L-Università ta' Malta

ESE 2023 Summer Training:

Automation and Prototyping

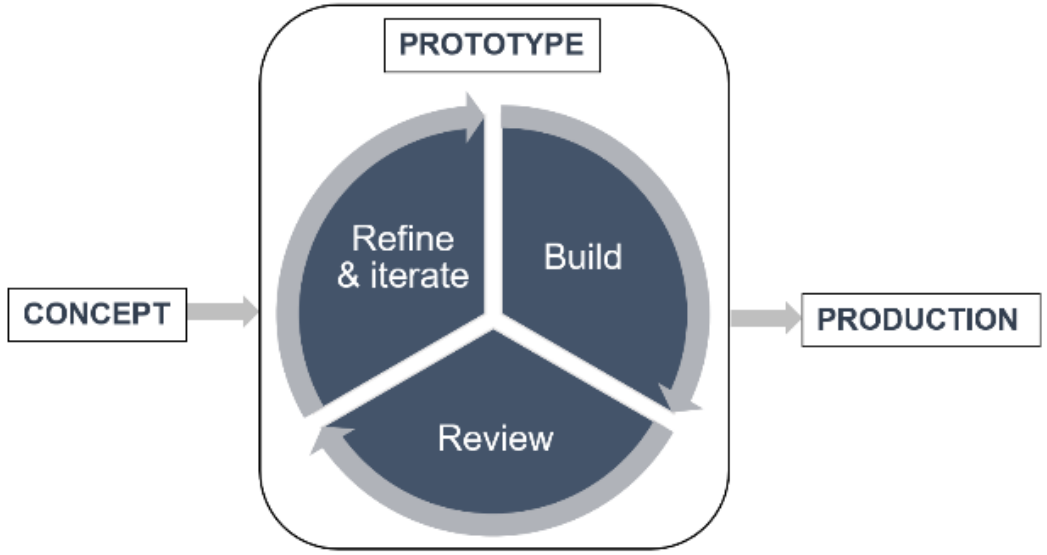
L-Università ta' Malta

ESE 2023 Summer Training

Day 1:
Pneumatic Systems

This week's training will focus on four main themes:

- Pneumatic system basics.
- Types of Control Systems & Prototyping using the Arduino.
- Interfacing a microcontroller to the outside world.
- Assembly of a system that tests the electrical operation of a push button switch.



Day 1:
What we will be covering:

Pneumatics:

- The various components that comprise a pneumatic system.
- Single and double acting cylinders.
- Using a valve to control a cylinder
- Understanding pneumatic valve diagrams.
- Solenoids
- Setting up a simple pneumatic cylinder system.

Pneumatic Systems

The vast majority of manufacturing facilities employ pneumatically-operated systems and a complete automated system may look very complicated indeed.

However, the main pneumatic elements are:

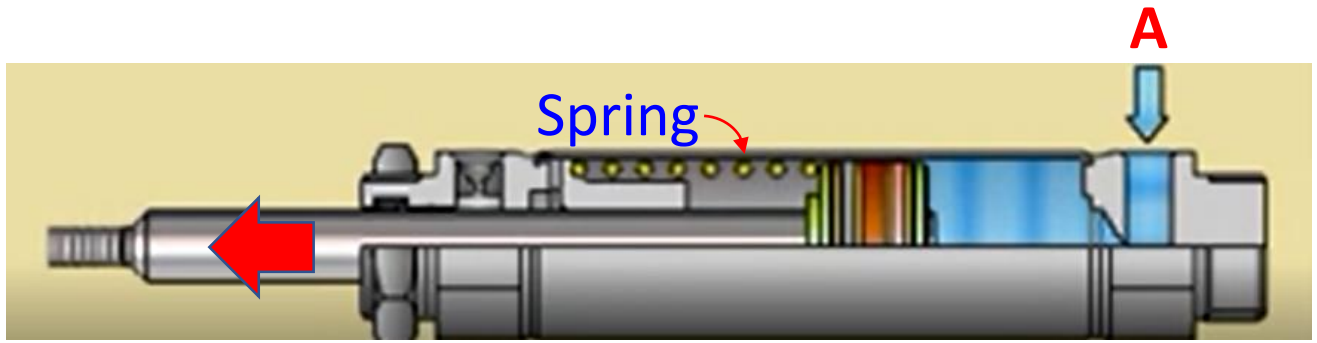
1. A simple single cylinder which consists of a rod that extends outwards or retracts back in again, according to how we control the cylinder.
2. A valve to activate the cylinder.

Note that the terms Cylinder and Actuator are used interchangeably in this presentation because both terms are commonly used.

Spring return (single acting) cylinder

Pneumatic cylinders need compressed air to operate. The compressed air is provided by an air compressor which is usually located in a separate room within the manufacturing facility. Typical air pressure generated by the compressor used in industry is around 8 bar or 800kPa, this is then regulated to lesser pressure values as required.

The simplest type of cylinder is the spring-return type. Here, pressurised air flows into port **A** which causes the piston to move to the left. Once air pressure is removed, a spring forces the piston back to the right and air is exhausted via the same port **A**.

