

AUTOMATICS

Simplifying pneumatics

Control pneumatics PLUS



AW4957

MATRIX
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Automatics control PLUS

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About this document:

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Developed for product code AW4955 – Automatics control add-on kit

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January 2013	First version released	AW4957-80-01
January 2015	New product codes and updated light sensor	AW4957-80-02

Worksheet 1

Electronic control

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In industry, complex pneumatic systems are often controlled by a microprocessor in systems called a programmable logic controllers (PLCs).

These make it relatively easy to:

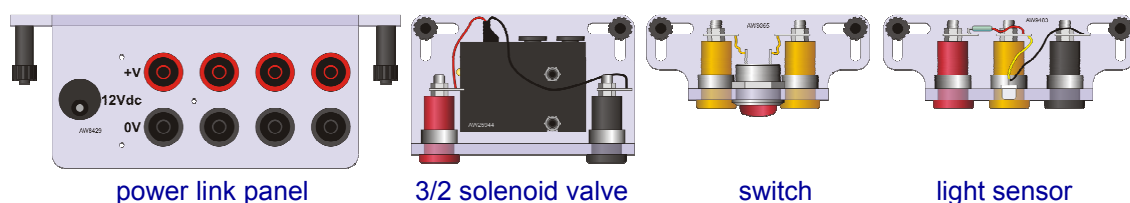
- extend and retract cylinders in any sequence;
- include timing and counting;
- make the system respond to sensors.

This module uses a MIAC (Matrix Industrial/Automotive Controller) to control pneumatic circuits.

Over to you:

- Build the arrangement shown on the next page, used to demonstrate how MIAC can control pneumatic valves. There are no pneumatic connections, only electrical ones!
- Clamp a switch and a light sensor to the platform.
 - Fasten a 3/2 solenoid valve to the platform.
 - Make the following connections:
 - power panel - red to MIAC V+ and black to MIAC 0V;
 - switch - red socket to power panel red and black socket to MIAC input 1;
 - light sensor - red socket to power panel red, black socket to power panel black and yellow socket to MIAC input 2;
 - solenoid valve - positive to MIAC output C and negative to power panel black.
- Plug in the power supply (12V), and switch on.
- At this point, you should create and transfer the controlling program 'Program 1' to the MIAC. Instructions for doing this start on page 6.
- Press the switch, and notice that the MIAC LED, labelled 'I1' lights. You should also hear the solenoid operate inside the control valve.
- Now shade the light sensor with your hand. Look at MIAC LED 'I2' as you do so. You should hear the solenoid valve operate again.

Automatics components:



power link panel

3/2 solenoid valve

switch

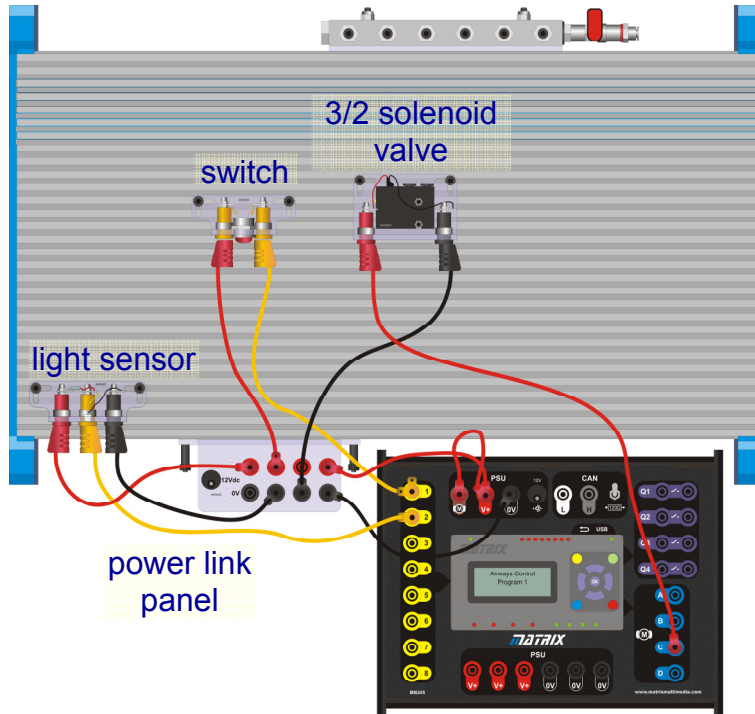
light sensor

Worksheet 1

Electronic control

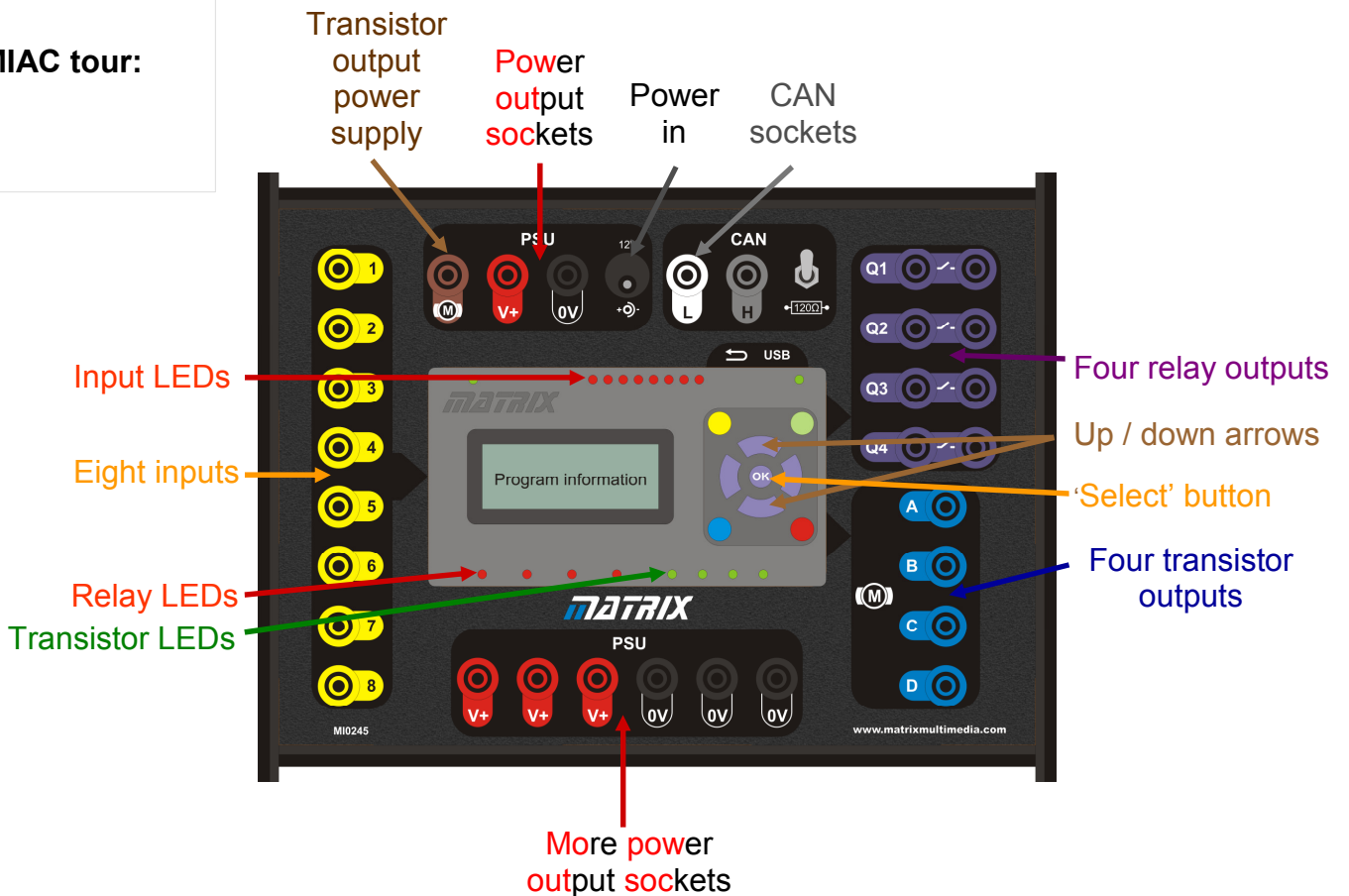
Automatics control PLUS

Layout for worksheet 1:



So what:

MIAC tour:



Worksheet 1

Electronic control

Automatics control **PLUS**

So what:

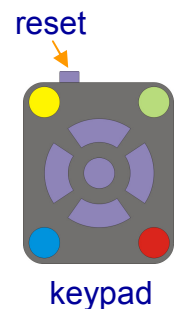
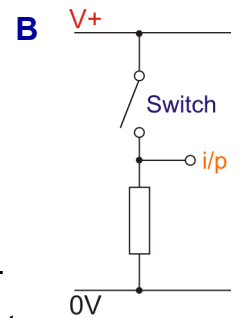
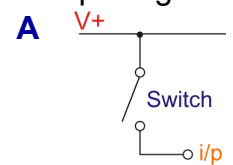
The tour continues:

- The MIAC is a fully specified industrial controller, housed in a rugged, anthracite grey plastic moulding at the centre of the unit, which is fitted with 4mm shrouded sockets, internally connected to all MIAC inputs and outputs (except CAN bus terminations).
- Designed to operate off 12 to 16V DC, it is powered by an 18F4455 microcontroller.
- It has eight analogue / digital inputs, (software controls whether each behaves as analogue or digital.) The input LEDs show analogue inputs at a brightness that reflects the input signal voltage. They are on or off when the input is configured as digital.

- A 10k pull-down resistor is connected to each input.

As a result:

- MIAC inputs sit at 0V when no external input signal is present;
- Passive sensing components like a switch or thermistor can be attached directly, as in circuit **A**, rather than requiring the full voltage divider sub-system, shown in circuit **B**.
- A keypad, consisting of nine input buttons is provided for user control.
- A 4 line 16 character LCD display shows system status and user information.
- The MIAC has four high current relay outputs and four transistor driven outputs. The output LEDs light when the corresponding output switches 'on'.
- The MIAC is programmed directly from the USB port of a computer. It is compatible with the Flowcode graphical programming language. Users can develop a program using Flowcode, press the reset button on top of the keypad, and the program will automatically download and start.



Overview of Program 1:

The sequence is:

- switch off the control valve;
- check whether the switch is pressed;
- if it is, switch on the control valve;
- then check whether the light sensor is in darkness;
- if it is, switch on the control valve;
- delay for a short interval;
- go back and start the sequence again.

In effect, the switch and light sensor are in a logic OR configuration.

The control valve switches on if the switch is pressed OR if the light sensor is in darkness.

Worksheet 1

Electronic control

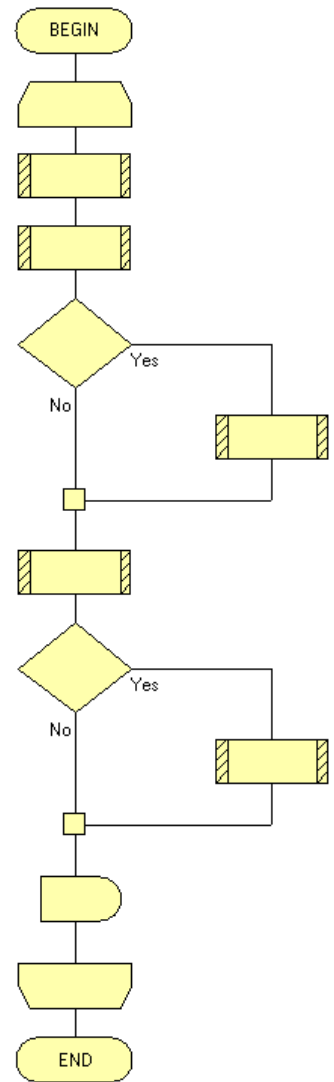
Automatics control **PLUS**

Over to you again:

The instructions that follow assume that the light sensor, switch and solenoid valve are connected to the MIAC as shown in the diagram on the page 4.

Creating program 1:

- Open the Flowcode program.
- Select 'Create a new Flowcode flowchart...'
- In the 'Project Options, Choose a Target' dialogue box, select 'MIAC' and click 'OK'.
- A flowchart window appears. In it, drag and drop a loop icon.
- Inside this loop icon, add:
 - two component macros, followed by
 - a decision icon, with a component macro in the 'Yes' loop
 - followed by another component macro
 - then a decision icon with a component macro in the 'Yes' loop
 - and finally a delay icon.
- The flowchart should resemble the one opposite:
- Next, add a MIAC icon to the panel area.
(If the panel is not visible, click the 'View / Panel' item.)
Then click on 'MIAC' under the 'Misc' tab.
- The next step is to configure the icons.
- First, create two variables - `switch` and `light`, as byte variables. You can do this by clicking on the down arrow which appears when the cursor is next to the 'Variables' label in the 'Edit / Variables...' dialogue box.
- Configure each icon by double-clicking on it and then modify it to match those shown on the next page.



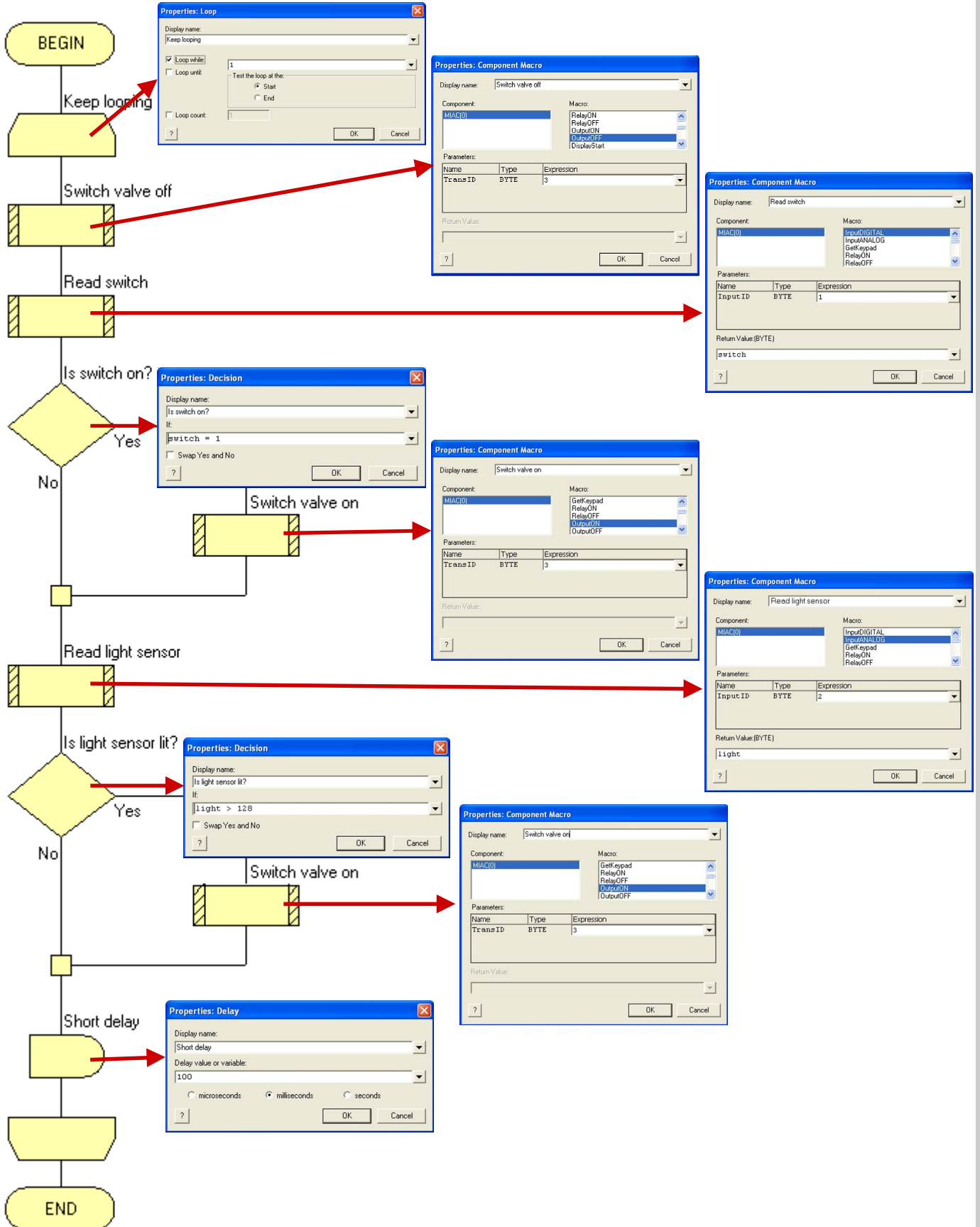
f1a

Worksheet 1

Electronic control

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Over to you again:



Worksheet 1

Electronic control

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PLUS**

Over to you again:

Save and transfer program 1:

- Save your program as 'Program 1'.
- Connect the USB port of your computer to the MIAC USB port.
- Transfer the program to the MIAC by clicking on 'Build / Compile to Chip...' option.
- The system is now ready for testing, following the procedure described on page 3.

For your records:

Use a multimeter to measure the quantities listed below.

