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1. How the Soil Moisture Sensor Operates  
Two metal probes or two probes coated in conductive material are inserted into the soil to measure soil moisture.  
• Basic idea: Because moist soil contains more water, it conducts electricity more effectively than dry soil.  
• The resistance (or conductivity) varies according to the soil's moisture content when a tiny voltage is applied between the two probes.  
A higher voltage reading results from wet soil's low resistance, which allows current to flow easily.  
o Dry soil: low voltage reading due to high resistance (poor current flow).  
Either an externally connected potentiometer or one within the sensor is present.   
(a tiny resistor that can be adjusted).

• The sensor can be adjusted for various soil types and crops by using the potentiometer to set a moisture level threshold.   
Typically, the module produces:   
1. An exact moisture value is provided by the analog signal (A0 pin) (0–1023 for Arduino, 0–4095 for ESP32). It is possible to convert this signal into a percentage.   
For Arduino, the percentage is [Reading/1024]×100.   
For esp, the percentage is [Reading/4095]×100.   
2. Depending on the potentiometer's threshold, the digital signal (D0 pin) only returns 0 (dry) or 1 (wet).

2. How an Ultrasonic Sensor Operates   
An ultrasonic sensor, such as the HC-SR04, measures distances by using sound waves at a frequency higher than human hearing, typically 40 kHz.  
• Transmitter (Trig pin): Transmits a brief ultrasonic sound pulse.   
  
• Receiver (Echo pin): Watchs for sound waves to return from an object.   
Procedure:   
1. A brief pulse, typically lasting 10 μs, is sent to the Trig pin by the microcontroller.   
2. Ultrasonic waves are released by the transmitter.   
3. The waves return if there is an object in front of them.   
4. After detecting the echo, the receiver signals the microcontroller.   
5. A measurement is made of the interval between sending and receiving.   
6. To calculate distance, use:

Distance is equal to [Time × Sound Speed]/2 (sound speed in air is approximately 343 m/s at room temperature).  
A digital output mode on certain ultrasonic sensors only indicates a HIGH (1) when an object is within a specific distance and a LOW (0) otherwise.  
3. How the ESP32-CAM with OV2640 Camera Operates  
A tiny module called the ESP32-CAM has an ESP32 microcontroller that can connect to Bluetooth and Wi-Fi.  
• An OV2640 camera module for streaming video or taking pictures.  
Procedures for Working:  
1. The OV2640 records a continuous video stream or an image.  
2. This data is processed by the ESP32.  
3. Bluetooth or Wi-Fi are used to send the data.

o It can transmit data to a cloud server or local network via Wi-Fi.   
o If both are on the same network, you can watch the video stream using a browser or a mobile app.   
4. To ensure privacy, the video is only accessible to authorized users in a private network configuration.   
Additionally, the ESP32-CAM can: • Use AI-based image recognition for object detection; • Store images on a microSD card.