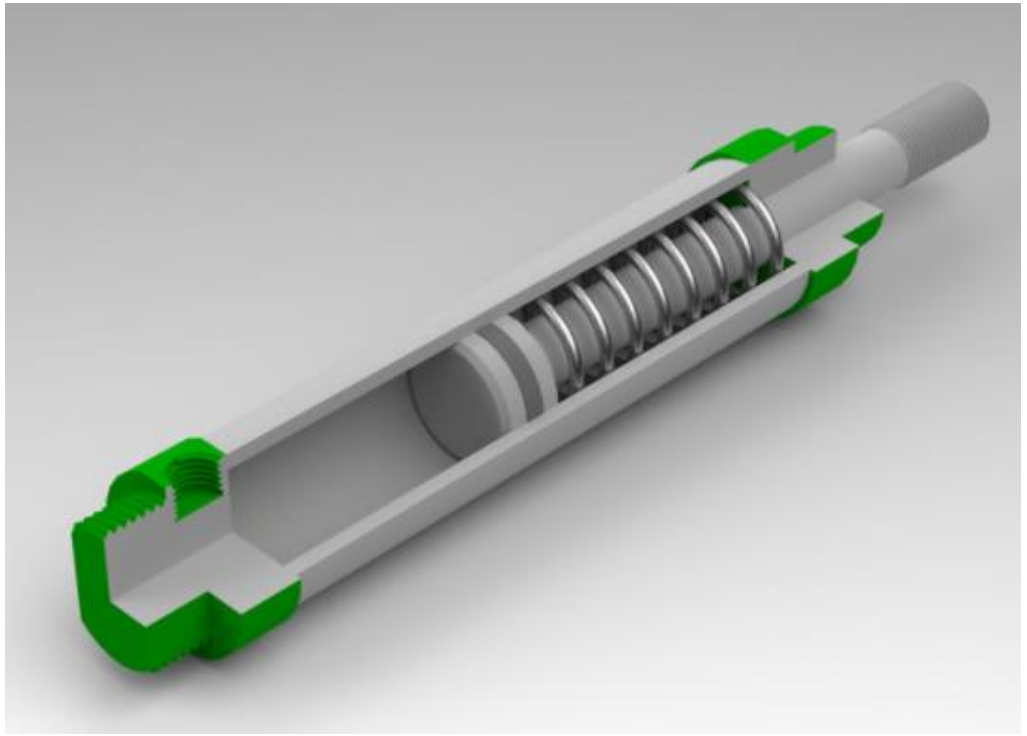


Limitations of a Single Acting Cylinder

A single acting, (spring return), cylinder is very easy to set-up and quite handy for simple applications, but it also has its limitations, namely:

1. The spring itself takes up space and therefore limits the stroke, (that's how much the rod can extend).

2. As the spring ages, overall operation may become less consistent.

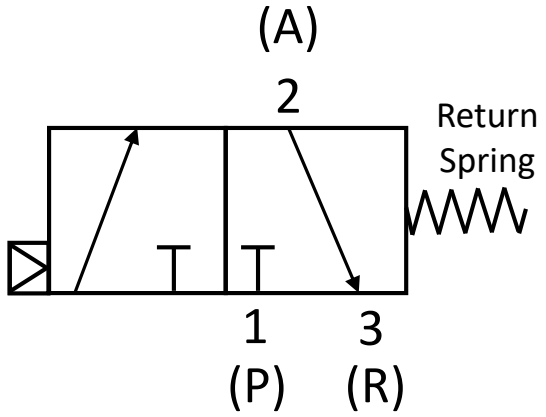


Pneumatic Valves - a 3/2 valve

To activate our pneumatic cylinder, air pressure needs to be applied to its inlet port.

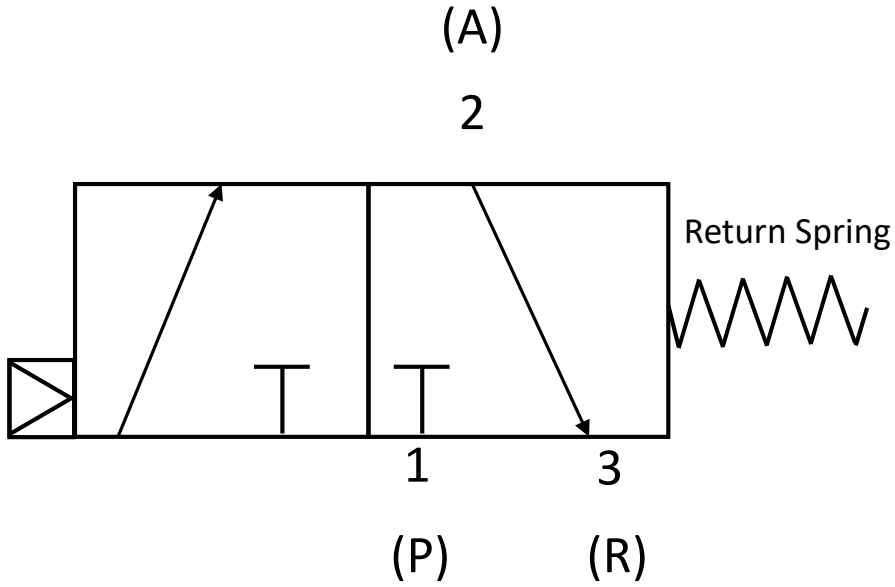
In order to guide the air pressure into the cylinder, we use a valve.

The top photo shows an actual valve, while below, we have a schematic diagram of what is known as a 3/2 pneumatic valve. The 3 indicates that the valve has 3 ports (1, 2 & 3) and the 2 represents the valve's two possible states: Activated or not activated.



3/2 Pneumatic Valve

As we have seen, the three ports are numbered 1, 2 and 3.



Let’s look at the box on the right for starters:

1 (P) This is where Air Pressure from a compressor is supplied into the valve.

2 (A) This is connected to the inlet port of the Actuator (Cylinder).

3 (R) is the Exhaust port through which air is expelled as the actuator returns to its rest position.

So here , the valve is in exhaust mode.

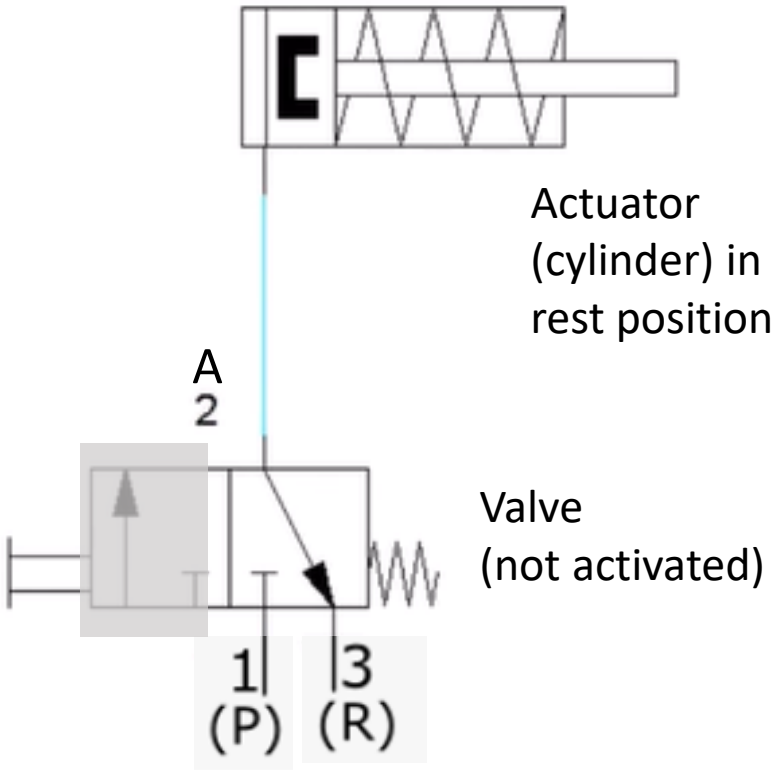
Valve & Actuator - Rest Position

In this schematic we have a representation of the whole arrangement - i.e. valve and cylinder.

