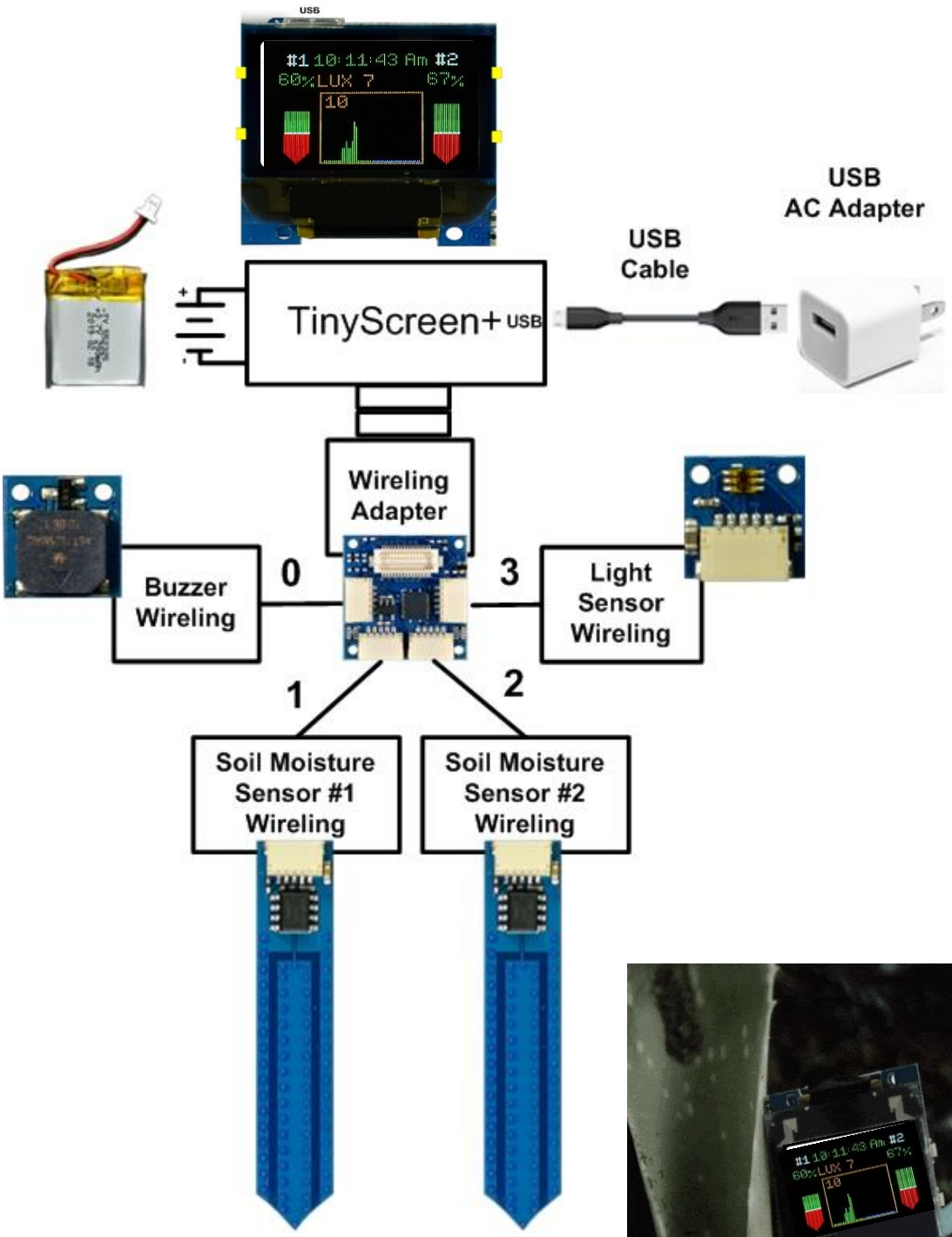
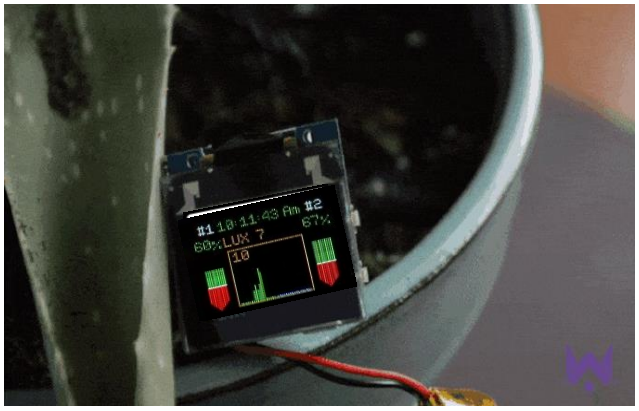
Plant Monitor Kit User Manual v1.02





