1. Description

The ES1881 is a Bipolar Hall effect sensor IC fabricated from mixed signal CMOS technology. The device integrates a voltage regulator, Hall sensor with dynamic offset cancellation system, Schmitt trigger and an open-drain output driver, all in a single package.

It incorporates advanced chopper stabilization techniques to provide accurate and stable magnetic switch points. There are many applications for this HED – Hall Electronic Device – in addition to those listed below in “Applications”. The design, specifications and performance have been optimized for commutation applications in 5V and 12V brushless DC motors.

Thanks to its wide operating voltage range and extended choice of temperature range, it is quite suitable for use in automotive, industrial and consumer applications.

The device is delivered in a Small Outline Transistor (SOT) for surface mount process and in a Plastic Single In Line (TO-92S flat) for through-hole mount. Both 3-lead packages are RoHS compliant.

2. Features

◆ Wide operating voltage range from 3.5V to 24V
◆ High magnetic sensitivity – Multi-purpose
◆ CMOS technology
◆ Chopper-stabilized amplifier stage
  □ Superior temperature stability
  □ Extremely low switch point drift
  □ Insensitive to physical stress
◆ Low current consumption
◆ Open drain output
◆ Tiny SOT23-3L and flat TO-92S-3L, both are RoHS compliant packages

3. Applications

◆ Automotive, Consumer and Industrial
◆ Solid-state switch
◆ Brushless DC motor commutation
◆ Speed detection
◆ Linear position detection
◆ Angular position detection
◆ Proximity detection
4. Functional Block Diagram

![Functional Block Diagram]

5. Glossary of Terms

<table>
<thead>
<tr>
<th>Glossary</th>
<th>Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>MilliTesla (mT)</td>
<td>Gauss, Units of magnetic flux density: 1mT = 10 Gauss</td>
</tr>
<tr>
<td>RoHS</td>
<td>Restriction of Hazardous Substances</td>
</tr>
<tr>
<td>SOT</td>
<td>Small Outline Transistor (SOT package) – also referred with the package code “SO”</td>
</tr>
<tr>
<td>ESD</td>
<td>Electro-Static Discharge</td>
</tr>
<tr>
<td>BLDC</td>
<td>Brush-Less Direct-Current</td>
</tr>
<tr>
<td>Operating Point (B_{OP})</td>
<td>Magnetic flux density applied on the branded side of the package which turns the output driver ON (V_{OUT} = V_{DSon})</td>
</tr>
<tr>
<td>Release Point (B_{RP})</td>
<td>Magnetic flux density applied on the branded side of the package which turns the output driver OFF (V_{OUT} = high)</td>
</tr>
</tbody>
</table>

6. Pin Definitions and Descriptions

<table>
<thead>
<tr>
<th>SO Pin No.</th>
<th>UA Pin No.</th>
<th>Name</th>
<th>Type</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>V_{DD}</td>
<td>Supply</td>
<td>Supply Voltage Pin</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>OUT</td>
<td>Output</td>
<td>Open Drain Output Pin</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>GND</td>
<td>Ground</td>
<td>Ground Pin</td>
</tr>
</tbody>
</table>
High Sensitivity Hall Latch

7. Detailed General Description

The ES1881 exhibits latch magnetic switching characteristics. Therefore, it requires both south and north poles to operate properly.

The OUT pin of these devices switches low (turns on) when a magnetic field perpendicular to the Hall sensor exceeds the operate point threshold, $B_{OP}$. After turn-on, the output voltage is $V_{DDH}$. Note that the device latches, that is, a south pole of sufficient strength towards the branded surface of the device turns the device on. The device remains on if the south pole is removed ($B \rightarrow 0$). This latching property defines the device as a magnetic memory.

When the magnetic field is reduced below the release point, $B_{RP}$, the OUT pin turns off (goes high). The difference in the magnetic operate and release points is the hysteresis, $B_{HYS}$, of the device. This built-in hysteresis prevents output oscillation near the switching point, and allows clean switching of the output even in the presence of external mechanical vibration and electrical noise.

The device behaves as a latch with symmetric operating and release switching points ($B_{OP} = |B_{RP}|$). This means magnetic fields with equivalent strength and opposite direction drive the output high and low.

Powering-on the device in the hysteresis region (less than $B_{OP}$ and higher than $B_{RP}$) allows an indeterminate output state. The correct state is attained after the first excursion beyond $B_{OP}$ or $B_{RP}$.

The SOT-23 device is reversed from the UA package. The SOT-23 output transistor will be latched on in the presence of a sufficiently strong North pole magnetic field applied to the marked face.

8. Unique Features

Based on mixed signal CMOS technology, Innosen ES1881 is a Hall-effect device with high magnetic sensitivity. This multi-purpose latch suits most of the application requirements.