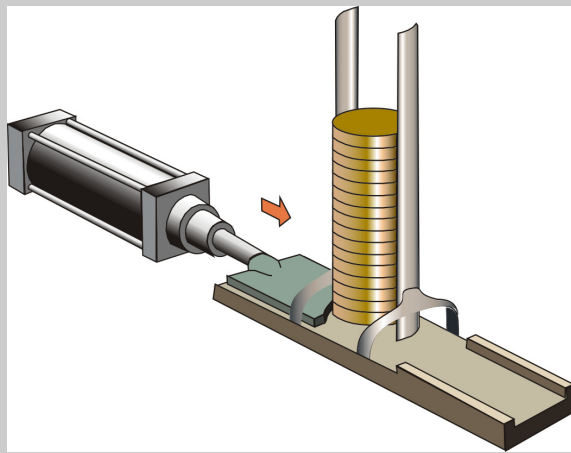
Then copy and complete the table with your results.

Quantity	Measurement
MIAC input 1 – switch not pressed	
MIAC input 1 – switch pressed	
MIAC input 2 – light sensor in daylight	
MIAC input 2 – light sensor in darkness	
MIAC output C – solenoid not activated	
MIAC output C – solenoid activated	

Worksheet 2

Magazine feed

Automatics control PLUS



In automated production, it is often necessary to feed blanks into the process from a store, known as a magazine.

Pneumatics offers a reliable and speedy way to do this, as the diagram illustrates. A single-acting cylinder pushes a new blank onto the conveyor belt, and then retracts.

This worksheet examines how an electronic control system can automate this part of the process.

Over to you:

- **Read the safety rules given on the next page before you start.**
- **The red lever on the manifold must be turned off at this stage.**
- Build the arrangement shown on the next page. Compare the physical and pneumatic circuit diagrams, as you do so.
 - Clamp a switch and a 3/2 solenoid valve to the platform.
 - Add a flow-control valve, to restrict flow in the direction shown by the arrow.
 - Make the following electrical connections:
 - power panel - red to MIAC V+ and black to MIAC 0V;
 - switch - red socket to power panel red and black socket to MIAC input 1;
 - solenoid valve - positive to MIAC output **C** and negative to power panel black.
- Plug in the power supply (12V), and switch on.
- Turn on the air supply.
- Next, create and transfer the controlling program 'Program 2A' to the MIAC. Instructions for doing this start on page 11.
- The switch represents a safety device:
 - It could ensure that a cover is in place over the machinery.
 - It could be a 'dead-man's handle' (emergency stop button) which stops the process unless the operator keeps the switch pressed.
- Press and hold down the switch. The cylinder extends and retracts repeatedly, governed by the time delays built into the program. This is described later.
- Adjust the flow rate with the flow control valve so that the cylinder extends fully, within the time allowed, but does so at a moderate speed.

Worksheet 2

Magazine feed

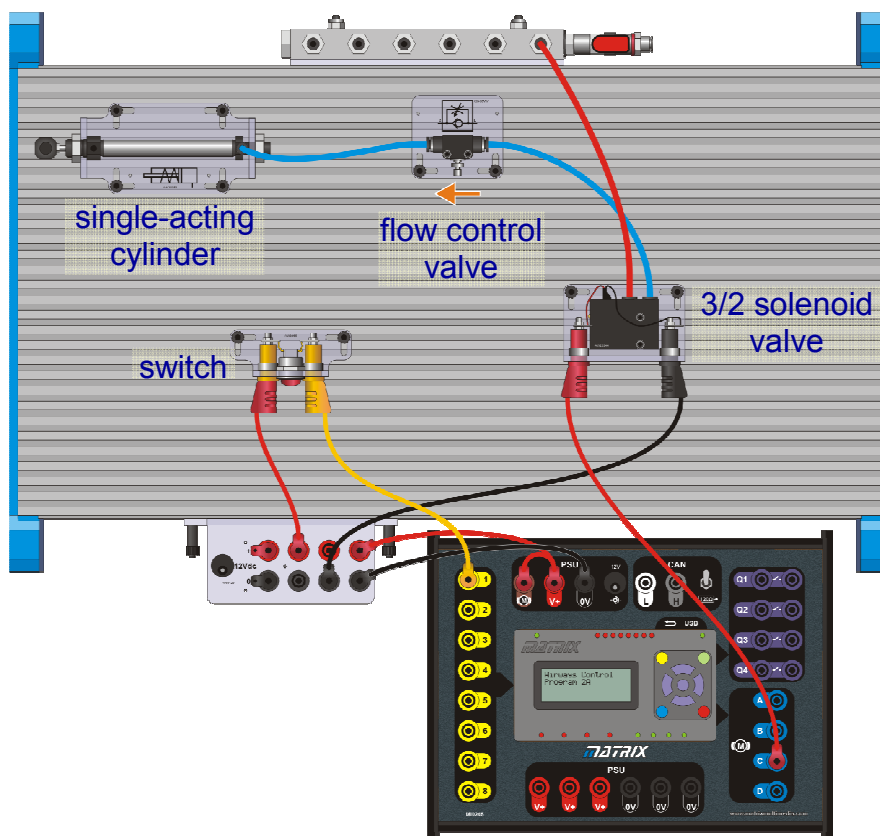
**Automatics control
PLUS**

Safety Rules for Pneumatic Systems

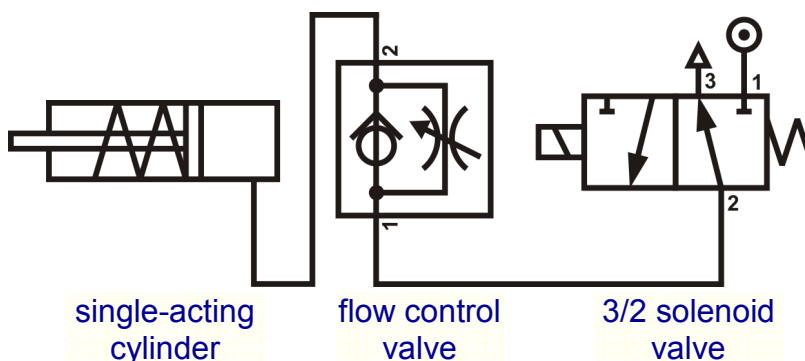
Remember that compressed air and its components are capable of exerting large forces.

1. Never blow compressed air at anyone.
2. Don't turn on the air supply until the circuit is complete.
3. If you find an air leak, turn off the air supply at once.
4. Always turn off the air supply before you alter a circuit.
5. Keep fingers clear of moving parts such as piston rods.
6. Wear safety spectacles when building and operating pneumatic circuits.

Layout for worksheet 2:



Pneumatic circuit for worksheet 2:



Worksheet 2

Magazine feed

Automatics control PLUS

Over to you:

Overview of Program 2A:

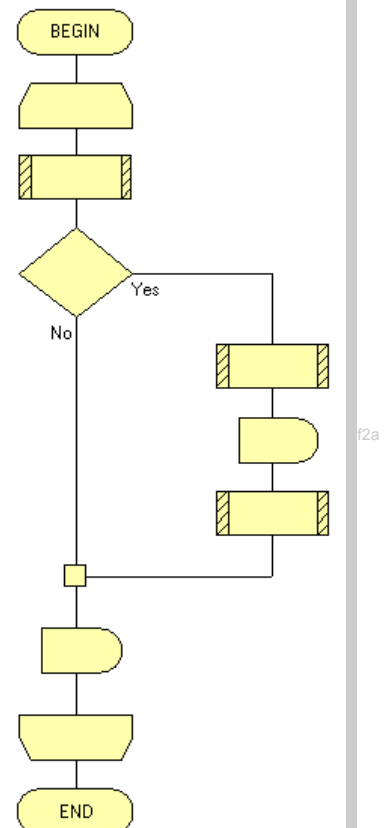
The program is similar to that used in worksheet 1, except that the light sensor is not needed. There are two delays, one to allow the cylinder to extend fully, and one to delay the next blank until the production process is ready for it.

The sequence is:

- check whether the switch is pressed;
- if it is, switch on the control valve;
- wait while the valve extends (1 second);
- switch off the control valve;
- wait until the process needs the new blank (3 seconds);
- go back and start the sequence again.

Creating program 2A:

- Open the Flowcode program.
- Select 'Create a new Flowcode flowchart...'
- In the 'Project Options, Choose a Target' dialogue box, select 'MIAC' and click 'OK'.
- A flowchart window appears. In it, drag and drop a loop icon.
- Inside this loop icon, add:
 - a component macro,
 - then, a decision icon with, in the 'Yes' loop:
 - a component macro,
 - a delay,
 - a second component macro,
 - and finally a second delay icon.
- The flowchart should resemble the one opposite:
- Next, add a MIAC icon to the panel area, by clicking on 'MIAC' under the 'Misc' tab.
(If the panel is not visible, click the 'View / Panel' item.)
- The next step is to configure the icons.
- First, create a new variable - switch, as a byte variable.
You can do this by clicking on the down arrow which appears when the cursor is next to the 'Variables' label in the 'Edit / Variables...' dialogue box.
- Configure each icon by double-clicking on it and then modify it to match those shown on the next page.

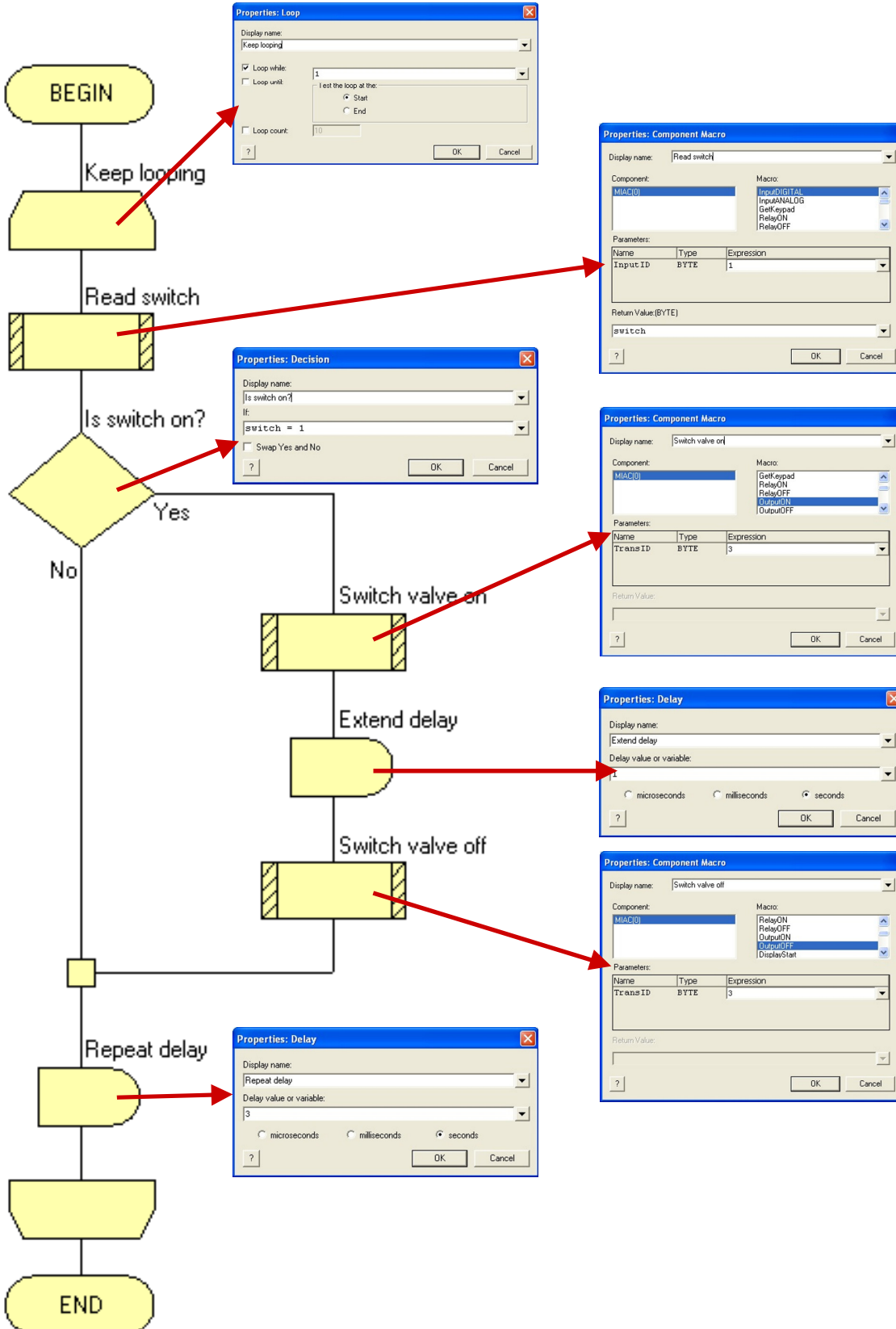


Worksheet 2

Magazine feed

Automatics control PLUS

Over to you:



Worksheet 2

Magazine feed

Automatics control PLUS

Over to you again:

Save and transfer program 2A:

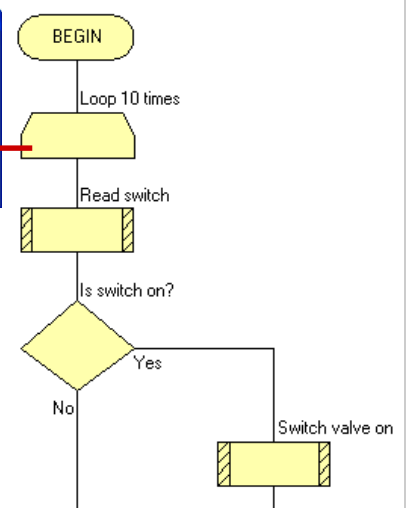
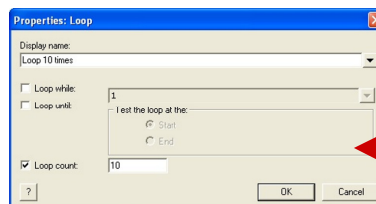
- Save your program as 'Program 2A'.
- Connect the USB port of your computer to the MIAC USB port.
- Transfer the program to the MIAC by clicking on 'Build / Compile to Chip...' option.
- The system is now ready for testing, following the procedure described on page 9.

A modification:

The processing company may want a limited run on a particular commodity. The program you just developed keeps running as long as the switch is pressed.

A modification to this, Program 2B, will loop back only ten times, causing only ten blanks to be processed.

- The only change needed is to the way the loop is configured. This is shown in the diagram opposite:
- Save the modified program as 'Program 2B', and transfer it to the MIAC as described above.
- Test it by pressing and holding down the switch. The cylinder now extends and retracts only ten times. The microprocessor keeps a loop count, and only carries out the looping ten times.



For your records:

- Copy the flowchart for program 2B, given above.
- Explain the function of each icon in the flowchart.
- Which icon would be modified to:
 - make the process repeat 20 times;
 - increase the time between the cylinder extending and retracting;
 - increase the time between process cycles.
- How would you make the cylinder extend more quickly?

Worksheet 3

Bank vault door controller

Automatics control **PLUS**



Bank vaults often have heavy steel doors for enhanced security. Their weight makes them difficult to move manually.

They can be opened and closed pneumatically, using a double-acting cylinder. This can be linked to an electronic security system, requiring a correct PIN number, finger-print or retina scan.

This worksheet looks at the control system for the pneumatic circuit.

Over to you:

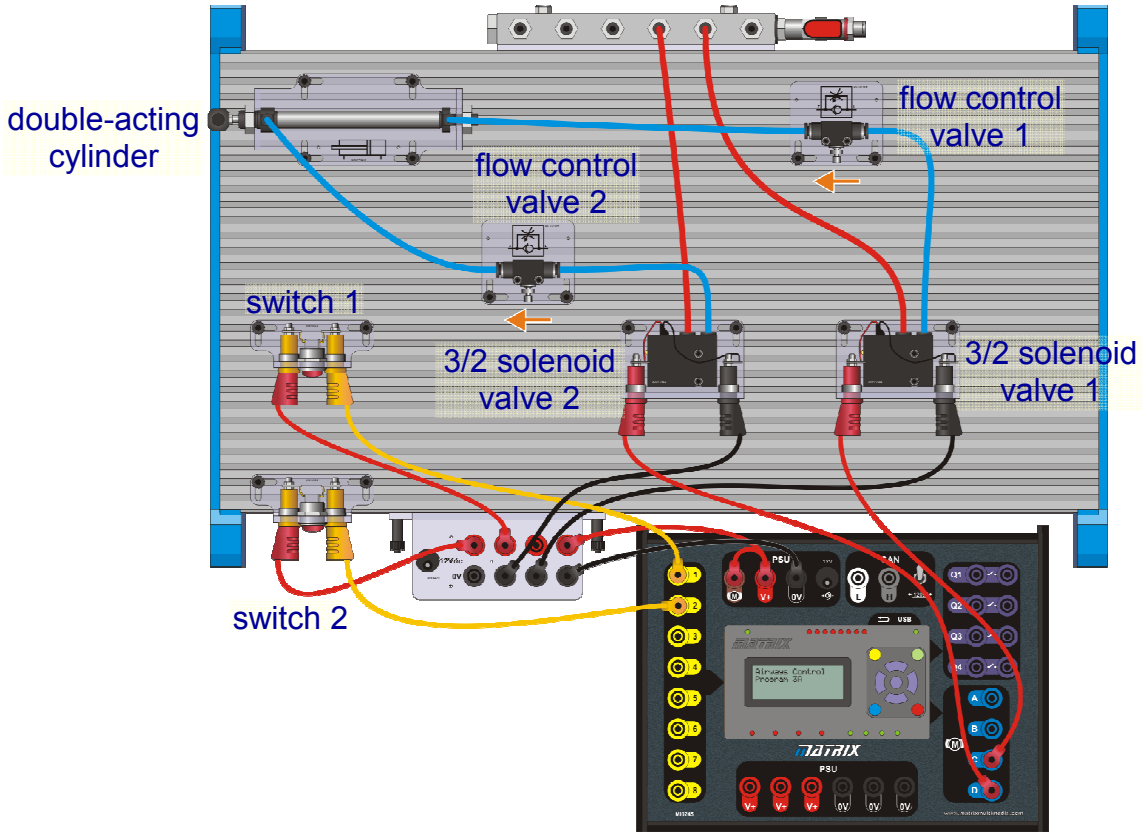
- **Make sure that you apply the safety rules given in the previous worksheet!**
- **The red lever on the manifold must be turned off at this stage.**
- Build the arrangement shown on the next page. Again, compare the physical and pneumatic circuit diagrams.
- Make the following electrical connections:
 - power panel - red to MIAC V+ and black to MIAC 0V;
 - switch 1 - red socket to power panel red and black socket to MIAC input 1;
 - switch 2 - red socket to power panel red and black socket to MIAC input 2;
 - solenoid valve 1 - positive to MIAC output **C** and negative to power panel black;
 - solenoid valve 2 - positive to MIAC output **D** and negative to power panel black.
- Plug in the power supply (12V), and switch on.
- Turn on the air supply.
- Next, create and transfer the controlling program 'Program 3A' to the MIAC. Instructions for doing this start on page 16.
- Press and hold down switch 1. The cylinder extends. Adjust the flow rate with flow control valve 1 so that it extends fully at a moderate speed.
- Press and hold down switch 2. The cylinder now retracts. Again, adjust the flow rate, now with flow control valve 2 so that it also retracts at a moderate speed.

