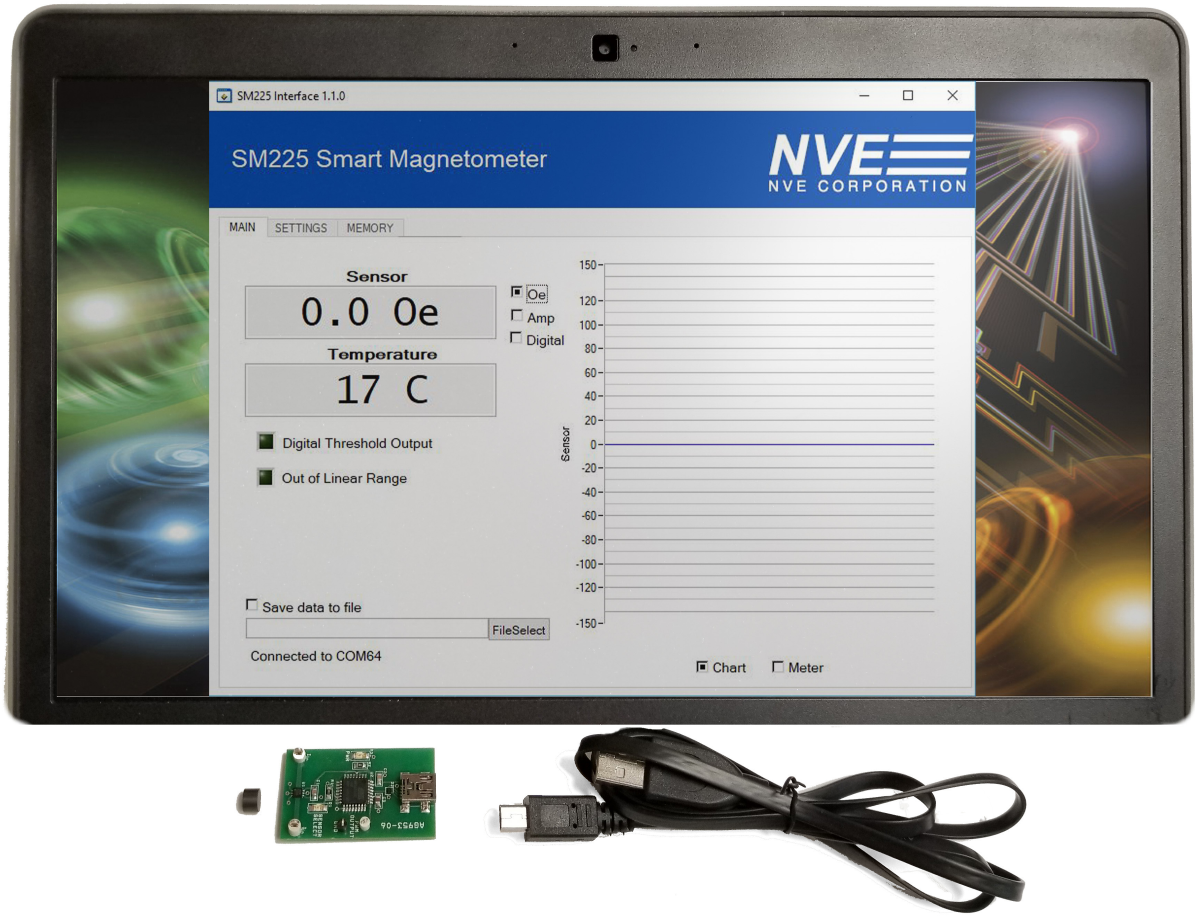
AG953: SM225 TMR SPI Smart Magnetometer Evaluation Board



Summary

The AG953 Evaluation Board provides a sophisticated user interface for the SM225-10E Smart Magnetometer. The evaluation kit includes:

- USB-powered Evaluation Board with:
  - an SM225-10E sensor
  - a microcontroller connected to the sensor via SPI
  - a regulated 3.3 volt supply to power the SM225-10E
  - a current-carrying trace under the sensor for evaluating as a current sensor

- A small ceramic magnet for evaluating as a proximity sensor
- USB cable to connect the Evaluation Board to a computer
- A powerful, intuitive graphical user interface

Contents

NVE Corporation 11409 Valley View Road, Eden Prairie, MN 55344-3617 Phone: (952) 829-9217 www.youtube.com/NveCorporation www.nve.com

1. Overview

This Evaluation Kit Includes:

- An evaluation board including:
  – An SM225-10E Smart Magnetometer
  – A microcontroller
  – A USB computer interface
  – A PWM analog output

- Easy to install Windows-compatible software and graphical user interface

- A disk magnet

- USB to mini-B cable

SM225-10E Features:

- Tunneling Magnetoresistance (TMR) for precision and low power
- SPI communication interface
- In-plane sensitivity—more usable than Hall effect sensors
- Factory calibrated
- Programmable offset and gain correction
- Internal temperature compensation
- Optional magnet temperature calibration
- 1.7 to 3.6V supply
- −40°C to 125°C operating range
- Ultraminiature 2.5 x 2.5 x 0.8 mm TDFN6 package

SM225-10E Key Specifications:

- Wide 0 to 150 Oe (0 to 15 mT) linear range
- ±2% of full-scale accuracy from 0 to 125°C
- ±4% of full-scale accuracy for −40°C to 125°C
- Fast 15000 samples per second update rate

2. Quick Start

2.1. Connect the Evaluation Board to a computer via the USB cable.

2.2. Download the AG953 software from our GitHub repository (https://github.com/NveCorporation).

2.3. Install the software and launch the application.

2.4. The user interface will show the applied field, which can be changed by moving a magnet relative to the sensor:

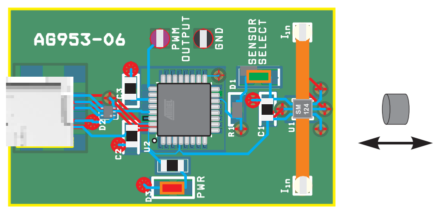


Figure 1. Measuring the field from a magnet with the SM225 Evaluation Board.

3. The Evaluation Board

3.1Board Layout

The evaluation board communicates with a host computer via USB and a Smart Magnetometer via SPI:

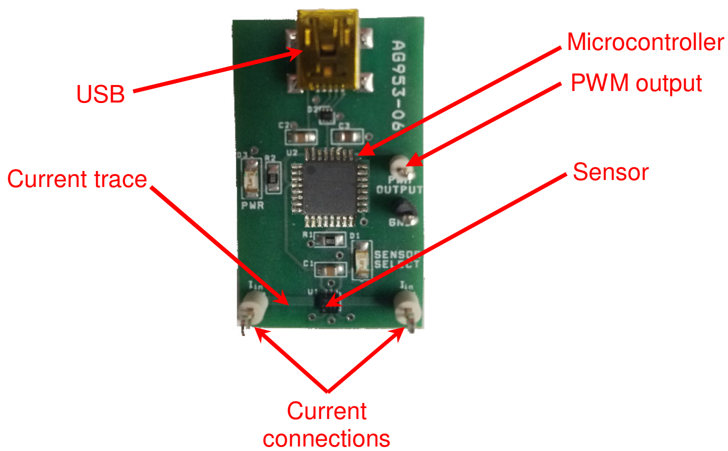


Figure 2. The Evaluation Board (actual size).

Part Number	Designator	Manufacturer	Qty	Description
				Board-Level Components
SM225-10E	U1	NVE	1	SMART TMR SPI MAGNETOMETER SENSOR
ATMEGA16U2-AU	U2	Microchip Technology	1	IC MCU 8BIT 16KB FLASH 32TQFP
APT3216LZGCK	D1	Kingbright	1	LED GREEN CLEAR 1206 SMD
APT3216LSECK	D3	Kingbright	1	LED RED CLEAR 1206 SMD
	R1, R2	Generic	1	RES 3K OHM 1% 1/4W 0805
TPD2E001DRLR	D2	Texas Instruments	1	TVS DIODE 5.5V SOT5
885012207016	C2	Wurth Electronics Inc.	2	CAP CER 0.1UF 10V X7R 0805
GRM21BR71C105KA01I	C1, C3	Murata Electronics North An	1	CAP CER 1UF 16V X7R 0805
690-005-299-043	J1	EDAC Inc.	1	CONN MINI USB RCPT RA TYPE B SMD
500x	3.3V, GND, PWM_OUT	Keystone Electronics	3	TEST POINT PC MINI .040"D
5007	Iin	Keystone Electronics	2	TEST POINT PC COMPACT .063"D WHT
				Package-Level Components
12216	N/A	NVE	1	6 MM DIA. X 4 MM THICK DISK MAGNET
	N/A	Generic	1	3ft FLAT USB 2.0 480Mbps Type A Male to Mini