Overview

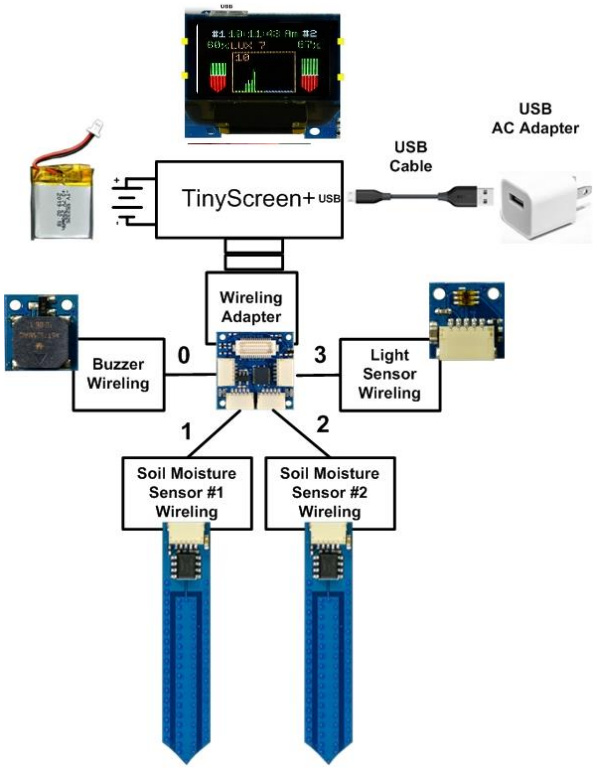
If you've got a green thumb and everything grows for you, then this Kit may not be for you. But if you're like most of us who see a plant at the store that's growing like crazy (under the worst of conditions), buy it and then bring it home just to watch it die in a few days (under the best of conditions), then read on…

We're speaking about the **Plant Monitor Kit** that you have, which takes a lot of the guesswork out of growing and maintaining an indoor plant. Two important elements for good growth are moisture and light. This Kit monitors both and alerts you to when one, or the other, is less than optimal. In the end we can't guarantee a thriving plant with this Kit but, at least, you'll have a better than fighting chance for growing it successfully.

Kit Description

The **Plant Monitor Kit** is composed of two separate elements – hardware and software. First, the hardware.

The hardware consists of TinyShields (tiny circuit boards), Wirelings (even tinier boards) and assorted cables. The **Block Diagram** below details each one in the kit and how it relates to the overall system. The TinyScreen+ with OLED and Wireling Adaptor shields are tied together with mating connectors. The other interconnecting lines between the major blocks are the 5-wire cables that allow everything to be attached together without soldering. The **Appendix** has a detailed description of each module and cable should you be interested in knowing more about them.



Next comes the software.

The software or, more specifically, the firmware is written in Arduino's version of C++ and can be seen on the TinyCircuits website at www.tinycircuits.com . Since we encourage you to view what goes on inside the TinyScreen+ processor you are free to modify the code to your desires; after all, it's your kit. Portions of the firmware, specifically variables, are listed in the **Appendix** for you to modify to your needs, then recompile the code and load it in.

The OLED Screen

Perhaps the most striking feature of the **Plant Monitor Kit** is the OLED screen, which is the top part of the TinyScreen+.

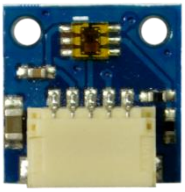
Among other things, it gives the Kit the color-graphic features that makes understanding what's happening to your plant a simple matter. Compare these graphics to just seeing numbers. If there's a problem with the soil moisture or light, the OLED display visually alerts you to it with colors and plots that beat simple numbers including flashing warnings when things aren't up to par. Plus, there's the buzzer that sounds to make you aware of "minimum conditions" as well. But we digress.

The OLED is a 96h x 64v 16-color display in a 1 square-inch package.
It also has four (4) buttons, two on each side, that allow you to change the time as well as the soil moisture limit and lux plot range. More on each of these features under their own topic.

