METROlab

*Magnetic precision has a name*

# Three-axis Hall Magnetometer THM1176

## User's Manual

**Version 1.3**

**(Revision 1.1)**

**April 2012**

# REVISION HISTORY

| | | |
|---|---|---|
| v. 1.0 r. 1.0 | May 2008 | First release |
| v. 1.0 r. 1.1 | May 2008 | Various fixes |
| v. 1.1 r. 1.0 | July 2008 | Various fixes |
| v. 1.2 r. 1.0 | December 2009 | Updates for version 3.x of software<br>Updates for version 2.x of firmware<br>Updates for THM1176-LF<br>Various fixes |
| v. 1.2 r. 1.1 | February 2010 | Add notice concerning WEEE Directive |
| v. 1.2 r. 1.2 | July 2010 | Restore formatting of -HF dimensions |
| v. 1.3 r. 1.0 | January 2012 | Update for software release 4.0 and firmware release 3.0<br>Update links for external documentation<br>Add documentation for THM1176-HFC |
| v. 1.3 r. 1.1 | April 2012 | Correct installation procedure |

# CONTENTS


**GETTING STARTED ..... 1**

**1- Introduction ..... 1**

**GETTING STARTED ..... 3**

**2- Quick Start Guide ..... 3**

2-1 Using the THM1176 with a desktop computer ..... 3
*2-1-1 PC: Software Installation ..... 3*
*2-1-2 Mac: Software Installation ..... 3*
*2-1-3 PC or Mac: Measurement ..... 4*

2-2 Using the THM1176 with the Handheld ..... 4
*2-2-1 Handheld: Assembly ..... 4*
*2-2-2 Handheld: Measurement ..... 5*

2-3 Software Development ..... 5

2-4 Precautions ..... 6

2-5 Notes ..... 9

**USING THE THM1176 ..... 11**

**3- Overview ..... 11**

3-1 Measurement ..... 11

3-2 Interface ..... 13

3-3 Probe Mechanical Design ..... 14

3-4 Desktop Kit ..... 15

3-5 Handheld Kit ..... 16

3-6 Calibration, Maintenance, Repair and Warrenty ..... 17

**USING THE THM1176 ..... 19**

**4- Software User Interface ..... 19**

4-1 Numeric Display ..... 19

4-2 Plot Display ..... 21

4-3 File Display ..... 23

4-4 Setup Display ..... 25

4-5 Measure Setup Dialog ..... 26

4-6 Alarm Setup Dialog ..... 28

4-7 Bus Trigger Dialog ..... 29

**PROGRAMMING THE THM1176 ..... 30**

**5- Application Programming Interface ..... 30**

5-1 General ..... 30

5-2 AVERage ..... 31

5-3 CALibration ..... 32

5-4 Close ..... 32

5-5 Enumerate ..... 33

5-6 Expand Data ..... 33

5-7 FORMat ..... 34
5-8 Initialize ..... 35
5-9 MEASure_FETCh_READ ..... 35
5-10 MMEMory ..... 37
5-1 Read STB w Timeout ..... 37
5-1 READ ..... 37
5-2 Reset ..... 38
5-3 Revision Query ..... 38
5-4 Self-Test ..... 39
5-5 SENSe ..... 39
5-6 STATus ..... 40
5-7 Straighten ..... 41
5-8 TRIGger ..... 42
5-9 UNIT ..... 43
5-10 Write and Read ..... 43

**PROGRAMMING THE THM1176 ..... 44**

**6- USB Interface ..... 44**

6-1 General ..... 44
6-2 SCPI Instrument Model ..... 45
6-3 IEEE 488.2 / SCPI status registers ..... 48
6-4 USBTMC-USB488 Controls ..... 51
6-5 IEEE 488.2 Common Commands ..... 52
6-6 SCPI Commands ..... 52
6-7 Programming Hints ..... 65

**REFERENCE ..... 68**

**7- Technical Specifications ..... 68**

7-1 Measurement ..... 68
7-2 Interface ..... 68
7-3 Operating conditions ..... 69
7-1 Mechanical – General ..... 69
7-2 Mechanical – THM1176-HF ..... 69
7-1 Mechanical – THM1176-HFC ..... 70
7-1 Mechanical – THM1176-LF ..... 71
7-2 Desktop kit ..... 72
7-3 Handheld kit ..... 73
7-4 Warranty, Calibration, Certification and Maintenance ..... 74

**REFERENCE ..... 75**

**8- THM1176-HF Sensor Details ..... 75**

**REFERENCE ..... 78**

**9- Error Codes ..... 78**

9-1 0: No Error ..... 78

9-2 -100: Command Errors ..... 78
*9-2-1 -102: Syntax error ..... 78*
*9-2-2 -104: Data type error ..... 78*
*9-2-3 -115: Unexpected number of parameters ..... 78*
*9-2-4 -123: Exponent too large ..... 78*
*9-2-5 -151: Invalid string data ..... 78*
*9-2-6 -171: Invalid expression ..... 79*

9-3 -200: Execution Errors ..... 79
*9-3-1 -221: Settings conflict ..... 79*
*9-3-2 -222: Data out of range ..... 79*
*9-3-3 -225: Out of memory ..... 80*

9-4 -400: Query Errors ..... 80
*9-4-1 -400: Query error ..... 80*
*9-4-2 -410: Query INTERRUPTED ..... 80*
*9-4-3 -420: Query UNTERMINATED ..... 80*
*9-4-4 -440: Query UNTERMINATED after indefinite response ..... 80*

9-5 100: Instrument-Dependent Command Errors ..... 80
*9-5-1 101: Invalid value in list ..... 80*
*9-5-2 103: Wrong units for parameter ..... 80*

9-6 200: Instrument-Dependent Execution Errors ..... 80
*9-6-1 200: Software Error ..... 80*
*9-6-2 204: Data buffer was overrun ..... 81*
*9-6-3 205: Measurements were over-range ..... 81*
*9-6-4 206: Timer was overrun ..... 81*
*9-6-5 207: Bad data compression ..... 81*

 Copyright © 2012 Metrolab Technology SA

# GETTING STARTED
# 1-Introduction

The Three-axis Hall Magnetometers THM1176 are used to measure magnetic field strength. Their unique, extraordinarily compact design allows them to be used as a portable instrument or directly connected to a PC. A THM1176 provides the total field no matter the orientation of the probe, which greatly facilitates many measurement tasks such as field mapping.

This manual covers the THM1176-HF ("High Field"), THM1176-HFC ("High Field Compact") as well as the THM1176-LF ("Low Field") models. For an overview of each of these instrument's capabilities, please see Chapter 3-Overview, Chapter 7-Technical Specifications and Chapter 8-THM1176-HF Sensor .

The THM1176 resembles other standard USB devices; it and its software are easy to install and easy to use. Nonetheless, please take a moment to browse through Chapter 2-Quick Start Guide and Chapter 4-Software User Interface. Pay particular attention to the cautionary notes in Chapter 2-Quick Start Guide.

It is easy to develop custom software for the THM1176, especially in LabVIEW. Please see Chapter 5-Application Programming Interface, Chapter 6-USB Interface, and Chapter 9-Error Codes.

Finally, keep your THM1176 accurate and up to date by having it recalibrated at regular intervals. The recommended calibration interval is 18 months. You can benefit from a discounted price for the calibration if you return your instrument to Metrolab at a time that corresponds to our batch calibrations; please see Section 7-4 for details.

You can also download the latest firmware, software and manual, free of charge. We post all updates on our website. The easiest way to be notified of updates is to sign up for our electronic newsletter, published twice a year; please see the Newsletter Subscription page of the News section of Metrolab's website. Section 3-6 provides some additional details.

We hope the THM1176 will help you perform your magnetic field measurements easily and accurately. If you have problems and your reseller cannot help you further, the Metrolab team is ready to help. Even if you don't have problems, we

are always interested in knowing more about how our instruments are used. Feel free to contact us at any time at contacts@metrolab.com.

# GETTING STARTED
# 2-Quick Start Guide

## 2-1 USING THE THM1176 WITH A DESKTOP COMPUTER

### *2-1-1 PC: Software Installation*

- Insert the installation CD.
- Install the National Instruments LabVIEW Runtime Engine 2010 SP1 by double-clicking on

  \PC\LVRTE2010sp1std.exe.
- Install the National Instruments VISA Runtime Library by double-clicking on

  \PC\visa511runtime.exe.
- Install the THM1176 software by double-clicking on

  \PC\THM1176\setup.exe.

### *2-1-2 Mac: Software Installation*

- Insert the installation CD and open the Mac directory.
- Install the National Instruments LabVIEW Runtime Engine 2010 SP1 by double-clicking on

  /Mac/mac LabVIEW 2010sp1 Run-Time Engine.dmg

  and then double-clicking on the installation package

  LabVIEW 2010 Runtime Engine.mpkg.
- Install the VISA Runtime Library by double-clicking on

  /Mac/NI-VISA-Runtime-5.1.1_Beta.dmg

  and then double-clicking on the installation package

  nivisaruntimei.mpkg.
- Install the THM1176 application by decompressing

  /Mac/THM1176.zip

  and copying the application to your Applications folder.

| NOTICE |
| --- |
| ⇒ If needed – for example, if you install a new operating system on your computer – you can download and install more recent versions of the VISA Runtime Library from the National Instruments website (http://www.ni.com).<br>⇒ You may already have NI-VISA installed, for example if you use LabVIEW. |

### *2-1-3 PC or Mac: Measurement*

- Start the THM1176 measurement software.
  In Windows, if you used the standard installation options, a THM1176 link is located in the Metrolab\THM1176 program group of the All Programs menu.
- Plug in the THM1176.
  The measurement software should automatically recognize the THM1176 and start measuring.
  In Windows XP, the New Hardware Wizard will run the first time you do so, requiring access to an Administrator account. Choose not to connect to Windows Update and to install the software automatically. Subsequently, chimes will indicate when the instrument has started up.
- Place the probe into the magnet. On the THM1176-HF, you can remove the probe cap to access narrow gaps – see Chapter 3-Overview. See Chapter 4-Software User Interface for details on using the software.
- Be sure to check the offset before each series of measurements by placing the probe in the Zero Gauss Chamber. If the offset is higher than desired, leave the probe in the Zero Gauss Chamber and perform the User Offset Correction procedure using the Offset / ZERO button on the Setup page.

## 2-2 USING THE THM1176 WITH THE HANDHELD

### *2-2-1 Handheld: Assembly*

- Install the battery in the PDA and charge it. You can charge the battery in three ways:
  - Lift the rubber cover covering the DC-in connector on the bottom left side of the PDA and plug in the AC adaptor.

- Plug the short USB-Host adaptor cable into the USB synchronization cable connector on the bottom of the PDA, and plug the AC adaptor into the power connector on the USB-Host adaptor cable.
- Plug the 1.2 m long USB-Device adaptor cable plugs into the USB synchronization cable connector on the bottom of the PDA, and plug the other end of the adaptor cable into the USB port of a PC.

- Turn on the PDA by: (1) sliding the Hold switch on the left side of the PDA to the unlocked position (up); and (2) pressing the Power button on the top right-hand corner of the front of the PDA.
- If you have not done so yet, plug the short USB-Host adaptor cable into the USB synchronization cable connector on the bottom of the PDA.
- Plug the THM1176 into the USB-Host adaptor cable.

### *2-2-2 Handheld: Measurement*

- Press the big button on the right side of the PDA to start the measurement software. Alternatively, you can use the THM1176 icon in the Programs folder of the Start menu.
- Press the big button on the left side of the PDA to bring up the virtual keyboard. Press it again to hide the keyboard. The software should show and hide the keyboard automatically when appropriate.
- Be sure to stop the measurement software using the Stop button before turning off the PDA or unplugging the THM1176 – see the note below.
- Manipulate the probe and check the offset as described in Section 2-1-3.

## 2-3 SOFTWARE DEVELOPMENT

- Insert the installation CD.
- Copy the Source folder to your hard drive. The API subfolder contains the Application Programming Interface – see 5-Application Programming Interface. The UIF folder contains the source code of the THM1176 measurement software.
- Modify the THM1176 measurement software, or write a measurement system from scratch, using the LabVIEW development system. Developing

software for the Handheld version requires the optional LabVIEW Mobile Module.

## 2-4 PRECAUTIONS

**⚠ CAUTION**

⇒ High magnetic field gradients – as found, for example, around an MRI or NMR spectroscopy magnet – will subject the THM1176 USB connector and the PDA to strong forces. To prevent injury from flying objects or whiplashing cables, be sure to hold these components securely when you are around a strong magnet.

*NOTICE*

⇒ Do not bend the probe cable sharply. This is a special cable with individually shielded signal wires, in order to minimize induction artifacts. Sharp bends break the shielding.

⇒ For details about using the PDA, please refer to the "SoMo™ 650 Quick Start Guide" flyer and "SoMo 650™ User's Guide" (file "SoMo-650_UG.pdf" on the "SoMo 650™ Companion CD"). These include important safety instructions.

⇒ When removing the adaptor cables from the synchronization cable connector on the bottom of the PDA, take care to squeeze the two release buttons on the side of the connector. Else you will destroy the cable locking mechanism, and in the future the connector can accidentally slip loose.

⇒ Due to a bug in the VISA library, the PDA version of the THM1176 software cannot handle disconnecting the THM1176 while it is measuring. This has two implications:

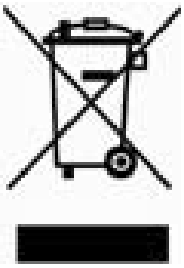
- You must stop the measurement software before unplugging the THM1176.
- You must also stop the measurement software before placing the PDA in sleep mode. The PDA can be placed in sleep mode manually by pressing the Power button. The PDA can also be placed in sleep mode

## NOTICE

automatically by the power saver – see
Start ▸ Settings ▸ System ▸ Power ▸ Advanced. By default, Metrolab disables automatic sleep for the THM1176.

Failure to follow these instructions will hang the measurement software in such a way that it cannot be stopped. The only way to reactivate it is to reset the PDA by using the stylus to press the Soft reset button on the bottom of the PDA.

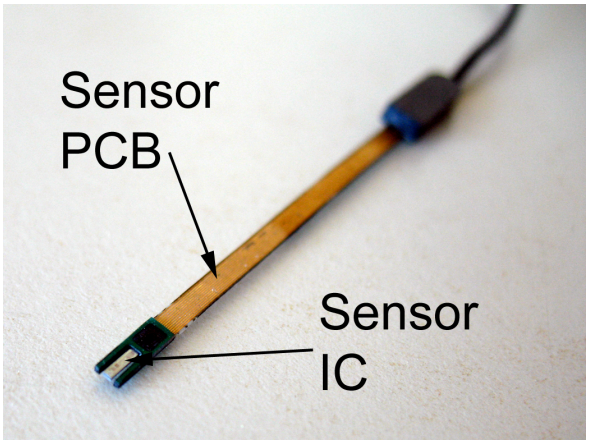
⇒ When exposed to a strong magnetic field, the touch screen of the PDA will cease to function. The power of the PDA must be cycled to restore full operation.

⇒ 

This product conforms to the WEEE Directive of the European Union (2002/96/EC) and belongs to Category 9 (Monitoring and Control Instruments). For proper environment friendly disposal, you can return the instrument free of charge to us or our local distributor.

## NOTICE

The following special precautions apply to the THM1176-HFC:




⇒ The probe is very fragile. Be extremely careful when handling; even the weight of the instrument cable is sufficient to damage the probe. Damage to either the sensor IC or PCB will destroy the sensor. We strongly suggest storing the probe in its protective case when not in use.

**NOTICE**

⇒ The probe cable is also fragile. Avoid pulling on it or bending it sharply, especially near the junction of the instrument and probe cables. Do not let the protective case hang by the sensor cable.

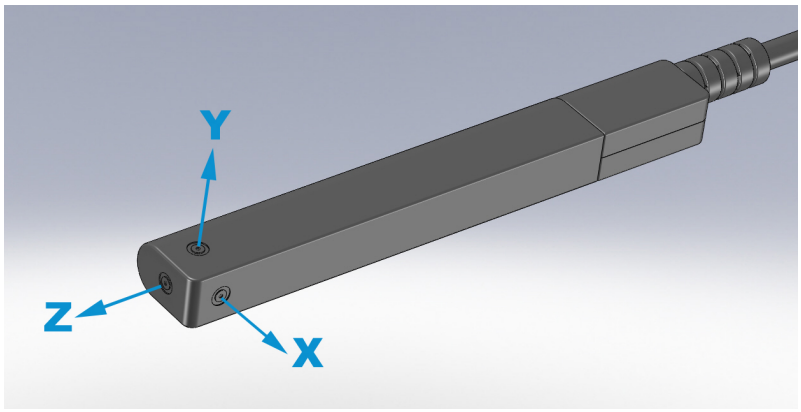
⇒ The sensor is sensitive to Electrostatic Discharge (ESD). Be sure to ground yourself and follow proper procedure when handling the sensor.

⇒ The probe is supplied with two ceramic plates that can be glued to the top and bottom of the sensor PCB. The benefits are that the sensor PCB is protected and rendered rigid, and that the ceramic provides a flat reference surface. The disadvantages are that the sensor becomes thicker, and that it cannot be recalibrated. Because of this trade-off, Metrolab have decided to leave it to the customer to decide whether or not they want to use the ceramic plates.

