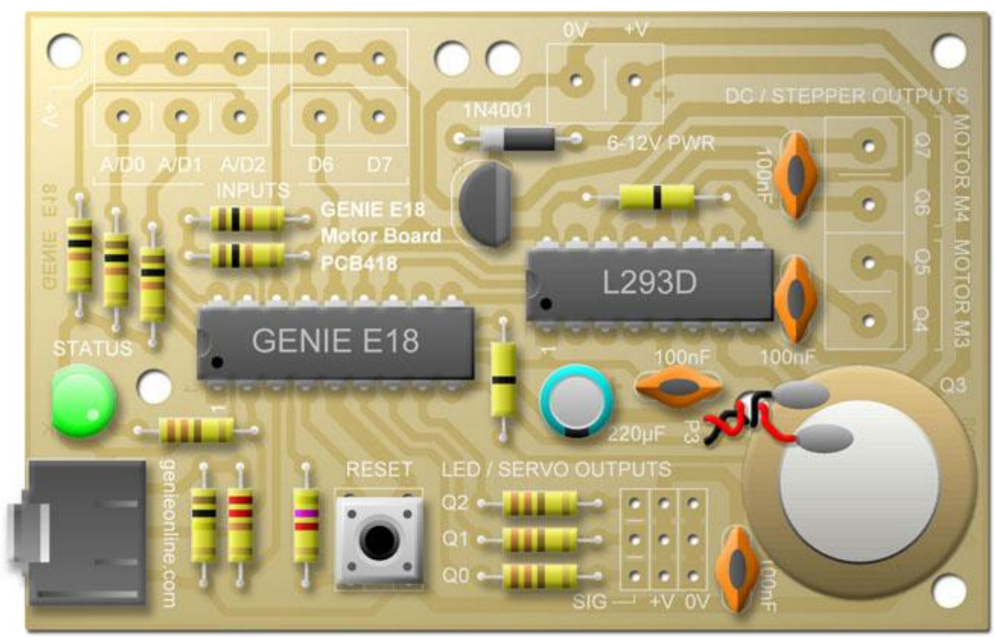
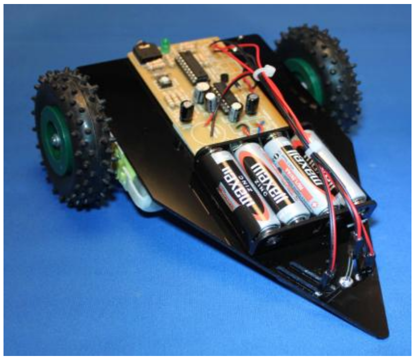
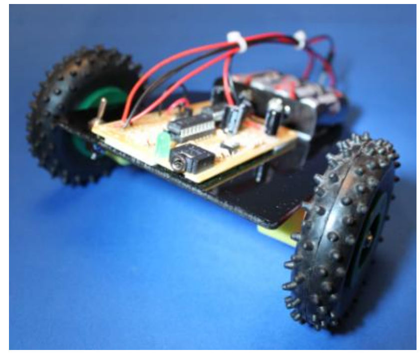
TECHNOLOGY SUBJECTS SUPPORT SERVICE

Using GENIE E18 Motor Control Board for Project Work



Foreword





The *t4 Prototype Line Follower Robot* has been developed as a low cost introductory model for educators interested in Applied Control and Robotics.

Line follower robots are used extensively in industry in areas where parts or materials need to be constantly delivered from one location to another. Generally known as AGVs (Automated Guided Vehicles) they are found mainly in the car manufacturing industry and anywhere that employs large warehousing where the robot follows tracks to and from the shelves they stock and retrieve from.

This line follower robot has the following features:

- One piece simple chassis easily made form acrylic sheet or even cardboard.
- Low centre of gravity and moment of inertia allowing quick deceleration.
- Two wheeled easily controlled differential drive and steering.
- Significant distance between line sensors and wheels allowing the robot time to react and reduce the instances of over-shooting.
- Line illumination LED.

The following should be noted when using this robot:

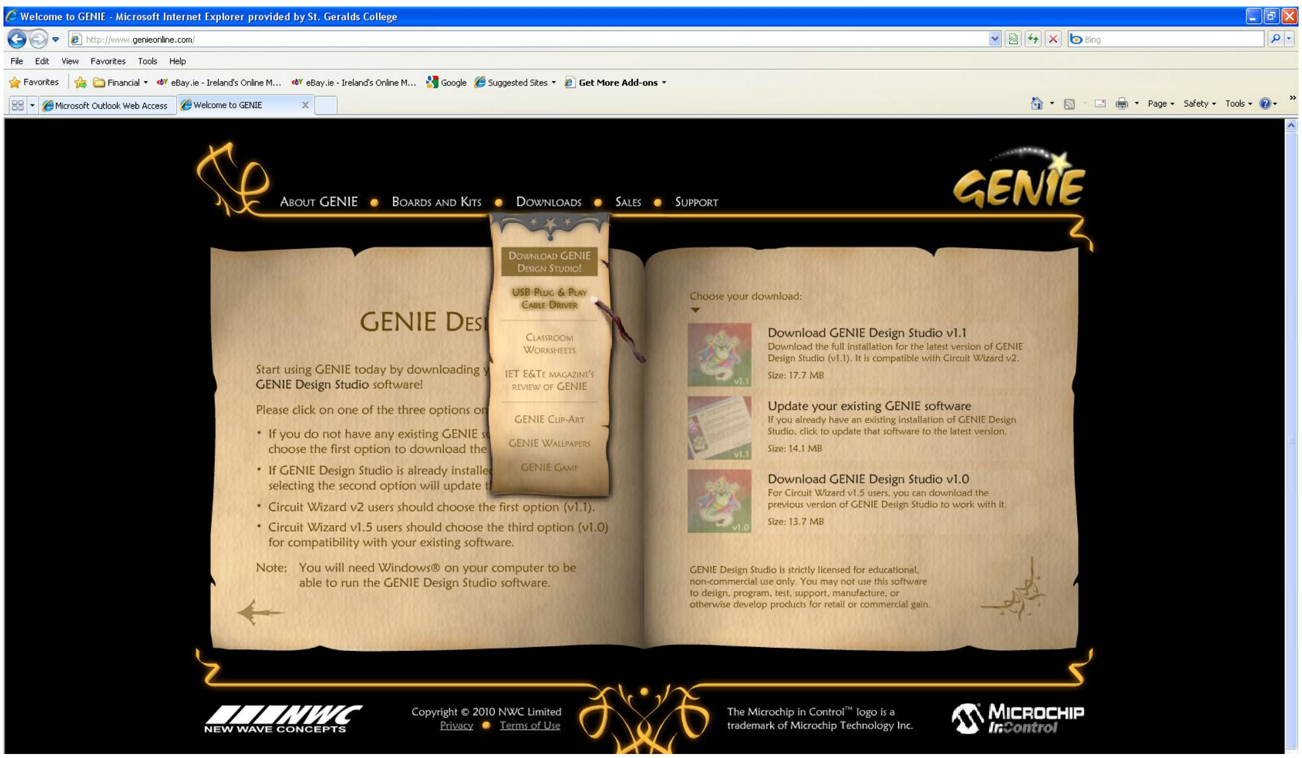
- It is not possible to program the DC motors supplied for a set number of rotations – more expensive stepper motors would be required for this type of control. It is possible to program the motors to turn for a set time period e.g. 1.5 seconds etc.
- All the settings for the LDR sensors indicated in the notes are examples only. Each robot will require its own settings for the sensors to be found through calibration. They will depend on the surface it is operating on, the whiteness of the line being followed, the charge in the batteries and indeed similar LDRs will differ slightly from each other.

Table of Contents

1. Downloading/Installing GENIE Design Studio Software

Copies of ***GENIE Design Studio Version 1.1*** software and associated ***USB Driver Installation Wizard*** is available in the folder *4.GENIE Design Studio Software* on the Technology resource DVD (Options/Applied Control Systems/Line Following Robot).

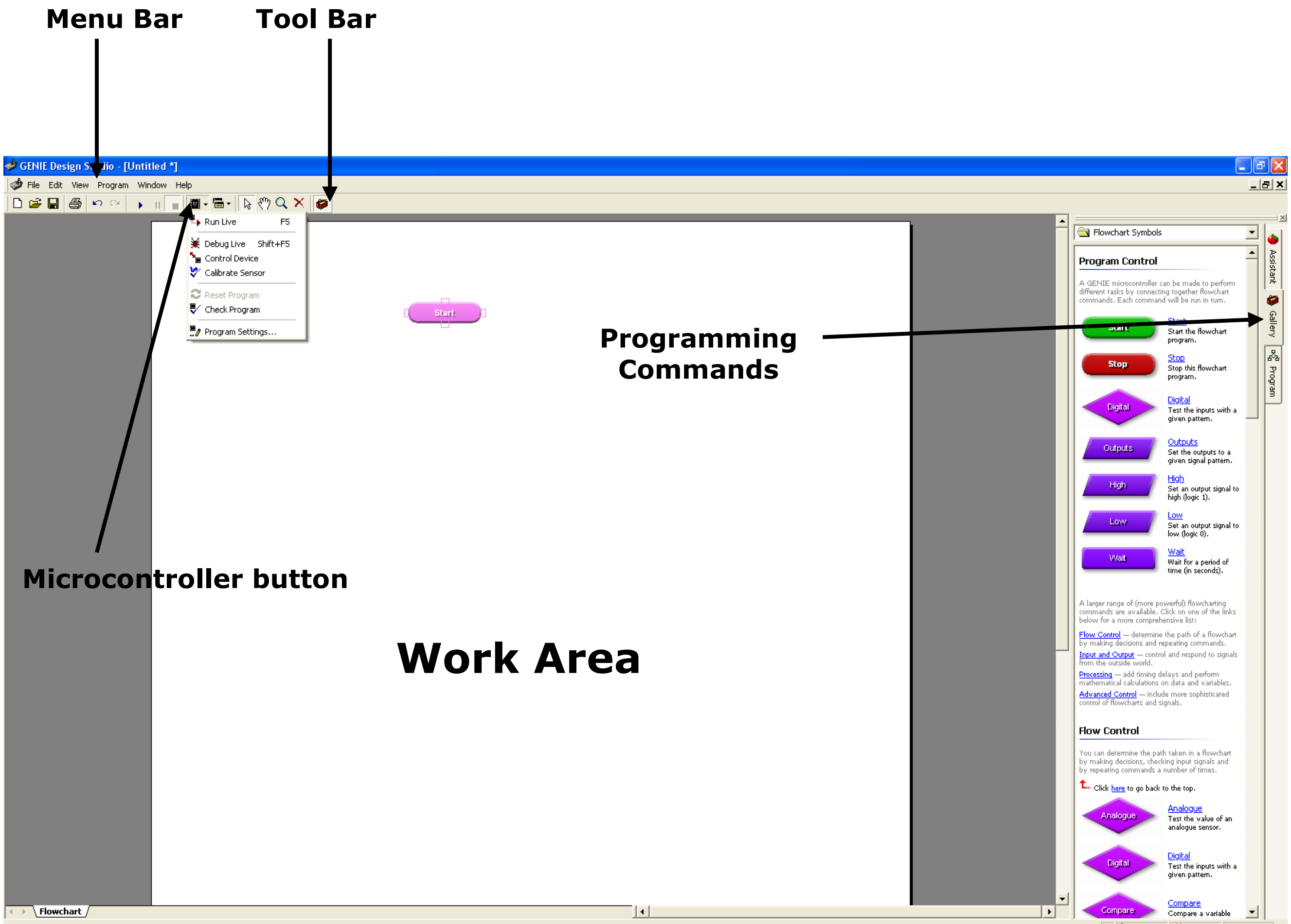
If you encounter any problems all the required software, drivers and troubleshooting tools etc can be downloaded free via the website www.genieonline.com by clicking on the tab **Downloads** as shown below.