The chopper-stabilized amplifier uses switched capacitor technique to suppress the offset generally observed with Hall sensors and amplifiers. The CMOS technology makes this...
High Sensitivity Hall Latch

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advanced technique possible and contributes to smaller chip size and lower current consumption than bipolar technology. The small chip size is also an important factor to minimize the effect of physical stress. This combination results in more stable magnetic characteristics and enables faster and more precise design.

The wide operating voltage from 3.5V to 24V, low current consumption and large choice of operating temperature range according to “L”, and “E” specification make this device suitable for automotive, industrial and consumer applications.

9. Absolute Maximum Ratings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Value</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Voltage</td>
<td>V\text{DD}</td>
<td>28</td>
<td>V</td>
</tr>
<tr>
<td>Supply Current</td>
<td>I\text{DD}</td>
<td>50</td>
<td>mA</td>
</tr>
<tr>
<td>Output Voltage</td>
<td>V\text{OUT}</td>
<td>28</td>
<td>V</td>
</tr>
<tr>
<td>Output Current</td>
<td>I\text{OUT}</td>
<td>50</td>
<td>mA</td>
</tr>
<tr>
<td>Storage Temperature Range</td>
<td>T_S</td>
<td>-50 ~ 150</td>
<td>℃</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>T_J</td>
<td>165</td>
<td>℃</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Operating Temperature Range</th>
<th>Symbol</th>
<th>Value</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature Suffix “E”</td>
<td>T_A</td>
<td>-40 ~ 85</td>
<td>℃</td>
</tr>
<tr>
<td>Temperature Suffix “L”</td>
<td>T_A</td>
<td>-40 ~ 150</td>
<td>℃</td>
</tr>
</tbody>
</table>

Note: Exceeding the absolute maximum ratings may cause permanent damage. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

10. General Electrical Specifications

DC Operating Parameters: T_A = 25℃, V\text{DD}= 3.5V to 24V (unless otherwise specified)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Test Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Voltage</td>
<td>V\text{DD}</td>
<td>Operating</td>
<td>3.5</td>
<td>24</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Supply Current</td>
<td>I\text{DD}</td>
<td>B &lt; B_{RP}</td>
<td>2</td>
<td>5</td>
<td>mA</td>
<td></td>
</tr>
<tr>
<td>Output Saturation Voltage</td>
<td>V_{DSn}</td>
<td>I_{OUT} = 20mA, B &gt; B_{OP}</td>
<td>0.5</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Leakage Current</td>
<td>I_{OFF}</td>
<td>B &lt; B_{RP}, V_{OUT} = 24V</td>
<td>&lt;1</td>
<td>10</td>
<td>μA</td>
<td></td>
</tr>
<tr>
<td>Output Rise Time</td>
<td>T_R</td>
<td>R_L = 1KΩ, C_L = 20pF</td>
<td>0.25</td>
<td>μs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Fall Time</td>
<td>T_F</td>
<td>R_L = 1KΩ, C_L = 20pF</td>
<td>0.25</td>
<td>μs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum Switching Frequency</td>
<td>F_{SW}</td>
<td></td>
<td>10</td>
<td>KHz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Package Thermal Resistance</td>
<td>R_{TH}</td>
<td>Single layer (1S) JEDEC board</td>
<td>301</td>
<td>℃/W</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: The output of ES1881 will be switched after the supply voltage is over 2.2V, but the magnetic characteristics won't be normal until the supply is over 3.5V.
High Sensitivity Hall Latch

11. Magnetic Specifications

DC Operating Parameters: \( T_A = 25^\circ C \), \( V_{DD} = 5V \) (unless otherwise specified)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Point</td>
<td>( B_{OP} )</td>
<td>10</td>
<td>35</td>
<td>60</td>
<td>Gs</td>
</tr>
<tr>
<td>Release Point</td>
<td>( B_{RP} )</td>
<td>-60</td>
<td>-35</td>
<td>-10</td>
<td>Gs</td>
</tr>
<tr>
<td>Hysteresis</td>
<td>( B_{HYS} )</td>
<td>65</td>
<td>70</td>
<td>95</td>
<td>Gs</td>
</tr>
</tbody>
</table>

12. Output Behavior versus Magnetic Pole

DC Operating Parameters: \( T_A = -40^\circ C \sim 150^\circ C \), \( V_{DD} = 3.5V \sim 24V \) (unless otherwise specified)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Test Conditions (SO)</th>
<th>OUT (SO)</th>
<th>Test Conditions (UA)</th>
<th>OUT (UA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>South pole</td>
<td>( B &lt; B_{RP} )</td>
<td>High</td>
<td>( B &gt; B_{OP} )</td>
<td>Low</td>
</tr>
<tr>
<td>North pole</td>
<td>( B &gt; B_{OP} )</td>
<td>Low</td>
<td>( B &lt; B_{RP} )</td>
<td>High</td>
</tr>
</tbody>
</table>

13. Application Information

It is strongly recommended that an external bypass capacitor be connected (in close proximity to the Hall sensor) between the supply (\( V_{DD} \) Pin) and ground (GND Pin) of the device to reduce both external noise and noise generated by the chopper stabilization technique. As is shown in the two figures in next page, a 0.1\( \mu \)F capacitor is typical.

