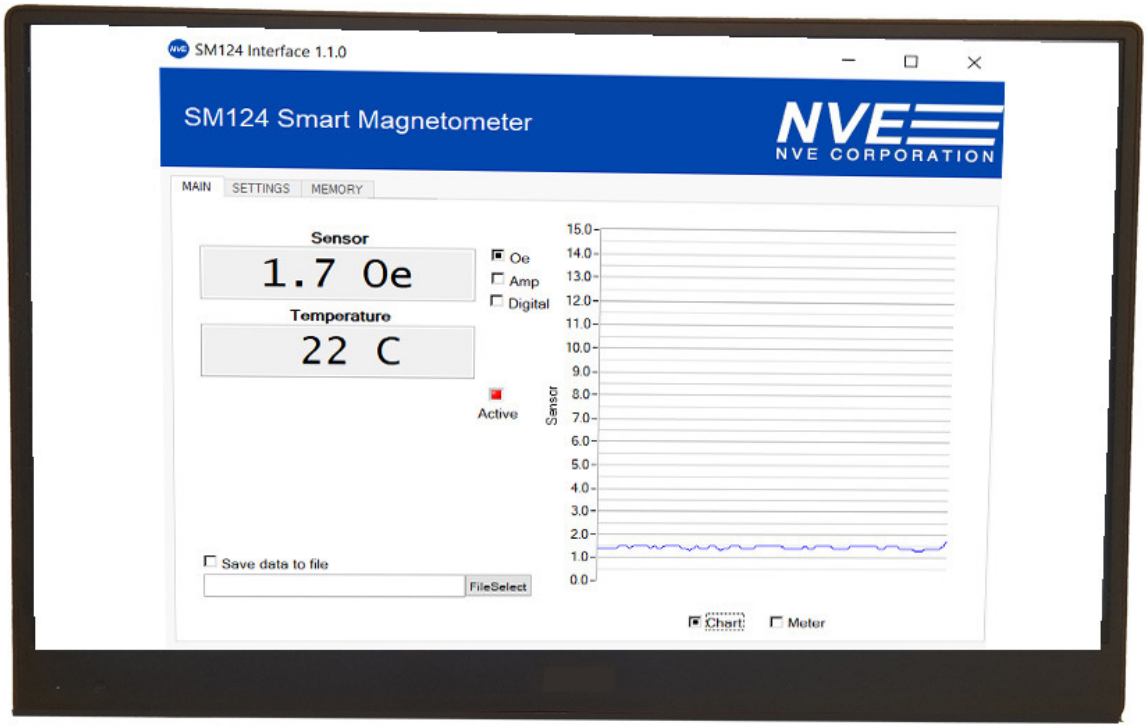
AG952: SM124 Smart I²C GMR Magnetometer Evaluation Board



Summary

The AG952 Evaluation Board provides an easy-to-use interface for the SM124-10E Smart Magnetometer. The evaluation kit includes:

- USB-powered Evaluation Board with:
  - an SM124-10E GMR Magnetometer sensor
  - a microcontroller connected to the sensor via I²C
  - a regulated 3.3 volt supply to power the SM124-10E
  - 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
- User interface software (download from *https://github.com/NveCorporation*)

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1. Overview

This Evaluation Kit Includes:

- An evaluation board including:
  – An SM124-10E Smart Magnetometer
  – A microcontroller
  – A USB computer interface

- Easy to install Windows-compatible user interface software via a GitHub repository

- A disk magnet.

- USB to mini-B cable

SM124-10E Features:

- Can detect magnets more than 50 mm away
- Slick single-byte communication interface
- I²C and digital threshold outputs
- In-plane sensitivity more usable than Hall effect sensors
- Programmable offset and gain correction
- Single-byte addresses and parameters to simplify firmware development
- Two hardware selectable I²C addresses
- Internal temperature compensation
- Optional magnet temperature calibration
- 2.2 to 3.6V supply
- 3.3 or 5V compatible I²C interface
- Ultraminiature 2.5 x 2.5 x 0.8 mm TDFN6 package

SM124-10E Key Specifications:

- 0 to 10 Oe (1 mT) range for high sensitivity
- High accuracy (5% over 0 to 85°C)
- 8 bit (<1%) output resolution
- 10 kSps sample rate for fast response
- Full –40°C to +125°C operating temperature range
- 6 mA typical supply current for low power