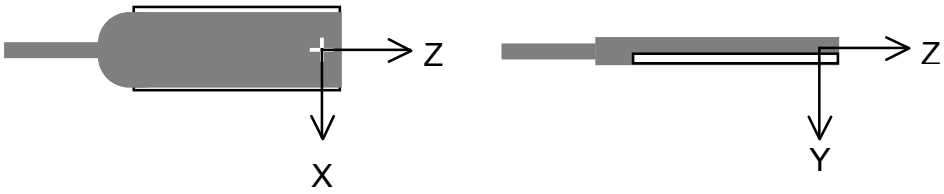
⇒ Without the ceramic plates, the sensor PCB can be bent anywhere in the front 15 mm of the sensor PCB. The minimum bend radius is 3-4 mm. Note that during calibration, Metrolab use a bend radius of 20 mm, using the entire length of the sensor PCB. The gold conductive traces should be on the inside of the bend.

## 2-5 NOTES

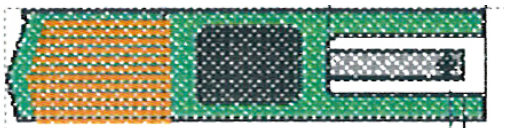
- The orientation of the axes relative to the probe is as follows:




For the THM1176-HF, the axis orientation relative to the sensor package is as follows:




For the THM1176-HFC, with the same axis orientations, the probe looks as follows:



- A recording file is an ASCII file organized into columns, delimited by tabs:
  - Block: sequential number for block of measurements.
  - B: total field.
  - Bx, By, Bz: X-, Y- and Z-components of field, respectively.
  - Units: as selected when the data was recorded.
  - Temperature: the units are arbitrary; i.e. not calibrated in degrees.
  - Timestamp: date and time, with 1 ms resolution.
  - Serial No.: instrument serial number.
  - Comment: as entered on the File panel.

Every line is terminated by an end-of-line marker.

- Some PDA USB-Host adaptor cables may not have a power connector. Plug the AC adaptor into the DC-in connector on the PDA instead.
- If you plug the THM1176 into the PDA before the PDA completes its initial boot procedure, you will see an "Unidentified USB Device" dialog. Simply unplug the THM1176, cancel the dialog, and plug the THM1176 back in when you see the PDA's Today screen.
- If you are using a Windows PC, the ActiveSync software included on the "SoMo 650™ Companion CD" will simplify file transfers between the PDA and your PC.
- The \PDA\Reinstall directory on the THM1176 installation CD contains the files and instructions required to reinstall the PDA software.

# USING THE THM1176
# 3-Overview

This chapter provides a quick overview of what you can do with the THM1176. Additional details are provided in subsequent chapters.

## 3-1 MEASUREMENT

- Three axes:
  Simultaneous measurement of all three axes of the magnetic field provides the total field, no matter the orientation of the probe.
- Field sensitive volume:
  On the THM1176-HF or -HFC, a sensor size of only 150 x 150 x 10 µm provides excellent localization and a self-consistent measurement of the three axes even in highly inhomogeneous fields. The active field volume on the THM1176-LF is much larger, 6 x 3.4 x 3 mm; this is usually sufficient for weak fields.
- Field strengths up to 20 T (THM1176-HF or -HFC) or 8.0 mT (THM116-LF):
  The THM1176-HF and -HFC have four measurement ranges – 100 mT, 500 mT, 3 T and 20 T – which allows measuring even very strong fields. The range may be selected manually, or the instrument can auto-range. The THM1176-LF has a single range, designed to measure weak fields up to 8.0 mT.
- Bandwidth of DC to 1 kHz:
  The 1 kHz bandwidth allows measuring AC fields generated, for example, by transformers and motors.
- Trigger modes:
  Three trigger modes allow the acquisition procedure to be fine-tuned for the measurement.
  - Immediate trigger mode:
    Immediate trigger mode – the default – starts an acquisition sequence immediately upon receiving the measurement command.
  - Timed trigger mode:
    Timed trigger mode is suitable for measuring rapidly varying fields.

The maximum sample rate – writing data into the acquisition buffer – is approximately 5 kSa/s, where one sample is a triplet ($B_x$, $B_y$, $B_z$). With a simultaneous readout via USB, the maximum sample rate is approximately 2.3 kSa/s.

- Bus triggered mode:
  The USB bus trigger command can be used to synchronize the acquisition with external events. The instrument allows up to about 400 bus triggers per second.

- Acquisition buffer:
  The THM1176 contains a local memory capable of holding 4096 samples, allowing data to be acquired more quickly than it can be read out by the USB interface.

- Accuracy and resolution:
  Three-axis calibration provides an accuracy of 1% of the measured value. At the bottom end of each range, the accuracy levels off at approximately 0.1% of full scale for the THM1176-HF or -HFC, and 20 µT for the THM1176-LF – see the specifications for details. Note that for a standard THM1176-HF, the 20 T range is only calibrated up to 3 T; for a standard THM1176-HFC, only up to 1.5 T.

- Averaging:
  Averaging can reduce measurement noise. The degree of averaging is controllable, since long integration periods might be beneficial for static fields, but counterproductive for time-varying fields. The THM1176 uses a simple arithmetic mean, and performs N measurements of each axis in succession; for example, for N=3, the measurement sequence would be:
  $B_x$, $B_x$, $B_x$, $B_y$, $B_y$, $B_y$, $B_z$, $B_z$, $B_z$, T
  where T is temperature. When performing multiple measurements into the acquisition buffer, the temperature is also averaged, in order to take into account temperature drift during a lengthy measurement sequence.

- User offset correction:
  To guarantee the specified accuracy, the measurement offset should be checked before each measurement sequence, using the zero-gauss chamber supplied. If needed, the offset correction procedure will measure

and correct this offset. The correction value is written to flash memory so that the same correction will be applied the next time the instrument is powered up.

- Readout options:
  The three field components are always acquired, but the readout can be limited to any selected components. The readout can include a single measurement or an entire array of measurements, and can be formatted as an ASCII message or as a binary block. Binary data may be compressed by a factor of two or four, for example to help reduce the traffic on a busy USB hub. The field values can be returned in Tesla, mTesla, µTesla, Gauss, kGauss or equivalent proton NMR frequency for the THM1176-HF or -HFC, and Tesla, mTesla, µTesla, Gauss or mGauss for the THM1176-LF. A timestamp (in ns) and temperature (arbitrary units, not calibrated) can also be read out.

## 3-2 INTERFACE

- USB interface:
  Compliance with the USB 2.0 mechanical, electrical and protocol standard provides basic connectivity with any USB-capable computer. The instrument supports USB full-speed communication (12 Mbps).

- Standardized USB class driver:
  Compliance with the USB Test & Measurement Class (USBTMC) allows the instrument to be connected without installing a custom USB driver. All that is required is a generic class driver for test and measurement equipment, as provided by suppliers of instrumentation software. The software supplied with this instrument includes the National Instruments USBTMC driver.

- Standardized IEEE488.2 protocol:
  Compliance with the USB488 protocol specification for USBTMC provides all the capabilities of an IEEE488 instrument on the USB bus. IEEE488, derived from HPIB/GPIB, is the world's most widely used instrumentation protocol. IEEE488 compliance allows any VISA library (Virtual Instrument Software Architecture) to control every aspect of the instrument. The

software supplied with the instruments includes the National Instruments VISA Runtime library.

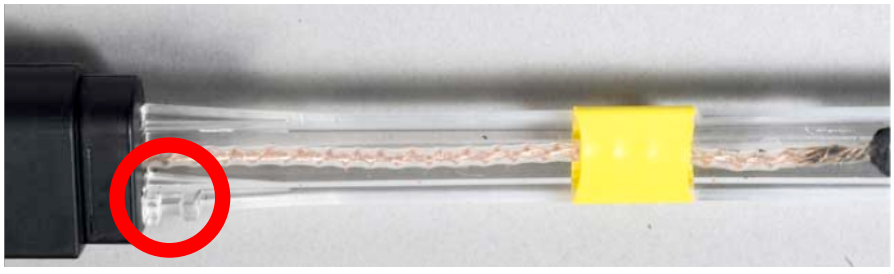
- Standardized instrument command protocol:
  The SCPI standard (Standard Commands for Programmable Instruments) is the standard developed and used by large instrumentation manufacturers such as Tektronix and HP/Agilent, and provides a programming interface familiar to many instrumentation system programmers.

## 3-3 PROBE MECHANICAL DESIGN

- Protection for the sensor:
  The Hall sensors are sensitive electronic components. The plastic cover of the THM1176-HF and THM1176-LF protects them from the bumps and scrapes of normal use. Please note the special handling precautions for the THM1176-HFC in Section 2-4, Precautions.

- Small gaps:
  The THM1176-HF and THM1176-LF probes are 10 mm thick. To measure in a smaller gap, the THM1176-HF probe cap can be removed, reducing the thickness to 4.1 mm. If needed, the THM1176-HF sensor package – only 2.3 mm thick – can be separated from the probe plastic; note, however, that the sensor wires are delicate and can easily be broken. For even smaller gaps, use a THM1176-HFC, whose probe is only 0.5 mm thick.

- Stationary installation (THM1176-HF only):
  Removing the cap also reveals a mounting point that allows the probe to be permanently mounted or attached to a scanning arm. The exact position of the field-sensitive point can be determined by optical sighting.



## 3-4 DESKTOP KIT

- A complete magnetic field measurement kit:
  The desktop kit includes everything except the computer: the THM1176 instrument, calibration, a zero-Gauss chamber, the National Instruments VISA runtime library and USBTMC driver, turn-key measurement software, all the LabVIEW source code, software licenses from Metrolab as well as National Instruments, and this manual.

- Measurements out of the box:
  Install the VISA Runtime library and measurement software, and plug in the THM1176. The software allows you to:

  - Display B, $B_x$, $B_y$ and/or $B_z$, either numerically or on a graphical display;
  - Display either the raw data or computed peak-to-peak, standard deviation or spectral values;
  - Visualize the direction of the B-vector relative to one of the probe's axes;
  - Set the units in which the results are displayed, including raw ADC value;
  - Capture the maximum field value;
  - Hold (freeze) a given measurement;
  - Record data to a file; and
  - Replay a recorded file.

  A Setup page allows you to:

  - Choose amongst multiple THM1176 plugged into your PC;
  - Display information about your instrument, such as model and serial numbers, version numbers of the electronics, probe and firmware, and the date of the last calibration;
  - Display version information about the software;
  - Select the measurement parameters, including the trigger source, sample rate, internal buffer size, averaging, and data compression;

- Set the measurement range (or auto-range);
- Set up audio and/or visual alarms when the measured field values exceed specified bounds; and
- Initiate the user offset correction procedure.

On-line help explains the use of all controls and displays. All relevant settings are saved when you quit the application and restored the next time when you restart it.

- Customized measurement software:
  A powerful and easy-to-use LabVIEW Application Programming Interface (API) allows instrumentation system programmers to readily integrate the THM1176 into their measurement system. This manual provides complete documentation of the API and command interface. The source code for the turnkey measurement software is also provided.

### 3-5 HANDHELD KIT

- Everything the PC software can do, in a portable instrument:
  A compact, lightweight and rugged handheld computer (Personal Digital Assistant, or PDA) allows you to take measurements in the field. The PDA software has the same functionality, interface and file-recording format as the PC software. The built-in battery lasts over six (THM1176-HF or -HFC) or three (THM1176-LF) hours.
- Includes the entire desktop kit:
  You can choose to connect the THM1176 either to the PDA included in the handheld kit, or to a PC. In the second scenario, you can do everything you can do with the desktop kit.
- A full-featured PDA:
  The PDA has many features that can be combined in creative ways to enhance your use of the magnetometer. For example, a THM1176 recording file can be inspected in Word Mobile, or imported, manipulated and plotted in Excel Mobile. Alternatively, you can transfer the files to a PC using the included USB-Device cable, via a CompactFlash or SDIO flash card, or via the 802.11 or Bluetooth wireless networks.

- Customized handheld applications:
  As with the PC software, you have all the source code, so you can write your own portable magnetic measurement application or to modify the standard one. The only thing you need is the Mobile Module, an add-on to LabVIEW.

## 3-6 CALIBRATION, MAINTENANCE, REPAIR AND WARRENTY

- Calibration procedure:
  The THM1176 can only be calibrated by Metrolab. This is because special magnets, tooling and software are required to calibrate all three axes, at multiple fields and temperatures, and write the results to flash memory.

- Recommended calibration interval:
  All customers are of course free to fix the intervals at which they send the THM1176 back for calibration, within the context of their quality assurance policy. Metrolab's recommendation is to send the instrument back for calibration at least once every eighteen months.

- Recommended calibration dates:
  To minimize costs, Metrolab establishes a limited number of dates in the year when batches of THM1176 magnetometers will be calibrated. To avoid substantial extra charges, you should ship the unit back to Metrolab in order to coincide with one of these dates. Please see Section 7-4 for a list of these dates.

- Upgrades:
  Via its website, Metrolab will make available improvements and bug fixes for the THM1176 firmware, software and manual. Customers will be notified about available upgrades via Metrolab's electronic newsletter (published twice yearly; see the Newsletter Subscription page of the News section of Metrolab's website) and the News articles on Metrolab's website. The Download page of the Metrolab website (http://download.metrolab.com/) will always contain the latest versions.

- Firmware upgrades:
  The THM1176 is designed such that you can upgrade the firmware yourself. Firmware upgrades are a delicate procedure, as a failure may

render the instrument unusable. Metrolab has made every effort to make the process foolproof, but please take your time and follow the instructions provided with the upgrade carefully.

- Upgrades to the PDA software:
  To comply with the license associated with the LabVIEW PDA module, Metrolab distributes upgrades to the PDA software in an encoded file. You need to contact Metrolab for the password for this file. Please send an e-mail with the serial number of your THM1176 to contacts@metrolab.com. The serial number is printed on the label located on the instrument electronics. It is also displayed on the Setup page of the measurement software.

- Repairs:
  Due to the highly integrated construction of the THM1176, Metrolab cannot replace individual electronic components. If you send a THM1176 back for repair, we will send you a replacement unit at a standardized exchange price – please contact Metrolab for a quotation. The replacement unit may contain parts recovered from units previously sent in for repair; however, it will of course be fully tested, calibrated and guaranteed.

- Warranty:
  The standard warranty period is two years from the date of purchase. During this period, Metrolab will replace a failing unit free of charge, unless it is clear that the unit has been abused (crushed probe or electronics, torn cable, etc.). We do not assume responsibility for consequential damage, for example to your PC.

# USING THE THM1176
# 4-Software User Interface

The THM1176 can be used as a laboratory instrument, plugged into a Personal Computer (PC), or, optionally, as a handheld instrument. The display of the handheld instrument will vary slightly from the illustrations below; however, the utilization is the same except when noted.

## 4-1 NUMERIC DISPLAY

**PURPOSE:**

Numerical display of last measurements.

**CONTROLS:**

**X**: Quit.

**?**: Help.

**k**: Display/hide on-screen keyboard. (PDA only)

**Max:** When checked, capture and hold the absolute maximum of the associated display. This allows you to find the approximate maximum field strength in a volume.

**Bx/By/Bz:** Selects the axis along which to orient the vector display.

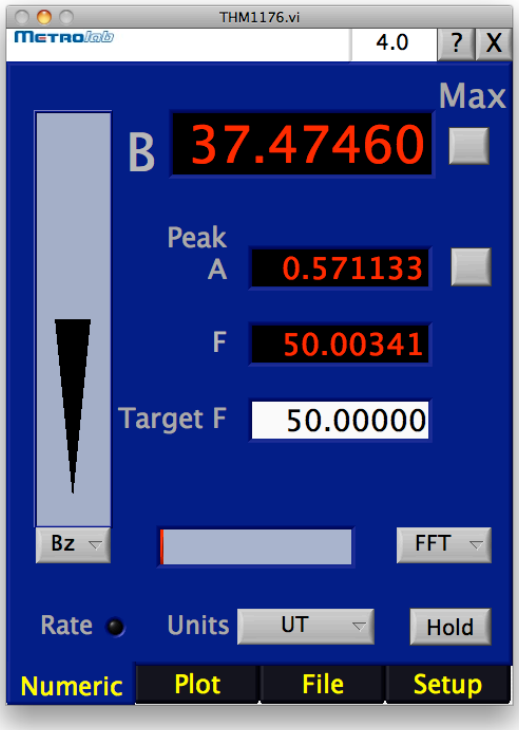
**Target F**: Approximate frequency of peak to be measured. Zero finds highest peak, other than DC. (FFT displays only)

**[Data display selector]:**

- Raw: last measurement
- sDev: Standard deviation of last block of measurements
- P-P: Peak-to-Peak amplitude of last block of measurements
- FFT, FFTx, FFTy, FFTz: amplitude and frequency of selected peak of FFT(B, Bx, By or Bz, respectively). In addition, shows last B value.

**[Units]:** The units in which to display the measurement results. Any one probe supports only some of the following units:

- T: Tesla




- MT: milli-Tesla (1T=$10^3$ mT)
- UT: micro-Tesla (1T=$10^6$ uT)
- NT: nano-Tesla (1T=$10^9$ nT)
- GAUSs: Gauss (1T=$10^4$ G)
- KGAUss: kilo-Gauss (1T=10 kG)
- MGAUss: milli-Gauss (1T=$10^7$ mG)
- MAHZp: NMR equivalent proton frequency (1T=42.5775 MHz-p)
- ADC: raw ADC values, without any calibration corrections

**Hold:** Freeze measurement or review.

**DISPLAYS:**

**[Vector display]:** 3D compass: arrow becomes fatter and longer when selected probe axis is aligned with magnetic field.