The Other Components

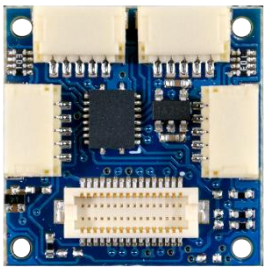
At the heart of the **Plant Monitor Kit** are the Moisture Sensor Wirelings. They both feature an ATtiny25, a high performance, low-power AVR 8-bit controller, and moisture is detected using capacitance to measure the dielectric permittivity of the surrounding medium. Again, your Kit comes with two of them – one for each plant you want to monitor or both for a large potted plant. When inserted into the dirt, the ATtiny25 micro detects and transfers the surrounding moisture level to the TinyScreen+ processor using I2C protocol via the Wireling Adapter. It also comes with a 5-pin connector that connects to the main unit's Wireling Adapter with no soldering.

Next comes the Ambient Light Sensor Wireling that uses the TSL2572 chip that detects the light coming to the plants. It's all packaged on a small 10x10 mm board with the standard 5-pin Wireling connector on it. And, of course, you get the connecting cable as well. Light, both indoor and sunlight, are measured in "Lux", which can vary quite a bit



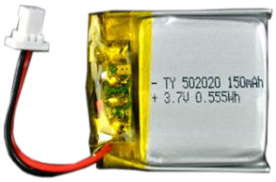
from single digits in very low light (0 – 9 lux) to thousands (1,000+) in direct sunlight, so we give you the ability to change the Lux plot to match the light that strikes your plant.

Then there's a buzzer to alert you to any problems with your plant's health and wellbeing. It generates three (3) separate tones – one beep at 2700 Hz for Moisture Sensor #1, two beeps at 3000 Hz for Moisture Sensor #2, and three beeps at 3300 Hz if the light levels are below minimums. And to find out what's really going on, simply view the OLED screen to see exactly what's up; you'll see "red" when things aren't right.



Moving up the electronic food chain we have the Wireling Adapter board (left) that connects all these external sensors to it by way of the supplied 5-pin connectors.

The Wireling Adapter then plugs into the TinyScreen+ (right) that features an Atmel SAMD21 32-bit ARM processor (the same one used in the Arduino Zero) running at 48 MHz with 256K Flash, 32K RAM, a USB port, a real-time clock, power management, battery charger and, at the top, a 16-color 96h x 64v OLED screen all packaged into one square inch.



And to power it all up simply plug in the supplied USB cable to a USB Wall Adapter (right) that's available nearly anywhere (not supplied). You probably have some laying around for your smart phones. They'll work fine. And if you're worried about power failure a LiPo battery (left) keeps the real-time clock at the right time even when the USB Wall Adapter is out of its socket (up to a few hours, that is). Just plug the battery into the connector on back of the TinyScreen+ as no soldering or wire cutting are needed.

How It Works

While it won't water your plants for you just yet (at least this version won't) the **Plant Monitor Kit** still does the important work of letting you know how your plants are doing and what they need from you.

It starts with inserting the two moisture sensors into the dirt. You should mark on them #1 and #2 just to keep things straight. Using a capacitive approach these sensors report the relative moisture content of the soil to the TinyScreen+ microcontroller via the Wireling Adapter using I2C protocol.

Then comes another I2C input from the Ambient Light sensor that monitors the amount of light the plant receives. This sensor should always be facing towards the light for the best readings. Finally, if something needs attention, like more water or light, the buzzer sounds.

All these peripheral devices are called Wirelings and communicate via I2C protocol to the Wireling Adapter shield that, in turn, communicates this combined information to and from the TinyScreen+ processor. All except the buzzer use I2C; instead, the buzzer simply uses a pin on the Wireling Adapter shield to activate it if the sensor readings are below minimums.

Turning It ON

On the side of the TinyScreen+ there's a slider switch that turns power ON and OFF. Simply slide the switch DOWN to turn it ON. In this image you can also see the four (4) push-button switches – 2 on each side. The thing at the top is the micro-USB connector.

