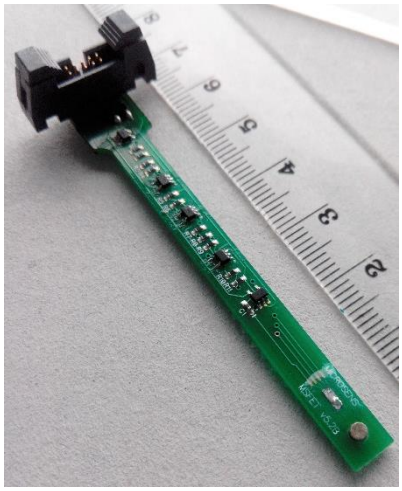
MICROSENS

Product Data Sheet

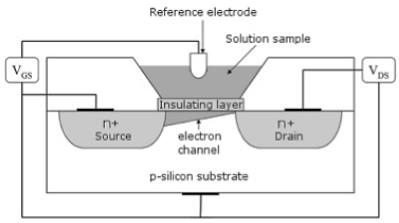
MSFET 3332

MICROSENS Miniature pH Sensor Module

Ta_2O_5 gate Ion Sensitive Field Effect transistor (ISFET)



The MSFET3332 pH sensor module comprises a pH-ISFET sensing element, an integrated miniature solid-state Ag/AgCl reference electrode and electronic circuitry. The latter drives the sensor via a fixed constant current/constant voltage setting and provides the analogue and digital (SPI) output. The output signal is proportional to the pH value of the measured liquid sample.



ISFET Principle

The sensitive element is a Field Effect Transistor whose metal gate is replaced by the solution of interest and a Reference electrode.

Special Features:

- Ta_2O_5 Insulating gate
- Integrated solid state reference electrode
- Integrated sensor driving circuitry
- analog and digital (SPI) readout
- Single supply, low power, small size

Applications:

- Water Quality monitoring
- Environment control
- Security, industrial process control

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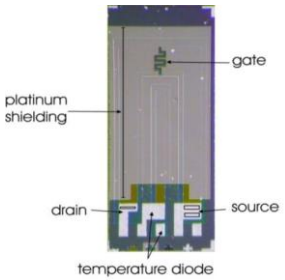
MSFET 3330 Integrated Sensor

Base structure

- Sensor base materials: Silicon, Polysilicon
- Technology: 4" planar CMOS process



Selective membrane

- pH-sensitive material: Ta_2O_5

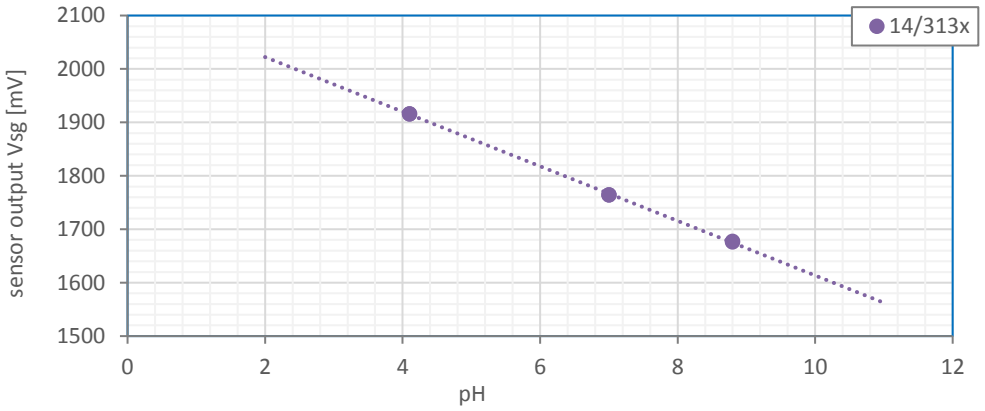
Sensor dimensions:

	Width	Length	Height	Unit
Chip dimensions	1.2	3	0.3	mm
Packaged sensor	6	60	3-5	mm

pH Sensor Characteristics

DC Specifications:

	min	typical	max	Unit
V_{ds}		0.5		V
I_{ds}		0.1		mA
Sensitivity (ΔVs/pH)	-50	-55	-59.2	mV/pH



