Technology
Education

MiRobot

Five Axis Mini Industrial Robot

Control System Manual

V1.1.0

TechnologyEducation

Table of Contents.

This Manual

This Manual will guide you through the connection and operation of the MIRobot Five Axis Mini Industrial Robots **Control System**, and use of the supplied MiRobot Software.

Some fundamental Robotic concepts and terms will also be explained.

An “Industrial Robot” as defined by the International Organization for Standardization (defined in ISO 8373) is “ An automatically controlled, re-programmable, multipurpose manipulator, programmable in three or more axes, which may be either fixed in place or mobile for use in industrial automation applications.”

When complete your Robot fulfills ALL these requirements - but obviously on a very small scale.

Differences from a commercial Industrial Robot.

- Isn’t as accurate in positioning as a full size industrial Robot.
  No bearings etc. and built with quite large tolerances.

- Can’t lift weight.
  Not all Robots are heavy duty, but as the weight to be manipulated increases, the use of high strength materials also increases. Your Robot is mostly plastic and so has a very limited lifting capacity.

- Axes can only rotate a maximum of 180 Degrees with less on some axis.
  Some Industrial Robot Axes are capable of continuous 360 rotation.

- The Servos are commonly used for Radio Controlled devices.
  Industrial Robots use powerful and complex Servo Motors and Controllers.

- The Robot program is stored in a separate Computer.
  Industrial Robots have powerful built in Computers and can be programmed and usually operated completely “stand alone”.

- Is far less dangerous.
  Industrial Robots must be fitted with complex guards and safety systems to prevent injury to people. They can move very quickly and with great force so getting in their way is VERY dangerous. Your Robot operates at six Volts DC and is therefore electrically safe.

But on the other hand your Robot can be built with relatively simple tools and equipment, quite quickly and doesn’t cost tens or hundreds of thousands of Dollars.

We have attached some References for those interested in the underlying technology and covering the more advanced functions of the MiRobot Control System

You don’t have to use the References or get involved in the advanced functions to construct or operate the MiRobot.

Introduction

This Manual and the Mechanical Assembly Manual contain all the information necessary to build the MiRobot (Mini Industrial Robot), install its control system and operate it with the MiRobot Software.

To complete the MiRobot you will need to follow the instructions in both the Mechanical Construction and Control System Manuals and of course manufacture and assemble the individual components as described.

We suggest you start building the mechanical components of the MiRobot..... its impossible to fit the control system to a Robot that doesn't exist.... so....

In general the construction steps are :

- Read and understand the Manuals.
- Check you have all the required components.
- Install the MiRobot Software which will create the files required for 3D printing.
- Print the components.
- Assemble the Mechanical Components including the Servo's.
- Complete the Control System installation.
- Test and Calibrate the completed Robot.
- Write some programs to try out the MiRobot.

During construction and assembly its VERY IMPORTANT to follow the instructions, sometimes its necessary to assembly components in a specific order, or components can be damaged by incorrect assembly.

If your not sure about something - re read the instructions or ask for help !

The MiRobot Software includes Advanced Functions that you may wish to try out, these enable you to write your own user interface or remotely control the MiRobot over a network or the Internet, you can also build groups of MiRobot's and interface them with other devices to perform complex operations.

These Advanced Functions require extra knowledge and skills ..... but will provide extra challenges and learning opportunities.

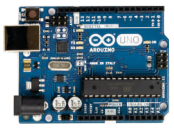
We hope you enjoy building your robot and learn a lot along the way.

The Technology Education Team

Supplied Components

What Control System Components are supplied ?

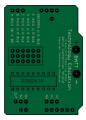
Item 1. An Arduino Uno or Uno clone Microprocessor



Item 2. Six Servo's (two different sizes)

Item 3. Collection of Servo Flanges, Arms and Screws

Item 4. A Servo connection Shield (Printed Circuit Board)
May be supplied unassembled by special order.



Item 5. A USB lead (Type A to Type B)

Item 6. A Six Volt DC Plug Pack

Item 7. Five Servo extension cables

What you need to have.....

- A Computer running Microsoft Windows XP®, Microsoft Vista®, Microsoft Windows 7®, Microsoft Windows 8 / 8.1® or Windows 10®
- The Computer must have one free USB port (USB Hub is acceptable).
- A two button Mouse
- DirectX compatible Video card or system (Standard nowadays...).
- A screen resolution of at least 1024 x 768 pixels.
- 1GB of RAM and 25MB of unused Hard Disk space for files.
- Four 1.5V "D" batteries. We suggest Alkaline or Rechargeable.

What you will need to install.....

- The MiRobot Control / Simulation Software available from Technology Educations or otherwise supplied.

Tools.....

- There are no tools required to connect / use the MiRobots Control System.

Industrial Robot Axes

Industrial robots come in a wide range of Axes configurations.

The majority use rotary Axis motion but some use linear or combinations of rotary and linear systems. These rotary and linear actions can and are assembled into a large number of different configurations as required for specific tasks. A Web search will show you just how many different styles of Industrial Robot there are.

Every Axis requires its own Servo and control system, and adds extra cost, so getting the task done with the minimum number of Axes makes sense.

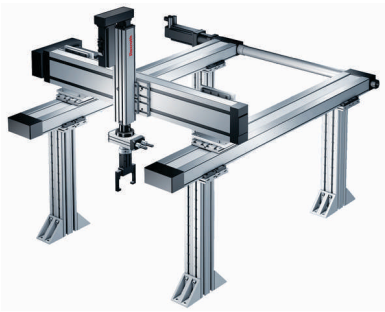
The more axes, also called degrees of freedom, the greater the robots manoeuvrability and work flexibility. Many articulated robots, feature six axes, but of course not all applications require as many to work effectively.
In the MiRobot, five axes are sufficient to provide a wide range of movement. It is also important to remember that the End Effector (a gripper or other device) is not considered an Axis.

Your Robot has five Axes, but uses six Servo's.

Different Robot manufactures identify their Axes with different combinations of letters, numbers or descriptions, there is no commonly used standard, so we are free to create our own Axes titles.

A six axis Articulated Industrial Robot. Commonly used for larger / heavier manipulation and assembly

A three axis SCARA Industrial Robot. Commonly used for Pick and Place packing and assembly



A three axis Cartesian Industrial Robot. Commonly used for Palletising and materials movement.

Some explanations from Wikipedia.....

SCARA acronym stands for Selective Compliance Assembly Robot Arm or Selective Compliance Articulated Robot Arm.

A Cartesian (also called linear robot) is a robot whose three principal axis of control are linear (i.e. they move in a straight line rather than rotate) and are at right angles to each other.

An articulated robot is a robot with rotary joints.

MiRobot Axes and Gripper

Your Robot uses the following Axes and descriptions.

Axis - A (Waist)

Rotary Action, 180 degree rotation, + 90 to - 90 Degrees
This axis, located at the robot base, allows the robot to rotate left to right. This motion extends the work area to include the area on either side of the arm.

Axis - B (Shoulder)

Rotary Action, 135 degree rotation, + 90 to - 45 Degrees
This axis allows the lower arm of the robot to extend forward and backward. It is the axis powering the movement of the entire lower arm.

Axis - C (Elbow)

Rotary Action, 180 degree rotation, + 90 to - 90 Degrees
The axis extends the robot's vertical reach. It allows the upper arm to raise and lower.

Axis - D (Wrist Pitch)

Rotary Action, 160 degree rotation, + 80 to - 80 Degrees
This axis allows the “wrist” of the robot arm to be rotated up and down.

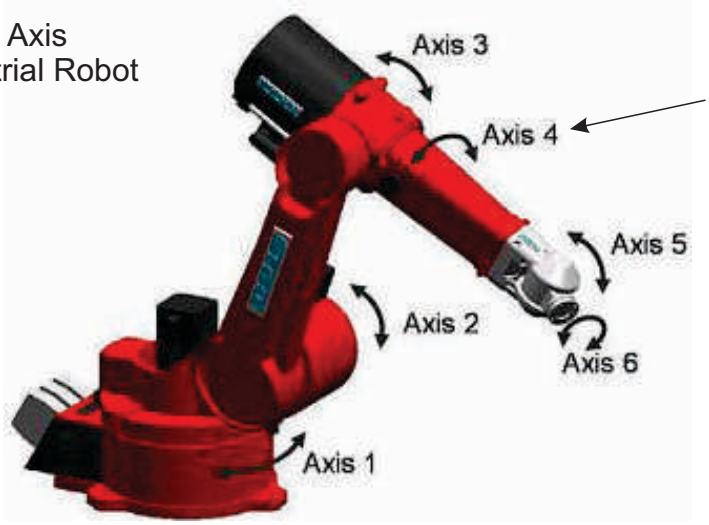
Axis - E (Wrist Roll)

Rotary Action, 160 degree rotation, + 80 to - 80 Degrees
This allows the “wrist” of the Robot to be rotated, both to position end effectors and to manipulate parts.

Gripper - G (Not an Axis)

Linear Action, 0 to 100% (of possible opening)
And of course an “End Effector which is NOT classed as a Axis.

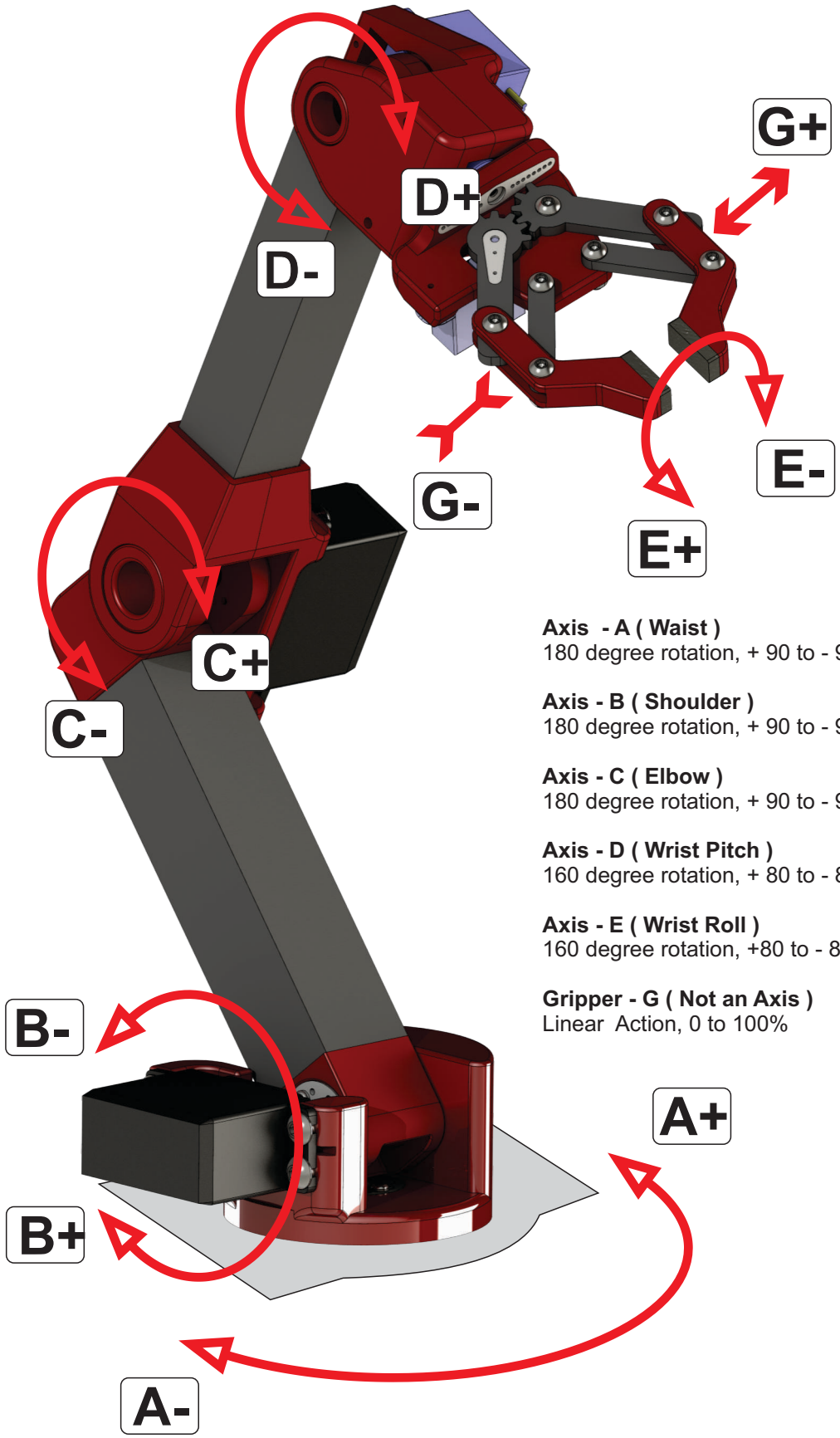
A commercial Six Axis Articulated Industrial Robot



This is the Axis we have deleted

Olympus Technologies Ltd.

MiRobot Axes and Gripper



Axis - A (Waist)
180 degree rotation, + 90 to - 90 Degrees

Axis - B (Shoulder)
180 degree rotation, + 90 to - 90 Degrees

Axis - C (Elbow)
180 degree rotation, + 90 to - 90 Degrees

Axis - D (Wrist Pitch)
160 degree rotation, + 80 to - 80 Degrees

Axis - E (Wrist Roll)
160 degree rotation, +80 to - 80 Degrees

Gripper - G (Not an Axis)
Linear Action, 0 to 100%

End Effectors

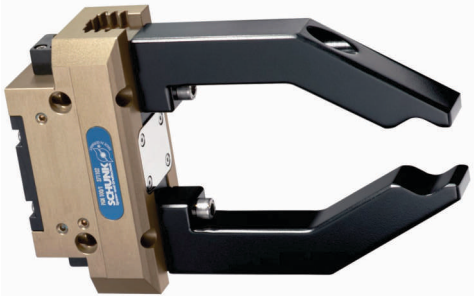
In Robotics, an End Effector is the device at the end of a robotic arm, designed to interact with the environment. The exact nature of the device depends on the application of the robot, and what it is required to do.

In the strict definition, the end effector means the last link (or end) of the robot. At this endpoint the tools are attached. End Effectors may consist of a gripper or a tool

Grippers

The most common mechanical gripper can be of two, three or even five fingers.

A Two Finger Gripper



A Three Finger Gripper

End-of-arm-tooling (EOAT)

End of Arm Tooling refers to a variety of options that are available to industrial robot users to complete industrial applications. Applications ranging from arc welding to material handling require EOAT specially designed to complete the task. Like the name implies, EOAT is installed on the wrist of the robot

A Laser Cutting Tool

A Nut Driver

MIG Welding Tool

Of course there are an almost unlimited number of possibilities for End of Arm Tooling, different products and assembly processes will require different tools, most of which are specially made for the application. Most Industrial Robots are designed so that Grippers or End of Arm Tooling can be easily attached by the user.

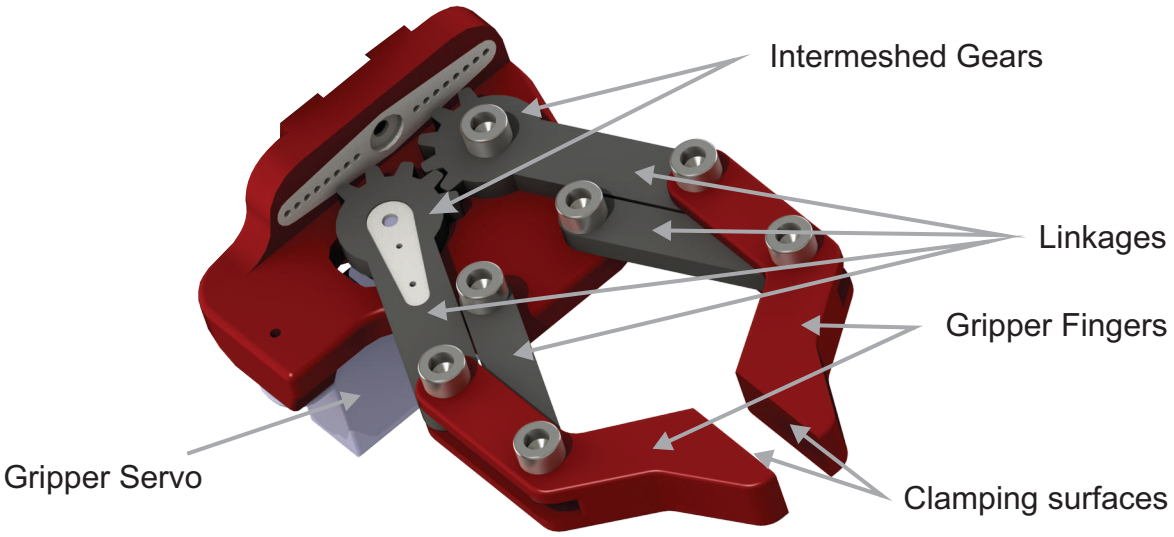
The MiRobot Gripper

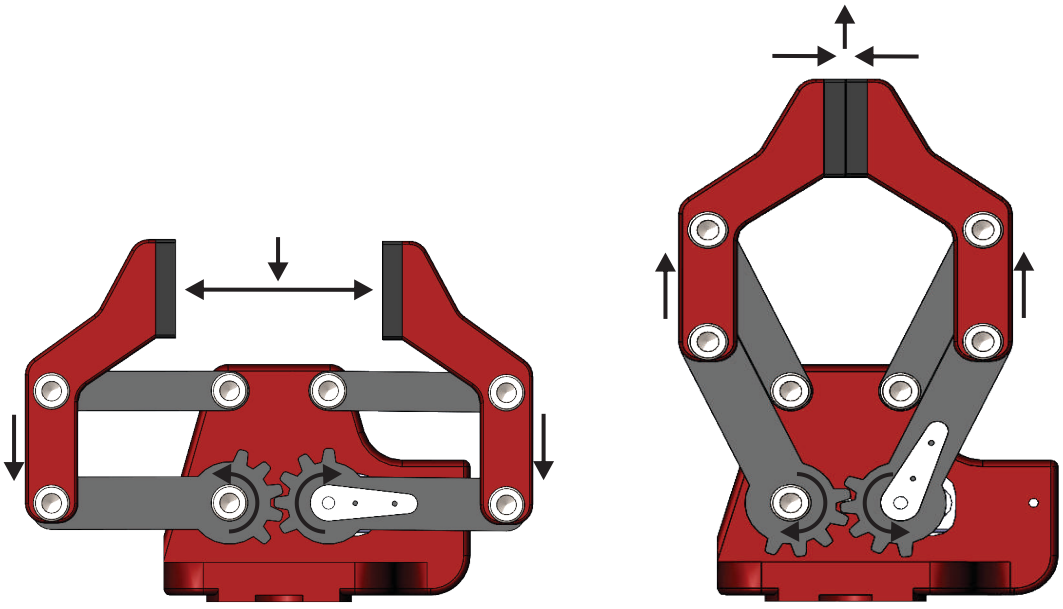
The MiRobot uses a Finger style gripper, which allows manipulation of a wide range of objects. It is also a compact system, allowing a large variation in opening without a bulky mechanism. Please remember.....the robot is designed to lift only small weights !

The gripper uses a single servo to turn a pair of intermeshed gears. Being meshed gears they turn in opposite directions.

These gears and the attached linkages form two links of a four link parallelogram, allowing the fingers to open and close with the gripping surfaces remaining parallel. Because of the parallel action, the gripping surfaces of the fingers move slightly forward when closing and backwards when opening.

The Gripper Fingers are also setup NOT to close completely, which could lead to excessive strain on the Servo, high current draw and short battery life. Foam rubber pads are fitted to provide clamping force, a non slip surface and a degree of “give”, allowing irregular objects to be more easily handled.