Setting the Time

The first thing you want to do after you turn your unit ON is to set the time. And for this you have two choices – Am/Pm or 24-hour time. While the unit has a battery it's not a dedicated battery backup for the clock, so you'll need to do this everytime you turn it ON. It's simple so here's what to do…

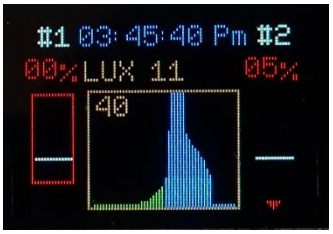
- Setting starts with choosing **Am**, **Pm** or **24**hr format  
- Push the Top Right button and **Am** is seen blinking
- If you want **Am** then push the Top Right Button again to advance to hours
- Otherwise, push either the Top Left(+) or Bottom Left (-) button to select **Pm** or **24** as below…

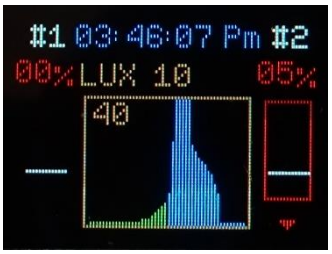
- Push the Top Right button again. The **Am/Pm/24** are stored, and the hours blink once a second 
- Use the Top Left (+) or Bottom Left (-) buttons to adjust the hour if necessary
- Push the Top Right button again. Hours are stored and the minutes blink once a second 
- Use the Top Left (+) or Bottom Left (-) buttons to adjust the minutes if necessary
- Push the Top Right button again. Minutes are stored and seconds blink once a second 
- Use the Top Left (+) or Bottom Left (-) buttons to adjust the seconds if necessary
- Push the Top Right button again. The seconds value is stored
- **Finally, push the Top Right button again and the time display will "flash" indicating that it's set**
- If you made a mistake, then simply repeat the procedure
- And that's it…

Remember, the time is NOT set until you see the white "flash" where the time is displayed. The white "flash" also gives you good visual feedback that you have set the time.

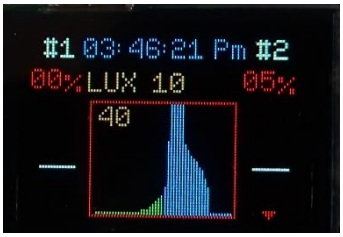
Changing the Soil Moisture Thresholds and LUX Range



- Push the Bottom Right button and a red rectangle begins flashing in the soil moisture #1 icon
- Use the Top Left (+) or Bottom Left (-) buttons to adjust the white line up to 80% or down to 20% or just leave it alone if you want it there.
- This image shows 00% for soil #1 moisture, but you can still move the white line if moisture is indicated in a red/green arrow (which is normal).



- Push the Bottom Right button again and a red rectangle begins flashing in the soil moisture #2 icon
- Use the Top Left (+) or Bottom Left (-) buttons to adjust the white line up to 80% or down to 20% or just leave it alone if you want it there.
- This image shows 05% moisture (see the small triangle tip at the bottom), but you can still move the white line if moisture is indicated in a red/green arrow (again, which is normal).



- Push the Bottom Right button a third time and a red rectangle begins flashing around the LUX plot area – the rectangle in the middle.
- Push the Top Left(+) or Bottom Left (-) buttons to adjust the lux plot range setting (the number in the upper-left corner) to match the level of LUX you desire. The plot will adjust with every push of the + or – buttons and the lux range will change by 10 each time – up or down -here we set it to 10.
- Finally, push the Bottom Right button to escape this mode as shown here
- In any of the above cases you can just wait 10 seconds and the flashing red rectangles will disappear. When this happens, the mode is canceled.

Turing the Buzzer OFF

The buzzer sounds between 4 Pm and 5 Pm – once every 10 seconds –to alert you to the following:

If either one of the soil moisture levels are below minimums, i.e., below the white line, the buzzer will sound. Also, if the total LUX value for the day is below what it should be the buzzer will also sound.

- One beep at 2700 Hz for soil moisture #1
- Two beeps at 3000 Hz for soil moisture #2
- Three beeps at 3300 Hz for low LUX levels

To turn the buzzer off….

- **Push the Bottom Right button once**

The buzzer will remain off until the following day between 4 Pm and 5 Pm– and will remain permanently off if the soil or light conditions are fixed before then.

