SM228 I²C Smart TMR Magnetometer

Features
- Analog field measurement
- Digital threshold output
- 3.3 or 5 volt compatible two-wire I²C interface
- Wide 0 to 15 mT linear range
- Can detect magnets more than 50 mm away
- Factory calibrated
- Internal temperature compensation
- In-plane sensitivity—more usable than Hall effect
- 2.2 to 3.6 volt supply
- Ultraminiature 2.5 x 2.5 x 0.8 mm TDFN6 package

Key Specifications
- 10-bit output resolution
- −40°C to +125°C operating range
- 2% FS accuracy for 0 to 125°C
- 15kSps sample rate for fast response
- 5mA typical supply current

Applications
- Current sensing
- Proximity sensing
- Automotive applications
- Cylinder position sensing
- Security and intrusion detection

Description
SM228 Smart Magnetometers provide precise magnetic field measurements. The sensors combine precise Tunneling Magnetoresistance (TMR) sensor elements with easy-to-use digital signal processing.

The SM225 has an I²C interface that provides magnetic field data, and is used to set parameters. A digital comparator output allows programmable thresholds.

The SM225 is also available with similar sensor elements and an SPI interface.

Unlike awkward, old-fashioned Hall-effect sensors, TMR is sensitive in-plane for optimal current sensing and easy mechanical interfaces. TMR also provides more sensitivity, higher precision, higher speed, and lower noise than Hall effect sensors.

The device is factory calibrated for high accuracy, and calibration coefficients are stored in internal nonvolatile memory.
### Boundary Ratings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min.</th>
<th>Max.</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply voltage</td>
<td>−12</td>
<td>4.2</td>
<td>Volts</td>
</tr>
<tr>
<td>Input and output voltages</td>
<td>−0.5</td>
<td>$V_{cc} + 2.5$ up to 5.8</td>
<td>Volts</td>
</tr>
<tr>
<td>(SDA, SCL, and DOUT)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output current</td>
<td>−100</td>
<td>+100</td>
<td>mA</td>
</tr>
<tr>
<td>Storage temperature</td>
<td>−55</td>
<td>150</td>
<td>°C</td>
</tr>
<tr>
<td>ESD (Human Body Model)</td>
<td></td>
<td>2000</td>
<td>Volts</td>
</tr>
<tr>
<td>Applied magnetic field</td>
<td></td>
<td>Unlimited</td>
<td>Tesla</td>
</tr>
</tbody>
</table>
### Operating Specifications

\( T_{\text{min}} \) to \( T_{\text{max}} : 2.2 < V_{\text{DD}} < 3.6 \) V unless otherwise stated

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
<th>Test Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating temperature</td>
<td>( T_{\text{min}} ) to ( T_{\text{max}} )</td>
<td>−40</td>
<td>125</td>
<td>°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supply voltage</td>
<td>( V_{\text{DD}} )</td>
<td>2.2</td>
<td>3.6</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supply current</td>
<td>( I_{\text{DD}} )</td>
<td>4</td>
<td>7</td>
<td>mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power-on Reset supply voltage</td>
<td>( V_{\text{POR}} )</td>
<td>1.4</td>
<td></td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brown-out power supply voltage</td>
<td>( V_{\text{POR}} )</td>
<td>0.75</td>
<td>1</td>
<td>1.36</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Start-up time</td>
<td>( T_{\text{STA}} )</td>
<td>15</td>
<td></td>
<td>ms</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Magnetics

- Linear range: \([-15 \, \text{mT}, 15 \, \text{mT}]\)
- Resolution: \( \delta H = 0.01 \, \text{mT} \) (1 mT = 10 Oe in air)
- Accuracy (% of linear range): ±4 % FS, 0 to 125°C

### Precision and Speed

- Digital precision: 10 bits
- Update rate: 15 kSPS
- Magnetic bandwidth: 7.5 kHz
- Start-up time: \( T_{\text{STA}} = 15 \, \text{ms} \)

### Internal Temperature Sensor

- Temperature accuracy (factory calibrated): ±2.5 °C, 25 to 85°C; ±5 °C, −40 to 125°C

