SPX24
Soil Parameter Sensor Datasheet

Hypothetical Sensors Inc.

Version 1.0

General Description

The SPX24 sensor is designed to measure key soil parameters such as moisture, pH, and temperature. It outputs an analog signal representing the measured value. The sensor interfaces with a microcontroller when a valid reading is available after data stabilization.

Key Features

- Accurate analog measurement of soil parameters.
- Trigger-based measurement initiation.
- Stabilization signal for valid data retrieval.
- Low power consumption.
- Compatible with $3.3V$ and $5V$ microcontrollers.

Pin Configuration

Pin	**Description**
`VCC`	Power Supply ($3.3V$ / $5V$)
`GND`	Ground
`TRG`	Trigger input (High signal initiates the measurement process)
`AD`	Analog data output ($0 - 3.3V$ / $0 - 5V$ depending on `VCC`)
`DR`	Data ready (High signal indicates valid measurement)
`CTRL0`	Control pin 0 (used for parameter selection)
`CTRL1`	Control pin 1 (used for parameter selection)

Parameter Selection

The parameter to be measured is selected using the `CTRL0` and `CTRL1` control pins:

CTRL0	**CTRL1**	**Mode**
0	0	Measure soil moisture
0	1	Measure soil pH
1	0	Measure soil temperature
1	1	Reserved

Measurement Process

1. Set the `CTRL0` and `CTRL1` pins according to the parameter you want to measure.
2. Set the `TRG` pin high for at least 10ms to begin measurement.
3. Wait for the `DR` pin to go high, indicating that the measurement is complete.
4. Read the analog voltage from the `AD` pin, corresponding to the selected parameter.

Operating Conditions

- **Power Supply:** 3.3V or 5V DC
- **Operating Temperature:** -10°C to 60°C
- **Measurement Time:** $<$ 500ms from TRG activation to DR high
- **Analog Output Range:** 0 to VCC (proportional to measured parameter)
- **Trigger Signal (TRG):** Active high, minimum pulse width 10ms
- **Data Ready Signal (DR):** Active high, signals when the data is valid

Data Conversion Formulas

The analog output V_{AD} from the SPX24 sensor corresponds to the measured soil parameters. The following formulas provide detailed conversion methods to interpret the analog signal for soil moisture, pH, and temperature measurements.

1. Soil Moisture Conversion

The analog output voltage V_{AD} is linearly related to the moisture content.

$$\theta = \left(\frac{V_{AD} - V_{min}}{V_{max} - V_{min}}\right) \cdot (\theta_{max} - \theta_{min}) + \theta_{min}$$

Where:

- V_{AD}: Analog output voltage from the sensor.
- V_{min}: Minimum voltage corresponding to 0% moisture (typically 0V).
- V_{max}: Maximum voltage corresponding to 100% moisture (typically V_{CC}).
- θ_{min}: Minimum soil moisture content (typically 0%).
- θ_{max}: Maximum soil moisture content (typically 100%).

2. Soil pH Conversion

The relationship between the analog output voltage and pH is logarithmic, expressed as:

$$\text{pH} = pH_{ref} + \log_{10}\left(\frac{V_{AD}}{V_{ref}}\right)$$

Where:

- V_{AD}: Analog output voltage from the sensor.
- pH_{ref}: Reference pH value (typically 7).
- V_{ref}: Reference voltage corresponding to neutral pH (typically $V_{CC}/2$).

3. Soil Temperature Conversion

The relationship between the analog output voltage and temperature is exponential, expressed as:

$$T[K] = T_0 \cdot e^{k(V_{AD} - V_0)}$$

Where:

- T_0: Reference temperature at V_0.
- V_0: Reference voltage corresponding to T_0.
- V_{AD}: Analog output voltage from the sensor.
- k: Exponential constant determined by sensor calibration.

Usually $T_0 = 273K$, $V_0 = 0V$

To calculate k, use two known temperature points T_1 and T_2, and their corresponding analog output voltages V_1 and V_2:

$$k = \frac{\ln\left(\frac{T_2}{T_1}\right)}{V_2 - V_1}$$

Where:

- T_1 and T_2: Two known temperatures.
- V_1 and V_2: Analog output voltages corresponding to T_1 and T_2.

Note: For the SPX24 sensor, k is typically around $\frac{0.25}{V_{CC}}$. This value is based on the laboratory tests of the sensor and provides a reasonable balance between sensitivity and stability for temperature measurement. Calibration of the sensor may still be necessary to ensure optimal performance in specific applications.