Worksheet 3

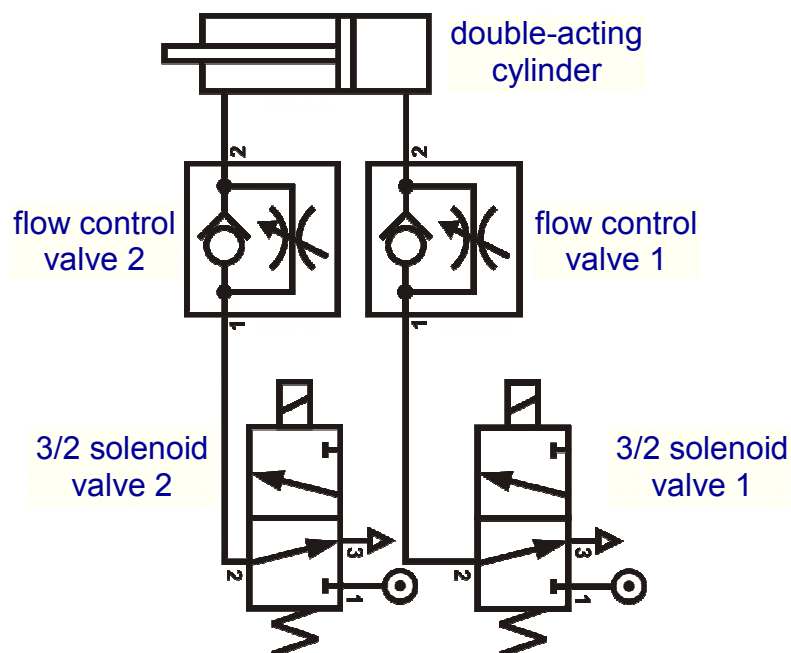
Bank vault door controller

Automatics control PLUS

Layout for worksheet 3:



Pneumatic circuit for worksheet 3:



Worksheet 3

Bank vault door controller

Automatics control **PLUS**

Over to you:

Overview of Program 3A:

There are two sections in the program. One responds to closing the 'extend' switch, and the other to closing the 'retract' switch

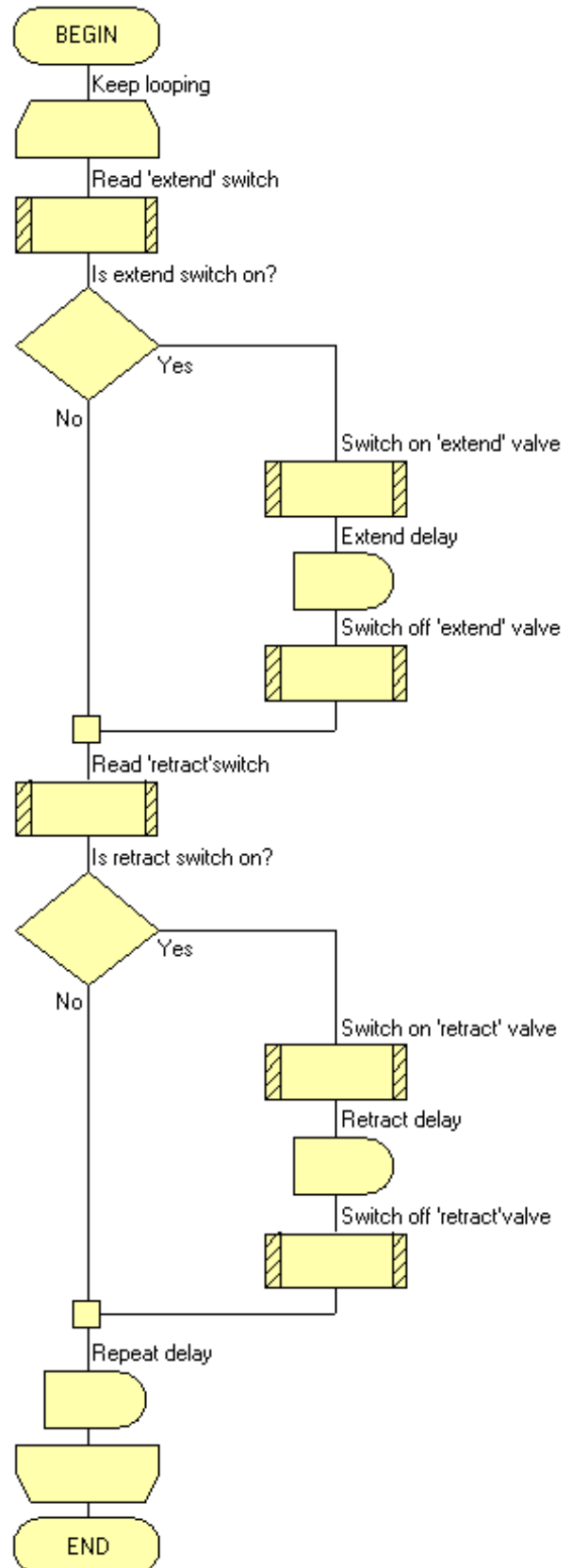
The sequence is:

- check whether the 'extend' switch is closed;
- if it is, switch on the 'extend' control valve;
- wait while the valve extends (0.5 second);
- switch off the 'extend' control valve;
- check whether the 'retract' switch is closed;
- if it is, switch on the 'retract' control valve;
- wait while the valve retracts (0.5 second);
- switch off the 'retract' control valve;
- wait to let the system settle (1 second);
- go back and start the sequence again.

Creating program 3A:

This time, less of the programming is done for you. Use your experience from the previous programs the sequence given above, and the outline opposite to complete the program for yourself.

- Open the Flowcode program, and create a new flowchart.
- In the 'Project Options, Choose a Target' dialogue box, select 'MIAC' and click 'OK'.
- In the flowchart window, create a flowchart like the one opposite:
- Add a MIAC icon to the panel area.
- Next, create two variables - `switch1` (for the 'extend' operation, and `switch2`, for the 'retract' operation. Both are a byte variables.
- Now configure the icons. (A possible solution is given in the Instructor's Guide.)



f3a

Worksheet 3

Bank vault door controller

Automatics control PLUS

Over to you:

Save and transfer program 3A:

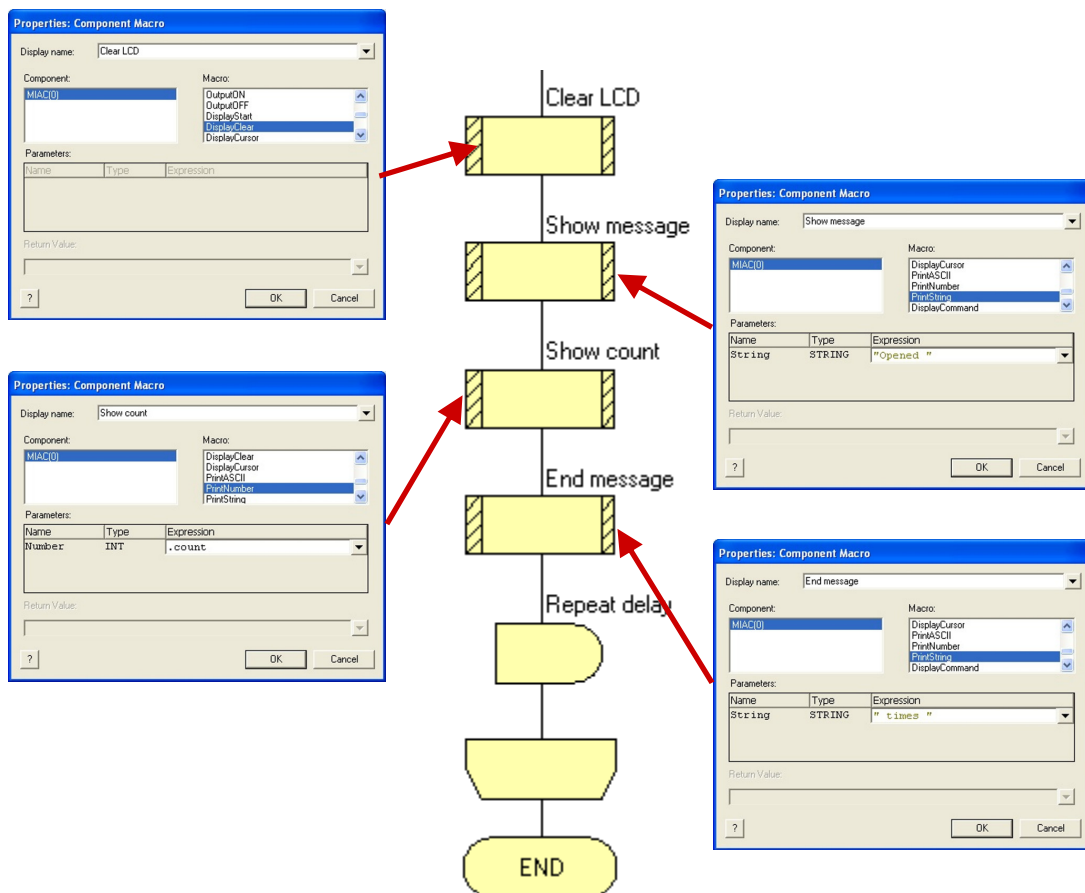
- Save your program as 'Program 3A', and transfer it to the MIAC in the usual way.
- Test the system, following the procedure described on page 14.

A modification:

The bank wants to monitor how many times the bank vault is opened. This is done by incrementing (adding one to) a counter, built into the MIAC, and displaying this on the LCD display.

There are **two** modifications to the flowchart. The first is shown below. The second is on the next page.

- Add a LCD component to the panel, from the 'Outputs' tab.
- Create a new variable 'count'.
- Modify the final section of the flowchart to match that shown below.
- Configure the added icons as shown.



Worksheet 3

Bank vault door controller

Automatics control PLUS

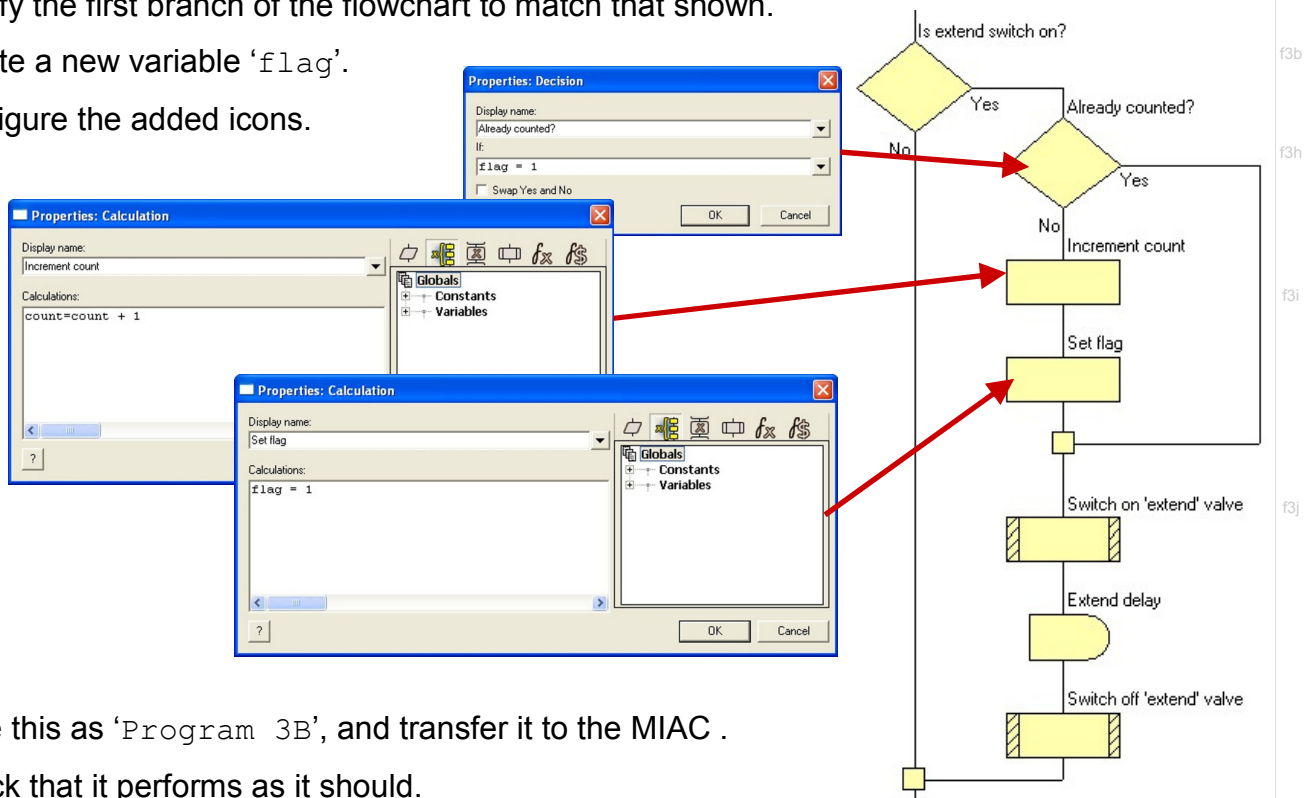
Over to you:

A complication! The program takes only milliseconds to complete. While a switch is pressed, it may cycle several times. We want to count how many times the door is opened, and then closed, not how many times the program cycles. This brings in the use of a flag.

When the door is first opened, the flag is not set ('flag' = 0), and so the count is incremented. In addition, the flag is set ('flag' = 1). When the program simply loops again, while that switch is still pressed, no further increments take place, as the flag remains set.

When the 'retract' switch is pressed, one effect is to reset the flag, ('flag' = 0 again.) The next time the door is opened, the count is incremented, and the process described above repeats.

- Modify the first branch of the flowchart to match that shown.
- Create a new variable 'flag'.
- Configure the added icons.



- Save this as 'Program 3B', and transfer it to the MIAC .
- Check that it performs as it should.

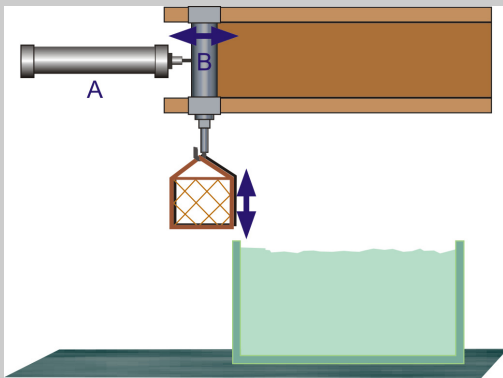
For your records:

- Explain why a double-acting cylinder is better than a single-acting cylinder for this application.
- The introduction hints at security features that could be linked to the door control system. These could use the same microprocessor as that used to open and close the door. Explain in less than 100 words the advantages and disadvantages of the following security features:
 - PIN.
 - retinal scan.
- Describe two additional safety / security features that could be built into this door controller.

Worksheet 4

In sequence

**Automatics control
PLUS**



Many applications of pneumatics require two, or more, cylinders to operate together in a sequence.

In the 'Automatics Pneumatics' module, it was shown how a purely pneumatic circuit could control a system used to move a basket of car components into and out of a tank of cleaning fluid. The sequence needed was **A+**, **B+**, **B-**, **A-**. That system used three 5/2 control valves, and five 3/2 control valves, and had to be rebuilt to accommodate any modification of the sequence.

In this worksheet, we show how a standard pneumatic circuit can be made to perform different sequences simply by choosing the appropriate program.