### I²C Interface

- Data transfer rate: 400 kBaud, Full duplex
- Bus voltage: \( V_{\text{BUS}} = 2.2 \) V
- Output response and transmission times: 20 µs, 400 kBaud
- Low level input threshold voltage: \( V_{IL} = 0.8 \) V
- High level input threshold voltage: \( V_{IH} = 2.2 \) V
- Low level output current: \( I_{OL} = 3 \) mA
- I/O capacitance: \( C_{I/O} = 10 \) pF
- Low level input threshold voltage: \( V_{IL} = 0.8 \) V
- High level input threshold voltage: \( V_{IH} = 2.2 \) V
- Low level output current: \( I_{OL} = 3 \) mA
- I/O capacitance: \( C_{I/O} = 10 \) pF

### Package Thermal Characteristics

- Junction-to-ambient thermal resistance: \( \theta_{JA} = 320 \) °C/W
- Package power dissipation: 500 mW
SM28 Overview

Direction of Magnetic Sensitivity
As the field varies in intensity, the digital output will turn on and off. Unlike Hall effect or other sensors, the direction of sensitivity is in the plane of the package. The diagrams below show two permanent magnet orientations that will activate the sensor in the direction of sensitivity:

![Direction of magnetic sensitivity](image)

Figure 1. Direction of magnetic sensitivity.

These sensors are bipolar, meaning they can detect the polarity as well as magnitude of magnetic fields.

Typical Operation

Position Sensing
A typical proximity sensor using an SM228-10E sensor and magnet is shown below. With a 0.4 mT (4 Oe) operate point, the sensor actuates with a rare-earth magnet at more than 50 mm (two inches) from the sensor:

![Position Sensing](image)

Figure 2. The SM228-10E sensor can be activated by a magnet more than 50 mm away.

Maximum sensitivity is in plane with the sensor, with the magnet axis in the pin 2/pin 5 sensor axis.

The part is sensitive to either north or south fields.

Cautions for Low Fields
Thresholds even lower than 0.4 mT (4 Oe) can be programmed, although care must be taken to account for the earth’s magnetic field, which is typically in the 0.05 mT range.

Magnet Distances
Typical magnetic operate distances for the SM228 is illustrated in the following graph with an inexpensive ceramic disk magnet:
Larger and stronger magnets allow farther operate and release distances. For more calculations, use our axial disc magnetic field versus distance Web application at:


**Noncontact Current Sensing**

SM228 sensors can measure the current through a circuit board trace by detecting the magnetic field generated by the current through the trace. The sensor is ideal for these applications because of the low fields generated. The threshold output can be used for current threshold detection or overcurrent protection.

Typical current sensing configurations are shown below:

Figure 4a. 0.05” (1.3 mm) trace on top of PCB (0.28 mT/amp; 7 A max. current).

Figure 4b. Five-turn, 0.0055” (0.14 mm) Trace on top of PCB (1.4 mT/amp; 1 A max. current).

Figure 4c. 0.5” (13 mm) 2 oz. trace on bottom of 0.062” (1.6 mm) thick PCB (0.04 mT/amp; 50 A max. current).
For the geometry shown below and narrow traces, the magnetic field generate can be approximated by Ampere’s law:

\[
H = \frac{2I}{d} \quad \text{[“H” in oersteds, “I” in amps, and “d” in millimeters]}
\]

For traces on the top side of the board, “d” is simply the distance of the sensor element from the bottom of the package, which is 0.5 millimeters.

Traces on the top side of the board are typically used for currents of five amps or less. Large traces on the bottom side of the PCB can be used for currents of up to 50 amps.

More precise calculations can be made by breaking the trace into a finite element array of thin traces, and calculating the field from each array element. We have a free, Web-based application with a finite-element model to estimate magnetic fields and sensor outputs in this application:

www.nve.com/spec/calculators.php#tabs-Current-Sensing
SM228 Operation

The SM228 is a high-speed noncontact magnetometer designed for proximity or current sensing. A detailed block diagram is shown below:

![SM228 Block Diagram](image)

**ADC**
The sensor output is digitized with a 12-bit ADC. The device’s output precision is 10 bits, and the extra bits ensure computational accuracy.

**Digital Filter**
A first-order Infinite Impulse Response (IIR) digital filter with a programmable cutoff frequency can be used for ultralow noise if high-frequency operation is required. The cutoff frequency is set by a filter constant, $m$, as follows:

$$f_{CUTOFF} = f_{SAMPLE}/\left(2\pi m\right)$$

Where $f_{CUTOFF}$ is the filter cutoff frequency and $f_{SAMPLE}$ is the sensor ADC sampling rate (approximately 15000/s). So for example, if $m = 10$, the cutoff frequency is approximately 300 Hz.

