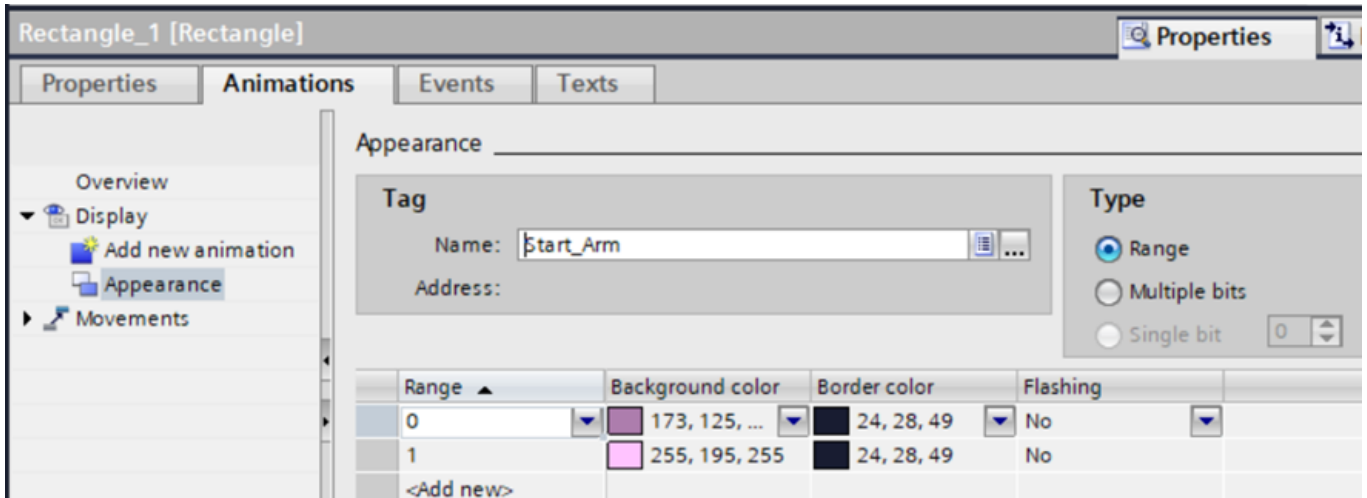
To add a control button, drag a button element from the toolbox onto a screen. Adjust position and size as required. In the properties for the element, select the Events tab. Choose the Release event and click on Add function. The drop down list that appears lists all the functions that can be configured to occur when the user touches and then releases the button. SetBit can be found under the Edit bits subheading. When the function is added, choose the tag that is to be set. TIA Portal will automatically set up the necessary communication with the PLC. If a switch element were chosen instead of a button then functions can be assigned to both Switch ON and Switch OFF events. SetBit and ResetBit would be logical choices here.
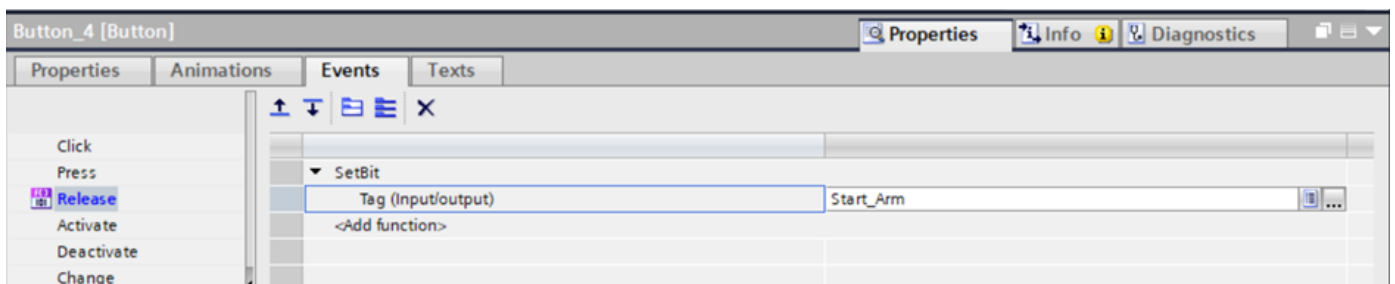
To add a navigation button, begin in the same way as adding a control button. Rather than setting a bit, add the ActivateScreen function to the button's Release event. When the user touches and then releases the button, the specified screen will be loaded.

Web server

The PLC contains a built-in webserver that can be invoked by adding a "WWW" object from the toolbox to a program block. The WWW object can be found in the Communication section of the toolbox.

Any files used by the webserver are included in the "Web Files" subfolder in the folder where the project is saved. These will include HTML pages, images, scripting libraries such as jQuerry and tables defining the tags that are accessible to the web server. The online documentation for TIA Portal outlines the process of compiling the web pages into data blocks that can be used by the web server. The example projects demonstrate how to control programs and report data using web pages.

To access the web server, a computer or mobile phone must be connected to the same network as the PLC. The web pages can be viewed by typing "http://" into the address bar of a web browser followed by the IP address of the PLC.