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2. Quick Start

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

2.2. Apply a magnetic field with the disk magnet included in the kit and verify that the LED turns on:

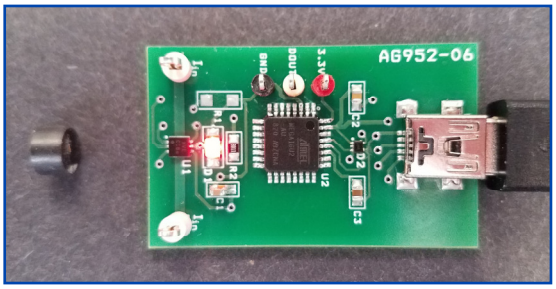

Figure 1. Activating the SM124 sensor with a disk magnet.

2.2. Download the AG952 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 the magnet relative to the sensor.

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3. The Evaluation Board

3.1 Board Layout

The evaluation board communicates with a host computer via USB and a Smart Magnetometer via I²C:

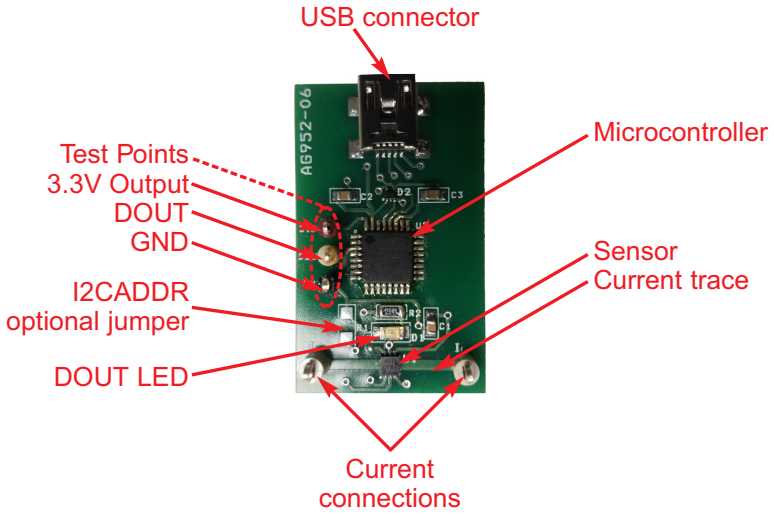

Figure 2. The Evaluation Board (actual size).

Part Number	Designator	Manufacturer	Qty	Description
		Board-Level Components		
SM124-10E	U1	NVE Corporation	1	SMART MAGNETOMETER SENSOR, 15 OE
ATMEGA16U2-AU	U2	Microchip Technology	1	IC MCU 8BIT 16KB FLASH 32TQFP
APT3216LSECK/J3-PRV	D1	Kingbright	1	LED RED CLEAR 1206 SMD
1206	R1	Generic	1	0-OHM JUMPER (DNP)
0805	R2	Generic	1	RES 3K OHM 1% 1/4W 0805
TPD2E001DRLR	D2	Texas Instruments	1	TVS DIODE 5.5V SOT5
885012207016	C1, C2	Wurth Electronics Inc.	2	CAP CER 0.1UF 10V X7R 0805
GRM21BR71C105KA01I	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, DOUT	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 Corporation	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-B/5-Pin Male Ca