Over to you:

- **Make sure that the red lever on the manifold is turned off.**
- Build the arrangement shown on the next page. Only the pneumatic circuit diagram is given. However, the connections for each cylinder are the same as in the last worksheet.
- Make the following electrical connections:
 - power panel - red to MIAC V+ and black to MIAC 0V;
 - switch 1 - red socket to power panel red and black socket to MIAC input 1.
 - switch 2 - red socket to power panel red and black socket to MIAC input 2.
 - solenoid valve **a+** - positive to MIAC output **A** and negative to power panel black.
 - solenoid valve **a-** - positive to MIAC output **B** and negative to power panel black.
 - solenoid valve **b+** - positive to MIAC output **C** and negative to power panel black.
 - solenoid valve **b-** - positive to MIAC output **D** and negative to power panel black.
- Plug in the power supply (12V), and switch on. Then turn on the air supply.
- Next, create and transfer the controlling program 'Program 4A' to the MIAC. Instructions for doing this start on page 20.
- Press and hold down switch 1. The sequence should begin by extending cylinder **A**, to move the basket of components over the tank. Adjust the flow control valve to give a sensible speed of movement.
- Press switch 2 to extend cylinder **B** to lower the basket into the tank. After a delay of ten seconds, cylinder **B** should retract, raising the tank.
- Now press switch 1 again. This time it retracts cylinder **A**, returning the basket to its initial position.

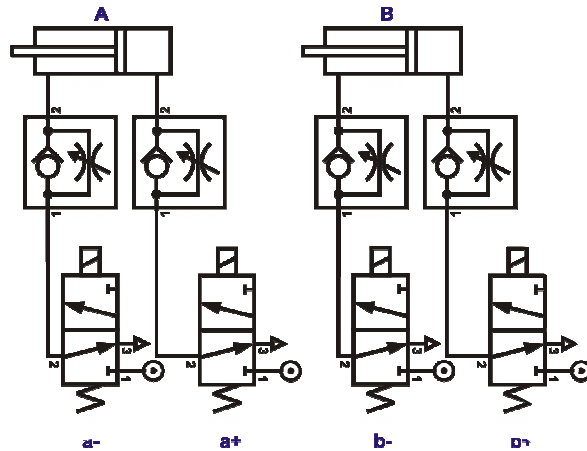
Worksheet 4

In sequence

**Automatics control
PLUS**

Over to you:

Pneumatic circuit for worksheet 4:



Overview of Program 4A:

The program is shown in four sections:

- The first monitors switch 1.
When it is pressed, cylinder **A** extends, to move the basket over the tank.
- The second waits until the first section is complete and then monitors switch 2.
When this is pressed, cylinder **B** extends, to lower the basket into the cleaning tank.
- The third follows automatically. The ‘immerse delay’ keeps the basket in the cleaning fluid for five seconds.
Valve **b+** is then switched off, and valve **b-** actuated to raise the basket from the tank.
- The fourth again monitors switch 1.
When pressed, valve **a+** is switched off, retracting cylinder **A** to return the basket to its starting position. The ‘return delay’ actuates valve **a-** for one second.

Creating program 4A:

Use your experience from the previous programs, the sequence given above, and the outline on the next page to complete the program for yourself.

- Open the Flowcode program, and create a new flowchart.
- Select the 18F4455 PIC microcontroller as target, and click ‘OK’.
- Create a flowchart combining all four sections shown on the next page. Notice the three break points, ‘A’, ‘B’ and ‘C’. The details of how to configure these are given on the next page.
- Add a MIAC icon to the panel area.
- Next, create two variables - ‘switch1’, and ‘switch2’. Again, both are a byte variables.
- Now configure the icons. Remember which MIAC output controls which valve!
(A possible solution is given in the Instructor’s Guide.)
- Save your program as ‘Program 4A’, and transfer it to the MIAC in the usual way.
- Test the system, following the procedure described on page 19.

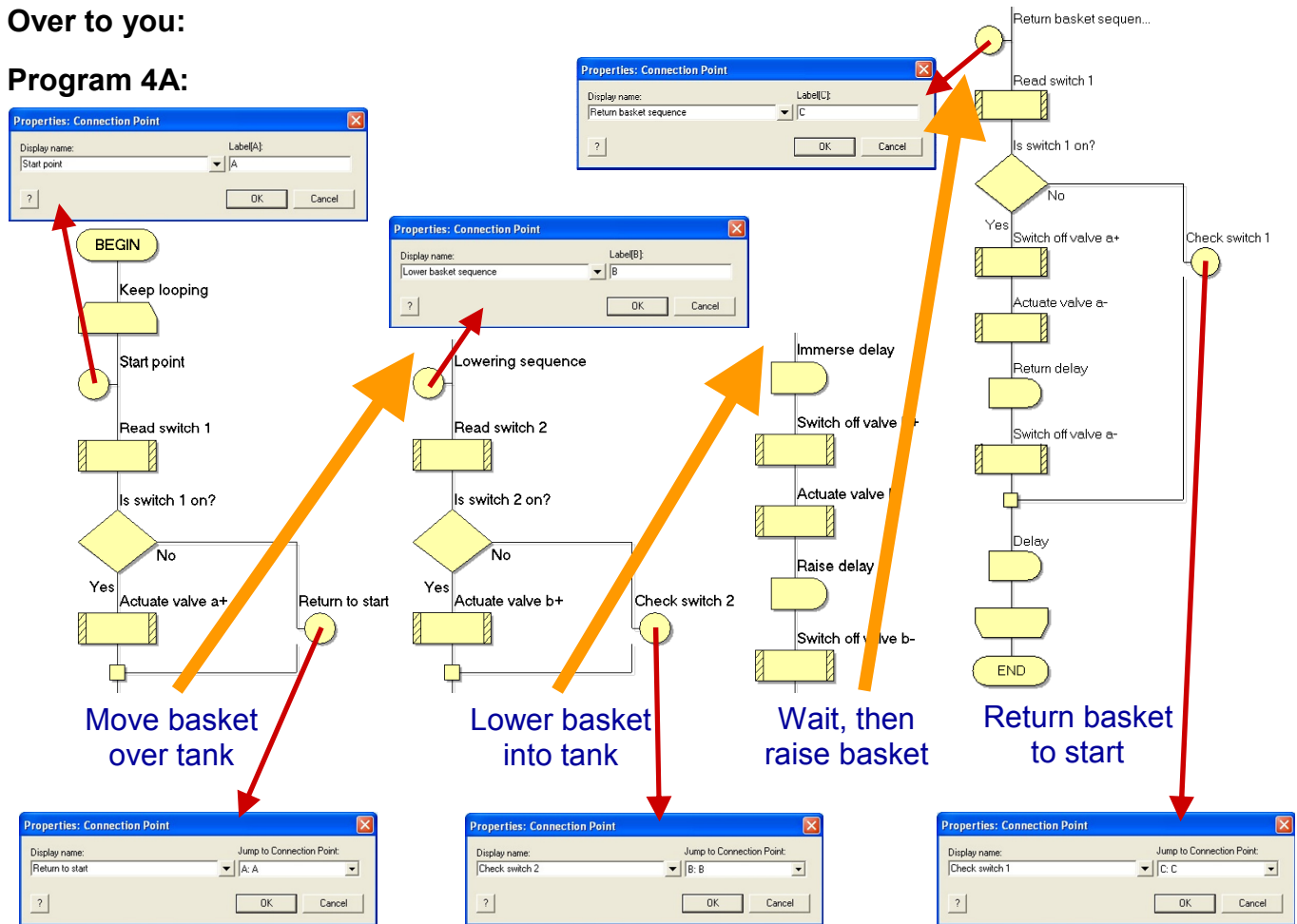
Worksheet 4

In sequence

Automatics control PLUS

Over to you:

Program 4A:



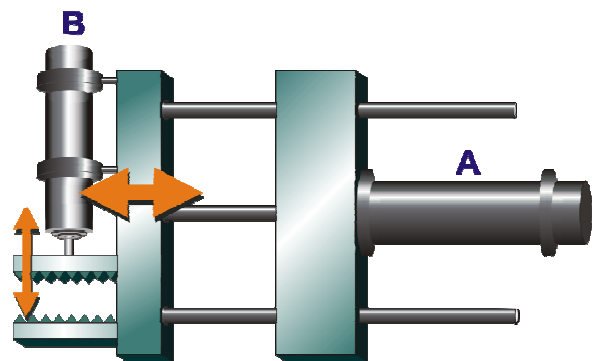
A change in the program but not in the hardware:

The next pneumatic control system operates a gripper. The aim is that the gripper reaches out and brings back an object, such as a cup, when a switch is pressed.

The sequence required is:

- reach out (**A+**);
- grip (**B+**);
- bring back (**A-**);
- release (**B-**).

The pneumatic circuit is the same as before.



Worksheet 4

In sequence

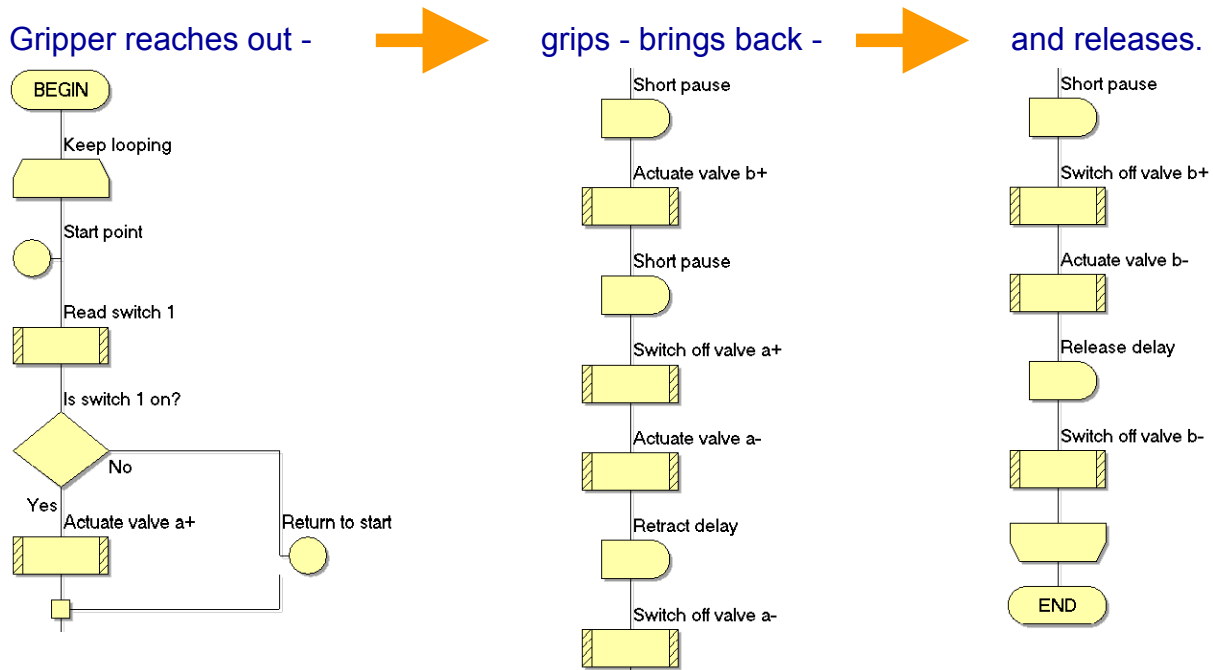
Automatics control PLUS

Over to you:

Overview of Program 4B:

The program is shown in three sections:

- The first checks switch 1, extending cylinder **A** when pressed, to move the gripper forwards.
- After a short pause, cylinder **B** extends to operate the grip mechanism. After a pause, **A** retracts, pulling the object back. The 'Retract' delay keeps valve **a-** actuated for one second.
- The third section retracts cylinder **B**, releasing the grip on the object, by actuating valve **b-** for one second, the 'Release' delay.
- The 'Short pause's allow a one second break between each stage of the sequence.



Creating program 4B:

- Create a new flowchart combining the three sections shown on the next page.
- Add a MIAC icon to the panel and create a variable - 'switch1'.
- Now configure the icons. Remember which MIAC output controls which valve!
- Save your program as 'Program 4B', and transfer it to the MIAC in the usual way.
- Press switch 1, and then release it. Check that the correct sequence follows.

For your records:

- A problem with the basket controller - the basket will lower itself again when **b-** switches off, because of the weight of the basket and contents. How do you overcome this?
- What sequence would be required to control an air lock, where cylinder **A** operates the outer door, and **B** the inner door? Explain each stage of the sequence as part of your answer.

Worksheet 5

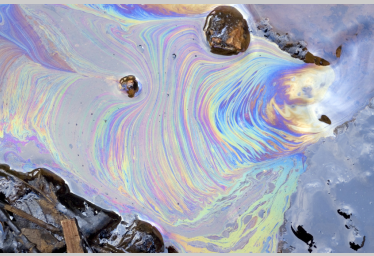
Feedback

Automatics control PLUS

The programs created so far operate blindly. The MIAC continues to send out signals without knowing whether the cylinders respond or not. The reed switch provides feedback to the control system, to let it know that a cylinder has extended or retracted, called 'proof of position'.

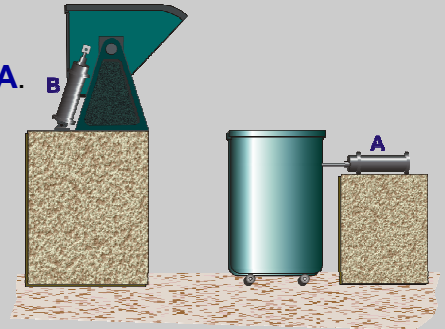
This worksheet illustrates why this is important.

The scenario - a container is pushed under a hopper by cylinder **A**.



Cylinder **B** then tips the hopper to pour its contents into the container.

The control system needs to know when cylinder **A** fails to function, as otherwise cylinder **B** will tip the contents of the hopper onto the floor!



Over to you:

Version 1 - No feedback

The sequence could be the same used at the beginning of worksheet 4.

We incorporate a slight modification, so that cylinders **A** and **B** retract at the same time.

- **Make sure that the red lever on the manifold is turned off.**
- Build the arrangement shown in the pneumatic circuit diagram on the next page. It is the same as in the last worksheet.
- Make the same electrical connections as in the last worksheet:
 - power panel - red to MIAC V+ and black to MIAC 0V.
 - switch 1 - red socket to power panel red and black socket to MIAC input 1.
 - solenoid valve **a+** - positive to MIAC output **A** and negative to power panel black.
 - solenoid valve **a-** - positive to MIAC output **B** and negative to power panel black.
 - solenoid valve **b+** - positive to MIAC output **C** and negative to power panel black.
 - solenoid valve **b-** - positive to MIAC output **D** and negative to power panel black.
- Plug in the power supply (12V), and switch on. Then turn on the air supply.
- Next, create and transfer the controlling program 'Program 5A' to the MIAC. Instructions for doing this start on the next page.
- Press switch 1 to initiate the sequence. It begins by extending cylinder **A**, to push the container into position. Adjust the flow control valve to give a sensible speed of movement. Then cylinder **B** extends to tip the hopper. Again, adjust the flow-rate to a sensible value. After a short delay, both cylinders retract, returning the hopper and container to their initial positions.

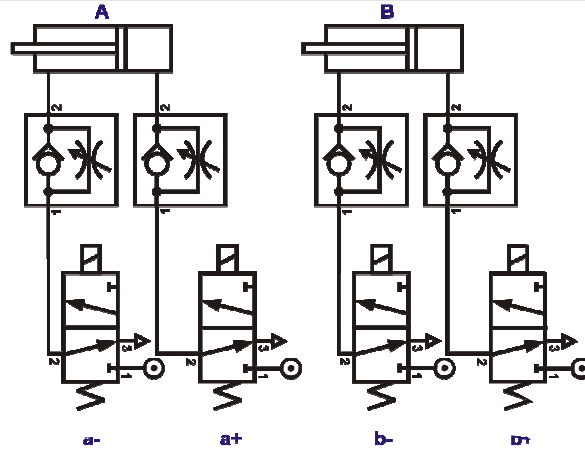
Worksheet 5

Feedback

Automatics control **PLUS**

Over to you:

Pneumatic circuit for worksheet 5:



Overview of Program 5A:

The program moves the container into position, tips it, waits and then returns both the hopper and container to the start.

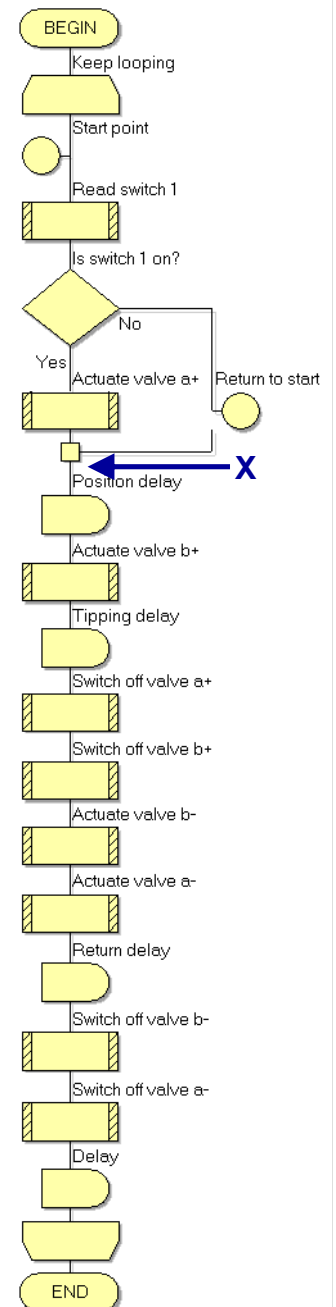
Initially, it is like earlier ones - there is no feedback to let the system know what the hardware is doing.

The flowchart is shown opposite. (The point labelled **X** is identified for later discussion about adding feedback. Ignore it for the moment!)

Creating program 5A:

Use the outline opposite to complete the program for yourself.