Handling Electronic Assemblies

Apart from the obvious potential for mechanical damage to electronic components and assemblies when they are mistreated, there is another more subtle and hidden risk..... Electrostatic Discharge (ESD)

With complete assemblies like your Uno, the ESD risk is low as the electronics have built in self protection that is effective once the components are assembled onto the Printed Circuit Board (PCB), but handling with care is always a good idea.

Some general information on ESD.....

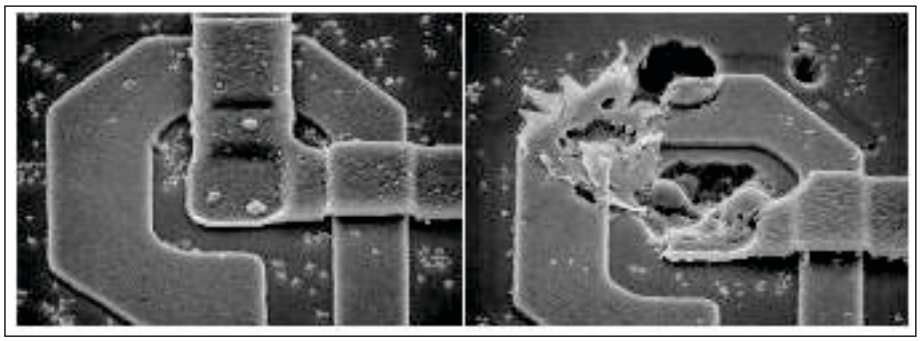
We experience occurrences of ESD everyday. For example, walking along a carpeted floor in a heated room during winter may generate sufficient static electricity to give us a small shock when we touch the door knob.

While this sudden discharge of static electricity does not result in any harm to the human body, it can be very damaging to electronic devices. It is possible for electronic devices to be damaged by ESD that is imperceptible to the human body.

The main Integrated Circuit on an Xbox One has around five million transistors in a package about the size of your thumbnail. The dimensions of the structures inside many electronic components are EXTREMELY small and electrically “fragile”, the energy from an Electrostatic Discharge can easily damage or destroy them.

Electron Microscope image of ESD damage
to the inside of an Integrated Circuit

Undamaged Damaged



Means of ESD generation and potential Voltages

Humidity	10-20%	65-90%
Walking across a carpet	35,000 V	1,500 V
Walking on a vinyl tile floor	12,000 V	250 V
Vinyl envelopes for work instructions	7,000 V	600 V
Worker at bench	6,000 V	100 V

Unassembled electronic components may be EXTREMELY sensitive to ESD damage so great care and adherence to safe working practices is absolutely essential. There is lots of technical information available on the safe handling of integrated circuits and electronic devices both in printed form and on the Internet.

The MiRobots Control System

Your Robot needs a control system in order to do anything.

This control system is responsible for receiving commands and converting them into position information that the Servomotors can work with.

To do this we are using a Micro Controller on an Arduino Uno circuit board. The Micro Controller used is an Atmel Corporation ATMEGA328P.

A Micro Controller is just a very small computer, similar in general principle to Laptops, Desktop Computers, Mobile phones, and....., in fact just about anything that is computer controlled.

Where it differs significantly is that all of the sub parts commonly found on a bigger computer are minimized and squeezed into a single Integrated Circuit. By full size computer standards a micro controller is very limited in computing power..... but as it doesn't have to create graphics for a screen, or communicate with the Internet etc. what processing power it has is completely committed to its single task.

By being completely focussed on this single task, a Micro Controller can be programmed to do many useful things.

Whilst Micro Controllers may seem inferior to other Computers, they frequently have inbuilt systems that make interfacing and controlling real world devices relatively simple.

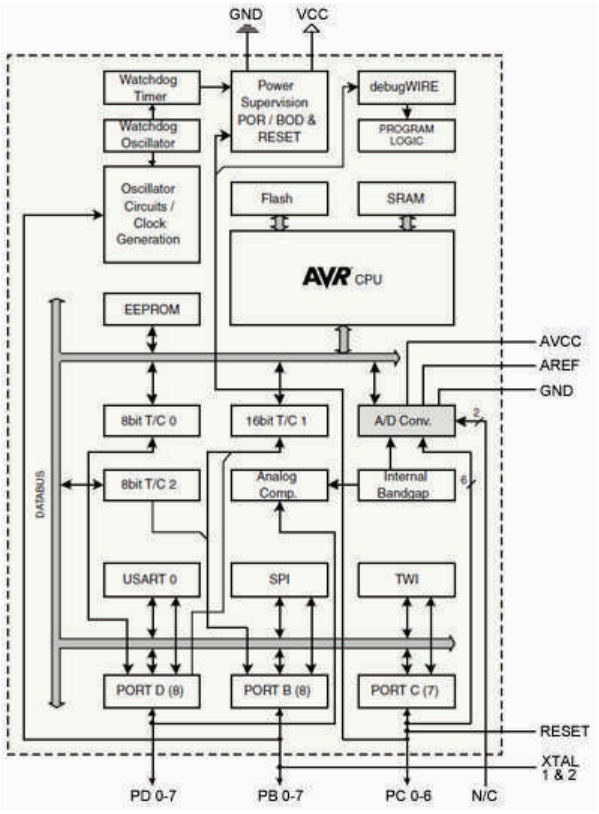
The ATMEGA328 has lots of Input and Output pins that can be used for connection to the outside world for both Digital (on / off) signals and continuously varying (Analog) voltages. They don't need disk drives or external memory to store the program or data... its all on the one chip.

They also have built in communication systems, some for working with other electronic devices and others for communicating with other computers, and of course us.

Just turn them on and away they go.... simple and focussed !

The ATMEGA328 we are using is a very useful small Micro Controller, but there are other far more powerful devices available.

The Block Diagram of a Atmel ATMEGA328..... you don't need to understand it, its just for reference.



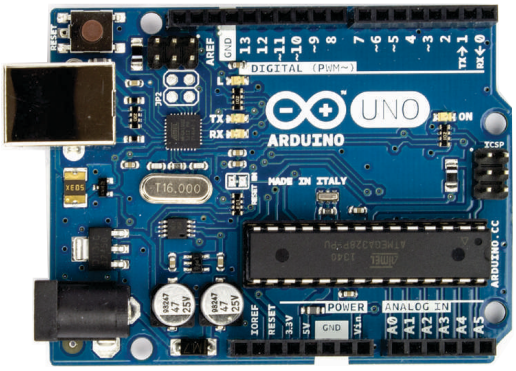
Your Robot uses a pre programmed Arduino Uno “clone” to generate the Servo control commands and communicate with a Microsoft Windows computer.

From the official Arduino web site : “Arduino is an open-source electronics platform based on easy-to-use hardware and software. It's intended for anyone making interactive projects”. The Uno is one of the simpler Arduino boards and is programmed in a variation of the C programming language.

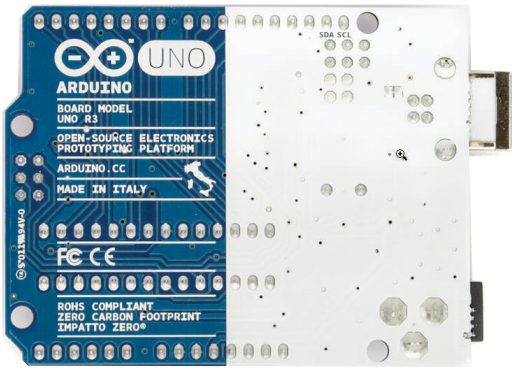
You can discover more about the Arduino Uno at the Uno web page :
http://www.arduino.cc/en/Main/ArduinoBoardUno

Arduino sell genuine circuit boards, but they are also “open source” allowing many other manufacturers to produce clones that are identical in outline, connector location, pinouts, programming and of course operation. To minimise confusion we’ll just call our Controller board a “Uno” from now on.

The Uno is also fitted with an extra “Shield” (Arduino speak for an extra circuit board) to make the connections to the Power Supply and Robot Servo’s easy.



The Top of a genuine Arduino Uno



The underside of a genuine Arduino Uno

VERY IMPORTANT

The MiRobots Uno is preprogrammed with a small Robot Operating System when you receive it.

Whilst it is possible to write your own “low level” Uno programs to control the Robot, when you upload them to the supplied Uno you will **PERMANENTLY OVERWRITE** the pre-loaded Robot Operating System, stopping the Robot from working. Once you upload new code to the Uno you can’t go back !

If you want to create your own Uno code, we strongly suggest you buy another Uno or clone and keep the pre programmed one just in case. You can get complete Uno clones for around $15 AUD if you search the Web.

There are many freeware packages allowing you to write and upload Arduino Uno code, but remember once you overwrite the supplied system your on your own !
The Arduino web site is a great place to start looking for more information.
You can discover more about Arduino at their web page : http://www.arduino.cc/

Robot Programming Languages

As with many things Computer related, there is no “standard” programming language for Robots.

This is partly because of the evolution of robots over time as they have become more complex and partly because each Robot manufacturer has their own ideas as to the ideal programming method (or perhaps they just want to be different).

Fortunately, there are enough similarities between the different manufacturers that it is possible to gain a general understanding of robot programming without having to learn each manufacturer's proprietary language.

Over the years programming languages have changed from simple sequences of positions to more complex coding that enables many high level functions to be undertaken like Maths, Network Communication, reading and writing Data etc.
In fact most of the programming concepts in high level Computer languages are available in the more powerful Industrial Robots.

A early example of a Robot programming language was “VAL” used by Unimate Robots. VAL is still used today (VAL3) in a more developed form.

```
PROGRAM PICKPLACE
  1. MOVE P1
  2. MOVE P2
  3. MOVE P3
  4. CLOSEI 0.00
  5. MOVE P4
  6. MOVE P5
  7. OPENI 0.00
  8. MOVE P1
.END
```

As you can see it is a simple sequential language, the Robot reads each line and moves to the required position or controls a device. When each line is completed it moves on to execute the next line until the Programs end..

Your Robot is programmed using a similar principle. Of course as we have a full size computer available we could undertake many more complex functions, however for our application a series of moves is all that’s required.

Other Programming languages used by commercial industrial robotics

Robot brand	Language name
ABB	RAPID
Comau	PDL2
Fanuc	Karel
Kawasaki	AS
Kuka	KRL
Yaskawa	Inform

Installing the "MiRobot" Control / Simulation Software.

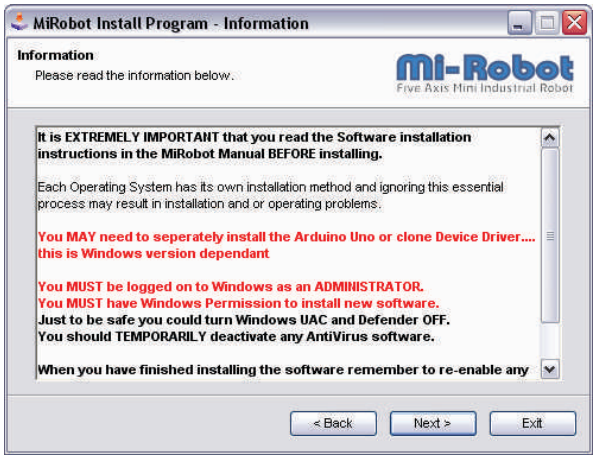
The MiRobot software runs on Microsoft Windows XP®, Vista®, Windows 7®, Windows 8 / 8.1® and Windows 10®.

Please ensure the latest Microsoft Windows® Service Packs / updates are installed..... Note - MiRobot is a 32 bit Microsoft Windows® application.

The MiRobot includes the MiRobot installation software, if in a school etc it may be available over the network.

If the MiRobot Installer package is downloaded (remember where you put it...), "right click" on it and choose "Run as Administrator " to start the installation process.

After reading the Welcome Window, Click "Next" to continue.

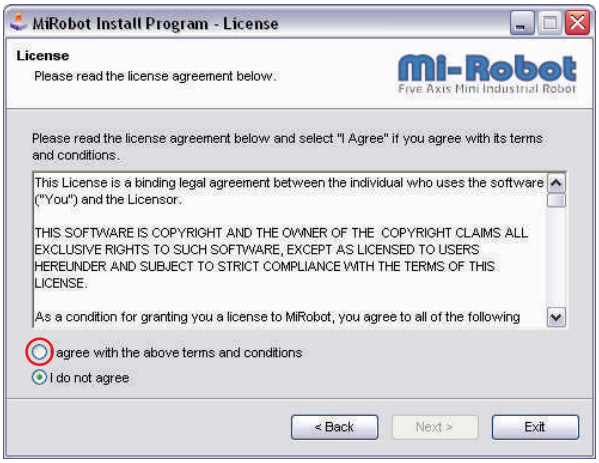


Its important to read the Installation notes.....

You SHOULD be an Administrator to install this software. You may need to have UAC turned all the way off.

If you have issues with your Anti Virus Software / Windows Defender during installation, temporarily disable them - but remember to re-enable them.....

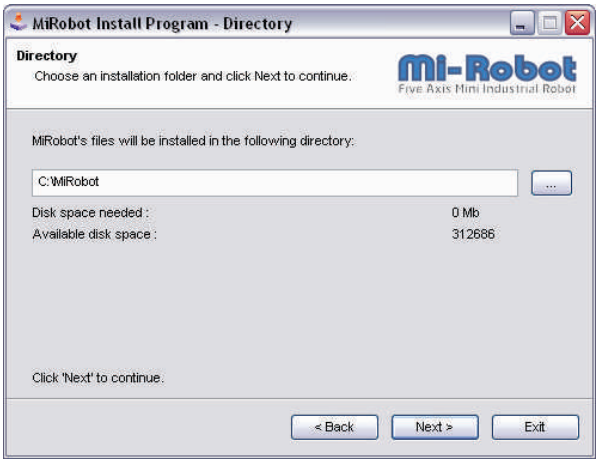
Click "Next" to continue.



Read and agree to the MiRobot License. You MUST click on "I Agree" (highlighted by the red circle at left) to continue instillation.

If you don't agree, the software will not be installed.

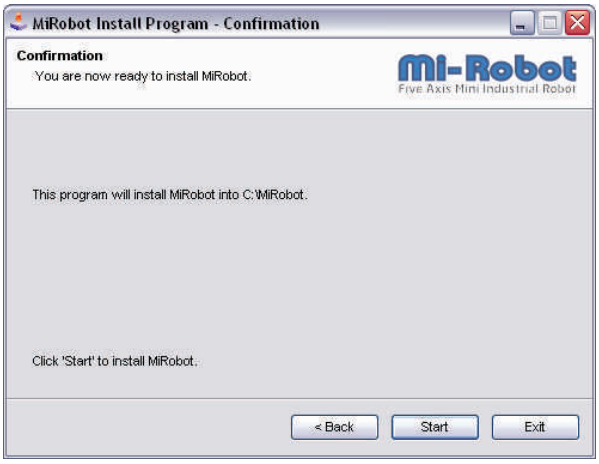
Click "Next" to continue.



You can select where the MiRobot software is to be installed, we suggest using the default location for simplicity.

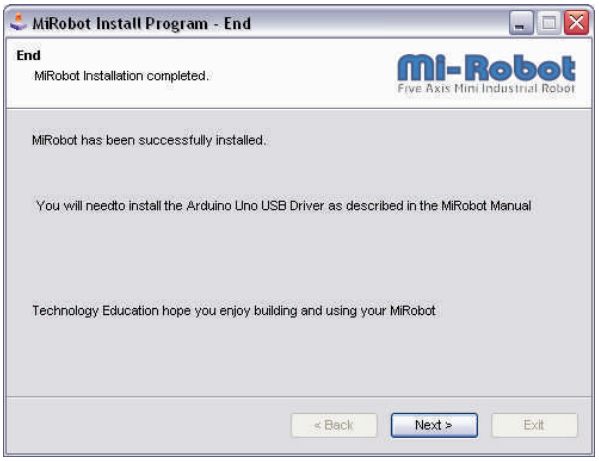
As the MiRobot requires a physical USB connection, installing on a network drive is not recommended.

Click “Next” to continue.



We are now ready to start the actual program installation.

Click “Next” to continue.



That’s it .....

If your installation has encountered problems extra information will be displayed.

Click “Next” to continue, finalize and exit from the MiRobot installation package.

You will now have a new Program installed called MiRobot and have a new shortcut on your desktop. MiRobot has also created an Un-Installer file should you wish to remove the MiRobot software.

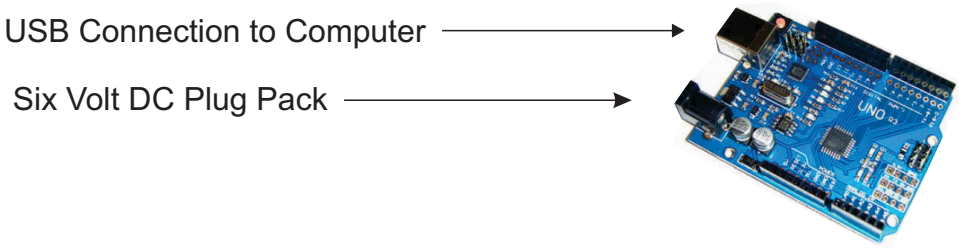
Install the Arduino USB driver as described on the next page.

IMPORTANT - the MiRobot software will NOT OPERATE without the MiRobot hardware being plugged in.

Power, USB and USB Drivers

The Uno connects to the PC by a Type B USB lead.

The Uno used in your Robot automatically draws power from the USB connection to the computer AND a Six Volt DC Plug Pack (supplied).



Installing drivers for the Uno with Windows 10, 8, 7, Vista, or XP.

Unfortunately there are a number of different “Device Drivers” used by Uno’s (genuine and clone) to interface with a Windows Computer. Some Windows versions already come with appropriate drivers, in others you will need to install them. With Windows 7 and up, in many cases Windows will already have the required drivers installed.

However some Uno’s will require manual installation. The driver installer was copied to the drivers folder of the MiRobot program if needed. If everything goes wrong, allowing Windows to search the Internet will usually locate and install the correct drivers.

The first time you plug your Uno into ANY USB Port, device drivers will be required... so it pays to plug your Uno into the same USB Port each time or when installing drivers plug the Uno into each port and repeat the driver installation process as required. Once drivers for the Uno are installed on a Port you will not need to repeat the process.

Each Windows version has slightly different installation procedures so its not possible to provide a “one size fits all“ explanation. Things to remember when installing drivers :

Are you an Administrator... ? You may need this permission to install ANY software and especially device drivers.

Is your Microsoft Windows version 32 or 64 bit ? Each version may require a different driver sub version.

Is UAC turned completely off ? You may need this permission to install ANY software.

Are you running a Microsoft Windows Version that requires “signed” Device Drivers (Windows 8 and up...) ? You will need to temporarily disable device signing to install your Uno.

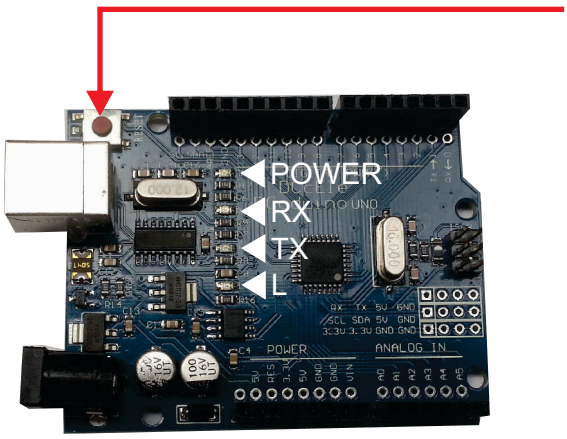
Your Anti Virus Package may need to be temporarily disabled to install a Program or Device Driver.

Connecting the MiRobot

You should connect the MiRobot to the Computer with the USB cable then connect the Plug Pack Power Supply **BEFORE** starting the MiRobot Program.

Uno's have a Reset Button, may need to press it to reset the MiRobot Hardware. If you are having problems connecting - press it.