**B:** Total field strength. Red on over-range, orange on alarm.

**Bx, By, Bz:** X, Y and Z components of field strength. Red on over-range, orange on alarm. (Raw, sDev and P-P displays only)

**Peak A, F:** Amplitude and frequency of selected peak. (FFT displays only)

**[Thermometer]:** Field strength as fraction of selected range. (Not shown when auto-ranging)

**Rate:**

- Red: Buffer overrun, trigger overrun or lossy compression
- Yellow: Reviewing a recording file

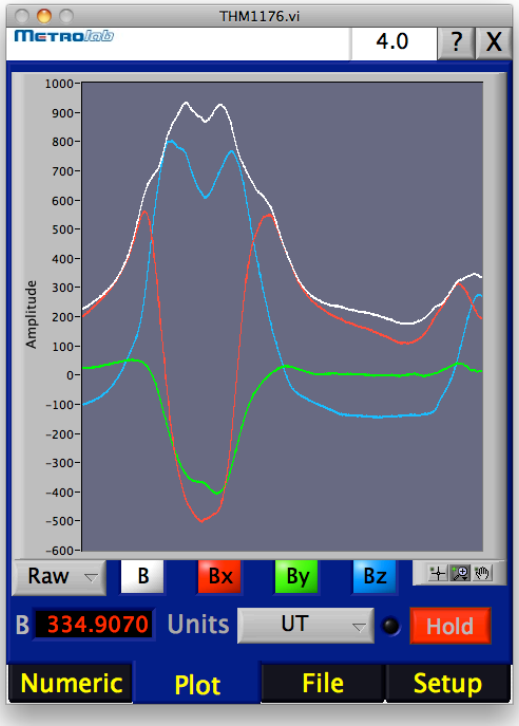
**NOTES:**

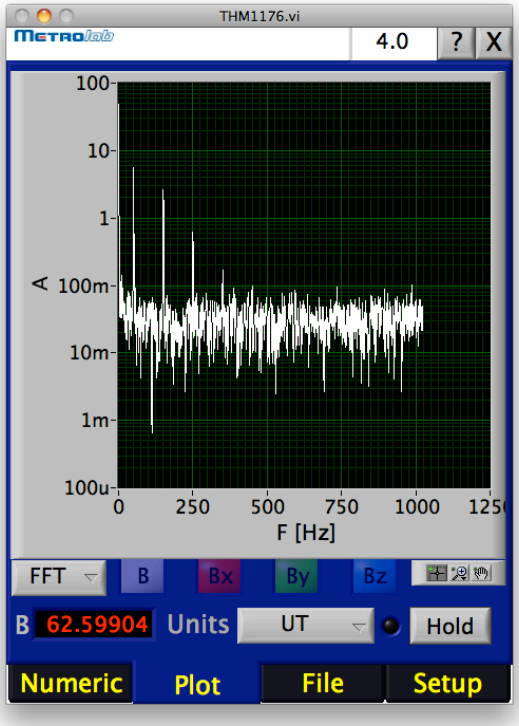
To enter the target frequency on a PDA, press the "k" button to bring up the on-screen keyboard. Remember that Windows Mobile offers multiple input methods, including handwriting recognition.

For the FFT displays, if Target F is non-zero, the frequency range searched is ±1% of the sample frequency.

Display is affected by settings in Setup and File pages.

## 4-2 PLOT DISPLAY




**PURPOSE:**

Graphical display of last measurements.

**CONTROLS:**

**X, ?, k, [Data display selector]:** See Section 4-1.

**B, Bx, By, Bz:** Enables or disables display of corresponding data. (Desktop version only; disabled in FFT displays)

**[Graph palette]**: provides tools to move cursors, zoom and pan. (Desktop version only)

**Units, Hold:** See Section 4-1.

**DISPLAYS:**

**[Graph]:** Displays selected data graphically. In Raw/sDev/P-P displays, also displays alarm limits.

**B, Rate:** See Section 4-1.

**NOTES:**

The y-axis uses the selected units, and is by default auto-ranging.

The x-axis uses the following units:

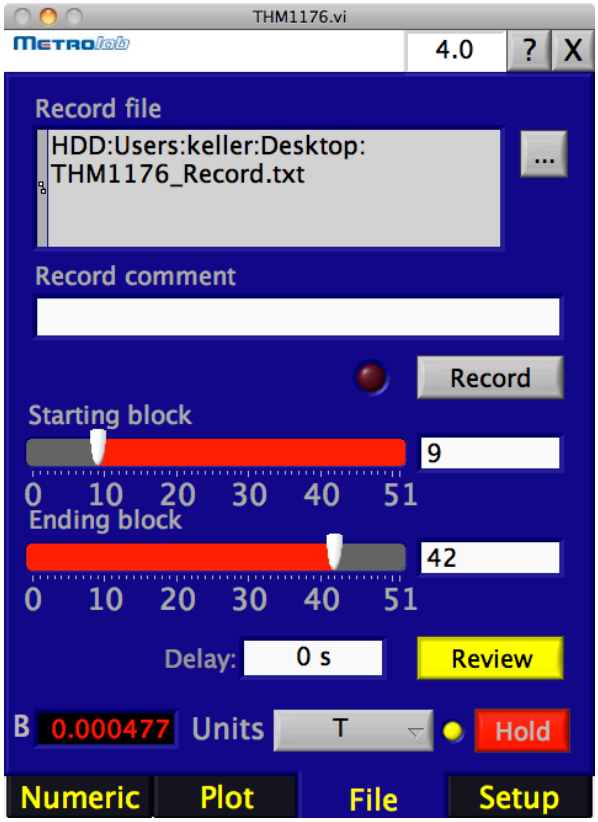
- Raw, sDev, P-P: time, using the time stamp. Scrolls at 6 s / screen. Exception: Raw data plots on PDA use sample number.
- FFT: frequency.

The graph palette includes:

- Cursor Movement Tool: Move cursor on display. Cursors must first be created, using the Cursor legend.
- Zoom: Zoom in and out of graph:
  - Zoom to Rectangle: click and drag to cover zoom area.
  - X-zoom: zoom in along the x-axis.
  - Y-zoom: zoom in along the y-axis.
  - Zoom In about Point: click a point to zoom into. Press and hold <Shift> to switch between Zoom In and

| | |
|---|---|
| | Zoom Out.<br>o Zoom Out about Point: click a point to zoom out from. <Shift>: see above.<br>o Zoom to Fit: auto-scale x and y-scales to show entire graph.<br>• Panning Tool: Picks up plot and moves it around in graph.<br><br>On the desktop version, additional tool palettes can be enabled by right-clicking on graph and checking items under "Visible Items":<br><br>• Plot Legend: Display names and colors of displayed graphs<br>• Scale Legend: Select manual or auto-scaling, and change appearance of axes and grid lines<br>• Cursor legend: manage cursors. The cursor palette contains the following tools for each cursor: (FFT displays only)<br>o Cursor name.<br>o Current X and Y values.<br>o Enable or disable movement with keypad.<br>o Change the cursor appearance.<br>o Allow the cursor to move freely, snap to the nearest data point, or lock onto a field component.<br>o Keypad for moving the enabled cursor(s) left, right, up or down.<br>• Digital display: (Raw/sDev/P-P displays only)<br>• X Scroll bar: Scroll the time-axis<br><br>Note that this display is not intended to make publication-quality graphs of your data. For this, record the data to a file using the File screen, and use a program like Excel or Matlab to make your plots.<br><br>Display is affected by settings in Setup and File pages. |

## 4-3 FILE DISPLAY




**PURPOSE:**

Record measurements to a file, and review recorded data.

**CONTROLS:**

**X, ?, k:** See Section 4-1.

**["..." button]:** Choose and/or create a Recording file.

**Record comment:** Optional comment describing current measurement.

**Record:** Start/stop recording.

**Starting, Ending block:** Range of blocks to review.

**Delay:** Delay between blocks reviewed:

- 0 s, 0.1 s, 1 s, 3 s: Delay as specified.
- Hold: Hold after each block.

**Review:** Start/stop review mode. Review mode plays back the data as when measuring "live". All display and alarm options are available.

**Units, Hold:** See Section 4-1.

**DISPLAYS:**

**Record file:** Name of recording file.

**[Record light]:** Recording in progress.

**B, Rate:** See Section 4-1.

**NOTES:**

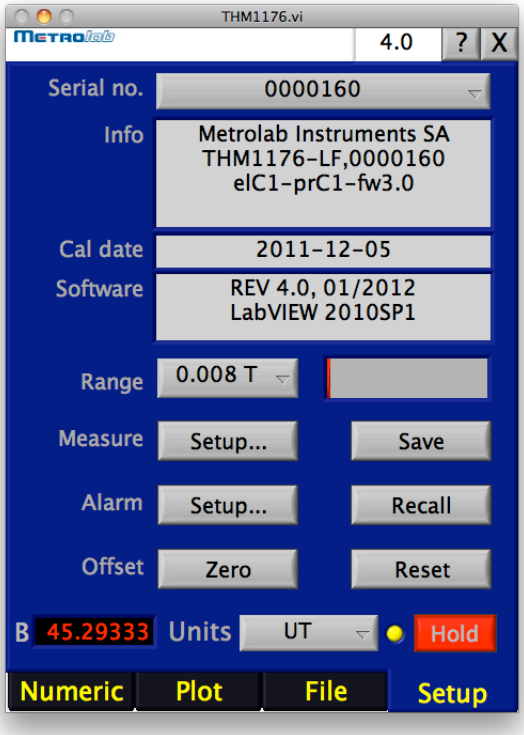
To enter a comment or starting/ending block number on a PDA, press the "k" button to bring up the on-screen keyboard. Remember that Windows Mobile offers multiple input methods, including handwriting recognition.

Recording to an existing file appends the new data.

By default, the entire file is reviewed, but you can review only a part by setting the Start and Stop block numbers.

| | |
|---|---|
| | The thermometer graphically displays the Start and Stop block numbers. You can move the thumbs.<br>When recording, Stop displays the last block recorded.<br>Recording is affected by settings in Setup page. |

## 4-4 SETUP DISPLAY




**PURPOSE:**

Sets up all measurement parameters.

**CONTROLS:**

**X, ?, k:** See Section 4-1.

**Serial no.:** Select active instrument.

**Range:** Select range, or auto-ranging.

**Measure Setup...:** Open dialog to set up measurement parameters.

**Alarm Setup...:** Open dialog to set up alarms.

**Offset zero:** Place probe in a zero Gauss chamber to measure and correct this instrument's zero offset.

**Save, Recall:** Save/recall software and instrument settings.

**Reset:** Reset settings to the factory defaults.

**Units, Hold:** See Section 4-1.

**DISPLAYS:**

**Info:** Information returned by instrument.

**Cal date:** Date of last calibration. Red if recommended calibration interval has expired.

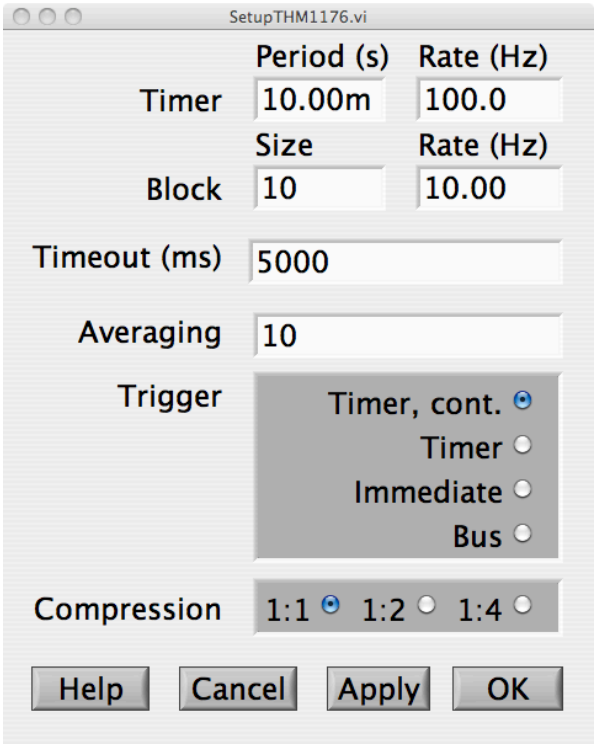
**Software:** Versions of this software and support library.

**[Thermometer]:** Field strength as fraction of selected range. (Not shown when auto-ranging)

**B, Rate:** See Section 4-1.

**NOTES:**

## 4-5 MEASURE SETUP DIALOG




**PURPOSE:**

Set up measurement parameters.

**CONTROLS:**

**Timer Period, Rate:** Measurement acquisition rate:

- Timed trigger: Specify desired period or rate.
- Immediate trigger: Empirically determined acquisition rate is shown, and cannot be changed.
- Bus trigger: Meaningless, since the rate is determined by the triggers. However, an approximate rate can be given for calculating time stamps.

**Block Size:** Number of measurements buffered in the instrument's local memory before transferring to the computer.

**Block rate:** Rate of transfer of data blocks. Depends on both the acquisition rate and block size; can be used to set the block size.

**Timeout:** Timeout period for an acquisition.

**Averaging:** Number of data points that are averaged together for each measurement.

**Trigger:** What starts an acquisition:

- Timer, cont.: a timer at the specified rate. Triggers continuously.
- Timer: a timer at the specified rate. Triggers stop when one block has been filled.
- Immediate: free-running; acquires as quickly as possible and stops when one block has been filled.
- Bus: acquires when triggered via USB. Triggers stop when one block has been filled.

**Help:** Open this help window.

**Cancel:** Close dialog without modifications.

**Apply:** Apply modifications without closing dialog.

| | |
|---|---|
| | **OK:** Apply modifications and close dialog.<br><br>**DISPLAYS:**<br>Current parameter values when dialog is opened.<br><br>**NOTES:**<br>To enter parameter values on a PDA, press the blue keyboard button at the bottom of the screen to bring up the on-screen keyboard. Remember that Windows Mobile offers multiple input methods, including handwriting recognition.<br>To fix error conditions indicated by red "Rate" light:<br>• Buffer overrun: increase block size.<br>• Timer overrun: reduce Timer rate and/or Averaging count.<br>• Lossy compression: reduce compression.<br>The Timer Period, rather than Rate, is the quantity used by the instrument. The period is rounded to the nearest processor clock cycle (24 MHz).<br>The Block size, rather than Block Rate, is the quantity used by the instrument. The size is limited to that allowable by the instrument.<br>For all trigger modes except "Timer, Continuous", the software enables Hold after each block. For Bus triggers, this behavior can be overridden.<br>By default, bus triggers are generated manually. By modifying a single sub-VI, the trigger can be synchronized with external events.<br>Data averaging reduces the noise; the peak-to-peak noise level will be reduced by approximately the square root of the "Averaging" setting. The data points are acquired in a single burst, at the maximum acquisition rate. |

## 4-6 ALARM SETUP DIALOG

**PURPOSE:**

Set field limits for visual and/or audio alarms.

**CONTROLS:**

**Audio:** Enable or disable audio alarm.

**Raw/sDev/P-P:** Each column provides the limits for the corresponding display:

- OFF/B/Bx/By/Bz: Whether to enable corresponding alarm, and whether the limits apply to B, $B_x$, $B_y$ or $B_z$.
- Min, Max: lower and upper limits, in currently selected units.

**Help:** Open this help window.

**Cancel:** Close dialog without modification.

**Apply:** Apply modification without closing dialog.

**OK:** Apply modification and close dialog.

**DISPLAYS:**

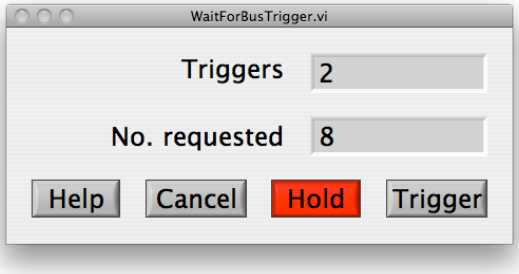
Current parameter values when dialog is opened

**Units:** Currently selected units

**NOTES:**

To enter parameter values on a PDA, press the blue keyboard button at the bottom of the screen to bring up the on-screen keyboard. Remember that Windows Mobile offers multiple input methods, including handwriting recognition.

## 4-7 BUS TRIGGER DIALOG




**PURPOSE:**

Generate triggers in Bus triggered mode.

**CONTROLS:**

**Help:** Open this help window.

**Cancel:** Abort the trigger sequence and close the dialog.

**Hold:** Whether or not to Hold after acquiring this block.

**Trigger:** Trigger a single acquisition.

**DISPLAYS:**

**Triggers:** Counts number of triggers in current block.

No. requested: Requested number of triggers per block.

**NOTES:**

When the acquisition timeout expires, the acquisition sequence is aborted and the dialog is closed.

Use the Measurement Setup dialog in the Setup page to set the number of triggers and timeout period.

Modify this sub-VI to synchronize bus triggers with external events.

# PROGRAMMING THE THM1176
# 5-Application Programming Interface

The LabVIEW programming Application Programming Interface (API) for the THM1176 allows users to easily write instrument control programs. Most, but not all, of the functions provided by the instrument's USB interface are made available through this API. Some logically related functions in the USB interface have been regrouped in the API. A standard low-level I/O utility function guarantees robust communications with the THM1176 and allows programmers to easily add any command or combination of commands that they require.

Both the LabVIEW API and User Interface (UIF) are included in source code format on the CD that came with your THM1176. If upgrades become available, you will be able to download them from the Metrolab website, download.metrolab.com. To build your own handheld applications, you will need the LabVIEW Mobile Module from National Instruments (www.ni.com).