If you encounter any difficulties click on the **Support** tab and you will be directed to the **GENIE Troubleshooting Guide** and the **Troubleshooting Tool**. Both of these are also available on the Technology resource DVD in the *4.GENIE Design Studio Software* folder.

2. GENIE Design Studio Interface

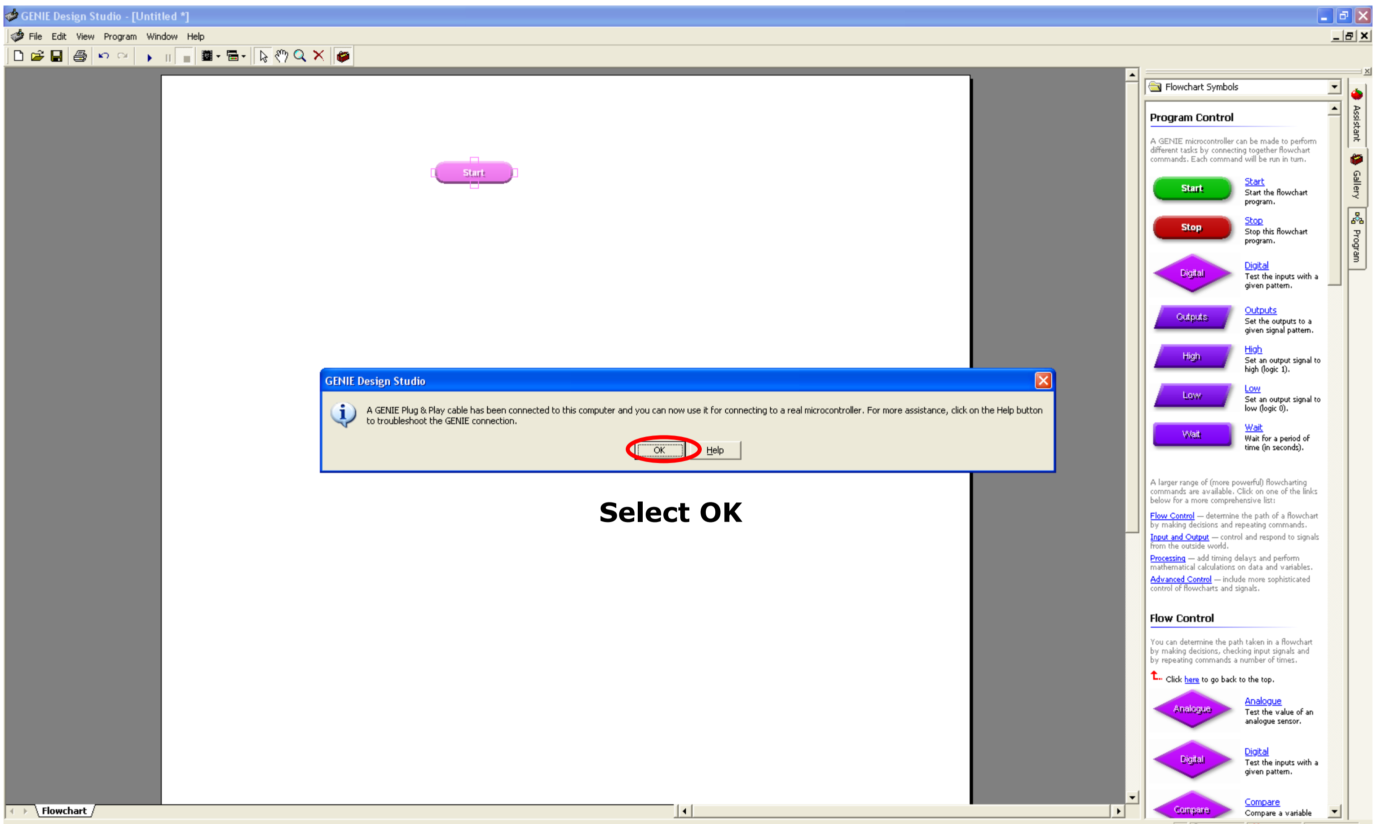
To open *GENIE Design Studio* click the *GENIE Design Studio* icon  on the desktop or use the start menu to locate the program.



3. Connecting the E18 Motor Control Board to your PC

Connect the GENIE USB Plug & Play cable.

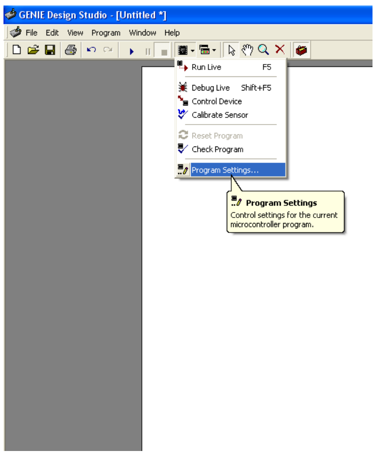
The following should appear:

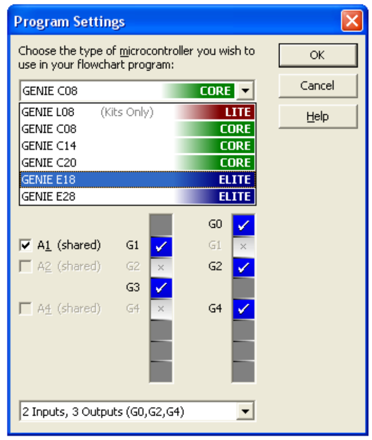


If the confirmation window does not appear then click on the Help button and consult the Troubleshooting Guide as described in Section 1.

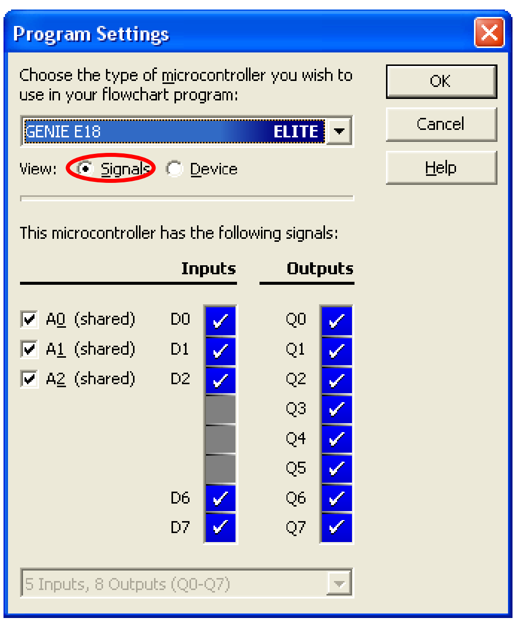
4. Testing the E18 Motor Control Board

Firstly you must tell the software what GENIE chip you are using. Select **Microcontroller** from the tool bar followed by **Program Settings**. Select the **GENIE E18** chip.

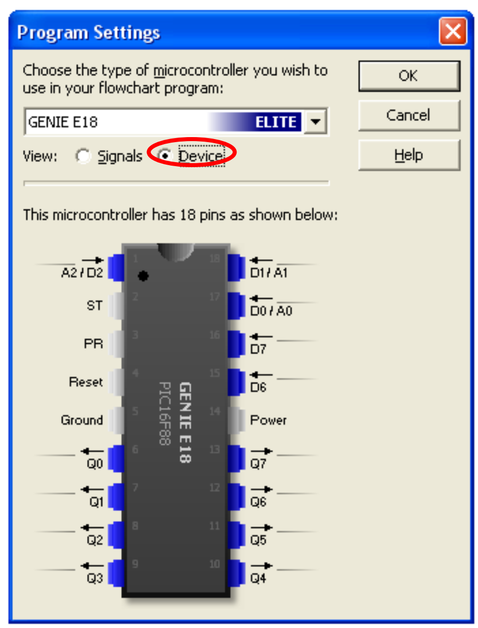




The **Program Settings** window provides information about the inputs and outputs available on the selected E18 chip:



Number of inputs and outputs available



Chip configuration

The E18 chip has the following features:

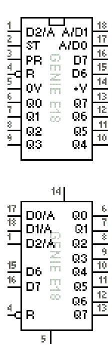
- 8 digital outputs labelled Q0 to Q7
- We are only using Q3 to Q7 incl. for this line follower robot
- These outputs are 'digital' in that they are either on (1) or off (0)
- 3 possible analogue inputs e.g. LDR, Thermistor etc labeled A0, A1 and A2
- 5 possible digital inputs e.g. switches labeled D0, D1, D2, D6 and D7
- As shown on the chip configuration:
  - Input A0 and D0 share Pin 17 – connected to A/D0 on PCB
  - Input A1 and D1 share Pin 18 – connected to A/D1 on PCB
  - Input A2 and D2 share Pin 1 – connected to A/D2 on PCB
- We are only using A/D0 and A/D1 for this line follower robot
- Power to the chip can be tested across Pin 5 (0v) and Pin 14 (2.5 to 5v)

GENIE E18 **ELITE**

Fully-featured 18-pin GENIE microcontroller.