Uno's have four Light Emitting Diodes (LED's) fitted, there are some variances in layout and colour so some checking may be required, but the functions are usual screen printed onto the UNO circuit board beside each LED.



RESET BUTTON

STANDARD UNO LED FUNCTIONS

Power -	When illuminated indicates that the Uno is ON.
RX -	When illuminated indicates that Data is being received.
TX -	When illuminated, indicates data is being Transmitted.
L -	General purpose indicator.

The L LED is used to indicate that the MiRobot Servos are enabled - we call it the Status LED from now on.

If the STATUS (L) LED it is not illuminated after starting the MiRobot software the system will NOT work. Close the MiRobot Software and press the Uno's Reset Button, then try again.

Connection Sequence

- Plug the Uno into the computer, the Power LED will illuminate and the Status LED will blink a few times.
- Connect the Plug Pack Power Supply.
- Start the Mirobot Program, the TX and RX LED's will blink a few times as well as the Status LED.
- After a few seconds the Power and Status LED's should **BOTH** be illuminated.

Unless BOTH the Power and Status LEDS' are illuminated the Mirobot and MiRobot Software will not work.

Unplugging during operation.

If you unplug the Mirobots USB Cable during operation you must reconnect the USB cable and **RESTART** the MiRobot Software. You cannot simply plug it back in as the Servo's will not be enabled.

Connecting the RC Servos

It would be great to have one type of universal connector that all RC Servo manufacturers use, but perhaps not unexpectedly this is not the case.

Having servo leads the right length would also be a plus, but we can't blame the Servo manufacturers for that, so we will also need to use Servo Extension Leads

Fortunately we've done the work for you and designed a Servo Connection Shield including "Overlay" text to guide you in connecting the Servo Cables / Servo Extension Leads. The whole system is "Plug and Play".

What is the Servo Connection Shield ?

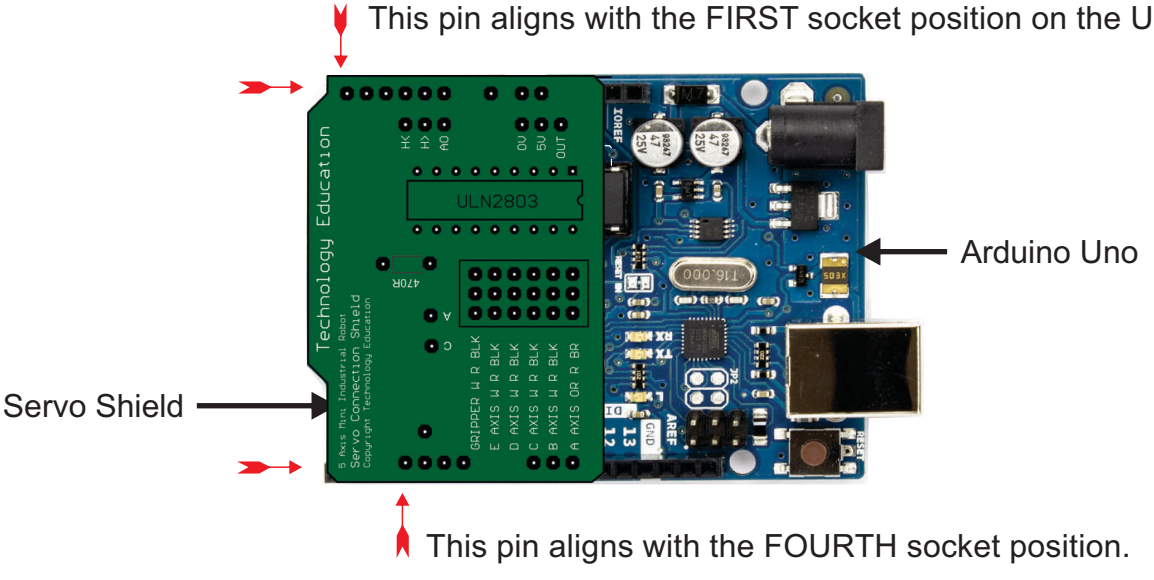
From the Arduino web page.... "Shields are boards that can be plugged on top of the Arduino PCB extending its capabilities. The different shields follow the same philosophy as the original toolkit : they are easy to mount".

Many Shields contain complex electronics to extend the capability of an Arduino, our shield is VERY simple, it does nothing more than allow easy connection for your Servo's and switches the Servo Motors power On and Off as required.

Arduino Shields are also very simple to assemble to the Arduino board, you simply align the downwards facing pins on the Shield with the sockets on the Arduino and CAREFULLY push them together.

Many Shields are designed to be stackable, with a set of sockets on top of the downwards facing pins, allowing Shields to be stacked. Your Shield is designed to be a top level Shield because of the number and type of connectors it will be used with.

Step 1 - Referring to the illustration below, align the Servo Shield with the back end of the Uno, making sure that the pins align with the sockets. Note - not every socket position on the Uno is connected to the Servo shield.



Step 2 - GENTLY and *EVENLY* squeeze the Boards together.

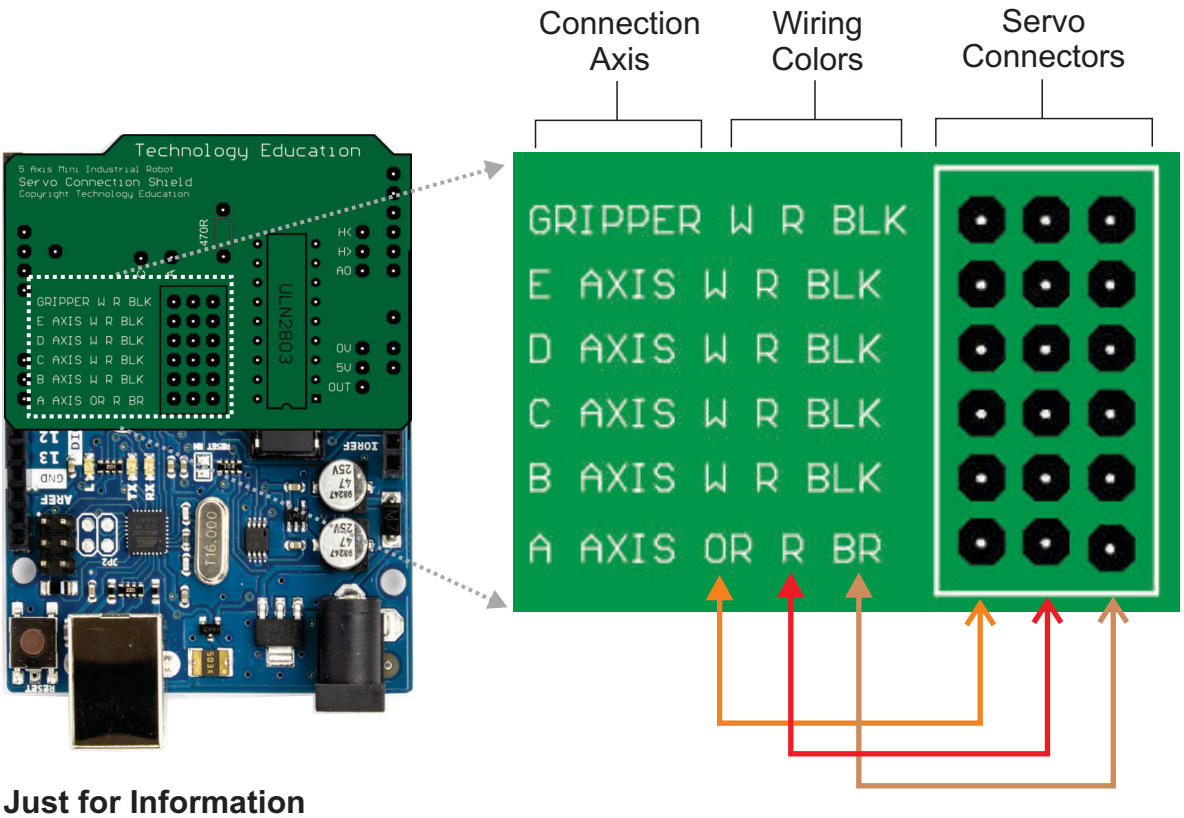
The Servo Connection Shield

In the centre of the Servo Connection Shield is a group of pin headers (6 x 3) for connection of your Servos - each Servo uses three pins.

At the left hand side of each row of pins is a description of what Axis it is designed to connect to, along with the colours of the connecting wires.

Flying leads are also provided for connection to the six Volt Battery Pack.

Because the Servo wires vary in colour, and there are rather a lot of them, we've had to get a bit "creative" with the labels. On any row the left hand colour label is associated with the left hand pin, the center colour label - the center pin and the..... you get the picture.....



Just for Information

We have listed a few other RC Servo Manufacturers Color Codes. It is highly recommended, before you experiment with an unknown servo to check what each wire does. Getting it wrong can be expensive. Servo Extension Leads also come in a range of different colors just to add to the confusion.

Manufacturer	Positive	Negative	Signal
Airtronics / Sanwa	RED	BLACK	BLUE or YELLOW
Futaba	RED	BLACK	WHITE
Hitec	RED	BLACK	YELLOW
Japan Radio	RED	BROWN	ORANGE
Tower Hobbies	RED	BLACK	WHITE
Kyosho / Pulsar	RED	BLACK	YELLOW

Connecting the Servos to the Servo Shield

Unfortunately the wiring fitted to the Servo's from the manufacturer is only long enough to directly connect Axis A.

All the other Axes and the Gripper require the use of Servo Extension Leads. This means you will need to use five Servo Extension Leads - they are all identical so it doesn't matter which one you use for any Axis.

These cables simply plug into the factory Servo wiring (they are available in an array of different lengths from different suppliers) and run inside the Robots arm down to the Servo Connection Shield on top of the Uno.

Any excess cable can simply be looped inside the Aluminum sections of the Robot to keep things looking neat and prevent the cables getting in the way.

When tidying up the Servo wiring, **ensure there is adequate cable slack available so that each Axis can move** throughout its entire travel without straining or jamming the wiring.

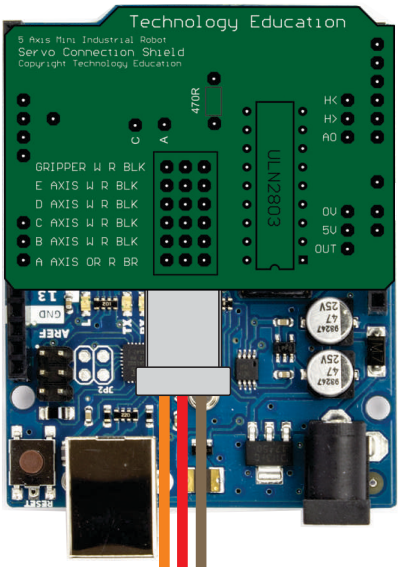
The full table of all the Servos, cable colours and the required connections are shown on the next page.....

The Servo Plugs are actually pushed down from the top NOT the side ..... the picture is to ensure you get the Plugs the right way around.

The pin headers are at a fixed spacing, and quite small. The Servo extenders may be a tight fit.

It is IMPORTANT that the Servo Plugs are fitted correctly, the Servo and / or the Uno could be damaged if you get it wrong.

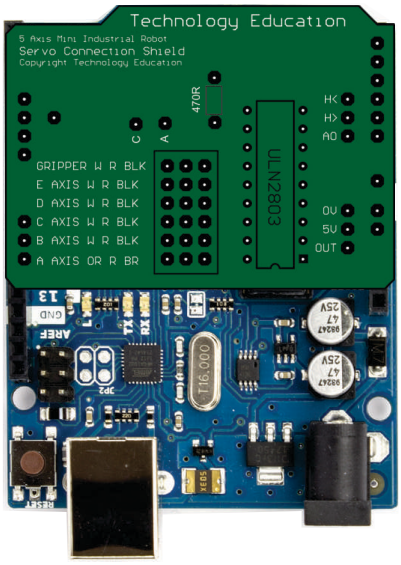
Try to get the correct Axis Plug on the correct Servo Connection Shield Connector, nothing will be damaged if you get it wrong - just the wrong Axis will move when commanded.

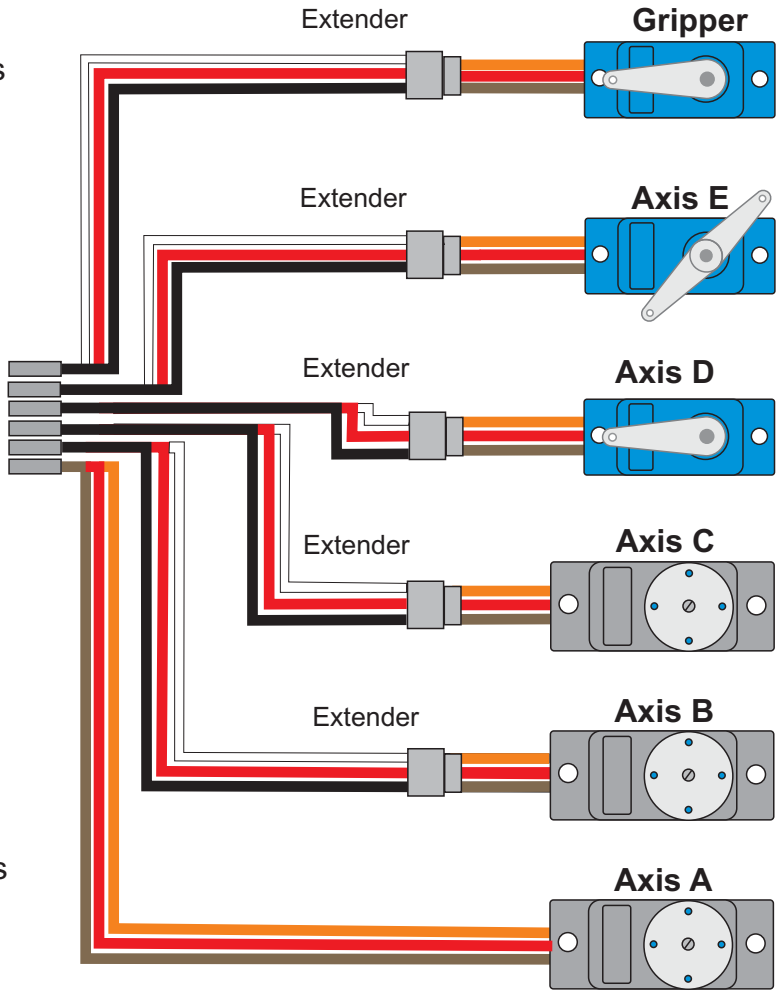


Servo / Extender / Servo Connection Shield- Connection Table

Axis	Servo Wire color	Extender Wire color	Wire color at Shield
A Axis	Brown		Brown
	Red		Red
	Orange		Orange
B Axis	Brown	Black	Black
	Red	Red	Red
	Orange	White	White
C Axis	Brown	Black	Black
	Red	Red	Red
	Orange	White	White
D Axis	Brown	Black	Black
	Red	Red	Red
	Orange	White	White
E Axis	Brown	Black	Black
	Red	Red	Red
	Orange	White	White
Gripper	Brown	Black	Black
	Red	Red	Red
	Orange	White	White

Ensure the Connector colours match those shown on the Servo Connection Shield





Do NOT force the Connectors onto the Servo Connector Shield Pins.

Robot Safety

Much of this section is for information only..... as it applies to Robots used in Industrial applications, your mini Robot has minimal risks when compared with full size units. Its can't exert much force, is battery powered and is lightweight. It might fall off your desk or spill you coffe if it hits something but that's about it, still be careful !

However full size Robots of any type CAN be extremely dangerous unless safety measures are taken.

The power and size of industrial Robots mean they are capable of inflicting severe injury or causing death if programmed incorrectly or used in an unsafe manner. Due to the mass and high-speeds of industrial Robots, it is never safe for a human to remain in the work area of the robot during automatic operation.

The system can begin motion at unexpected times and a human will be unable to react quickly enough in many situations, even if prepared to do so.
Even if the software is free of programming errors, great care must be taken to make an industrial Robot safe for human workers or human interaction, such as loading or unloading parts, clearing a part jam, or performing maintenance.

Industrial Robots are fitted with guards or installed in fenced off areas to ensure people are kept out of danger. Special systems are fitted to allow safe maintenance and programming.

NEVER ENTER AN AREA WHERE AN INDUSTRIAL ROBOT IS OPERATING.

FOLLOW ALL SAFETY PROCEDURES WHEN WORKING WITH A ROBOT.

Fortunately the risks of working with Robots is well understood and most countries have compulsory Standards governing their safe use. Some examples are:

AS 4024.3301-2009 Safety of machinery - Robots for Industrial Environments - Safety Requirements.

ANSI/RIA R15.06-2012 Safety Requirements.

I**SO 10218-1:2011** (robot)

ISO 10218-2:2011 (robot systems and integration)

These documents are very heavy reading. Robot manufacturers and resellers are also valuable sources of safety information and training for real world applications.

Using the MiRobot Program

After you have successfully completed the MiRobot software installation, you will have a MiRobot program shortcut on the desktop and an entry in “All Programs”.

Double click on the Icon or Program entry to start the MiRobot Program.

The MiRobot startup screen will be displayed, and it will attempt to find the robot hardware’s USB connection.

If it is the first time the program has been run, or the hardware is plugged into a different USB port (avoid using different USB ports unless you like installing Device Drivers.....) the default configuration most likely will not be correct.

A Window will open allowing you to search for the robot hardware.

Depending on your Windows version you can either use the Manual or Automatic “Link” Buttons. The Com Port display will turn RED and the software will try to locate the MiRobot hardware.

If Automatic doesn’t work, manually set the Com Port number (this Port Number can be found in the Windows Control Panel / Device Manager / Ports (Com and LPT).

If you have the MiRobot hardware plugged into a USB port (and the Arduino Uno has been installed as previously described.....), then it should be located and a success message displayed.

Click Ok on the “Found...” message and the MiRobot Program Window will open.

If the Mirobot hardware is not located then the MiRobot program cannot be used - make sure the USB cable is plugged into the Computer and into the MiRobot Hardware.

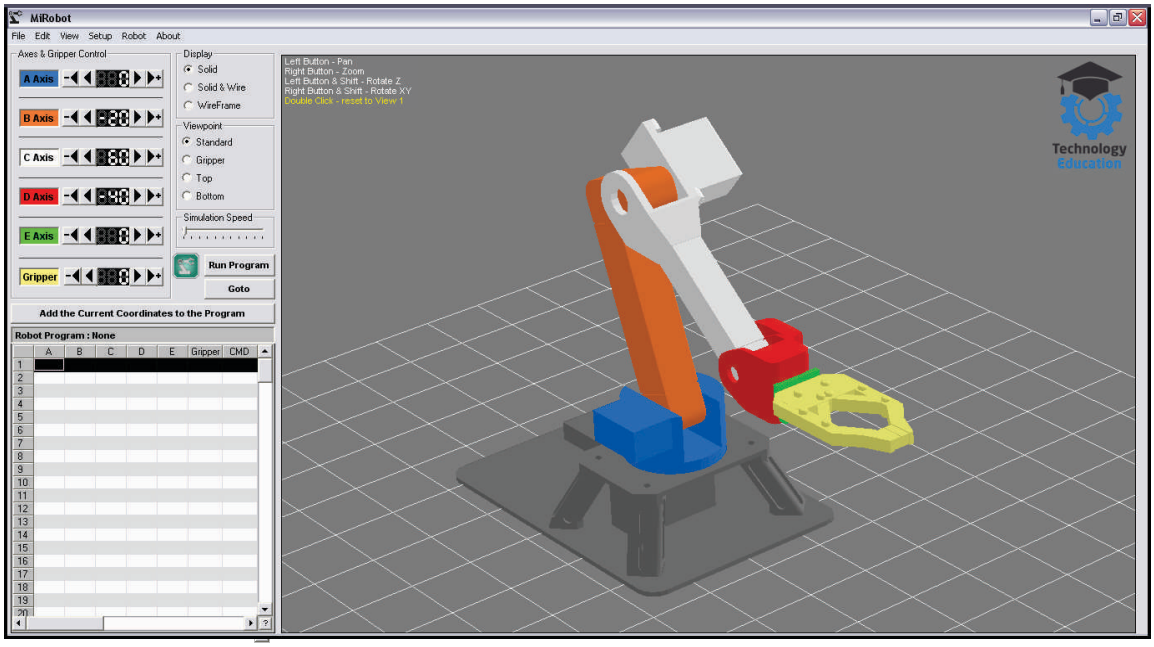
You can press the “Link” button again to try to “refind” the hardware as required.