Here the cylinder is at rest because pressure from the compressor is sealed off at Port 1 (P) of the valve.

Note that the greyed-out box in the schematic, is not applicable in this state.

The spring inside the Actuator, (cylinder), forces the piston to retract and any remaining air in the cylinder is exhausted via port 3 (R) of the valve.



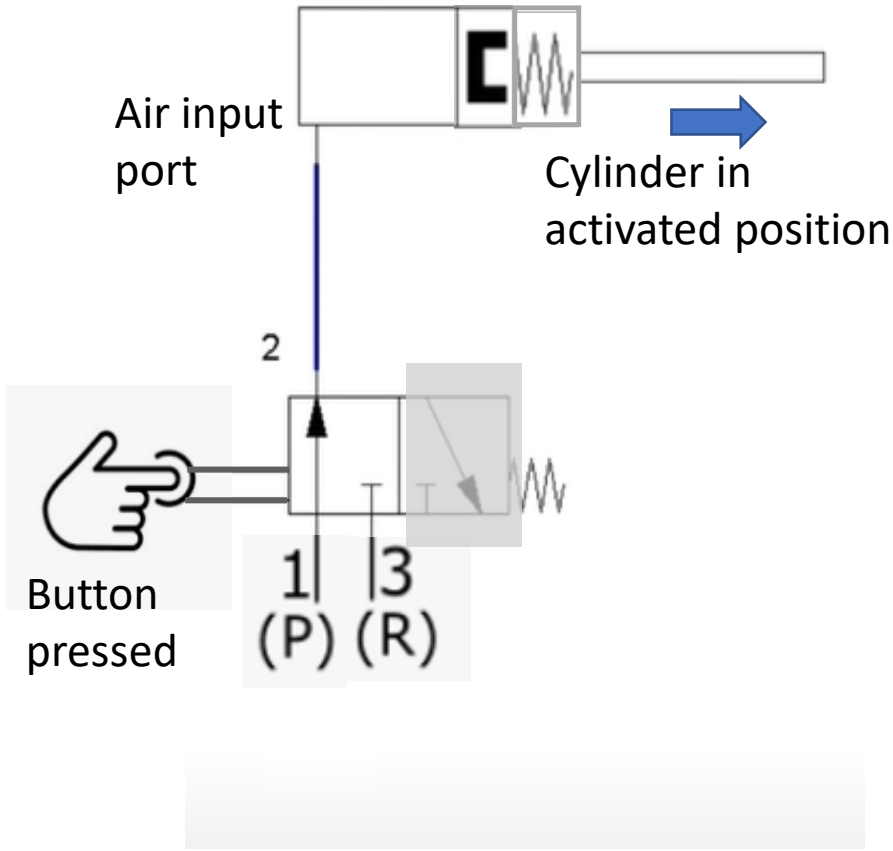
Valve and Cylinder in Activated State

Here we are manually pushing a button, (that is fitted on the valve), which mechanically switches the ports as in the diagram on the right.

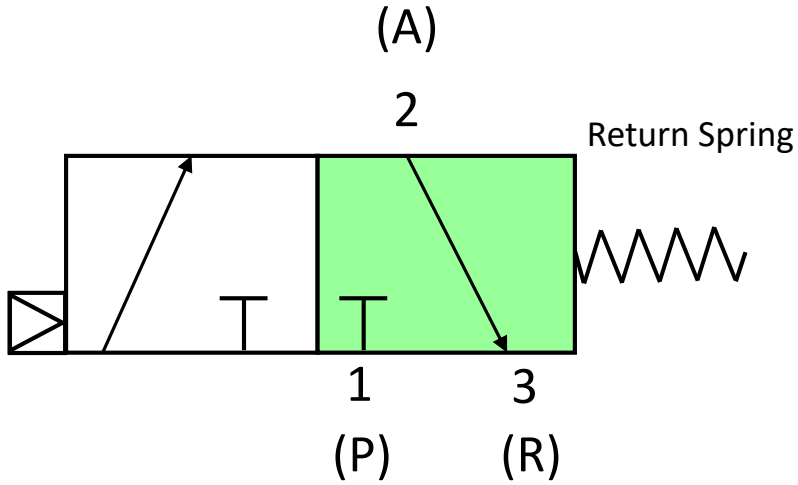
Now air pressure from the compressor is connected to the input port of the cylinder. This forces the piston to move to the right. Notice also that the exhaust port (R), is now sealed off.

Note also that this time, the ‘hidden’ box, is the one that corresponds to the inactive state.

Obviously in actual schematics none of the boxes are hidden.

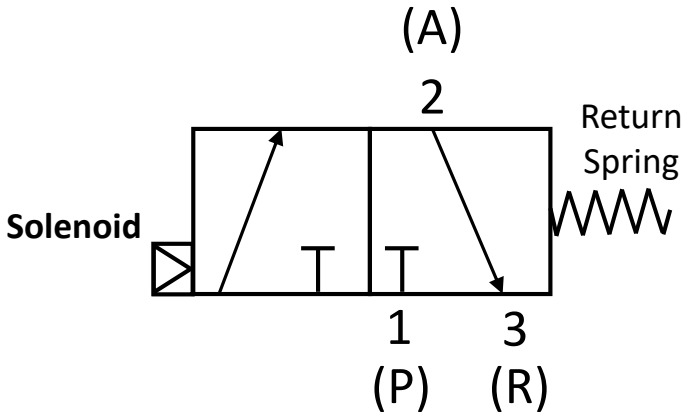


Pneumatic Valves



The spring indicates that when the valve is not activated, the spring will cause the valve to assume the position shown in the green box - supply of air pressure is blocked and the exhaust port is enabled, so the cylinder is not activated.