Pins

The GENIE E18 microcontroller has 18 legs (known as pins) and these are used as follows:



Pin	Description
1	Analogue input A2 or digital input D2
2	Status output (ST)
3	Programming input (PR)
4	Reset (when pin goes low)
5	Ground (zero volt) supply voltage
6	Digital output Q0
7	Digital output Q1
8	Digital output Q2
9	Digital output Q3
10	Digital output Q4
11	Digital output Q5
12	Digital output Q6
13	Digital output Q7
14	Power supply voltage (2-5.5V only)
15	Digital input D6
16	Digital input D7
17	Analogue input A0 or digital input D0
18	Analogue input A1 or digital input D1

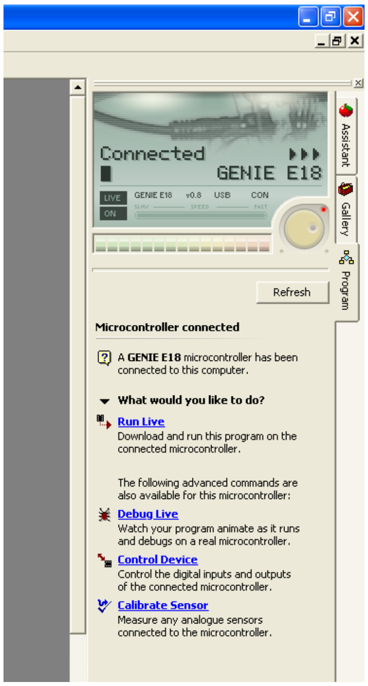
NOTE:

We are only using LDR inputs in this module but it is possible to use many other analogue inputs such as a thermistor, variable resistors etc with the GENIE E18.

Similarly it is possible to incorporate digital inputs such as micro switches with the robot for obstacle avoidance etc but they are not covered in this module.

It is possible to set the E18 as the default chip to be used by the software each time it is opened. Instructions for this are available by viewing the AVI file ***Setting GENIE E18 chip as default*** located in the folder *3.GENIE Design Studio Training for the E18 Motor Control Board*.

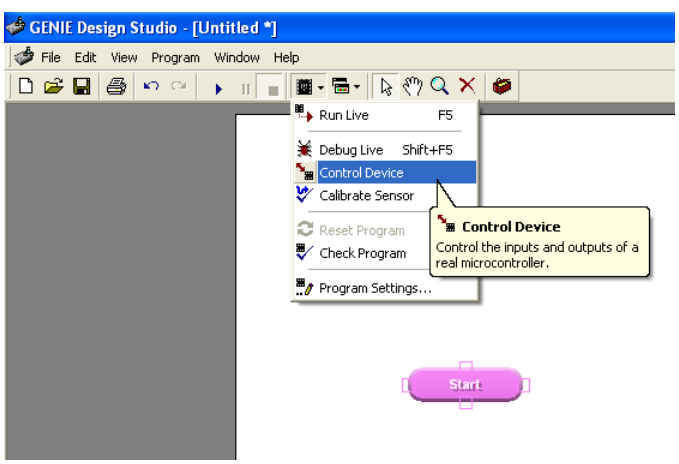
Connect the GENIE USB Plug & Play cable to the line follower robot and turn on power to the robot using the SPST switch on board.



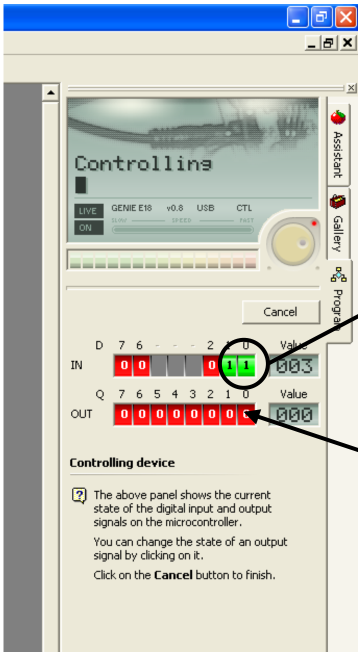
The green status LED should flash and the software should indicate that the microcontroller is now connected as shown.

We can now test that both motors and the line illumination LED are working.

We will use the **Control Device** command to test these outputs. This command can be activated from the menu shown above or by clicking the **Microcontroller** button on the tool bar as shown below.



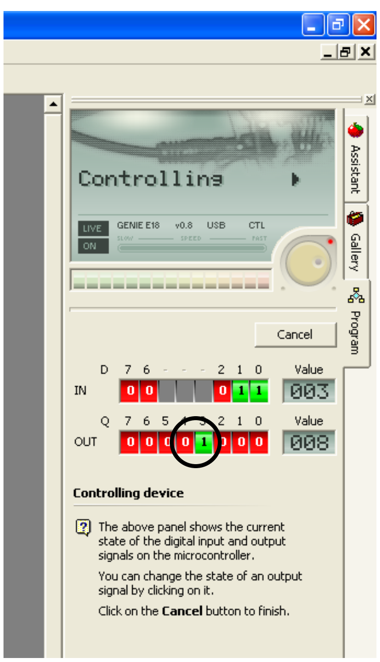
Activating the **Control Device** command opens the following window in the **Program** menu.



This indicates that the software recognises that A/D0 and A/D1 inputs are connected

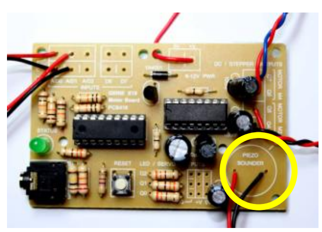
This indicates that all outputs are currently off (0)

By clicking on output Q3 and changing it from off (0) to on (1) we should be able to activate the line illumination LED at the front of the line follower robot as shown.



If the LED does not illuminate, check the following:

- Is the solderless LED holder connected into the PCB with correct polarity as shown below?



- Is the Solderless LED connected to the LED with correct polarity i.e. leg on flat side of LED connected into negative black?

Now, by turning on (1) and off (0) outputs Q7, Q6, Q5 and Q4 in turn, we should observe the clockwise and anticlockwise rotation of each motor M4 and M3.

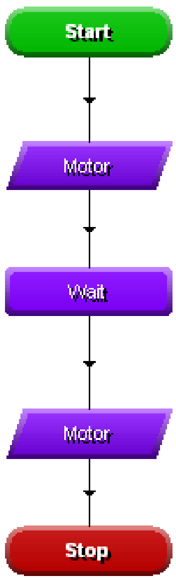
If the motors do not operate then check the following:

- Are the 2 cables from M4 connected into Q6 and Q7 on the PCB?
- Are the 2 cables from M3 connected into Q4 and Q5 on the PCB?

In the next section we will now look at how to write a simple program to operate both motors in order to create forward and reverse motion.

5. Driving the robot forward/reverse

We are now ready to write our first program to move the motor forward and reverse. Construct the following flowchart by left clicking and dragging the programming commands from the **Gallery**. Commands will automatically link together when you drop them in place.



The **Motor** command is located under the **Input and Output** section of the flowchart symbols.

The **Wait** and **Stop** commands are located under the **Program Control** section of the flowchart symbols.

Commands will automatically link together when you drop them in place.

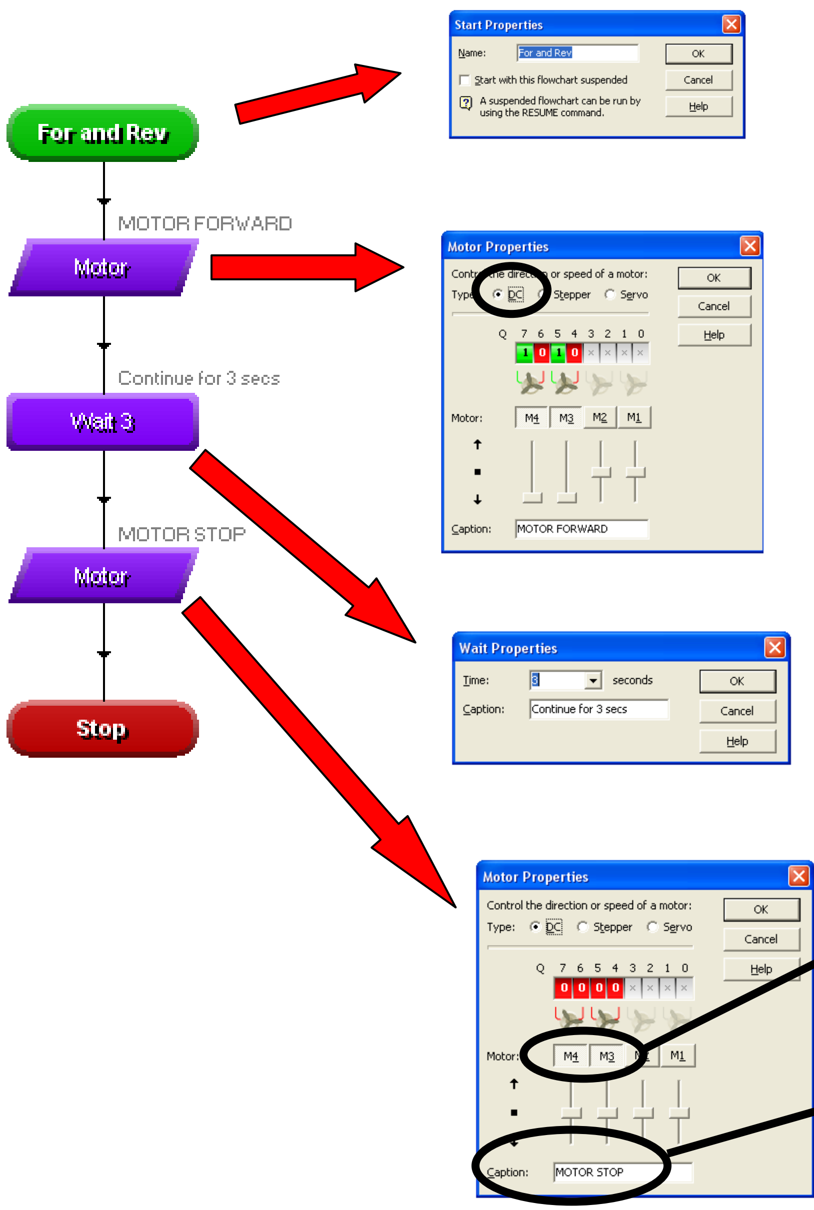
Each command must now be edited in order to complete the program.