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3.2 Schematic

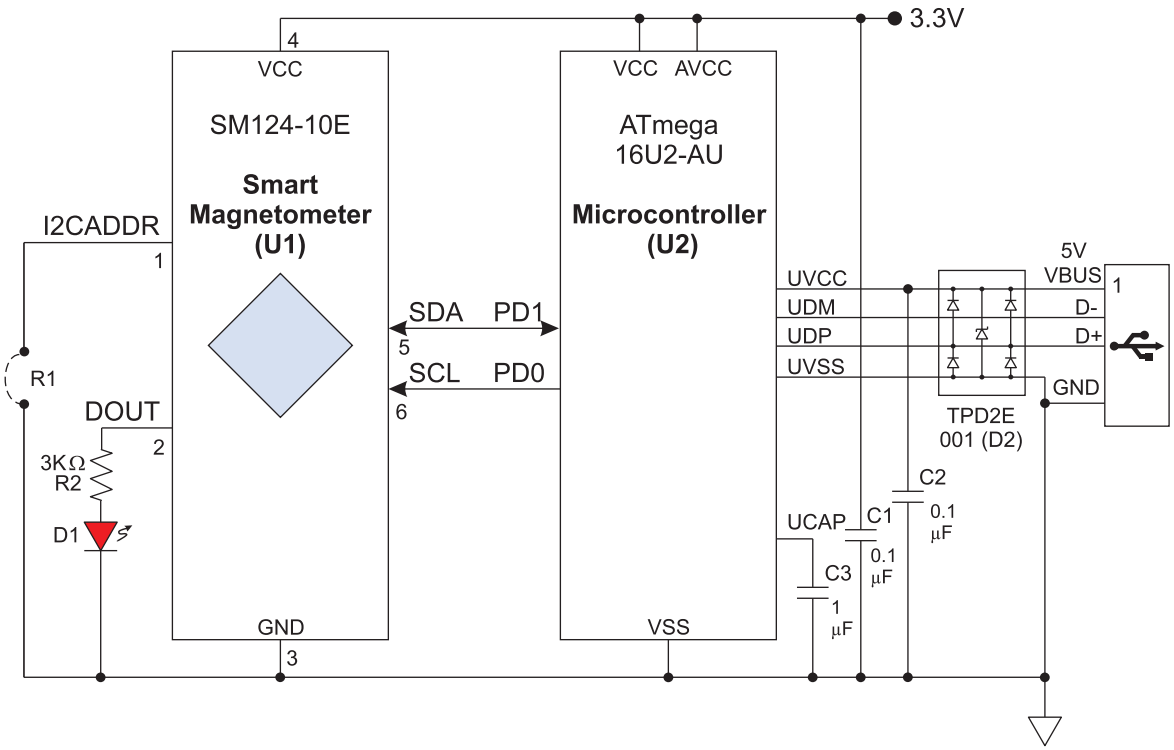

Figure 3. Evaluation Board Schematic.

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3.3 Circuit Description

The Sensor

The SM124 (U1) is a six-pin component, with power (VDD and GND); I²C (SCL and SDA), the DOUT digital threshold output, and the I2CADDR pin to set the part's slave address.

Microcontroller

The SM124 is compatible with any microcontroller. This evaluation board uses a popular ATMEGA16U2 8-bit microcontroller (U2), which has integrated I²C and USB interfaces.

The microcontroller also has an internal 3.3-volt regulator, which is used to power the sensor.

I²C

I²C links the sensor and microcontroller. The SM124 is an I²C Slave, and the microcontroller is configured as the Master. The SM124 I²C interface is compatible with 3.3 or five-volt microcontrollers. The evaluation board uses 3.3 volts for both the sensor and five-volts for the microcontroller.

Setting the I²C Address

By default, the I2CADDR line is left unconnected (R1 unpopulated) and the default I²C address is then 72 dec (48 hex). Installing a jumper (R1) to ground change s the sensor's I²C to 16 dec (10 hex).

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 5 amps with a safe temperature rise.

LED

Red LED D1 shows when the digital output (DOUT) is activated. A resistor (R2) sets the LED brightness.

Decoupling Capacitors

The board has 0.1 µF decoupling capacitors (C1 and C2) as recommended for the sensor and USB bus supply, and a 1 µF decoupling capacitor (C3) as recommended for the microcontroller's internal 3.3-volt regulator.

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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:

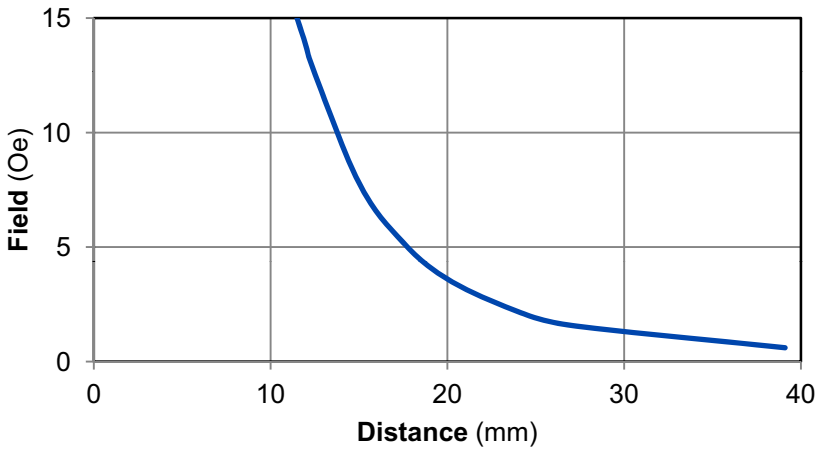

Figure 4. Magnetic field from the 6 mm dia. x 4 mm thick ferrite magnet (referenced to the center of the sensor).