## 5-1 GENERAL

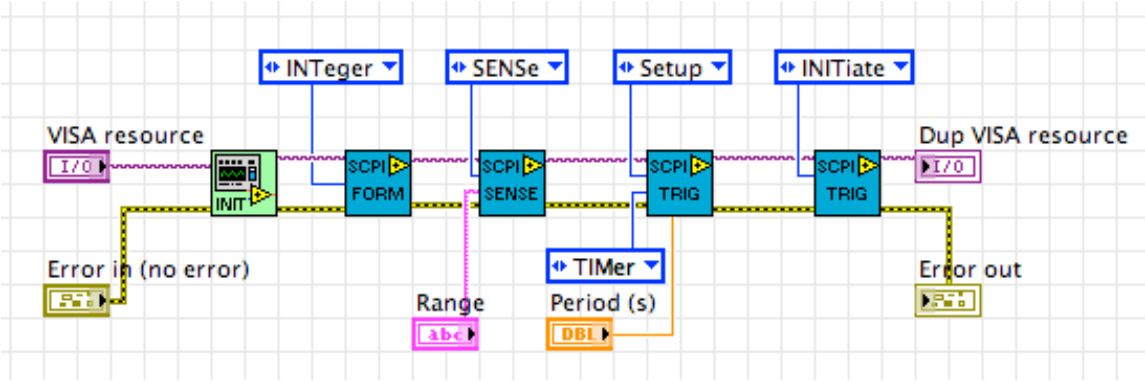
The VIs in the programming API have two standard inputs:

- VISA resource: VISA resource name that specifies the instrument with which we want to communicate;
- Error in: a standard error structure describing errors in previous VIs;

and two standard outputs:

- Dup VISA resource: a copy of VISA resource number;
- Error out: describes errors that occurred in this VI or in previous ones.

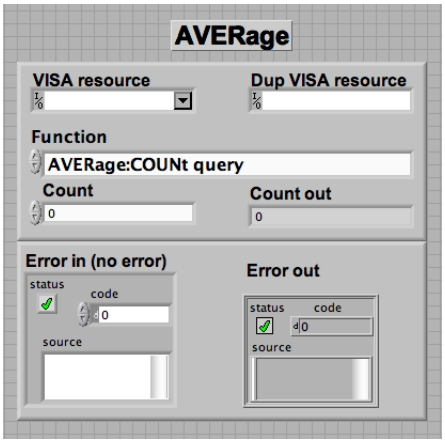
As is common practice in LabVIEW, the connectors for these standard inputs and outputs are located on the four corners of the VI's icon. In a sequence of VIs, the standard outputs of each VI are wired to the standard inputs of the succeeding VI, as shown in the example below:




This chaining serves two purposes: it forces the VIs to be executed in the given order, and it stops the execution of the chain if an error occurs. In fact, each VI checks whether its "Error in" input indicates that an error has occurred in a previous VI; if so, instead of its normal function, it simply copies "Error in" to "Error out." In this fashion, the "Error out" at the end of the chain indicates the precise error that caused the rest of the chain not to execute.

The sections below describe each Virtual Instrument (VI), with its inputs and outputs. The standard inputs and outputs, described above, are not documented for each VI.

## 5-2 AVERAGE




Set or retrieve the averaging count.

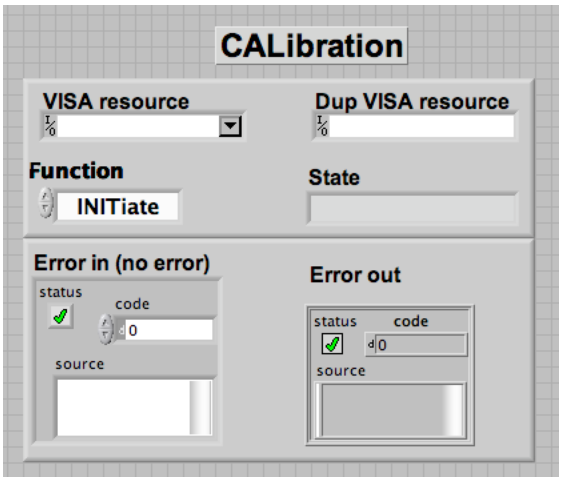
Function [In]: Function to perform:

- AVERage:COUNt: Set the averaging count
- AVERage:COUNt query: retrieve the averaging count

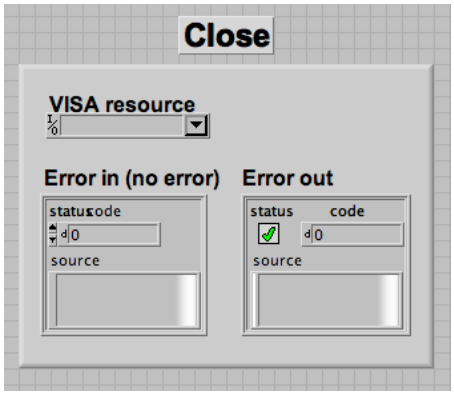
Count [In]: The new averaging count to be set

Count [Out]: The current averaging count returned by the query

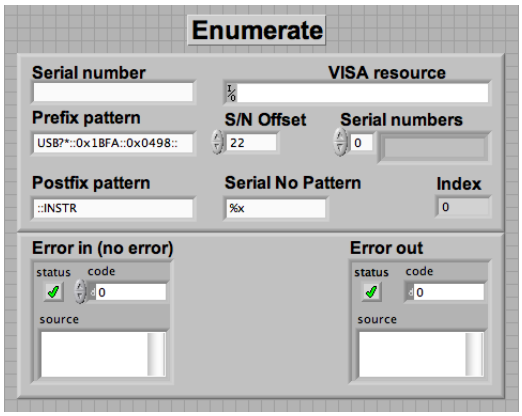
## 5-3 CALIBRATION

| | |
|---|---|
|  | Collects all functions dealing with the device calibration.<br>Function [In]: Function to perform:<br>- INITiate: Initiate offset correction procedure in zero-gauss chamber<br>- ZERO: Restore factory offset correction<br>- STATe query: Get current calibration state<br>- STATe ON: Apply temperature & gain calibration<br>- STATe OFF: Do not apply temperature & gain calibration<br>State [Out]: Displays the current calibration state for a STATe query |

## 5-4 CLOSE

| | |
|---|---|
|  | Closes the current session. |

## 5-5 ENUMERATE




Enumerate the VISA resource names of the instruments currently connected. The resource names must be some pattern ("Prefix pattern"), followed by the instrument's serial number, followed by another pattern ("Postfix pattern"). If the currently selected instrument is still connected, its index in the list is returned; else an index of zero is returned.

Serial number [In]: Serial number of selected instrument.

Prefix pattern [In]: The part of the search pattern that precedes the serial number.

Postfix pattern [In]: The part of the search pattern that follows the serial number.

Serial No Offset [In]: Byte offset of serial number in VISA resource name.

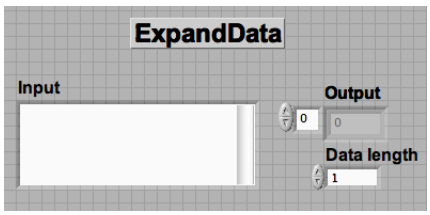
Serial No Pattern [In]: Format of serial number.

Serial numbers [Out]: The returned list of instrument serial numbers that match the search.

VISA resource [Out]: VISA resource name of instrument now active.

Index [Out]: The index of the selected instrument. If one of the entries in "VISA resource names" match "Serial number," the index of that entry is returned. Otherwise, zero is returned - i.e. the first entry in the list is selected by default.

## 5-6 EXPAND DATA




Expand compressed data. Only used as subVI for MEASure_FETCh_READ.vi.

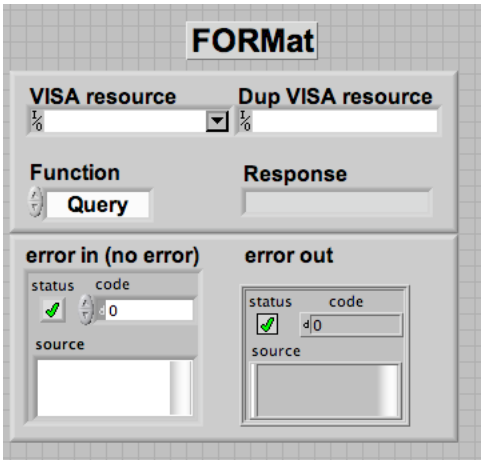
Input [In]: Data to be expanded.

Data length [In]: Degree of data compression:

- 1: 1 byte per data point
- 2: 2 bytes per data point
- else: 4 bytes per data point

Output [Out]: Decompressed data.

## 5-7 FORMAT




Sets the output format for measurements, or gets the current setting. The output format can be text ("ASCii"), uncompressed binary ("INTeger"), or compressed binary ("PACKed1" or "PACKed2"). The output format is further affected by the CALibration:STATe and UNIT settings:

- FORM=ASC, CAL:STAT=ON: Measurement in text, selected units
- FORM=ASC, CAL:STAT=OFF: Measurement in text, raw ADC values
- FORM=INT, CAL:STAT=ON: Measurement in 32-bit binary, µT
- FORM=INT, CAL:STAT=OFF: Measurement in 32-bit binary, raw ADC values
- FORM=PACKed1, CAL:STAT=ON: Measurement in 8-bit binary delta, µT
- FORM=PACKed1, CAL:STAT=OFF: Measurement in 8-bit binary delta, raw ADC values
- FORM=PACKed2, CAL:STAT=ON: Measurement in 16-bit binary delta, µT
- FORM=PACKed2, CAL:STAT=OFF: Measurement in 16-bit binary delta, raw ADC values

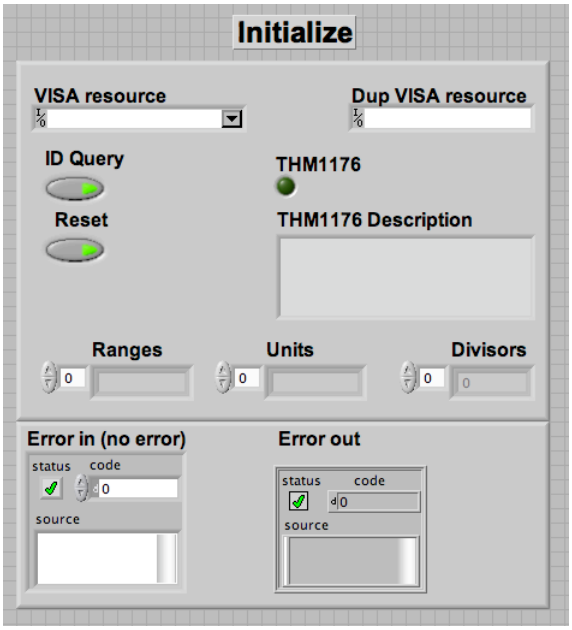
Note that MEASure_FETCh_READ parses binary, packed as well as text output.

Function [In]: Function to be performed:

- Query: Get current setting
- ASCii: Select ASCII output format
- INTeger: Select binary output format
- PACKed1: Select 1-byte packed format
- PACKed2: Select 2-byte packed format

Response [Out]: Returns current setting for a Query

## 5-8 INITIALIZE




Initialize the THM1176 LabVIEW API.

ID Query [In]: Use the *IDN command to verify that the instrument identifies itself as a THM1176.

Reset [In]: Reset the instrument after opening a session to it.

THM1176 [Out]: Instrument identified itself as THM1176. Only valid if ID Query is selected.

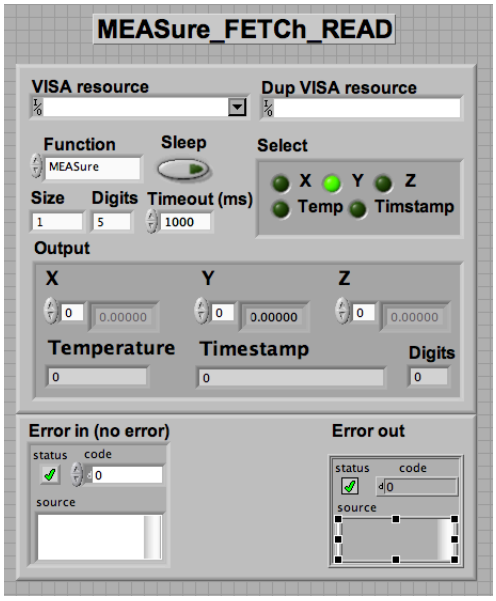
THM1176 Description [Out]: Instrument description returned by *IDN command. Only valid when "ID Query" is selected.

Ranges [Out]: List of the ranges supported by this instrument (in T). Only valid when "ID Query" is selected.

Units [Out]: List of the units supported by this instrument. Only valid when "ID Query" is selected.

Divisors [Out]: List of the divisors for each of the units supported by this instrument. If you fetch the measurement values in INTeger FORMat, you have to divide by this number to convert to the given units. Only valid when "ID Query" is selected.

## 5-9 MEASURE_FETCH_READ



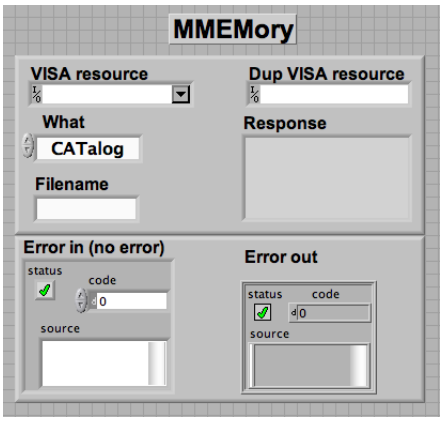

Performs a measurement and parses the result.

Function [In]: Selects the function to be performed:

- MEASure: Abort any pending triggers and perform measurements using the default acquisition parameters:
  - Continuous trigger initiation off
  - Trigger source = immediate
  - Apply calibration correction
  - No averaging
- READ: Abort any pending triggers and perform a measurement with the existing parameters
- FETCh: Fetch data values acquired during last MEASure, READ or INITiate.
  Note: The following actions invalidate

| | |
|---|---|
| | previously acquired data:<br>○ Reset;<br>○ Continuous trigger initiation;<br>○ Changing trigger parameters.<br><br>Sleep [In]: If set, the THM1176 will switch off the analog power after executing the command. (The THM1176 microcontroller also puts itself to sleep whenever it can, but this happens automatically.) The resulting power savings are significant in battery-powered applications. Switching the analog power back on happens automatically, before the next measurement - note, however, that this takes approximately 100 ms.<br><br>Select [In]: Select the values to be returned:<br>[0] = X<br>[1] = Y<br>[2] = Z<br>[3] = Temperature<br>[4] = Timestamp<br><br>Size [In]: Number of measurements.<br><br>Digits [In]: Number of significant digits in measurement result.<br><br>Timeout (ms) [In]: The delay between the write and when the read should occur. This gives devices time to respond.<br><br>Output [Out]: The returned measurement values (if any). The form of X, Y, Z depends on the settings of FORMat, CALibration:STATe and UNIT:<br><br>- CAL:STAT=ON, FORM=ASC: selected units<br>- CAL:STAT=ON, FORM=INT, PACKed1 or PACKed2: µT (THM1176-HF) or mG (-LF)<br>- CAL:STAT=OFF: raw ADC values<br><br>The temperature value is in arbitrary units.<br><br>The time stamp, in seconds since startup, refers to the end of the acquisition.<br><br>If FORM=ASC and Select includes X, Y or Z, the Digits output returns the number of digits behind the decimal point, to allow displays to be correctly formatted. |

## 5-10 MMEMORY




Read the THM1176 FLASH memory.

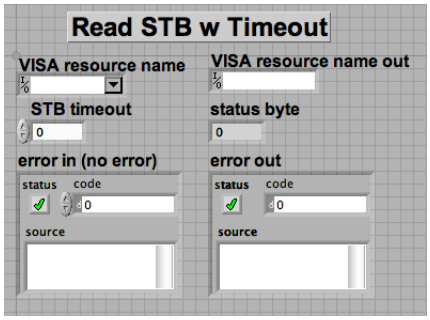
What [In]: What to read:

- CATalog: a list of files stored in FLASH.
- DATA: the contents of the file chosen.

Filename [In]: The filename for What=DATA.

Response [Out]: The returned list of filenames or file contents.

## 5-1 READ STB W TIMEOUT



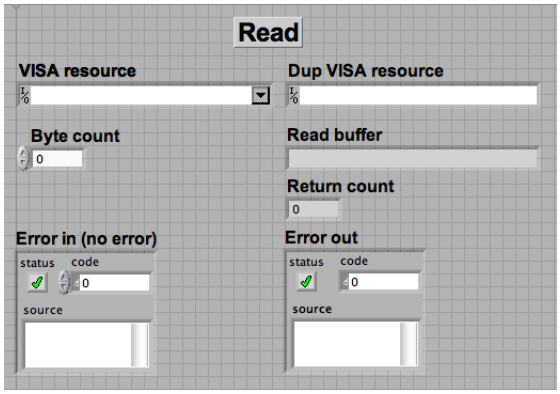

Read the status byte, with the given timeout value.

This VI is only used as a sub-VI for Write and Read.vi.

STB timeout [In]: Timeout value, in ms.

Status byte [Out]: Returned status.

## 5-1 READ

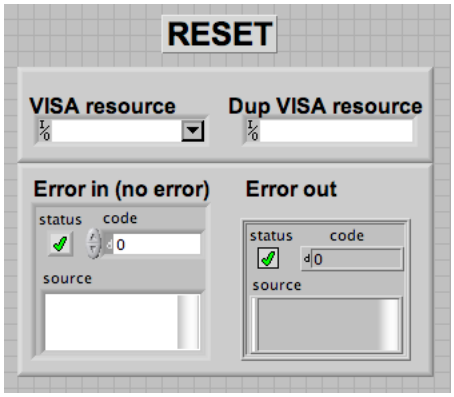



Performs a VISA Read, and a VISA Clear in case of error. Ignores VISA warning 1073676294, "The number of bytes transferred is equal to the requested input count. More data might be available."

This VI is only used as a sub-VI for Write and Read.vi.

See VISA Read for a definition of the parameters.