If the MiRobot Hardware cannot be located then close the MiRobot Comms Setup Window and the program will exit.

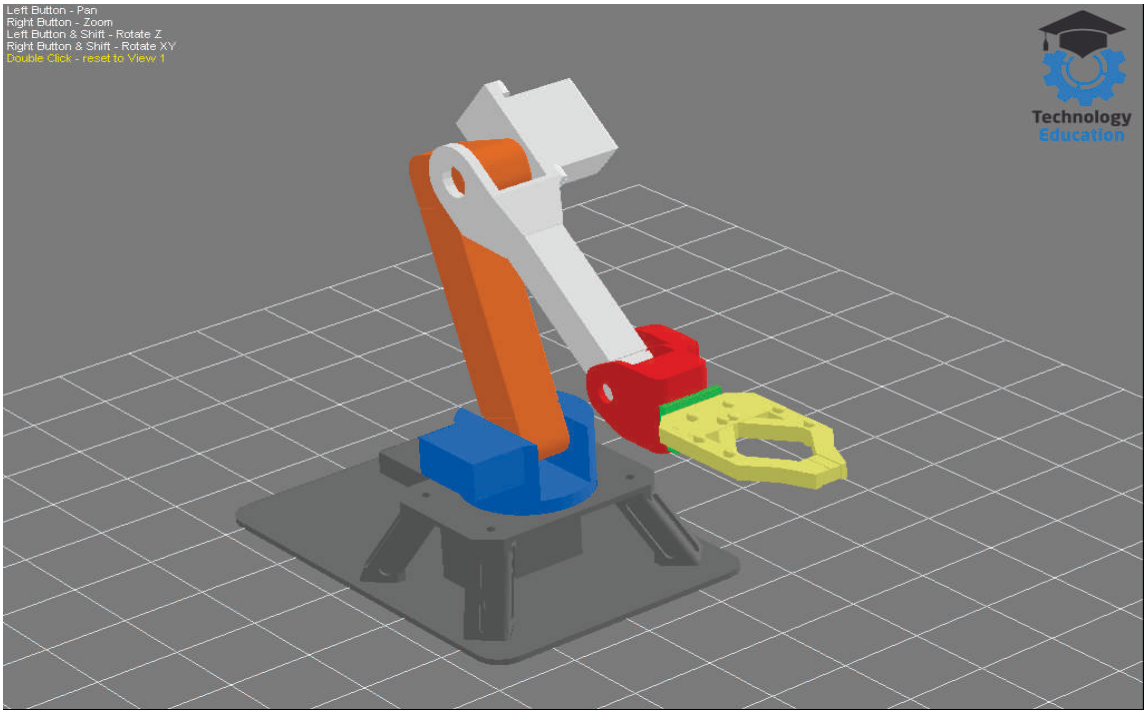
IMPORTANT : you cannot use the MiRobot software without the Mirobot.

The MiRobot Hardware is also not useable without the MiRobot software.

The MiRobot ProgramWindow



Simulation Section

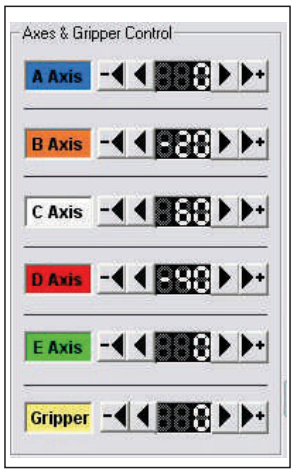


The Simulation section of the MiRobot Window, displays an animated graphic of the physical MiRobot Hardware. Mouse hints are displayed in the top left corner.

Changing the View :

Press the LEFT Mouse Button and move the Mouse to Pan (move) the viewpoint.
Press the RIGHT Mouse Button and move the Mouse to Zoom in and Out.
Hold the SHIFT Key and press and move the LEFT Mouse Button to rotate in Z.
Hold the SHIFT Key and press and move the Right Mouse Button to rotate in X/Y.

Manual Axes and Gripper Control



Each Axis has identical controls allowing the MiRobot to be manually moved.

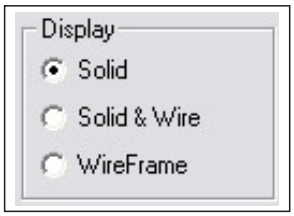
The numerical display indicated the Axis position in Degrees.

The Right and Left Arrow Buttons shift the axis by one degree. This can be quite slow but is safer especially when developing a program that has objects within the work area.

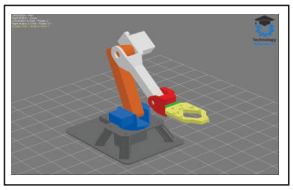
The Right and Left Arrow, Plus and Minus Buttons shift the Axis by five degrees.

The colour patch indicates the colour of the relevant Axis.(Clicking on the Colour Patch allows the Axes colours to be changed.)

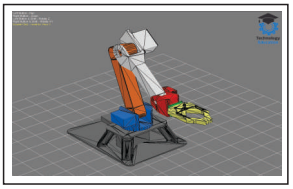
Display Controls



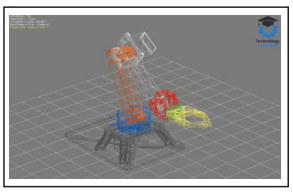
Display Controls



In the Display Section, selecting the “Solid” Radio Button sets the Simulation display to a Solid Rendering of the MiRobot,



In the Display Section, selecting the “Solid and Wire” Radio Button sets the Simulation display to a Solid Rendering with an overlayed Wire Frame.



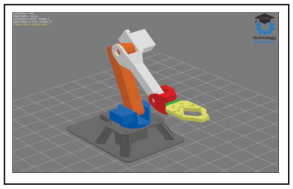
In the Display Section, selecting the “Wireframe” Radio Button sets the Simulation display to a simple Wireframe Rendering.

Viewpoint Controls

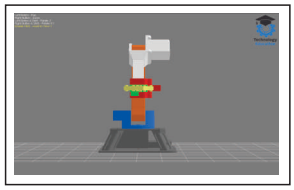
Hint

"Double Clicking" anywhere on the simulation will immediately reset the view to View 1.

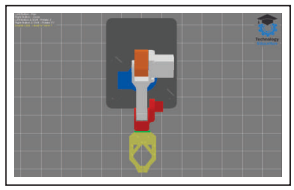
Viewpoint Controls



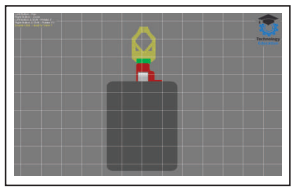
In the Viewpoint Section, selecting the "Standard" Radio Button sets the simulation viewpoint to the user default (Viewpoint 1).



Selecting the "Gripper" Radio Button sets the simulation viewpoint to the end of the Gripper.

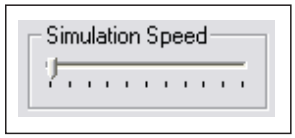


Selecting the "Top" Radio Button sets the simulation viewpoint to looking down on the top of the MiRobot.



Selecting the "Bottom" Radio Button sets the simulation viewpoint to looking up from the bottom of the MiRobot.

Simulation Speed Control



The Simulation Speed Control changes the animation speed of the simulation NOT the movement speed of the MiRobot Hardware.

Due to the huge differences is computer processing capability, it is not possible to provide a single setting that suits all users.

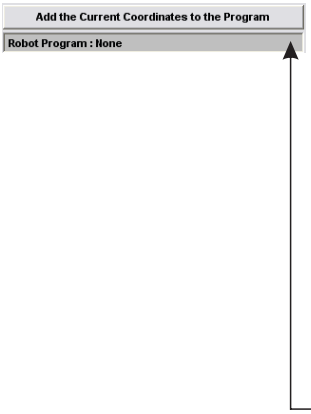
The optimum setting for a specific computer is for the MiRobot hardware to finish its commanded move **JUST BEFORE** the simulation completes its move.

Having the simulation running faster then the MiRobot hardware can move, will result in the actual movements of the hardware not being completed before the next position is sent from a stored program..... your program might not work correctly.

Individual Manual movements are not affected.

Once you have adjusted the Simulation Speed Control, it should not need ongoing adjustment..... it is stored as a default between sessions.

Program Display / Editing Section



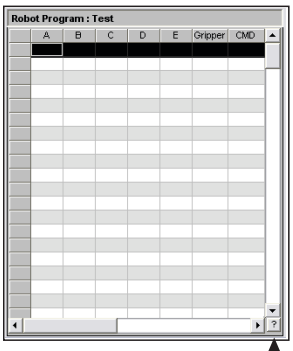
"Add the Current Co-ordinates to the Program" Button

Pressing this Button adds the current set of Axes Co-ordinates from the Manual Control Section to the END of the Program Table.

This allows a Program to be easily built up by manually moving the Axes using the Manual Controls, and when the desired position is reached adding it to the Program Table.

Robot Program Display

If a Program has been loaded, or the current program saved its name will be displayed in this area.



Hint

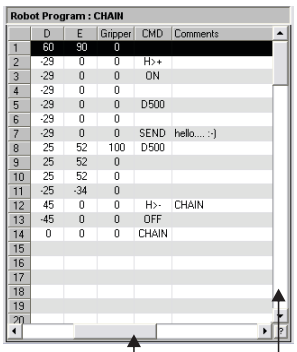
Clicking this Button will display a basic overview of available MiRobot Commands

The Program Table

The Program Table allows for the display and editing of a llist of points (a Program) that can be used to automatically control the MiRobot hardware.

The columns of the table are :

- The Axes Position (All Axes entries required)
  Type in the required Axis angle in Degrees.
- The Gripper Position (Required)
  Type in the required Gripper opening.
- CMD (Optional)
  Any Command (See Programming Commands)
- Comment (Optional)
  Any descriptive text as required.



Hint

Use the Scroll Bars to move to "hidden" program rows and to view Comments.

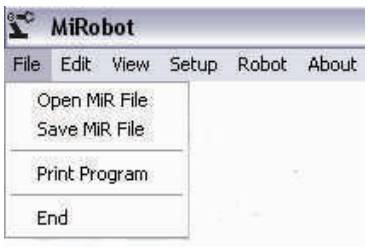
You can use the horizontal and vertical Scroll Bars on the Table to display sections that are hidden.

Each entry is checked for validity and corrected to default settings as required. Not all axes can be moved by 180 Degrees, so minimum and maximum values will vary with each Axis.

IMPORTANT NOTE : Each row of the Table represents a set of positions for the MiRobot, each Row MUST include angles for ALL Axes and the Gripper position. The CMD and Comment fields are optional.

The Dropdown Menu's

File : ⟶ **File > Open MiR File**



Opens a MiRobot File (.MiR file extension) and loads its contents into the Program Table. A standard Windows Dialog Box will open allowing you to select the required file.

Note : any existing Program Table contents will be lost.

File > Save MiR File

Saves the contents of the Program Table to a MiRobot File (.MiR file extension). A standard Windows Dialog Box will open allowing you to add the required file name.

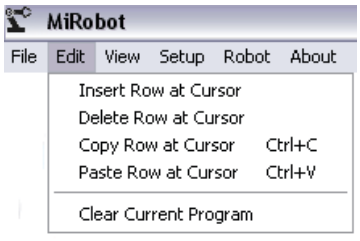
File > Print

Prints the contents of the Program Table to a connected Windows Printer.

File > End

Closes the MiRobot Program.

Edit : ⟶ **Edit > Insert Row at Cursor**



Inserts an empty row in the Program Table AFTER the currently selected row.

Edit > Delete Row at Cursor

Deletes the currently selected Row.

Edit > Copy Row at Cursor

Copies the Current Row to the MiRobot Clipboard (not the Windows Clipboard).

Paste Row at Cursor

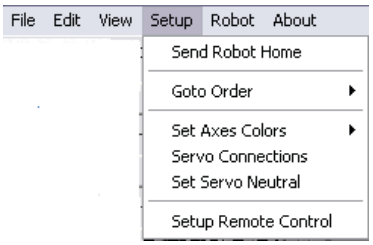
Pastes the contents from the MiRobot Clipboard (not the Windows Clipboard) to the current Row.

Clear Current Program

Clears the Current Program.

The Dropdown Menu's

View : ⟶



View > Viewpoint 1

Sets the currently displayed simulation Viewpoint to the saved Viewpoint 1. This is the default Viewpoint.

View > Viewpoint 2

Sets the currently displayed simulation Viewpoint to the saved Viewpoint 2.

View > Save Current View to Viewpoint 1

Sets the saved Viewpoint 1 co-ordinates to match the currently displayed simulation Viewpoint.

View > Save Current View to Viewpoint 2

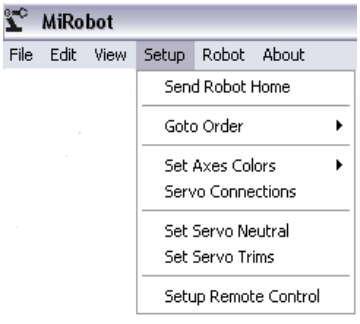
Sets the saved Viewpoint 2 co-ordinates to match the currently displayed simulation Viewpoint.

Be careful when saving Viewpoints, especially Viewpoint 1 (the startup default). Odd viewpoint can make understanding the MiRobot physical position difficult.

View > Video Feed

Advanced function - See Reference 10

Setup : ⟶



Setup > Send Robot Home

Sends the MiRobot to its "Home" position.

Setup > Goto Order

Allows the user to specify whether the Homing movement is undertaken from Axis E to Axis A or the other way around.

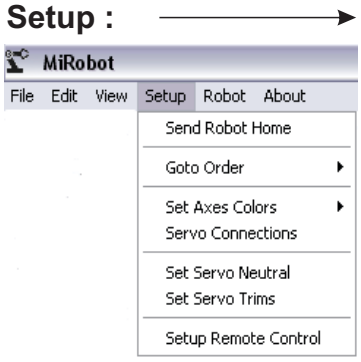
Setup > Set Axes Colours

Allows the User to select colours for each of the MiRobots Axes and the Gripper via a standard Windows Colour Selection Box.

Setup > Servo Connections

Displays the connections between the MiRobot Servo Connection Shield and the Servos. This is a duplicate of the information included in this Manual.

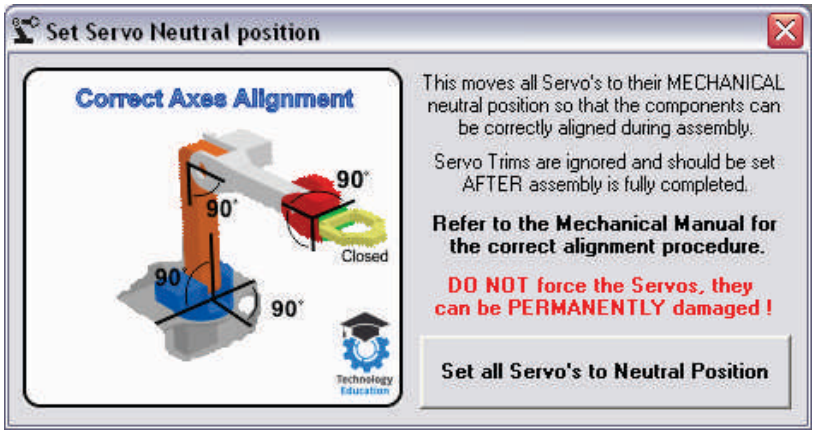
The Dropdown Menu's

Setup : 

Setup > Set Servo Neutral

This menu selection is mostly used when assembling the MiRobot.

It is EXTREMELY important that the alignment of the MiRobots physical components is correct.

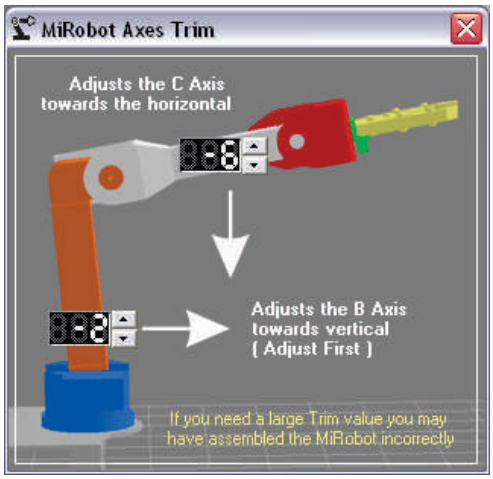


All Servo's are sent to the MECHANICAL Neutral position as shown.

Please refer to the Mechanical Assembly Manual for a full description of the mechanical alignment process.

Setup > Servo Trims

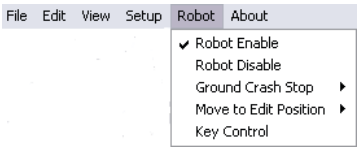
Allows for minor adjustment of the B and C Axes operating neutral position. Refer to the Servo Trim page for more information.



Setup > Remote Control

Advanced function - see Reference 9

Robot : →



Robot > Enable

With “Robot Enable” selected any movement in the MiRobot Software results in movement of the MiRobot hardware.

With “Robot Disable” selected the MiRobot Hardware WILL NOT move. All movements and Program commands are ignored.

Robot > Ground Crash Stop

Ground Crash Stop, allows you to turn off the system that warns that you are about to “crash” into the ground plane.

This setting is ON by default and must be turned off each time you run the MiRobot software.

In most case this system should be left ON... however you may genuinely need to reach below the Ground Plane so the system can be disabled as required.

Robot > Move to Edit Position

When activated, selecting a Row in the Program Table will automatically move the MiRobot to the positions set in that Row.

When editing is complete the MiRobot will automatically move to this edited position.

Use with great care as there may be objects in the MiRobots path. This option is TURNED OFF by default

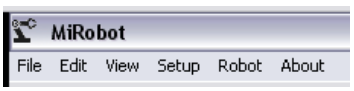
Robot > Key Control

Selecting this option will open a Window allowing control of the MiRobot from the PC Keyboard.

Unfortunately the Pc’s Keyboard layout doesn’t provide a layout that is ideal for control of so many Axes so be careful to familiarise yourself with the key layout.

See also - Advanced function - see Reference 9

About : →



About

Displays the MiRobot Software Information Screen.

Creating a MiRobot Program

Creating a sequence of movements for the MiRobot is simple.

The easiest approach is to use the manual controls to move each axis as required, then when the MiRobot is is the correct position, press the “Add the Current Co-ordinates to the Program” Button.

Robot Program : Handshake

	A	B	C	D	E	Gripper	CMD
1	0	-45	45	60	90	0	
2	-35	-26	52	-29	0	0	H>+
3	37	-26	52	-29	0	0	ON
4	0	-26	52	-29	0	0	
5	0	-45	52	-29	0	0	D2000
6	0	5	52	-29	0	0	H<
7	0	5	20	-29	0	0	SEND
8	0	5	20	25	52	0	
9	0	5	20	-25	-34	0	
10	0	5	20	79	0	0	H>-
11	0	5	20	-90	0	0	OFF
12	0	0	0	0	0	0	L2
13							
14							
15							
16							
17							
18							
19							
20							

Each “click” of the “Add...” button will add a new line to the Program, allowing you to build up a complex series of movements.

