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Smart Irrigation Controllers: What Makes an Irrigation Controller Smart?[1]

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This article is part of a series on smart irrigation controllers. The rest of the series can be found at https://edis.ifas.ufl.edu/collections/series_smart_irrigation_controllers.

Introduction

So-called "smart" irrigation controllers have been available on the market for residential and commercial applications since the early 2000s. The Irrigation Association (www.irrigation.org) defines smart irrigation controllers as “controllers that reduce outdoor water use by monitoring and using information about site conditions (such as soil moisture, rain, wind, slope, soil, plant type, and more), and applying the right amount of water based on those factors."

This Ask IFAS publication is intended for irrigation professionals, homeowners, Extension agents, master gardeners, scientists, and the general public. The objective is to provide basic information about smart irrigation controllers and how they could reduce irrigation water application when integrated into automatic irrigation systems.

Essentially, smart irrigation controllers receive sensor feedback from the irrigated area or use weather data from the region to schedule or adjust irrigation duration and/or frequency accordingly. For example, they would reduce watering during cooler months and increase it during hot and dry periods.

There are generally two types of smart controllers: climatologically based controllers and soil moisture-based controllers.

Evapotranspiration Controllers

Climatologically based controllers are also known as evapotranspiration controllers, ET controllers or “WBICs” (acronym for weather-based irrigation controllers). Generally, evapotranspiration (ET) is the process by which water is transferred from the land to the atmosphere by transpiration from plants combined with evaporation that occurs from plants, soil, and other surfaces. More information on the ET concept, definitions, and calculations can be found in *Evapotranspiration: Potential or Reference*? (https://edis.ifas.ufl.edu/AE256) and *Net Irrigation Requirements for Florida Turfgrass Lawns: Part 2 — Reference Evapotranspiration Calculation* (https://edis.ifas.ufl.edu/AE481).

ET controllers are irrigation scheduling devices integrated into automatic irrigation systems that determine watering schedules by considering multiple factors, including weather data (e.g., solar radiation, temperature, wind speed, relative humidity, rainfall), site-specific characteristics (e.g., slope, shade amount, soil type), plant attributes (e.g., newly planted or established lawn, root depth), and irrigation system parameters (e.g., sprinkler type, application rate) (Dukes et al., 2018). Different types of ET controllers may use all or some of these variables. The purpose of ET controllers is to replenish all or part of the water lost from the soil through ET since the last irrigation, without applying more water than necessary.

There are generally three types of ET controllers:

1. Signal-Based: Meteorological data are either collected from publicly available sources or obtained through agreements with weather station networks. The ET value is calculated for a hypothetical grass surface at that site and then transmitted to surrounding controllers via wireless communication. In some cases, the ET values are adjusted to account for controllers that are not near the weather data collection site. The ET controller then adjusts the irrigation run times or watering days accordingly. New trends in the industry include Wi-Fi signal-based ET controllers with smartphone app capability. These controllers do not require specialized communication networks or costly subscription services and have become increasingly popular in recent years.
2. Historical ET: This approach for ET controllers uses a pre-programmed crop water use curve for different regions, derived from historical ET data averages. The curve may be modified by a sensor, such as a temperature or solar radiation sensor, that measures on-site weather conditions (Figure 1).

3. On-site Weather Measurement: This approach uses real-time weather data measured at the controller's location (Figure 1) to continuously calculate ET and adjust irrigation times accordingly.

More information on ET controllers can be found at *Smart Irrigation Controllers: Programming Guidelines for Evapotranspiration-Based Irrigation Controllers* (https://edis.ifas.ufl.edu/AE445) and at *Smart Irrigation Controllers: Operation of Evapotranspiration-Based Irrigation Controllers* (https://edis.ifas.ufl.edu/AE446).

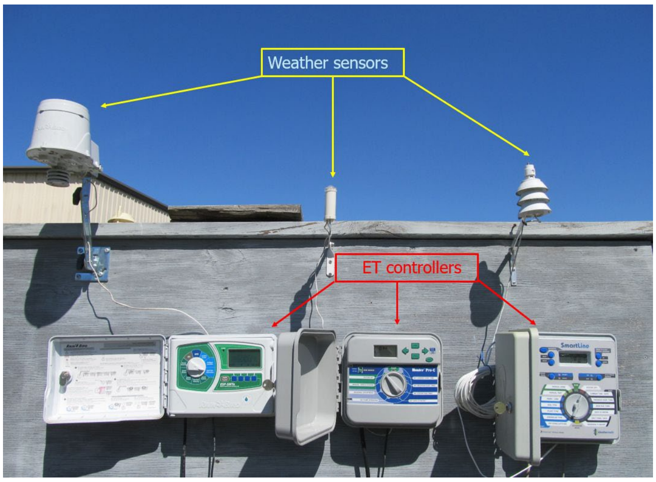

Figure 1. Three brands of ET controllers, each equipped with its own weather sensors, tested at the University of Florida, Agricultural and Biological Engineering Department. Note: The University of Florida does not endorse any particular brand and the information contained here is for illustrative purposes only.
Credit: Bernard Cardenas, UF/IFAS

Soil Moisture Sensor Controllers

Two types of control strategies are employed with soil moisture sensor (SMS) controllers: "bypass" and "on-demand".

