Unpowered Irrigation Controller for Solenoid Valves
User Manual

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May 2022

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1. Introduction

Any irrigation system with a conventional irrigation controller can be upgraded to an unpowered system where an Unpowered Irrigation Controller for Solenoid Valves (UICSV) is connected to each solenoid valve. The conventional irrigation controller and the associated wiring become redundant.

It is assumed the same drippers are used throughout the irrigation application. For NPC (non pressure compensating) drippers, it is assumed that the drippers are at approximately the same level and that frictional head loss is negligible.

This amazing invention lets you set the volume of water discharged by each dripper during the irrigation event. The dripper discharge is independent of the flow rate of the drippers (pressure compensating or non pressure compensating). The dripper discharge is also independent of the water supply pressure.

The UICSV uses onsite weather conditions to control irrigation scheduling rather than the static timer intervals in conventional devices.

After irrigation and as water evaporates from the soil, water also evaporates from the container. The water in the container eventually reaches a low level corresponding to the soil drying out. A ring magnet under the container is connected to a float inside the container. When the float reaches the low level, the magnet opens the valve and irrigation begins. An irrigation dripper attached to the irrigation system refills the container during the irrigation. When the water in the container reaches a high level corresponding to the required watering of the plants, the magnet disengages from the valve, the valve shuts off and the cycle restarts.

Ring magnet and float at the low level at the start of the irrigation event

Ring magnet and float at the high level at the end of the irrigation event

Once correctly calibrated, the UICSV only sends water when the plants need it and does not overwater. It responds to the same local weather conditions as the soil. Deep or shallow watering, frequent or delayed watering – all can be accommodated. You don't have to 'turn it off' over winter as rain and cooler temperatures keep the container from drying out. You can leave your irrigation system unattended for weeks on end.

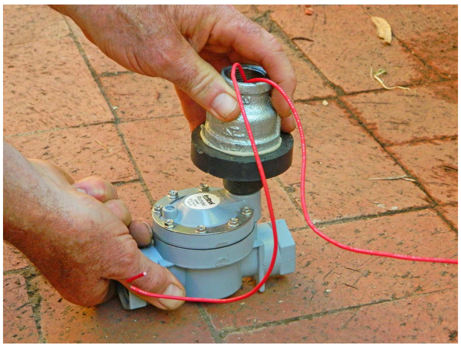
A polyester cloth wicks water from inside the container to outside the container to evaporate and so the cloth is always wet.

A polyester cloth wicks water from inside the container to outside the container to evaporate

2. Installing the Unpowered Irrigation Controller for Solenoid Valves

Step 1. The ring magnet has an outer diameter of 72 mm and an inner diameter of 32 mm. Check that the ring magnet can activate the solenoid by sliding the magnet over the solenoid. You should hear a click as you lower the magnet on to the solenoid. Irritrol, Orbit, and Toro (Pope) solenoid valves all work with one ring magnet.

If the ring magnet does not activate the solenoid, two ring magnets joined together should be strong enough to activate the solenoid. For example, Hunter solenoids valves require two ring magnets to activate the solenoid.



Check that the ring magnet can activate the solenoid

Hunter solenoids require two ring magnets

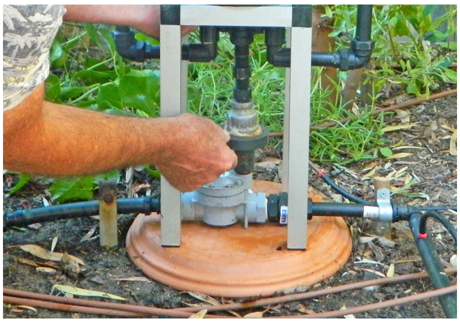
It is assumed that the solenoid is non-latching.

Step 2. As power is no longer required to operate the solenoid, you may wish to cut off the two wires connected to the solenoid. It is preferable that the solenoid valve is in a location where the evaporation at the valve matches to the evaporation from the soil. For example, if the garden is in full sun, then the valve should also be in full sun.

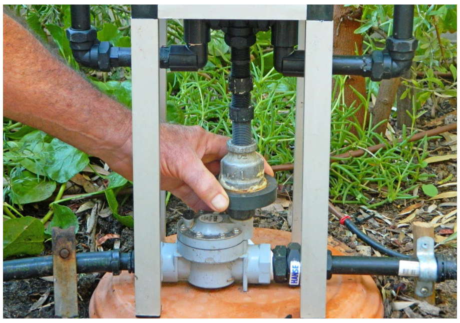
Solenoid valve with wires removed in a location where the evaporation at the valve matches the evaporation from the soil

Step 3. Connect the water supply to the valve inlet and connect the irrigation application to the valve outlet. Turn on the water supply.