3.2 Schematic

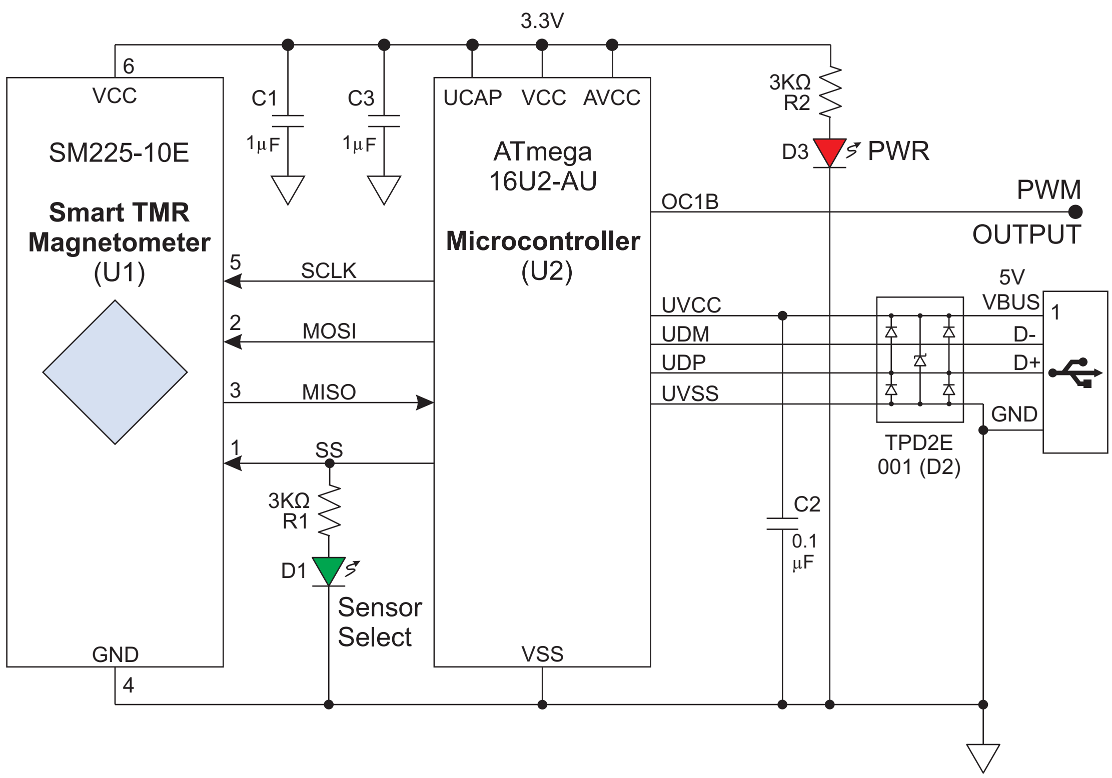


Figure 3. Evaluation Board Schematic.

3.3 Circuit Description

The Sensor

The SM225 (U1) has six pins: power (VDD and GND) and SPI (SCLK, MOSI, MISO, and SS).

Microcontroller

The SM225 is compatible with almost any microcontroller. This board uses a popular ATMEGA16U2 8-bit microcontroller (U2), which has integrated SPI and USB interfaces. The microcontroller also has an internal 3.3-volt regulator, which is used to power the board.

SPI

SPI links the sensor and microcontroller. The SM225 is an SPI Slave, and the microcontroller is configured as the Master. The SM225 SPI interface is compatible with 3.3 or five-volt microcontrollers. The evaluation board uses 3.3 volts for both the sensor and microcontroller. In accordance with industry standards, the SM225 SCLK, MOSI, and SS lines are open-drain, and the microcontroller's internal pull-up resistors are activated in software. When external pull-ups are used with different power supplies, they should be connected to the lower supply voltage.

PWM Analog Output

A PWM output from the microcontroller tracks the field measured by the sensor, and can be connected to a multimeter or data acquisition system. The output is scaled to 0.01 volts/oersted, or 1.5 volts at the full 150 Oe linear range. The output is ratiometric with the 3.3 V regulated supply. Note that the PWM output is from the microcontroller, not directly from the sensor.

USB Interface

The microcontroller has an integrated USB UART. A Transient Voltage Suppressor (D2) protects the microcontroller.

Current-Sensing Trace

The board has a current trace under the sensor IC (I_{in} connections) for evaluating the magnetometer as a current sensor. The trace is 0.05 inches (1.3 mm) wide and one-ounce copper, and can carry up to seven amps with a safe temperature rise.