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

The default magnetic threshold is 10 Oe, and common thresholds are 4 to 10 Oe. Thresholds even lower than 4 Oe can be programmed, although care must be taken to account for the earth's magnetic field, which is typically on the order of 0.5 Oe.

The magnetic threshold is expressed as a percentage of the sensor's range, and can be changed by writing to the appropriate address in the sensor's nonvolatile memory. The magnetic hysteresis can also be set.

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

Parameter		Activation field	Nominal magnet distance
Threshold	Hysteresis		
100%*	10%*	13 Oe	12.5 mm
50%	5%	5 Oe	18 mm
20%	2%	2 Oe	24 mm

*Factory defaults

Table 1. Typical proximity-sensing settings.

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4.2 Temperature Compensation

The sensor is factory calibrated and temperature compensated to accurately read magnetic field over temperature. The default reading is the temperature-compensated number. The uncompensated output can be read from a different address.

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5. Current Sensing

SM124-10E 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:

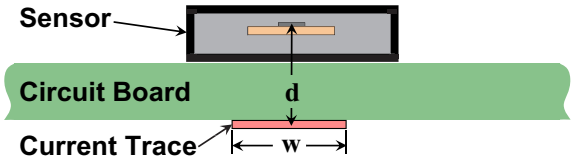

Figure 6. Current-sensing over a circuit board trace (side view).

$$H = \frac{2I}{d}$$ ["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 linear to approximately 10 Oe or 3.5A.

Typical parameters for overcurrent sensing are summarized in the following table:

Parameter		Current Threshold	
Threshold	**Hysteresis**	**On**	**Off**
100%	90%	3.5 A	0.35 A
30%	27%	1 A	0.1 A
15%	5%	0.5 A	0.35 A

Table 2. Typical overcurrent detection settings.

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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 package from ***https://github.com/NveCorporation***

6.2.2. Run ***setup.exe*** to begin installation.

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

6.3 USB driver installation

6.3.1. Disconnect any AG952 boards connected to the PC.

6.3.2. Locate the USB driver ***NVESmartSensor.inf*** in the ***drivers*** folder of the installation package.

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 AG952 board to a USB port.

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

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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 and its hysteresis.

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

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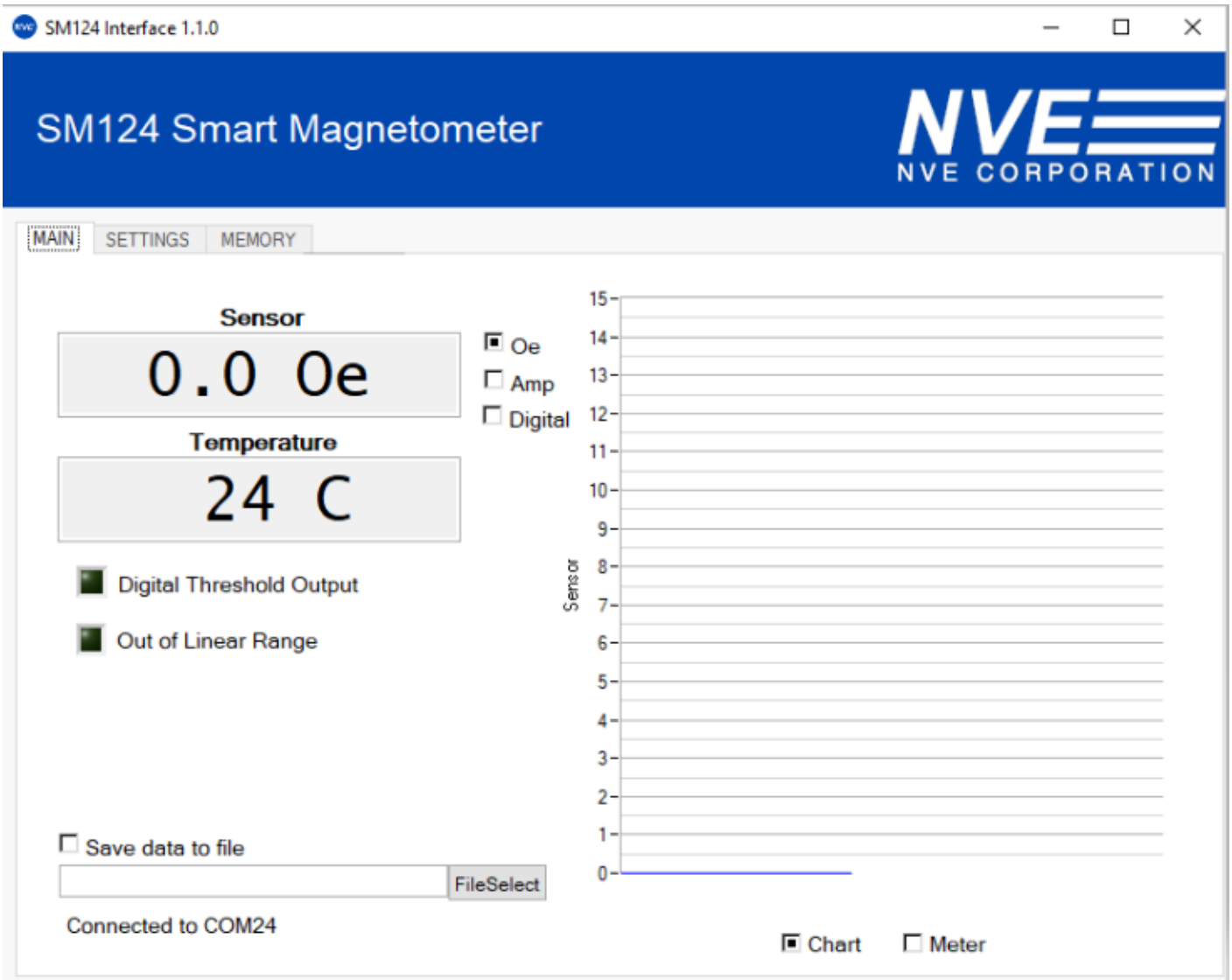
7.1. Main Tab