NOTE:

The following conventions are used when editing outputs and inputs:

- **0** Make output low (off).
- **1** Make output high (on).
- **T** Toggle this output (where high is set to low and low is set to high).
- X Leave output alone.

Double click on each of the commands except the **Stop** and edit as shown below. Remember to set the type of motor being used to DC:



It is good practice to give every program a name to appear in the Start symbol.

Push down the M3 and M4 sliders in order to set both to forward motion.

NOTE: Depending how you have connected each motor polarity you may find that you need to set the sliders in the up position or one slider up and the other down in order to achieve forward motion when you download and Run Live.

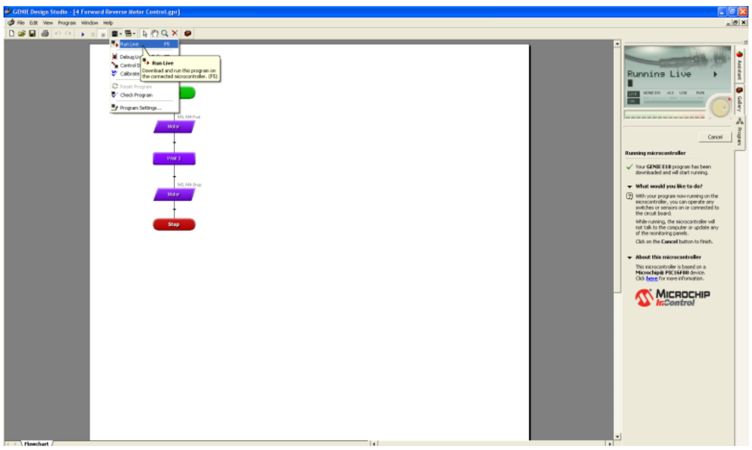
Set the Wait time to 3 seconds. This instructs the program to continue running the last command for 3 seconds.

Click on the M3 and M4 buttons to turn both motors off.

It is also good practice to include a caption indicating what each command is doing.

In order to download the program to the robot, click on the **Microcontroller** button and select **Run Live**. The Program window will indicate that it is *Accessing the PIC* chip and then that it is *Running Live*. The program will start immediately once it is downloaded. The USB cable can then be removed and the program rerun by pressing the small reset switch on the PCB.

The following commands and screen will be seen when using **Run Live**.



As mentioned previously, when you run this program live you may now discover one of the following scenarios depending on how you have connected the motor polarity either at the motors or on the PCB:

a) The motor is actually going in reverse. In this case you simply set both M3 and M4 sliders to the down position instead of the up in order to get forward motion.
b) One motor is going forward and the other going in reverse. In this case you will have to move M3 slider up and M4 down or vice versa.

EXERCISE 1

Edit the program so that your robot moves forward for 2 seconds and then reverse for 2 seconds.

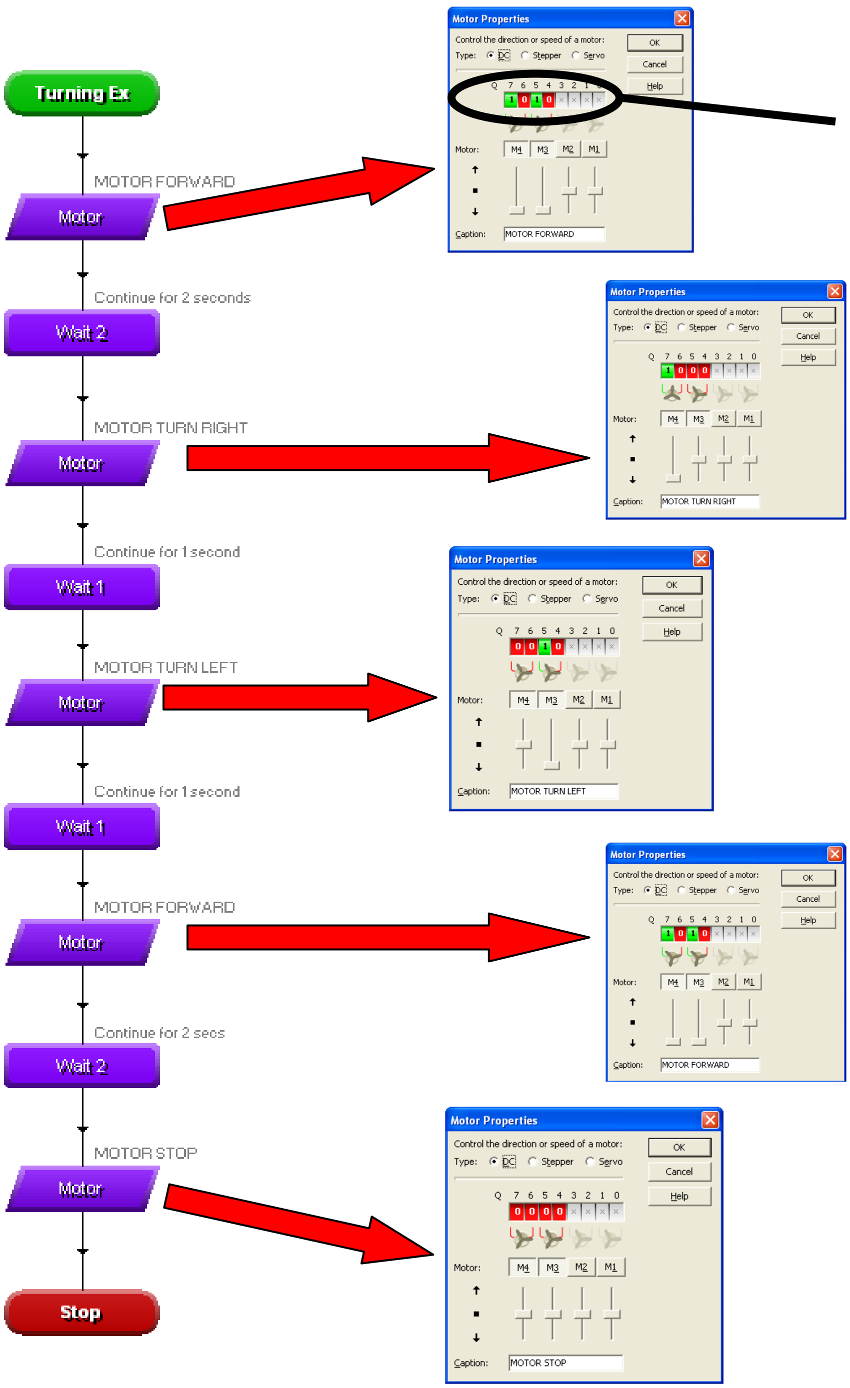
Use Run Live to download and run the program.

The solution, called *Exercise 1*, is available in the *Line Follower Programs* folder.

6. Turning the robot

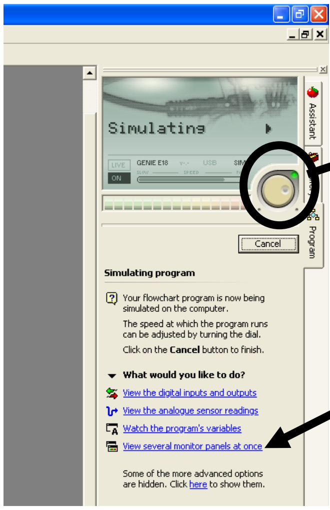
The procedure for turning the robot while it is moving is based simply on turning off one motor and leaving the other running.

Construct and edit the following flowchart as shown. Settings for motor control are shown.



You will see these output settings appear in the **Multiple Panel View** when we simulate this program.

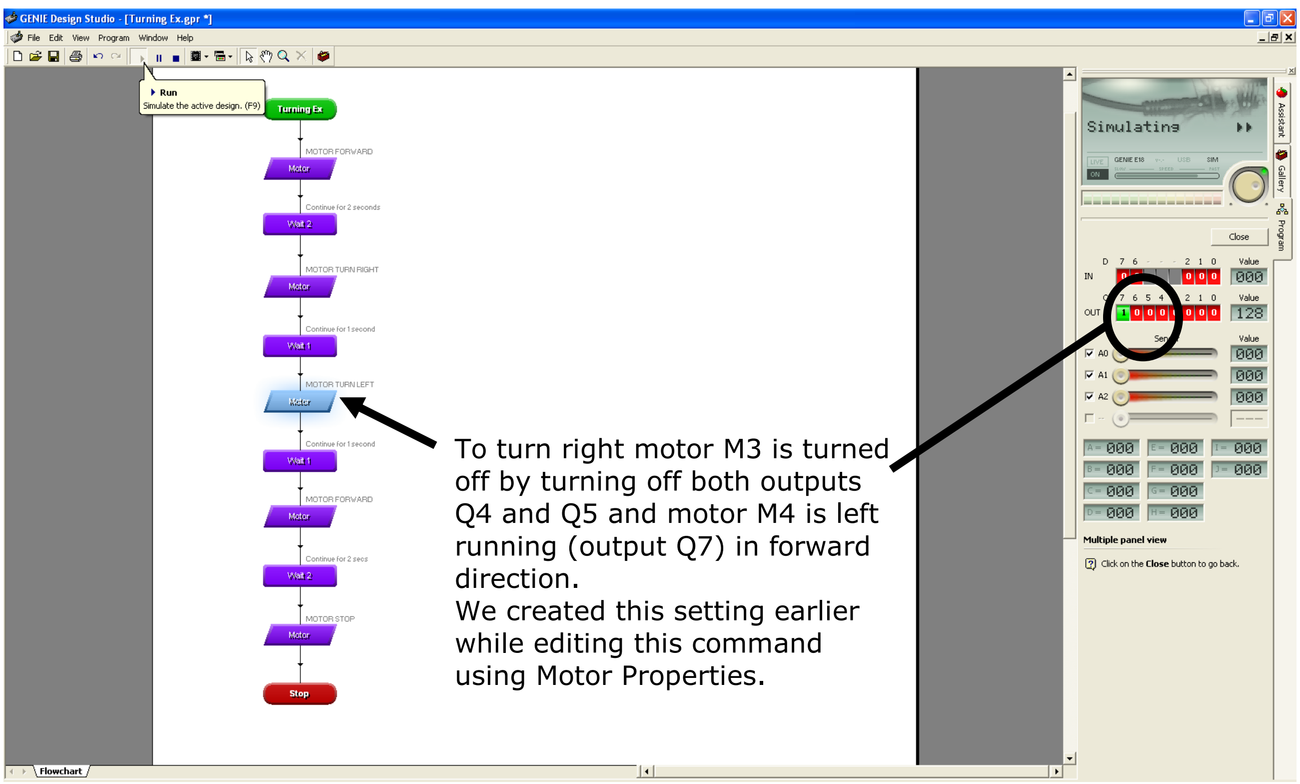
Select the **Run** command on the tool bar.