The OLED Screen Explained

Time

At the top of the OLED screen is the time display “in color”:

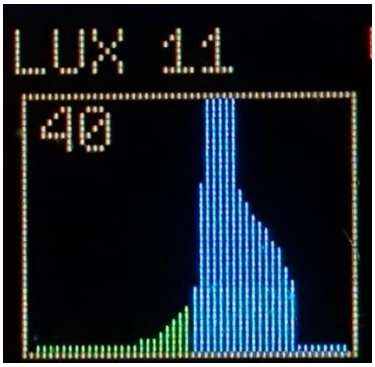
- **Green** – between 12:00:00 am (midnight) and 11:59:59 am (one second before noon)
- **Blue** - between 12:00:00 pm (noon) and 11:59:59 pm (one second before midnight)
- **Yellow** – all day for 24-hour time
    - 00:00:00 (midnight)
    - 06:00:00 (6 am)
    - 12:00:00 (noon)
    - 18:00:00 (6 pm)
    - 23:59:59 (one second before midnight – rolls over to 00:00:00 as above)

There wasn’t room for date, so it’s left out.

Soil Moisture #1 and #2

These icons look like the soil moisture Wirelings on either side of the screen. The horizontal white line divides the display into red (below the line) and green (above it). If either of the icons are “in the red” after 4 pm (16:00:00 military time), then the buzzer will sound with one or two beeps depending on which one(s) are below minimums. The ones pictured here look OK.

LUX Display



The LUX display is the rectangle in the middle between the soil icons.

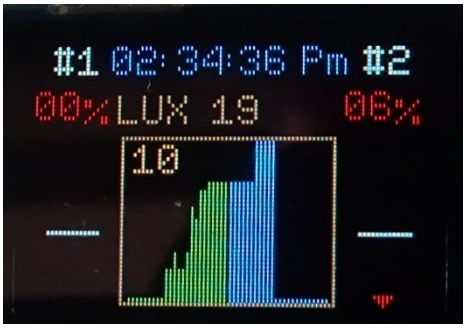
The LUX value just above the rectangle always displays the real-time LUX value that the sensor detects. It shows 11 here.

Inside the LUX rectangle is another number between 10 and 1000 that represents the top LUX value for the plot inside the rectangle. You can change this value from the default 10 LUX (at turn on) up to 1,000 LUX in increments of 10. This image shows 40.

Also, inside the rectangle the LUX plot is displayed as a series of 48 vertical lines going from bottom to top or somewhere in between depending the LUX level. Each line represents the “average” of received LUX for each 15-minute interval between 6 am and 6 pm – green for morning and blue for afternoon. Remember, this is the “average” value over 15 minutes and usually doesn’t reflect the “real-time” LUX value.

In the morning there is usually very little light, so the LUX value is normally single digits between 0 (no detectable light) to 9.

As the morning progresses into afternoon, the LUX value increases, and the resulting line plot may "clip" at the top as seen on the right.



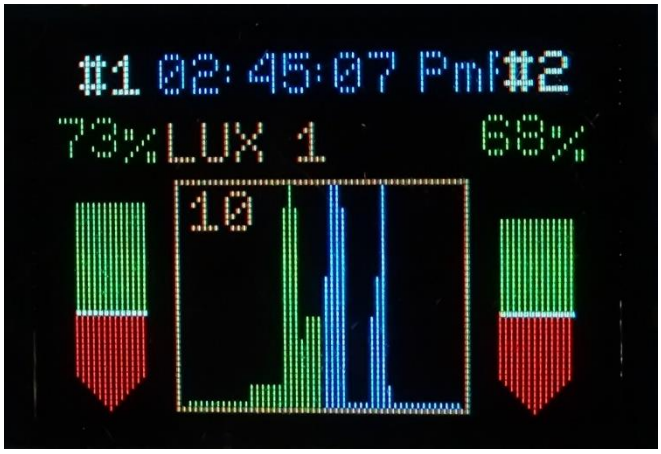
To see the entire LUX plot simply push the Bottom Right button until the LUX rectangle flashes "red"; then push the Top Left (+) or Bottom Left (-) buttons to adjust the lux number in the upper-left corner (the one that says 10 now). Again, this number inside the rectangle is the maximum LUX value for the plot and the green/blue line plot will automatically adjust to it. Once again, the number above the rectangle is the real time LUX value (19 in this case).

A new LUX plot is generated every day between the hours of 6 Am and 6 Pm and it remains there for the entire evening. The LUX plot is reset every morning one second before 6 am and a new plot is started.

If the total daily LUX is below minimums after 4 pm, the buzzer will sound. The software adds up the total lux for the day and compares it against a fixed value in the firmware. If it's below this value the buzzer will sound. You can only change this fixed value by digging into the code and changing it there. See the **Appendix** for details on how to do so.