$m = 1$ disables filter so the output is simply updated with each sample. The factory default is the filter turned off.

**Sensor Offset**
The sensor core of the SM228 is factory calibrated for highest accuracy, and a programmable parameter, sensor_offset, is available for user adjustments to environments with non-zero magnetic fields. sensor_offset is a signed integer.

**Internal Temperature Sensor**
A factory-calibrated internal temperature sensor compensates for temperature effects, and optionally compensates for temperature effects on permanent magnets. Sensor temperature can also be read via the I²C interface.

**Threshold Output**
The SM228 has a programmable threshold output. There are two threshold / hysteresis pairs (THRSH1/HYST1 and THRSH2/HYST2). Normally, the threshold output is high if the field exceeds the threshold, but it can be inverted by setting the “TOUT_invert” bit.
The factory default is an omnipolar threshold output with 10 mT thresholds and 1 mT hysteresis:

![Diagram of threshold output](image)

**Fig. 7a.** Factory default threshold output (THRSH2 = +10 mT; THRSH1 = −10 mT; HYST1 = HYST2 = 1 mT). The output turns on when the field magnitude exceeds the threshold, and operates the same with either magnet pole.

The thresholds can be configured to provide “omnipolar” or “bipolar” responses. Here are two examples of common settings:

![Diagram of threshold output](image)

**Fig. 7b.** “Bipolar” symmetrical threshold output (HYST1 = 2 x THRSH1; THRSH2 not used). The output turns on with a north magnetic pole and off with a south pole.

**Fig. 7c.** “Unipolar” threshold output (HYST1 < THRSH1; THRSH2 not used). The output turns on with a north pole but not with a south pole, and turns off when the field is reduced.

Thresholds parameter constraints are as follows:
- THRSH2 should be greater than THRSH1.
- HYST1 and HYST2 should be positive or zero.
- Unused parameters can be set to 0xFFFF, or set the same as the other parameter.
FC Interface

Changing the I²C Address in Nonvolatile Memory
The default I²C address is stored in nonvolatile memory, and can be changed like any other parameter. The I²C standard reserves certain addresses, so recommended I²C addresses are 16 to 238 (0x10 to 0xEE hex).

Note that if there are multiple SM228s on the same I²C bus there will be a collision before addresses can be changed. Therefore changing the address in this way may require a single-sensor programming setup.

Overriding the I²C Address with an External Jumper
Grounding the I²C address override pin ("I2CADDR") changes the I²C address to 16 dec regardless of the programmed address. Leaving the pin open or tied HIGH invokes the I²C address in nonvolatile memory, which is 72 dec by default but can be reprogrammed by the user in memory location 0x17. The pin is checked only on power-up.

Eight-Bit I²C Address
In accordance with industry standards, SM228 sensors have eight-bit I²C addresses (seven bits plus an R/W bit). Some I²C Master devices (such as Arduinos) send seven-bit addresses. In this case, the sensor address should be divided by two, so for example a default PC address of 36 rather than 72 would be used.

Reading and Writing the Sensor Memory
Data is read by first writing an address byte to the sensor (with the I²C Read/Write bit set to “Write”). Subsequent I²C read commands will return the data or parameter in the active address.

On startup the default memory address is 0, which is the calibrated sensor output.

Reading the Sensor
To read the sensor, the master simply writes zero for the address, then reads the two-byte output, which is expressed in hundredths of millitesla. The active address will remain the same until changes, so the output can be read repeatedly without writing the address each time.

Reading and Writing Parameters
Reading and writing parameters are simple three-byte sequences. The master writes a byte for the parameter address, then reads or writes two bytes for the parameter value.

The number of bits in different parameters varies. Unused bits are sent as zeros by the sensor. Similarly, unused bits should be written as zeros to the sensor to avoid an out-of-range parameter that could be ignored.