You will see each flowchart command highlight as the program simulates.

The **Speed Dial** can be rotated to adjust the speed at which the simulation runs.

Now click on the **View several monitor panels at once** command in order to open **Multiple Panel View**.
This allows us see what each flowchart command is doing as shown below.



To turn right motor M3 is turned off by turning off both outputs Q4 and Q5 and motor M4 is left running (output Q7) in forward direction.
We created this setting earlier while editing this command using Motor Properties.

Click on the **Microcontroller** button and select **Run Live** in order to download the program to the robot. The Program window will indicate that it is *Accessing the PIC chip* and then that it is *Running Live*. The program will start immediately once it is downloaded. The USB cable can then be removed and the program re-run by pressing the small reset switch on the PCB.

EXERCISE 2

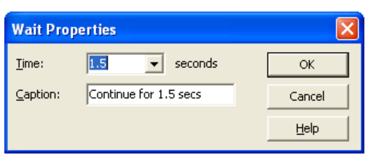
Like all learner drivers you need to learn how to complete a 3 point turn.

Edit the previous *Turning Ex* program to have your robot execute a 3 point turn.

One possible solution, called *Exercise 2 Three Point Turn*, is available in the *Line Follower Programs* folder.

Points to consider:

- There are numerous solutions to this exercise.
- Ensure your wheels are tightened on to the motor shaft to ensure proper movement.
- It is not possible to control the number of revolutions of a DC motor as it is with a servo or stepper motor.
- Controlling the amount your robot turns using the Wait command is accomplished by trial and error.
- It is possible to set the Wait Properties to fractions of seconds by typing the value in rather than selecting the set values from the drop down menu as shown below.



- The turning circle of a robot such as this depends on the diameter of the wheel and the distance between the wheel centres. This could be the basis for an applied maths question for your students.

Having completed this exercise why not try to program your robot to drive in a square, drive in a figure 8 or even set up a parking bay that it must park in using parallel parking!

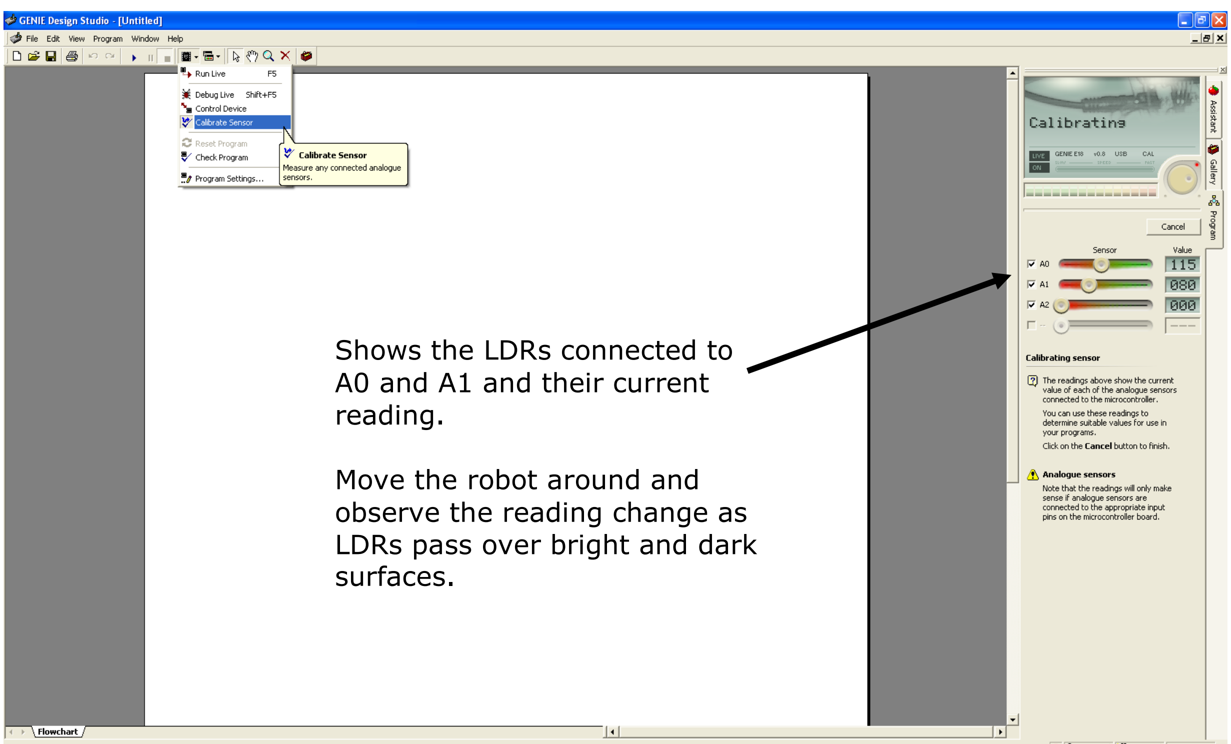
7. Using the LDRs to detect a line.

Before we can successfully use the LDR to detect a line we must learn how to understand the digital reading that the LDR creates in the software.

The resistance of the miniature LDR supplied goes from approx 1KΩ in normal light to approx 15KΩ in normal darkness i.e. it's resistance increases as it gets darker.
Theoretically it goes from 0KΩ in total brightness to 1MΩ in total darkness.

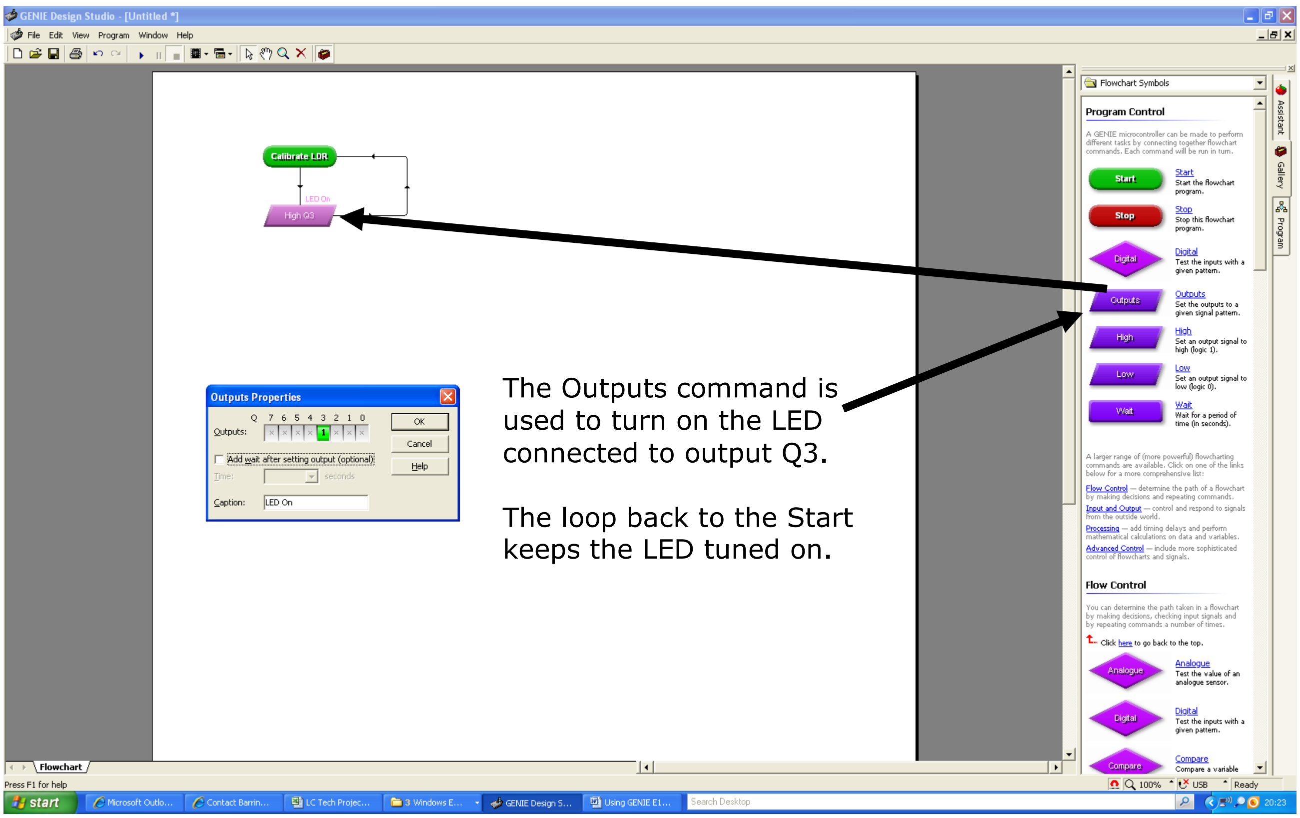
The GENIE software takes whatever analogue resistance value the LDR has at any given moment and converts it into a digital reading of between 0 and 255.
A digital value of 0 corresponds to an LDR resistance of 1MΩ i.e. total darkness.
Similarly, a digital reading of 255 corresponds to an LDR resistance of 0KΩ i.e. total brightness.

Turn on your robot, connect it to the USB and select **Calibrate Sensor** from the **Microcontroller** menu on the tool bar. You should see the screen shown below.

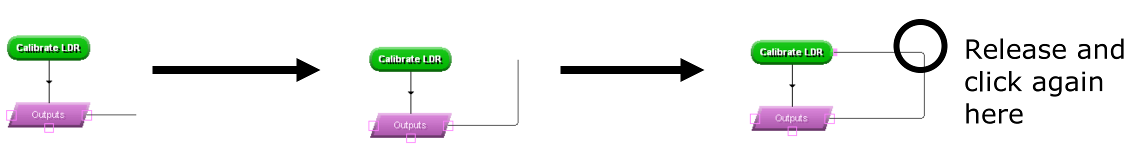


The area underneath the LDRs on the robot will, by virtue of its design, be quite dark. This could create difficulties when trying to detect a white line on a dark surface. In order to solve this problem a LED has been installed between them to illuminate the line and surface.