A Sunny / Rainy / Cloudy Day

Here's a LUX plot from a day where there were some significant interruptions to the light (lux) levels due to rain in the morning and afternoon along with sun and clouds in between the showers. As you can see the LUX line plots reflect this weather system perfectly. By viewing the vertical line plots, green for morning and blue for afternoon, you can see when the sun was shining and, also, when clouds were blocking the sun.



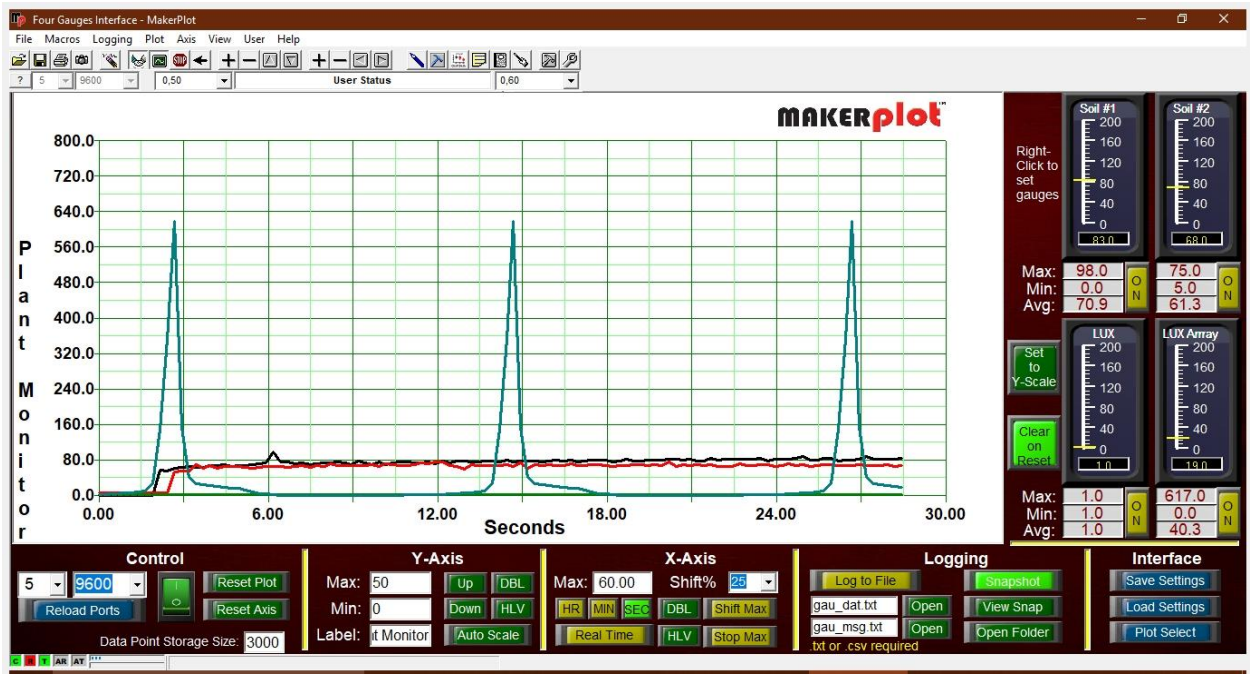
Plotting Data

If the USB port is connected to a computer, then you can see the real-time soil moisture and LUX data. There are basically two ways to do this – using a Terminal or Microsoft ® Excel program – or MakerPlot (Windows only) that plots these values and, also, shows their values on meters.

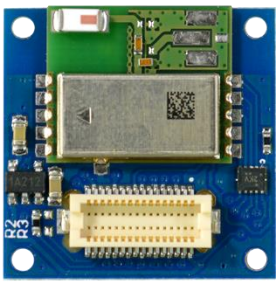
The data output comes in four (4) separate plots:

- Soil 1 moisture percent (0-99) – **Black** in MakerPlot
- Soil 2 moisture percent (0-99) - **Red** in MakerPlot
- LUX real-time value (0 to 1,000+) – **Green** in MakerPlot
- LUX daily average plot – **Blue** in MakerPlot (the spikes)

