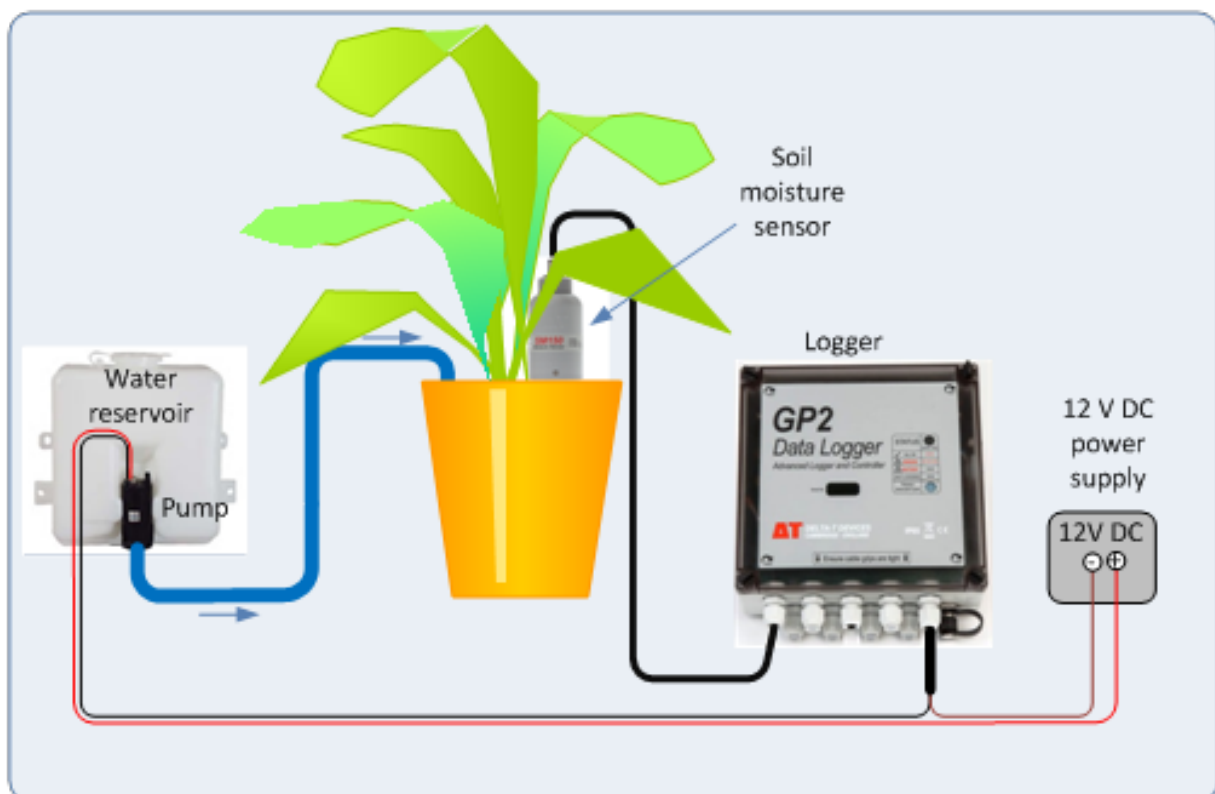


Simple Irrigation Control Program Tutorial



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This tutorial introduces you to using the GP2 to control and record a simple irrigation system. It also works quite well as an introduction to the GP2, along with the **GP2 User Manual**.

The GP2 Introductory Video Tutorials are also a great way to get started.

See <http://www.youtube.com/user/DeltaTDevices/videos>

Use the Simulator in Part 1 - then Part 2 - do it for Real

In Part 1 we use the DeltaLINK GP2 simulator to simulate the logger, the irrigation system, the weather and the movement of the moisture through the soil while a crop grows.

We see the results of running on the Simulator and see how to interpret the results to be sure it is doing what it ought.

To work through Part 1 of this tutorial you just need a PC running DeltaLINK 3. This software is free to download and use. You can get it at www.delta-t.co.uk/techsupport. Everything else is simulated.

In Part 2 you do it for real. You wire up a real logger, sensor(s) and irrigation equipment (as outlined below) and wait for a plant to grow. Whilst the equipment may only take a few hours to set up, it will, of course, take days and weeks for a plant to grow. So Part 2 is not so much a tutorial as project.

This two-step approach – simulate first then do “real” - also reflects the way we think most users will use their GP2 logger. The simulator lets you quickly develop, test, and understand your logging program/controller/experiment. This simulator has been written particularly with irrigation control in mind so it also useful for helping develop the control side of an irrigation program. However, the crop growth model is pretty basic so do not rely on its predictions for anything important.

Always test any model with real data from a properly designed test experiment before you rely on it.

See also **Appendix 2: About the GP2 Simulator** on page 21

Part1

What it Does

This irrigation program waters the plant once an hour if the soil is dry, but not if it is wet. It also keeps a record of the soil moisture.

How We Do It

We use a soil moisture sensor to keep an eye on things, and a GP2 logger to do the maths and turn the tap on.

First we use the GP2 simulator to show us what the results might look like.

The simulator is not an accurate model of the environment, so we don't rely on it for that. But it's great for checking out our control program because we can run it speeded up and see what happens.

When we are happy with the simulated results we wire up a real soil moisture sensor to the logger connect the sprinkler to a relay, and we are ready to go.

Choose Limits

We were told this plant is quite happy down to 25% volumetric water content, so we should keep the soil wetter than this. Actually I am going to set my lower limit to 30% - just to be on the safe side.

But we don't want it too wet either, so we are going to set an upper limit.

Now in our soil we know 60% is very wet mud, so we don't want to go there - the plant does not like it and besides, there is the water bill to pay. So purely in the interests of plant welfare we will pick an upper limit close to 30% - but not too close - because we don't want the damn thing turning on all the time. How about an upper limit of 35%? Does that sound OK to you? If we don't like it we can always change it later.

So water on below 30%, water off above 35%, and we will check it once an hour (or rather, the logger will).

Here is one I made earlier

This was the simulator graph without any irrigation control.

The horizontal axis denotes the time and date, starting at midnight on March 1 2012.

The vertical axis shows the measured values seen in (or by), the simulator.

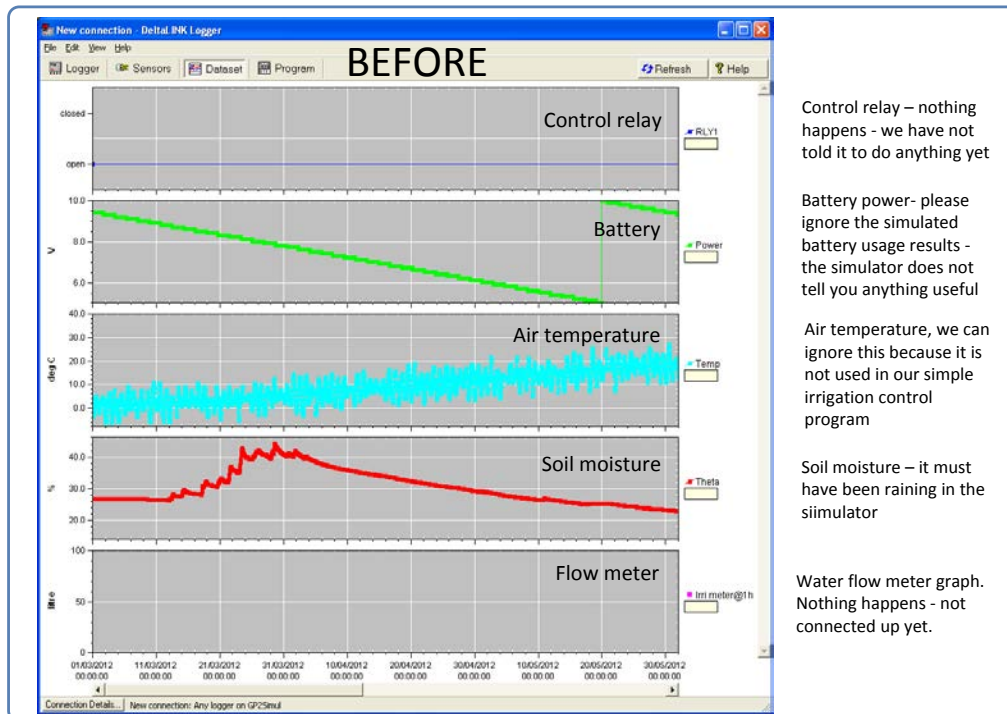


Figure 1 A GP2 simulated weather pattern with the irrigation control disabled

And this, below, is the same simulated weather, but with our irrigation controller working