Because of the slower speed of the sensor’s nonvolatile memory, allow 15 ms for parameter writes.
Memory Map

Data and parameter memory addresses are shown in the following table:

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Default</th>
<th>Range</th>
<th>Address</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensor output (calibrated)</td>
<td>Sensor</td>
<td>−1500 – +1500</td>
<td>0x00</td>
<td>1500 = 15 mT or 150 Oe</td>
</tr>
<tr>
<td>Temperature</td>
<td>Temperature</td>
<td>−40 – 125</td>
<td>0x02</td>
<td>°C</td>
</tr>
<tr>
<td>Threshold output</td>
<td>DOUT</td>
<td>−1500 – +1500</td>
<td>0x03</td>
<td></td>
</tr>
<tr>
<td>Threshold 1</td>
<td>THRSH1</td>
<td>−1000 – +1000</td>
<td>0x10</td>
<td>1000 = 100 Oe / 10 mT; THRSH2 &gt; THRSH1; HYST1, HYST2 ≥ 0; 0xFFFF to disable</td>
</tr>
<tr>
<td>Hysteresis for THRSH1</td>
<td>HYST1</td>
<td>100 – 1500</td>
<td>0x11</td>
<td></td>
</tr>
<tr>
<td>Threshold2</td>
<td>THRSH2</td>
<td>+1000 – +1500</td>
<td>0x12</td>
<td></td>
</tr>
<tr>
<td>Hysteresis for THRSH2</td>
<td>HYST2</td>
<td>100 – 1500</td>
<td>0x13</td>
<td></td>
</tr>
<tr>
<td>Threshold invert</td>
<td>TOUT_invert</td>
<td>0 – 1</td>
<td>0x14</td>
<td>HIGH to invert TOUT</td>
</tr>
<tr>
<td>Sensor offset</td>
<td>sensor_offset</td>
<td>0 – 1500 – +1500</td>
<td>0x15</td>
<td></td>
</tr>
<tr>
<td>Digital filter constant</td>
<td>m</td>
<td>1 – 127</td>
<td>0x16</td>
<td>( f_{\text{CUTOFF}} = f_{\text{SAMPLE}}/(2\pi m); ) ( f_{\text{SAMPLE}} = 15 \text{ kSps} ) ( m = 1 ) disables filter</td>
</tr>
<tr>
<td>PC address</td>
<td>I2CADDR</td>
<td>72 (0x10 to 0xEE)</td>
<td>0x17</td>
<td>The PC address with the I2CADDR pin floating or HIGH</td>
</tr>
<tr>
<td>Lot code</td>
<td>YY</td>
<td>N/A</td>
<td>0x80</td>
<td>ASCII date code in the form YYWWXX, where:</td>
</tr>
<tr>
<td>WW</td>
<td>N/A</td>
<td>0x81</td>
<td></td>
<td>YY = year; WW = work week; XX = internal code. The left-most character is in address 0x80 and the right-most in 0x85.</td>
</tr>
<tr>
<td>XX</td>
<td>N/A</td>
<td>0x82</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1. SM228 Memory Locations.
Power-Up and Initialization
All parameters are nonvolatile so they can be set once (via I²C), and remain for the life of the product if desired.

Minimizing Magnetic Interference
Several precautions can be taken for applications requiring the best accuracy:
- Components such as resistors and capacitors are generally slightly magnetic, and should be located at least several millimeters from the sensor. Such components should not be placed between magnet and the sensor.
- If components must be located near the sensor, ultrasmall components such as 0201 (0603 metric) contain less ferromagnetic material than larger components.
- Nonmagnetic resistors and capacitors can be used for extremely sensitive applications. A nonmagnetic 0.1 µF bypass capacitor can be used close the sensor, with a conventional 10 µF ceramic capacitor at least several millimeters away.

Minimizing Noise
Several steps minimize noise:
- Inadequate bypassing can cause noise or anomalous device behavior. 10 µF total bypass capacitance is recommended. To minimize magnetic field disruption, a small (e.g., 0201 / 0603 metric) 0.1 µF ceramic capacitor can be placed as close as possible to the V_DD and GND pins. The small capacitors contain very little ferromagnetic material. An additional 10 µF ceramic capacitor is also recommended, placed a few millimeters away so that it does not magnetically interfere with the sensor.
- Use a circuit board ground plane.
- If the sensor is not being used for current over trace sensing, ground the sensor’s center pad so the leadframe acts as a shield.
Applications

Typical Microcontrollers Interface
A typical microcontroller interface is shown below:

The SM228 is configured as a Slave and the microcontroller should be configured as the Master. The SM228 I²C interface is compatible with a 3.3V or 5V bus.

The SCL and SDA lines are open-drain, so the microcontroller’s internal pull-up resistors should be activated in software. External resistors can be used to maximize rise time for high-speed I²C operation, or to preserve I²C speed if there are multiple slaves or a multi-master configuration adding bus capacitance. If external pull-ups are used with different power supplies, they should be connected to the lower supply voltage. A typical external pull-up resistor value is 10 kΩ. If I²C speed is not critical, the effects of bus capacitance can be overcome by slowing the I²C speed.

