User Manual - DIY solar drip irrigation kit

This document is for smallholders using gravity feed drip irrigation on a small plot of land. Using the kit, you can automate your drip irrigation system so that water is pumped automatically from your farm pond (or other water supply) to the header tank and all your plants are irrigated automatically. As well as reading this document, I recommend that you watch the YouTube video with the title “DIY solar drip irrigation kit”.

The DIY solar drip irrigation kit can be purchased online from the Measured Irrigation website: www.measuredirrigation.com.au. All the other parts required for the automation may be purchased locally (for example, a solar panel and a battery).

By automating your drip irrigation system you can leave your plot unattended for weeks. This will allow you to become involved in other activities away from the plot; for example, travelling to the market to sell your produce.

This document has step by step instructions for installing the DIY solar drip irrigation kit. The kit uses measured irrigation, a new method of irrigation scheduling that responds to the prevailing weather conditions. This means that you use much less water without affecting the yield.

It is assumed that the depth of the farm pond is no more than 4 metres.

When the automation of your drip irrigation system is complete, you may wish to share your knowledge and experience with others.

Farm pond in Kenya for gravity feed drip irrigation

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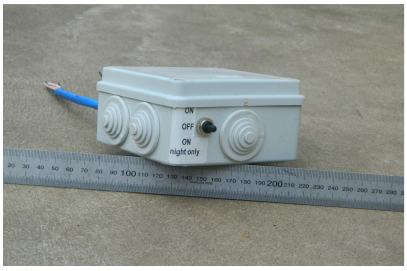
DIY solar drip irrigation kit without pump

For some applications the water supply is higher than land to be irrigated, and so the land can be irrigated directly from the water supply. For such applications, a header tank and a pump are not required.

Contents of DIY solar drip irrigation kit with pump (as indicated in brackets below, some of the contents are not in the DIY solar drip irrigation kit without pump)

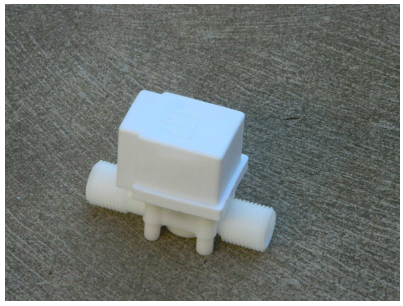
As well as the User Manual, the kit includes the following components:



a waterproof irrigation controller

a light sensor

a double pump with filter and 10 metres of waterproof electrical cable (not in kit without pump)



a solenoid valve

two float switches (only one float switch in kit without pump)

an adjustable dripper

20 screw connectors for electrical wire

The kit does not include:

evaporator

soil moisture probe (steel pipe)

battery

solar panel

extra 2-strand electrical cable.

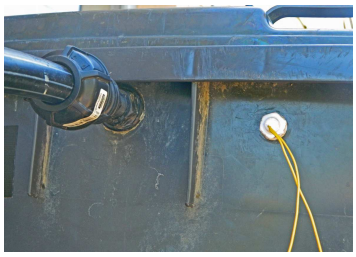
Step by step instructions for installing DIY solar drip irrigation

Step 1. Remove the inlet pipe from the farm pond and connect it to the pump (skip this step for kit without pump).

WARNING: The inlet and outlet of the pump are fragile, so be careful not to apply force to the inlet or outlet at any time.

Step 2. Install a float switch on the header tank (skip this step for kit without pump)

Drill a 13 mm (half inch) hole in the side of the header tank so that the hole is about 3 cm lower than the inlet to the header tank. Install one of the float switches so that the float shaft points down.



Float switch on header tank is 3 cm lower than the inlet

Float switch on header tank with float shaft pointing down

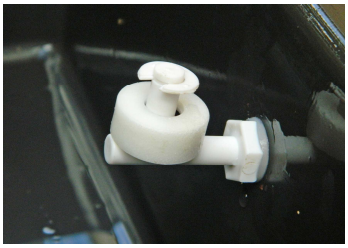
Step 3. Choose a suitable evaporator

The evaporator can be any container with vertical sides and with a suitable surface area of evaporation (for example, a bucket).