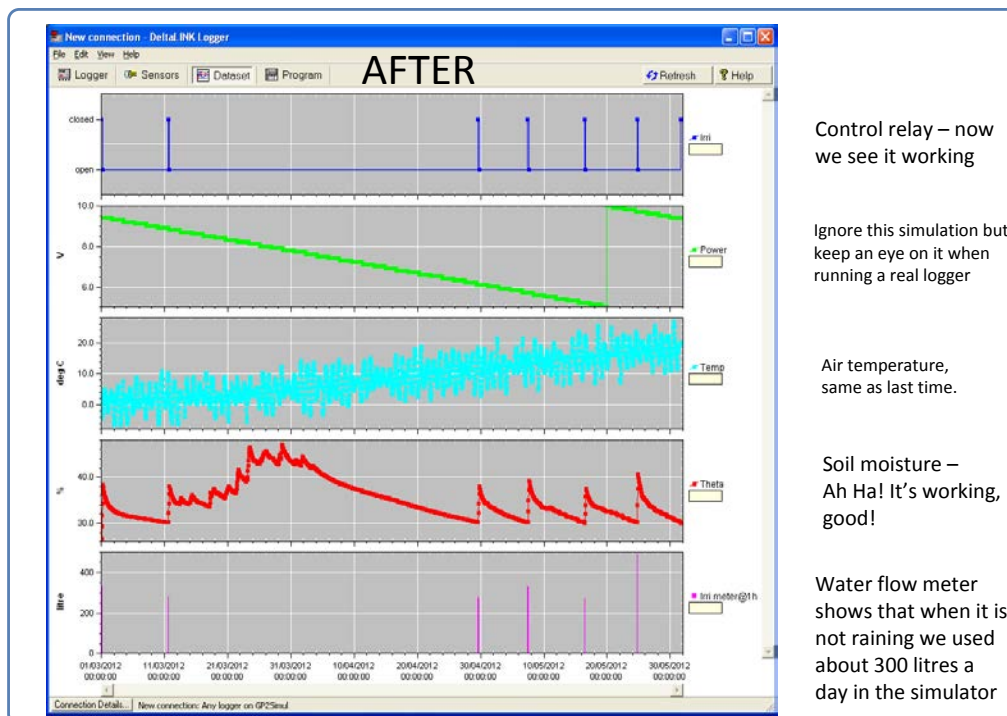


Figure 2 The same simulated weather as in Figure 1 but with a simple irrigation control program enabled

Equipment

A **soil moisture sensor**, preferably from Delta-T. In this example we use an SM150. This has wires for connecting to the GP2 logger. (You can also connect this sensor to our HH150 or HH2 hand-held meters).

1. A **GP2** data logger/controller.
2. A **PC** running **Windows XP or later** and with a USB (or RS232) serial connector and the **DeltaLINK 3** software installed.
3. A **plant** in a pot or in the ground.
4. A **water supply**, either in a pipe under pressure or in a reservoir of some sort.
5. Water **hoses and connectors**.
6. A **power source** for the control relay or water pump - but please read all of item 8 first.
7. The GP2 provides a control signal to turn the water on and off, but you need something mechanical – a **valve or pump**, at the wet end of the business to respond by physically turning the water on and off.

If you have water under pressure in a pipe then you need an electronically controlled valve. This is often called a solenoid valve (so-called because it uses the force created by an electrical wire winding around an iron core – a solenoid - to open and close the valve).



Figure 3 - A typical commercial greenhouse set-up with an isolation tap, a 24 V electronically-controlled water valve and a water flow meter. See Appendix for details.

Figure 3 shows a typical commercial greenhouse-type of solenoid valve in the pipework, along with a tap and a flow meter. The valve will open when 24 V AC is applied across the two brown wires coming out at the top. On the right of Figure 3 we see a typical commercial flow meter. This one has an ordinary dial gauge and also a signal output cable with two wires- which can be connected to the GP2, on one of its four digital event input channels, to automatically record on how much water you use. The water direction can matter. In this instance the water should go from left to right.

If you have a small reservoir and no pressure head, then you can use a smallish water pump.

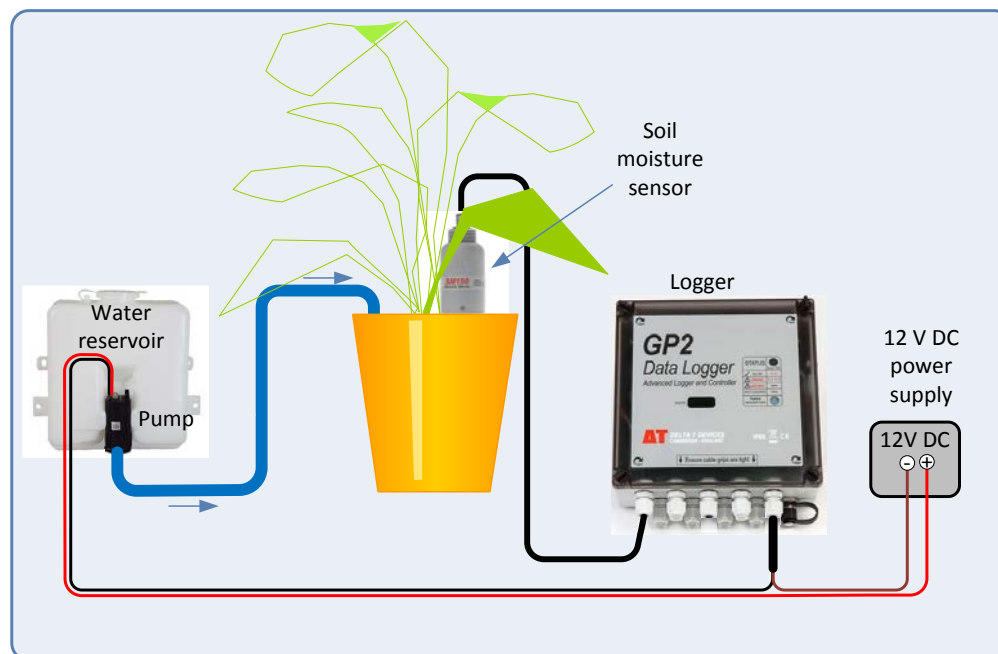


Figure 4 Nick's Simple Irrigation system – the desktop version.

This example uses a miniature 12V DC power supply and a water resevoir plus water pump - from a car's windscreen washer. The external 12 V DC power supply to the pump is switched on an off by the logger. Note: the logger's internal 12V supply is not used to run the pump in order to preserve the life of the battery. If you want to copy this please sit the plant and water resevoir on a tray deep enough to catch any leakages. Please also check with the car owner first!

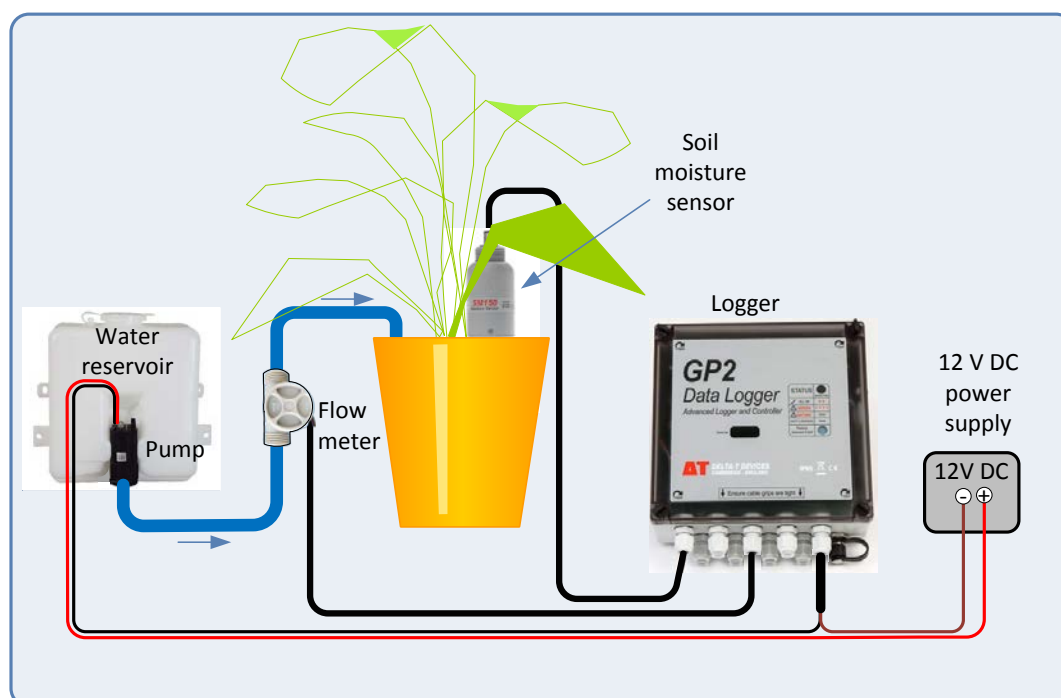


Figure 5 Nick's simple irrigation control desktop version modified with a miniature flow meter added. Just a couple more wires – and the right instructions, and the GP2 can work out how much water you use. When you are more comfortable with the logger you will find it can do a lot more ...