Ta_2O_5 gate ISFET pH sensitivity
(integrated Ag/AgCl pellet electrode, V_{ds} = 0.5V, I_d = 100µA, Slope = -51.1 mV/pH)

pH Sensor Specifications

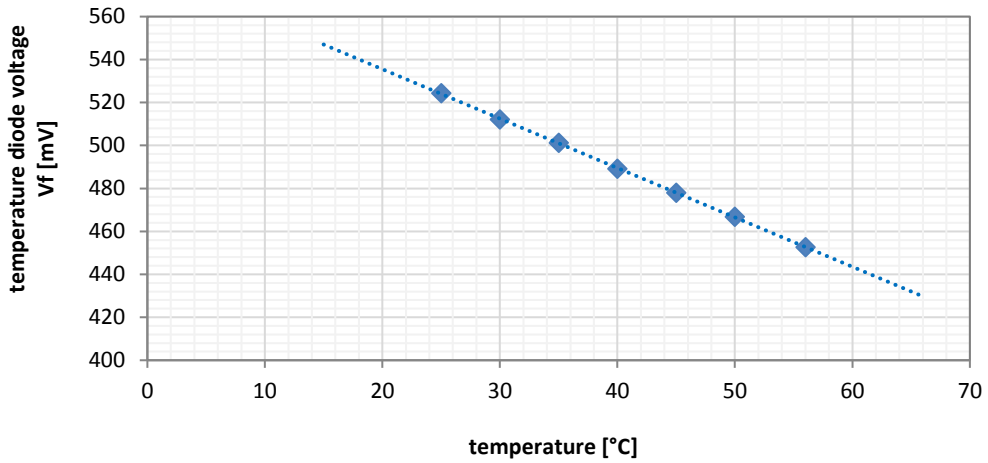
Sensitivity: -55 mV/pH unit
Range: pH 2 … pH 11
Accuracy: 0.1 pH
Operating temperature: 5°C … 75°C
Response time: depends on application. In a flow-through cell configuration the response time is below 1s.

Note:
The pH related sensor output may change during longer periods of storage. Therefore it might be necessary to recalibrate the ISFET output before measurements.

Temperature Sensor Characteristics

DC Specifications:

	min	typical	max	Unit
V_f (25°C, I_f = 0.1mA)	0.5		0.6	V
I_f		0.1		mA
Sensitivity (ΔV_f/°C)	-2	-2.5	-3	mV/°C



Temperature response of the integrated temperature diode
(I_f = 0.1mA)

Temperature Sensor Specifications

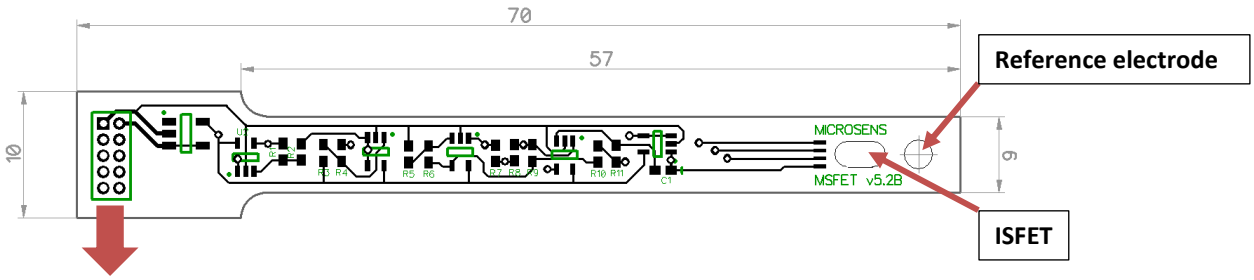
Sensitivity: -2.5 mV/degC
Range: 5°C … 75°C
Response time: < 1s

Note:
The temperature diode can be accessed through the designated connections of the sensing module. When using the temperature diode for measurements, it is important to set the potential of the diode's anode to the same value as the ISFET source in order to avoid leakage currents inside the sensor chip. We recommend to activate the temperature diode only for short measurements in order to avoid influencing the pH measurement via leakage currents.

MSFET3332 Sensing Module

The MSFET3330 chip is bonded to a PCB holder element and encapsulated via an epoxy based polymer.

Dimensions and Pin assignment of the packaged probe



1: V-	**2:** V+
3: REF	**4:** Vsg
5: D+	**6:** NC
7: D-	**8:** CS
9: SCLK	**10:** SDD

PCB connector denomination (the table represents the pin positions, as indicated in the figure above)

Pin	Name	Description
1	V-	GND (floating)
2	V+	Input voltage
3	REF	Internal reference voltage (applied to reference electrode) = Vg
4	Vsg	Analogue sensor output voltage = Vs-Vg
5	D+	Temperature diode (Anode)
6	NC	Not connected
7	D-	Temperature diode (Cathode)
8	CS/SHDN	Chip Select when LOW, Shutdown Mode when HIGH
9	SCLK	Data Clock synchronizes the serial data transfer and determines conversion speed.
10	SDD (SPI)	The serial output data word is comprised of 12 bits of data. In operation the data is valid on the falling edge of SCLK. The second clock pulse after the falling edge of CS enables the serial output.

DC Specifications

Input

	min	typical	max	Unit
V_{in} – MSFET3332	7	9	16	V
I_{in}	0.5	1	2	mA

The circuit maintains the ISFET working point via a constant drain current (I_D) – constant voltage (V_{DS}) configuration, providing an output voltage (V_{SG}) linearly depending on pH.