You can also manually enter (or edit) each line of co-ordinates, although this can be a very time consuming and difficult to visualize process.

Double clicking in a cell will....

1/ Move the Mirobot to the currently selected row position. (if the Mirobot is enabled)

2/ Open the specified cell for editing.

3/ When editing is complete the MiRobot will move to the new position. (if the MiRobot is enabled)

Commands (CMD)

The CMD column allows a **SINGLE** programming command to be added per row.

“D#####”	A programable delay at the end of the program movement. The Delay is specified in mS (thousandths of a second), with a maximum of 30,000 (30 Seconds).
“L###”	Loop causes the Program to jump to the provided (valid) line number.
“ON”	Turns on the User Output (Advanced Function - Reference 12)
“OFF”	Turns off the User Output (Advanced Function - Reference 12)
“H<”	Wait for Handshake In (Advanced Function - Reference 13)
“H>+”	Turn ON Handshake Out (Advanced Function - Reference 13)
“H>-”	Turn Off Handshake Out (Advanced Function - Reference 13)
“SEND”	Transmits the Comment to the Remote Link (if active).
“CHAIN”	Loads the “filename” from the Comment Column. File must be in the “\MiRobot\Programs” folder.

Comments

The use of Comments for lines is a great idea.... its often difficult to remember exactly what each movement does in a long program. When creating any type of Computer Software, lack of documentation is considered poor practice.

Chaining MiRobot Programs

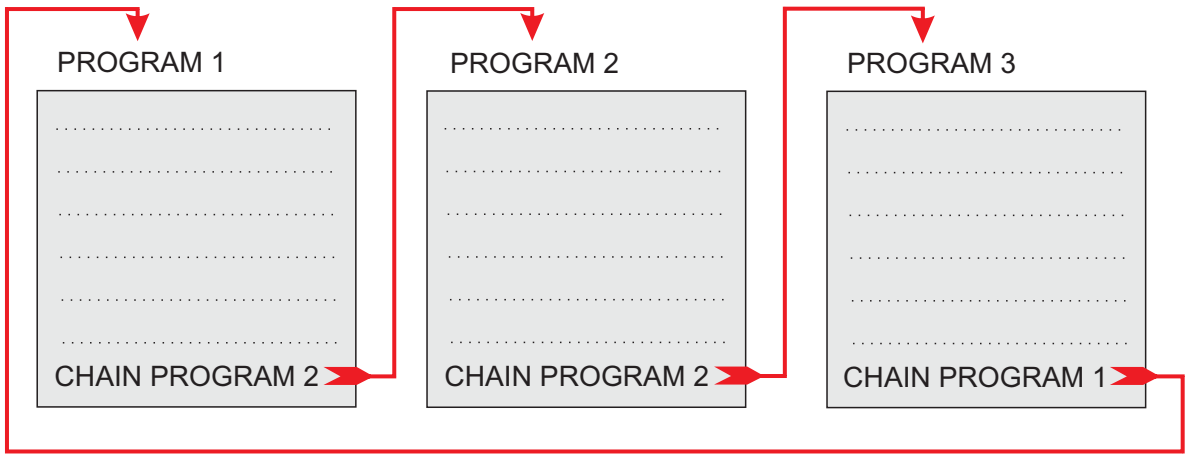
A complete sequence of movements does not have to be created in a single MiRobot Program, you can create smaller “sub Programs” and then use the CHAIN Command to have the MiRobot automatically load the CHAINed Program at the end of the current Program.

There is no limit to the number of Programs that can be chained together

For very complex systems it can be easier to write and test smaller programs to perform individual actions then when they are complete and working create a final program by chaining together all the sub programs

Technically the CHAIN Command can be used anywhere in a Program.... but it would be a little unusual as everything after the CHAIN command would not be executed unless the L Command was used to divert Program flow.

An “endless loop” of CHAINed Programs



Each CHAINed Program is just a normal MiRobot Program and can be created and tested as a stand alone program. All functions and Commands work exactly as usual.

If the CHAINed Program is not found the MiRobot simply stops.

CHAINing when under Remote Control

If you load a Program using Remote Control it will be executed as usual and CHAIN any included programs.

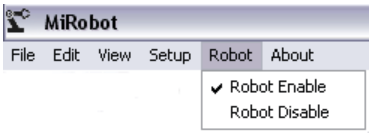
Of course if you have created your own interface you can just wait for the current program to end, remotely command the next Program to be loaded then run it..... loading and running as many Programs as you want.

Testing and Running a MiRobot Program

Testing a MiRobot Program

After a Program has been loaded, created or edited, it is ready to be “Run”.

Its is ALWAYS a good idea to check out your Program “on screen” before activating the MiRobot hardware to avoid “crashes”, or unexpected moves - especially if you are used any of the Advanced Functions with other MiRobots or devices.



You might not want the MiRobot to physically move when testing your program - select the Dropdown Menu item ” Robot > Disable Robot” which will allow the on screen simulation to be displayed without the MiRobot actually moving.

Most Commands behave exactly the same when the MiRobot is disabled, however the H< command is slightly different. Instead of waiting for a real Handshake In signal, a Windows dialogue box will open allowing you to “simulate” this signal.

Clicking the “Run Program” Button will execute the complete program on screen. During Program execution all of the on screen Status Indicators function normally.

Remember to re-enable the MiRobot using the Dropdown Menu item “Robot > Robot Enable” after you have finished checking your program.

Stopping a Running Program

Regardless of wether the MiRobot is disabled or enabled, clicking on the RED or Orange “CLICK TO STOP” indicator will pause a running Program. You are able to Continue or Stop / Reset the Program.

Note: the simulation may move a little after the Stop Indicator is “clicked”.

Using the Goto Button

Another way of testing individual moves in your Program is to use the Goto Button.

Select the desired Row in the Program Table (black highlight), and then “click” on the Goto Button. The MiRobot will move directly to the selected position.

IMPORTANT NOTE : This move will be DIRECT from where the MiRobot current is positioned to the new position. If something is in the way.....

The Goto Button does NOT execute any commands..... it is strictly a movement control.

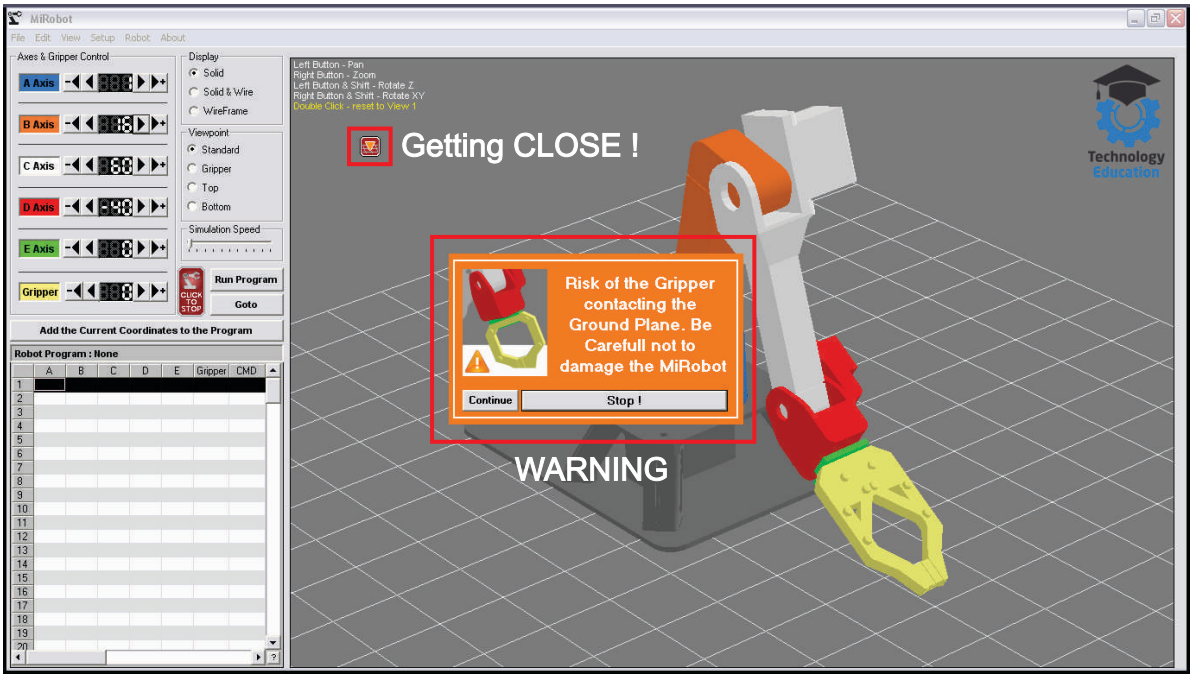
Testing and Running a MiRobot Program

Ground Plane “Crash” Warning

The MiRobot Software includes a **SIMPLE** form of Ground Plane “Crash” warning.

As the software does not know about its surroundings or objects held in the Gripper, it is only possible is to warn the user when the calculated position of gripper tips are close to the Ground Plane (the onscreen grid beneath the MiRobot).

The crash warning system **assumes the Mirobot is set up correctly**..... if the mechanical position does not match the on screen position then the warnings will be inaccurate. That’s why we spent time setting the Neutral positions when building.



This system has two stages and changes slightly depending on whether the MiRobot hardware is enabled.....

IMPORTANT :
The large warning appears ONLY during simulation, its is quite possible that you really do want your MiRobot to reach below the Ground Plane and this warning would interrupt operation, so its not displayed when a Program is running.

Hardware NOT Enabled (On Screen Simulation)

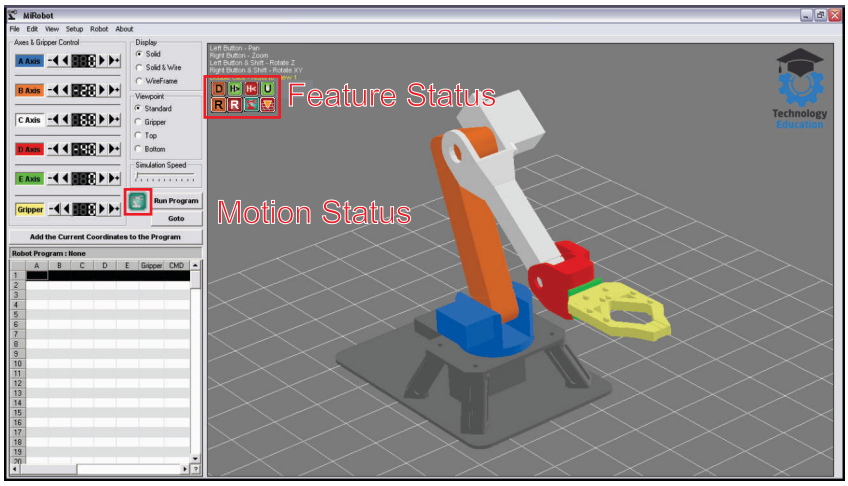
An Icon appears on Screen when you are close to the Ground Plane.
A Warning Message appears on Screen when you are likely to touch the Ground Plane, and the Ground Plane flashes on Screen.

You can continue to move the MiRobot past the Ground Plane once you have been warned..... we can only hope you know what your doing !

Hardware Enabled

An Icon appears on Screen when you are close to the Ground Plane.

On Screen Indicators



When the MiRobot is running, there are a number of on screen indicators used to show the operating status.

Some of these indicators are only visible when a feature is activated, so you may not see all of them.

Motion Status

The MiRobot is stationary and is OK to touch or work on.

The MiRobot is MOVING and is NOT a good idea to touch or work on it.

The MiRobot is PAUSED and is NOT a good idea to touch or work on it.

The Mirobot is moving, clicking on the Indicator will allow the running program to be Stopped or Paused, and is NOT a good idea to touch or work on it.

The Mirobot is in a Delay, clicking on the Indicator will allow the running program to be Stopped or Paused, and is NOT a good idea to touch or work on it.

Feature Status

The User Controlled Output is turned ON.

The Handshake Output is turned ON.

The Mirobot is waiting for a Handshake Input.

The MiRobot can receive Remote Commands.

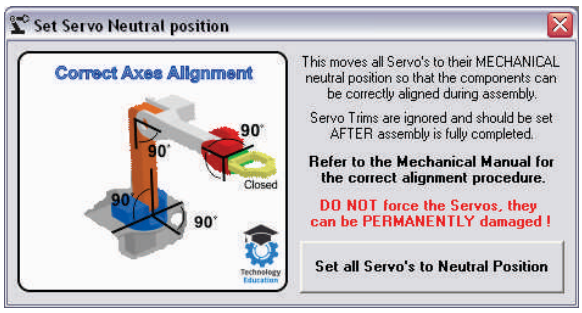
A Remote Command is being executed.

Delay mode active.

Robot Disabled.

Ground Plane Proximity Warning.

Servo Trims



During construction of the MiRobot you used the Set Servo Neutral position system to align the Servomotors with the mechanical components.

Due to slight variations in Servomotors and the 3D printed components you might have had to settle for a “not quite right” setup..... with the Axes not being exactly as required.

On most of the Axes this doesn’t make much difference, but with B and C Axes being quite long - errors multiply rapidly. The major concern is that angular errors in B and C have a very large effect on MiRobots Ground Crash Detection system.

MiRobot calculates the EXPECTED position of the gripper fingers assuming the mechanical assembly is PERFECT. If the actual MiRobot geometry differs, then the real vs calculated positions will be different and the warning system will no longer be useful. In the worst case, the Mirobot will hit the ground well before any warning.

How do we fix this ?

The MiRobot software includes an Axes “Trim” function for the B and C Axes. This allows minor correction for geometry errors from within the MiRobot software.

Using the normal movement buttons on the Main Screen, move the B and C Axes so that both indicate Zero degrees on their displays.

If B is vertical and C horizontal then no trimming is necessary.

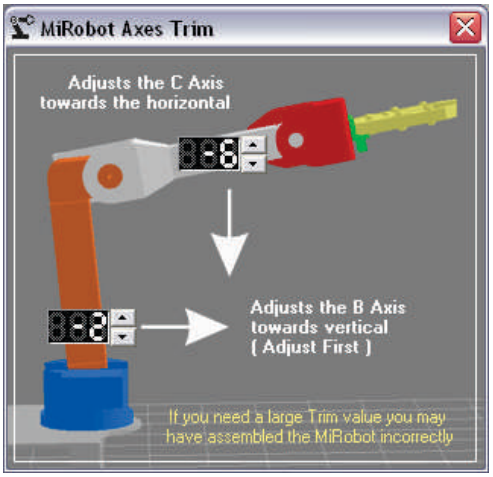
If either is out of alignment, select Setup > Axes Trim, from the MiRobot Main Window drop down menu’s.

Adjust the B axis <u>first</u> until it is vertical.

Adjust the C axis until it is horizontal.

Close the Axes Trim Window..... all done !

The MiRobot software will now automatically correct for the B and C Axes errors.



IMPORTANT
The Axes Trim function corrects for the MiRobot that is <u>currently connected</u>. If you use a different MiRobot or Computer then the Trim settings are unlikely to be correct. In this case you will need to re trim to match the current MiRobot.

Warnings, limitations, reminders

Connect the Battery Pack / Power Supply to the Mirobot before connecting the USB Lead or opening the MiRobot Program.

Remember to disconnect the Battery when you are finished using the MiRobot.

Test run your Programs to ensure they work as expected, especially if there are other objects in the MiRobots working envelope.

Set the Simulation Speed slider so that the MiRobot completes its move BEFORE the MiRobot software visualisation.

Save you Program..... its VERY frustrating to have to re do a program once completed and misplaced.

The MiRobot needs to be treated with care. The Servo's have capacity limitations, the parts are in most cases plastic, so can be broken. Replacing damaged parts will take time and potentially cost money.

The MiRobot is NOT designed to lift weight. You may exceed the capacity of the Servo's causing mechanical damage or flatten the battery as the Servo's struggle to hold the weight.

DO NOT attempt to move any of the MiRobot axes or gripper by hand when the MiRobot is on. You can easily damage the Servo's.

If you must move the Mirobot Axes or gripper when the power is **OFF**, do it **SLOWLY** and **GENTLY** to avoid Servo damage.

Do not allow Axis movements to cause the MiRobot to collide with other objects / benchtops etc. The MiRobot has quite a large operating "envelope" and can reach downwards for some distance.

DO NOT disconnect the USB cable whilst the MiRobot Program is running You cannot just "plug it back in... ", you need to close the MiRobot software, press the Hardware reset button and restart the MiRobot Software

DO not make DIY electrical connections to the MiRobot unless you really understand what your are doing. Read the Reference Sections for specifications, **If in doubt - DON'T !**

DO NOT upload new firmware to the supplied Arduino Uno. You will **PERMANENTLY OVERWRITE** the pre-loaded Robot Operating System making the MiRobot and the MiRobot software unuseable.

Reference 1 : How a Radio Control Servomotor Works

An RC Servomotor (Servo) as used in your MiRobot is a device that incorporates an electric motor, gear set, a positioning measuring device, and driver electronics.

Three wires extend from the Servo housing, one for power, the second for ground, and the final one is the control input wire.

The shaft of the Servo can be positioned to specific angular positions by sending a coded signal. As long as the coded signal exists on the input line, the Servo will maintain the angular position of the shaft. If the coded signal changes, then the angular position of the shaft changes.

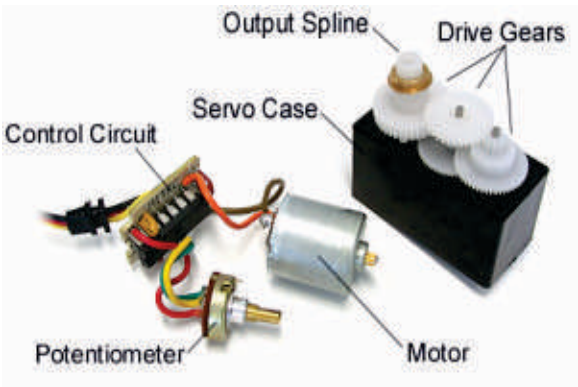
RC Servos come in different sizes but use similar control concepts and are extremely useful for many applications. The Servo's are compact and are extremely powerful **for their size**. They also draw power proportional to the mechanical load. A lightly loaded Servo, doesn't consume much energy. RC Servos work with voltages between 4 and 6 volts DC (Direct Current).

RC Servos are available in a wide range of sizes. The driver electronics all work in pretty much the same manner in all analog RC Servos, but the mechanical components vary depending on the Servos size and quality.

The gears of a Servo vary between models and manufacturers. Inexpensive Servos have plastic gears, and more expensive Servos have metal gears which are much more rugged

Servos can be damaged if rotated by hand, so be careful not to force them.

RC Servos are constructed from three basic components, a motor, a potentiometer (variable resistor) that is connected to the output shaft, and a control board.
The potentiometer allows the control circuitry to monitor the current angle of the servo motor. The motor, through a series of gears, turns the output shaft and the potentiometer simultaneously.



The potentiometers signal is fed into the servo control circuit and when the control circuit detects that the position is correct, it stops the motor.

If the control circuit detects that the angle is not correct, it will turn the motor in the right direction until the angle is correct. Normally a servo is used to produce an angular motion of between 0 and 180 degrees. It is not mechanically capable (unless modified) of turning any farther..

The amount of power applied to the motor is proportional to the distance it needs to travel. So, if the shaft needs to turn a large distance, the motor will run at full speed. If it needs to turn only a small amount, the motor will run at a slower speed.

Reference 2 : RC Servo Control

Normally a servo is used to produce an angular motion of between 0 and 180 degrees. It is not mechanically capable (unless modified) of turning any farther.

There are 360 Degree Servo's available, these are often used to drive Robot wheels or winches of model sailboats, but in this case the command signal controls the speed and direction not the position.

RC Servos are controlled by sending an on/off pulse train (a repeating series of pulses) of variable pulse width. The control wire is used to send this Pulse Train to the Servo's internal electronics. The pulse parameters are configured so they have minimum and maximum values, and a repetition rate.