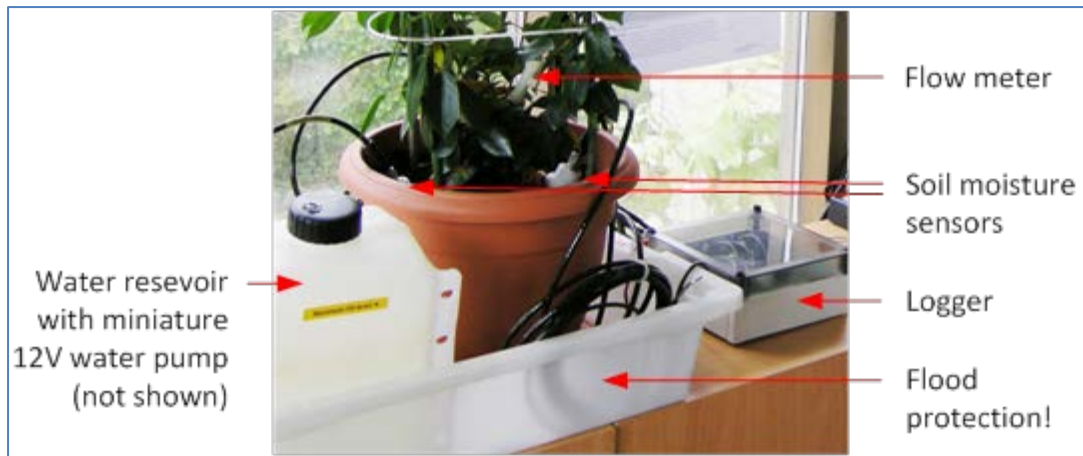


Figure 6 Karl's irrigation control experiment set up in the window at Delta-T. Karl had 3 soil moisture sensors in his pot, which appears a bit like overkill, but was useful testing the DeltaLINK software. (Karl had it working out the average soil moisture from the three sensors.)

If you have a large commercial water reservoir then you probably already have irrigation pipe work installed and under pressure, in which case your set-up would be more like **Figure 3**

The GP2 has two switches, called relays in the trade, which can be used to close the electrical circuit which provide the power to turn the water on and off. With a GP2 Relay Module you can expand this to 6 in total. So you could run 6 independent irrigation zones each with a soil moisture sensor and its own solenoid valve or water pump.

The thing is – these relays are OK but they are only little. They can only take up to 1 Amp from a low voltage source, up to 24 Volts AC or up to 32V AC. So don't even think about connecting these little guys directly to the mains!! That would be dangerous.

Install DeltaLINK on your PC

You can download and install this from <http://www.delta-t.co.uk/software-downloads.asp>.

It is also provided on the **Delta-T Software and Manuals DVD**.

Installation instructions are provided with the install software and in the **GP2 Quick Start Guide**.

As DeltaLINK 3 is free, and it includes the GP2 Simulator, the GP2 video tutorials, and several applications notes and Quick Start Guides, you can obtain and play with all this before you buy a logger. Not bad!

Run DeltaLINK

Start DeltLINK 3. The following screenshot indicates what should appear the first time it runs.

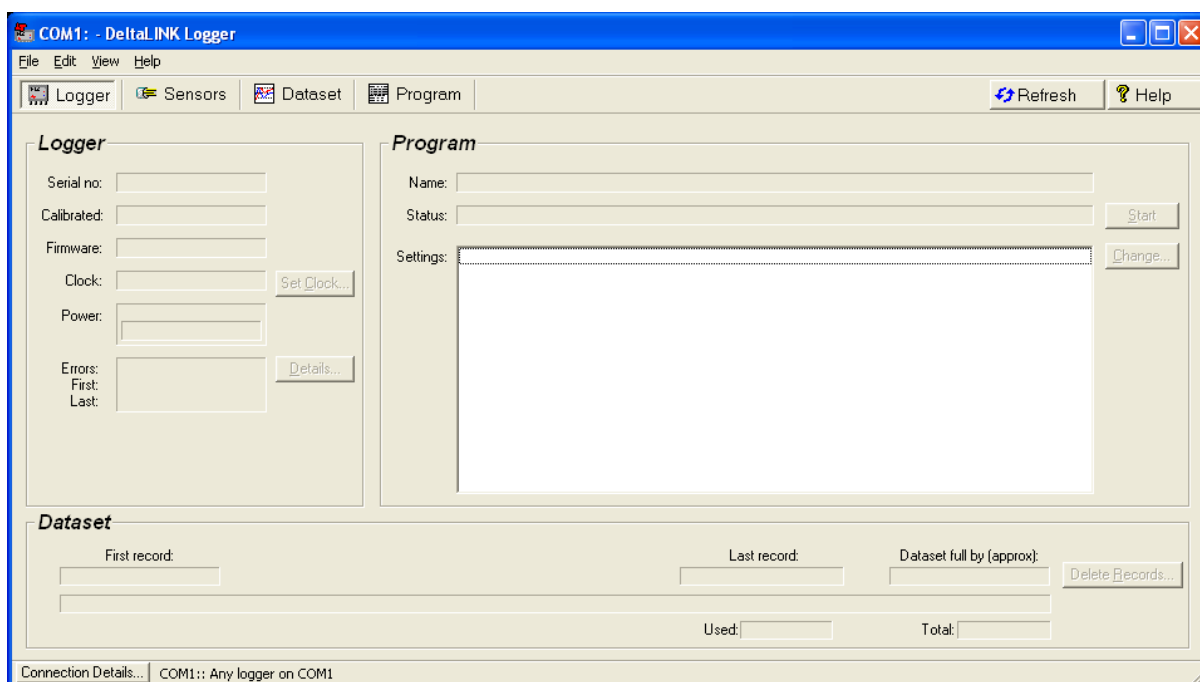


Figure 7 When you start first DeltaLINK it will look for a logger on COM1. If it cannot find it it will pop up a note to that effect. Click OK and DeltaLINK should appear as above if no logger is connected.

In the above example DeltaLINK is looking for a logger on COM1, but has not found it yet.

In this case that is because I have not connected my GP2 to the PC using a serial cable yet.

Your GP2 might well be on another COM port. If so you will need to find out which one it is on and point DeltaLINK at it.

If you don't want to mess about now, we can connect to the GP2 Simulator instead, and sort out the logger connection later.

How to Connect to the GP2 Simulator

In DeltaLINK click on the Connection Details button and follow the steps shown in Figure 8