Step 4. Install the other float switch on the evaporator

Drill a half inch (13 mm) hole in the side of the evaporator so that the centre of the hole is 5 cm lower than the overflow level for the evaporator. Install the other float switch so that the float shaft points up.

Float switch on evaporator with float shaft pointing up



Float switch on evaporator with float shaft pointing up

Step 5. Install the solenoid valve

Install the solenoid valve at ground level so that cover protects the solenoid from the weather.

Solenoid valve

Step 6. Solar Panel (Note that the solar panel and the battery may be replaced by a 12V 5A power adaptor).

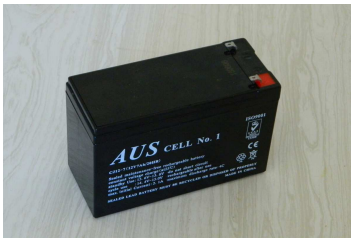
Provided that each irrigation event uses less than 1000 litres, a 12 volt 20 watt solar panel should provide all the power required. You may purchase the solar panel either locally or online. If an irrigation event uses more than 1000 litres, an additional solar panel may be required.

You need to find a low cost method of mounting the solar panel. In the southern hemisphere the solar panel should face the sun when the sun is in the north. In the northern hemisphere the solar panel should face the sun when the sun is in the south. The ideal angle of the solar panel changes throughout the year. It is easy to adjust the orientation of the solar panel if it is mounted on a pole as shown.

20 watt solar panel mounted on a pole

Step 7. Battery

A rechargeable 12 volt lead acid battery is required. You may be able to find a used car battery in good condition. If you buy a new battery then I recommend a sealed lead acid battery with a capacity of at least 7 amp hours.



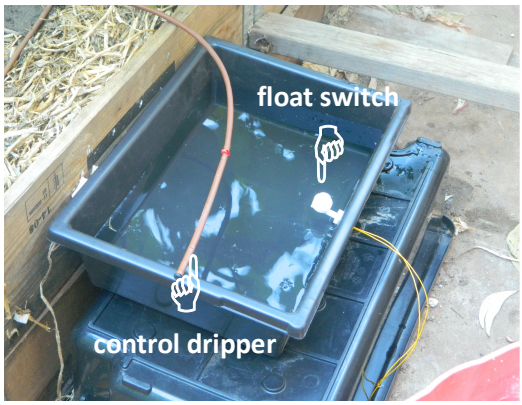
7 amp hour battery

Step 8. Install the evaporator

The evaporator is positioned so that one of the drippers in the irrigation system drips water into the evaporator during the irrigation event. This dripper is called the control dripper. All of the drippers in the plot (including the control dripper) should be at approximately the same level. This ensures that each dripper in the plot emits the same volume of water as the control dripper. Between irrigation events the water level in the evaporator falls due to evaporation. You may wish to cover the evaporator to prevent animals drinking the water, but make sure that the cover does not impede the evaporation (chicken wire is OK).


Control dripper

Fill the evaporator with water so that the water level is just below the float switch



Evaporator with control dripper positioned so that it drips water into the evaporator during the irrigation event

Step 9. Connecting the irrigation controller

The irrigation controller has 15 colour-coded wires which need to be connected to the various components as follows:

Connect the **red** wire to the positive terminal on the battery.
Connect the **black** wire to the negative terminal on the battery.
Connect the **dark blue** wire to the positive wire form the solar panel.
Connect the **dark green** wire to the negative wire form the solar panel.
Connect the **grey** wire to one of the wires from the float switch on the header tank (ignore the grey wire for the kit without pump).
Connect the **brown** wire to the other wire from the float switch on the header tank (ignore the brown wire for the kit without pump).
Connect the **purple** wire to one of the wires from the float switch on the evaporator.
Connect the **pink** wire to the other wire from the float switch on the evaporator.
Connect the **yellow** wire with the spade terminal to one of the terminals on the solenoid valve (already connected in the kit).
Connect the **white** wire with the spade terminal to the other terminal on the solenoid valve (already connected in the kit).
Connect the **orange** wire to the yellow wire from the pump (ignore the orange wire for the kit without pump).
Connect the **white** wire without a spade terminal to the white wire from the pump (ignore the white wire without the spade terminal for the kit without pump).
Connect the **light green** wire to the black wire from the light sensor (already connected in the kit).
Connect the **light pink** wire to the white wire from the light sensor (already connected in the kit).
Connect the **light blue** wire to the red wire from the light sensor (already connected in the kit).

Step 10. Submerge the pump in the farm pond

The pump inlet should be at least 15cm above the bottom of the pond to avoid pumping sediment from the bottom of the pond and clogging the inlet filter. If clogging of the filter becomes a problem, you may wish to install a larger filter.

When the header tank is full the float switch on the header tank is in the off position. When the water level in the header tank falls below the float switch, the float switch turns on and activates a delay timer and 3 minutes later the pump starts working. The time delay can be adjusted by pressing the buttons on the delay timer inside the irrigation controller.

The inlet/outlet manifold on each pump may break if too much force is applied to the pump. If you break the inlet/outlet manifold, a replacement manifold (or a replacement pump) can be purchased from the Solar Project UK: www.solarproject.co.uk
The pump is also available from the Measured Irrigation website.

Step 11. Start irrigating

Turn the switch on the side if the irrigation controller to the ON position (switch up) and the irrigation will start. The irrigation stops automatically when the water level reaches the float switch. During the day the water level in the evaporator falls due to evaporation. The switch is a three position switch with UP ON (24 hour operation), CENTRE OFF, DOWN ON (night only operation).

The switch on the irrigation controller has 3 positions

With the switch in the up position (24 hour operation), the irrigation will start automatically as soon as the water level in the evaporator has fallen below the float switch.

With the switch in the down position (night only operation), the irrigation is restricted to dark hours only. If you do not wish to irrigate during the heat of the day, turn the switch to the NIGHT ONLY position (switch down) so that the irrigation starts automatically at sunset (provided that the water level is below the float switch).

To stop the irrigation at any time, turn the switch to the OFF position.

How to adjust the water usage

The amount of water that your plants need will depend on many factors in addition to the weather. For example, as the plants grow and become bigger they will need more water. Plants growing in sandy soil will need more water than plants growing in heavy soil.

To take account of all these additional factors, I recommend that you use a length of steel pipe to check the moisture level in the soil. I suggest that the diameter of the pipe be between 30 and 40 mm. An angle grinder can be used to cut some slots in the steel pipe to that you can inspect the soil inside the pipe. I suggest that the width of the slots be about 13 mm. You can also use the angle grinder to sharpen the edge of the end of the soil moisture probe.

A suitable soil moisture probe may be purchased from the Measured Irrigation website www.measuredirrigation.com.au


An angle grinder can be used to make some slots in a length of steel pipe


Early in the morning after irrigation the night before, hammer the steel pipe into the soil near a dripper so that the slots face the dripper.


Remove the steel pipe from the soil and use the slots to inspect the moisture level in the soil and the position of the wetting front.

By checking the moisture level in the soil through the slots in the steel pipe, you can decide whether the plants have been irrigated the night before with too much or too little water.

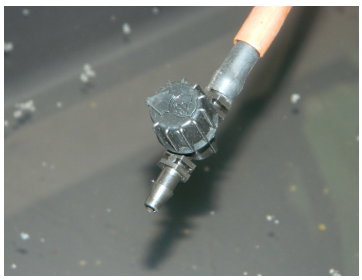
Early in the morning after irrigation the night before, hammer the steel pipe into the soil near a dripper so that the slots face the dripper.