MakerPlot software is sold separately and can be found at www.makerplot.com



Monitoring Your Plants Via The Web

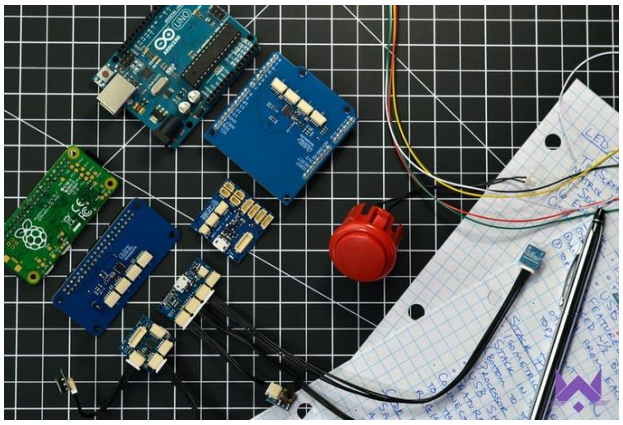


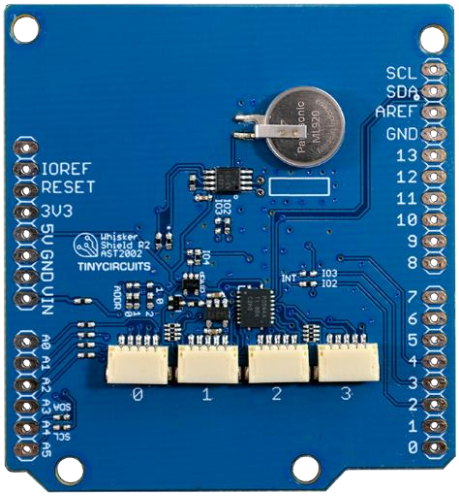
The logical extension to the **Plant Monitor Kit** is putting the data on the web. We've got you covered here (at least in hardware) with either the BLE TinyShield (left) or the WiFi TinyShield (right). Just plug either one in to the TinyScreen+ processor and Wireling Adapter stack and you're all set. This is where your DIY skills come into play as you'll need to create the Arduino code as well as an "app" for them. Let us know if you do so and (with your permission) we'll feature it on our website at www.tinycircuits.com so that others can learn from you.

Using Your Own Arduino or Raspberry PI Instead

If you're adventurous and know something about your own Arduino shield or Raspberry PI, you can substitute them for the TinyScreen+ and Wireling Adapter and roll your own **Plant Monitor**. But you'll still need the moisture sensors, ambient light sensor and buzzer, so to help out TinyCircuits also supplies Wireling adapters for the Arduino and Raspberry PI that plug right into these devices.

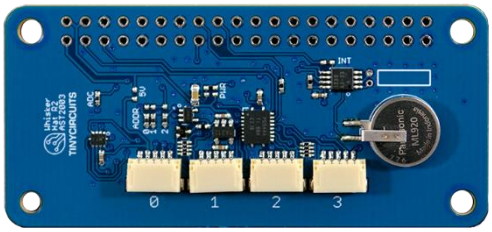
There is nothing preventing you from rolling your own Plant Monitor except, perhaps, your expertise to do so. TinyCircuits gives you the hardware to add Wirelings to either your Arduino or Raspberry PI micros. The rest is up to you.





The Arduino Shield on the left allows you to add Wirelings to your Arduino projects. Featuring a 4-channel Multiplexer, Real-Time Clock (RTC), on-board voltage regulation and level shifting, this board allows you to add up to 4 Wireling sensors to your project with ease!

The Pi Hat on the right allows you to add Wirelings to you Pi projects with the same features found above. And, yes, the coin cell in both shields is for the Real-Time clock.



Appendix

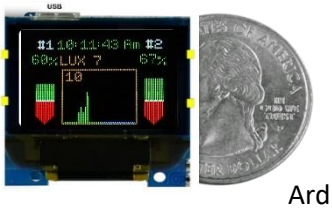
Plant Monitor Kit Contents

LUX Defined

TinyScreen+ Buttons

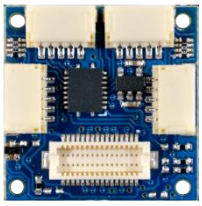
Changing Variables in Code

Plant Monitor Kit Contents



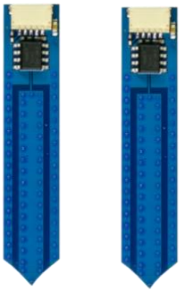
Qty 1 - TinyScreen+ Processor

This is an ARM processor/OLED combination that runs at 48 MHz and includes 256K of Flash and 32K of RAM, and the processor is the same as the one used in the Arduino ZERO so it can be programmed using the Arduino IDE. The 16-color OLED (96h x 64v pixel) is less than one-inch square and acts as the primary display for all the collected data. It also has a micro-USB port for battery charging, data input and output and, as previously mentioned, reprogramming.