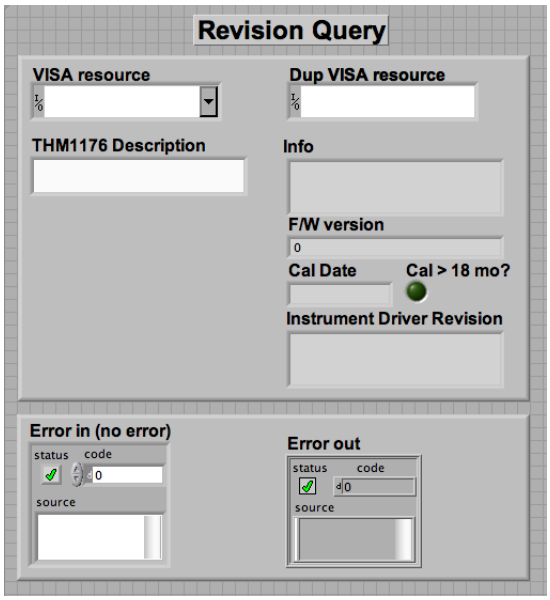
## 5-2 RESET




Reset the instrument to startup settings:

- Averaging: 1
- Acquisition buffer: empty
- Trigger source: Immediate
- Trigger count: 1
- Trigger timer: 100 ms
- Range: Auto
- Calibration state: On
- Units: Tesla
- Format: ASCII
- Status: cleared, enable registers reset

## 5-3 REVISION QUERY




Queries the current instrument firmware revision and instrument driver revision.

THM1176 Description [In]: Description string returned by *IDN? command. If empty, an *IDN? command is performed automatically.

Info [Out]: Instrument information returned by *IDN? command, formatted to be legible.

F/W version [Out]: The revision of the instrument firmware.

Cal Date [Out]: Date of the last calibration.

Cal > 18 mo? [Out]: True if the instrument was last calibrated more than 18 months ago (the recommended calibration period).

Instrument Driver Revision [Out]: The revision of the instrument driver software.

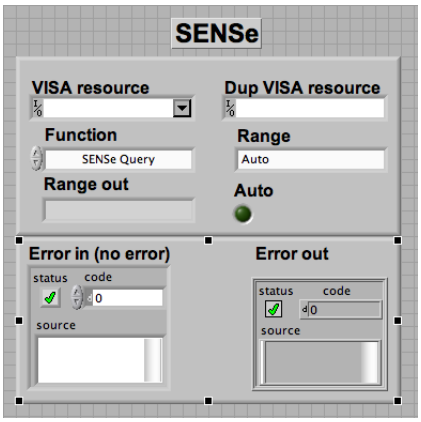
## 5-4 SELF-TEST

Run instrument self-test.

Note: the THM1176 currently does not support self-test.

Self-test response [Out]: Response from *TST? self-test command.

## 5-5 SENSE




Sets the measurement range, or gets the currently selected range. Note that it can be very useful to get the currently selected range after performing an auto-ranging measurement.

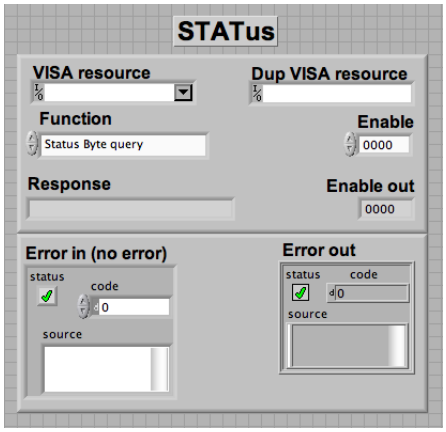
Function [In]: Whether to set the range or to get the currently selected range.

Range [In]: The range, for when setting the range.

Range out [Out]: Returns the currently selected range, in response to a query.

Auto [Out]: Returns whether or not auto-ranging is selected, when querying the currently selected range.

## 5-6 STATUS




Collects all commands concerning the IEEE488.2 / SCPI status system in the THM116. See Section 6-3 for more details about the status registers.

Function [In]: The function to perform. For each of the four status registers (Status Byte, Standard Event Status Register, OPERation Status, and QUEStionable Status), you can:

- Get (and clear) the current value of the event register;
- Get the current value of the event enable register;
- Set the event enable register.

In addition, for the OPERation and QUEStionable Status registers, you can:

- Get the current value of the condition register.

Finally, you can:

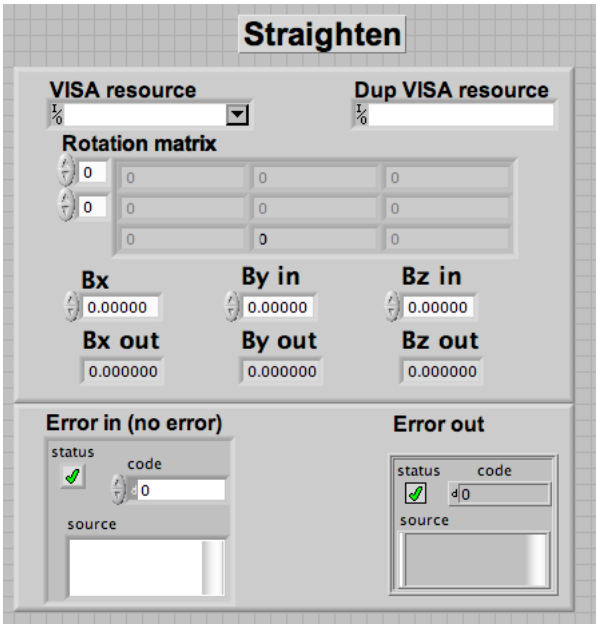
- Retrieve the next entry in the error/event queue;
- Clear all event registers and queues; and
- Reset the OPERation and QUEStionable enable registers to their default values.

Enable [In]: The new value when setting the value of an enable register.

Response [Out]: Response to command.

Enable out [Out]: The current value when retrieving the current value of an event or event enable register.

## 5-7 STRAIGHTEN



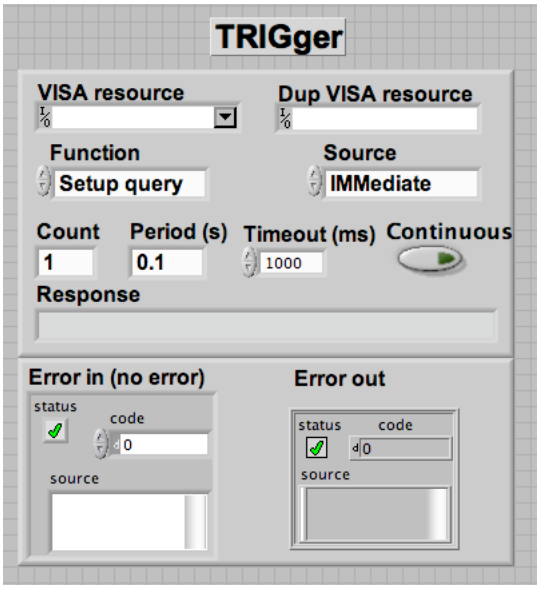

Compensate measurements for possible angular misalignments of the sensor ICs.

Bx in, By in, Bz in [In]: X, Y and Z components, respectively, of the measured field vector.

Bx out, By out, Bz out [Out]: X, Y and Z components, respectively, of the corrected field vector.

Rotation matrix [Out]: Rotation matrix for this instrument. The matrix transforms the measured field vector to an orthogonal coordinate system fixed relative to the outside of the probe. The field vectors are considered column vectors.

## 5-8 TRIGGER




Manages all functions of trigger system.

Function [In]: Select function to be performed:

- Setup: set up the trigger system with the parameters given.
- Setup query: get current trigger setup.
- INITiate: enable the trigger.
- ABORt: abort any pending triggers.

Source [In]: Trigger source, for Setup function:

- IMMediate: no wait
- TIMer: periodic trigger
- BUS: USB488 trigger

Count [In]: Trigger count, for Setup function.

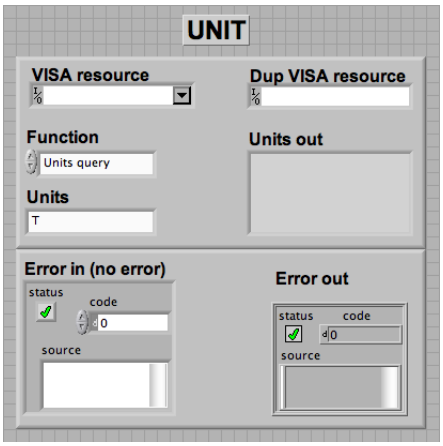
Period [In]: Trigger period, for Setup function.

Timeout (ms) [In]: The delay between the write and when the read should occur. This gives devices time to respond.

Continuous [In]: Continuous-initiation mode, for Setup function. Note: continuous initiation only works with a periodic trigger.

Response [Out]: Response to any of the query functions.

## 5-9 UNIT




Sets the units in which measurements are returned, or queries the currently selected units.

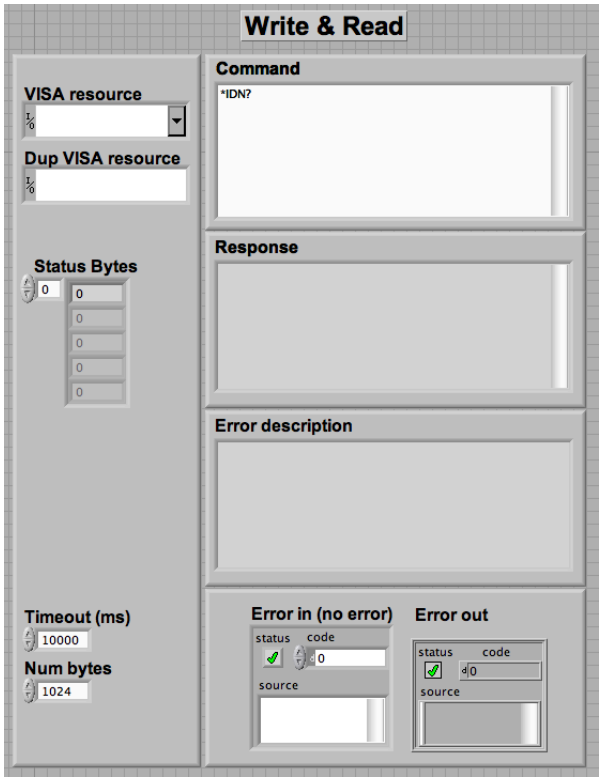
Note that units are only used if FORMat is Ascii and CALibration:STATe is On.

Function [In]: Function to perform: set units, or get currently selected units.

Units [In]: If setting units, selects units in which measurement results are to be returned.

Units out [Out]: If querying currently selected units, returns the currently selected units.

## 5-10 WRITE AND READ




Write a command to the instrument and read the response.

Nearly all the commands issued by the instrument API pass through this VI.

It is highly recommended that any custom commands also use this utility VI.

Command [In]: Command to write.

Timeout [In]: The delay between the write and when the read should occur. This gives devices time to respond.

Num bytes [In]: Size of transfer buffer. If the response is longer than this value, the response will be read in multiple transactions.

Response [Out]: Response returned by instrument when command was executed.

Error description [Out]: List of error descriptions returned by instrument.

Status Bytes [Out]: If querying currently selected units, returns the currently selected units.

# PROGRAMMING THE THM1176
# 6-USB Interface

## 6-1 GENERAL

The THM1176 communicates with a host – either a Personal Computer (PC) or a Personal Digital Assistant (PDA) – via a Universal Serial Bus (USB) interface.

If you use the LabVIEW driver or programming API, it is generally not necessary to refer to the information in this chapter. You may, however, want to write a LabVIEW program optimized for your application, bypassing or complementing the general-purpose API provided by Metrolab. This chapter will provide you with the information necessary to do so.

The THM1176 was designed to plug-and-play with a Virtual Instrument Software Architecture (VISA) compliant software library – in particular, the NI-VISA library from National Instruments (see http://www.ni.com/). If you are not using NI-VISA, you will probably need information that is not provided in this chapter:

- USB 2.0
  See "Universal Serial Bus Specification, Revision 2.0, April 27, 2000," available from http://www.usb.org/developers/docs/usb_20_101111.zip.
- USBTMC and USBTMC-USB488
  See "Universal Serial Bus Test and Measurement Class Specification (USBTMC), Revision 1.0, April 14, 2003" and "Universal Serial Bus Test and Measurement Class, Subclass USB488 Specification (USBTMC-USB488), Revision 1.0, April 14, 2003," available from http://www.usb.org/developers/devclass_docs/USBTMC_1_006a.zip.
- SCPI
  See "Standard Commands for Programmable Instruments (SCPI), VERSION 1999.0, May, 1999," available from http://www.ivifoundation.org/docs/scpi-99.pdf.
- IEEE 488.2
  See "IEEE Standard Codes, Formats, Protocols, and Common Commands for Use With IEEE Std 488.1-1987, IEEE Standard Digital Interface for Programmable Instrumentation, IEEE Std 488.2-1992," available from

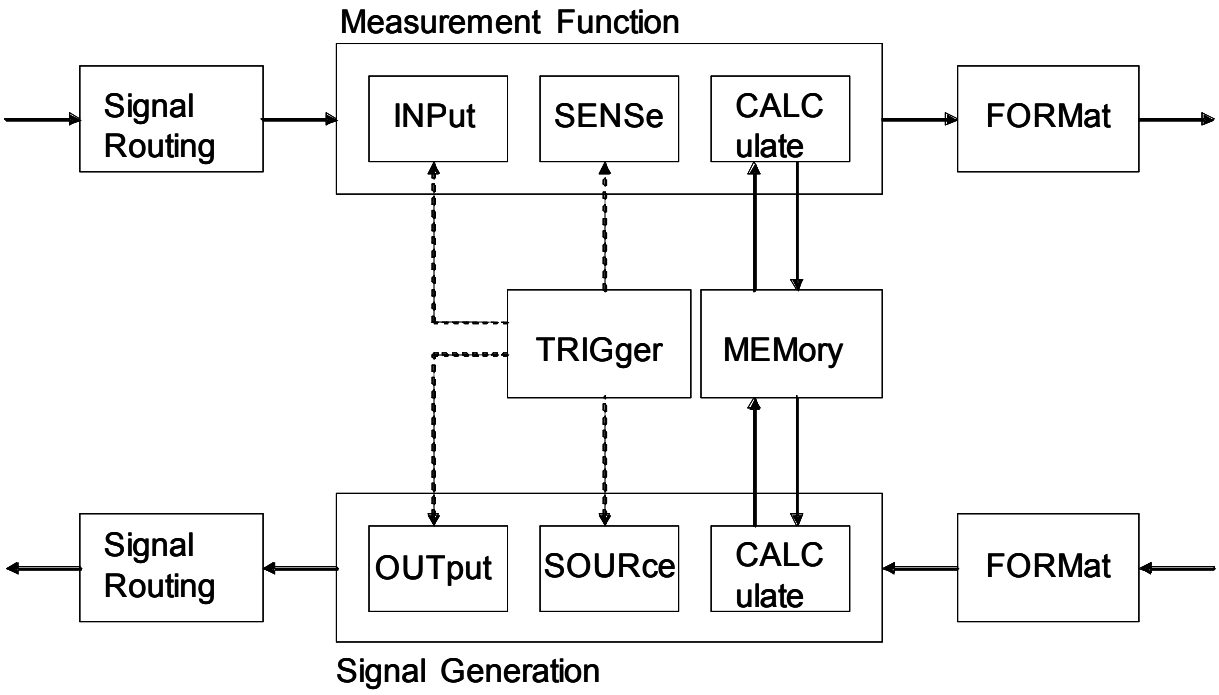
http://standards.ieee.org/reading/ieee/std_public/description/im/488.2-1992_desc.html.

- VISA

  See "VPP-4.3: The VISA Library," "VPP-4.3.2: VISA Implementation Specification for Textual Languages," "VPP-4.3.3: VISA Implementation Specification for the G Language," VPP-4.3.4: VISA Implementation Specification for COM," all Revision 2.2 (March 17, 2000) by the VXI plug & play Systems Alliance, available from http://www.ivifoundation.org/Downloads/Specifications.htm.

## 6-2 SCPI INSTRUMENT MODEL

The THM1176 complies with the Standard Commands for Programmable instruments (SCPI) standard. SCPI uses a standard instrument model to organize the command structure. The diagram below shows the subsystems concerning the signal flow.