Step 4. Choose the appropriate shaft extension and position the UICSV so that the ring magnet fits over the solenoid without starting the irrigation. Rotate the magnet to progressively lower the magnet over the solenoid until the magnet activates the valve and the irrigation starts. An additional full rotation of the magnet is recommended.



Position the UICSV so that the ring magnet fits over the solenoid without starting the irrigation



Rotate the magnet to progressively lower the magnet over the solenoid until the magnet activates the valve and the irrigation starts

Step 5. Connect an irrigation dripper to the irrigation system and use the cable tie to position the dripper so that it drips water onto the lid of the container. There are small holes in the lid so that the water can drain into the container.

Use the cable tie to position the dripper so that it drips water into the container via the lid of the container

Step 6. Make sure that the polyester cloth is wet.

Step 7. You may wish to protect the UICSV with a cage or a tree guard, but make sure that the evaporation is not impeded.

3. Setting the dripper discharge

The volume of water delivered to the container during the irrigation event is called the **control volume**. The control volume is also the volume of water that evaporates between irrigation events.

The float inside the container is adjustable. **The gap between the upper and lower float determines the dripper discharge, regardless of the flow rate of the drippers and the water supply pressure.**

gap between the upper and lower floats	dripper discharge
zero gap	870 mL
3 mm	988 mL
6 mm	1106 mL
9 mm	1224 mL
12 mm	1342 mL
15 mm	1460 mL
18 mm	1578 mL
21 mm	1696 mL
24 mm	1814 mL
27 mm	1932 mL
30 mm	2050 mL

Table 1. Dripper discharge for various gaps between the upper and lower floats

Instead of connecting a single irrigation dripper to the UICSV, suppose that multiple irrigation drippers are delivering water to the container. The following table shows the dripper discharge for various gaps between the upper and lower floats when multiple drippers are delivering water to the container. The drippers delivering water to the container are referred to as control drippers.

gap between the upper and lower floats	dripper discharge with 2 control drippers	dripper discharge with 3 control drippers	dripper discharge with 4 control drippers
zero gap	435 mL	290 mL	217 mL
3 mm	494 mL	329 mL	247 mL
6 mm	553 mL	369 mL	276 mL
9 mm	612 mL	408 mL	306 mL
12 mm	671 mL	447 mL	335 mL
15 mm	730 mL	487 mL	365 mL
18 mm	789 mL	526 mL	394 mL
21 mm	848 mL	565 mL	424 mL
24 mm	907 mL	605 mL	453 mL
27 mm	966 mL	644 mL	483 mL
30 mm	1025 mL	683 mL	512 mL

Table 2. Dripper discharge for various gaps between the upper and lower floats and multiple control drippers

4. Adjusting the irrigation frequency

The frequency of watering is determined by how quickly water evaporates from the container via the polyester cloth. The irrigation frequency is adjusted by exposing more or less of the polyester cloth outside the container. The time interval between irrigation events can be from half a day to a week or more.

Large area of polyester cloth exposed

Small area of polyester cloth exposed

An irrigation event can be started manually at any time by pushing the float down. An irrigation event can be stopped manually at any time by lifting the float up.

3. Calibrating the Unpowered Irrigation Controller for Solenoid Valves

The UICSV controls the irrigation in 2 ways:

- The volume of water applied during each watering, and
- The length of time between waterings

Both these factors are determined by the water level in the UICSV container. Water evaporates from the container and when the water level reaches the low level, irrigation starts and the control dripper then delivers water into the container. Eventually the rising water level lifts the float and magnet away from the solenoid below and irrigation stops. The amount of water that the control dripper delivers to the container is called the **control volume**. The control volume is also the amount of water that evaporates between irrigation events.

The following two steps work together to calibrate the controller:

First, you set how much water is discharged from each emitter during the irrigation event by adjusting how long it takes for the control dripper to deliver the control volume to the container. So while the container is filling, the plants are being watered. The time it takes to fill the container is adjusted by changing the flow rate of the control dripper (by turning the orange part). If you set the control dripper to a fast flow rate, the container fills more quickly; thus there will be less time for watering and the plants receive less water. If you set the control dripper to a slow flow rate, the container fills more slowly and the plants receive more water.