Pneumatic Valves



Connector and Solenoid

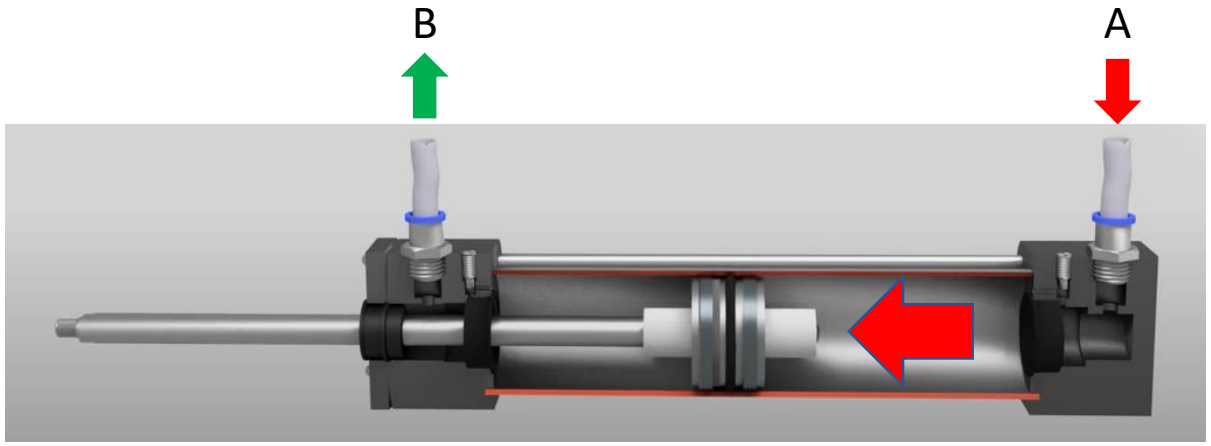
As we have seen, most valves are fitted with a small button, or some other mechanical means, to enable manual activation.

In addition, valves are fitted with a connector block to enable electrical operation by means of a solenoid which would be fitted inside a small compartment adjacent to the valve.

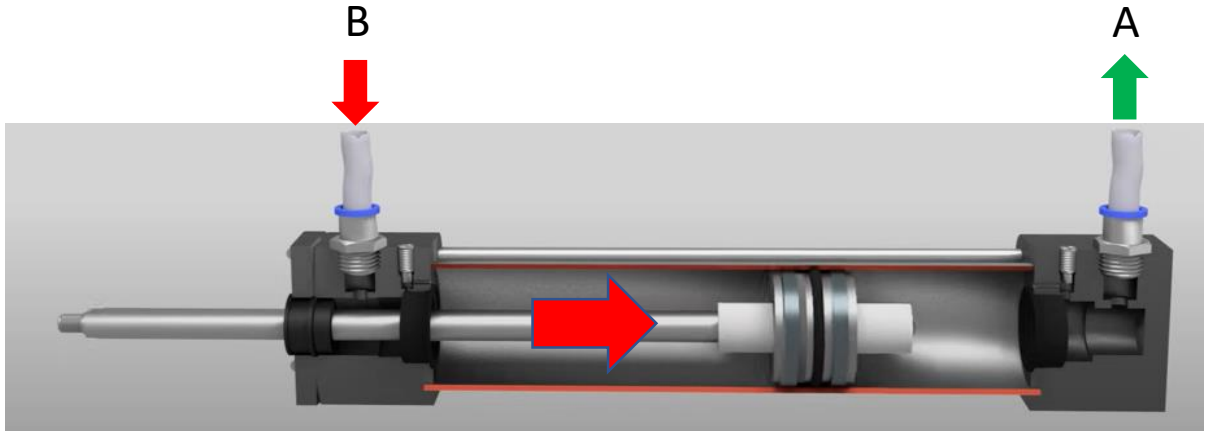
The symbol that shows a little triangle inside the square on the left, indicates that the valve is fitted with a solenoid to enable electrical operation.

Double acting cylinders

In Double Acting Cylinders, retraction of the plunger is achieved by reversing the path of the air flow. In the picture below, air pressure through port A, forces the piston to move to the left with air being exhausted through port B.



If we now reverse the direction of flow such that air pressure is now directed through port B, then the piston moves back to the right, and air is exhausted through port A.



5/2 valve

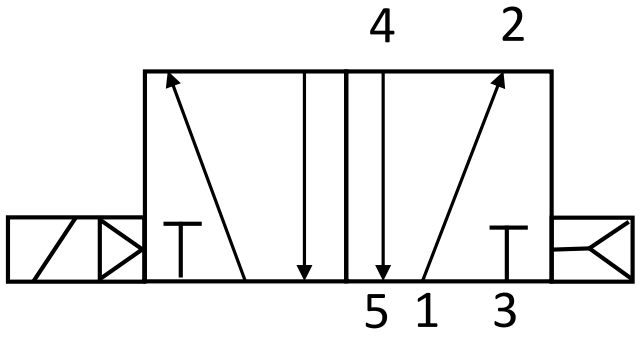
The double acting cylinder is widely used in industry and therefore it is important to understand the basic operation of the valve that is used to control it.

The top photo shows a typical 5/2 valve. Just barely visible, is the schematic of the valve which is printed adjacent to the CE mark.

This schematic is shown below the photo.

This valve is called a 5/2 valve because it has 5 ports and 2 possible states:

Activated or not Activated.