The sensor can be sensitive to the fields generated by clip leads, so for precise measurements the lead positioning should be fixed, and ideally at right angles to the trace to minimize their effect on the sensor.

LEDs

Red LED D3 shows the sensor is powered, indicating the board is connected to a powered USB port, and that the microcontroller power supply is operating.

Green LED D1 indicates the sensor is selected as a slave.

Decoupling Capacitors

The board has 1µF decoupling capacitors (C1 and C3) as recommended for the sensor and the microcontroller. There is also a 0.1µF decoupling capacitor (C2) as recommended for the USB bus supply.

4. Magnets and Magnetic Operation

The Evaluation Kit includes a popular ferrite disk magnet. The magnetic field from the magnet at the center of the sensor is shown in this graph:

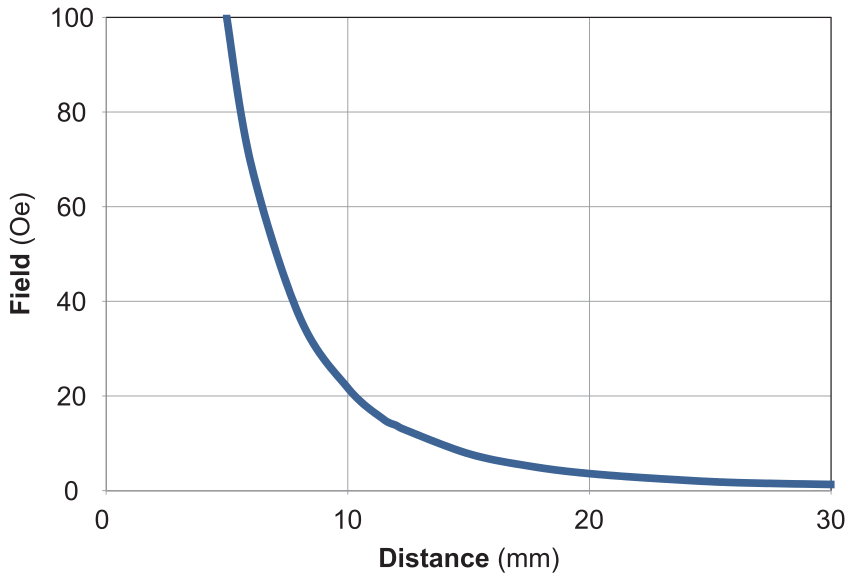


Figure 4. Magnetic field from the 6 mm dia. x 4 mm thick ferrite magnet
(referenced to the center of the sensor).

Larger and stronger magnets allow farther operate and release distances. For more calculations, use our axial disc magnetic field versus distance Web application at:

www.nve.com/spec/calculators.php#tabs-Axial-Disc-Magnet-Field.

4.1 Magnetic Thresholds
Typical thresholds for proximity sensing with the magnet included in the kit are shown in the following table:

Magnetic Threshold	Magnet Distance
100 Oe*	5 mm
20 Oe	10 mm
5 Oe	18 mm
2 Oe	24 mm

*Factory default

Table 1. Typical magnetic thresholds.

4.2. Magnet Temperature Compensation
In addition to sensor element temperature compensation, outputs are available that also compensate for the decrease in magnet strength at higher temperatures. Two corrections are calculated: one for low-cost ferrite magnets and another for high field rare-earth magnets.

5. Current Sensing

SM225-10E sensors can measure the current through a circuit board trace by detecting the magnetic field generated by the current through the trace this application. The digital output can be used for current threshold detection or overcurrent protection.

The evaluation board includes a current-sensing trace:

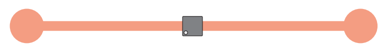


Figure 5. Current trace (top view).

The board trace is on the top side of the circuit board for high current sensitivity, but traces can also be run on the bottom side of the PCB for higher currents. The magnetic field generated in either case can be approximated by Ampere's law:

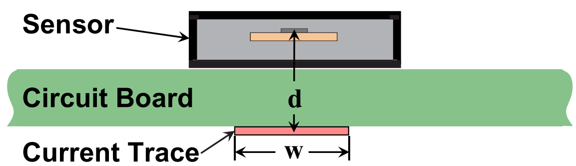


Figure 6. Current-sensing over a circuit board trace (side view).

$$H = \frac{2I}{d}$$ ["H" in oersteds, "I" in amps, and "d" in millimeters]

For the trace on the top of the circuit board, "d" is the distance from the bottom of the sensor package to the sensor element, which is 0.7 millimeters. The field is therefore approximately 3 Oe/A, and is usable up to the seven amp maximum trace current.