- Create a new flowchart, correctly targeted, based on the flowchart.
- Add a MIAC icon to the panel area.
- Next, create a variable - 'switch1'.
- Now configure the icons.
Remember which MIAC output controls which valve!
(A possible solution is given in the Instructor's Guide.)
- Save your program as 'Program 5A', and transfer it to the MIAC in the usual way.
- Test the system, following the procedure described on the previous page.



Worksheet 5

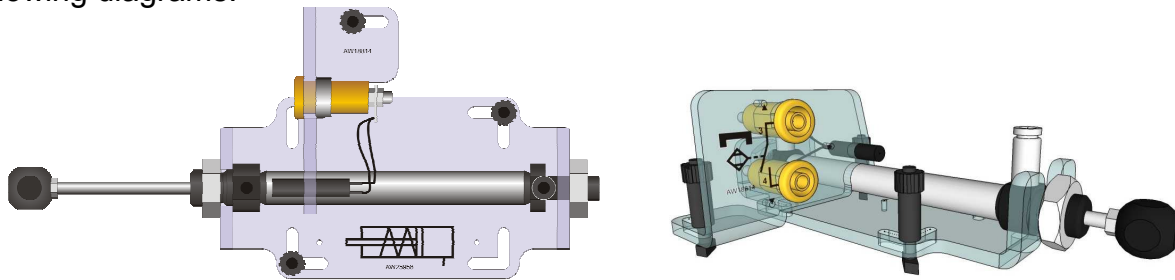
Feedback

Automatics control PLUS

Over to you:

Version 2 - with feedback:

- Switch off, and then disconnect the power supply.
- Using the same pneumatic circuit as before, add a reed relay to cylinder **A**, as shown in the following diagrams:



- The piston inside the cylinder is magnetised, and when it approaches the reed relay, the magnetic field causes the contacts in the reed relay to close.
- Connect one socket on the reed relay to MIAC V+, and the other to MIAC input 2.
- Plug in the power supply (12V), and switch on.
- Next, create and transfer the controlling program 'Program 5B' to the MIAC. Instructions for doing this start on the next page.
- Press switch 1 to initiate the sequence. As before, it begins by extending cylinder **A**, to push the container into position, and then extends cylinder **B** to tip the hopper, before both cylinders retract.
- **Turn the red lever to switch off the air supply.**
- Identify the pipe that supplies cylinder **A** from the manifold, and disconnect it from the manifold. (Remember that the manifold outlets are self-sealing. Air will not come out unless a pipe is pushed in.)
- Turn on the air supply, and press switch 1 again. Notice the difference!

w5d

w5e

Worksheet 5

Feedback

Automatics control **PLUS**

So what:

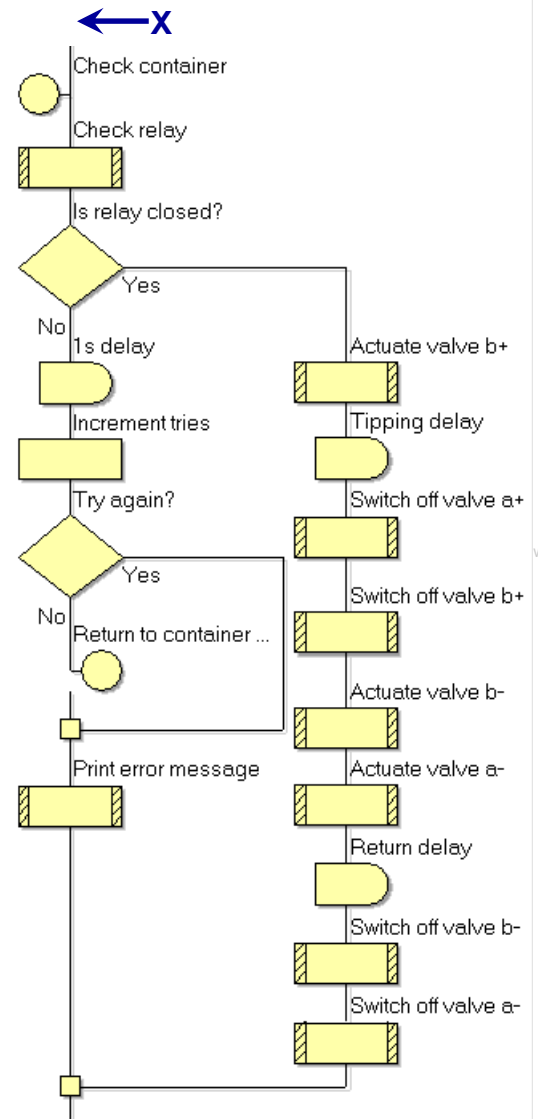
Overview of Program 5B:

The program is the same as program 5A, except that:

- it requires a LCD component on the panel;
- it requires another variable 'tries';
- it starts with a macro to clear the LCD;
- it adds the section shown opposite, at the point **X**, in the earlier diagram of program 5A. This uses the reed relay output to check that cylinder **A** has extended.
 - If it has, the program proceeds as before, by extending cylinder **B** etc.
 - If it has not, then the program loops back to check the relay five times, including a one second delay each time, before posting an error message on the LCD.
- the 'Position delay' is removed because the reed relay actively senses when cylinder **A** is extended.

Creating program 5B:

- Modify program 5A, as outlined above.
- Save your program as 'Program 5B'.
- Transfer it to the MIAC in the usual way.
- Test the system, following the procedure described on the previous page.

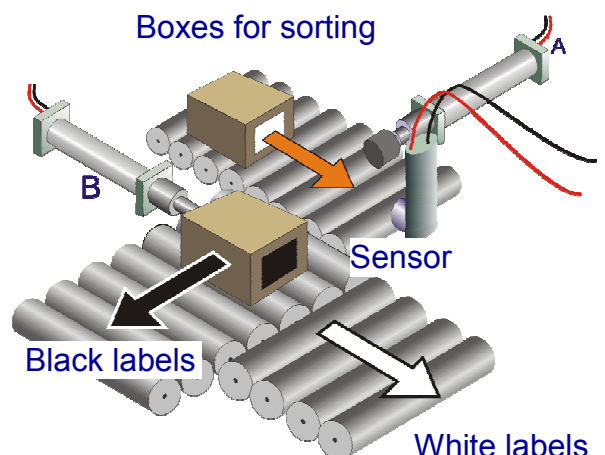


For your records:

Many modern production facilities use pneumatic systems to sort their products. In one version, a sensor 'reads' a barcode stuck on the side of the product.

Design a system that models this behaviour. Instead of a bar code, the products carry either a black label or a white one. They are sorted and sent down the appropriate conveyor belt.

Draw the flowchart for this system, using the ones given in the worksheets so far as a guide.



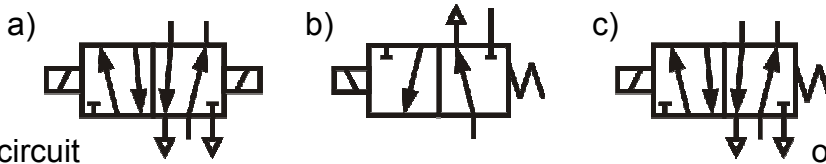
Revision questions

Automatics control PLUS

About these questions

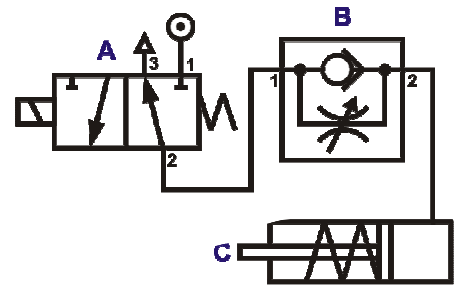
For questions 1 to 6, choose the correct answer (a, b or c).

- Electrically operated pneumatic valves are operated by a:
 - solenoid
 - lever
 - permanent magnet
- Which is the correct description of a 'normally-open' push switch, connected in a circuit?
 - It has no cover on it.
 - It has a very low resistance when pressed.
 - it has a high voltage across it when pressed, and a low voltage when not pressed.
- What kind of switch is actuated by the magnetic piston ring of a cylinder?
 - reed switch
 - push switch
 - toggle switch
- Which is the correct symbol for a solenoid operated, spring return 5/2 control valve?
 - Port 3 on valve **A** is an exhaust port.
 - Flow control valve **B** is connected the wrong way round to control the flow of air into cylinder **C**.
 - When valve **A** is actuated, cylinder **C** will retract.



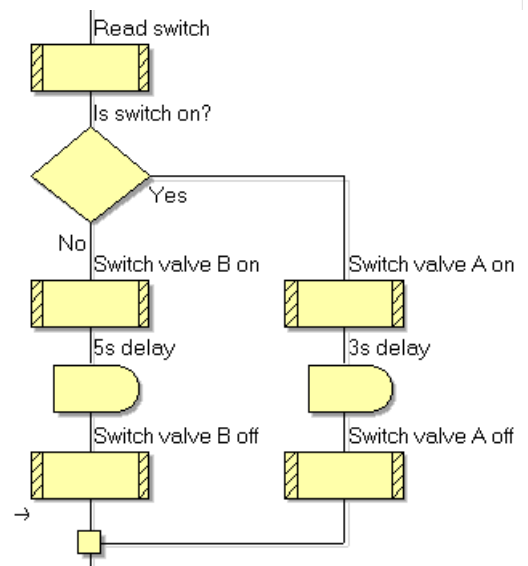
5. Which the pneumatic circuit

- Port 3 on valve **A** is an exhaust port.
- Flow control valve **B** is connected the wrong way round to control the flow of air into cylinder **C**.
- When valve **A** is actuated, cylinder **C** will retract.



6. Look at the segment of a Flowcode program shown below. Which statement is true?

- When the switch is pressed, valve **B** is actuated.
- Before valve **A** actuates, there is a 3 second delay.
- Before valve **B** de-actuates, there is a 5 second delay.

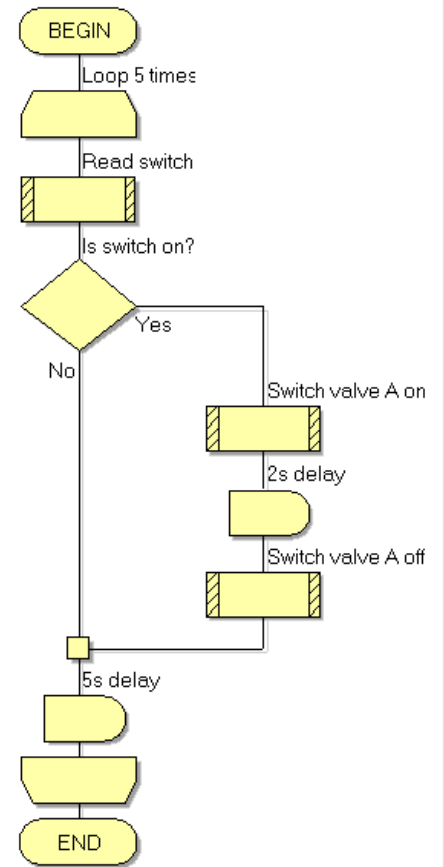


Revision questions

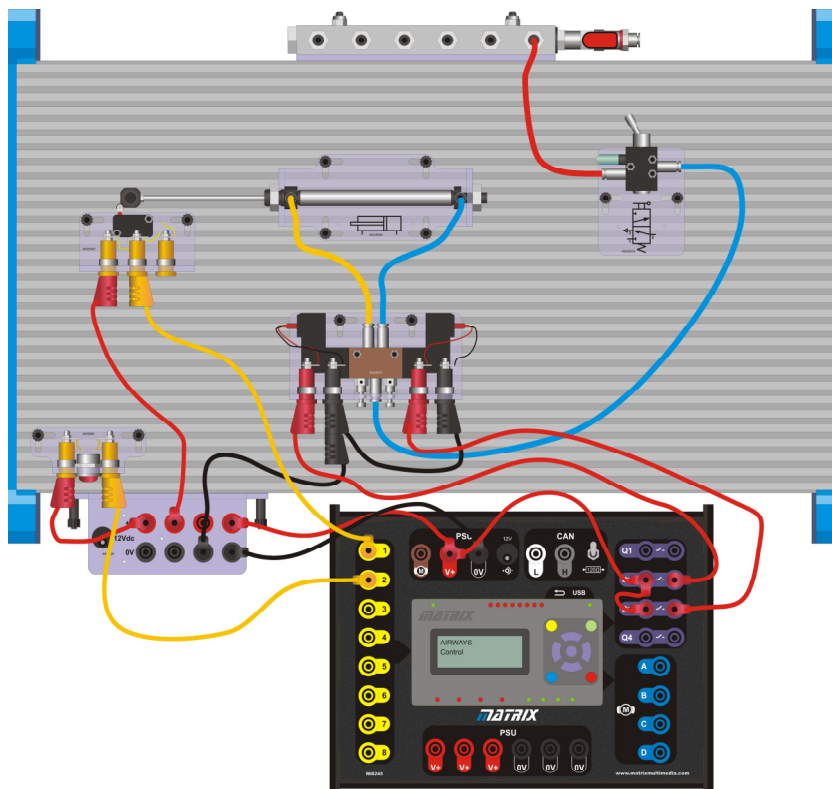
Automatics control **PLUS**

Look at the Flowcode program opposite.

7. Which icon would be modified to make the process repeat ten times?
8. For how many seconds is the cylinder extended?
9. How long does it take to complete one cycle of the program after the switch is pressed?



10. Draw the pneumatic circuit diagram for the following system .



Design Scenarios

Automatics control PLUS

Design a program to satisfy the requirements set out in the following letters.

For each, provide a flowchart, like those in the worksheets, together with a description of what each section of the program does.



PLAYFUN TOYS LTD

Dear Designer,

Could you please design a control system for our new wooden toy gluing system?

Components move along a conveyor belt to the machine. As each arrives, it activates a sensor. When five components have arrived, a pneumatic cylinder pushes them into position in the machine.

A second cylinder then carries out five process cycles. In each, the cylinder waits for five seconds in the extended position to hold the components in place while the glue sets.

Yours faithfully,

Coldham Borough Council Department of Health and Safety

Dear KnivesRUs,

Our inspector noted on her last visit that your knife-sharpening machine makes use of two pneumatic cylinders operating in the sequence A+, A-, B+, B-.

A machine guard must be fitted immediately to protect the operator from possible injury.

The guard must be designed so that it presses a switch when closed. The guard switch and On/Off switch must both be pressed to start the machine.

While the machine is running, it must stop automatically if the guard is opened, or if the On/Off switch is pressed again.

Yours sincerely,

Ken~Ju Martial Arts Clothing

Dear Designer

We use a pneumatically-operated test rig, with a continuously reciprocating cylinder to test fabric samples for wear and tear. The system counts the number of cycles completed by the cylinder.

Unfortunately, it can provide misleading information because it continues to count even when the air supply is switched off by mistake.

Please design a new counting system that stops counting when the cylinder stops moving, no matter whether extended or retracted, and then displays the number of test cycles completed.

Yours faithfully

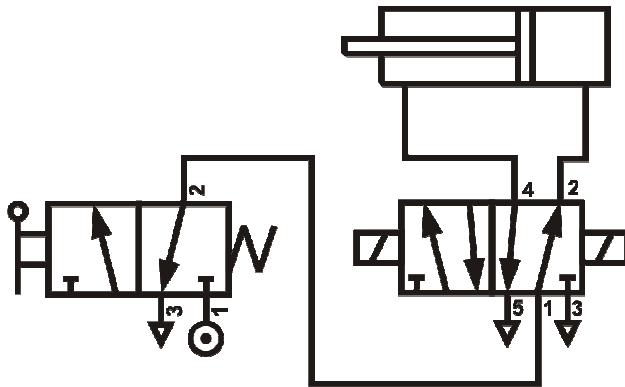
ds1

Answers to revision questions

Automatics control PLUS

Answers to revision questions (see page 23)

- 1. a)
- 2. b)
- 3. a)
- 4. c)
- 5. a)
- 6. c)
- 7. Loop icon
- 8. 2s
- 9. 7s
- 10.



q10ans

Tutor's notes

Automatics control PLUS

About this course

Introduction

This module reinforces learning for courses such as BTEC Nationals in Engineering, Unit 15, "Electro, Pneumatic and Hydraulic Systems and Devices" and BTEC Higher Nationals in Mechanical Engineering, Units 9 and 26: "Applications of Pneumatics and Hydraulics" and Programmable Logic Controllers".

It provides practical activities and investigations to complement such courses. In addition, it develops programming skills using the graphical 'Flowcode' programming language.

The learning aims are to:

- identify industrial electro pneumatic components, and use them correctly and safely.
- design, build and test control systems for pneumatic circuits to meet a given specification.
- read and draw pneumatic circuit diagrams using CETOP standard symbols.
- know how pneumatic systems are used in industry, transport and leisure contexts.
- design, create and test control programs, using Flowcode.

Automatics equipment makes it quick and easy to construct and investigate basic pneumatic circuits, which, thanks to the symbols printed on each component carrier, look exactly like the circuit diagram.

Prior Knowledge

Students should have followed the 'Automatics essentials' course, or have equivalent knowledge, and have the study skills and mathematical competence required to use these worksheets effectively.