The following table provides a summary of the THM1176 capabilities, organized according to the SCPI instrument model. The supported commands include IEEE 488.2 "Common Commands" (start with "*") as well as SCPI commands. Many commands have additional options, or query forms to return the currently set

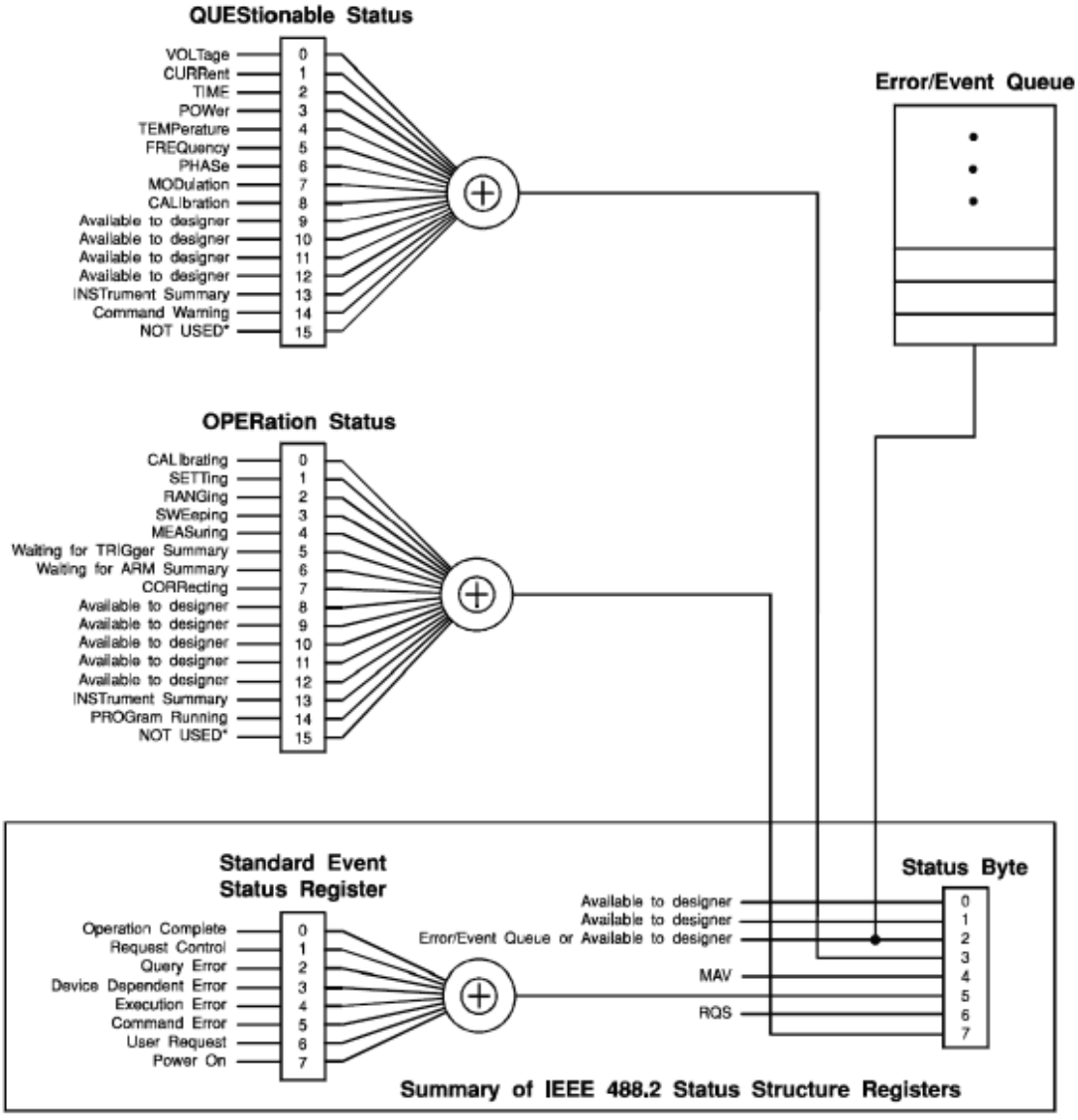
value; see later sections for details. In addition to ASCII commands, the THM1176 also supports certain USBTMC-USB488 controls, also noted in this table.

| **Functional Block** | **Command(s)** | **Function** |
|---|---|---|
| **Measurement Function** | :MEASure … | Measure with standard settings. Equivalent to *RST;:READ … |
| | :READ … | Measure with custom settings. Equivalent to :ABORt;:INITiate …;:FETCh … |
| | :FETCh … | Fetch measurement results previously acquired with MEASure, READ or INITiate |
| | :CALCulate … | Control averaging |
| • **Signal Routing** | - | Not used in THM1176 |
| • **INPut** | - | Not used in THM1176 |
| • **SENSe** | :SENSe … | Select range and auto-ranging |
| • **CALCulate** | CALibration … | Compute and apply calibration factors |
| **FORMat** | :FORMat … | Set output format |
| | :UNIT … | Set output units |
| **TRIGger** | *TRG USBTMC-USB488 | Generate a trigger |
| | :INITiate … | Enable triggers |
| | :ABORt | Abort triggers |
| | :TRIGger … | Select trigger source and characteristics |
| **MEMory** | - | Not used in THM1176 |

| Functional Block | Command(s) | Function |
|---|---|---|
| **Signal Generation** | - | Not used in THM1176 |
| **STATus** | *CLS | Clear status |
| | *STB?, *SRE<br>USBTMC-USB488 | Read and enable bits in Status Byte |
| | USBTMC-USB488 | Request service from host |
| | *ESR?, *ESE | Read and enable bits in Standard Event Status Register |
| | *OPC, *WAI | Detect and wait for operation complete |
| | :STATus … | Read and enable bits in OPERation and QUEStionable registers |
| | :SYSTem:ERRor | Query error queue |
| **SYSTem** | USBTMC-USB488 | Clear input and output buffers |
| | USBTMC-USB488 | Remote/local control – ineffective since THM1176 has no local controls |
| | *RST | Perform reset |
| | *TST? | Perform self-test (not supported by THM1176) |
| | *IDN? | Return Instrument ID |
| | :SYSTem:VERSion | Return SCPI version |
| | :SYSTem:HELP … | Provide command help |
| | :SYSTem:SLEEp | Power down analog subsystem |
| **MMEMory** | :MMEMory … | Manipulate FLASH memory files |
| **DIAGnostic** | :DIAGnostic: … | Initiate firmware upgrade |

## 6-3 IEEE 488.2 / SCPI STATUS REGISTERS

IEEE 488.2 compliant instruments have at least two registers: the Status Byte and the Standard Event Status Register. SCPI adds the Operation Status Register, Questionable Status Register and Error/Event Queue. The diagram below, taken from the SCPI standard, provides a good summary. This section describes how the THM1176 uses these status registers.




* The use of Bit 15 is not allowed since some controllers may have difficulty reading a 16 bit unsigned integer. The value of this bit shall always be 0.

- Status Byte

  Contains a 1-byte status summary. The THM1176 uses the following bits:

| Bit | Name | Description |
|---|---|---|
| 2 | EAV | Error AVailable (in Error/Event Queue) |
| 3 | QSB | Questionable Summary Bit |
| 4 | MAV | Message AVailable: response ready to be read |
| 5 | ESB | Event Summary Bit |
| 6 | RQS | ReQuest for Service |
| 7 | OSB | Operation Summary Bit |

- Standard Event Status Register

  Latches certain standardized events. The THM1176 uses the following bits:

| Bit | Name | Description |
|---|---|---|
| 0 | Operation Complete | *OPC has flagged operation complete |
| 2 | Query Error | Error in preceding query |
| 3 | Device Dependent Error | Errors specific to the THM1176, including internal errors |
| 4 | Execution Error | Error detected during command execution |
| 5 | Command Error | Error in preceding command |
| 7 | Power On | THM1176 has been powered up |

- OPERation Status

  Captures conditions which are part of the instrument's normal operation. The THM1176 uses the following bits:

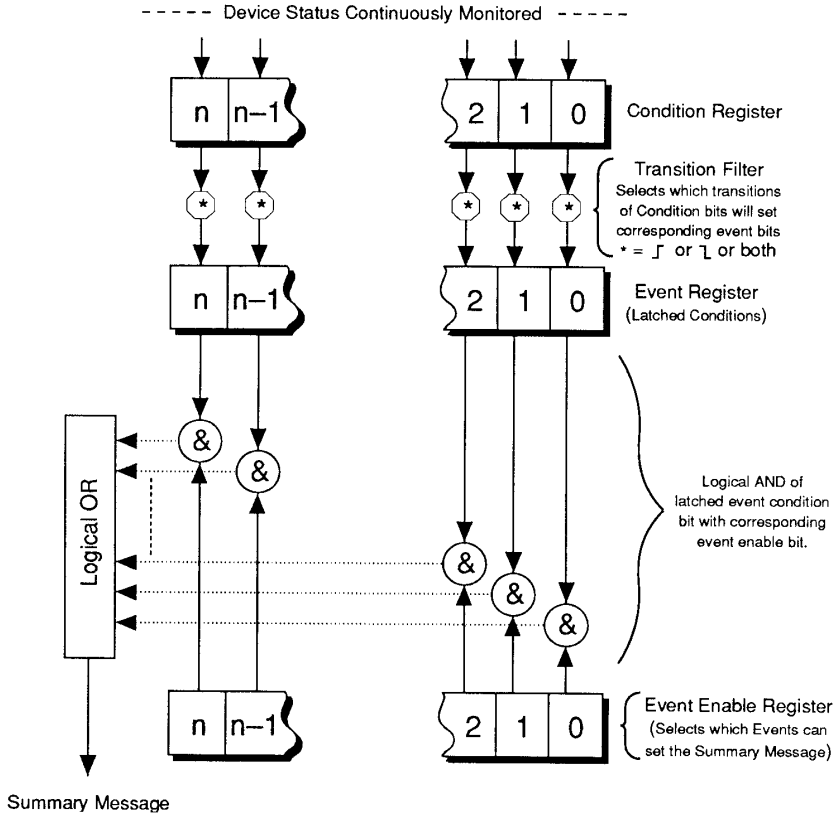
| Bit | Name | Description |
|---|---|---|
| 0 | CALibrating | Measuring zero-offset |
| 2 | RANGing | Changing range |
| 4 | MEASuring | Measuring magnetic field strength |
| 5 | Waiting for TRIGger | Waiting for trigger |

- QUEStionable Status

  Indicates conditions that may reduce the quality of the measurement. The THM1176 sets the following bits:

| Bit | Name | Description |
|---|---|---|
| 5 | FREQuency | The acquisition buffer or the timed trigger has been overrun, which makes the frequency questionable |
| 9 | – | The measurement was over-range, which makes the amplitude questionable |

As shown in the figure below, taken from the IEEE 488.2 standard, each of the registers above is actually a set of three registers:




- Condition Register

  Read-only register that is constantly updated to reflect the current state of the instrument.

- Event Register

  Transitions in a Condition Register are latched in the corresponding Event Register. The THM1176 only latches transitions from 0 to 1. Event Registers are cleared when read.

- Event Enable Register

  A mask indicating what bits in the Event Register are included in the Summary bit. The enable mask of the Status Byte is called the Status Enable register, and it determines which bits cause an RQS (ReQuest for Service).

## 6-4 USBTMC-USB488 CONTROLS

The following functions are supported directly by the USBTMC-USB488 protocol. Historically, these correspond to dedicated hardware signals in IEEE 488.1 (HPIB or GPIB).

| Command | Description |
|---|---|
| INITIATE_CLEAR | Clears the device input and output buffers |
| TRIGGER | Assert bus trigger |
| SRQ | Requests service from host |
| READ_STATUS_BYTE | Read status byte |
| REN_CONTROL | Remote Enable (no effect on THM1176) |
| GO_TO_LOCAL | Enable local controls (no effect on THM1176) |
| LOCAL_LOCKOUT | Disable local controls (no effect on THM1176) |

## 6-5 IEEE 488.2 COMMON COMMANDS

As any IEEE 488.2 compliant instrument, the THM1176 supports the following commands.

| Command | Name | Description |
|---|---|---|
| *CLS | Clear status | Clear all event registers and queues (not enable registers) and error buffer |
| *ESE <NRf> | Program event enable | Program standard event enable register |
| *ESE? | Event enable query | Read standard event enable register |
| *ESR? | Event status query | Read standard event register and clear it |
| *IDN? | Identification query | Returns the following information: manufacturer; model; serial number; and version of electronics, probe and firmware. Note that this query returns "Arbitrary ASCII Response Data" (see IEEE488.2 standard) and cannot be followed by another query in the same command sequence. |
| *OPC | Set operation complete | Set the operation complete bit in the standard event register after all commands have been executed |
| *OPC? | Operation complete query | Returns an ASCII "1" after all commands have been executed |
| *RST | Reset | Reset device to power-on configuration |
| *SRE <NRf> | Program status enable | Program status enable register Important: you must also enable service requests on the host. See Section 6-7 for details. |
| *SRE? | Status enable query | Read status enable register |
| *STB? | Status byte query | Read status byte register |
| *TRG | Trigger | Generate bus trigger |
| *TST? | Self-test Query | Perform complete self-test, return 0 if successful, 1 if not |
| *WAI | Wait-to-Continue | Wait until previous commands have completed |

## 6-6 SCPI COMMANDS

In the command definitions below, the following conventions are used:

[] optional keywords or parameters

<> value

The abbreviated form of each command is written in capital letters. For example, the "MEASure" command can be written as "MEASURE" or "MEAS", or, since capitalization doesn't matter, "measure" or "meas".

Each command is presented with its subcommand(s) indented below it. For example:

| | | |
|---|---|---|
| :FETCh | | |
| [:SCALar] | | Fetch values acquired during last MEASure, READ or INITiate |
| [:FLUX] | | |
| :X? | [<digits>] | Fetch x-component of flux density measurement |
| [:Y]? | [<digits>] | Fetch y-component of flux density measurement |

According to this table, the following commands are legal:

:FETC:SCAL:FLUX:Y?

:FETC? (same as above, omitting optional keywords)

:FETC:X? (fetches x-component of flux density measurement)

The following special parameters are recognized:

MINimum

MAXimum

DEFault

Numeric parameters usually require units. Analogously, the values returned by queries contain units, as specified by the UNIT command. In addition, some units can have prefixes:

N = nano ($10^{-9}$)

U = micro ($10^{-6}$)

M = milli ($10^{-3}$)

K = kilo ($10^{3}$)

MA = mega ($10^{6}$)

The table below lists the units supported by the THM1176. Note that different models recognize different ranges of magnetic field strength units, depending on their measurement range; all model recognize T (Tesla).

| **Magnetic field strength** | | |
|---|---|---|
| T | M, U, N | Tesla (default) |
| MAHZP | | Megahertz proton |
| GAUSS | K, M | Gauss |
| **Other** | | |
| S | M, U | Seconds |

The following tables list the legal commands for the THM1176, in alphabetical order.

| Command | Parameters | Description |
|---|---|---|
| :ABORt | | Reset the trigger system:<br>- Aborts acquisition in progress<br>- Disables trigger<br>- Disables continuous trigger |

| Command | Parameters | Description |
|---|---|---|
| [:CALCulate]<br>:AVERage | | |
| :COUNt? | [MINimum \| MAXimum \| DEFault] | Query averaging count |
| :COUNt | <count> \| MINimum \| MAXimum \| DEFault | Set averaging count |

| Command | Parameters | Description |
|---|---|---|
| :CALibration | | |
| [:INITiate] | | Initiate the offset correction procedure in zero-gauss chamber |
| :ZERO | | Restore factory offset correction |
| :STATe? | [DEFault] | Query calibration state |
| :STATe | <boolean> \| DEFault | Set calibration state: whether or not temperature and gain calibration is applied. ON by default. |

| Command | Parameters | Description |
|---|---|---|
| :DIAGnostic<br>:UPGRade<br>[:INITiate] | | Initiate a firmware upgrade. The THM1176 will disconnect from the USB bus and reconnect as a DFU (Device Firmware Upgrade[1]) device, with the following alternate settings: CODE, DATA, RESERVED and HWINFO. |

| *NOTICE* |
|---|
| The :DIAGnostic:UPGRade:INITiate command is intended for use by the manufacturer only. It can cause your THM1176 to become nonoperational. |

| Command | Parameters | Description |
|---|---|---|
| :FETCh | | |
| [:SCALar] | | Fetch data values acquired during last MEASure, READ or INITiate. The following actions invalidate previously acquired data:<br>- Reset;<br>- Continuous trigger initiation; and<br>- Changing trigger parameters.<br>Return at least the requested number of significant digits. |
| [:FLUX] | | |
| :X? | [<digits>] | Fetch x-component of flux density measurement<br><digits><br>min=1, max=5, def=3 |
| [:Y]? | [<digits>] | Fetch y-component of flux density measurement<br><digits><br>min=1, max=5, def=3 |
| :Z? | [<digits>] | Fetch z-component of flux density measurement<br><digits><br>min=1, max=5, def=3 |

[1] See "Universal Serial Bus Device Class Specification for Device Firmware Upgrade," Version 1.1, Aug 5, 2004, available from http://www.usb.org/developers/devclass_docs/DFU_1.1.pdf.