Typical overcurrent thresholds are summarized in the following table:

Magnetic Threshold	Current Threshold
20 Oe	7 A
10 Oe	3.5 A
3 Oe	1 A

Table 2. Typical overcurrent detection settings.

6. User Interface Software Installation

6.1 System Requirements

The software system requirements are:

- Windows 7 or later
- 100 MB system memory
- One USB 2.0 port

6.2 Software Installation

6.2.1. Download the software installation executable from ***https://github.com/NveCorporation*****.**

6.2.2. Run the executable to begin installation.

6.2.3. Follow prompts for installing the NVE software and supporting National Instruments files.

6.3 USB driver installation

6.3.1. Disconnect any AG953 boards from the PC.

6.3.2. Locate the USB driver *NVESmartSensor.inf* in the "*C:\Program Files (x86)\NVE"* folder.

6.3.3. Right click on *NVESmartSensor.inf* and click "Install."

6.3.4. Restart the computer to complete the installation.

6.3.5. Connect the AG953 board to a USB port.

6.3.6. The connection can be verified by checking for "NVE Smart Sensor" under "Ports (COM & LPT)" in the Device Manager.

7. User Interface Operation

The User Interface allows reading sensor data, setting the digital output threshold, and reading and writing the nonvolatile sensor calibration constants.

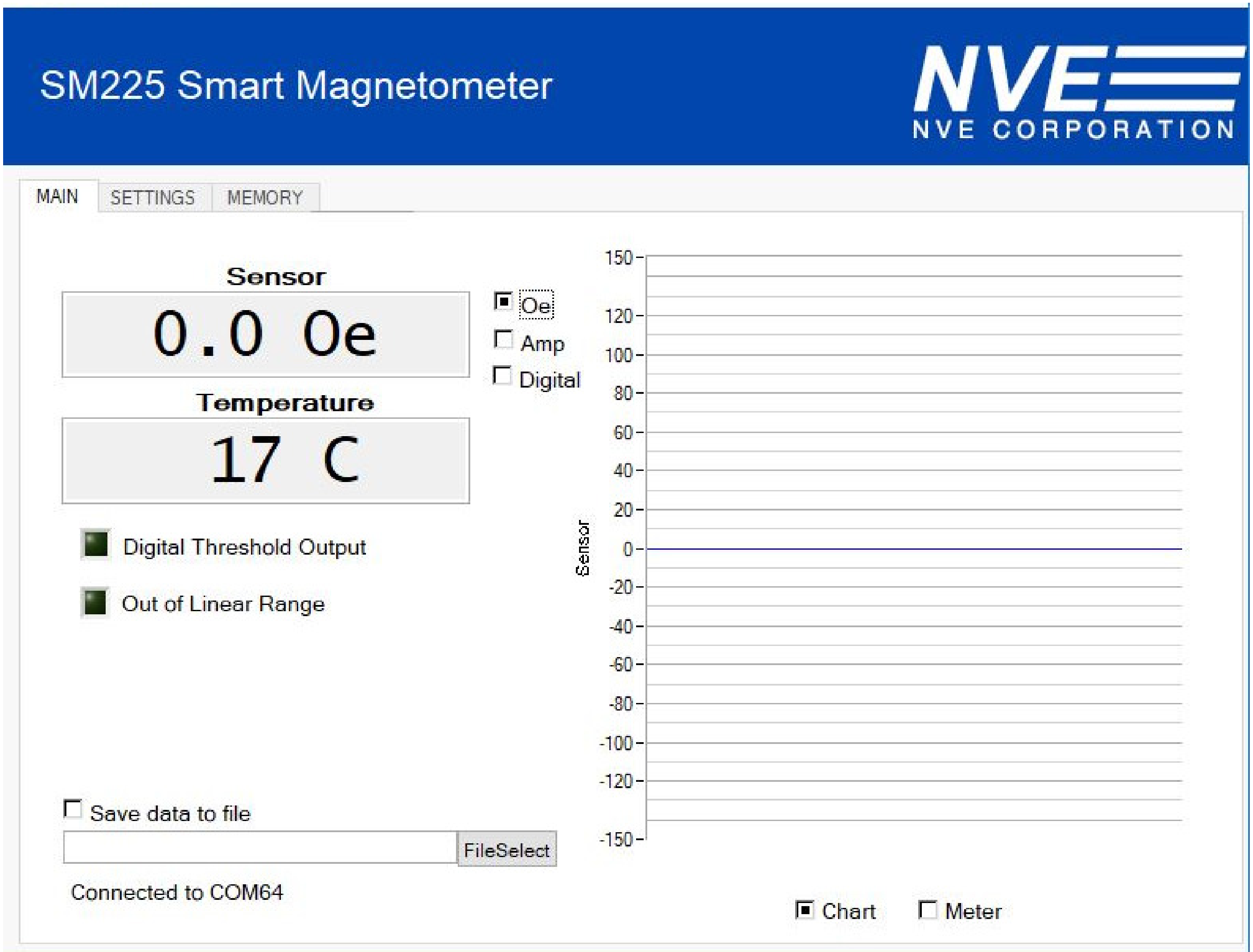
After starting the application, a single window with three tabbed panels is displayed. The three tabs are:

1. Main – Displays measurement results in both digital and graphical formats.

2. Settings – A graphical interface to change the digital output threshold, hysteresis, offset, and digital filter constant. Parameters are changed by entering a number and hitting “Enter.” This tab also allows for changes in the output type. To change between omnipolar, unipolar, and bipolar digital outputs press either the desired image or the corresponding radio button.

3. Memory – A table shows the sensor’s data and calibration constants. Parameters can be changed by double-clicking on the appropriate cell, typing a new number, and then hitting “Enter.”

7.1. Main Tab



Main tab elements are described below:

Sensor – Displays the output of the device in either Oersteds, Amps, or the sensor's integer digital output as selected by the radio buttons. Double right-clicking the display changes the precision.

Temperature – Displays the calibrated temperature from the sensor in degrees Celsius.

Digital Threshold Output – A virtual LED turns on when the sensor's virtual comparator is HIGH. The threshold, hysteresis, and configuration can be set in the Settings Tab.

Out of Linear Range – Warns that the sensor field exceeds its linear range, so the reading may be inaccurate.

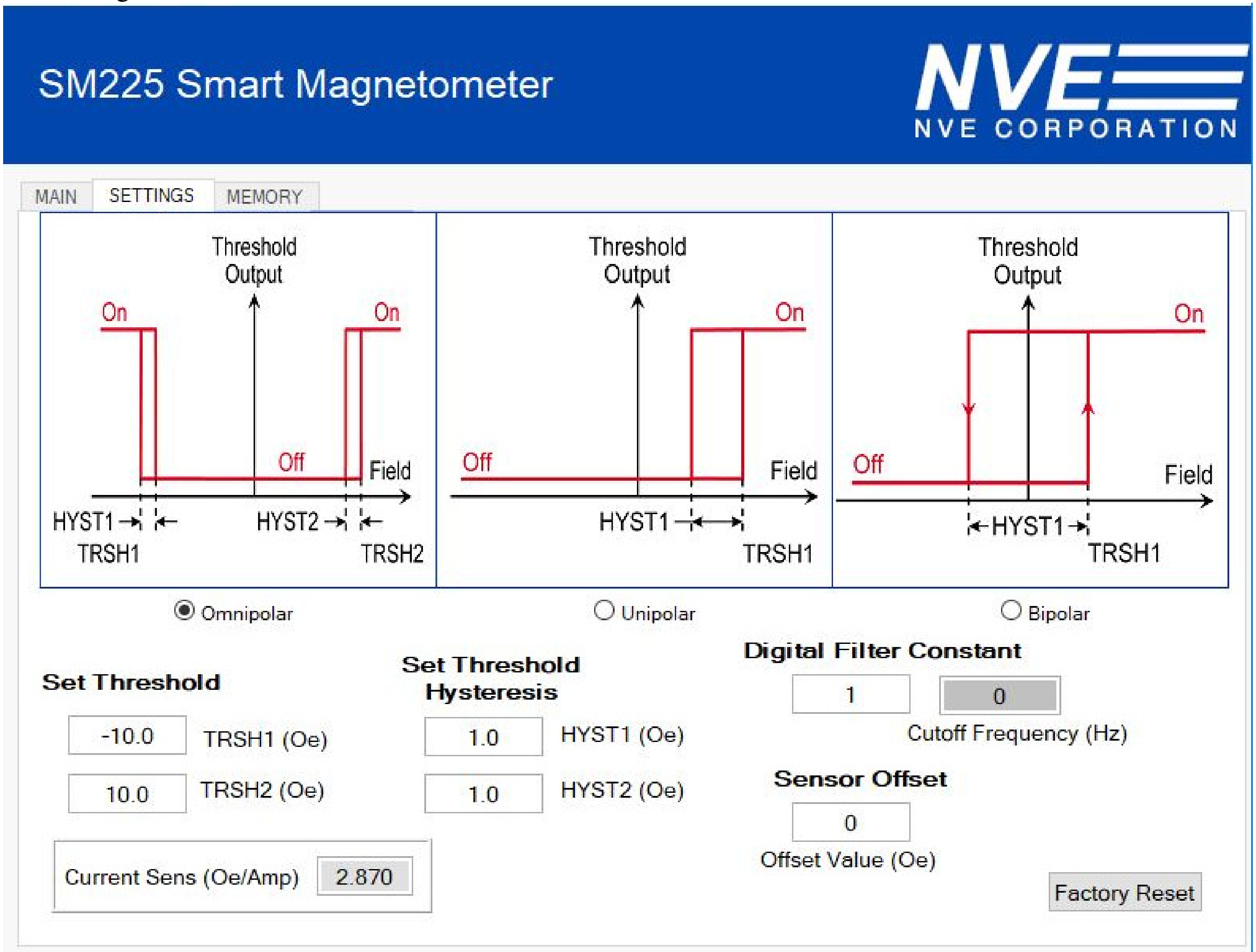
Chart – Displays a "strip chart" on right side of the tab showing the measurement on the y-axis. The chart is updated with each measurement.