Main tab elements are described below:

Upper Digital Display – Displays the output of the device in either Oersteds or Amps. Double right-clicking on the display changes the precision.

Lower Digital Display – Displays the calibrated temperature from the sensor in degrees Celsius.

Oe – Sets upper display to Oersteds.

Amp – Sets the upper display to Amps.

Digital – Sets the upper and lower displays to either hexadecimal or decimal.

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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.

Digital Threshold Output – A virtual LED turns on when the sensor reading is above the threshold. The threshold and hysteresis can be set in the Settings Tab.

Out of Linear Range – Indicates the magnetic field exceeds the sensor's linear range.

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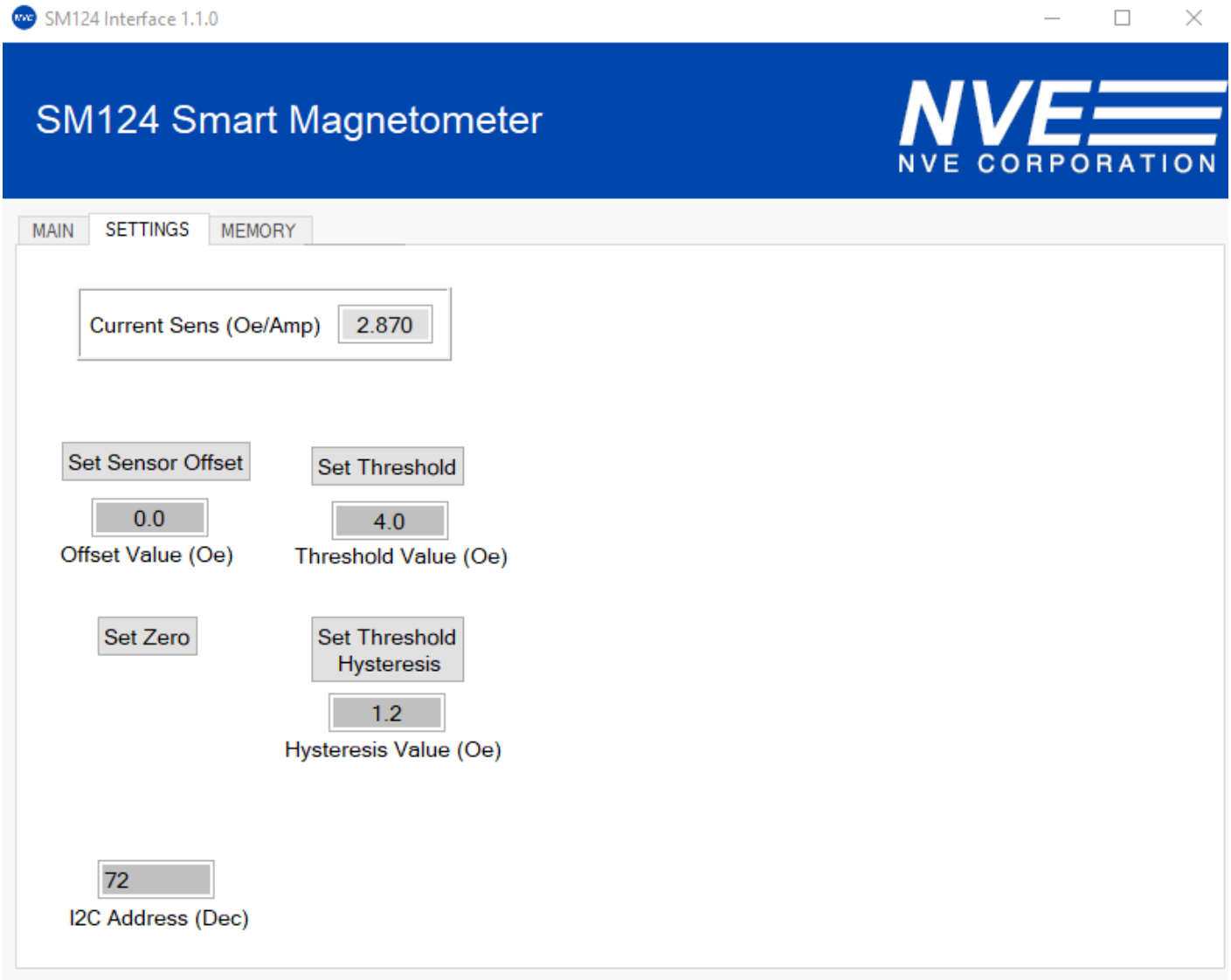
7.2. Settings Tab



Set Sensor Offset – This button sets the sensor offset, which is useful for zeroing out background magnetic fields.

Set Zero – Sets the sensor offset to the present sensor output.

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.*

I2C Address – The sensor's I²C slave address in decimal format.

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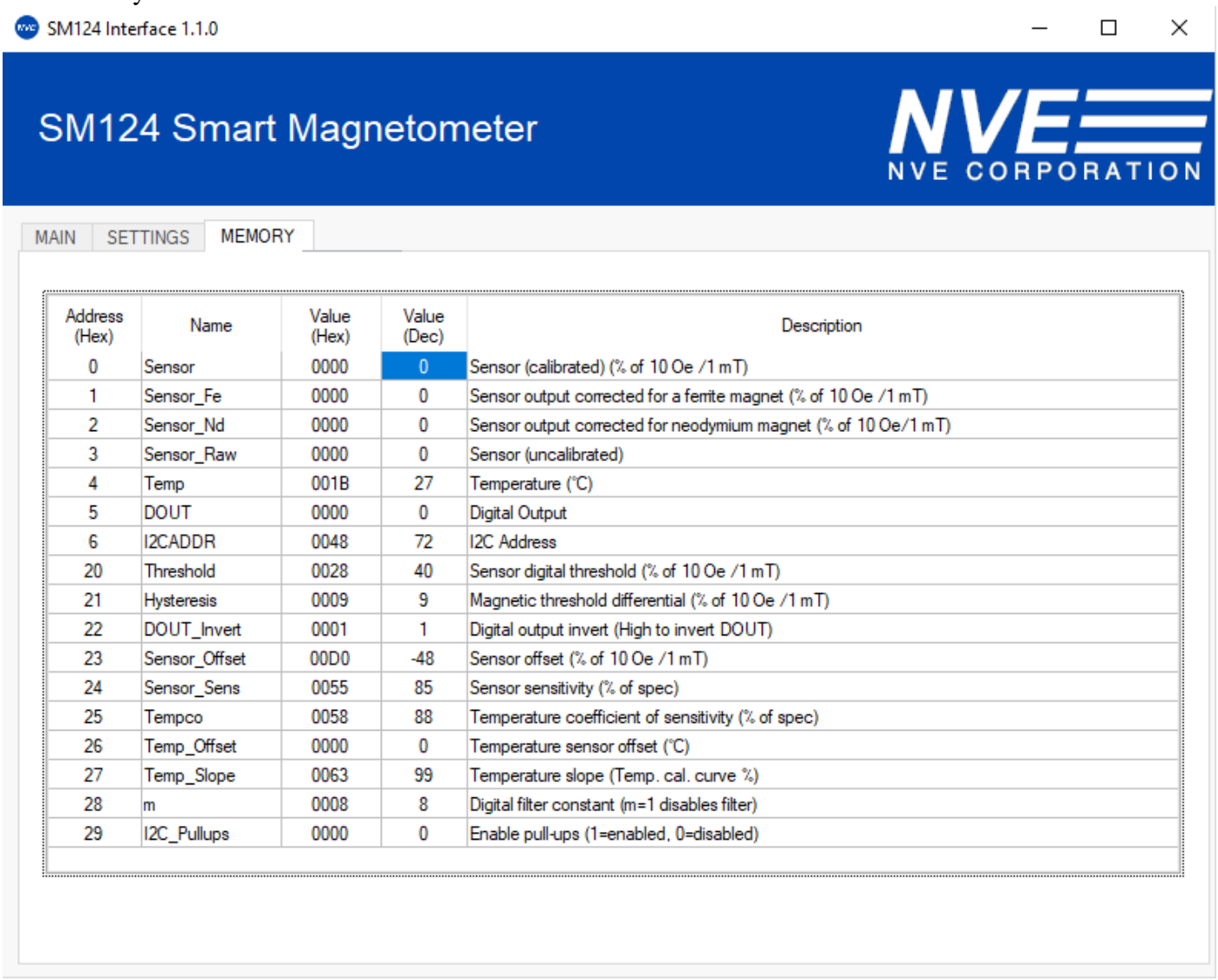
7.3. Memory Tab