The I2CADDR pin can be left unconnected for the default I²C address (72 decimal/48 hex), or the pin can be grounded to select an alternate address (16 decimal/10 hex).

An LED can be used to indicate the digital output. The appropriate series resistor depends on the supply voltage and LED type. A high-efficiency LED will operate over the sensor’s entire 2.2 to 3.6V supply range with the 1 KΩ resistor, although its brightness will change with the supply voltage.
**Overcurrent Protection**

An SM228 digital output can be used as a “virtual circuit breaker” for overcurrent protection of a load such as a DC motor:

![Circuit Board Trace](image)

**Figure 9. Typical overcurrent protection circuit.**

The IL710-1E is an ultraminiature (MSOP8) data coupler that isolates the controller power from the load power. The DC002-10E is a high-voltage tolerant, five-volt regulator to power the gate drive. The power MOSFET has 4.5 volt drive voltage and 3.6 amp and 40 volt drain-to-source voltage capability. The sensor is located over a trace that carries current to the motor.

In this configuration, DOUT\_invert is set to 1 to invert DOUT so that the output goes LOW for overcurrent. Typical values are THRSH1 = −100 (dec); THRSH2 = +100; HYST1 = HYST2 = 200. Setting the hysteresis to the difference in the thresholds causes DOUT to latch ON if the current exceeds the threshold. The output can then be reset by via I²C or by cycling the sensor power.

If the field generated by the motor current exceeds the threshold, DOUT goes LOW, the isolator output also goes LOW, the MOSFET turns off, and power is removed from the load.

The SM228’s high sample rate ensures rapid detection of an overcurrent condition. But unlike shunt resistor-based circuits, there are virtually no losses associated with current sensing, and the controller can be electrically isolated from the motor for less noise and more safety.

An SM228 can also drive solid-state relays rather than the isolator and MOSFET in Figure 9. Relays are normally connected from DOUT to VDD to take advantage of the output’s high output sink capability. Relays with a three-volt “Must Turn On Voltage” and fairly high input impedance can be driven directly by the sensor output.
**Reciprocating Actuator**

A back-and-forth actuator can be constructed with just a single SM228 smart sensor, one magnet. No microprocessors are needed. The sensor’s digital threshold output is connected to the direction input of a stepper motor driver board, so the actuator motor reverses as the sensor turns on and off:

![Reciprocating Actuator Diagram](image)

**Figure 10. Reciprocating actuator using an SM228 smart sensor.**

The flexibility and wide range of the sensor’s digital threshold output makes it ideal for this application. For example, a 1 mT turn-on threshold with 0.9 mT hysteresis provides a 0.1 mT turn-off threshold and a distance of more than one inch (25 mm) between the turn-on and turn-off thresholds using a small rare-earth magnet. Using symmetrical thresholds ensures the control works with either magnet polarity.

The programmed thresholds are nonvolatile, so the sensor can be programmed once and then operated without a computer or microprocessor interface.
Illustrative Arduino / Trinket Code to Read Sensor Output Continuously

```c
#include <TinyWireM.h> // ATTiny85 I²C Master library
// Use Wire.h for Arduino and replace "TinyWireM." with "Wire."

int sensor, digit; // Sensor output; digit counter
void setup() {
    TinyWireM.begin();
}

void loop() {
    TinyWireM.requestFrom(36,2); // Request two bytes from I²C address 72 (36 = 72/2)
    sensor = TinyWireM.read()<<8; // Read sensor MSB
    sensor|=TinyWireM.read(); // Read sensor LSB

    // Display sensor output
    TinyWireM.beginTransmission(0x71); // Write to 7-segment display (I²C address 0x71)
    TinyWireM.write(0x76); // Clear display
    TinyWireM.write(0x77); // Set decimal point
    TinyWireM.write(0b010); // Displays xx.xxmT
    for(digit=1000; digit>0; digit/=10) { // Start at 1000s digit
        TinyWireM.write((sensor%(digit*10))/digit); // Scan through display digits
    }
    TinyWireM.endTransmission();
    delay(100); // 10 samples/second
```
Illustrative Arduino / Trinket Code to Set Digital Output Thresholds

```cpp
#include <TinyWireM.h> // ATTiny85 I²C Master library
// Use Wire.h for Arduino and replace "TinyWireM." with "Wire."

int sensor; // Sensor reading
char addr; // Sensor memory address
const int parameter[] = {
  // Sensor parameters starting at address 0x30:
  -1000, // Threshold 1 (-100 Oe / -10 mT)
  100,   // Hysteresis for Threshold 1 (10 Oe / 1mT)
  1000,  // Threshold 2 (100 Oe / 10 mT)
  100,   // Hysteresis for Threshold 2 (10 Oe / 1mT)
};

void setup() {
  TinyWireM.begin();
  for (addr = 0x10; addr <= 0x13; addr++) {
    // Threshold and hysteresis memory addresses
    // Write address
    TinyWireM.write(addr); // Address

    // Write parameter to sensor
    TinyWireM.write(parameter[addr-0x10]>>8); // parameter MSB
    TinyWireM.write(parameter[addr-0x10]&0xFF); // parameter LSB
    delay(20); // Delay 20 ms to allow writing to nonvolatile memory
  }
  // Next address
}
```
Evaluation Support