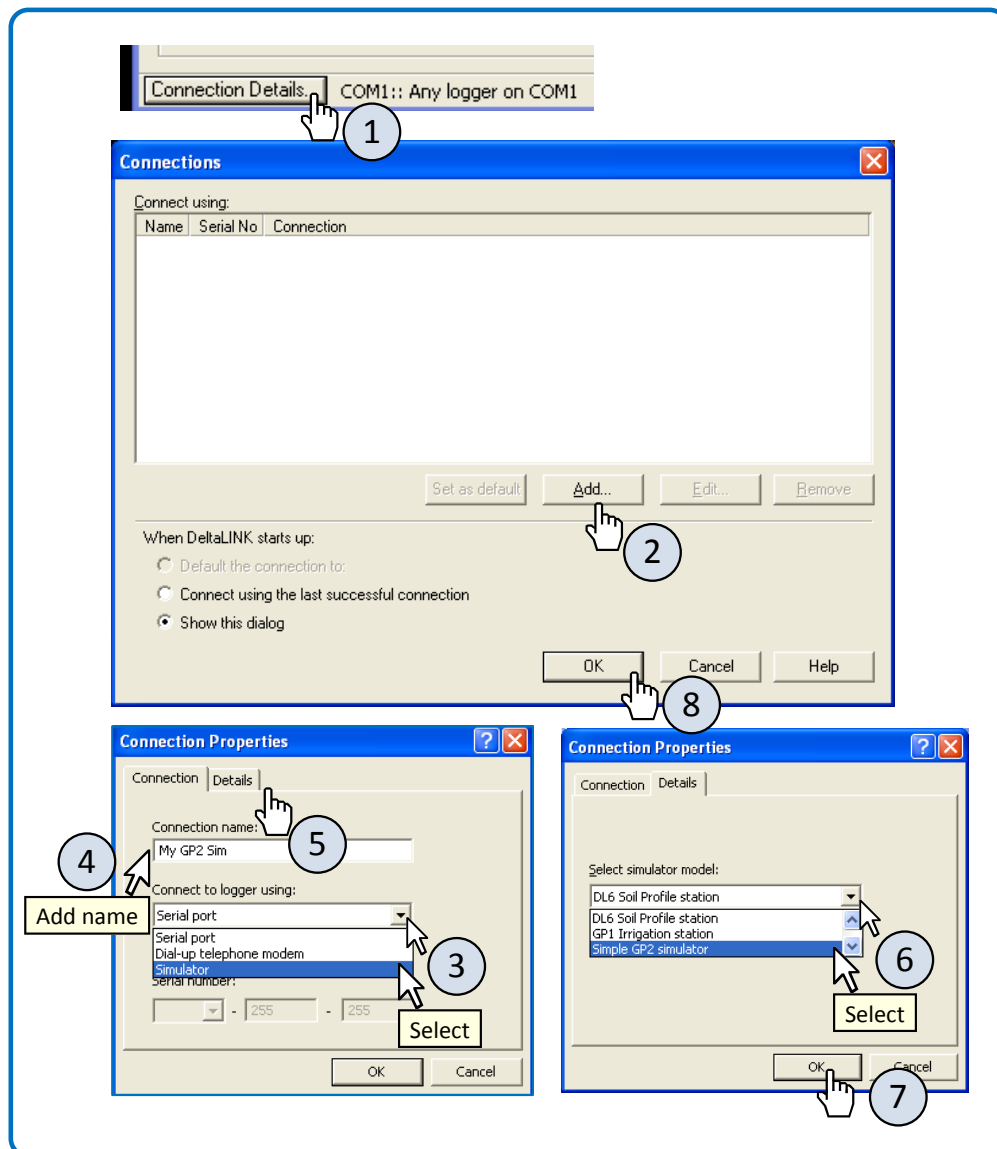


Figure 8 Steps to making a connection between DeltaLINK and the GP2 Simulator.

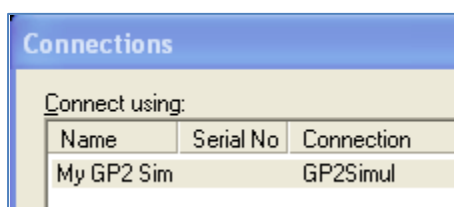


Figure 9 Following steps 1-8 above you now have a connection established to the simulator. You can now send GP2 logger programs to as if it were just another logger.

Having done this you can now run programs on the simulator, which appears just like another logger in your Connections list. This list can be grown to include a large number of different real loggers on a network.

Load up the Simple Irrigation Control Program

We created this program to get you started, and will show you how to import it into the desktop program DeltaLINK, and from there into the GP2 simulator or an actual GP2 logger.

Before you do that you might like to take the tour and view the [GP2 Introductory Tutorials](#)

1. Open **DeltaLINK, Program**
2. If DeltaLINK is not already connected to the GP2 Simulator, connect now as described above
3. Select the **Program** window and click on **Change**
4. Select **Edit, Import Program, Nick's Simple Irrigation Control.pg6**.
This can be found in "[Installation folder]\Samples"
The location of the installation folder depends on where DeltaLINK3 is installed, for example:-
`C:\Program Files\Delta-T\DeltaLINK 3.0\Samples\`
On a 64 bit machine "Program Files" becomes "Program Files (x86)".
5. Click on Apply to send it to the GP2 Simulator
6. On the **Logger** window select **Start** and watch the clock on the GP2 simulator window racing along.

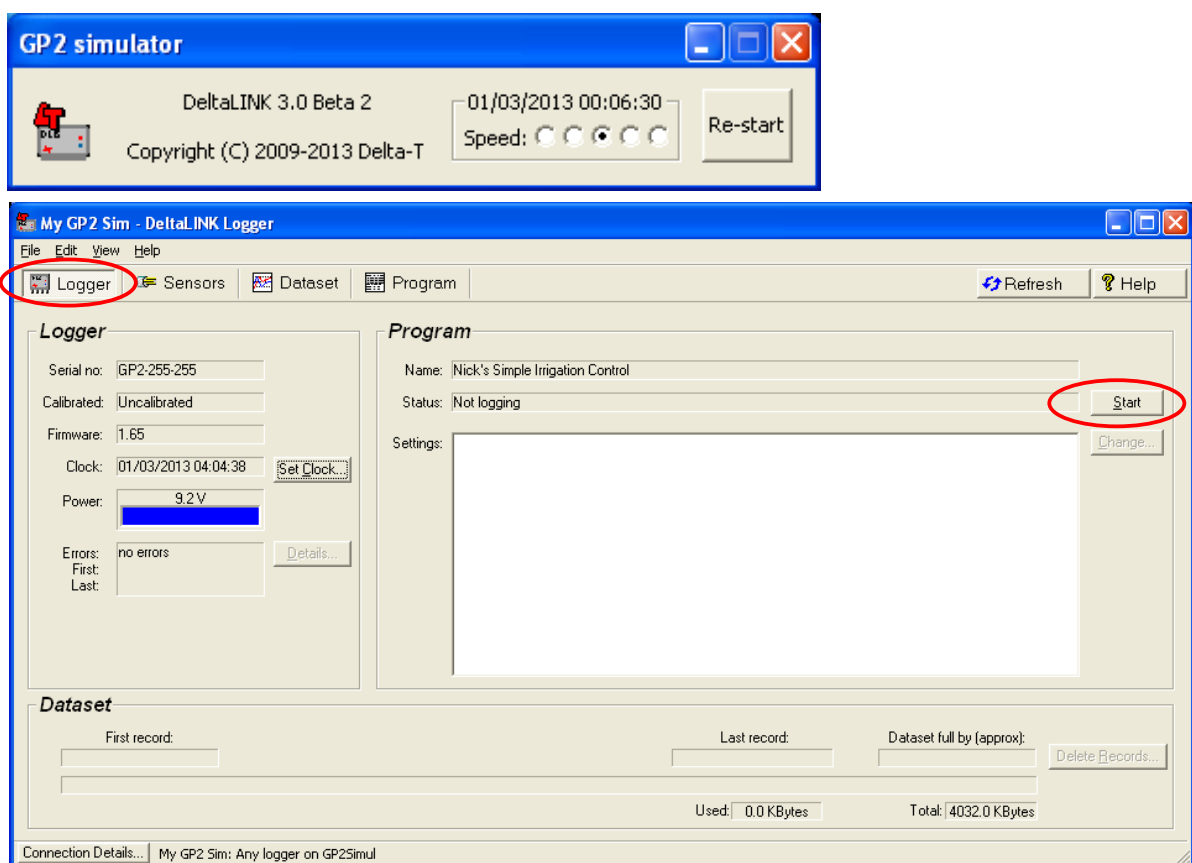


Figure 10 DeltaLINK Logger Window (i.e. the first of the four horizontal tabs, showing that Nick's Simple Irrigation Control program has been installed. The text along the bottom indicates which logger it is connected to "My GP2Sim" on the GP2 Simulator.

7. Select **Dataset, Refresh** to display a graph of the simulated data
Once about 6 months data is generated go to the Logger window and press **Stop**

An example is given below.

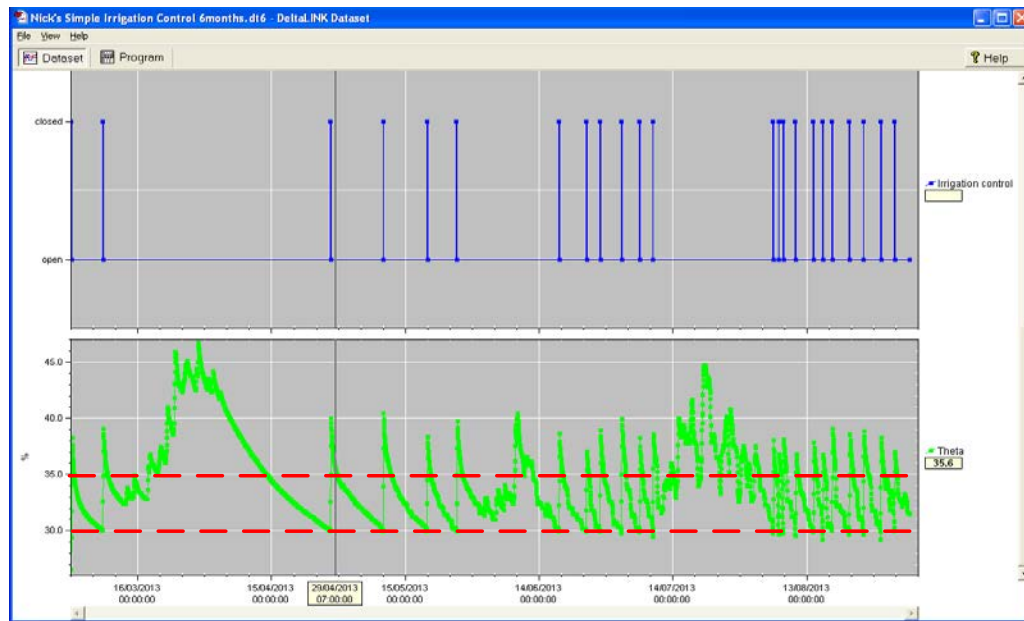


Figure 11 DeltaLINK Dataset graph from the GP2 simulator after running Nick's Simple Irrigation Control. The lower graph is volumetric soil moisture recorded as percentage with date along the horizontal axis. The dotted red lines were added later to show the set points we chose at 30 and 35% The upper graph shows whether the relay, i.e. switch is open or closed. When the switch is closed it turns on the power and opens the tap. This is the view you see after saving the dataset to file on the PC

To understand what is going on it helps to zoom into an individual irrigation event.