1. The bypass configuration is the most common for small sites including most residential and light commercial sites. These SMS controllers are add-on devices that connect to conventional irrigation system timers (Figure 2). Their primary purpose is to prevent unnecessary irrigation cycles. An SMS system includes a probe (or sensor) that is inserted into the soil and a controller (or interface) where a threshold from "dry" to "wet" is set. This threshold can be adjusted by the user to suit specific plant, soil, and microclimate needs.

The soil moisture content is routinely checked by the sensor and compared to the threshold setpoint. When the timer sends the electric signal to initiate irrigation, if the measured soil moisture is above the setpoint (too wet), irrigation is not allowed. The typical mechanism used by SMS systems to bypass an irrigation cycle is by electronically breaking the common wire (Figure 2).

For more information see the document of this EDIS series: *Smart Irrigation Controllers: How Do Soil Moisture Sensor (SMS) Systems Work?* (https://edis.ifas.ufl.edu/ae437). The bypass mode of operation is very similar to that of a rain sensor (see EDIS publication *Residential Irrigation System Rainfall Shutoff Devices, or Rain Sensors* (https://edis.ifas.ufl.edu/ae221).

Many of these systems include only one soil moisture sensor, in which case the sensor should be buried in the driest irrigation zone and the run times for the other zones should be adjusted to limit overwatering. Controllers that contain multiple sensors allow for the installation of a sensor in each irrigation zone.

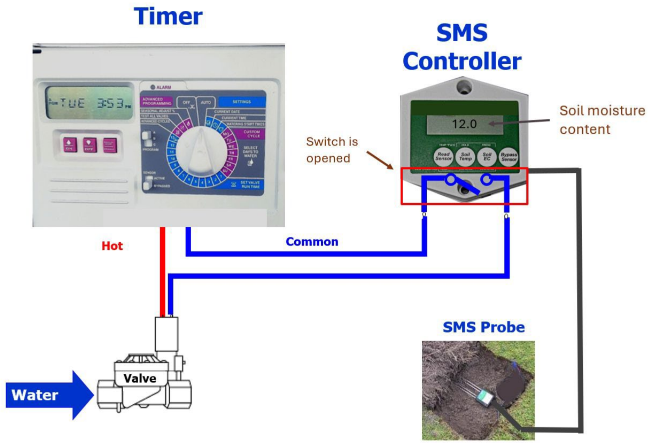

Figure 2. Simplified diagram showing how a soil moisture sensor (SMS) is typically connected to an automated irrigation system. The irrigation timer is connected to a solenoid valve through a hot and a common wire. The common wire is spliced with the SMS system (a controller that acts as a switch, and a probe buried in the root zone that estimates the soil water content). The SMS probe takes a reading of the amount of water in the soil and the SMS controller uses that information to open or close the switch.
Credit: Bernard Cardenas, UF/IFAS

2. An on-demand SMS controller initiates irrigation when the soil moisture level reaches a pre-programmed "low" soil moisture threshold and terminates irrigation when the sensor reading reaches the "high" threshold. This type of controller is often used where a high level of customization or control is needed, such as at commercial sites or locations with many irrigation zones. Thus, this controller initiates and terminates irrigation events, whereas a bypass controller—depending on its threshold settings—only allows or bypasses irrigation events that are already scheduled in the timer (i.e., on a specific day of the week, time of day, and run time).

In summary, a Smart Controller is "smart" due to the feedback received from the irrigated system whether it be weather measurements or soil moisture measurements. This feedback is then used to adjust irrigation application to match plant needs. In contrast a "dumb" irrigation timer simply applies water at the pre-programmed date and time.

Smart Controller Water Conservation Potential

A group of researchers at the University of Florida has been testing various Smart Controller technologies under both field plot conditions and at cooperating homes in Florida. To date, the water conservation potential of these technologies varies depending on brand tested, weather conditions, and site characteristics (e.g., soil and microclimate). For SMSs tested in field plots, irrigation savings ranged from 35% to 54% during dry weather conditions (Cardenas-Lailhacar et al., 2010) and reached up to 70%–90% under normal Florida rainfall conditions (Cardenas-Lailhacar et al., 2008). In homes that used reclaimed water for irrigation, those retrofitted with SMSs applied 44% less water than homes that were only monitored over a 32-month period (Cardenas and Dukes, 2016).

Studies on field plots equipped with ET controllers in Florida resulted from 14% more water applied to 68% water use reduction compared to treatments without sensor feedback (Shober et al., 2009; Rutland and Dukes, 2012; Cardenas et al., 2020). Under residential landscapes, Davis and Dukes (2015) reported a 21%–31% reduction in water use for properly installed and programmed ET Controllers.

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