Analogue Output

	min	typical	max	Unit
Vsg	0		3.5	V
REF		1.5		V

Digital Output (SPI)

	min	default	max	Unit
V_{IH}	3		5.3	V
V_{IL}	-0.3		0.8	V
V_{OH}	3.5			V
V_{OL}			0.4	V
Data Format	Straight binary			

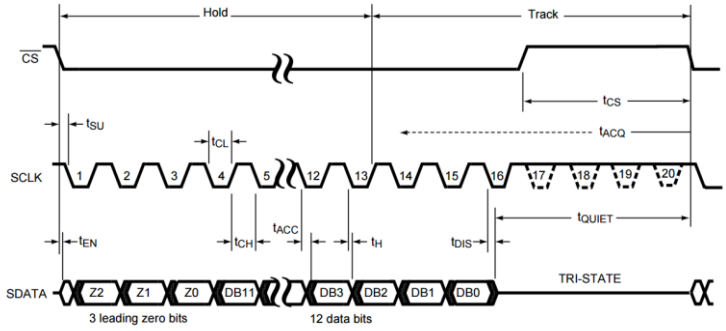
Digital Interface

Serial Interface

The MSFET3332 pH-sensor module communicates with microprocessors and other digital systems via the synchronous 3-wire serial interface (SPI) of the ADC121S021 (Texas Instruments). Basic operation of the ADC begins with $\overline{CS}$ going low, which initiates a conversion process and data transfer. Subsequent rising and falling edges of SCLK will be labelled with reference to the falling edge of $\overline{CS}$; for example, "the third falling edge of SCLK" shall refer to the third falling edge of SCLK after $\overline{CS}$ goes low. At the fall of $\overline{CS}$, the SDATA pin comes out of TRI-STATE, and the converter moves from track mode to hold mode. The input signal is sampled and held for conversion on the falling edge of $\overline{CS}$. The converter moves from hold mode to track mode on the 13th rising edge of SCLK (see timing diagram below). It is at this point that the interval for the T_{ACQ} specification begins. At least 350ns must pass between the 13th rising edge of SCLK and the next falling edge of $\overline{CS}$. The SDATA pin will be placed back into TRI-STATE after the 16th falling edge of SCLK, or at the rising edge of $\overline{CS}$, whichever occurs first. After a conversion is completed, the quiet time (t_{QUIET}) must be satisfied before bringing $\overline{CS}$ low again to begin another conversion.

Sixteen SCLK cycles are required to read a complete sample from the ADC. The sample bits (including leading zeroes) are clocked out on falling edges of SCLK, and are intended to be clocked in by a receiver on subsequent rising edges of SCLK. The ADC will produce three leading zero bits on SDATA, followed by twelve data bits, most significant first.

If $\overline{CS}$ goes low before the rising edge of SCLK, an additional (fourth) zero bit may be captured by the next falling edge of SCLK.



Basic timing diagrams of the digital interface.

Data Format

The output data is in Straight Binary format as shown in the following table. This table represents the ideal output code for the given input voltage and does not include the effects of offset, gain error, or noise.

DESCRIPTION	ANALOG VALUE	DIGITAL OUTPUT: STRAIGHT BINARY	
		BINARY CODE	HEX CODE
Full Scale Range	V_{REF}	1111 1111 1111	FFF
Least Significant Bit (LSB)	$V_{REF}/4096$	1000 0000 0000	800
Full Scale	V_{REF} –1 LSB	0111 1111 1111	7FF
Midscale	$V_{REF}/2$	0000 0000 0000	000
Midscale – 1 LSB	$V_{REF}/2$ – 1 LSB		
Zero	0V		

Ideal Input Voltages and Output Codes (V_{REF} = 5V)

Storing and Handling Recommendations

Storing:

- The MSFET3332 should be stored in dry and dark conditions to maintain the stability of the reference electrode.

Conditioning:

- The MSFET3332 needs to be conditioned for 12h in a 0.1M KCl solution before the first use after storage in dry conditions.
- Subsequent uses will not require conditioning as long as the MSFET3332 is not subjected to extended periods of drying.

Recommended Operating Conditions:

- The ISFET is sensitive to light, it is then preferably operated out of direct light as calibration is normally performed in the dark.

Cleaning recommendations:

- Rinse with DI water
- Let dry in air (dust free environment)
    - Alternatively: blow dry

- Avoid:
  - Rinsing with solvent (acetone, ethanol, isopropanol)
  - Rinsing with detergents
  - Drying with blotting tissues

Important precautions:

- Avoid any electrostatic discharge at the ISFET connections when handling in air. As a precaution the sensor module should be powered down, when the sensor is removed from the solution.
- Switch off the sensor module before disconnecting it from the power supply.
- Store the module under dry conditions. Avoid excessive illumination.
- Avoid contact with high concentrations of solvents (acetone, isopropanol) or soap.