To zoom in on a small time slice left click and hold on the lower graph and drag it horizontally a short section across one of the irrigation events – then right click and select **Zoom In**

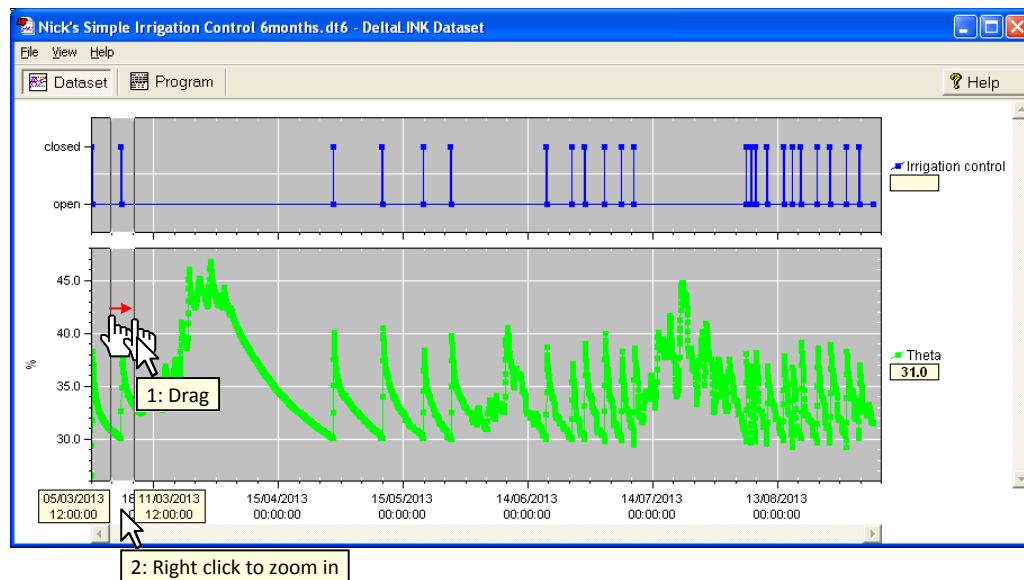
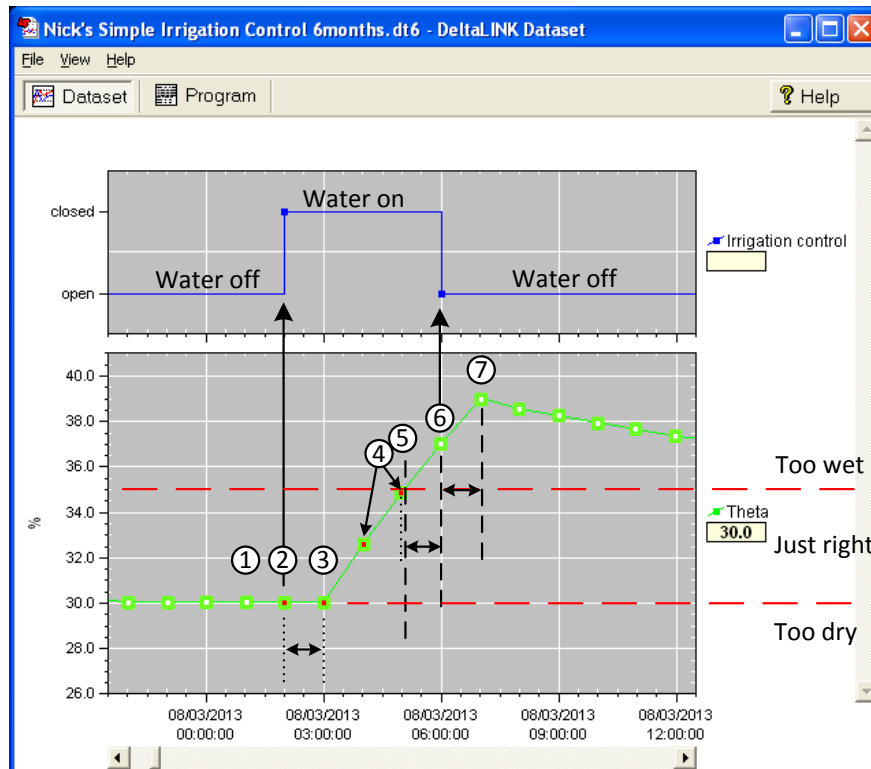


Figure 12 How to select a small interval of time around an irrigation event, to see what is going on.

How to Read an Irrigation Control Graph

How to Read an Irrigation Control Graph Record



- ① Soil is drying out slowly from above 30%
- ② Soil reaches 30% so the logger closes the switch, turning on the water
- ③ It takes a while for the water to seep into the soil
- ④ The logger checks the soil moisture.
It is below 35% so the logger goes back to sleep.
- ⑤ The soil moisture goes above 35% but the logger is still asleep.
- ⑥ When the logger next wakes the soil moisture is above 35%
so it turns the water off.
- ⑦ It takes a while for the soil to respond. The soil moisture overshoots
the target by an amount which depends on all sorts of things – e.g.
how much water you are applying, how long it takes to seep down to
where sensor is buried, how frequently the GP2 wakes, etc.

fs

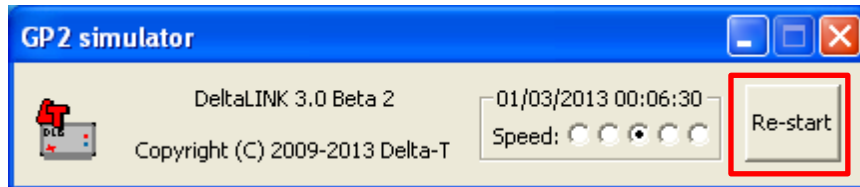
Figure 13 By zooming in to an individual irrigation event you can check to see the program is working properly. It takes a bit of getting used to, but is entirely logical. This graph came from the simulator. In the real world the results will probably be quite different, but still should be logical.

In this program the logger wakes up once an hour. If it is drier than 30% it turns the water on. If wetter than 35% it stops watering. In this example, (based on our simplistic and artificial simulation model), the water was on for three hours. In real life you may want to set limits on how long the tap can be on, and add other conditions too. DeltaLINK can do this, and more. The behaviour will then be different from the above but it should always be logical. If the behaviour does not appear to

be logical then look around for clues. Did a pipe burst, or the power get cut off, or the sensor become disconnected, or is my program plain wrong?

Notes on the Simulator

- To compare two different programs run over the same weather you should click on the GP2 simulator **Restart** to set the time back to March 1 2013.



- Both simulations need to run from the same start date to reproduce the same weather.
- If you **Reset** the clock on the DeltaLINK **Logger** window this will load a new random weather pattern.

See also **Appendix 2: About the GP2 Simulator** on page 21

Under the Hood – a Look Inside the Simple Irrigation Program

To recap – the story so far

- Considered the watering needs of our plant,
- Looked at some irrigation equipment,
- Chose some fairly arbitrary control limits for the soil moisture,
- Took a quick look at the results from the one I made earlier,
- Fired up our trusty old GP2 program DeltaLINK,
- Told it to connect to our GP2 logger simulator,
- Imported a simple irrigation control program into DeltaLINK
- Applied it to the simulator and started it logging
- Waited for simulated time to pass...
- Inspected the graphed results
- Zoomed in to a single irrigation event
- Tried to understand it.