| | | |
|---|---|---|
| :TIMestamp? | | Fetch time stamp. Returns an 8-byte hexadecimal number, in ns. Note that the timer resolution is 167 ns. |
| :TEMPerature? | | Fetch temperature. Returns unsigned integer between 0 and 64K, with arbitrary units. |
| :ARRay | | Fetch values acquired during the last MEASure:ARRay or READ:ARRay. <size> must be no greater than the acquisition size. If FORMat is ASCii, returns a comma-separated list of values. The other parameters are as for :FETCh:SCALar. |
| [:FLUX] | | |
| :X? | <size>[,<digits>] | Fetch x-component of flux density measurement<br><size><br>min=1, max=2048, def=1<br><digits><br>min=1, max=5, def=3 |
| [:Y]? | <size>[,<digits>] | Fetch y-component of flux density measurement<br><size><br>min=1, max=2048, def=1<br><digits><br>min=1, max=5, def=3 |
| :Z? | <size>[,<digits>] | Fetch z-component of flux density measurement<br><size><br>min=1, max=2048, def=1<br><digits><br>min=1, max=5, def=3 |

| Command | Parameters | Description |
|---|---|---|
| :FORMat | | |
| [:DATA]? | [DEFault] | Query data output format |
| [:DATA] | ASCii \| INTeger \| PACKed[,<length>] \| DEFault | Set format for returned flux density measurement data.<br><br>– ASCii by default.<br><br>– INTeger returns an IEEE488.2 definite-length block, consisting of an 8-byte header of the form "#6nnnnnn" and followed by nnnnnn bytes of binary data. The data consists of a 32-bit big-endian signed integer for each flux density value, containing the 16-bit big-endian raw measurement value if calibration correction is disabled, or the flux density value in μT (THM1176-HF or -HFC) or mG (THM1176-LF) otherwise.<br><br>– PACKed,<length> returns compressed data, where <length> is the number of bytes per sample: 1 or 2, 2 by default. The data will be returned as an IEEE488.2 definite-length block, consisting of a 7-byte header of the form "#5nnnnn" and followed by nnnnn bytes of binary data. The first byte is <length>, encoded in ASCII; the following four bytes are the first field value, in the same format as for INTeger; and the following 8- or 16-bit signed integers represent the remaining data samples, as a delta relative to the previous sample. |

| Command | Parameters | Description |
|---|---|---|
| :INITiate | | |
| [:IMMediate] | | |
| [:ALL] | | Enable the trigger, where the trigger source, trigger count and trigger period are set with TRIGger commands |
| :CONTinuous? | [DEFault] | Query continuous-trigger state |
| :CONTinuous | <boolean> \| DEFault | Set continuous-trigger mode, where the trigger is automatically re-enabled after each acquisition. OFF by default. Continuous trigger is only allowed if the TRIGger:SOURce is TIMer. |

| Command | Parameters | Description |
|---|---|---|
| :MEASure | | Abort any pending triggers and perform measurements using the default acquisition parameters:<br>- Immediate trigger<br>- Continuous initiation off<br>- Averaging count 1<br>- Calibration state on<br>- Default range |
| [:SCALar] | | Perform a single measurement. Set the range for the expected value if provided; auto-range if not. Return at least the requested number of significant digits. |
| [:FLUX] | | <expected_value><br>min=0T, max=20T, def=0T<br><digits><br>min=1, max=5, def=3 |
| :X? | [<expected_value>]<br>[,<digits>] | Return x-component of flux density measurement |
| [:Y]? | [<expected_value>]<br>[,<digits>] | Return y-component of flux density measurement |
| :Z? | [<expected_value>]<br>[,<digits>] | Return z-component of flux density measurement |
| :ARRay | | Perform a series of <size> measurements. The other parameters are as for :MEASure:SCALar. |
| [:FLUX] | | <size><br>min=1, max=2048, def=1<br><expected_value><br>min=0T, max=20T, def=0T<br><digits><br>min=1, max=5, def=3 |
| :X? | <size><br>[,[<expected_value>]<br>[,<digits>]] | Return x-component of flux density measurement |
| [:Y]? | <size><br>[,[<expected_value>]<br>[,<digits>]] | Return y-component of flux density measurement |
| :Z? | <size><br>[,[<expected_value>]<br>[,<digits>]] | Return z-component of flux density measurement |

| Command | Parameters | Description |
|---|---|---|
| :MMEMory | | Read the THM1176 FLASH memory |
| [:CATalog]? | | Read the file directory.<br>Returns:<br>- Total bytes used<br>- Total bytes available<br>- File entries consisting of:<br>- File name<br>- File type<br>- File size |
| :DATA? | <filename> | Read the contents of the given file. |

| Command | Parameters | Description |
|---|---|---|
| :READ | | Abort pending triggers and perform a measurement with existing parameters. Note: cannot be used when TRIGger:SOURce is BUS. |
| [:SCALar] | | Perform a single measurement. Set the range for the expected value if provided; use the previously selected range if not. Return at least the requested number of significant digits. |
| [:FLUX] | | <expected_value><br>min=0T, max=20T, def=0T<br><digits><br>min=1, max=5, def=3 |
| :X? | [<expected_value>]<br>[,<digits>] | Return x-component of flux density measurement |
| [:Y]? | [<expected_value>]<br>[,<digits>] | Return y-component of flux density measurement |
| :Z? | [<expected_value>]<br>[,<digits>] | Return z-component of flux density measurement |
| :ARRay | | Perform a series of <size> measurements. The other parameters are as for :READ:SCALar. |
| [:FLUX] | | <size><br>min=1, max=2048, def=1<br><expected_value><br>min=0T, max=20T, def=0T<br><digits><br>min=1, max=5, def=3 |
| :X? | <size><br>[,[<expected_value>]<br>[,<digits>]] | Return x-component of flux density measurement |
| [:Y]? | <size><br>[,[<expected_value>]<br>[,<digits>]] | Return y-component of flux density measurement |
| :Z? | <size><br>[,[<expected_value>]<br>[,<digits>]] | Return z-component of flux density measurement |

| Command | Parameters | Description |
|---|---|---|
| :SENSe | | |
| [:FLUX] | | |
| [:RANGe] | | |
| [:UPPer]? | [MINimum \| MAXimum \| DEFault] | Query the current range setting |
| [:UPPer] | THM1176-HF or -HFC: 0.1\|0.5\|3\|20 T<br>THM1176-LF: 0.008 T<br>\| MINimum \| MAXimum \| DEFault | Set the range. Select highest range by default. |
| :AUTO? | [DEFault] | Query the auto-ranging setting |
| :AUTO | <boolean>\| DEFault | Set auto-ranging ON or OFF. ON by default. |
| :ALL? | | Return a list of all the ranges supported by this instrument, in T. |

| Command | Parameters | Description |
|---|---|---|
| :STATus | | |
| :OPERation | | Query/set OPERATION register sets |
| [:EVENt]? | | Read and clear operation event register |
| :CONDition? | | Read operation condition register |
| :ENABle? | | Query enable register |
| :ENABle | <numeric_value> | Set enable register.<br>"0" by default. |
| :QUEStionable | | Query/set QUEStionable register sets |
| [:EVENt]? | | Read and clear operation event register |
| :CONDition? | | Read operation condition register |
| :ENABle? | | Query enable register |
| :ENABle | <numeric_value> | Set enable register.<br>"0" by default. |
| :PRESet | | Reset OPERation and QUEStionable enable registers |

| Command | Parameters | Description |
|---|---|---|
| :SYSTem | | |
| :ERRor | | |
| [:NEXT]? | | Query error queue |
| :VERSion? | | Query SCPI version (e.g. 1999.0) |
| :HELP | | |
| :HEADers? | | List all available commands. |
| :SYNTax? | <command_header> | List syntax for a command. |
| :SLEEp | | Power down the acquisition electronics. Power-up is automatic at the next acquisition, but takes approximately 100 ms. |

| Command | Parameters | Description |
|---|---|---|
| :TRIGger | | |
| :COUNt? | [MINimum \| MAXimum \| DEFault] | Query trigger count |
| :COUNt | <value> \| MINimum \| MAXimum \| DEFault | Set the number of triggers required to complete an acquisition.<br><value><br>min=1, max=2048, def=1<br>Note: resets the trigger system. |
| :SOURce? | [DEFault] | Query trigger source |
| :SOURce | IMMediate \| TIMer \| BUS \| DEFault | Trigger source:<br>- IMMediate = no wait<br>- TIMer = periodic trigger<br>- BUS = USB488 TRIGGER<br>IMMediate by default.<br>Note: resets the trigger system. |
| :TIMer? | [MINimum \| MAXimum \| DEFault] | Query trigger timer |
| :TIMer | <meas_time> \| MINimum \| MAXimum \| DEFault | Set period for periodic trigger.<br><meas_time><br>min=122 µs, max=2.79 s, def=0.1 s<br>Note 1: resets the trigger system.<br>Note 2: if the specified trigger period is too short, a timer overrun error will be returned when the results are fetched (see Section 9-6-4). |

| Command | Parameters | Description |
|---|---|---|
| :UNIT? | [DEFault] | Query units |
| :UNIT | T \| MT \| UT \| NT \| GAUSs \| KGAUss \| MGAUss \|MAHZp \| DEFault | Set units in which flux density measurements are returned if FORMat is ASCii.<br>T by default.<br>Note: not all models support all units. Use UNIT:ALL? to determine which units are supported. |
| :ALL? | | Return a list of all the units supported by this instrument, followed by the divisor for each set of units. The divisor converts the instrument's base units (µT for the THM1176-HF or -HFC, and mG for the THM1176-LF) to the associated units. |

## 6-7 PROGRAMMING HINTS

Note that National Instruments' "Measurement & Automation Explorer" (part of the full NI-VISA package on Windows systems) provides a very useful tool to explore the command set. Select the THM1176 under "System / Peripherals & Interfaces / USB Devices," and click the "Open VISA Test Panel" icon. This opens a window from which you can try all functions available through NI-VISA.

Here are a few notes on how the command set is intended to be used:

- For simple measurements with the standard settings in single-channel mode, use the MEASure? command. MEASure:ARRay? returns a time series.
- Use the UNIT and FORMat commands to change the format in which the results are returned.
- Use the READ commands for measurements with non-standard trigger parameters, or to return raw measurement data without applying calibration corrections. As with MEASure, READ:ARRay? returns a time series.
- Use the FETCh command to retrieve all data corresponding to a preceding MEASure?, READ? or INITiate command, or FETCh:ARRay for the data corresponding to a MEASure:ARRay?, READ:ARRay?, or INITiate with TRIGger:COUNt > 1.

- Try to build a CALibration sequence with a zero-gauss chamber into the beginning of any lengthy measurement sequence. The THM1176 is designed to have very low offset and offset drift, but as with any Hall device, these remain a significant source of error.
- After an INITiate command with TRIGger:SOURce = BUS, the THM1176 expects TRIGger:COUNt triggers before resuming normal operation. During this interval, the following commands are illegal: CALibration:INITiate, FETCh, INITiate:IMMediate:ALL, SENSe:FLUX:RANGe:UPPer, SENSe:FLUX:RANGe:AUTo. The following commands are legal, but cause an ABORt and therefore terminate the acquisition sequence: *RST, ABORt, MEASure, READ.
- INITiate:CONTinuous is used for TRIGger:SOURce = TIMer or BUS, to avoid losing triggers while data is read out.
- Using the *OPC command, you can generate a ReQuest for Service (RQS) when a measurement (or any other action) is complete. Set bit 0 of the Standard Event Enable register and the ESB (Event Summary Bit) in the Status Enable register. Now, the execution of an *OPC command will generate an RQS.
- Alternatively, set bit 4 (MAV = Message AVailable) in the Status Enable register and append the *OPC? command to the previous commands. This will generate an RQS because *OPC? places a "1" on the output.
- If you program the instrument to generate an RQS, it is **very important** to Enable Service Requests on the host. This posts a read on the appropriate USB endpoint, the Interrupt endpoint. In the USB protocol, the host initiates all transfers; so if the host has not posted a read, the instrument cannot complete its RQS transfer. This will block the Interrupt endpoint, and any other commands using this endpoint – notably the USBTMC-USB488 Read Status Byte function – will fail.
- Be sure to check the status after every command. The Standard Event, OPERation and QUEStionable Status registers provide a general idea of what went wrong, and the status message on the Error/Event Queue (retrieved by SYSTem:ERRor?) provides a detailed diagnostic. See Chapter 9-Error Codes

for the exact interpretation of these error messages. It may be convenient to set up the Enable bits to generate a ReQuest for Service (RQS) when an error is encountered.

# REFERENCE
# 7-Technical Specifications

## 7-1 MEASUREMENT

| | | | | |
|---|---|---|---|---|
| Ranges:<br>(auto- or manual ranging) | THM1176-HF or -HFC: 100 mT, 500 mT, 3T, 20T<br>THM1176-LF: 8.0 mT | | | |
| Data output: | - $B_x$, $B_y$, $B_z$ (ASCII or binary, single point or array, calibrated or not)<br>- Temperature (uncalibrated)<br>- Time stamp (10ms resolution) | | | |
| Units:<br>- THM1176-HF or -HFC<br>- THM1176-LF | <br>T, mT, µT, G, kG, MHz p (proton NMR frequency)<br>T, mT, µT, G, mG | | | |
| Sample rate:<br>- Immediate trigger (default)<br>- Timed trigger<br><br>- Bus trigger (via USB) | <br>Approx. 6.8 kSa/s (free-running, until internal buffer is full)<br>Into internal buffer: 0.36 Sa/s to 5.3 kSa/s (jitter ~ 0.2 µs std. dev.)<br>During USB readout: 0.36 Sa/s to 2.3 kSa/s (jitter ~ 1.2 µs std. dev.)<br>Up to approx. 400 Hz (until internal buffer is full)<br>*Notes: 1 sample = ($B_x$, $B_y$, $B_z$); Internal buffer size = 4096 samples* | | | |
| Bandwidth: | DC to 1 kHz | | | |
| Resolution:<br>- THM1176-HF or -HFC<br>- No averaging<br>- Averaging 100 samples<br>- THM1176-LF | 100 mT range<br>300 µT<br>30 µT<br>No averaging: | 500 mT range<br>500 µT<br>50 µT<br>2 µT | 3 T range<br>3 mT<br>300 µT<br>Averaging 100: | 20 T range<br>15 mT<br>1.5 mT<br>0.2 µT |
| Accuracy:<br>(To 3 T for THM1176-HF,<br>to 1.5 T for THM1176-HFC,<br>full range for THM1176-LF) | The greater of:<br>- ±1% of reading, and<br>- specified resolution (THM1176-HF or -HFC) or 20 µT (THM1176-LF) | | | |
| User offset correction: | To be performed before each series of measurements, in Zero Gauss Chamber supplied | | | |

## 7-2 INTERFACE

| | |
|---|---|
| Interface: | USB 2.0, full speed (12 Mbps) |
| Class / USB driver: | USBTMC (USB Test & Measurement Class) / USB488<br>DFU (Device Firmware Upgrade) |
| Protocol: | IEEE 488.2, SCPI (Standard Commands for Programmable Instruments) |
| Connector: | USB Type A |
| Power: | USB bus-powered, 4.3V to 5.25V<br>35 mA min (idle, power-saver on), 90 mA max |
| Wake-up time from power-saver: | 100 ms |

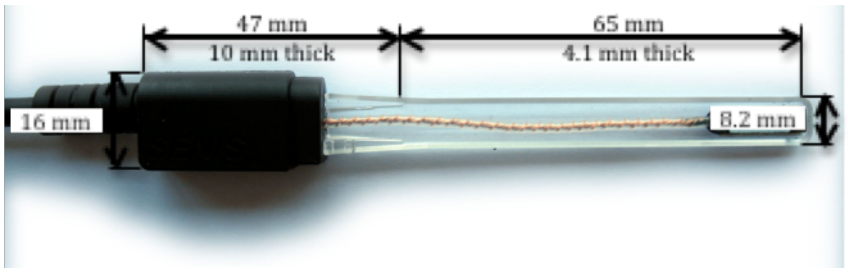
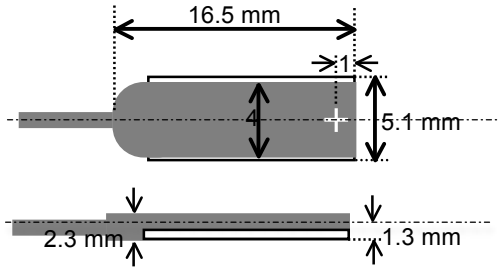
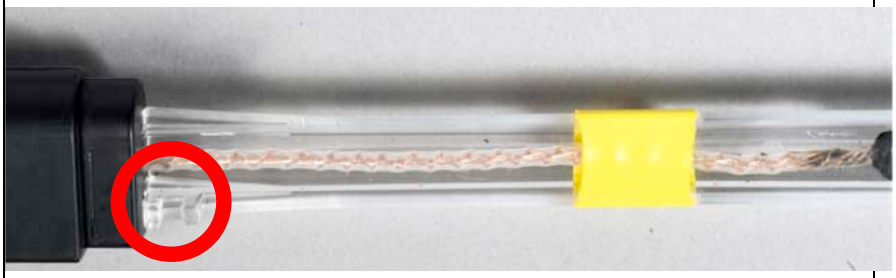
## 7-3 OPERATING CONDITIONS

| | |
|---|---|
| Operating temperature: | 0°C to +40°C |
| Storage temperature: | -20°C to +60°C |
| Operating magnetic field: | Instrument electronics: 3 T max |

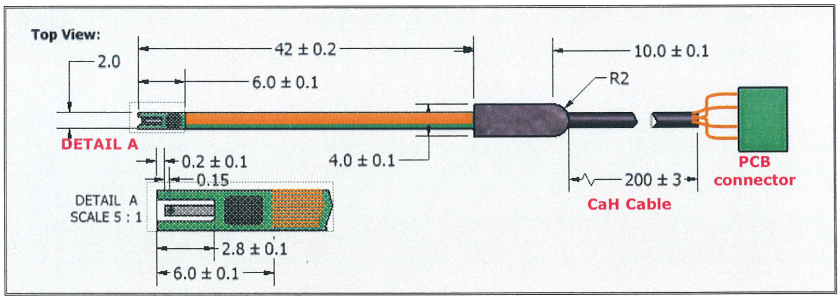
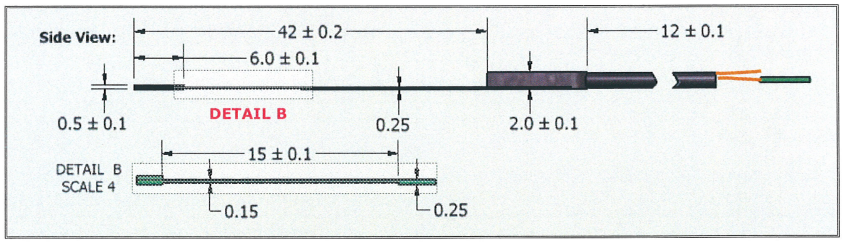
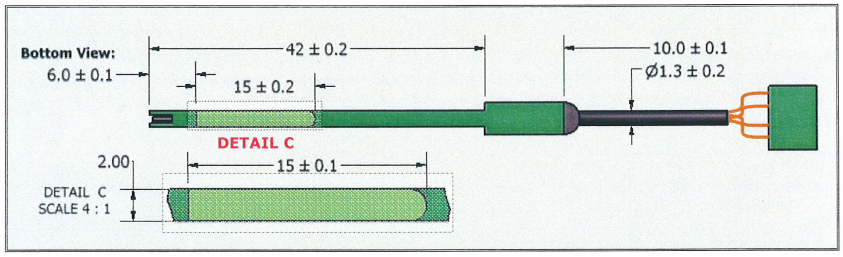
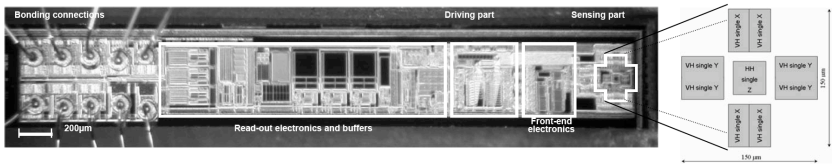
## 7-1 MECHANICAL – GENERAL

| | |
|---|---|
| Size:<br>- Instrument electronics | <br>76 x 22.5 x 14 $mm^3$ |
| Weight:<br>- With 2 m cable<br>- With 5 m cable | <br>150 g<br>280 g |