Remove the steel pipe from the soil and use the slots to inspect the moisture level in the soil and the position of the wetting front. You may wish to use the slots to remove some soil from the pipe and to squeeze the soil sample between your fingers.

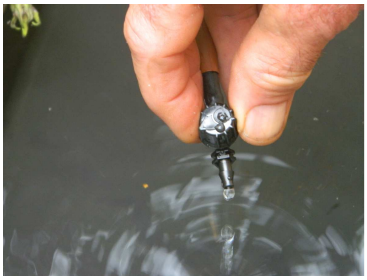
You may wish to place a measuring container under one of the drippers so that you can measure the volume of water emitted by the dripper during an irrigation event.

An easy way to adjust your water usage is to use an adjustable dripper for your control dripper. Increase the flow rate to reduce your water usage, and reduce the flow rate to increase your water usage. To help you make an appropriate adjustment, it is recommended that the irrigation be running while the adjustment is being made.

A suitable adjustable control dripper may be purchased from the Measured Irrigation website www.measuredirrigation.com.au



Adjustable dripper used as control dripper



Increase the flow rate of the adjustable control dripper to reduce water usage

Fully-automatic scheduling with float switch

Set the switch on the irrigation controller to the NIGHT ONLY position (switch down) so that the irrigation is restricted to dark hours only. Fully-automatic scheduling with float switch is equivalent to sunset scheduling for manual systems.

After irrigation at sunset on 3 or more consecutive days without rain, use the soil moisture probe at sunrise to check the moisture level in the soil below one of the drippers. If the moisture in the soil extends below the maximum depth of the root zone, too much water is being used so increase the flow rate of the adjustable control dripper. If the moisture in the soil does not reach the maximum depth of the root zone, not enough water is being used so decrease the flow rate of the adjustable control dripper. After another 3 or more consecutive days without rain, repeat the process until no further adjustments are required. The water usage should stabilise at an appropriate level for the plants at their current stage of growth.

As your crop grows and the water requirement of the crop changes, you may wish to repeat the process of adjusting the water usage.

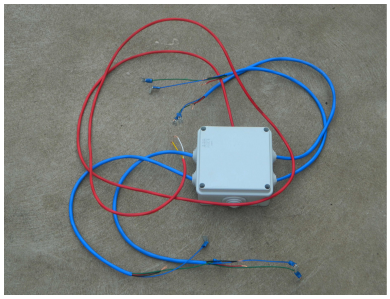
Measured irrigation uses much less water

By implementing measured irrigation scheduling using the DIY solar drip irrigation kit, you may use half as much water compared with programmed irrigation scheduling. My research has demonstrated that by upgrading from programmed irrigation scheduling to measured irrigation scheduling, water usage may be reduced by 50% or more without affecting the yield (see the Research Report: Improvement in crop yield per litre using Measured Irrigation, available from the Measured Irrigation website www.measuredirrigation.com.au).

Additional irrigation zones

In some applications you may wish to use more than one irrigation zone. For example, different crops may require separate zones. On sloping ground it is preferable to have a number of irrigation zones where each zone is at a different level. For each additional zone you will need an evaporator, an adjustable control dripper, a solenoid valve, and a float switch.

To install measured irrigation in additional zones you will need the **four-zone adaptor** in conjunction with the DIY solar drip irrigation kit (or kit without pump). Included with the four-zone adaptor are 4 adjustable drippers and 10 electrical wire connectors. The four-zone adaptor, additional solenoids valves and additional float switches are available from the Measured Irrigation website. www.measuredirrigation.com.au



four-zone adaptor

The four-zone adapter has 3 colour-coded wires which need to be connected to the irrigation controller as follows:

Connect the **yellow** wire to the purple wire from the irrigation controller.

Connect the **white** wire to the white wire from the irrigation controller.

Connect the **black** wire to the grey wire from the irrigation controller.