That is all very well. But now we have to get our hand dirty and look under the hood at that program. Our next goal is understand enough to feel confident that we can create our own program. Now at this point the best thing you could do is to go off and watch the [GP2 Introductory Video Tutorials](#) 1 to 4.

Nick's Simple Irrigation Control Program Window

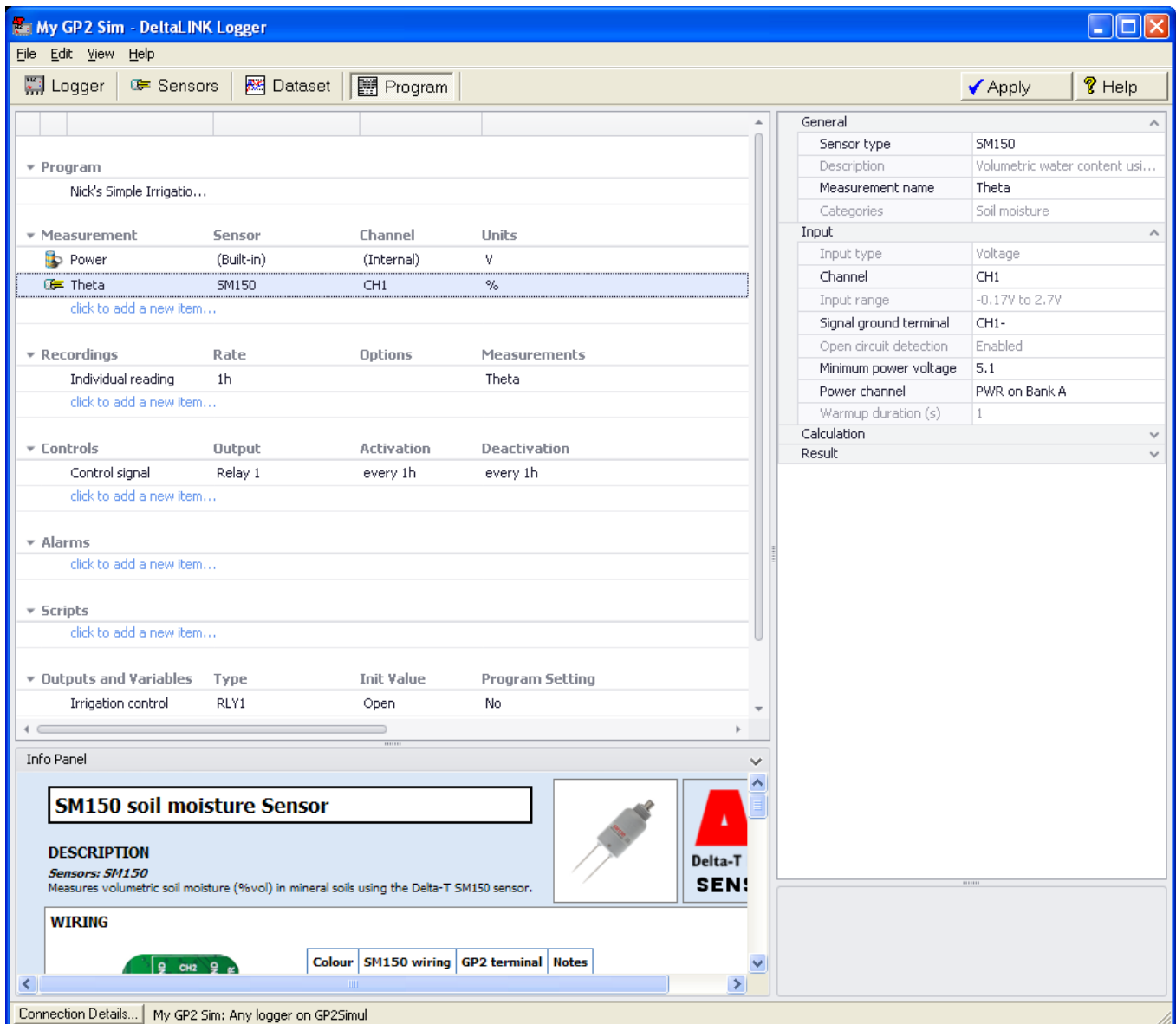


Figure 14 Nick's Simple Irrigation Control Panel . This is what you see when you click on the Measurment row called Theta. Note the details about the measurment that appear on the right, Also the corresponding Information Panel with wiring instructions and other sensor connection information at the bottom left. See also Figure 17.

Note you can view this page whilst logging but will need to stop logging and delete the logged data before you can **Change** this program.

Program Details

Summary

Measurement

| Measurement | Sensor | Channel | Units |
|-------------|------------|------------|-------|
| Power | (Built-in) | (Internal) | V |
| Theta | SM150 | CH1 | % |

This defines the sensor, a type SM150 soil moisture sensor. The measurement is called Theta. It will be wired up to Channel 1. Sensor power will be supplied via Power bank A

Details

| General | |
|------------------------|---------------------------------|
| Sensor type | SM150 |
| Description | Volumetric water content usi... |
| Measurement name | Theta |
| Categories | Soil moisture |
| Input | |
| Input type | Voltage |
| Channel | CH1 |
| Input range | -0.17V to 2.7V |
| Signal ground terminal | CH1- |
| Open circuit detection | Enabled |
| Minimum power voltage | 5.1 |
| Power channel | PWR on Bank A |
| Warmup duration (s) | 1 |
| Calculation | |
| Result | |

Recordings

| Recordings | Rate | Options | Measurements |
|--------------------|------|---------|--------------|
| Individual reading | 1h | | Theta |

This defines the reading as a simple, individual reading of Theta once per hour. This is the default offered when you create the measurement. The internal Power reading was offered too but I deleted it (it annoyed me).

| General | |
|-----------------------|--------------------|
| Name | Individual reading |
| Recording rate | 1h |
| Recording offset | 0m |
| Measurements | |
| Recorded measurements | Theta |

Controls

| Controls | Output | Activation | Deactivation |
|----------------------------|---------|------------|--------------|
| Control signal | Relay 1 | every 1h | every 1h |
| click to add a new item... | | | |

This defines the behaviour of the control signal. It is sent to Relay 1. The Activate and Deactivate conditions have been defined (by right clicking to the right of the Activate condition box – which takes you to another window). The repeat rates are left at the default values of 1 hr. All the other details are left at their default values too.

| General | |
|------------------------|--------------------------|
| Name | Control signal |
| Output | |
| Output channel | RLY1(Irrigation control) |
| Pulsed output | False |
| Activate | |
| Activate condition | Defined |
| Condition evaluated | every 1h |
| Evaluation schedule | Repeating |
| Evaluation repeat rate | 1h |
| Evaluation offset | 0m |
| Evaluation event | |
| Deactivate (rest) | |
| Deactivate condition | Defined |
| Condition evaluated | every 1h |
| Evaluation schedule | Repeating |
| Evaluation repeat rate | 1h |
| Evaluation offset | 0m |
| Evaluation event | |
| Safety conditions | |
| Record while active | |

Outputs

| Outputs and Variables | Type | Init Value | Program Setting |
|-----------------------|------|------------|-----------------|
| Irrigation control | RLY1 | Open | No |

This defines the name and behaviour of the relay. Using "Irri" in the name tells the simulator it will be used for irrigation

| General | |
|---------------------------|--------------------|
| Name | Irrigation control |
| Type | Relay |
| Settings | |
| Output channel | RLY1 |
| Active state | Closed |
| Record output state | True |
| Show as 'Program Setting' | False |
| Persistent | False |

Figure 15 An examination of the details presented in the Program Window when you inspect Nick's Simple Irrigation Control Program. The details appear in the right when you click on the corresponding row on the left hand.

It may look scary but most of the detail is created automatically for you. See also [video tutorials 1 to 4](#).

The Activate and Deactivate Instructions for the Simple Irrigation Program

We are now close to the heart of the program where the Expression Editor resides.