Qty 1 - Wireling Adapter

The 20x20 mm Wireling Adapter includes four (4) 5-pin connectors that connect the soil moisture and LUX sensors and buzzer to the main processor via I2C signaling protocol. Physically, the Wirelings are connected to the Wireling Adapter using pre-wired and terminated connector cables, so no soldering is required.



Qty 2 -Soil Sensor Wirelings

These Wireling sensors feature the ATtiny25, a high performance, low-power AVR 8-bit controller. Soil moisture is detected using capacitance to measure dielectric permittivity of the surrounding medium (dirt or potting soil).

Qty 1 - Ambient Light Wireling

This Wireling lets you measure ambient light levels via the TSL2572 chip that mimics the human eye.

Qty 1 - Buzzer Wireling

This Wireling uses the AST7525MATRQ buzzer to give you the ability to “hear” when things are not right with your plant’s soil moisture or light levels.

2 – 100mm, 2- 200mm Wireling Cables & 3’ USB Cable

With the kit you’ll get all the cables you’ll need for it to work. This includes the Wireling cables that attach the Wireling sensors to the Wireling Adapter Board as well as the micro-USB cable that attaches to your comp

Qty 1 – [290mAh LiPo Battery]

This is a rechargeable Lithium ion polymer battery that can power the entire unit. The battery has a capacity of 290mAh at 3.7V. It includes protection circuitry to protect the battery from over charging or completely discharging.

LUX Defined

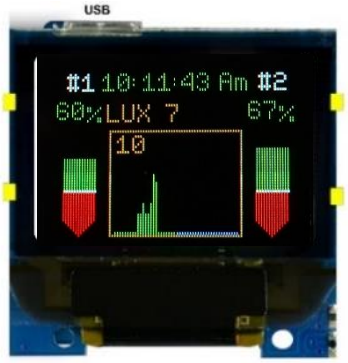
According to Wikipedia "The **lux** (symbol: **lx**) is the SI (System of Units) derived unit of illuminance, measuring luminous flux per unit area. It is equal to one lumen per square meter. In photometry, this is used as a measure of the intensity, as perceived by the human eye, of light that hits or passes through a surface." This is the formal LUX definition but the more LUX you expose your plants to, the better they'll grow (or at least that's what we've been told).

Lux varies greatly from single digits up to 60,000 in full sunlight, and the **TSL2572** LUX sensor in this Kit is capable of the following:

- Approximates Human Eye Response
- 45,000,000:1 Dynamic Range
- An operation to
    - 0-10 lux in very dim light
    - up to
    - 60,000 lux in full sunlight

TinyScreen+ Buttons

The TinyScreen+ has four (4) small buttons – 2 on each side. They look like little rectangles poking out from the sides, and here's how to use them in this application.



Top Left Plus – increments the chosen number value

Bottom Left Minus – decrements the chosen number value

Top Right Set Time – selects the HH, MM, SS and Am/Pm/24hr to be adjusted with the Plus and Minus buttons. If the numbers seem OK, then just push this button to move on.

Bottom Right Halt Buzzer – pushing silences the buzzer until the next update at 4 Pm. If the alarm condition has been satisfied before then, the buzzer will not sound.

Adjust Levels – adjust soil #1 and #2 white line levels and LUX plot screen maximum.

Changing Variables in Code

Here's where to find the code variables that you can change. You can find them in the Arduino code under the following headings. Just changing these will affect the rest of the code so you won't have to hunt any further.

```
//----------Buzzer Variables----------

const int lux_buzzer_min = 48*5;   //lux_total must be greater than this to avoid the buzzer beeping - see update_buzzer()


const byte  buzzer_start_time = 16; //24hr start time for buzzer if below minimums - set_limits()

const byte  buzzer_stop_time  = 17; //24hr stop  time for buzzer if below minimums - set_limits()


//----------Limit Variables----------

const int lux_top_plot_level_min = 10;      //min top lux inside LUX rectangle

const int lux_top_plot_level_max = 1000;  //max top lux inside LUX rectangle


const byte  soil_moisture_limit_min = 20; //min and max soil_moisture_limit values for limit_lines

const byte  soil_moisture_limit_max = 80;
```