Address (Hex)	Name	Value (Hex)	Value (Dec)	Description
0	Sensor	0000	0	Sensor (calibrated) (% of 10 Oe /1 mT)
1	Sensor_Fe	0000	0	Sensor output corrected for a ferrite magnet (% of 10 Oe /1 mT)
2	Sensor_Nd	0000	0	Sensor output corrected for neodymium magnet (% of 10 Oe/1 mT)
3	Sensor_Raw	0000	0	Sensor (uncalibrated)
4	Temp	001B	27	Temperature (°C)
5	DOUT	0000	0	Digital Output
6	I2CADDR	0048	72	I2C Address
20	Threshold	0028	40	Sensor digital threshold (% of 10 Oe /1 mT)
21	Hysteresis	0009	9	Magnetic threshold differential (% of 10 Oe /1 mT)
22	DOUT_Invert	0001	1	Digital output invert (High to invert DOUT)
23	Sensor_Offset	00D0	-48	Sensor offset (% of 10 Oe /1 mT)
24	Sensor_Sens	0055	85	Sensor sensitivity (% of spec)
25	Tempco	0058	88	Temperature coefficient of sensitivity (% of spec)
26	Temp_Offset	0000	0	Temperature sensor offset (°C)
27	Temp_Slope	0063	99	Temperature slope (Temp. cal. curve %)
28	m	0008	8	Digital filter constant (m=1 disables filter)
29	I2C_Pullups	0000	0	Enable pull-ups (1=enabled, 0=disabled)

***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 28 (hex) is “1” (disabled). For demonstration purposes, the user interface invokes a filter constant.

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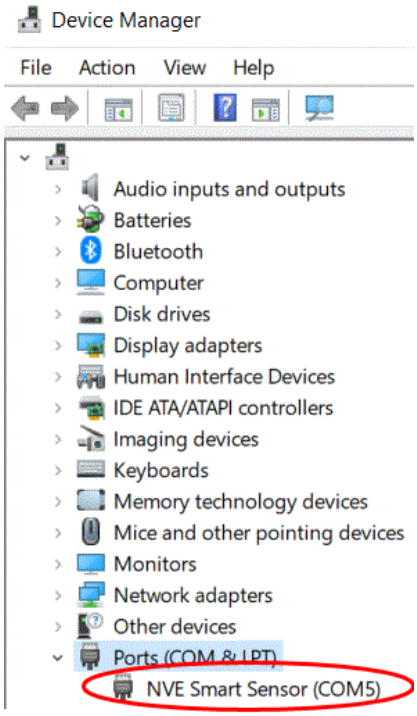
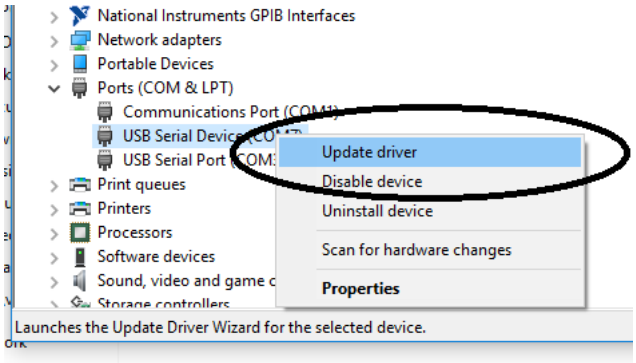
8. Troubleshooting