Breakout Board
The AG968-07E breakout board provides easy connections to an SM228-10E sensor with a six-pin connector. It also has the recommended 10 µF bypass capacitor:

![Breakout Board Image]

Figure 11. AG968-07E breakout board (actual size)
0.5" x 0.6" (12 mm x 15 mm)

Evaluation Kit
This simple evaluation board includes an SM228-10E Smart Magnetometer and a microcontroller that interfaces to the SM228 via PC and to a PC via USB.

The sensor can be activated with a magnet or an on-board current trace. A Windows-based user interface provides two-way communication with the sensor to display the sensor outputs and change sensor programmable parameters. A microcontroller PWM output on the board provides an analog representation of the measured field:

![Evaluation Kit Image]

Figure 12. AG969-07E: SM228 Smart Magnetometer Evaluation board
1" x 1.625" (25 mm x 41 mm)(actual size)

Socket Board
The AG954-07E provides a TDFN6 socket for easy interface to smart sensors such as the SM228-10E without soldering:

![Socket Board Image]

Figure 13. AG954-07E: TDFN socket board
1.5" x 2" (38 mm x 50 mm)(actual size)
# SM28 I²C Magnetometer

## 2.5 x 2.5 mm TDFN6 Package

<table>
<thead>
<tr>
<th>Pad</th>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SCL</td>
<td>PC Clock (input)</td>
</tr>
<tr>
<td>2</td>
<td>SDA</td>
<td>PC Data (bidirectional; open drain)</td>
</tr>
<tr>
<td>3</td>
<td>DOUT</td>
<td>Digital Output (CMOS output; default HIGH if field is above threshold)</td>
</tr>
<tr>
<td>4</td>
<td>GND</td>
<td>Ground/(V_{SS})</td>
</tr>
<tr>
<td>5</td>
<td>I2CADDR</td>
<td>PC address override (LOW-true input; read on power-up). Grounding this pin changes the PC address to 16 dec regardless of the programmed address. Open or HIGH invokes the PC address in nonvolatile memory.</td>
</tr>
<tr>
<td>6</td>
<td>VDD</td>
<td>Power Supply (bypass with a 10 (\mu)F capacitor)</td>
</tr>
</tbody>
</table>

Center pad Internal leadframe connection; connect to GND to minimize noise.

**Notes:**
- Dimensions in millimeters.
- Soldering profile per JEDEC J-STD-020C, MSL 1.

![Diagram of the TDFN6 package](image-url)
SM228 - 10E TR13

Product Family
SM = Product Family (Smart Magnetometers)

Base Part Number
2 = TMR element with 2-byte data
2 = Magnetic Orientation (cross-axis, i.e., sensitive to a field vector in the pin 2 / pin 5 direction)
8 = I²C Interface; Magnetic Field Linear Range 0 to 15 mT

Part Package
10E = RoHS-Compliant 2.5 x 2.5 mm TDFN6 Package

Bulk Packaging
TR13 = 13” Tape and Reel Package

Available Product Variants

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Linear Range</th>
<th>Accuracy</th>
<th>Interface</th>
<th>Breakout Board</th>
<th>Evaluation Kit</th>
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<td>SM225-10E</td>
<td>0 to 15 mT</td>
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<td>AG959-07E</td>
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## Revision History

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<td>SB-00-127-RevA</td>
<td>July 2020</td>
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<td>Initial release.</td>
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