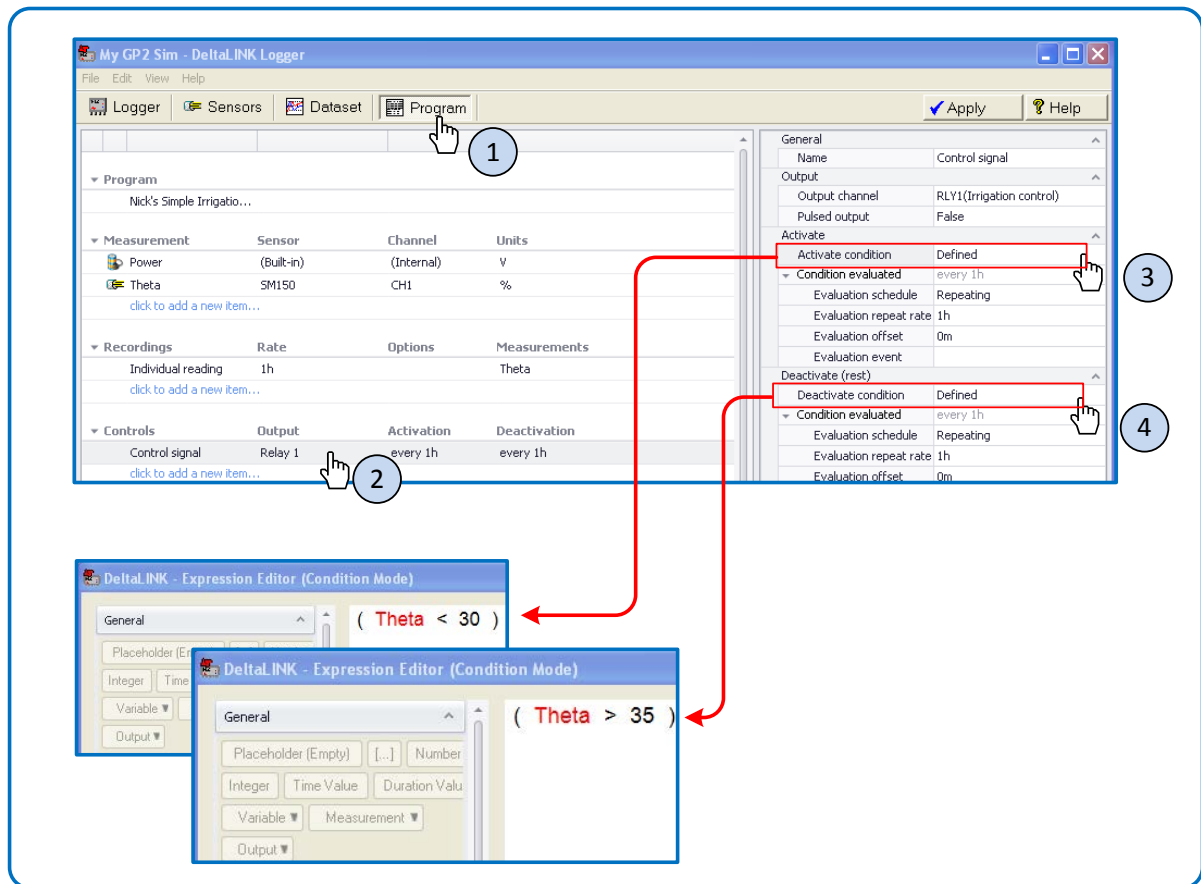


Figure 16 We get to the heart of the Simple Irrigation Program. Steps 3 and 4 expose the corresponding logic thresholds in the Expression Editor. So the Activate Condition is defined to be active when Theta is less than 30% volumetric water content in the soil, and deactivated when it rises above 35% . These steps are only possible if you have toggled the Apply/Change button to permit you to change the program.

In this example we have very simple logical conditions for activating and deactivating the program.

The Expression Editor provided is relatively easy to use and allows you to create control instructions without needing a university degree in programming.

Karls Video Tutorials 4 to 6 and their associated .pg6 GP2 logger programs are a good place to start looking at the more advanced features.

See also the Applications Note on the use of a PID control for irrigating a Poinsettia plant. This is a quite a sophisticated feedback control system which is probably overkill for most plants. The main purpose of mentioning it here is that you can do quite clever things with the Logger controller if you wish to – so this is intended to appeal to research scientists and engineers

Part 2: Do it for Real

So far we have just run our program on the GP2 logger simulator. We learn a lot, but not nearly enough. The simulator is only a model. The most important part is yet to come.

Now go round again with a real plant and real equipment.

Wire it up

Open up your GP2 and using the diagram on page 5 of the **GP2 User Manual** identify the parts of the logger and in particular the terminals used for wiring up sensors and relays.

Sensor Wiring Instructions

Refer to the **DeltaLINK Help** and sensor **Info Pages** for installation and programming notes for every Delta-T sensor.

Relay Wiring Instructions

Refer to page 12 of the **GP2 User manual**. This tells you how to wire up a relay.

Two relays are provided on the GP2 main board.

Note: You can also add another 4 using the optional GP2 Relay Expansion Board. This allows you to control up to 6 different irrigations zones differently (in which case you would need a separate soil moisture sensor and relay for each zone).

Send the program to your logger

Examine the status bar on the bottom of the DeltaLINK Window. For example screen shot in Figure 14, and reproduced below, shows that DeltaLINK is still connected to the GP2 simulator.



To send your program to your GP2 logger see **Connect to GP2** on page 7 of the **GP2 User Manual**. See also: **How to find your USB COM Port** on page 19 of the **GP2 User Manual**.

Once successfully connected to a real logger the procedure from here on is similar to that you followed when connected to the simulator

Check the sensor is working using Read Now

See also page 11 of the **GP2 User Manual**.

Use this to check if the irrigation control is working. You could remove the sensor from the soil to simulate dry soil and put the pins half-immersed in a cup of water to simulate wet.

Start Logging

See also page 11 of the **GP2 User Manual**

Things to watch out for

The simple program logs and checks the soil moisture water once an hour. This means if it starts irrigating it won't stop for an hour. This may flood a small amount of soil and even wash it away, and be expensively wasteful if irrigating a large area.

So now is the time to tune up your program. You have a wide range of choices. Some of these are dealt with in the tutorial videos at <http://www.youtube.com/user/DeltaTDevices/videos>

Hints: You could reduce the measurement period to say 1 minute, or program the logger to check the reading every 1 minute, or define a maximum period of time the relay can be on.

Appendix 1: How to add a soil moisture sensor type in 6 Easy Steps

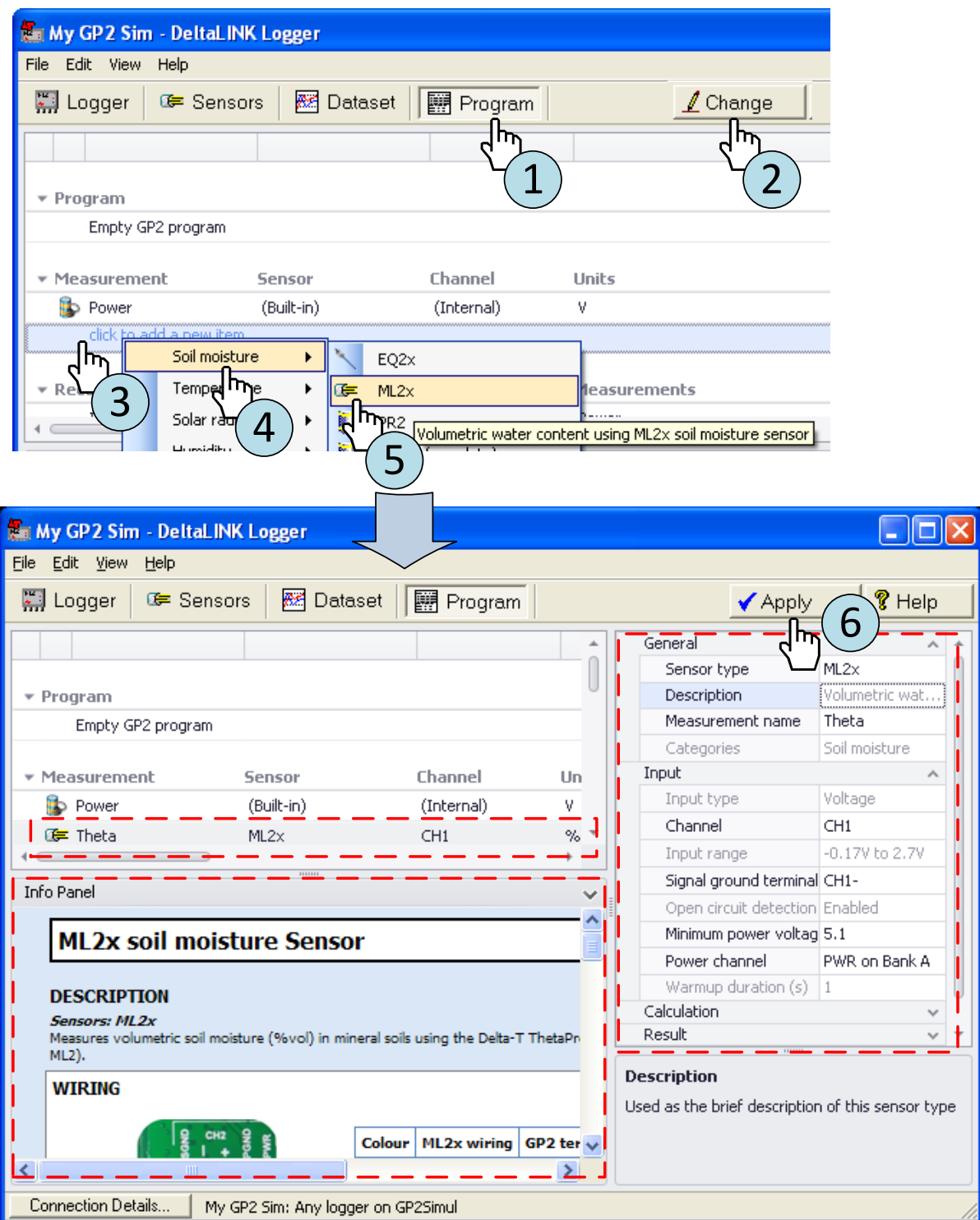


Figure 17 How to add a soil moisture sensor to a GP2 logger program. In this example we choose an ML2x – one of our most accurate soil moisture sensors. Notice in the status bar the DeltaLINK program is still looking at the simulator, but at any stage you can tell it to communicate with your logger.