## 7-2 MECHANICAL – THM1176-HF

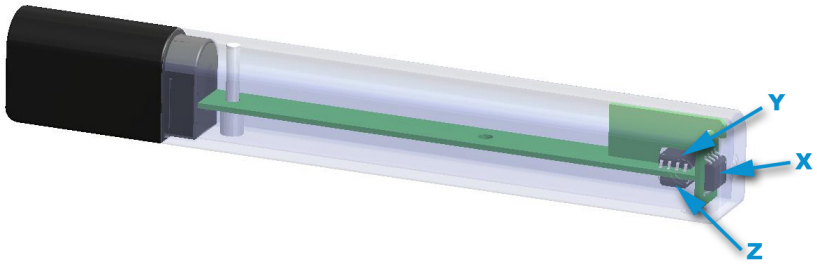
| | |
|---|---|
| Dimensions:<br>- Probe with housing | <br>113 x 16 x 10 $mm^3$ |
| - Probe without housing |  |
| - Sensor package |  "+" marks the field sensitive point. |
| - Field sensitive point | 150 µm x 150 µm x 10 µm |
| Stationary mounting point: |  <br>For M2.5 screw (not included). Note: to avoid breaking the mounting point, use a spacer and do not over-tighten the screw. |

## 7-1 MECHANICAL – THM1176-HFC

| | |
|---|---|
| Dimensions:<br>- Top view |  |
| - Side view |  |
| - Bottom view |  |
| - Field sensitive point | 150 µm x 150 µm x 10 µm |
| Location of field sensitive point: | Marked by "+" in "DETAIL A," above. With the proper lighting, the sensor IC structures can be seen under a microscope, and the exact location of the Hall elements can be ascertained visually. The image below identifies the major structures on the IC:<br>  |

 Copyright © 2012 Metrolab Technology SA

## 7-1 MECHANICAL – THM1176-LF

| | |
|---|---|
| Dimensions:<br>- Probe with housing<br>- Field sensitive point | <br>113 x 16 x 10 $mm^3$<br>6 x 3.4 x 3 mm |
| Sensor locations (THM1176-LF) |  |

## 7-2 DESKTOP KIT

| | |
|---|---|
| Contents: | - 3-Axis Hall Probe with 3 or 6 meter cable<br>- Zero Gauss Chamber<br>- Calibration:<br>THM1176-HF: to 3 T<br>THM1176-HFC: to 1.5 T<br>THM1176-LF: over full range<br>- CD with acquisition software for PC (Windows XP/Vista), LabVIEW source code for all PC software, and user's manual<br>- Software license from Metrolab, including free updates |
| Software functions: | - Display B, $B_x$, $B_y$ and/or $B_z$, either numerically or graphically<br>- Display raw data or computed peak-to-peak, RMS or FFT values<br>- Visualize direction of the B-vector relative to probe<br>- Select units for displayed results<br>- Capture maximum field value<br>- Hold (freeze) a given measurement<br>- Record data to a file, either continuously or point-by-point<br>- Display a recorded file<br>- On-line help<br>- Settings saved upon exit, restored at restart<br>Setup page:<br>- Select one of many THM1176<br>- Display model, serial and version numbers, date of last calibration<br>- Display version information about the software<br>- Select measurement parameters, including sample rate, internal buffer size, averaging, and data compression<br>- Select measurement range (or auto-ranging)<br>- Initiate user offset correction procedure<br>- Define alarms for when measurements exceed specified bounds |
| Record file format: | ASCII tab delimited; compatible with Handheld file format |

## 7-3 HANDHELD KIT

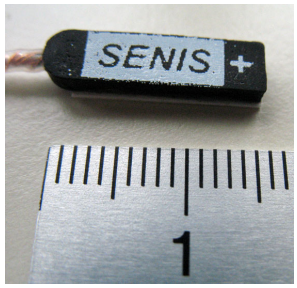
| | |
|---|---|
| Contents: | Contents of the desktop kit, plus:<br>- Industrial-quality PDA<br>- Heavy duty Li-Ion battery (2600 mAh), plus spare (1200 mAh)<br>- AC adaptor/charger (100-240 VAC 50/60 Hz, 500 mA) with wall socket adaptor plugs for Europe, UK, USA, Australia<br>- USB-Host adaptor cable to connect PDA to THM1176<br>- USB-Device adaptor cable to connect PDA to PC<br>- Pre-installed acquisition software, with licenses from Metrolab, including free updates, and from National Instruments<br>- CD with acquisition software for PC (Windows XP/Vista) and PDA (Windows Mobile), LabVIEW source code for all PC and PDA software, and user's manual<br>- Carrying Case |
| PDA type: | Windows Mobile® 5.0 with USB host interface |
| PDA size: | 127 x 75 x 21 $mm^3$ |
| PDA weight: | 230 g with 2600 mAh battery, stylus and USB adaptor cable |
| Display: | 64K colour TFT LCD, 3.5", 240 x 320 pixels |
| Input Device: | Stylus or fingertip |
| Connectors: | - Power jack<br>- 2.5mm audio headset jack<br>- 26 pin connector for ActiveSync, USB 1.1 host and USB 2.0 client<br>- CompactFlash and SDIO expansion slots |
| Audio: | Built-in microphone and speaker |
| Memory: | 128 MB SDRAM, 256 MB NAND Flash |
| Wireless LAN: | IEEE 802.11 b/g; internal antenna |
| Bluetooth: | V2.0 + EDR class 1 |
| Battery life: | 6 hours min (THM1176-HF or -HFC), 3 hours min (THM1176-LF) |
| Record file format: | ASCII tab delimited; compatible with Desktop file format |
| Pre-loaded software: | - Acquisition software (same functionality as desktop software)<br>- Word Mobile, Excel Mobile, PowerPoint Mobile<br>- Outlook Mobile, IE Mobile, MSN Messenger Client<br>- Windows Media Player 10.2 Mobile<br>- ActiveSync Client<br>- Socket Mobile Wi-Fi Companion<br>- Programmable Home Screen, Calculator, Utility programs |
| PDA operating temperature: | 0° to 50°C |
| PDA operating magnetic field: | 1 T max. The PDA may experience forces as high as 50 N.<br>Note: The touch screen of the PDA will cease to function. The power of the PDA must be cycled to restore full operation. |

## 7-4 WARRANTY, CALIBRATION, CERTIFICATION AND MAINTENANCE

| | |
|---|---|
| Warranty | 2 years |
| Recommended calibration interval: | 18 months (3-Axis Hall Probe only)<br>Note that for logistical reasons, Metrolab recalibrates the THM1176 in batches. Four weeks in the year are fixed to perform batch calibrations:<br>Week 10, Week 24, Week 37, Week 50<br>To benefit from the discounted pricing for this batch operation, you must ensure that your instrument arrives at Metrolab the week before. |
| Certification | CE approved |
| Maintenance | Firmware upgradable by end user |

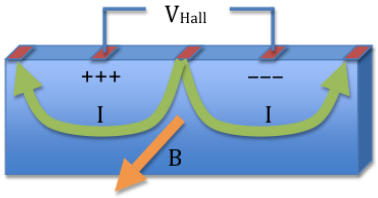
# REFERENCE
# 8-THM1176-HF Sensor Details

*This chapter is adapted from an article by Philip Keller of Metrolab in the June/July 2008 issue of Magnetics Business & Technology (http://www.MagneticsMagazine.com).*



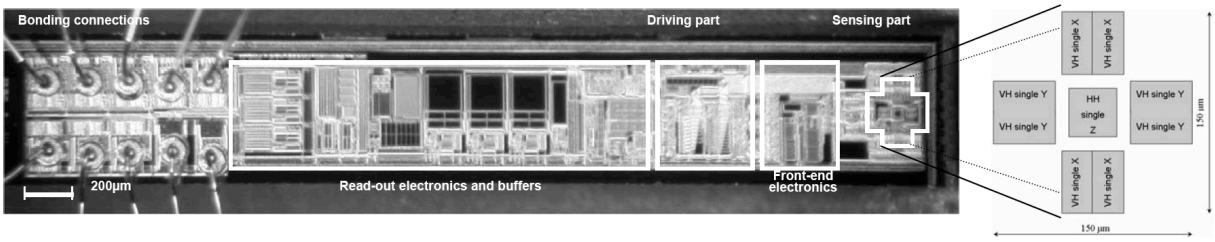

To measure the total field, we need three orthogonally oriented Hall sensors. Typically, three individual sensors are glued into a cube, roughly five to ten millimeters on a side. But now there is another way: a single IC containing one conventional planar Hall element and two sets of "vertical" Hall elements.

The vertical elements can be thought of as plates of N-type silicon inserted vertically into a P-type substrate. If a current is injected into the center terminal and extracted from the two end terminals, the currents in the two halves of the plate flow in opposite directions, resulting in a Hall voltage on the remaining terminals.



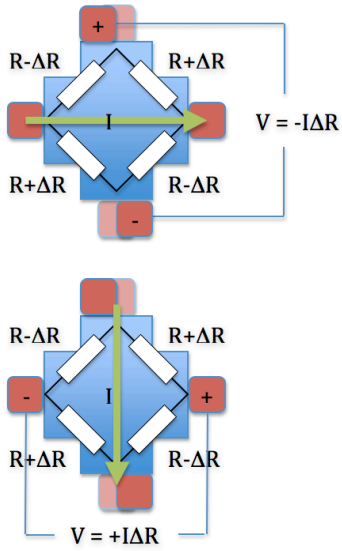

A team at the EPFL in Switzerland, led by Dr. Popovic, applied this technique to design a 3-axis sensor on an IC, called the MAG3D. The array of Hall elements measures 150 x 150 x 10 $\mu m^3$ – a million-fold reduction in active volume compared to a conventional approach! This allows precise position determination as well as consistent measurements of all three components even in highly inhomogeneous fields.

But MAG3D contains much more than the Hall elements. To build a Hall magnetometer, we need to supply a current and measure a voltage. By increasing




the current and/or amplifying the voltage, one can increase the sensitivity. All this is done on the IC; the external electronics only supplies 5V power and two digital lines to select one of four ranges (.1, .5, 3 or 20 T). This represents a tremendous simplification of the magnetometer as a whole. (Image courtesy of Senis GmbH)

But there's more… All Hall magnetometers suffer from measurement offset – in other words, the instrument measures a non-zero result even in a zero field. What's more, this offset varies with time and temperature. One should calibrate the instrument in a zero-gauss chamber before each use, and the instrument has to continuously correct the measurement for temperature variations. Even so, offset remains a significant source of error.




Where does offset come from? One common source is misalignment of the terminals. As shown in the figure, the effect can be modeled with a resistance network, where the longer current paths result in higher resistances, and vice versa. In our example, the resulting offset voltage would be negative. But if we exchange the current and voltage leads, thereby functionally rotating the Hall element by 90°, the offset voltage becomes positive. It is important to note that the Hall voltage is unaffected by this rotation.

The MAG3D exploits this effect in two ways. The "spinning current" technique, where the voltage and current leads are rapidly switched back and forth and the results averaged, compensates for manufacturing imperfections such as terminal misalignment. In addition, by wiring orthogonally oriented pairs of sensors in series, the MAG3D increases its sensitivity while at the same time compensating for dynamic offset errors. This includes the planar

Hall effect, whose magnitude changes sign when the current direction is rotated by 90°. The combination of these techniques results in a sensor with significantly reduced offset, offset drift, and sensitivity to planar Hall effect.

# REFERENCE
# 9-Error Codes

Error codes returned by the USB Interface are numbered according to the SCPI standard.[2] Sections 21.8.9 through 21.8.16 of Volume 2 of the SCPI manual, "Command Reference", provide a generic description of all possible error codes. In general, the codes are between -800 and 300. This chapter describes only the error codes produced by the THM1176, and the circumstances that might produce each error.

In addition to the SCPI errors, the THM1176 Application Programming Interface might produce additional errors, in the range of -1073807360 to -1073807192 and 1073676290 to 1073676457 (0xBFFF00xx and 3FFF00xx – the former are errors and the latter are warnings). These are VISA error codes, and are not documented here. See the LabVIEW on-line help under "VISA Error Codes," or right-click on the error indicator and select "Explain error."

## 9-1 0: NO ERROR

Zero indicates no error.

## 9-2 -100: COMMAND ERRORS

### *9-2-1 -102: Syntax error*

The command header did not match any of the known commands.

### *9-2-2 -104: Data type error*

A parameter within the command was of a type invalid for the command.

### *9-2-3 -115: Unexpected number of parameters*

The wrong number of parameters was given in the command.

### *9-2-4 -123: Exponent too large*

The command contains a numeric parameter that was too large to be stored internally. This occurs if the value has an exponent greater than ±43.

### *9-2-5 -151: Invalid string data*

The parameters in the command contain an unmatched single or double quote.

[2] Standard Commands for Programmable Instruments – see Section 6-1 for the complete reference.

#### *9-2-6 -171: Invalid expression*

The parameters in the command contain an unmatched bracket.

### 9-3 -200: EXECUTION ERRORS

#### *9-3-1 -221: Settings conflict*

Indicates that a legal program data element was parsed but could not be executed due to the current device state:

- Starting an acquisition when trigger is not enabled;
- Sending a bus trigger when trigger is not enabled, when the trigger source is not BUS, or when the expected number of triggers have already been received;
- Sending a CALibration:INITiate, FETCh, INITiate:IMMediate:ALL, READ, or SENSe:FLUX:RANGe command when triggers were enabled in BUS trigger mode;
- Sending an INITiate:CONTinuous command when in IMMediate trigger mode;
- Sending SYSTem:SLEEp when trigger is enabled.

#### *9-3-2 -222: Data out of range*

Indicates that a legal program data element was parsed but could not be executed because the interpreted value was outside the legal range as defined by the device:

- A numeric parameter is smaller than the allowable minimum or larger than the maximum;
- A character parameter does not match one of the allowable choices;
- FETCh: fetching more data than what was acquired;
- FORMat[:DATa] : <length> specified for ASCii or INTeger ;
- MEASure, READ: the <expected_value> is too large;
- MMEMory:DATa: the file does not exist;
- SENSe: the requested range does not exist; or
- SYSTem:HELP: requesting help for a non-existent command.

#### *9-3-3 -225: Out of memory*

The device has insufficient memory to perform the requested operation:

- when writing the new User Offset Zero file to Flash.

### 9-4 -400: QUERY ERRORS

#### *9-4-1 -400: Query error*

Generic query error:

- Device being cleared when query was received.

On the THM1176, no other conditions should generate this error. If this is not the case, please report to Metrolab the circumstances under which you received this error.

#### *9-4-2 -410: Query INTERRUPTED*

The host has sent a new command before finishing reading the response to a preceding query.

#### *9-4-3 -420: Query UNTERMINATED*

The host is trying to read a response without having sent a complete query.

#### *9-4-4 -440: Query UNTERMINATED after indefinite response*

Indicates that a query was received in the same program message after a query requesting an indefinite response was executed. On the THM1176, the only command returning an indefinite response ("Arbitrary ASCII Response Data") is *IDN.

### 9-5 100: INSTRUMENT-DEPENDENT COMMAND ERRORS

#### *9-5-1 101: Invalid value in list*

One or more values in a numeric list parameter are invalid, e.g. floating point when not allowed.

#### *9-5-2 103: Wrong units for parameter*

A parameter within the command has the wrong type of units for the command.

### 9-6 200: INSTRUMENT-DEPENDENT EXECUTION ERRORS

#### *9-6-1 200: Software Error*

The firmware has encountered an unexpected error:

- the User Offset Zero file has been corrupted;
- the ADC driver returned an unknown error code;
- the command parser or dispatcher returned an unknown error code;
- encountered an error formatting a result;
- could not open one of the data files file;
- unable to perform reset;
- encountered an unknown choice for character data;
- encountered something other than a value, MINimum, MAXimum or DEFault for a numeric parameter;
- encountered something other than a Boolean or DEFault for a Boolean parameter; or
- encountered an unknown parameter type.

Please report to Metrolab the circumstances under which you received this error.

#### *9-6-2 204: Data buffer was overrun*

In timed-trigger mode, data was lost because the read-out did not keep up with the acquisition.

#### *9-6-3 205: Measurements were over-range*

The field value exceeded the selected range.

#### *9-6-4 206: Timer was overrun*

In timed trigger mode, a measurement was still in progress when the timer to start the next measurement expired. The next measurement was skipped.

#### *9-6-5 207: Bad data compression*

When returning data in PACKed FORMat, the true dynamic range of the data could not be accurately represented by the delta values. The maximum delta value was used, while attempting to correct the error on the subsequent sample(s). It is recommended to use a lesser degree of compression.