Adjusting the control dripper

Next, you set the frequency of watering by adjusting how quickly water evaporates from the container. This is done by exposing more or less of the polyester cloth outside the container. To make this adjustment you may need to remove the float from the container (see Appendix). The time interval between irrigation events can be from half a day to a week or longer.

Large area of polyester cloth exposed

Small area of polyester cloth exposed

The control volume depends on the particular solenoid being used. The following table shows the control volume of a number of solenoids from different manufacturers.

Manufacturer	Approximate control volume
Irrritrol	470 ml
Hunter	270 ml
Orbit	650 ml

It is important to realize that the control dripper is simply replacing water that has evaporated from the container. This means that an irrigation event may be started or stopped manually at any time without affecting the water usage rate (litres per week for example). An irrigation event can be started manually by pushing the float and magnet down. An irrigation event can be stopped manually by lifting the float and magnet up.

The volume of water applied during an irrigation event (and the water usage rate) can be increased by temporarily removing the control dripper.

4. Weather-based irrigation control

The time it takes for the control volume of water to evaporate depends on the prevailing on-site weather conditions. When it is hot and dry, the water evaporates more quickly and so the interval between irrigation events is shorter. When it is cool and overcast, the water evaporates more slowly and so the interval between irrigation events is longer.

When it rains, water enters the container, and so the start of the next irrigation event is delayed. Any rainwater that has entered the container between irrigation events needs to evaporate before the next irrigation event can start.

To avoid irrigating during the heat of the day, you can turn off the water supply. Alternatively, a tap timer can be used so that water is only available between sunset and sunrise.

The UICSV uses on-site weather data (namely, evaporation and rainfall). Most smart irrigation controllers do not use on-site weather data. Instead they use weather data from the nearest weather station of the Bureau of Meteorology.

5. Pressure independent dripper discharge

Conventional drip irrigation systems control the dripper discharge by using PC (pressure compensating) drippers to control the flow rate and an irrigation controller to control the time. In a domestic garden with mains water supply, many zones are usually required to ensure that the pressure in each zone does not fall below the lower limit for pressure compensation. The irrigation controller is programmed so that each zone is irrigated at a different time.

If you use the Unpowered Irrigation Controller for Solenoid Valves and the following three conditions are satisfied, the dripper discharge is approximately the same for all drippers and is independent of pressure:

- Identical drippers are used including the control dripper
- All drippers are at approximately the same level
- Frictional head loss is negligible.

When the three conditions are satisfied, the pressure independent dripper discharge is the same as the control volume. Note that the pressure independent dripper discharge is also independent of the flow rate of the irrigation drippers. For example, 4 L/H (at 100 kPa) NPC (non pressure compensating) drippers will deliver the same pressure independent dripper discharge as 2 L/H (at 100 kPa) NPC drippers. For this example the duration of the irrigation event for the 2 L/H drippers will be twice as long as the duration of the irrigation event for the 4 L/H drippers.

If the water supply pressure decreases, the flow rate of the NPC drippers also decreases. However, the duration of the irrigation event increases automatically to ensure that the control volume of water is discharged by each dripper. For domestic gardens on level ground, the irrigation system can usually be designed so that variations in pressure due to frictional head loss are negligible.

The adjustable control dripper is replaced by one of the dripline irrigation drippers

By using the UICSV with pressure independent dripper discharge, many zones with PC drippers can be combined into a single zone with NPC drippers and a single UICSV and solenoid valve, and so the cost of the irrigation system can be reduced significantly.

By using the UICSV with pressure independent dripper discharge, solenoid valves with flow control can be adjusted to suit the pressure limitations of the irrigation system without affecting the dripper discharge. For example, if you prefer not to use hose clamps on barbed fittings, then you can use the flow control on the solenoid valve to reduce the pressure accordingly.

To determine the pressure independent dripper discharge (control volume), position an empty container under one of the drippers so that water drips into the container during the irrigation event. At the end of the irrigation event, the pressure independent dripper discharge is the volume of water in the container

Measuring the pressure independent dripper discharge

If the pressure independent dripper discharge is more than your plants require at their current stage of growth, the pressure independent dripper discharge can halved by using 2 irrigation drippers for the control dripper. On the other hand, if the pressure independent dripper discharge is less than your plants require at their current stage of growth, increase the number of irrigation drippers so that your plants get more water.