Appendix 2: About the GP2 Simulator

- The GP2 Simulator simulates a temperate maritime climate at 51 deg latitude in the northern hemisphere – such as might be encountered in the UK.
- Mean annual temperature is 12.5 deg C.
- Rainfall is variable, with dry spells interspersed with rainy periods. Average annual rainfall is 555mm.
- Soil water, nutrient and heat fluxes are simulated by a simple resistance model, in which flow rates between adjacent soil layers are driven by gradients and stabilized by a 'sink' at depth.
- Moisture is lost to the atmosphere through surface evaporation and from lower layers by transpiration. Transpiration patterns are modelled on a spring sown crop (March) which is harvested in late autumn (October/November). Water uptake peaks in high summer, nutrient uptake peaks somewhat earlier.
- Soil water is replenished by rainfall, and also by irrigation which is modelled by switching of the GP2's relays. Irrigation can be with fresh water or saline/nutrient solution – these differ in their effect on soil salinity – and can be measured by a simulated flow meter.

Limitations and what the simulator does not do

The simulator does not model the built environment, such as a greenhouse.

The simulator crop model does not respond to the environment.

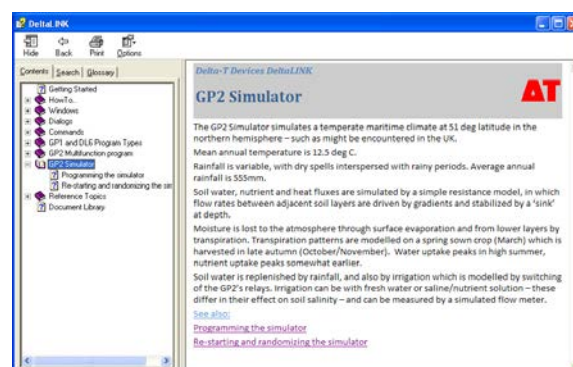
The crop model is a very basic simple one. It does not know how to grow better if you optimise the irrigation or provide more sun or a higher temperature. This would be nice but that would make the model much more complicated.

So if your course tutor says "Use the simulator to design an optimum irrigation regime that maximises crop growth while minimise water use age" say it can be done - but not with this simulator¹.

- What you can do with the GP2 Simulator is check that your program appears to be working the way you think it should.
- It can help you design real experiments with a real crops, which DeltaLINK can then control and run.

See also in **DeltaLINK 3, Help** the following topics

- Programming the simulator
- Re-starting and randomising the simulator



Note: We regret to say that the battery usage model in the simulator offers no useful information at all - so please ignore the simulated battery chart (but not the real one of course).

¹ There are crop simulation models out there, such as GUICS at <http://www.ars.usda.gov/Research/docs.htm?docid=6339>

Appendix 2: Equipment used in this Tutorial.

| | | |
|--|--|--|
|  <p>A black rectangular data logger with a label that reads 'GP2 Data Logger Advanced Logger and Controller'. It has several white cable connectors at the bottom and a small display screen on the right side.</p> | GP2 Logger | www.delta-t.co.uk |
|  <p>A small grey rectangular sensor with two thin white cables extending from the bottom.</p> | SM150 soil moisture sensor and cable | www.delta-t.co.uk |
|  <p>A black cylindrical solenoid valve with a blue handle on top and a black fitting at the bottom.</p> | 24 V AC Solenoid valve. TORO EZ-FLO valve 3/4inch fitting is part number EV-2253 | Supplier TopTurf Irrigation +44 (0) 1903 278241 |
|  <p>A clear plastic flow meter with a black handle on top and a black fitting at the bottom.</p> | Flow meter 1/2inch Part no 705-905W | Supplier Altenic +44 (0) 1785 218200 |
|  <p>A manual isolating valve with a blue handle and a black body, shown next to a black connector.</p> | Manual isolating valve, Pipework and connectors | from local hardware store |
|  <p>A white plastic car water windscreen washer water tank with a black pump at the bottom.</p> | Car water windscreen washer water tank with integral 12V DC pump. | Found it on E-Bay |
|  <p>A white 12V DC water flow meter with a black handle and a black fitting at the bottom.</p> | 12V DC water flow meter. | For a refrigerator apparently. Found on E-Bay too. |

Appendix 3 Homework

Part 1: Simulator-based Homework

All you need for this section is a PC with DeltaLINK 3 installed on it.

DeltaLINK 3 is freely available as a download from www.delta-t.co.uk/techsupport

- 1) Work through the above tutorial
 - a. Install DeltaLINK
 - b. Load the Simple Irrigation Program
 - c. Run it on the Simulator
 - d. Look at the simulated results
- 2) Add a flow meter to the experiment
 - a. Run it on the simulator
 - b. Check your results
 - c. Explain your results
- 3) Change the program so it also only irrigates between 9 AM to 5 PM
- 4) Change the program to add a PID controller feedback loop.
- 5) Add a simple potential evapotranspiration predictor to the control loop

Part 2: Practical Experiments

For this section you need also need the following

- The equipment described on page 6
 - The GP2 Logger User Manual, available as a free download from www.delta-t.co.uk/techsupport
- 6) Repeat steps 1 to 3 with a real plant, logger, soil moisture sensor and water supply and water valve as described earlier.
Wire up the soil moisture sensor and valve to the GP2.
 - 7) Repeat but scale up to a patch of real soil.
 - 8) Design an experiment to determine the optimum irrigation regime for a particular crop and soil type answering the following questions.
 - a. What are the ideal soil moisture set points and why?
 - b. Is a diurnal soil moisture profile better than a fixed soil moisture value?
 - c. Does adding an evapotranspiration model yield any improvement over irrigation based on fixed soil moisture set points.
 - d. Which works best for the plant, control based on simple soil moisture sets points, control based on Evapotranspiration, or a control based on PID feedback, or a combination?
 - 9) Design an experiment to measure the optimum volume of soil pore air changes per day required for optimum plant growth.
 - 10) Design a program to control lighting, ventilation rate, CO₂ levels and irrigation in a plant growth chamber using flood trays.
 - 11) Design an experiment to measure the effect on plant growth of electric fields from overhead fluorescent tube lighting in a growth chamber.

Further Reading

All available at www.delta-t.co.uk

GP2 Logger Documents

- GP2 User Manual
- GP2 PID scientific poster paper
- GP2 Evapotranspiration scientific poster paper

GP1 Logger Irrigation-related Applications Notes

The following notes are written for use with a GP1 logger working with an earlier version of DeltaLINK. They illustrate a variety of different irrigation systems and control scenarios.

Whilst the details of the programming interface are quite different, the use and interpretation of the control logic and the resulting graphs are very useful.

These are available at www.delta-t.co.uk

- Dual rate soil moisture recording with DeltaLINK
- Example of Time of Day in the DeltaLINK
- How the DeltaLINK Control Logic Works

Video Tutorials

On YouTube:

<http://www.youtube.com/user/DeltaTDevices/videos>



They are also available at www.delt-t.co.uk and on the Delta-T Software and Manuals DVD.

- GP2 Intro Series - Tutorial 1 - Your first look at the new GP2 multi-function program
- GP2 Intro Series - Tutorial 2 - Measurements - Creating and editing
- GP2 Intro Series - Tutorial 3 - Recordings - Creating and editing
- GP2 Intro Series - Tutorial 4 - Controls- Creating and editing
- GP2 Intro Series - Tutorial 5 - Alarms - Creating and editing
- GP2 Intro Series - Tutorial 6 - Scripts, Variable and Outputs- Creating and editing

Figure 18 GP2 Introductory video tutorials.



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