Meter – Displays a virtual meter on the right side of the tab.

Save Data to File – Checking this box saves the datapoints to a file chosen under the *File Select* button.

File Select – Opens a pop-up window to select the data file.

7.2. Settings Tab



Omnipolar (the default configuration) – The output turns on when the magnitude of a field of either polarity exceeds the threshold. The field can be. Uses both TRSH and both HYST parameters.

Unipolar –The output turns on when one pole is applied, and turns off when the field is reduced or reversed. Only requires TRSH1 and HYST1; HYST1 < |TRSH1|.

Bipolar – The output will turn on when the field exceeds the threshold and off with the opposite field. Only requires TRSH1 and HYST1; HYST1 > |TRSH1|.

Sensor Offset –Sets the sensor offset, which can be used to zero background magnetic fields.

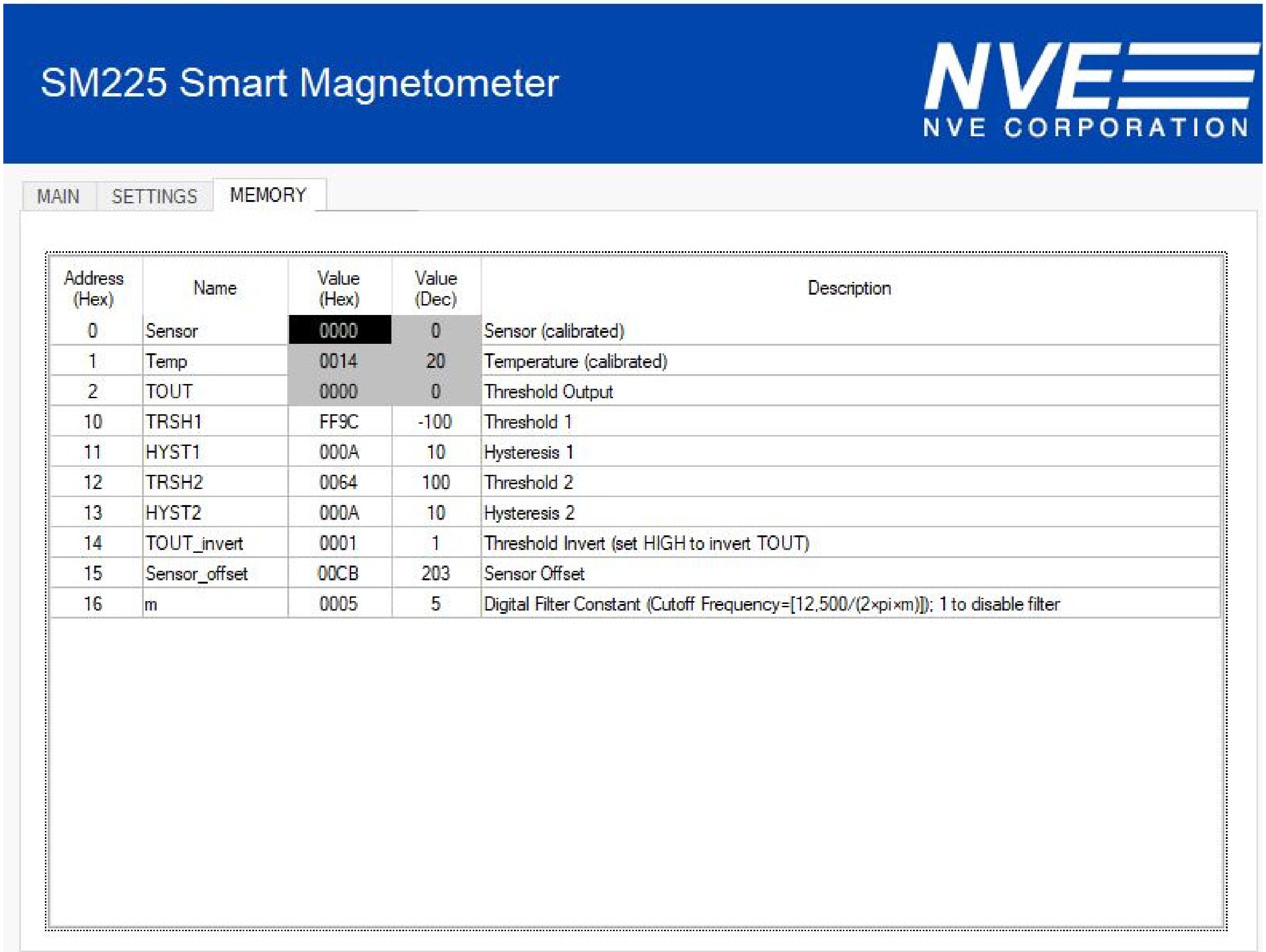
Factory Reset – Sets the calibration constants back to the factory defaults.