6. Key features

1. Unpowered (no batteries, no wires, no solar panels, no electronics, no computers, and no WiFi)
2. If you upgrade to the UICSV, the conventional irrigation controller and associated wiring become redundant
3. Use for any size irrigation application
4. Use for sprinkler irrigation or drip irrigation
5. Use with PC (pressure compensating) drippers or NPC (non pressure compensating) drippers
6. Adjust the dripper discharge by adjusting the control dripper
7. Adjust the interval between irrigation events by adjusting the exposed surface area of the polyester cloth
8. Adjusting the dripper discharge does not affect the interval between irrigation events, and adjusting the interval between irrigation events by adjusting the polyester cloth does not affect the dripper discharge
9. Responds automatically to on-site evaporation and rainfall
10. The irrigation frequency increases significantly during a heat wave
11. When it rains, water enters the container and delays the start of the next irrigation event
12. Provided the same drippers are used throughout the irrigation application (including the control dripper), the dripper discharge is independent of the water supply pressure
13. Water in the container is protected from debris, algae, mosquitoes and thirsty animals
14. UV resistant including the container and polyester cloth
15. Simple, unpowered, and low tech, and therefore fewer things can go wrong
16. Leave your irrigation application unattended for months on end

Unpowered Irrigation Controller for Solenoid Valves prior to installation

7. Conclusion

The Unpowered Irrigation Controller for Solenoid Valves uses measured irrigation, a radically different approach to irrigation scheduling (see the Measured Irrigation website for more information: www.measuredirrigation.com.au)

Conventional irrigation systems **indirectly** control the volume of water discharged by a dripper by using PC drippers to control the flow rate and an irrigation controller to control the time. However, measured irrigation **directly** controls the volume of water discharged by a dripper, rather than controlling the flow rate and the time. Because it is no longer necessary to control the flow rate, one can use NPC drippers as well as PC drippers.

The UICSV uses the prevailing on-site weather information rather than information from the Bureau of Meteorology, and so it is ideal for greenhouse applications.

Suppose your irrigation system has a conventional irrigation controller. When one of the solenoid valves for a particular zone fails to operate, you can take the opportunity to upgrade the zone to measured irrigation by installing a UICSV. Because the controller is unpowered, the valve can still operate even when the solenoid coil has failed. The performance of the UICSV can then be compared with the performance of the conventional irrigation controller for the other zones.

Weather-based smart irrigation controllers

According to the Irrigation Association (USA), weather-based controllers use weather data to calculate evapotranspiration, the amount of water that evaporates from the soil surface or is used by the plant. Based on local weather conditions, smart controllers automatically adjust the irrigation schedule. Different controllers use different sources of weather data. These include on-site weather sensors or data from nearest weather station.

The cost of the on-site weather sensors required to calculate evapotranspiration is prohibitively expensive. Hence almost all weather-based irrigation controllers use data from the nearest weather station to approximate the on-site evapotranspiration. Weather-based irrigation controllers calculate evapotranspiration by multiplying the crop coefficient by the reference evapotranspiration. Reference evapotranspiration uses a formula based only on weather data that does not include the evaporation rate. Furthermore, the crop coefficient is a theoretical value that depends upon the stage of growth of the crop.

The UICSV responds to changes in the actual on-site evaporation. This approach to irrigation control is more appropriate than using a theoretical formula based on off-site weather data. Research done by the Bureau of Meteorology has demonstrated a strong correlation (about 90%) between pan evaporation and reference evapotranspiration:
http://www.bom.gov.au/watl/eto/reference-evapotranspiration-report.pdf
My own research has demonstrated a correlation greater than 90%. See *Evapotranspiration and Measured Irrigation: Report for Smart Approved Watermark* which can be downloaded from the Measured Irrigation website: https://www.measuredirrigation.com/

Appendix. Installing the float and polyester cloth

Components of the Unpowered Irrigation Controller for Solenoid Valves

Step1. Wet the polyester cloth and place it over the outer container so that the desired exposed surface area forms a skirt around the outside of the container

Step 2. Insert the inner container into the outer container

Step 3. Insert the float

Step 4. Place the container on the terracotta saucer on the stand

Step 5. Use the two sockets to connect the external frame of the float assembly to the upper tee of the float assembly

Step 6. Use a screw driver to tighten the clamps

To remove the float and the polyester cloth, do the steps in reverse order.