1. No communications
   - Basic Steps
     1. Check the USB cable.
     2. Verify the USB port under Windows Device Manager:



     3. Reinstall the USB driver.
   - Manually set the driver
     1. Use Windows Device Manager to determine how the evaluation board USB is configured.

     2a. If the board appears as “USB Serial Device”:
       - Right click, “Update Driver”



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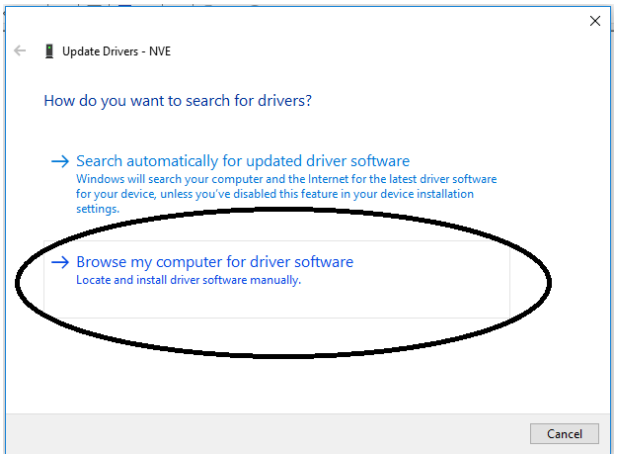
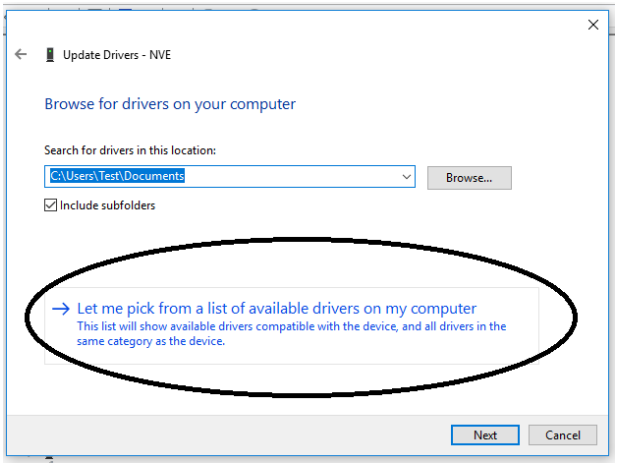
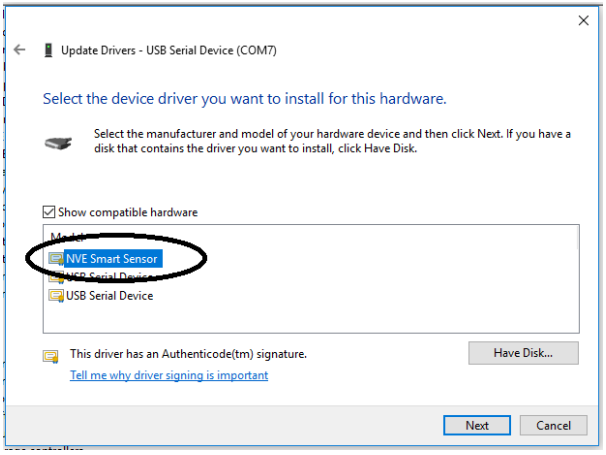
- Choose “Browse my computer for driver software”:



- Choose “Let me pick from a list of available drivers on my computer”:



- Select “NVE Smart Sensor”



2b. If the device does not appear as a “USB Serial Device”:

- Right click “Update Driver.”
- Choose “Browse my computer for driver software.”
- Choose “Let me pick from a list of available drivers on my computer.”
- Select “USB Serial Device.”
- Go to step 2.

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9. Revision History

SB-00-076-A December 2018	**Change** • 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