Activating the valve

The valve can be activated in two ways:

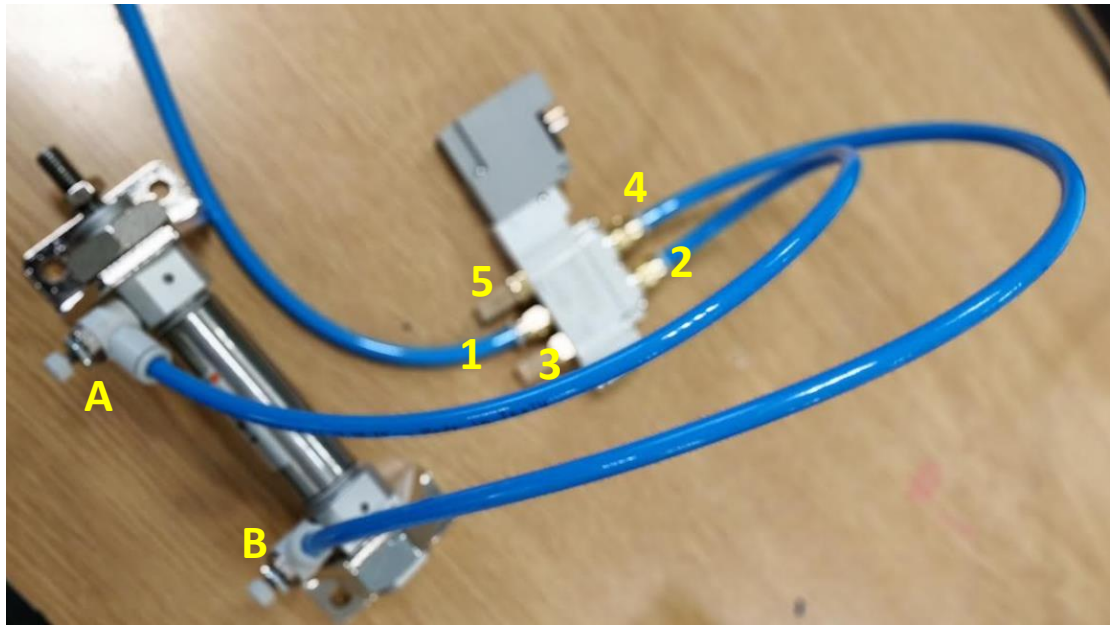
- Manually: by pressing the tiny blue button, circled in red.
- Electrically via the terminals shown circled in blue.

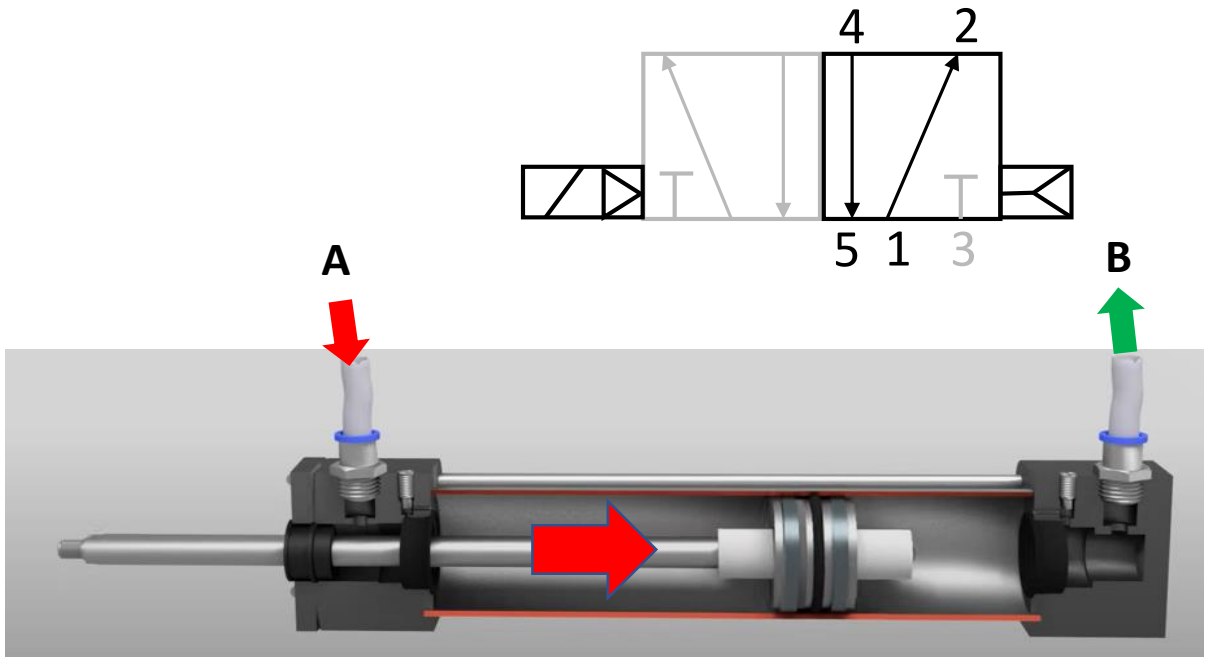
In the next few slides, we will be activating the cylinder manually via the blue button.

5/2 valve (Valve not activated)

Air pressure enters via port 1; exits through port 2 of the valve, and into port A of the cylinder. This air pressure forces the piston inside the cylinder to the right. In this position, the valve is not activated and the cylinder rod is retracted. Any remaining air is expelled from the cylinder via port B; through port 4 of the valve, and exhausted out into the atmosphere via port 5. Note that port 3 on the valve is closed and not in use while the valve is not active.

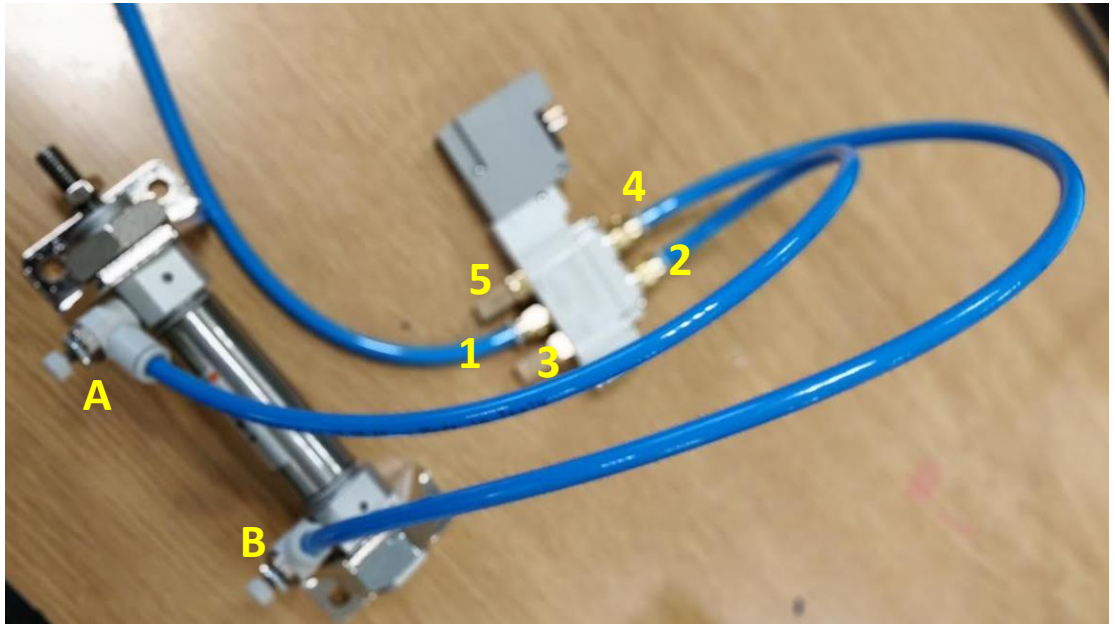
The greyed-out symbols are only active when the valve is energized.

