This project presents an automated irrigation system designed to monitor soil moisture levels and control a water pump using a Raspberry Pi Pico microcontroller. By integrating a capacitive soil moisture sensor, a solar-powered battery system, and a MOSFET-controlled pump, the system ensures efficient and autonomous watering of plants. The goal is to reduce water waste, improve plant care, and enable remote operation without requiring constant human supervision.

This automated irrigation system is centered around the Raspberry Pi Pico microcontroller, which serves as the main control unit. The Raspberry Pi Pico is based on the RP2040 chip, a dual-core ARM Cortex-M0+ processor with flexible GPIO capabilities and three analog-to-digital converter (ADC) channels, making it well-suited for interfacing with analog sensors and digital actuators. In this design, it receives data from a capacitive soil moisture sensor, interprets the signal, and based on soil conditions, decides whether or not to activate a submersible water pump through a MOSFET transistor switch. The capacitive soil moisture sensor operates at 5V and is known for its durability and resistance to corrosion, unlike resistive models. This sensor measures the dielectric permittivity of the soil, which changes as moisture levels fluctuate. It has three terminals: VCC, GND, and an analog output. The analog output is connected to pin GP26 on the Pico, which is ADC0. As the soil dries out, the voltage on this output increases; when the soil is moist, the voltage is lower. This allows for continuous monitoring of soil hydration.

To allow for manual control or testing, a physical push-button is included in the circuit. This button is connected to GPIO pin GP15, and a 10kΩ pull-down resistor is placed between the pin and ground to ensure that the microcontroller reliably detects the default LOW state when the button is not pressed. When pressed, the button pulls the pin HIGH, allowing the program logic to detect user input. This button can be configured to override the automated logic to manually activate the pump, reset the system, or calibrate the moisture threshold.

To control the water pump, which requires more current than the Raspberry Pi Pico can directly provide, an N-channel MOSFET such as the IRF520 is used. This MOSFET acts as an electronic switch controlled by the microcontroller. The gate of the MOSFET is connected to GPIO pin GP14 on the Pico. When this pin is set HIGH by the program, the MOSFET enters conduction mode, allowing current to flow from the pump's positive terminal through the MOSFET to ground. The source pin of the MOSFET is grounded, and the drain is connected to the negative terminal of the pump. The pump's positive terminal is connected to the 5V output of a step-up voltage converter. A diode, specifically a 1N4007, is placed in parallel with the pump in reverse bias (cathode to the positive terminal) to protect the MOSFET and other sensitive electronics from voltage spikes. These spikes occur due to the inductive nature of the motor when it is suddenly turned off, and the diode provides a safe discharge path for this stored energy, preventing reverse current flow into the system.

The water pump used is a small 5V submersible type, suitable for low-volume irrigation in pots, raised beds, or small garden plots. It is compact and efficient, drawing power only when activated. The power source for the entire system is designed to be renewable and autonomous. A solar panel charges a single-cell 3.7V Li-Ion battery via a TP4056 charging module. This module provides intelligent battery management, including overcharge, over-discharge, and short-circuit protection. It ensures that the battery is safely charged from the solar panel while simultaneously powering the load.

However, since 3.7V is insufficient for the 5V pump and sensor, a DC-DC boost converter (MT3608) is used. This module takes the lower voltage from the battery and increases it to a regulated 5V output, which is then used to power the pump and the sensor. The same 5V output is also fed into the VSYS pin of the Raspberry Pi Pico, which is capable of accepting up to 5V and internally regulates it to 3.3V for its logic circuitry. This allows the microcontroller to function reliably while simplifying power distribution across components.

In summary, the Raspberry Pi Pico acts as the intelligent controller, reading analog values from the moisture sensor and activating the pump through a MOSFET only when soil dryness exceeds a programmed threshold. A manual push-button gives the user additional control, while the system is powered sustainably through solar energy. The use of a boost converter ensures that the voltage requirements of each component are met, and safety elements like the 1N4007 diode and TP4056 protections enhance the reliability and longevity of the system. Overall, this configuration enables fully automated, energy-efficient irrigation suited for remote or off-grid agricultural applications.