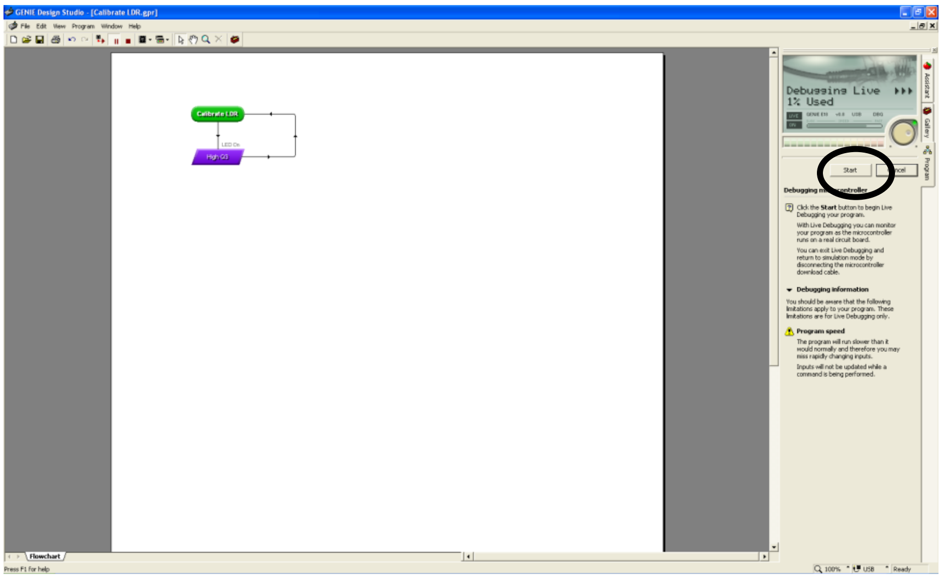
In order to calibrate the LDRs while this LED is on we will use the **Debug Live** command. Construct and edit the following flowchart, also available in *Line Follower Programs* folder.



To create the loop, firstly left click and hold the mouse over the right connection point on the Outputs symbol. Drag the connecting line to the right and then upwards to create the first 90°bend. To create the second 90°bend, release the left mouse button and then click again at a point approximately in line with the Start command. Continue dragging the line to complete loop.

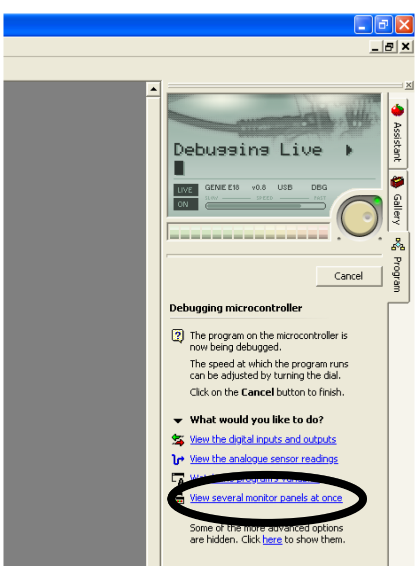


Place your robot on a dark surface, in order to create a contrast with the masking tape line later, turn on and select **Debug Live** from the **Microcontroller** menu. You will see the screen shown below.



Click **Start** to begin **Debug Live**. This facility allows you watch your program animate as it runs live on the microcontroller.

By clicking on **View several monitor panels at once** as shown below we can now observe what the LDRs are reading along with what inputs/outputs etc are activated.



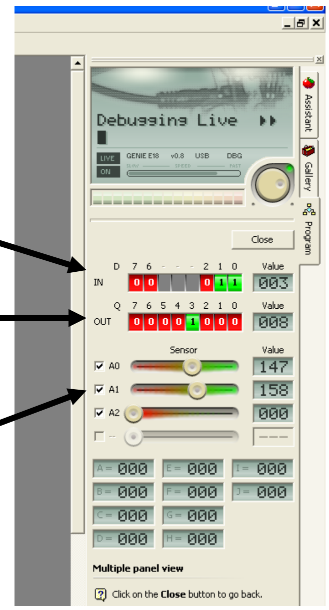
You could choose to view the inputs/outputs or the analogue sensor readings etc on their own but the View several monitor panels at once option shows nearly everything and is demonstrated on the following page.

You should now see the screen shown below.

Indicates that inputs A0 and A1 are connected.

Indicates that the LED connected to output Q3 is on.

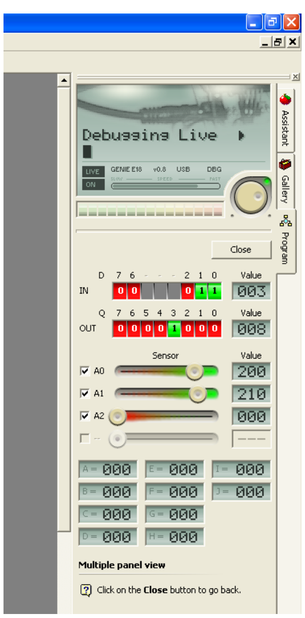
Readings from LDRs connected to A0 and A1.



Place a strip of white masking tape on the surface and move the front of the robot over the tape in order that the LDRs detect the new reading associated with the white tape. The new readings will display as before. Take note of the dark surface readings and the readings while on the tape. The screen shown above shows an example of readings on a black surface and the screen below shows an example of reading when positioned on the white masking tape.

The following link shows a video of a *Debug Live* calibration in progress:

http://www.youtube.com/watch?v=NKKa0Aphl4A



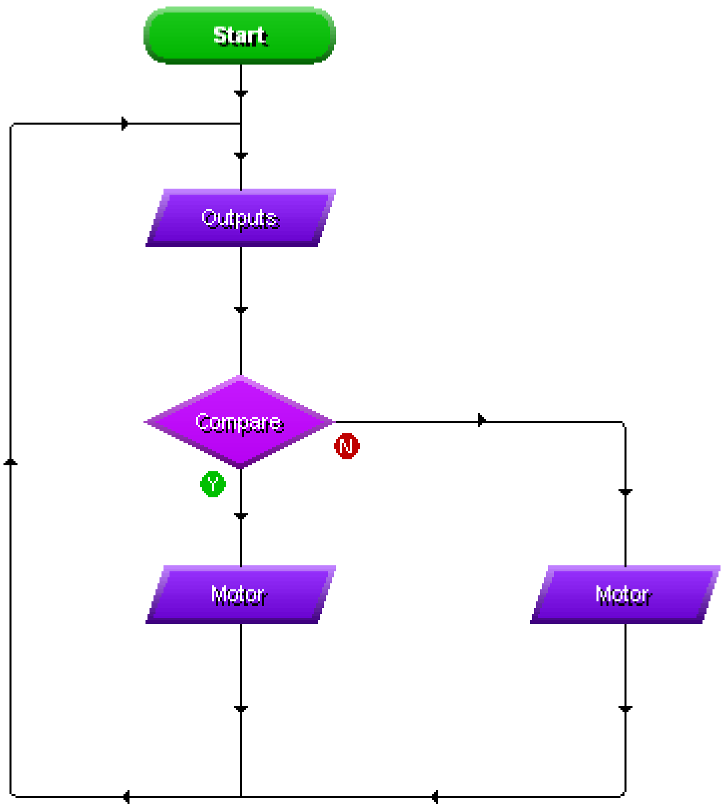
The data gathered in this example shows:

- LDRs read a max of approx 160 on the dark surface
- LDRs read a max of approx 210 on the white masking tape

The most important fact is that when the LDRs are reading anything below 160 the robot is on the dark surface. Anything above 160 indicates that the robot has moved on to (or close to) a white surface.

We can now use this information to create a program to stop the robot from driving over the white masking tape line.

Construct the following program shown below.



The **Compare** command is found in the Flow Control section of the flowchart symbols.

It is used to compare the LDR readings and decide whether to follow the Yes (**Y**) or No (**N**) route in the program.

The first line connected to the Compare command will indicate the Yes (Y) route to follow and the second line connected will indicate the No (N) route to follow.

These can be swapped by right clicking the **Compare** command and selecting **Swap Yes and No** if necessary.

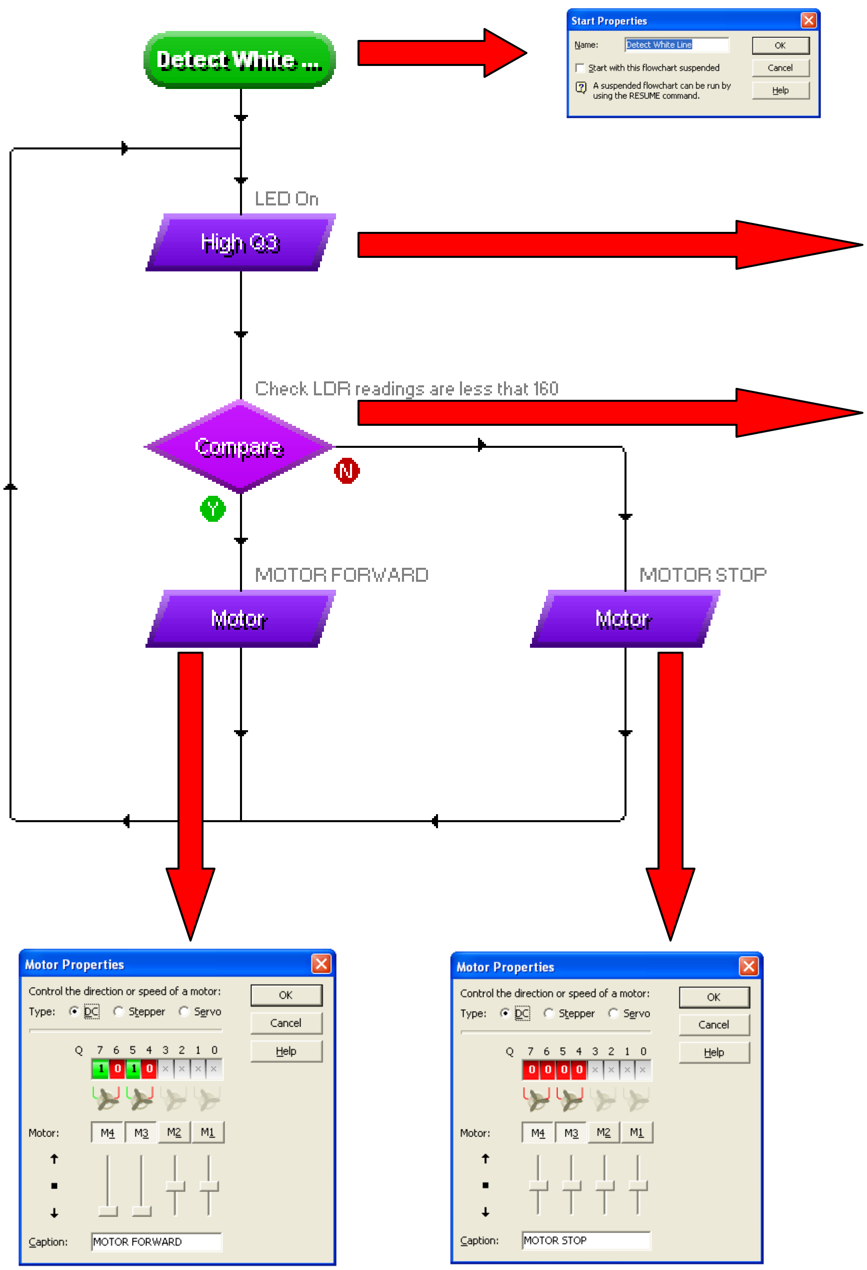
We will now edit this flowchart so that it carries out the following program:

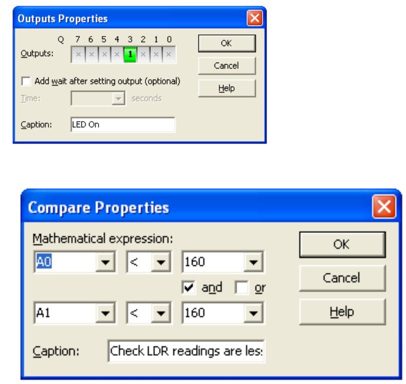
1. Turn on the line illumination LED connected to Q3
2. Check if the LDR readings are less than 160
3. If so then drive the robot forward as it is still on the dark surface
4. If not then stop the robot as it has detected the white masking tape line
5. The loop will ensure that the program continually checks the readings

NOTE:

The settings used i.e. less than 160 will need to be adjusted to suit the dark surface that your robot is operating on. Use the reading found while calibrating using *Debug Live* earlier.

The edited flowchart symbols are shown on the next page.





Tick the **and** box to open the second expression.
This instructs the program to compare both readings from A0 and A1 to see if they are less than 160.

If they are, then the robot is still on the dark surface and continues forward.

If they are more than 160 the robot has encountered the white line and stops.

NOTE:

Remember to use your own readings that you found earlier while calibrating during Debug Live.

EXERCISE 3

Mark out an enclosed area on a floor using the white masking tape inside which the robot will be free to maneuver.

Edit the previous program Detect White Line so that the robot remains inside the marked area.

One possible solution, called *Exercise 3 Staying Inside Area*, is available in the *Line Follower Programs* folder.

Points to consider:

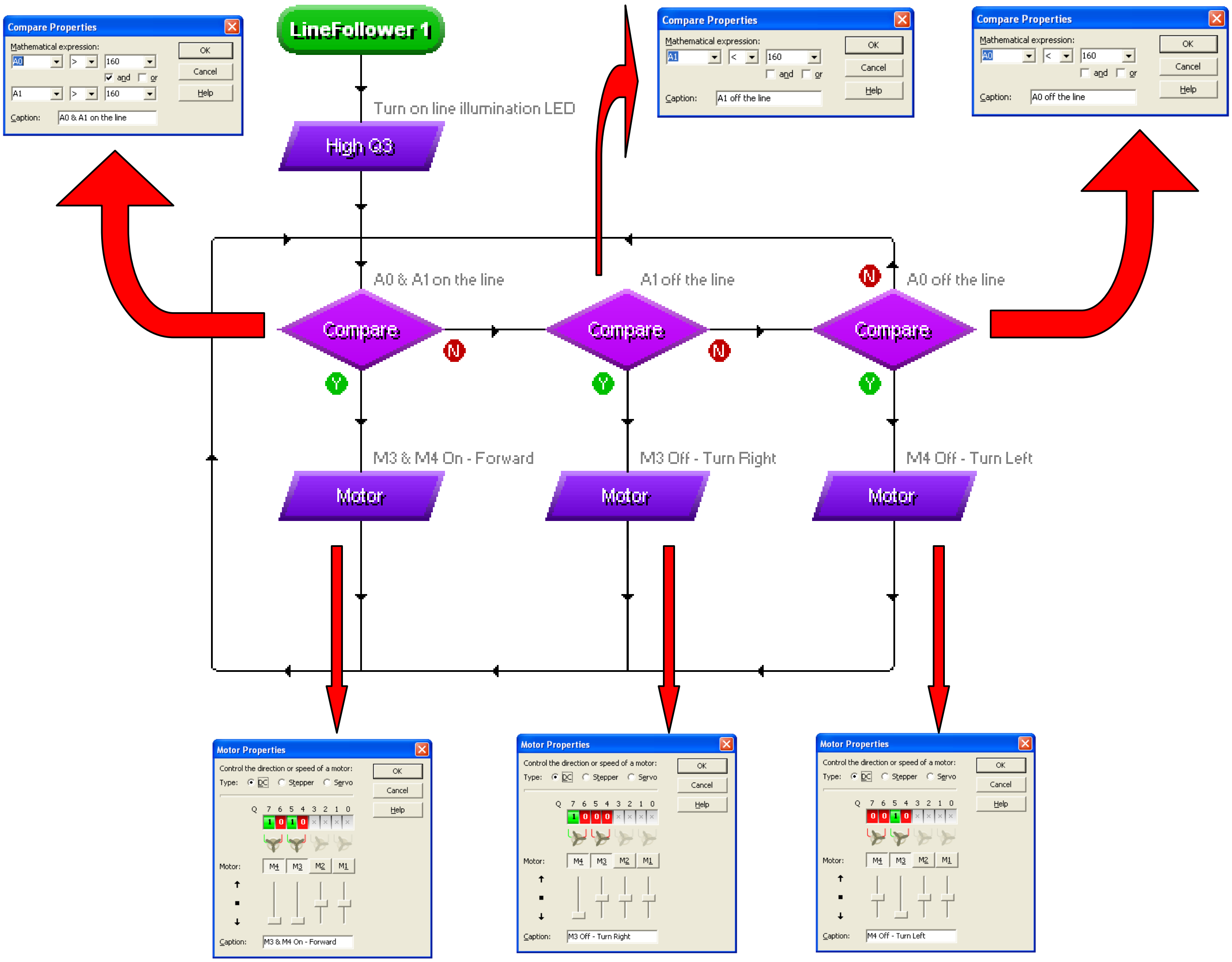
- There are a number of solutions to this exercise.
- Ensure your wheels are tightened on to the motor shaft to ensure proper movement.
- You may have to recalibrate the LDRs with the LED activated using **Debug Live** if the floor area you are using is a lot darker or brighter than the area you used for the previous program Detect White Line.

Click on the following link to see a video of the robot carrying out this exercise:

http://www.youtube.com/watch?v=GiHYn9ch-vs

8. Using the LDRs to follow a line

Construct and edit the program shown below.



NOTE:

- In the first **Compare** command the LDRs are set so that if they both read more than 160 i.e. they are both detecting the white masking tape then both motors are on moving the robot forward.
- In the second **Compare** command if A1 reads less than 160 then the robot has moved off the line to the left and motor M3 is turned off in order to move the robot to the right and back to the line.
- In the third **Compare** command if A0 reads less than 160 then the robot has moved off the line to the right and motor M4 is turned off in order to move the robot to the left and back to the line.

Mark out a line on the floor using the masking tape. Include curves and 90° bends in the line. Turn on your robot, connect via USB and select **Run Live** to download this program *Line Follower 1*. A copy of the program is also available in the *Line Follower Programs* folder.
Turn off, disconnect your robot from the USB and set it up at the start of the line. Turn on and observe how well it follows the line.

Points to consider:

- Ensure your wheels are tightened on to the motor shaft to ensure proper movement.
- You may have to recalibrate the LDRs with the LED activated using **Debug Live** if the floor area you are using is a lot darker or brighter than the area you used previously.

Click on the following link to see a video of the robot carrying out this exercise:

http://www.youtube.com/watch?v=VHkEDG8Q42E

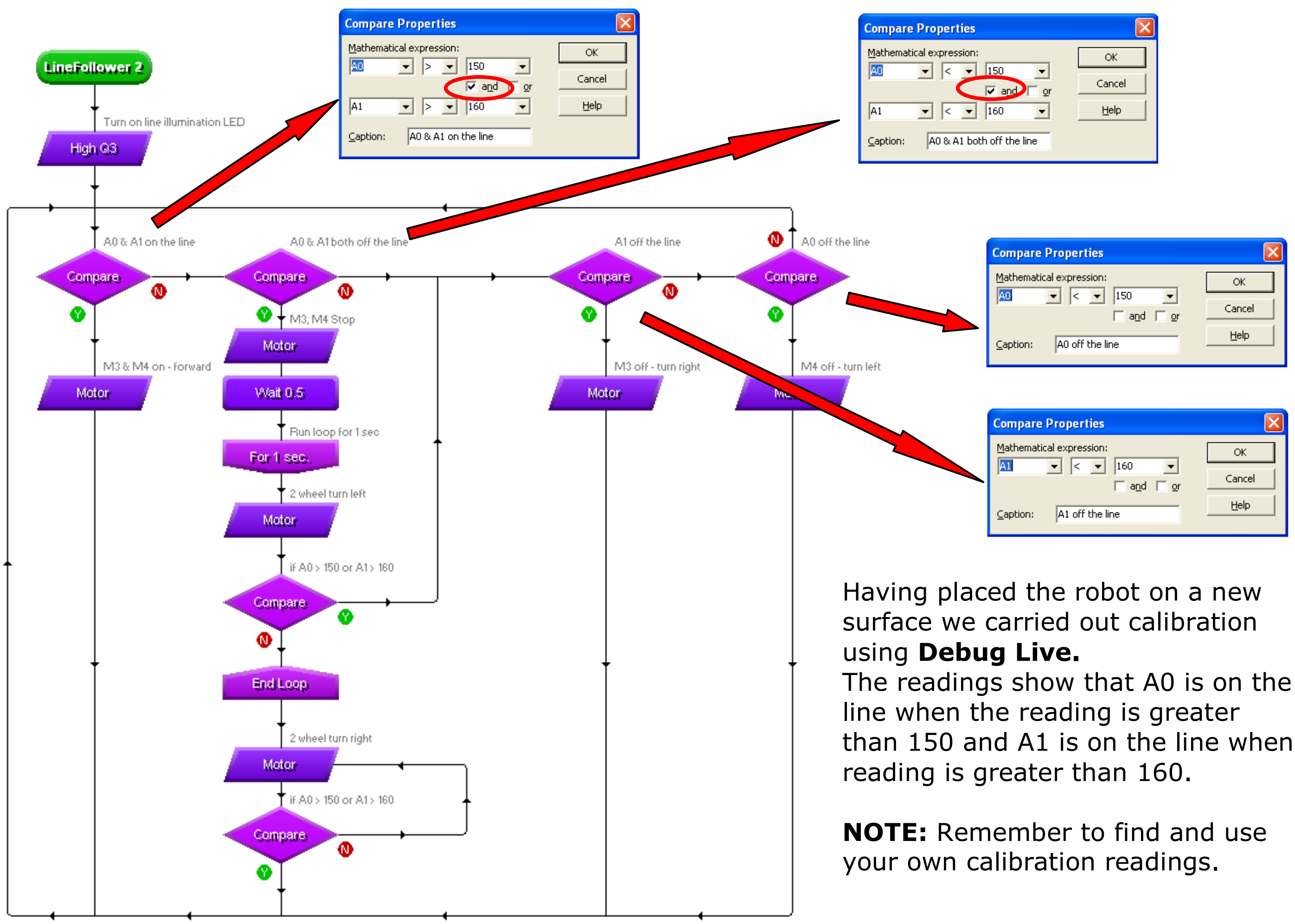
Note how the program is able to deal with the first 90° right bend but unable to deal with the second 90° left bend!

In the next section we will look at one possible way of dealing with this problem.

9. Using a defined loop during a program

In order to deal with the problem encountered during the previous exercise of the robot losing sight of the line, we need to program it to look for the line. This is best accomplished by inserting a loop in the program that will instruct the robot to firstly look left and if it does not find the line there, to then look right until it does.

Edit the previous program to create the following flowchart. As you will see in the video later, we are using a different surface and so we will look at the initial LDR settings before moving on to look at the defined loop in detail.



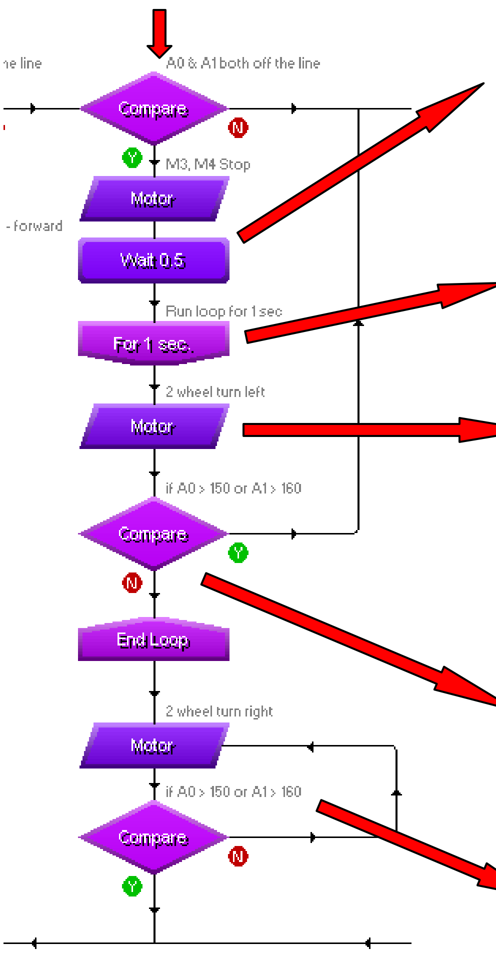
Having placed the robot on a new surface we carried out calibration using **Debug Live.**

The readings show that A0 is on the line when the reading is greater than 150 and A1 is on the line when reading is greater than 160.

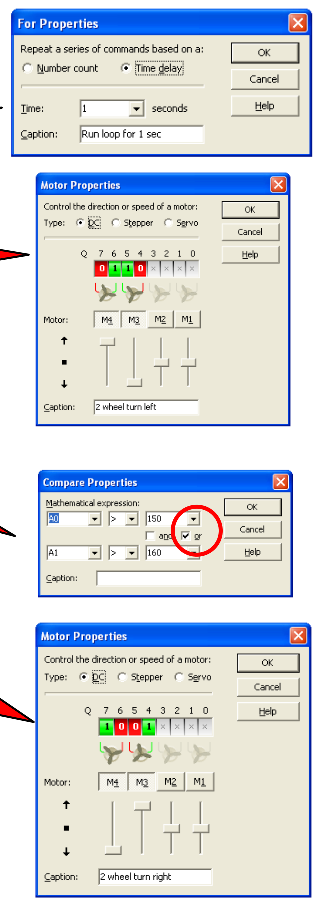
NOTE: Remember to find and use your own calibration readings.

Apart from new LDR settings these parts of the flowchart are the same as in *Line Follower 1*. The motors are programmed as before with either M3 or M4 off if A1 or A0 moves off the line and both on while A0 and A1 are on the line. We will now look at the new loop in the program.

We will now look at what happens when A0 reads less than 150 and A1 reads less than 160 meaning that both LDRs have moved off the line.



Once the program detects that the sensors A1 and A0 are both off the line the motor stops briefly for half a second. This minimises the amount of over-shoot of the line.



The **For** command is found in the **Flow Control** section of the flowchart symbols. It runs the series of commands between it and the **End Loop** command either a set number of times or for a given number of seconds – in this case, for 1 second.

The **Motor** command that follows causes the robot to perform a two wheeled left turn in order to look for the line.

The **Compare** command checks to see either if A0 **or** A1 are on the line during the left turn. If they are then the program follows the Y route back to the main section of the program.

If not, after the 1 second loop ends, the motor performs a two wheeled right turn continuously until a further **Compare** command detects the line in the other direction. When it does the program follows the Y route back to the main section of the program.

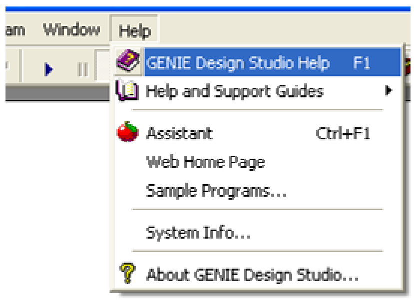
In this section of the program the robot is initially looking left for the line and if it is not found after 1 second (approx a 90° turn) it looks right continuously until it is found. Depending on the layout of the line being followed the time of the initial loop may need to be extended. A copy of the program is also available in the *Line Follower Programs* folder. Click on the following link to see a video of the robot carrying out this exercise:

http://www.youtube.com/watch?v=aV4oSjNv8VM

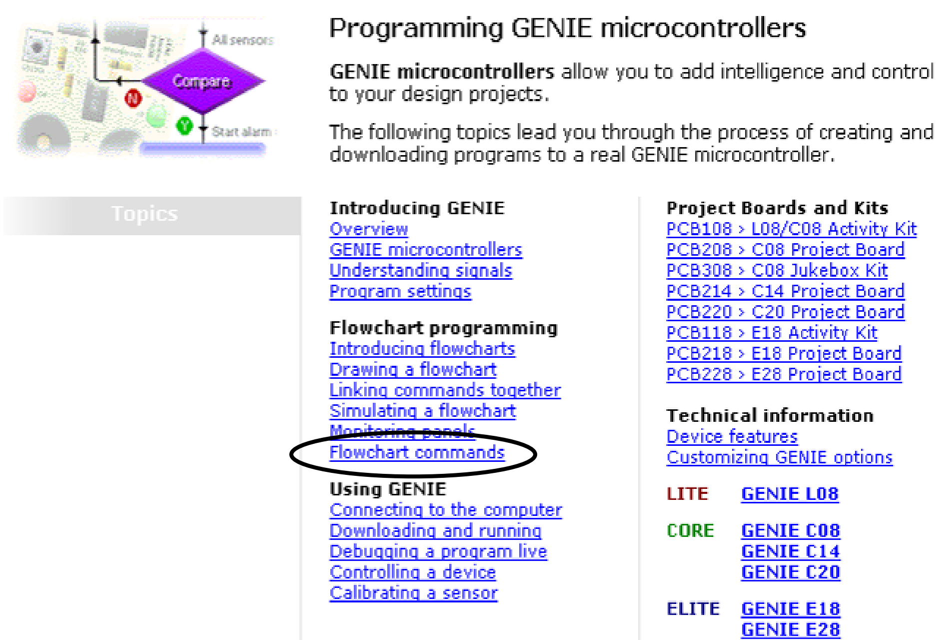
10. GENIE Design Studio Help

These notes are only an introduction to *GENIE Design Studio*. It contains many more commands that have not been mentioned at all.

Explanations of these other commands can be found in the **Help** section of the software by clicking on **GENIE Design Studio Help** as shown below:



Then select **Flowchart commands** as shown:



This will open a window displaying all current GENIE commands. By clicking on any command the user will be given a simple explanation of what the command does along with a sample flowchart showing how the command may be used.

10. Useful links

The following is a sample of websites that may be useful for further study in the area of PIC microcontrollers:

- http://www.genieonline.com/
- http://www.rev-ed.co.uk/
- http://www.picaxeforum.co.uk/
- http://www.logicator.co.uk/
- http://www.technologystudent.com/pics/picdex1.htm
- http://www.ajbox.co.uk/
- http://www.new-wave-concepts.com/
- http://www.youtube.com/watch?v=u4Ia_YRUCy0
- http://www.t4.ie/Professional_Development/RD8_Technology/Robotics/A%20Guideline%20to%20using%20%20Pic%20Logicator.pdf
- http://www.economatics-education.co.uk/secondary/education/90,94,0/1536/PIC-Logicator_Version_2.htm
- http://www.bbc.co.uk/science/robots/techlab/sub_selector.shtml