For reverse voltage protection, it is recommended to connect a resistor or a diode in series with the \( V_{DD} \) pin. When using a resistor, three points are important:
- the resistor has to limit the reverse current to 50mA maximum (\( V_{CC} / R1 \leq 50mA \))
- the resulting device supply voltage \( V_{DD} \) has to be higher than \( V_{DD} \) min (\( V_{DD} = V_{CC} - R1*I_{DD} \))
- the resistor has to withstand the power dissipated in reverse voltage condition (\( P_D = V_{CC}^2/R1 \))

When using a diode, a reverse current cannot flow and the voltage drop is almost constant (\( \approx 0.7V \)). Therefore, a 100\( \Omega \)/0.25W resistor for 5V application and a diode for higher supply voltage are recommended. Both solutions provide the required reverse
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voltage protection. When a weak power supply is used or when the device is intended to be used in noisy environment, it is recommended the following right figure. The low-pass filter formed by R1 and C1 and the zener diode Z1 bypass the disturbances or voltage spikes occurring on the device supply voltage $V_{DD}$. The diode D1 provides additional reverse voltage protection.

**Typical Three-Wire Application Circuit**

The ES1881 have been optimized for commutation applications in 5V and 12V brushless DC motors. The follow figure is the typical application circuit for 3 phase brushless DC motors.

**Automotive and Severe Environment Protection Circuit**

- **Driver & Control Logic**
- **Hall Motor Driver**

3 Phase Hall Motor
14. Standard information regarding manufacturability of Innosen’s Hall IC with different soldering processes

Our products are classified and qualified regarding soldering technology, solderability and moisture sensitivity level according to the following test methods:

Reflow Soldering SMD’s (Surface Mount Devices)

- IPC/JEDEC J-STD-020
  - Moisture/Reflow Sensitivity Classification for Nonhermetic Solid State Surface Mount Devices
- EIA/JEDEC JESD22-A113
  - Preconditioning of Nonhermetic Surface Mount Devices Prior to Reliability Testing

Wave Soldering SMD’s (Surface Mount Devices) and THD’s (Through Hole Devices)

- EN60749-20
  - Resistance of plastic- encapsulated SMD’s to combined effect of moisture and soldering heat
- EIA/JEDEC JESD22-B106 and EN60749-15
  - Resistance to soldering temperature for through-hole mounted devices

Iron Soldering THD’s (Through Hole Devices)

- EN60749-15
  - Resistance to soldering temperature for through-hole mounted devices

Solderability SMD’s (Surface Mount Devices) and THD’s (Through Hole Devices)

- EIA/JEDEC JESD22-B102 and EN60749-21
  - Solderability

15. ESD Precautions

Electronic semiconductor products are sensitive to Electro Static Discharge (ESD). Always observe Electro Static Discharge control procedures whenever handling semiconductor products.
16. Package Information

16.1 UA Package (TO-92S flat)

Notes:
1). Controlling dimension: mm;
2). Leads must be free of flash and plating voids;
3). Do not bend leads within 1 mm of lead to package interface;
4). PINOUT:  Pin 1  VDD  
            Pin 2  GND  
            Pin 3  Output

Marking:
18 -- Code of Device (ES1881);
xxxxx -- Production Lot;
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16.2 SO Package (SOT23-3L)

Notes:
1). PINOUT: Pin 1 V_{DD}
Pin 2 Output
Pin 3 GND
2). All dimensions are in millimeters;

Marking:
18 -- Code of Device (ES1881);
xxx -- Production Lot.;

Top View

Side View

End View

Hall plate location

Bottom View of SOT-23 Package

Chip

Notes:
1). PINOUT: Pin 1 V_{DD}
Pin 2 Output
Pin 3 GND
2). All dimensions are in millimeters;
### 17. Ordering Information

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Temperature Suffix</th>
<th>Package Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>ES1881</td>
<td>E (-40°C ~ 85°C)</td>
<td>SO (SOT-3L)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>UA (TO-92S)</td>
</tr>
<tr>
<td></td>
<td>L (-40°C ~ 150°C)</td>
<td>SO (SOT-3L)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>UA (TO-92S)</td>
</tr>
</tbody>
</table>

**Contact Information:**

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