Learning Objectives

On successful completion of this course the student will have learned to:

- apply six safety rules when building and using pneumatic circuits;
- turn on a solenoid operated pneumatic control valve using an input device such as a switch;
- use a flow-control valve to modify the speed of a cylinder while either extending or retracting;
- set up and control a reciprocating pneumatic cylinder;
- set up and control a sequence involving two pneumatic cylinders;
- describe two electronic security features that could be built into an electronic door control system;
- describe the advantages of incorporating feedback into a control system;
- use a reed relay to provide feedback in a 'proof of position' situation;
- use a light sensor as part of a sorting system to distinguish between two kinds of object.
- analyse a given 'Flowcode' program;
- design a Flowcode flowchart, from a program overview and specification;
- create a new Flowcode program, and choose an appropriate microcontroller target;
- create loops, both infinite and finite, within a Flowcode program;
- configure time delays;
- insert and configure conditional branching (decision boxes);
- insert and configure break points within a Flowcode program;
- configure component macros, to read MIAC inputs and control MIAC outputs;
- configure component macros, to control a LCD component and display a message;
- use a software flag to monitor the state of an input;

Tutor's notes

Automatics control PLUS

What students will need:

The Automatics control add-on kit contains the equipment shown in the table.

Qty	Code	Legacy Code	Description
1	MI0245	MI0245	MIAC controller
2	AU8030	AW-ESWP	Switch, push-to-make
1	AU8025	AW-ERS	Reed Switch and Holder
2	AU3022	AW-V22FC	Valve, flow control
1	AU8010	AW-ELS	Sensor, light
4	AU6010	AW-V32ES	Valve, 3/2, solenoid-spring
1	HP2777	HP2777	Power supply
1	AU8020	AW-EPD	Power panel
6	LK5603	LK5603	Lead, 4mm to 4mm, red
6	LK5604	LK5604	Lead, 4mm to 4mm, black
2	LK5607	LK5607	Lead, 4mm to 4mm, yellow

This kit is intended as a supplement to the Automatics essentials solution, so you may also require the following equipment:

Qty	Code	Legacy Code	Description
1	AU9020	AW20801	Automatics essentials solution
1	AU1050	AW30100	Compressor
1	LK1110	LK1110	Multimeter

Please note: New product codes for Automatics products were created in January 2015. The "legacy codes" in the tables above refer to the part numbers prior to this date and are included as a convenience for customers who bought products before the part number change.

Students will also require access to a Windows PC with an unused USB port, and the Flowcode software installed. There are several user licence options for Flowcode...

Code	Description
TEFLSI5	Flowcode professional licence (single user)
TEFLC105	Flowcode 10 user licence
TEFLCSL5	Flowcode site licence (50 users)

Tutor's notes

Automatics control PLUS

Using this course:

It is expected that the worksheets are printed / photocopied, preferably in colour, for the students' use. Students should retain their own copy of the entire workbook.

Worksheets usually contain:

- an introduction to the topic under investigation and its practical application;
- step-by-step instructions for the investigation that follows;
- a section headed 'So What?' which aims both to challenge learners by questioning their understanding of a topic and also provides a useful summary of what has been learned. It can be used to develop ideas and as a trigger for class discussion.
- a section headed 'For Your Records' which provides important summary information that students should retain for future reference, and extension exercises.

This format encourages self-study, with students working at a rate that suits their ability. It is for the tutor to monitor that students' understanding is keeping pace with their progress through the worksheets and to provide additional work that will challenge brighter learners. One way to do this is to 'sign off' each worksheet, as a student completes it, and in the process have a brief chat with the learner to assess their grasp of the ideas involved in the exercises that it contains.

A set of revision questions has been provided to conclude the work in this unit. These are of mixed difficulty and are designed to help students identify topics which might need more work. It is recommended that students should attempt these questions under examination conditions and without the use of notes.

Three scenarios are included for students to use as realistic design problems (without solutions, as there are a number of valid approaches to each). These can be used as homework tasks if the instructor so wishes.

The 'Tutor Notes' outline the activities specified in the worksheets, highlight significant concepts and potential problems involved in them, and give sample solutions to the programming tasks set.

Time:

It will take most students between five and eight hours to complete the practical work and exercises in the worksheets. It is expected that a further, similar length of time will be needed to support the learning in a class, tutorial or in a self-study environment.

Tutor's notes

Automatics control PLUS

Worksheet	Notes for the Tutor	Timing
1	<p>The worksheet introduces the MIAC controller, and demonstrates its role in operating control valves in response to signals from input devices. It also revisits the method used to attach components to the Automatics platform. In carrying out the assembly, students should consult the MIAC diagram, and the component layout on page 4.</p> <p>The next page lists features of the device. In particular, students should be aware that LEDs monitor the MIAC inputs and outputs, and are reliable indicators of the progress of the 'program running on the MIAC.</p> <p>Page 5 onwards provides an overview of this program, and details of how to create and configure it. No previous knowledge of Flowcode programming is required, though some reassurance and help from the instructor may be needed.</p>	40 - 60 minutes
2	<p>This worksheet starts with the safety rules for pneumatic circuits. Instructors should emphasise their importance and enforce them strictly.</p> <p>The task involves setting up a reciprocating cylinder. The action is initiated by pressing a switch, though it is pointed out that, in practice, this may be an emergency stop button, attached to a safety guard, for example.</p> <p>Page 10 shows two diagrams - the physical component layout and the pneumatic circuit diagram. Students should take time to relate one to the other. Later worksheets will offer only the pneumatic circuit diagrams, and so the student must be adept at interpreting these. The instructor should stress that the circuit diagram is an abstract representation, that does not reflect the actual position of the components on the platform, but only the connections between them. Students should be encouraged to make the layout clear by using coloured pipes. In particular, it is a useful convention to use red pipes in all connections to the manifold.</p> <p>Page 11 gives an overview of 'Flowcode' program 2A. It contains an infinite loop, making the sequence repeat indefinitely as long as the switch is pressed, a 'component macro' to copy the state of the switch into a variable, a decision box that uses the value stored in that variable to check whether the switch is pressed or not, two further 'component macros', to actuate the control valve that extends the cylinder, and to actuate the valve that retracts it, and two delays, that cause the controller to make no changes until these have expired. Again, students are given detailed instructions on how to create, save, transfer and test this program.</p> <p>Program 2B modifies this behaviour by re-configuring the loop to cycle only ten times. This is shown on page 13.</p>	50 - 70 minutes

Tutor's notes

Automatics control **PLUS**

Worksheet	Notes for the Tutor	Timing
<p>3</p>	<p>Now, attention moves to the double-acting cylinder, as the return spring in the single-acting cylinder is unlikely to be strong enough to operate the door mechanism.</p> <p>Incorporating two flow-control valves allows control of the piston while extending and while retracting. Again, both the physical layout and the pneumatic circuit diagram are provided for the student to relate.</p> <p>Page 16 provides an overview of program 3A, which is structurally similar to program 2A, except that, in turn, it monitors switch 1 then switch 2. As written, should switch 2 be pressed when the door is already closed, the valve controlling retraction is actuated, but will do nothing. An alternative would be to use break points, as in program 4A, to make the program wait until switch 1 is pressed before doing anything else. The instructor may wish to set this as an extension exercise for more able students.</p> <p>This time, only the structure of the program is given. The students must use their experience from the previous worksheets to configure the individual icons.</p> <p>The control system is next modified to display the number of times the door is opened, stored in a variable called 'count' within the program. Using 'Flowcode' the LCD is controlled using component macros - four in all. The first deletes any text present; the second displays the first part of the message; the third displays the count, and the fourth completes the message. The worksheet then highlights an important feature of similar counting programs, that the execution time of the program may so short that it cycles several times before any change in the hardware occurs. The program must take steps to prevent multiple counts resulting from one hardware operation. Here, that is achieved by use of a software flag, a variable called 'flag'. On the first cycle, this flag is not set ('flag' = 0), and so the program adds one to the value stored in the variable 'count' (using the calculation "count = count + 1".) It also sets the flag ('flag' = 1.) On subsequent cycles, the program recognises that the flag is set, and so ignores the command to increase the value of 'count' further. When the 'retract' switch is pressed, it both operates the retract cylinder, and also resets the flag, ready for the next operation of the door. The modified program, program 3B, is described starting on p.17. The instructor may need to check that students understand these modifications fully.</p> <p>The worksheet ends with a research project in which students investigate a number of electronic security features which could be incorporated into a more elaborate control system.</p>	<p>50 - 70 minutes</p>

Tutor's notes

Automatics control PLUS

Worksheet	Notes for the Tutor	Timing
4	<p>This worksheet shows that the behaviour of a standard set of pneumatic components can be changed radically by changing the control program, without changing the hardware configuration. The programs produced act as a template to generate any sequence of operation.</p> <p>In the earlier module, a sequence of cylinder operations was created entirely pneumatically. However, to change that sequence required changes to the physical layout of the components. Here, the only change is to the program that controls the system.</p> <p>The first program, 4A, produces the sequence, A+, B+, B-, A-, used earlier to control a de-greasing tank in a car factory. The separate parts of the sequence are still controlled manually, using two switches, but could be automated instead, using time delays to initiate lowering, raising and returning the basket. This program is described starting on page 20. Once again, the outline of the flowchart is given, and students are expected to configure most of the icons themselves. However, this program introduces the idea of break points. These are used to hold up the progress of the program until, in this case, a switch is pressed. The student is shown how to use these and configure the associated icons on page 21.</p> <p>Next, the program is changed to generate a different sequence, A+, B+, A-, B-, with the same hardware set up. The new program controls the gripper, shown on page 21, which could be part of a robot arm assembly. The elements of the new program, 4B, are the same as in program 4A, but now time delays are used to automate the process. One switch is used to initiate the sequence, which then proceeds automatically. The overview of this program is given on page 22. The students use this to create the new program, and then transfer it to the microcontroller and test it.</p> <p>Although the de-greasing system appears to work as planned on the Automatics platform, in reality, the weight of the basket and contents would probably pull the basket back into the cleaning solution when the valve controlling the retraction of cylinder B is switched off. The students are asked how the program could be modified to prevent this. The obvious solution is to keep valve b- actuated as long as the basket is in the raised position.</p> <p>They are also asked to identify the sequence needed to control an air lock of two doors. In this case, the sequence is probably A+, A-, B+, B-.</p>	50 - 70 minutes

Tutor's notes

Automatics control **PLUS**

Worksheet	Notes for the Tutor	Timing
<p>5</p>	<p>The introduction to this worksheet makes the point that often some kind of feedback is needed to ensure that a particular part of the process has taken place. This involves the use of a sensor, here a reed relay.</p> <p>This is mounted onto cylinder A, and detects whether or not it has extended. (The piston inside the cylinder is magnetised, and closes the reed relay contacts when in close proximity.) The program uses the output of the reed relay to confirm that cylinder A has extended, before the program proceeds to subsequent commands.</p> <p>First of all, the program, 5A, runs without any feedback, to illustrate the problem. It is simply a sequential operation of two cylinders, similar to that in worksheet 4. It is described on page 24. The students create the program using the overview provided, and test it.</p> <p>Then the reed relay is used as a 'proof of position' sensor. Page 25 shows how to assemble the hardware. The modification to the program, quite minor but very powerful, is described on page 26, and students go on to incorporate this into their program. They then test it by simulating a fault, disconnecting the air supply from the control valve. The program should pause instead of tipping the contents of the hopper onto the floor!</p> <p>In a practical situation, some warning device would sound to alert the operator. Here, an error message appears on the screen. The instructor may wish to set the task of modifying this to more able students.</p> <p>A similar application of sensors is in the sorting of components. The students are asked to design a program to sort out a mixture of black-labelled boxes from white-labelled boxes, using a light sensor, to model this kind of system. Although no solution is provided here, as there are a number of ways to do this, the students could be asked to deliver a presentation of their solution to the group, or document it as an item of coursework for the instructor.</p> <p>Several design scenarios are presented on page 30. These are a challenging test of the student's understanding of this module. Again, there is no single solution to each, but students can be asked to deliver their solution to the group in a presentation, or to document it for the instructor. The tasks could be set as class work or as homework as the instructor sees fit.</p>	<p>60 - 80 minutes</p>

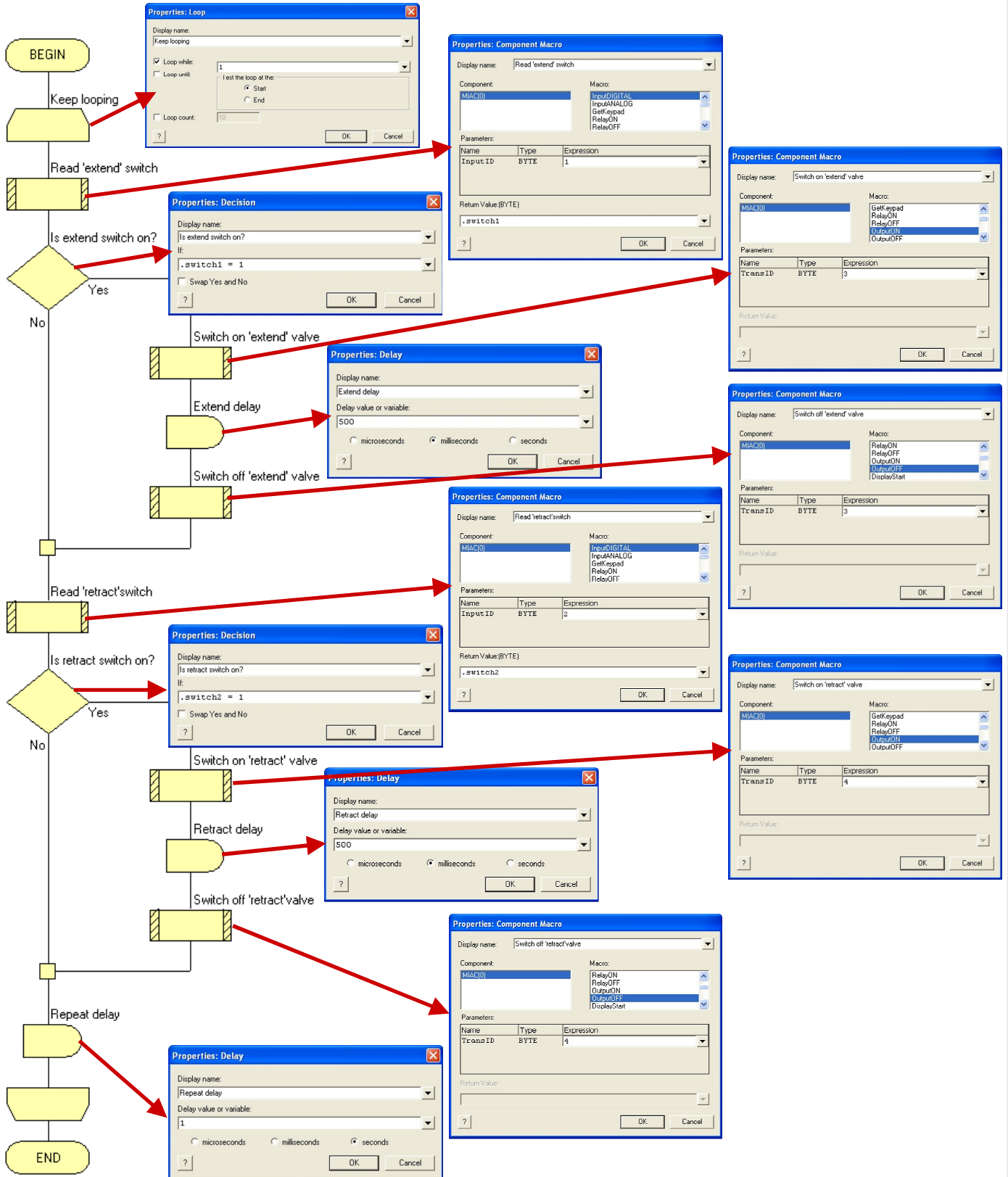
Solutions to Flowcode programs

These programs give possible solutions to the tasks set.
They assume that the hardware is set up as described in the worksheets.
However, there are a number of other ways to solve these problems,
and other ways to configure the hardware.

