Winsense ISFET pH Sensor (WIPS)

**Special Features:**
- $\text{Si}_3\text{N}_4$ (Silicon Nitride) Insulating gate
- Operates as a MOSFET at a constant voltage $V_{ds}$ current $I_{ds}$
- Quality control by predetermined electrical measurement cycle after packaging
- Single supply, low power, small size

**Product Description:**

Sensing principle:
The sensitive element is a Field Effect Transistor; whose metal gate is replaced by a Reference Electrode and the solution of interest.

The ISFET devices are realized with microelectronic technology compatible with CMOS processes.

- $\text{Si}_3\text{N}_4$ insulating gate ISFET devices measure the pH value in a wide range from basic to acidic solutions

**Applications:**
- Smart farming
- Water Quality monitoring
- Environment control
- Security, industrial process control

**Interface electronics:**
- Analog read out circuit with output 1-2 V.

**Characteristics**

**Input/Outputs:**
- Bias condition: $V_{ds}=0.3$ mV $I_{ds}=25$-$35$ uA
- Output: Analog voltage 1-2 V

**Base structure**
- Sensor base materials: Silicon, Silicon nitride, Silicon dioxide
- Technology: 6” planar CMOS process

**Selective membrane**
- pH-sensitive material: $\text{Si}_3\text{N}_4$

**Sensor dimensions:**

<table>
<thead>
<tr>
<th></th>
<th>Width</th>
<th>Length</th>
<th>Thickness</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensor chip dimension</td>
<td>1400</td>
<td>3550</td>
<td>650</td>
<td>Um</td>
</tr>
<tr>
<td>PCB dimension</td>
<td>2</td>
<td>20</td>
<td>1.6</td>
<td>mm</td>
</tr>
</tbody>
</table>
pH Sensor Characteristics

DC Specifications:

<table>
<thead>
<tr>
<th></th>
<th>Min</th>
<th>Typical</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biased Vds</td>
<td>0.3 V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biased Ids</td>
<td>30 μA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sensitivity (ΔV/ΔpH)</td>
<td>45 mV/pH</td>
<td>50 mV/pH</td>
<td>58 mV/pH</td>
</tr>
<tr>
<td>Temperature coefficient</td>
<td>1.29 mV/°C (pH 10)</td>
<td>1.84 mV/°C (pH 7)</td>
<td>2.15 mV/°C (pH 4)</td>
</tr>
</tbody>
</table>

\[ f(x) = 0.05226667x + 0.60924000 \]
\[ R^2 = 0.99999993 \]

\[ f(x) = -0.001293x + 1.16375 \]
\[ R^2 = 0.9947732795 \]

\[ f(x) = -0.0018496x + 1.022129 \]
\[ R^2 = 0.9986625299 \]

\[ f(x) = -0.0021504x + 0.871481 \]
\[ R^2 = 0.9993457795 \]
**pH Sensor Specifications**

- **Sensitivity:** 50 mV/pH
- **Range:** pH 2 - pH 12
- **Accuracy:** 0.01 pH
- **Operating temperature:** 0°C - 100°C
- **Response time:** 10 s

**Temperature Sensor Characteristics**

**Temperature Sensor Diode:**

- **Sensitivity:** -2.93 mV/degC
- **Range:** 0 - 100°C
- **Response time:** 1 s

**Temperature Sensor Specifications**

- **Sensitivity:** -2.9300 mV/degC
- **Range:** 0 - 100°C
- **Response time:** 1 s

**Sensor terminals and connections:**
Chip connections and connections of packaged sensor:

From top to bottom:

1. ISFET chip
2. Temperature (left) and ISFET (right) chips wire bonded on a PCB
3. Temperature (left) and ISFET (right) chips wire bonded on another PCB with shorter wiring
4. ISFET wire bonded to PCB after encapsulation

Reference-electrode

For stable measurements an Ag/AgCl Reference electrode is required. Submerged together with the packaged ISFET chip, it acts as metal gate electrode and provides a stable reference potential.
WIPS Control Electronic

Measurement circuit:

Operating mode:

**Principle:** The circuit configuration is used to keep a constant drain current ($I_{ds}$) and voltage ($V_{fs}$) for the ISFET operation providing an output voltage ($V_g$) linearly depending on pH level of the solution under test.

**Recommended Handling and Operating Conditions:**
- The ISFET is sensitive to light, it is then preferably operated out of direct light as calibration is normally performed in dark.

**Important precautions:**
- Avoid any electrostatic discharge at the ISFET connections when handling in dry air
- Store the Ref Electrode in KCl solution when not in use.