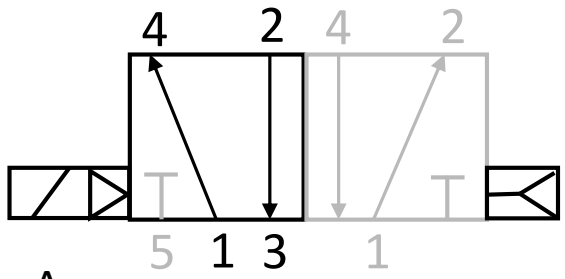


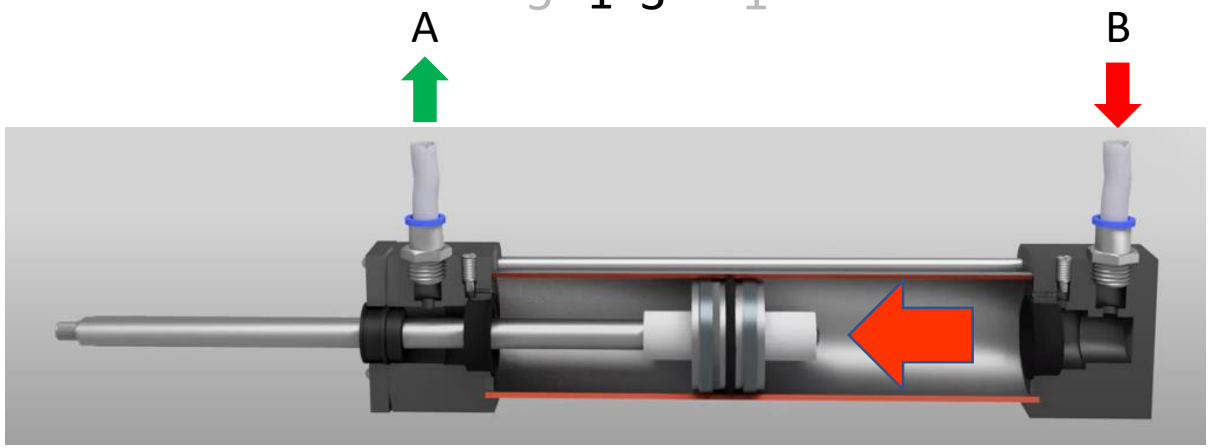


5/2 valve (Valve activated)

Air pressure enters via port 1; exits through port 4 of the valve, and into port B of the cylinder. This air pressure now forces the piston inside the cylinder, to the left. In this position, (valve is activated), the cylinder rod now moves out. Any remaining air inside the cylinder, is expelled from port A of the cylinder, via port 2 of the valve, and exhausted out into the atmosphere via port 3, (port 5 is now closed).







Electrical (solenoid) operation of valves

Operating a valve manually is quite useful when doing fault-finding work or in some simple applications.

However, in the majority of cases, and particularly in automation, we need to operate actuators through electrical signals that come from a purposely designed control system.

To do this, we use a solenoid which is simply an electromagnet which actuates a metal plunger to switch the valve to the ON state. The picture on the right shows a typical solenoid, (circled), mounted onto a valve.

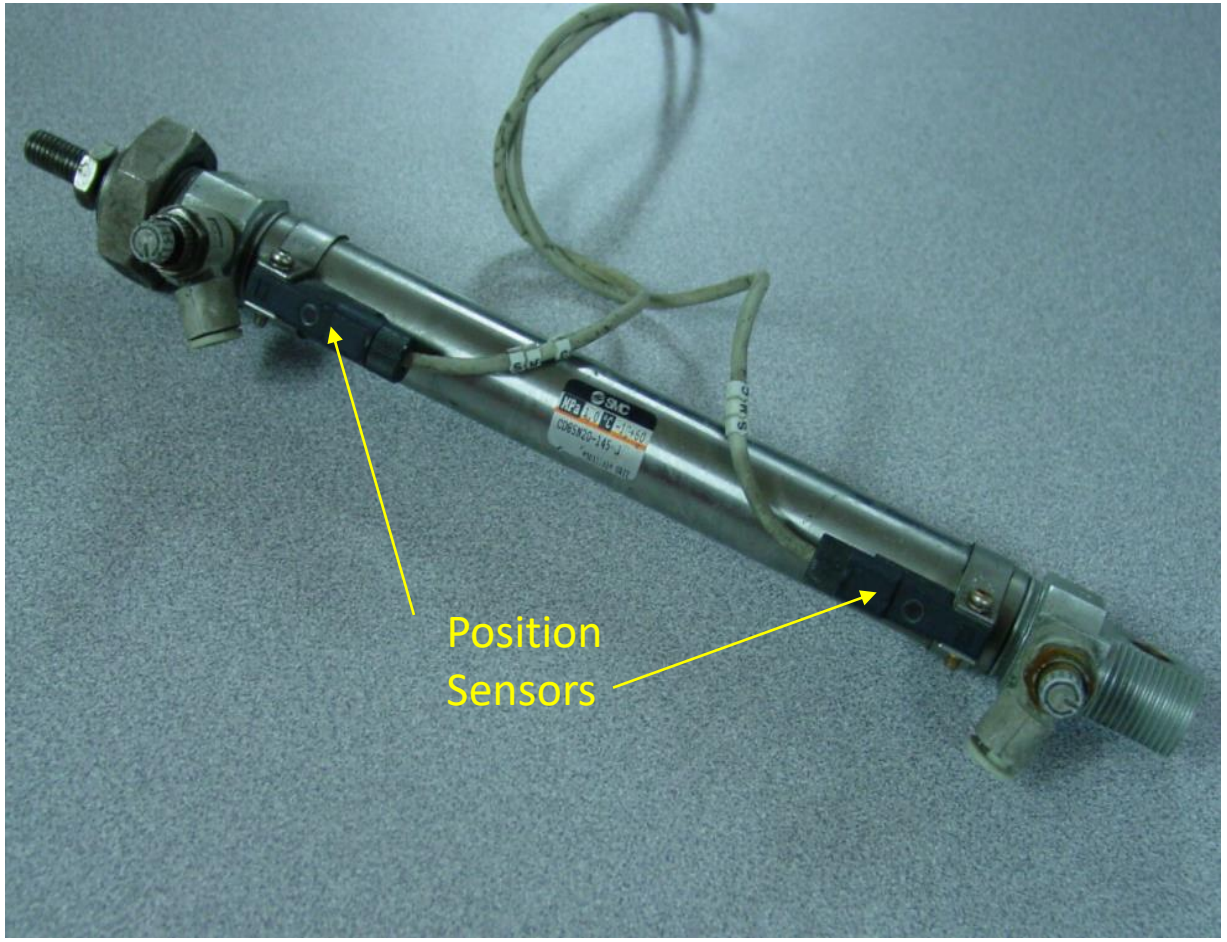
Solenoids come in various operating voltages but the most commonly used are the 12V and 24V types.