Set Threshold – Sets the sensor's digital output (DOUT) turn-on threshold.

Set Threshold Hysteresis – Used to change the magnetic threshold differential located in the nonvolatile memory. The digital output will turn off at *Threshold – Hysteresis.*

Digital Filter Constant – Sets the filter constant which will change the cutoff frequency of the internal filter. The cutoff frequency will be updated and displayed to the right.

7.3. Memory Tab



Address (Hex)	Name	Value (Hex)	Value (Dec)	Description
0	Sensor	0000	0	Sensor (calibrated)
1	Temp	0014	20	Temperature (calibrated)
2	TOUT	0000	0	Threshold Output
10	TRSH1	FF9C	-100	Threshold 1
11	HYST1	000A	10	Hysteresis 1
12	TRSH2	0064	100	Threshold 2
13	HYST2	000A	10	Hysteresis 2
14	TOUT_invert	0001	1	Threshold Invert (set HIGH to invert TOUT)
15	Sensor_offset	00CB	203	Sensor Offset
16	m	0005	5	Digital Filter Constant (Cutoff Frequency=[12,500/(2×pi×m)]); 1 to disable filter

This tab allows direct access to the sensor's internal memory. Data and parameters are two-byte signed integers.

***Notes*:**

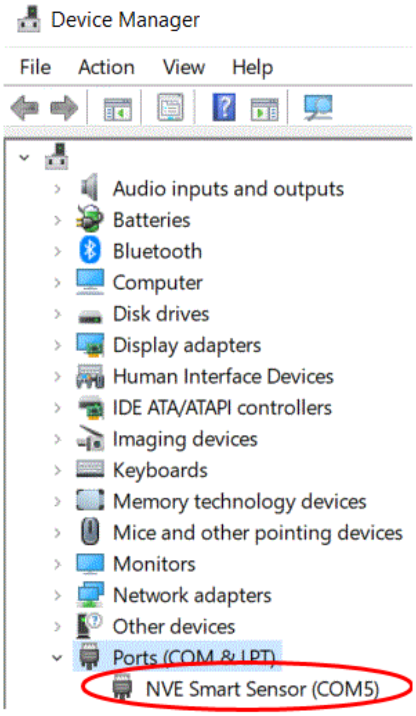
- Calibration constants are set at the factory and vary from part to part.

- The factory default for the digital filter constant in memory location 16 (hex) is "1" (disabled). For demonstration purposes, the user interface invokes a filter constant.

8. Troubleshooting

No communications

1. Check the USB cable.
2. Verify the USB port under Windows Device Manager:



3. Reinstall the USB driver.

9. Revision History

SB-00-080-A	**Change**
June 2019	• Initial Release

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NVE Corporation
11409 Valley View Road
Eden Prairie, MN 55344-3617 USA
Telephone: (952) 829-9217
www.nve.com
e-mail: sensor-info@nve.com

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