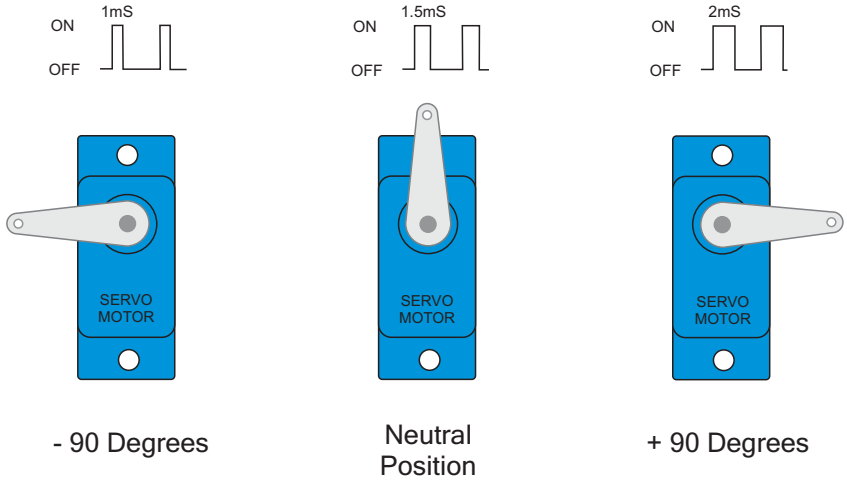
Given the rotational limits of the Servo, neutral is defined as the position where the Servo has exactly the same rotation in the clockwise direction as it does in the counter clockwise direction. It is important to note that different Servos will have different limits to their rotation, but they all have a neutral position and that position is achieved with a pulse width of around 1.5 mS (0.015 Seconds).

The Servo's shaft angle is determined by the duration of the pulse that is applied to the control wire. This is called Pulse Width Modulation (PWM).

The Servo requires a pulse every 20mS (0.02 Seconds). The length of the pulse will determine how far the Servo turns. For example, a 1.5mS (0.015 Second) pulse will make the Servo turn and hold its neutral position.

When a pulse is sent to the Servo that is less than 1.5mS, the Servo rotates and holds its output shaft a number of degrees counterclockwise from the neutral point. A pulse greater than 1.5mS will result in clockwise rotation from the neutral point.

RC Servo Position vs Control Signal



- 90 Degrees | Neutral Position | + 90 Degrees

When servos are sent a command signal they will move and hold that position. If an external force pushes against the servo, the servo will resist moving from its commanded position.

The maximum force the Servo can exert is its torque rating. Servos cannot be guaranteed to hold their position without a command signal, the pulse must be repeated (a pulse train) to ensure the servo stays in the desired position.

Reference 3 : Arduino Uno Robot Pin Mapping

REPEATING SOME IMPORTANT INFORMATION !

The Robots Uno is preprogrammed with a small Robot Operating System when you receive it. If you upload a new program to the Uno you will **PERMANENTLY OVERWRITE** the pre-loaded Robot Operating System.

If you want to create your own Uno code, we strongly suggest you buy another Uno or clone and keep the pre programmed one just in case.

So your going to modify the Electronics.....

Making the wrong connections to ANY Computer may result in permanent damage, so you need to understand how the Uno works and its specifications BEFORE making modifications. If you don't fully understand - don't do it.

The Robot Servo Shield makes the connections show below to the main Uno circuit board. If your sticking with RC Servo's there's little to be gained by not staying with the Axis pins as allocated. Clone Uno's may look a little different but the external connections will be the same as a genuine Uno.

Some extra Inputs and Outputs

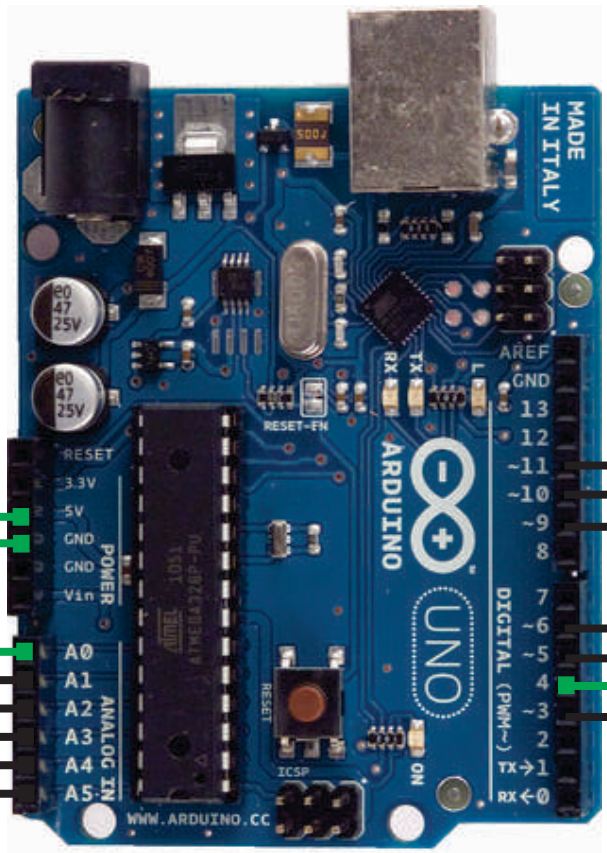
We have also provided a number of connections to spare pins that can be used by YOUR program as general purpose Digital (On/Off) or Analog (varying Voltage) inputs or Digital outputs. There's also regulated 5VDC and ground connections - these must only be used to power LOW CURRENT sensors etc.

GREEN TEXT

Unused I/O and Power connections available on the Servo Connection Shield.

BLACK TEXT

Required I/O and Power connections used by the Servo Connection Shield.



5 Volt DC
Ground

I/O 0 Pin A0
H> Pin A1
H< Pin A2
SE 2 Pin A3
SE 1 Pin A4
UO Pin A5

Axis A - Pin 11
Axis B - Pin 10
Axis C - Pin 9

Axis D - Pin 6
Axis E - Pin 5
I/O 3 - Pin 4
Gripper - Pin 3

Reference 4 : Uno Pin Electrical Specifications.

If you don't understand Electrical terms like mA / Volts etc. and how they effect an electrical circuit, then we strongly suggest you don't start making custom connections to your Uno - especially **DON'T MODIFY the Uno supplied with the MiRobot.**

However, if you have another Uno and want to create your own code.....

There are pin headers fitted to the Servo Connector Shield for the extra I/O pins, You can choose to fit a connector or solder directly to the board if you have the right equipment and skill.

The extra Uno pins can function as :

- Digital Inputs - they can be used to "read"wether a pin is at 5VDC or 0VDC.
- Analog Inputs - they can be used to "read" varying voltages. (0 to 5VDC)
- Digital Outputs - they can be used to output 5VDC or 0VDC.

These pins are identified in Uno documents as A0 - A5, 5V and Gnd.

Pin Ratings when used as INPUTS.

- Digital Inputs, 5VDC = On , 0VDC = Off
- Analog Inputs, 0 to near 5 VDC (1024 steps)

Pin Ratings when used as OUTPUTS.

When a Pin is ON, it is at 5VDC and can "Source" Current (Current can flow OUT of the pin to Ground).

When a Pin is OFF, it is at 0VDC and can "Sink" Current (Current can flow from the 5VDC supply INTO the pin.)

Pin Current Limitations when used as Outputs

- Pin SOURCE Current Limitations:

  Any single pin - 20 mA (recommended MAXIMUM)
  The sum of all the extra I/O pins should not exceed 150 mA.

- Pin SINK Current Limitations:

  Sn single pin - 20 mA. (recommended MAXIMUM)
  The sum of all the Extra I/O pins should not exceed 100 mA.

A brief explanation of Source and Sink is provided on the next page.....

Reference 5 : Sourcing and Sinking Current.

Sinking and Sourcing are terms used to define the control of current flow in a Direct Current (DC) electrical circuit.

A Sourcing digital output provides a Voltage and Current source to the Load, whereas a Sinking digital output provides a Ground connection to the Load.

It can all be a bit confusing..... things seem to be “on” when the Uno’s output is off and the other way around !

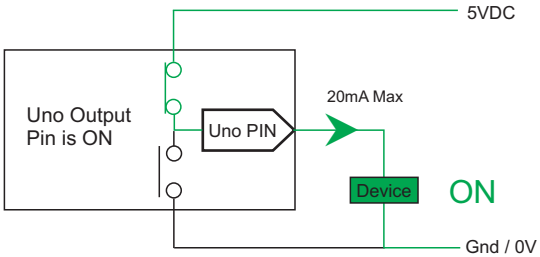
It makes more sense when you understand that the Uno not only provides 5V to its output pins when you turn them on, but also provides a Ground when you turn them off. So depending on exactly where the “other” side of the Load is connected, you will get different results.

Consider a simple circuit that consists of a Load connected to a digital Output. Electric Current by definition flows from Positive to Negative (Conventional Current),

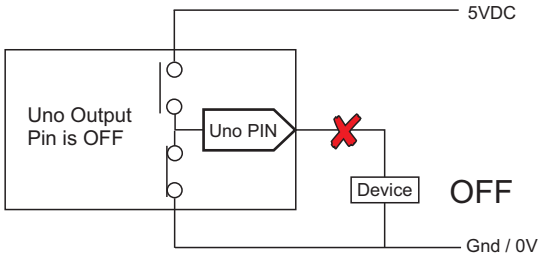
To operate correctly the circuit requires a Voltage source, a Ground, and of course a COMPLETE circuit from Positive through the UNO and Load to Ground.

A S**ourcing** digital output provides the **Voltage and Current** needed for the circuit.
Note that the side of the Load NOT connected to the Uno is connected to Ground.

A Circuit configured to “Source” Current in the ON State

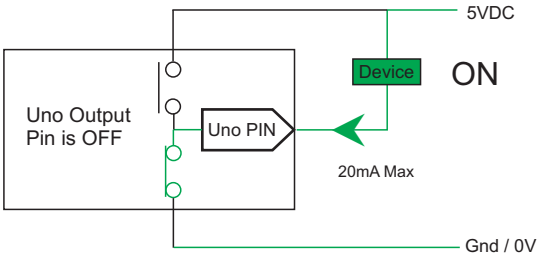


A Circuit configured to “Source” Current in the OFF State

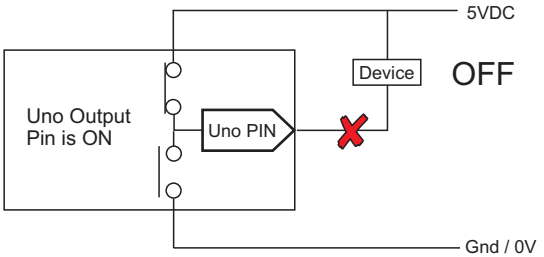


A S**inking** digital Output provides the **Ground** needed in the circuit.
Note that the side of the Load NOT connected to the Uno is connected to 5VDC.

A Circuit configured to “Sink” Current in the ON State



A Circuit configured to “Sink” Current in the OFF State



Reference 6 : Arduino Uno Description

This is a slightly edited version of the Arduino Uno Web Page.....

The Arduino Uno is a microcontroller board based on the Atmel ATmega328. It has 14 digital input / output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button.

It contains everything needed to support the microcontroller - simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. "Uno" means one in Italian.

Summary

Microcontroller	Atmega328P
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
Flash Memory	32 KB, 0.5 KB used by bootloader
SRAM	2 KB
EEPROM	1 KB
Clock Speed	16 MHz
Length	68.6 mm
Width	53.4 mm
Weight	25 g

Note: The Arduino reference design can use an Atmega8, 168, or 328, Current models use an ATmega328, but an Atmega8 is shown in the schematic for reference. The pin configuration is identical on all three processors.

Power

The Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically.

External (non-USB) power can come either from an AC-to-DC adapter or battery. The adapter can be connected by plugging a 2.1mm center - positive plug into the board's power jack.

Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector.

The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable.

If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

Power Pins

VIN. The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.

5V. This pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack (7 - 12V), the USB connector (5V), or the VIN pin of the board (7-12V). Supplying voltage via the 5V or 3.3V pins bypasses the regulator, and can damage your board. We don't advise it.

3V3. A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA.

GND. Ground pins.

IOREF This pin on the Arduino board provides the voltage reference with which the microcontroller operates. A properly configured shield can read the IOREF pin voltage and select the appropriate power source or enable voltage translators on the outputs for working with the 5V or 3.3V.

Memory

The ATmega328 has 32 KB (with 0.5 KB used for the bootloader). It also has 2 KB of SRAM and 1 KB of EEPROM.

Input and Output

Each of the 14 digital pins on the Uno can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 kOhms. In addition, some pins have specialized functions:

Serial: 0 (RX) and 1 (TX). Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.

External Interrupts: 2 and 3. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value.

PWM: 3, 5, 6, 9, 10, and 11. Provide 8-bit PWM output with the analogWrite() function.

SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). These pins support SPI communication using the SPI library.

LED: 13. There is a built-in LED connected to digital pin 13.

The Uno has 6 analog inputs, labeled A0 through A5, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and the analogReference() function. Additionally, some pins have specialized functionality:

TWI A4 or SDA pin and A5 or SCL pin.

There are a couple of other pins on the board:

AREF Reference voltage for the analog inputs. Used with analogReference().

Reset Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

The Arduino Uno has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers.

The ATmega328 provides UART TTL (5V) serial communication, an ATmega16U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer.

The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board. The RX and TX LEDs on the board will flash when data is being transmitted via the USB-to-serial chip and USB connection to the computer (but not for serial communication on pins 0 and 1).
The ATmega328 also supports I2C (TWI) and SPI communication.

Programming

The Arduino Uno can be programmed with the Arduino software. Select "Arduino Uno from the Tools > Board menu (according to the microcontroller on your board). .

The ATmega328 on the Arduino Uno comes preburned with a bootloader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol (reference, C header files).

Automatic (Software) Reset

Rather than requiring a physical press of the reset button before an upload, the Arduino Uno is designed in a way that allows it to be reset by software running on a connected computer.

USB Overcurrent Protection

The Arduino Uno has a resettable polyfuse that protects your computer's USB ports from shorts and overcurrent. Although most computers provide their own internal protection, the fuse provides an extra layer of protection.

If more than 500 mA is drawn from the USB port, the fuse will automatically break the connection until the short or overload is removed.

Reference 7 : MiR File Format

There is nothing complex about the file format used to store your MiRobot program.

It is simply a number of rows of Axes positions, delays and comments separated by Comma's. If you don't like the Programming Tools included in the MiRobot Software you can use a PLAIN Text Editor (Notepad, WordPad etc) or even write your own.

Its is VERY important however that you get the format correct, errors will lead to unexpected results,

This is what a MiR file looks like when opened in Notepad.

```
 0,-26, 52,-29, 0, 0,N/A,N/A
-35,-26, 52,-29, 0, 0,N/A,N/A
 37,-26, 52,-29, 0, 0,N/A,N/A
 0,-26, 52,-29, 0, 0,N/A,N/A
 0,-45, 52,-29, 0, 0,N/A,N/A
 0, 5, 52,-29, 0, 0,N/A,N/A
 0, 5, 20,-29, 0, 0,N/A,N/A
 0, 5, 20, 25, 52, 0,N/A,N/A
 0, 5, 20,-25,-34, 0,N/A,N/A
 0, 5, 20, 79, 0, 0,N/A,N/A
 0, 5, 20,-90, 0, 0,N/A,N/A
 0, 0, 0, 0, 0, 0,N/A,N/A
```

Each Row contains a value separated by a Comma (",").

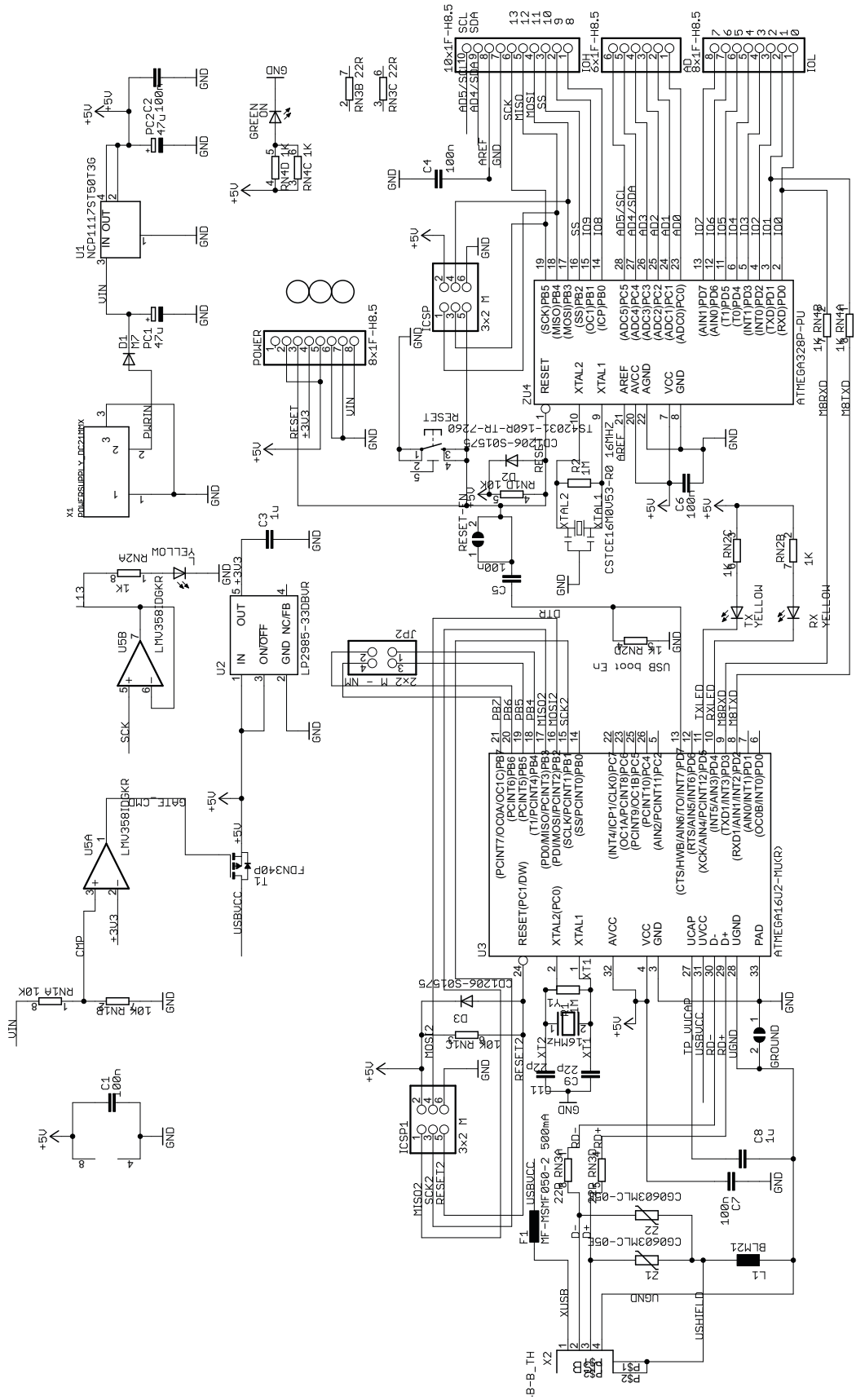
First Number -	Axis A position in Degrees
Second Number -	Axis B position in Degrees
Third Number -	Axis C position in Degrees
Forth Number -	Axis D position in Degrees
Fifth Number -	Axis E position in Degrees
Sixth Number -	Gripper opening in Degrees
Command -	Valid Command OR N/A.
Comment -	User Comment OR N/A

ALL numbers MUST be provided and be Integers only.
Command and Comment MUST use "N/A" if not used.