For each additional zone, the four-zone adaptor has 4 colour-coded wires which need to be connected to the various components as follows:

Connect the **blue** wire with the spade connection to one of the terminals on the solenoid valve for the zone.

Connect the **green** wire with the spade connection to the other terminal on the solenoid valve for the zone.

Connect the **red** wire to one of the wires from the float switch for the zone.

Connect the **brown** wire to one of the other wire from the float switch for the zone.

For each additional zone, you will need to adjust the water usage as described previously using the soil moisture probe (steel pipe) and an adjustable dripper.

If you are using the four-zone adaptor with the DIY solar drip irrigation kit, an extra solar panel or an extra battery may be required.

Semi-automatic scheduling with float switch

For fully-automatic scheduling with float switch, the irrigation starts automatically at sunset (provided that the water level is below the float switch). For plants with deep roots or for plants in clay soils, it is preferable to irrigate with more water less frequently to enable the water to reach the bottom of the root zone. Between irrigation events the soil near the surface is allowed to dry out, but there should still me moisture in the root zone If you decide that your plants need irrigating less frequently than daily (for example, once a week), then the following semi-automatic irrigation scheduling method is recommended.

Step 1. Set the switch on the irrigation controller to the OFF position. Allow the soil to dry out over several days until the soil is dry between the surface and the bottom of the root zone (use the soil moisture probe).

Step 2. Empty the evaporator. Set the switch on the irrigation controller to NIGHT ONLY. Place a measuring container under one of the drippers to collect the water when the irrigation starts at sunset. During the course of the irrigation, regularly check the depth of the moisture below various drippers (use the soil moisture probe). As soon as the moisture is close to the bottom of the root zone, turn of the irrigation by setting the switch to the OFF position. Record the volume of water in the measuring container. This will be called the **dripper control volume** and it is the volume of water required to moisten the soil below a dripper as far as the bottom of the root zone when the soil is dry.

Step 3. Fill the evaporator with water until the water level turns off the float switch.

Step 4. With the switch on the irrigation controller in the OFF position, allow the soil to dry out over several days until the soil is dry between the surface and the bottom of the root zone (use the soil moisture probe). Mark the low level line on the inside of the evaporator. The gap between the float switch and the low level line is the evaporation required to the dry out the soil from the surface to the bottom of the root zone.

Step 5. Empty the measuring container below one of the drippers. Set the switch on the irrigation controller to NIGHT ONLY so that the irrigation starts at sunset and stops when the water level in the evaporator turns off the float switch. When the irrigation is completed, set the switch on the irrigation controller to the OFF position.

Step 6. Check the volume of water in the measuring container. If the volume is less than the dripper control volume then the moisture below the dripper is unlikely to have reached the bottom of the root zone. So reduce the flow rate of the adjustable control dripper (to increase the duration of the irrigation event) in preparation for the next irrigation. If the volume is more than the control volume then the moisture below the dripper is likely to have extended beyond the bottom of the root zone. So increase the flow rate of the adjustable control dripper (to decrease the duration of the irrigation event).

Step 7. Check the water level in the evaporator at sunset each day. When the water level has reached the low line, repeat Steps 5 and 6 until the volume of water in the measuring container is the same as the dripper control volume recorded in Step 2.

After a few adjustments to the control dripper, the water usage should stabilise at an appropriate level for the plants at their current stage of growth.

As your crop grows and the water requirement of the crop changes, you may wish to repeat the process of adjusting the water usage.

Unpowered measured irrigation

If you don't need an automated drip irrigation system, you can upgrade your drip irrigation system to measured irrigation at almost no cost. All that is needed is an evaporator and a length of steel pipe (soil moisture probe). Instead of using a float switch, mark a level line on the inside of the evaporator about 3 cm below the overflow level. Simply irrigate the plants until the water level in the evaporator reaches the level line.

Evaporator and steel pipe

Stop irrigating when the water level reaches the level line.