Position Sensors

Once a solenoid is energised, we would naturally expect the actuator to move forward, or retract, as the case may be.

However, a number of circumstances may arise where, due to some fault situation, the cylinder does not perform the required movement.

Possible causes may be a drop in the air pressure; leaks in the system; a faulty cylinder, a defective solenoid, or even some physical obstruction that may be blocking the motion of the actuator.



Position sensors mounted on the cylinder, enable us to verify whether the actuator has indeed changed state or not.

Mode of operation is quite simple:

Two magnets are internally mounted at each end of the piston. When the magnet and the sensor are within proximity of each other, the sensor is activated.

The output of the sensor is usually either a simple, mechanically-operated, switching element, or a transistor output.

Air Pressure regulator

This is a very useful device as it enables us to control the amount of pressure into the valve and cylinder.

To adjust the pressure, you need to lift up the grey knob first and turn clockwise or anticlockwise as required. Once the desired air pressure is reached, the knob can be pushed down to ensure that the setting is maintained.

The regulator can also be used to completely shut off the air supply. That is particularly convenient when doing adjustments rather than having to plug and unplug the pneumatic connector from the service point.

Air pressure regulators are also available with a pressure gauge which is quite useful if you need to ensure that the system operates within a designated pressure range.

Speed controller

Another simple but quite useful accessory, frequently used in automation systems, is the speed regulator.

The speed regulator is frequently mounted directly onto the cylinder as shown. However, in situations where the cylinder is not easily accessible, it may be a better idea to use an *in-line* regulator as shown in the bottom picture.

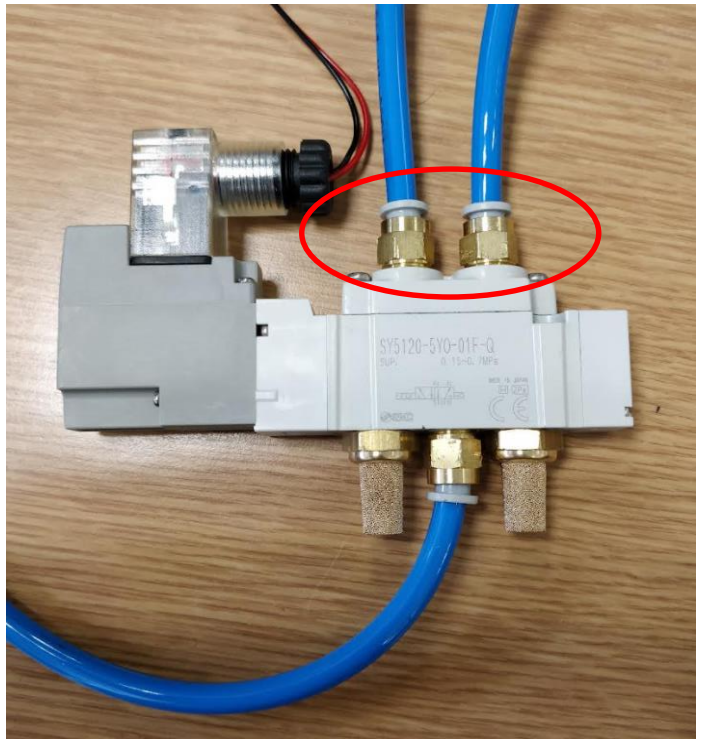
Speed control is simply a matter of turning the screw clockwise or anticlockwise. Once the desired speed is achieved, the lock down ring can be tightened gently to secure the setting.

Silencers

These devices are simply screwed into the exhaust ports of the valve and reduce the noise level during the exhaust cycle.