All numbers MUST be within limits :

First Number -	Axis A, -90 to 90 Degrees
Second Number -	Axis B, -45 to 90 Degrees
Third Number -	Axis C, -90 to 90 Degrees
Forth Number -	Axis D, -90 to 90 Degrees
Fifth Number -	Axis E, -90 to 90 Degrees
Sixth Number -	Gripper, 0 to 40
Command -	Valid Commands
Comment -	No Limitations

Reference 8 : Arduino Uno R3 Schematic



Arduino is a registered trademark
Arduino Uno - http://www.arduino.cc/en/Main/ArduinoBoardUno

Reference 9 : Remote Control

It is possible to remotely control the MiRobot Software and therefore the Mirobot. This is achieved by sending Serial Data commands to the MiRobot PC Software. You can create your own Software using whatever programming language you want, with any degree of complexity. Its entirely up to you.

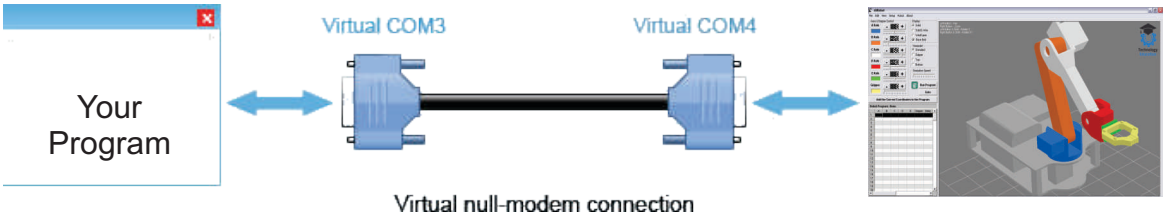
The MiRobot Software has a drop down menu selection, Setup > Setup Remote Link that allows you to specify which COM Port your commands will be received on.

Use the Up/Down arrows on the Port Number to select the COM Port that the MiRobot Software will use to receive your commands.
Press the “Disabled” Button to enable Remote Control, press the Button again to disable it.

Communications settings are 115200 Baud, 8 bit, No Parity and 1 Stop Bit.

You can link two computers together by a USB to USB serial connection cable, or by a traditional RS232 cable depending on what your computer is fitted with.

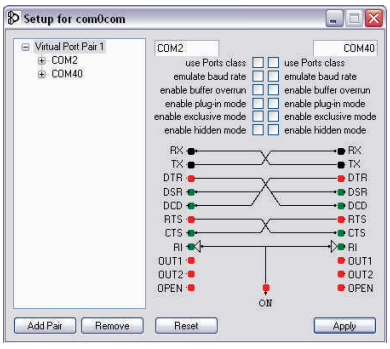
You can create Virtual COM Port Pairs on a single Computer allowing you to link your “creation” to the MiRobot software without using separate Computers.



Virtual null-modem connection

Sourceforge hosts com0com for creating virtual serial port pairs (there are no doubt many others). com0com is free but not digitally signed so you may need to disable driver signature enforcement on current Windows versions.
There is also com2tcp which enables redirecting serial to TCP/IP and TCP/IP to serial for remote control over a network or Internet.

Download from - http://sourceforge.net/projects/com0com/



At left is a Screenshot of com0com creating a Virtual COM Port pair on a single computer. Data sent to COM2 will be received by COM40 and vice versa. So.... if MiRobot Remote Command is set to COM2, your creation can communicate via COM40 and the data will be exchanged.

You can use a simple Terminal Program and type in the Commands by hand to see it at work.

We have included “Termite” a simple freeware Terminal Program (provided by CompuPhase) in the MiRobot\Termite folder. You don’t need to install Termite just “double click” on Termite.exe to run it.

See http://www.compuphase.com/index_en.htm for instruction on its use.

Remote Control Commands

A###	Move Axis A to Position ### in degrees Max. length four characters. Integer Only - Span -90 to 90 Degrees
B###	Move Axis B to Position ### in degrees Max. length four characters. Integer Only - Span -45 to 90 Degrees
C###	Move Axis C to Position ### in degrees Max. length four characters. Integer Only - Span -90 to 90 Degrees
D###	Move Axis D to Position ### in degrees Max. length four characters. Integer Only - Span -90 to 90 Degrees
E###	Move Axis E to Position ### in degrees Max. length four characters. Integer Only - Span -90 to 90 Degrees
G##	Move Gripper Max. length three characters. Integer Only - Span 0 to 40
H>+	Handshake Output On. (Remote Control receive a “H<” when a Handshake In is received.)
H>-	Handshake Output OFF
H<	Handshake IN (Only when Robot Movement is DISABLED)
I	Add Current Coordinates to Program
M+	Robot Movement Enabled
—	Robot Movement Disabled
ON	Turns ON User Output
OFF	Turns OFF User Output
P	Clear current Program
R	Run Program.
S	Stop Program.
T(*filename)*	Loads the filename from the MiRobot\Programs folder. .MiR file extension is optional.
U(*filename)*	Saves Program to the MiRobot\Programs folder. .MiR file extension is optional.
V	Returns the MiRobot Programs version number.
W	Returns the current Mirobot position for all axes and the gripper.
?	Lists all valid commands.

Remote Control Commands - Continued

J#	Sets the increment in Degrees for all the <and > commands Minimum Value - 1, Maximum Value - 10. Initial default is ONE degree for Axes and ONE Percent for the Gripper
<A	Decrease the A Axis Position by the increment (J) degrees.
>A	Increase the A Axis Position by the increment (J) degrees.
<B	Decrease the B Axis Position by the increment (J) degrees.
>B	Increase the B Axis Position by the increment (J) degrees.
<C	Decrease the C Axis Position by the increment (J) degrees.
>C	Increase the C Axis Position by the increment (J) degrees.
<D	Decrease the D Axis Position by the increment (J) degrees.
>D	Increase the D Axis Position by the increment (J) degrees.
<E	Decrease the A Axis Position by the increment (J) degrees.
>E	Decrease the A Axis Position by the increment (J) degrees.
<G	Open the Gripper by the increment (J) percent.
>G	Close the Gripper by the increment (J) percent.

Remote Control - Feedback Messages

All of the 33 possible commands sent to the Remote Control Interface generate return messages.

These should be taken as confirmation that the MiRobot Control System has understood or executed your remote command.

The V command can be used by a remote program to ensure there is actually an active link to the MiRobot.

The ? Command will list all the available command codes and is usefully when you are working from a terminal program such as Termite.

If you are creating your own software it is important that you include a handler for these return messages. Any command that is not understood by MiRobot will generate an "Invalid Command : XXXX" return message with XXXX being the command you sent.

Keyboard Control

When the Keyboard Control function is activated a Window will be shown with a picture of the MiRobot and the keys on the Computer Keyboard that can be used to move each Axis.

Both small and large movement increments(1 & 5 degrees) are possible in all directions.

If a key is held down the MiRobot will continuously move the selected Axes until it is released.

This Keyboard Control Window MUST BE THE TOPMOST WINDOW AND BE SELECTED (HAVE FOCUS) otherwise key presses will not be processed.

Interesting Possibilities.....

For example, some Virtual Reality systems allow you to operate a keyboard in a virtual workspace..... you could control the MiRobot this way.

Some EEG (Brain Wave Reading) Headsets also allow you to use a keyboard by thought control..... once again you could control the Mirobot this way.

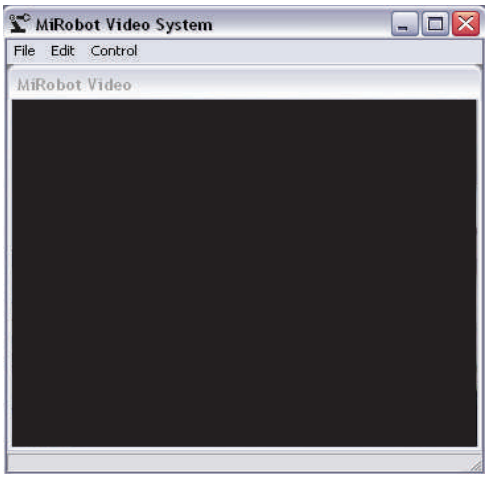
Obviously these examples require extra hardware from other companies and sometimes are quite challenging to use, but we have described these applications as examples of what is possible. Experiment away !

Reference 10 : Video Feed.

If you have a free standing WebCam installed on your computer it is possible to display the video in a Window within the MiRobot Program.

Obviously a WebCam installed at the top of a Notebook Screen will be of no use as it will display you, not the MiRobot operating !

You could use this video to remotely monitor the MiRobot working.



Installing and setting up the WebCam is your responsibility, if you can't get it to work normally on your Computer then it won't work in the MiRobot program !

Select View > Video Feed from the MiRobot Main Window's dropdown menu. The MiRobot Video System Window will open.

This Window will by default stay on top of other Windows and can be positioned and scaled anywhere you want by moving its Title Bar.

If you have a second Monitor installed on your Computer, you can drag the Video Window onto it so that the main MiRobot Software Window is not obscured.

As a brief overview - the MiRobot Video System allows you to select between various WebCams, set the viewed and captured image size, capture a single frame to the Windows Clipboard and capture a video stream to an AVI File.

Depending on the Video Codecs installed on your computer various file formats and compression schemes may be available. Some are supplied with Windows, others are third party commercial add ons.

As capturing Video is secondary to the real role of the MiRobot Software, we won't attempt to cover all the options and possibilities - most PC Users are quite familiar with the Operation of Webcams.

There are of course other programs that can display / record Video... use whatever you are familiar with.

Performance Warning

Displaying and Capturing Video whilst the MiRobot simulation is running may cause the on screen simulation to be less smooth than usual, depending on the processing power of your computer.

If you have an older computer the performance **MAY** still be acceptable, you will just have to try it out and see.

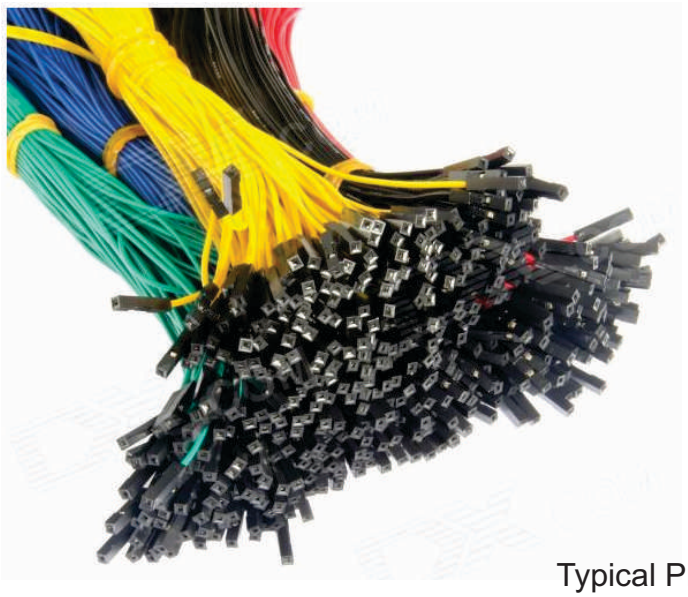
Reference 11 : Connections for Advanced Functions

There are **LOW CURRENT** pin headers (connectors) fitted to the MiRobot Servo Shield for the Advanced Functions.

Of course you can directly solder the wires directly to the PCB but this can be a bit limiting when your experimenting.

Doing the "wiring"

Many suppliers of Adruino parts carry sets of coloured "Jumper Wires" that simply slide over 0.1" Pin Header Pins. They come in a range of colours making it MUCH easier to make the right connection or troubleshoot later if things aren't working as expected.



Typical Pin Header Jumper Wires.

Higher Currents

It is NOT advisable to draw more than the recommended maximum current or apply "odd" voltages to the Servo connection Shield as it is possible to destroy or damage the PCB and / or the Uno.

The pin header for the user Output is NOT capable of reliably carrying 500mA and the small Jumper wires would also be over stressed so we strongly advise keeping the current as low as possible. Of course you can CAREFULLY solder to the Servo Connection Shield if you need to draw currents up to the maximum.

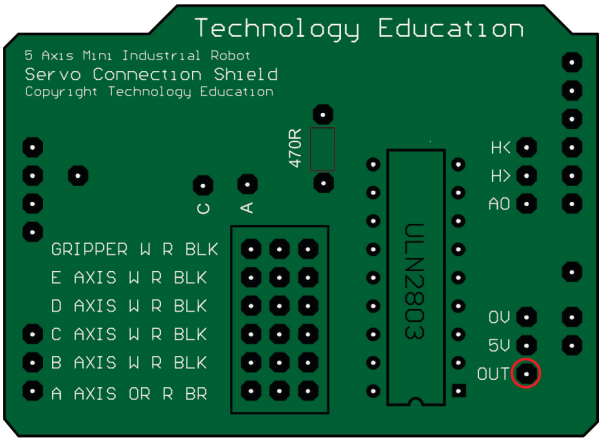
User output - up to 500mA and voltages up to 15 VDC MAXIMUM.

Handshaking Pins - TTL Voltage and currents levels

Reference 12 : User Output.

The MiRobot Servo Shield has a single Output that can be controlled by the “ON” and “OFF” commands in a program.

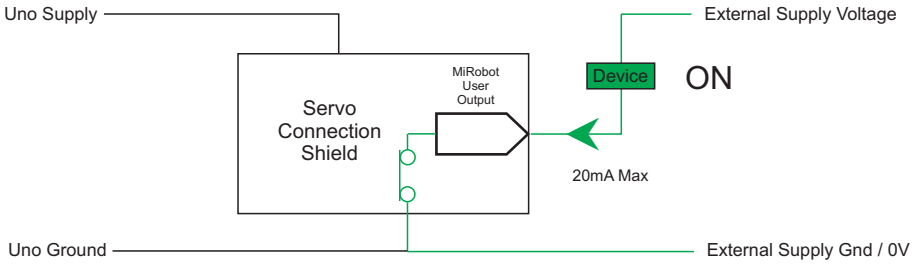
This output (highlighted by the RED Circle) is a current sink..... in other words it provides a switched ground connection for up to 500mA and voltages up to 15 VDC.



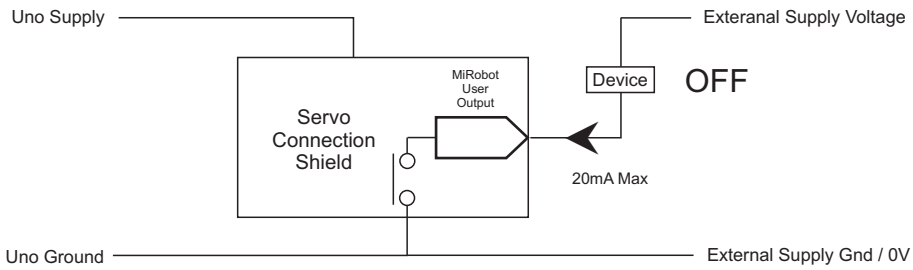
CAUTION - the Uno and Servos should NEVER be power by more than 6 Volt DC.

This “switched ground” concept means that it can be used in circuits that have voltages higher or lower than the five volts DC used by the Uno, providing a degree of design flexibility.

The User Output in its ON State



The User Output in its OFF State



Care should be taken using this output, ideally you would use it to control a relay that actually switches the connected device. The User Output has an internal diode to protect the system from voltage spikes as commonly created when switching a relay coil.

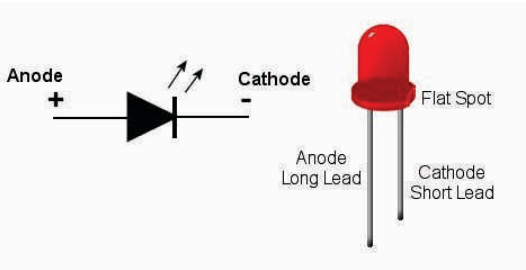
Ideally you would use a separate power supply to power the relay and external load as the six volt battery used in the MiRobot is really not suitable for high current loads.

Exercise care - you could damage the Servo Shield and Uno.

CONNECTING A LED TO THE USER OUTPUT

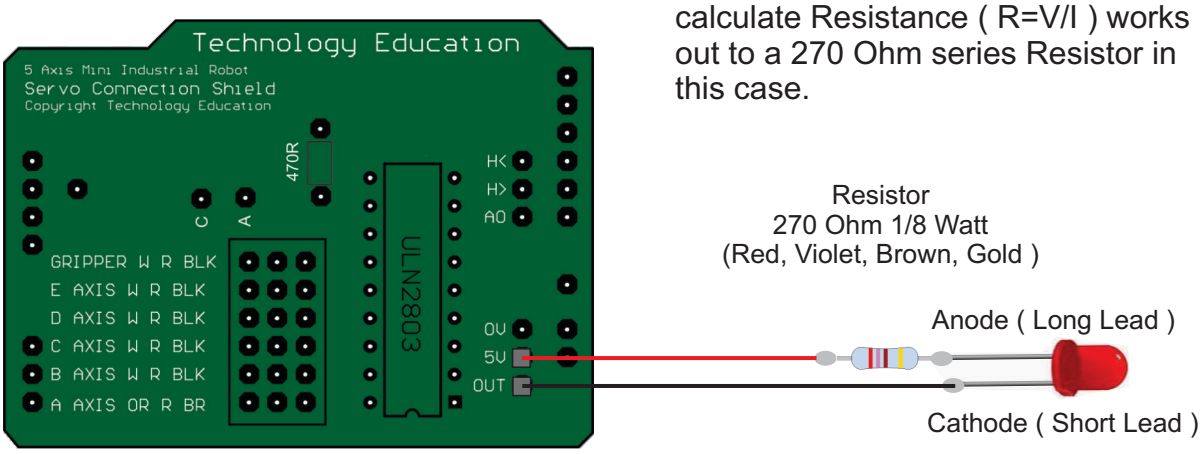
A Light Emitting Diode (LED) can be easily connected and controlled by the MiRobot using the USER output and included program command.

However..... you must connect it correctly and use a current limiting resistor.



For example we will use a LED current of 12mA, a forward voltage drop across the LED of 1.7 Volts and the Uno's five Volt supply in our calculation.

The variation of Ohms Law used to calculate Resistance (R=V/I) works out to a 270 Ohm series Resistor in this case.



WRITING THE CODE

Once the LED is correctly connected, turning it on and off is very simple. In the CMD field of the program, simple use the ON command to turn the User Output (the LED) on and the OFF Command to turn it off.

In the sample Program below the LED will turn on at line 3 and stay illuminated until after line 11 has executed.

Robot Program : Handshake

	A	B	C	D	E	Gripper	CMD
1	0	-45	45	60	90	0	
2	-35	-26	52	-29	0	0	H>+
3	37	-26	52	-29	0	0	ON
4	0	-26	52	-29	0	0	
5	0	-45	52	-29	0	0	D2000
6	0	5	52	-29	0	0	H<
7	0	5	20	-29	0	0	SEND
8	0	5	20	25	52	0	
9	0	5	20	-25	-34	0	
10	0	5	20	79	0	0	H>-
11	0	5	20	-90	0	0	OFF
12	0	0	0	0	0	0	L2
13							

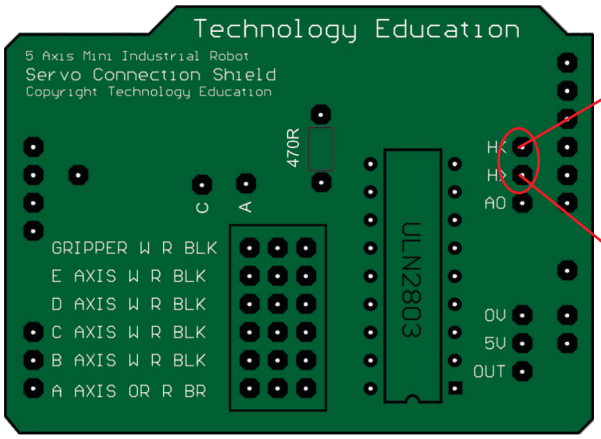
LED ON

LED OFF

Reference 13 : Inter Device Handshaking.