Tutor's notes

Automatics control PLUS

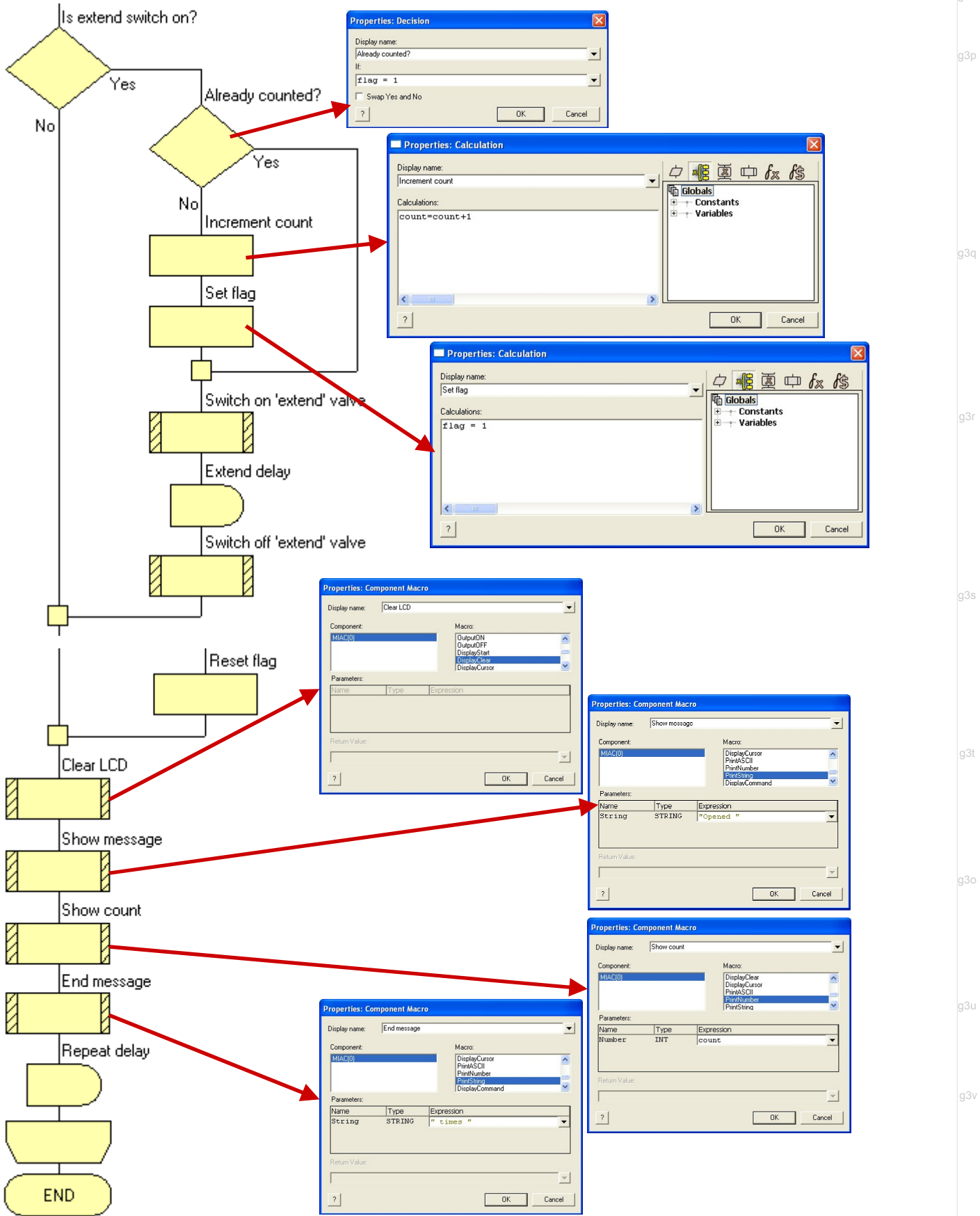
Program 3A:



Tutor's notes

Automatics control PLUS

Program 3B: Most of the program is identical to 3A. Only additional icons have been shown.

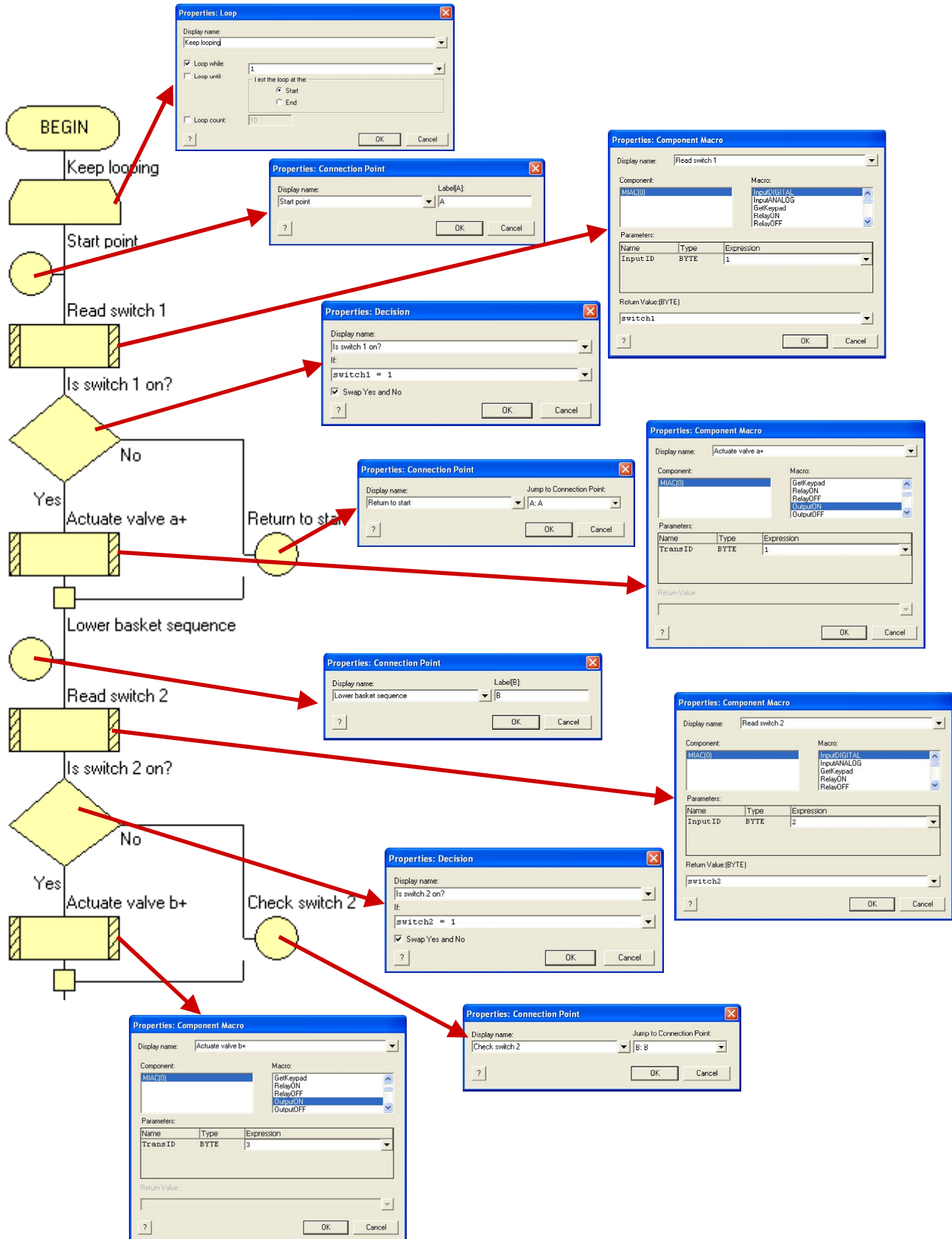


Tutor's notes

Automatics control PLUS

Program 4A:

Part 1:

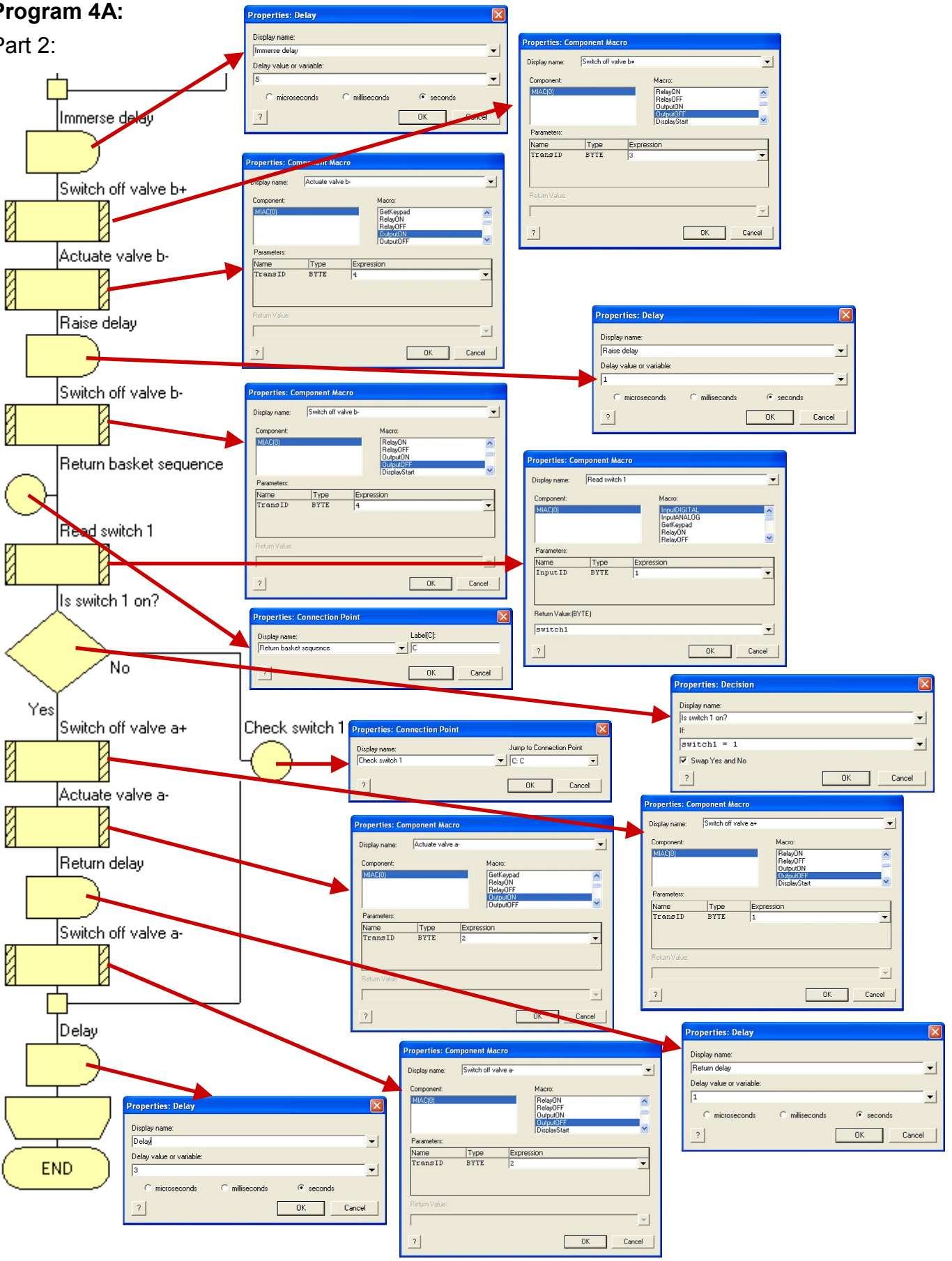


Tutor's notes

Automatics control PLUS

Program 4A:

Part 2:

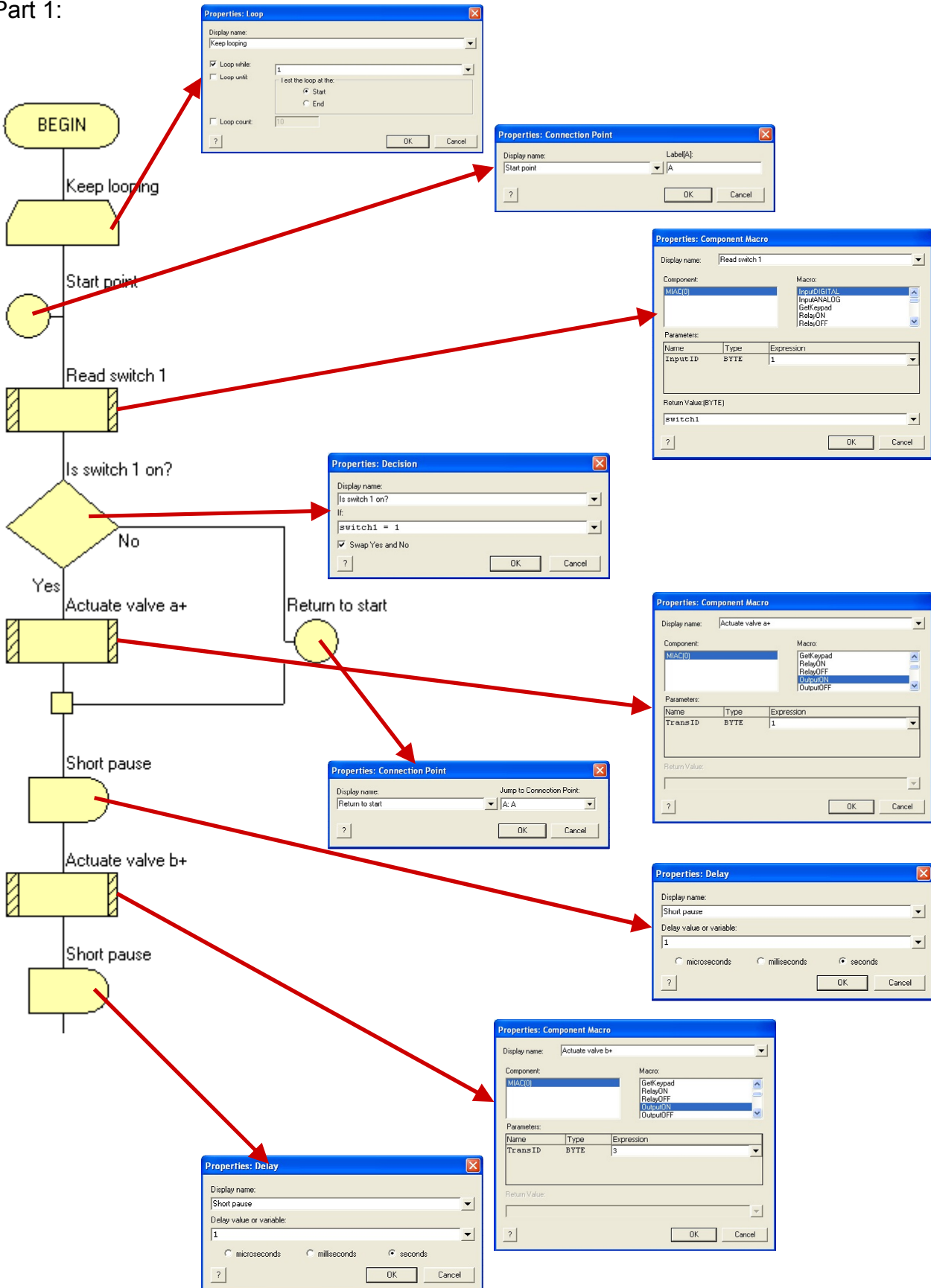


Tutor's notes

Automatics control PLUS

Program 4B:

Part 1:

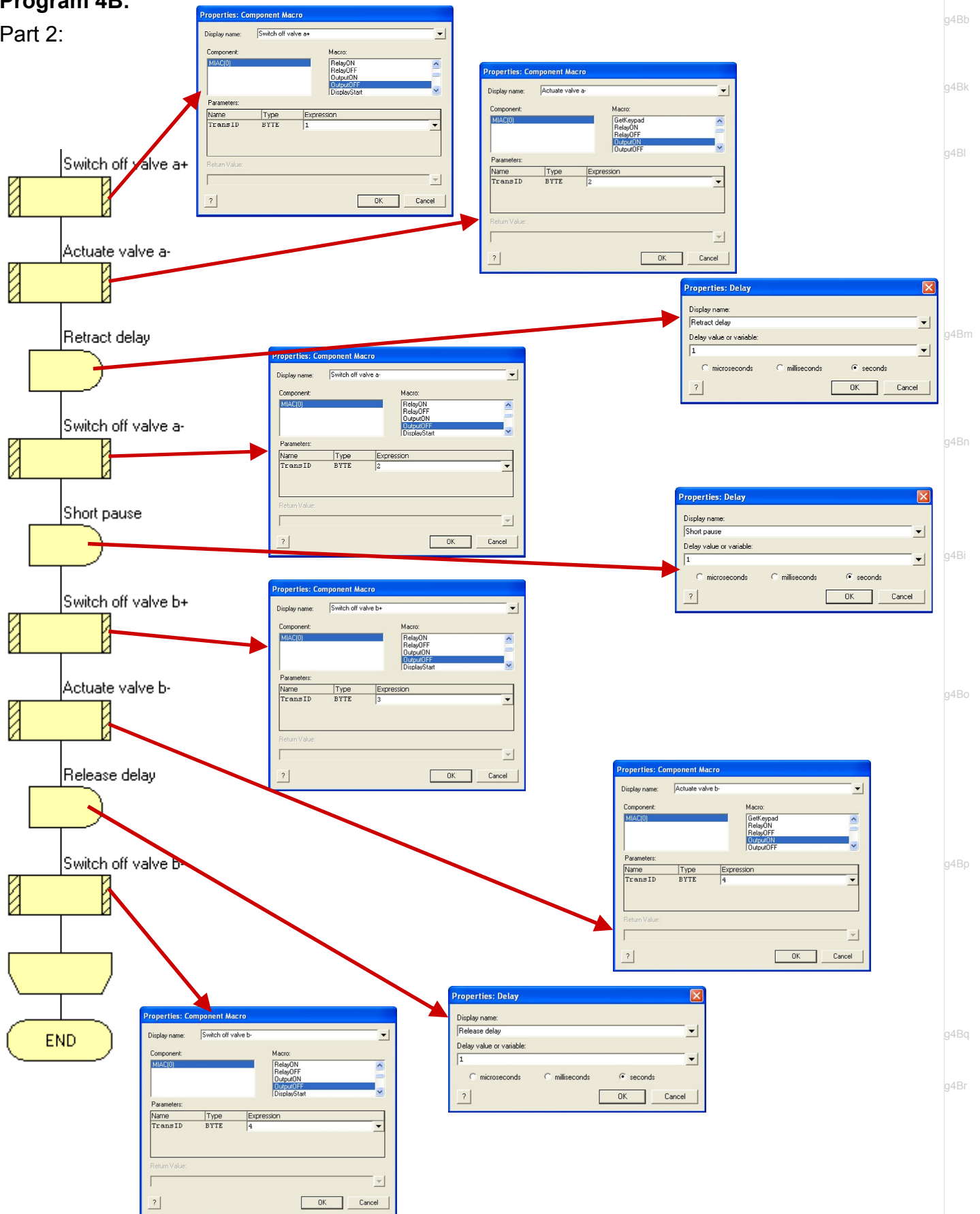


Tutor's notes

Automatics control PLUS

Program 4B:

Part 2:

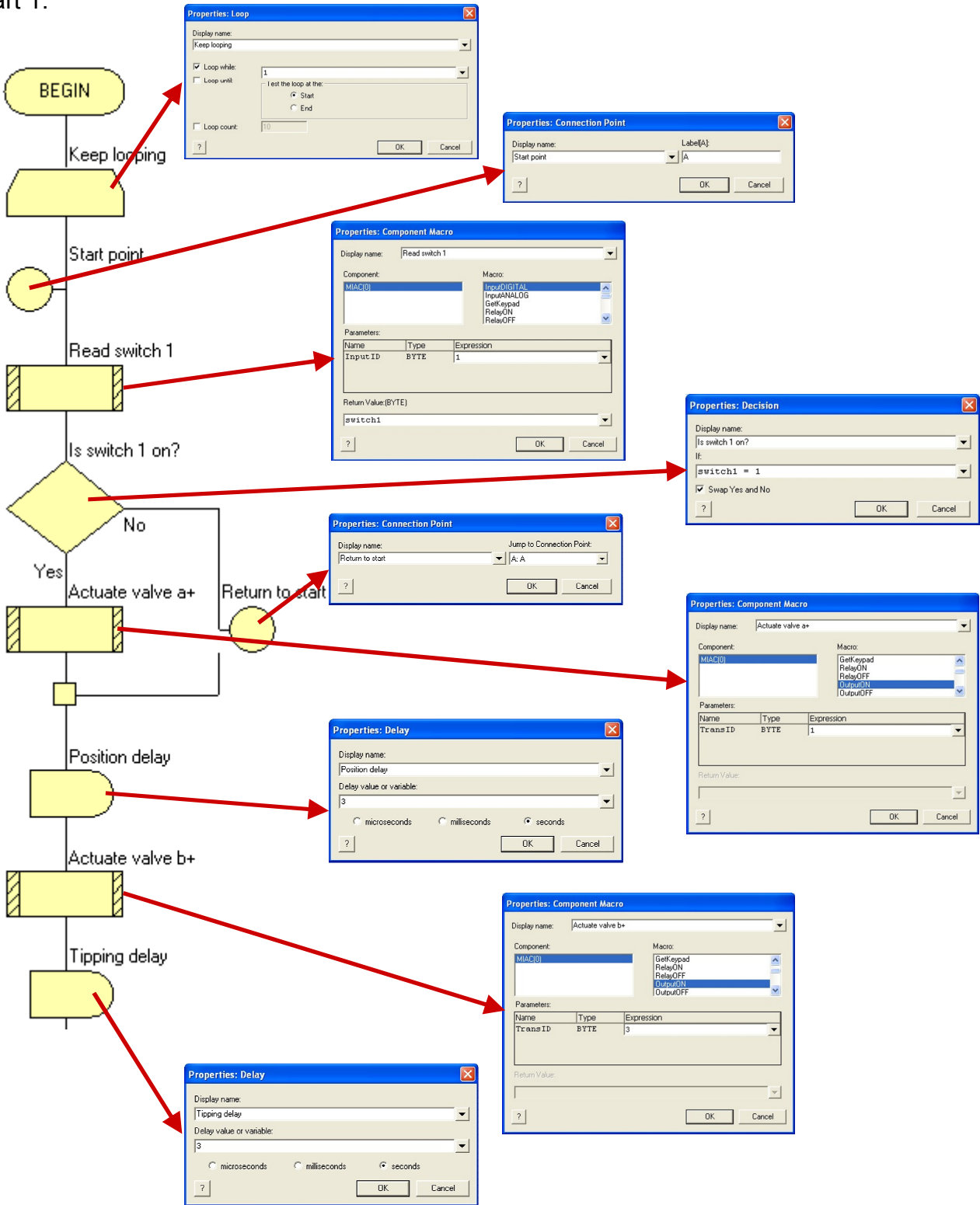


Tutor's notes

Automatics control PLUS

Program 5A:

Part 1:

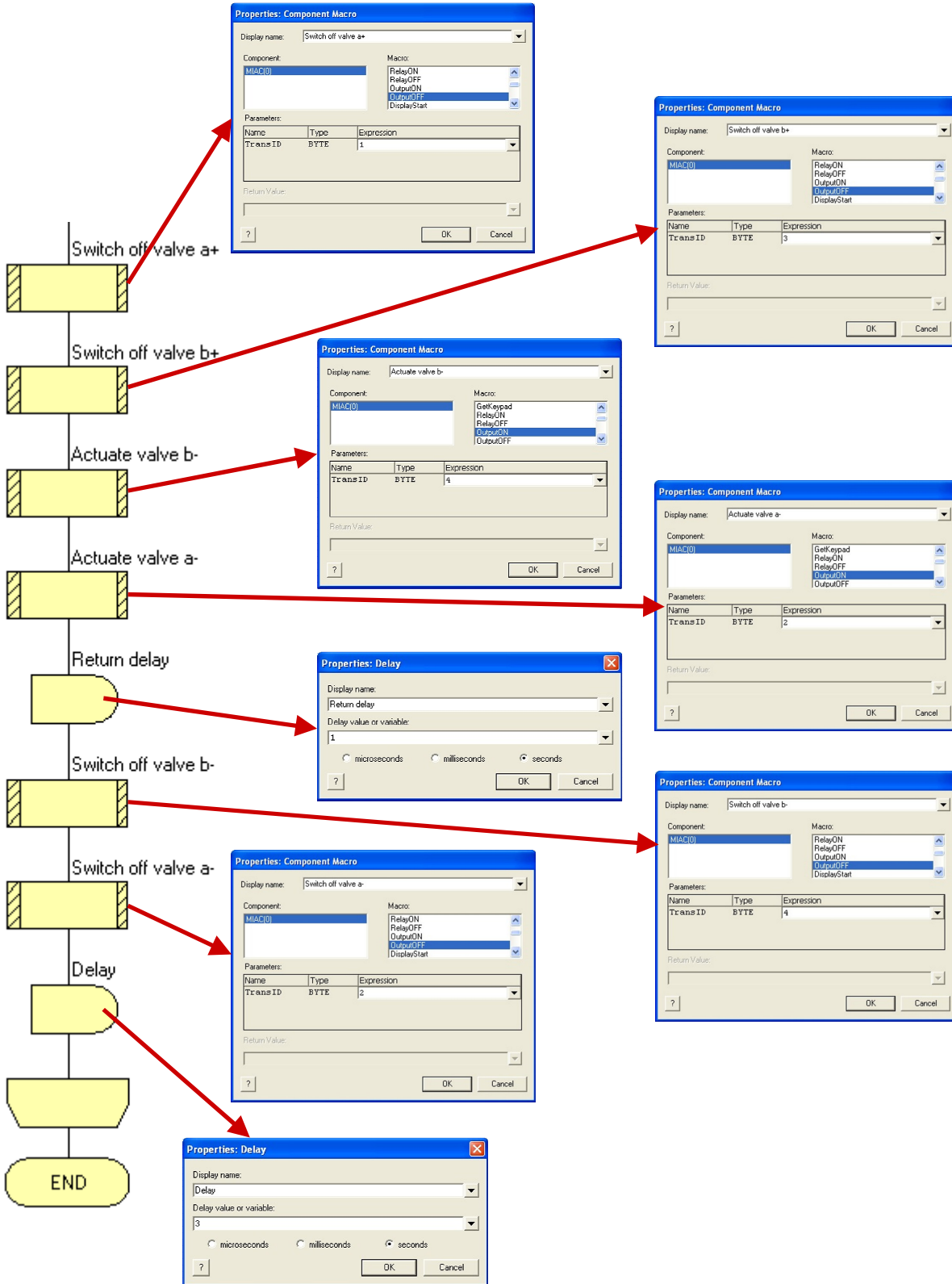


Tutor's notes

Automatics control PLUS

Program 5A:

Part 2:

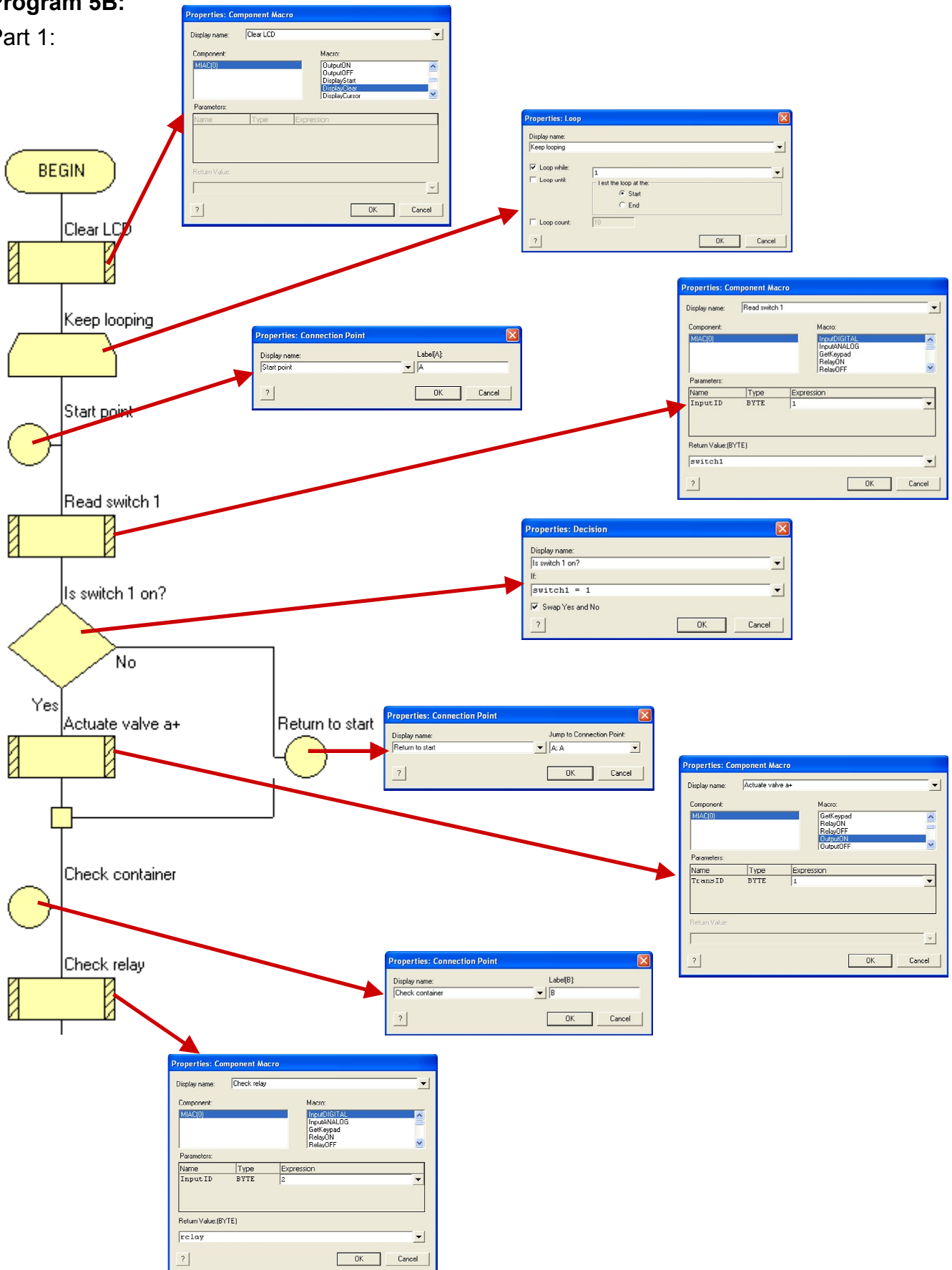


Tutor's notes

Automatics control PLUS

Program 5B:

Part 1:

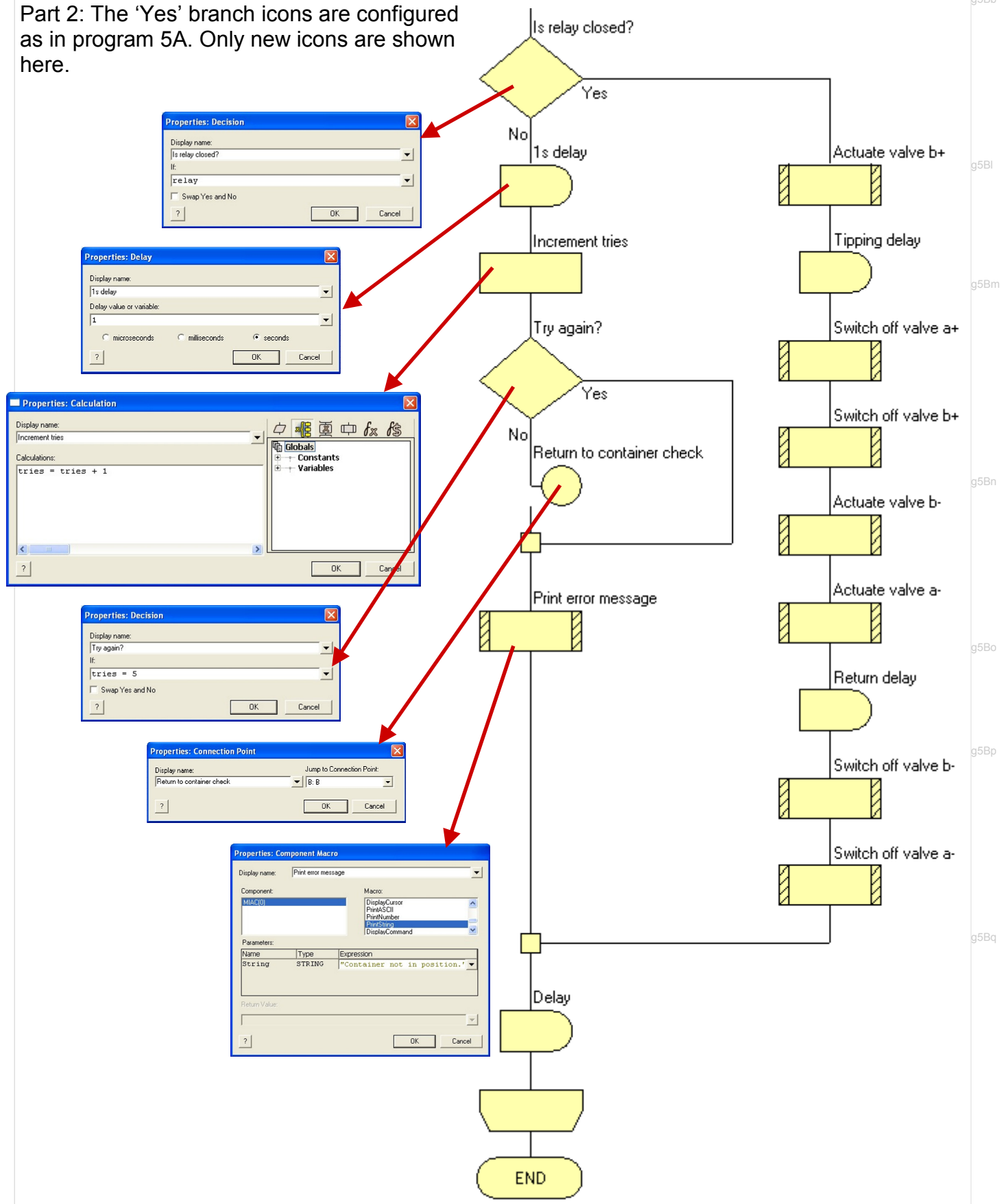


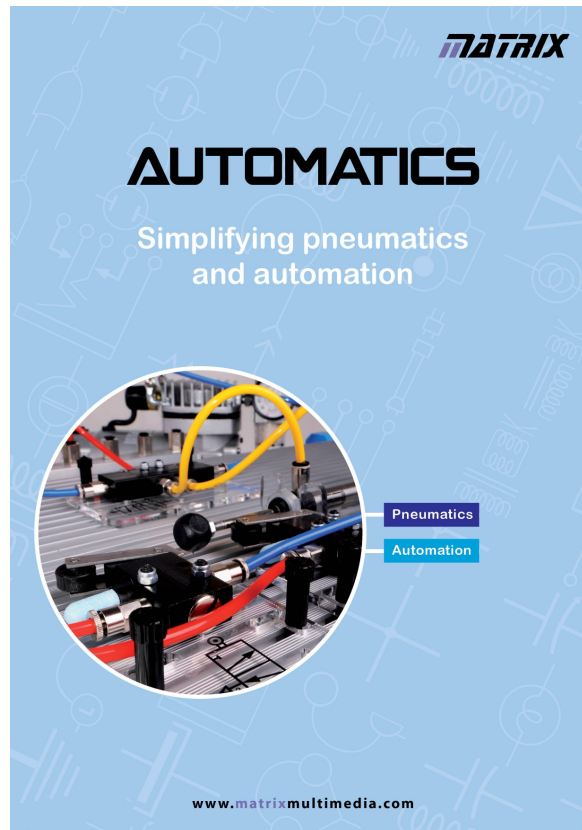
Tutor's notes

Automatics control PLUS

Program 5B:

Part 2: The 'Yes' branch icons are configured as in program 5A. Only new icons are shown here.





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MATRIX

Matrix Multimedia Ltd.
23 Emscote Street South
Halifax
HX1 3AN

t: +44 (0)1422 252380
e: sales@matrixmultimedia.co.uk

www.matrixmultimedia.com