Push to Connect Fittings

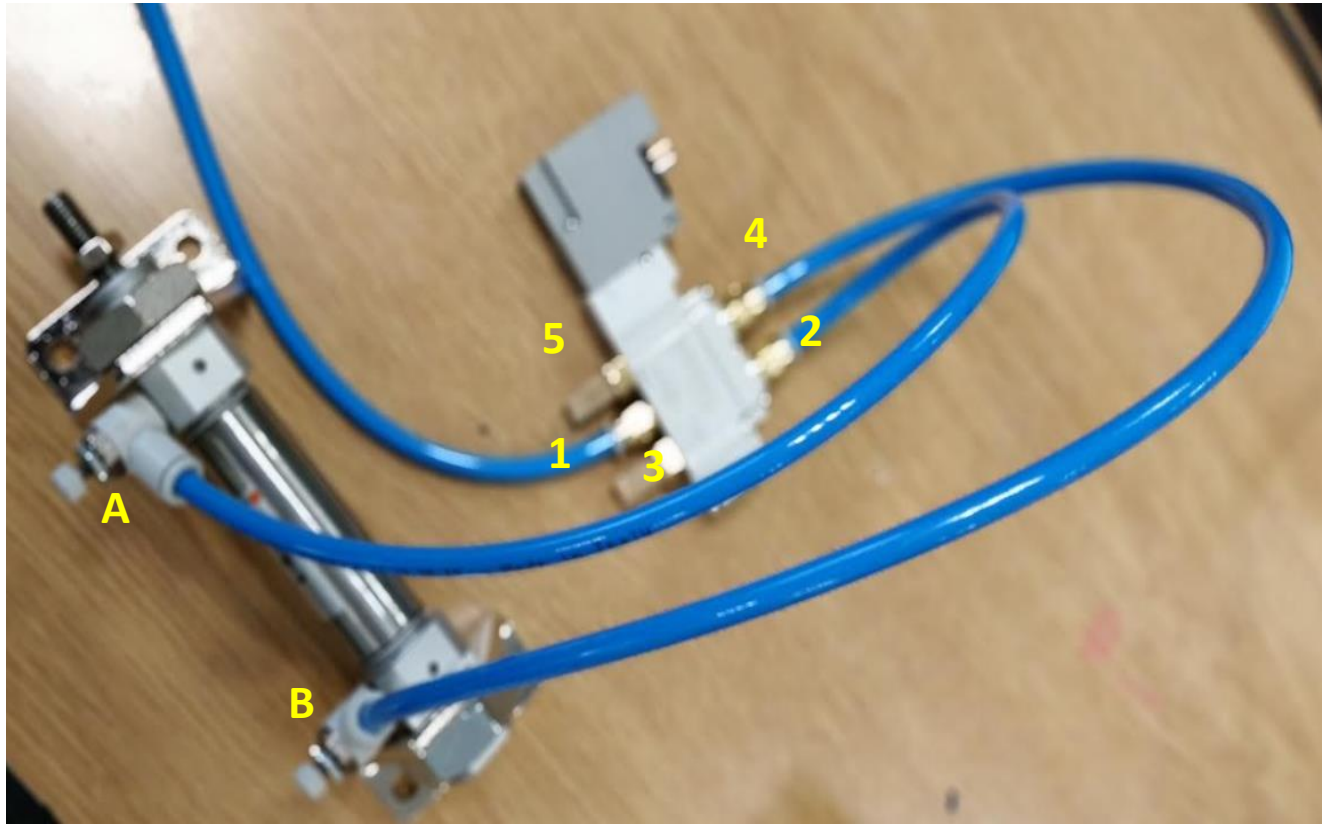
These devices are the ‘interface’ between the blue pipe and the valve. The fitting is screwed into the valve and at the other end, the pipe is simply push-fitted to make a secure connection. Pressing the white top piece down will enable us to remove the pipe , should we need to do so.



Here, we’re using a similar, but a larger-size fitting to connect to the regulator.

Setting up a complete system

The picture shows the complete set-up of a double acting cylinder, complete with an air pressure regulator which allows us to control the air pressure that is applied to the system.



Your turn!

All the items and fittings are supplied:

Your task is to:

1. Hook up the system.

2. Once finished, please ask any of the technicians to check your set-up.

3. Once the set-up has been checked, you can then verify that it operates correctly.

Getting familiar with the set-up!

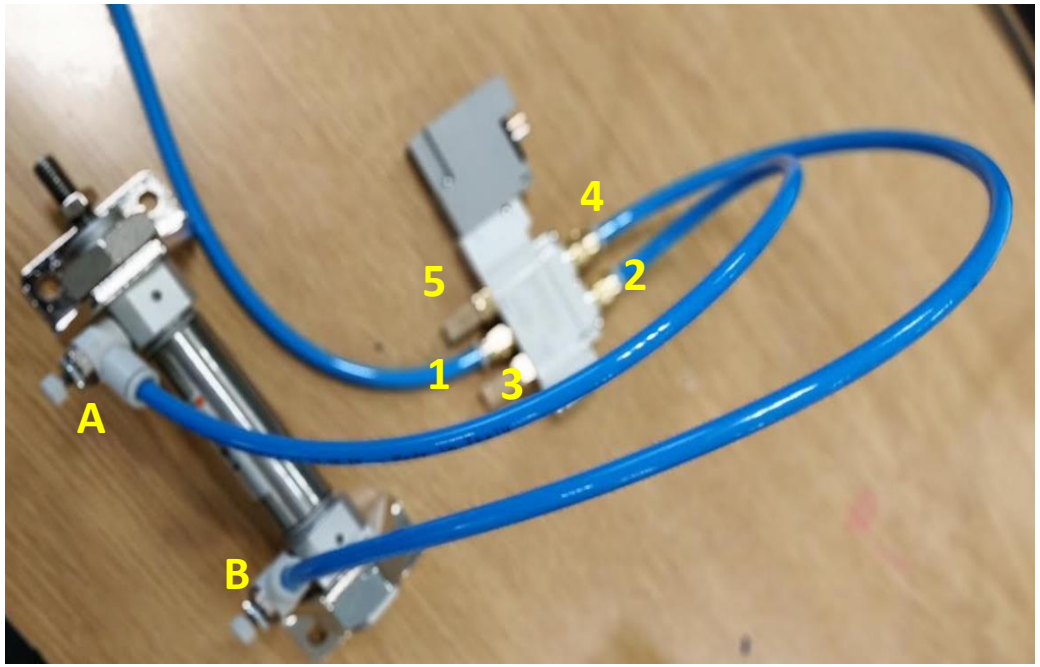
Now that you have set up the system try the following:

Turn on the air supply via the pressure regulator.

Operate the cylinder via the blue button on the valve, (circled in red).

Adjust the regulators, A & B, one at a time, and observe the change in speed.

Turn off the air supply and swap pipes 2 and 4 on the cylinder. Turn the air pressure back on again and notice what happens. Press the blue button and again note what happens.



Electrical operation

Set the power supply to 24V, and connect the grey cable. This type of solenoid is not polarity sensitive. However, as a rule, the brown wire goes to the positive end of the power supply while the blue goes to 0V or ground.

You can now control the cylinder by switching the power supply on or off.