The MiRobot Servo Shield has Handshake In and Handshake Out pins that can be used to control and synchronize one or more MiRobots or devices. Like the connections for other advanced functions, you will need to connect to the MiRobot Servo Shield.

Whilst we will illustrate the applications with MiRobots, other devices can also be used - its up to your imagination, electronic ability or programming skills



The H< connection is the Handshake IN a signal is sent FROM a MiRobot (or device) TO the MiRobot.

The H> connection is the Handshake OUT - the MiRobot sends a signal FROM your MiRobot TO a MiRobot (or device).

The signals are TTL Logic Levels (as used by the Uno) so direct connection Pin to Pin is all that is required.

Due to the design of the Uno the Handshake signals are Active Low.

Handshake Commands

This Handshake Input and Output is controllable from the program using the following commands:

“H<” Handshake In
When “HI” is entered as a Command, and the program is run, the execution will stop and wait for the “HI” input at the appropriate line before continuing.

“H>+” Handshake Out ON

When “H>+” is entered as a Command, and the Program is run, the Handshake Out Pin will be turned ON at the appropriate line.

“H>-” Handshake Out OFF
When “H>-” is entered as a Command, and the Program is run, the Handshake Out Pin will be turned OFF at the appropriate line.

Caution :

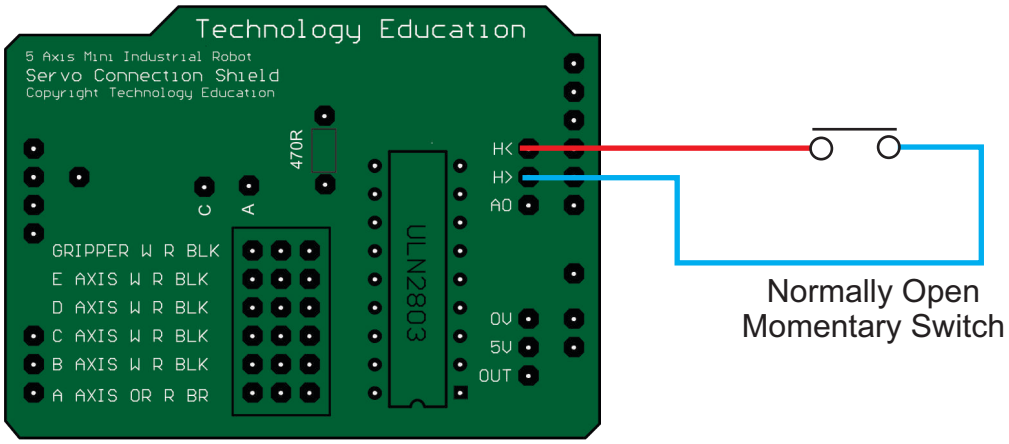
Exercise care when developing code that uses Handshaking, getting it wrong may cause mechanical damage if your MiRobots hit each other or other objects.

A Single MiRobot

The Handshake system can be used to halt a MiRobot Program at a particular Program Line until an external event occurs that closes the Handshake circuit.

For example the MiRobot is Paused until an object is placed on a platform with a switch in it. The Object closes the switch so the MiRobot moves, picks up the object and moves it somewhere else.

Include a Loop “L#” command and the miRobot will pick up and move the object every time it is place on the platform.



Using Handshaking on a single MiRobot

A simulated MiRobot Program that prepositions the arm, pauses, then when a switch is closed by an object moves to pick it up and move it somewhere.

This sequence is repeated for as long as objects are placed on the switch.

MiRobot Program

Line	Coordinates	Command	Comment
1	A,B,C,D,E,G		Preposition MiRobot.
2	A,B,C,D,E,G		
3	A,B,C,D,E,G		
6	A,B,C,D,E,G		
7	A,B,C,D,E,G	H>+	Turn ON Handshake OUT.
8	A,B,C,D,E,G	H<	Set to WAIT.
WAITING FOR SWITCH TO CLOSE			
9	A,B,C,D,E,G		Pickup Object and move it.
10	A,B,C,D,E,G		
11	A,B,C,D,E,G		
12	A,B,C,D,E,G		
13	A,B,C,D,E,G	H>-	Turn Off Handshake Out.
14	A,B,C,D,E,G	L7	Loop back to Line Seven.

How it Works

Both programs execute until MiRobot 1 gets to its Line 7, at the end of which it halts (caused by “H<”) and waits for the H>+ signal from MiRobot 2's Program at Line 10.

At Program Line 13, MiRobot 2 halts (“H<”) waiting for the H>+ Command from MiRobot 1's Line 14 H>+ Command.

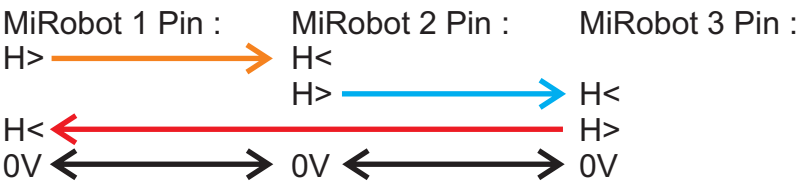
Note : its necessary to turn off the Handshake Out Signal using “H>-”. This may seem like an extra unnecessary command but the Handshake system could also be used to control other devices that need to remain on for longer periods so separate On and Off commands are necessary.

Note : As MiRobots and their controlling Computers may operate at different relative speeds and different programs could include different time delays, writing Programs for multiple MiRobots to work together can be quite a challenge. Take your time, test each program separately and only then allow them to operate in the same physical space.

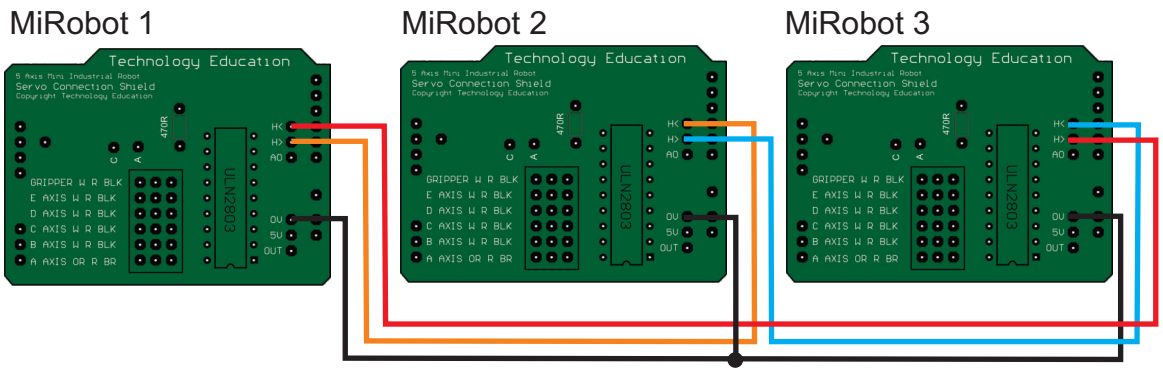
You can appreciate just how much work is involved in programming an Assembly line with many Robots working in synchronisation.

Synchronising Multiple MiRobots

The operation of more than two MiRobots (or devices) can be synchronised with the following connections



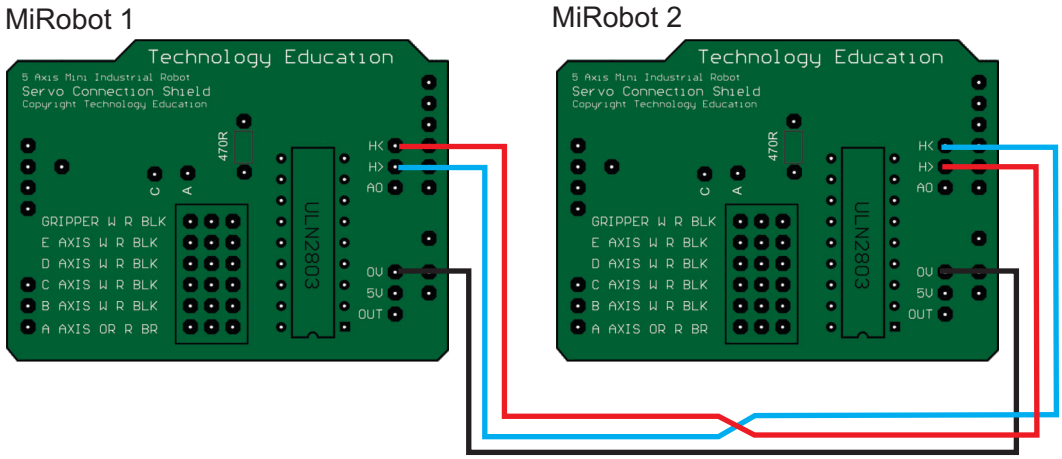
This is a chained link, each MiRobot can be programmed to send handshaking signals to the **NEXT** MiRobot in the chain. This type of connection allows many MiRobots to be chained but offers less programming flexibility than a direct Bidirectional connection.



Synchronising Two MiRobots

The operation of two MiRobots can be synchronised with the following connections

This is a Bidirectional link, each MiRobot can be programmed to send handshaking signals to each other to synchronize their operation when the appropriate programming commands are added.



Shown below are to simulated MiRobot Programs, A to G are MiRobot Axes Coordinates.

MiRobot 1 Program		**MiRobot 2 Program**	
Line Coordinates	Command	Line Coordinates	Command
1 A,B,C,D,E,G		1 A,B,C,D,E,G	
2 A,B,C,D,E,G	D2000	2 A,B,C,D,E,G	D2000
3 A,B,C,D,E,G		3 A,B,C,D,E,G	
4 A,B,C,D,E,G	H<	4 A,B,C,D,E,G	
		5 A,B,C,D,E,G	
		6 A,B,C,D,E,G	
		7 A,B,C,D,E,G	H>+
5 A,B,C,D,E,G		8 A,B,C,D,E,G	H>-
6 A,B,C,D,E,G		9 A,B,C,D,E,G	
7 A,B,C,D,E,G		10 A,B,C,D,E,G	H<
8 A,B,C,D,E,G			
9 A,B,C,D,E,G			
10 A,B,C,D,E,G			
11 A,B,C,D,E,G	H>+	11 A,B,C,D,E,G	
12 A,B,C,D,E,G	H>-	12 A,B,C,D,E,G	
13 A,B,C,D,E,G		13 A,B,C,D,E,G	
14 A,B,C,D,E,G	L2	14 A,B,C,D,E,G	L2

Waiting For....

Waiting For....

Handshaking with other Digital Devices.

We are now is really interesting territory.....

Whilst we have described the use of Handshaking in single and between multiple MiRobots, these Handshaking lines can be connected to other digital devices.

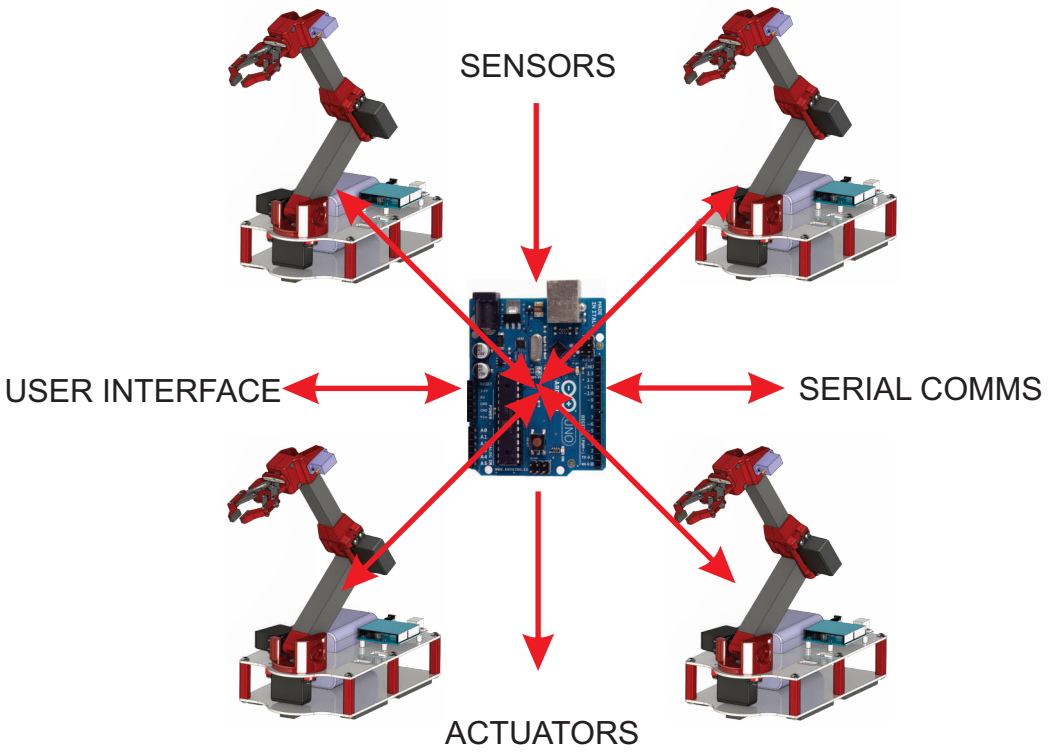
The Handshake Lines are :

Handshake Output -	Active Low TTL signal
Handshake Input -	Active Low TTL signal.

For a really complex automation project, you could connect a group of MiRobots to a stand alone “Master” Arduino or other Microprocessor, programmed to synchronize the operation of the whole Robot group and other components.

There are a range of Arduino Microcontrollers or you could use a Raspberry Pi or similar. Even a full PC can be used as the Master Controller.

Its really a matter of how ambitious you are and how much coding experience you have - or want to develop.



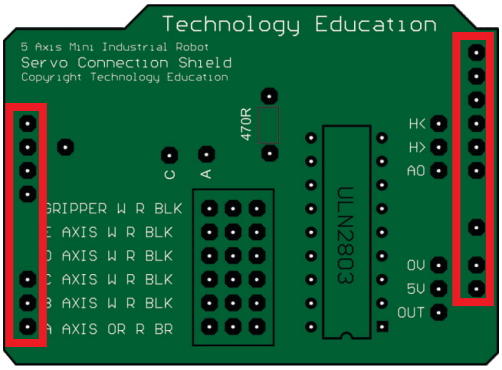
There are lots of Arduino add ons.. its impossible to cover even a small fraction of the possible systems, but with the Mirobots Handshaking system and the ability to remote control it via Serial Communications just about anything is possible.

Reference 14 : MiRobot Servo Shield Assembly

The MiRobot Servo Shield **MAY** be ordered unassembled. It is not a complex or difficult electronic assembly, but we suggest that you develop your soldering skills with other exercises before starting assembly.

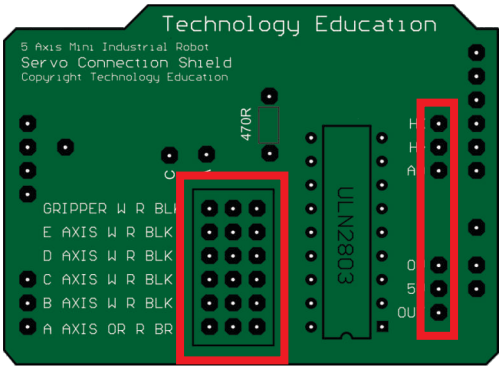
Required Parts :

1/ 1 x Technology Education Servo Shield Printed Circuit Board
2/ 40 x Pin Headers (may be supplied in strips or individually)

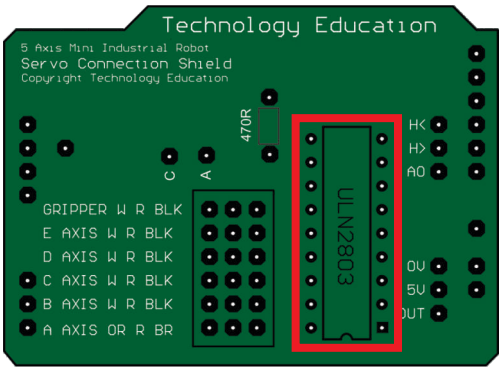


Start by cutting and inserting and soldering the PCB Pin Headers, there's no functional difference between inserting groups or individual pins but have a think about the best method of cutting the strips before you start.

IMPORTANT - the long side of the pins fitted to the outside of the PCB pins **FACE DOWNWARDS** with the soldering being done on the **TOP** (Text Side) of the PCB.



The long side of all the remaining Pin Headers **FACE UPWARDS** with the soldering being done on the **UNDERSIDE** of the PCB. Some of these pins may not be used on your particular build as they give access to advanced features, but whilst your assembling and soldering you should fit them.



And finally, insert the ULN2803 IC from the top of the PCB and solder its pins from the underside. This IC is not especially static sensitive but its always important to handle and solder them correctly.

The IC may be supplied in an antistatic plastic holder or on conductive foam... both of these are discarded after use.

Reference 15 : Useful Links.

General Arduino Information

Arduino Web site : http://www.arduino.cc/
Arduino Forum : http://forum.arduino.cc/

Arduino Uno Information

Arduino Uno Web Page : http://www.arduino.cc/en/Main/ArduinoBoardUno

Programming IDE's

Arduino IDE : http://www.arduino.cc/en/Main/Software
Alternative IDE's : http://playground.arduino.cc/Main/DevelopmentTools

Some Suggestions :

AVR Studio with Visual Micro plugin
http://www.visualmicro.com/page/Arduino-for-Atmel-Studio.aspx

Visual Studio with Visual Micro plugin
http://www.visualmicro.com/

CodeBlocks
http://arduinodev.com/codeblocks/

Arduino Language Reference

http://www.arduino.cc/en/Reference/HomePage

http://www.ele.uri.edu/courses/ele205/ELE205Lab/ELE205_Lab_files/Arduino%20-%20Reference.pdf

Arduino Application Guide

http://www.me.umn.edu/courses/me2011/arduino/arduinoGuide.pdf

Atmel Home Page

(manufacturers of the Microprocessor used on many Arduino boards)
http://www.atmel.com/

com0con& com2tcp (Virtual Serial Port Freeware)

http://com0com.sourceforge.net/

USB to USB Null Modem Cable (communicate between two computers)

http://www.ftdichip.com/Products/Cables/USBtoUSB.htm

MiRobot Specifications

Axes :	Five - Rotary
Gripper :	Two Finger Parallel.
Supply Voltage :	Five Volt DC Nominal, Six Volt DC Maximum.
Servomotors :	Six (two sizes all with metal gears). Analog RC type.
Folded Size :	160 High x 140 Wide x 310 Long.
Working Max Size :	460 High x 450 Wide x 560 Long.
Materials :	Metal and Plastic.
Robot Controller :	Arduino Uno or Uno clone. Technology Education Servo Connection Shield. Power supplied from USB Connection and Batteries.
Control System :	Technology Education.
MiRobot Software :	Technology Education Microsoft Windows Compatible. Windows XP, 7, 8, 8.1, 10
Simulation :	On Screen animated 3D Graphics.
User Controls :	On Screen via Mouse / Keyboard.
Video In :	Can use a Windows installed WebCam.
Program Type :	Axes Coordinate Sets. Unlimited Lines Delay and Loop. Advanced Programming Functions. User Output Control. Handshaking Control. Comments
Program Storage :	Load and Save to PC using .MiR Files.
Printing :	Any Microsoft Windows supported Printer.
Communication :	USB to Virtual Serial Port.
Cable :	USB Type A to USB Type B.
User Output :	One. 500mA Sink Max. 15VDC Max.
Handshake :	One pair. Handshake OUT (TTL Logic Level - Active LOW). Handshake IN, (TTL Logic Levels - Active LOW).
Indicators :	On Arduino Uno. Power. Communications Transmit. Communications Receive. Servos Enabled
Remote Control :	ASCII Commands via Serial Port (Real or Virtual)

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