

NMR PRECISION TESLAMETER PT2026

THE GOLD STANDARD FOR MAGNETIC FIELD MEASUREMENT



USER'S MANUAL

Version 2.1



ISO 17025 ACCREDITED

September 2025

REVISION HISTORY

v. 2.1 r.1.1	Sept 2020	Regulation status bits documented: QUESTionable:BIT12 bit 12 added OPERation:BIT11 bit 14 added OPERation:BIT12 bit 7, 12, 13, 14 & 15 added : REGUlation command points toward the RG8026 User Manual.
v. 2.1 r.1.2	May 2022	Fix min, max and default values for SCPI commands. Fix misnamed GAUSs to GAUSS. Documents missing bits in status registers. Add explanation about the different programming options. Remove :CONFigure:SEARch:LEVel commands. Add :CONFigure:SEARch:ENABLE commands. Fix “binary format” of FETCh commands.
v. 2.1 r.1.3	Nov 2022	Replace software documentation with explanation on contextual help. Remove API documentation (self-documented).
v. 2.1 r.1.4	June 2025	Some typos fixed Specifications revised and included in this document Comparison with PT2025 removed MODBUS is now described in a separate document.

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GETTING STARTED

1- INTRODUCTION

NOTICE

See the “Installation and Safety Manual,” delivered in printed form with your instrument, for safe installation and operation of the PT2026 hardware. The most recent version of this manual is also available for download from the Metrolab website, www.metrolab.com.

The Precision Teslameter PT2026 is a magnetometer, used to very precisely measure the flux density (“field strength”) of strong magnetic fields.

The PT2026 relies on Nuclear Magnetic Resonance (NMR) as measurement technique. NMR is unique in magnetometry due to its unrivalled precision and accuracy, and practically total lack of drift.¹ For these reasons, NMR magnetometers are widely used as a secondary magnetic-field standard, serving as reference to calibrate other magnetometers. They are also routinely used in scientific and industrial applications that need to measure, map, monitor or regulate magnetic fields with extreme precision.

It is important to note that NMR magnetometry also has limitations. Most importantly, the magnetic field gradients in the volume to be measured must be close to zero. In addition, NMR is best suited for measuring strong magnetic fields. Finally, NMR is a relatively slow measurement technique.

The contents of this manual are as follows:

- Chapter 2- “Quick Start Guide” and Chapter 3- “Overview” provide information to get started;
- Chapter 4- “Host Interfaces” explain how to write instrument control software;
- Chapter 5- “Key Specifications” lists the key instrument characteristics; and

Updates to the software, firmware and documentation are posted on the Metrolab website, www.metrolab.com, and can be downloaded free of charge. The firmware in the PT2026 Main Unit can be upgraded in the field. The easiest way to be notified of updates is to sign up for our electronic newsletter, on the News page of our site.

¹ See Chapter 5-Key Specifications for details.

We hope the PT2026 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

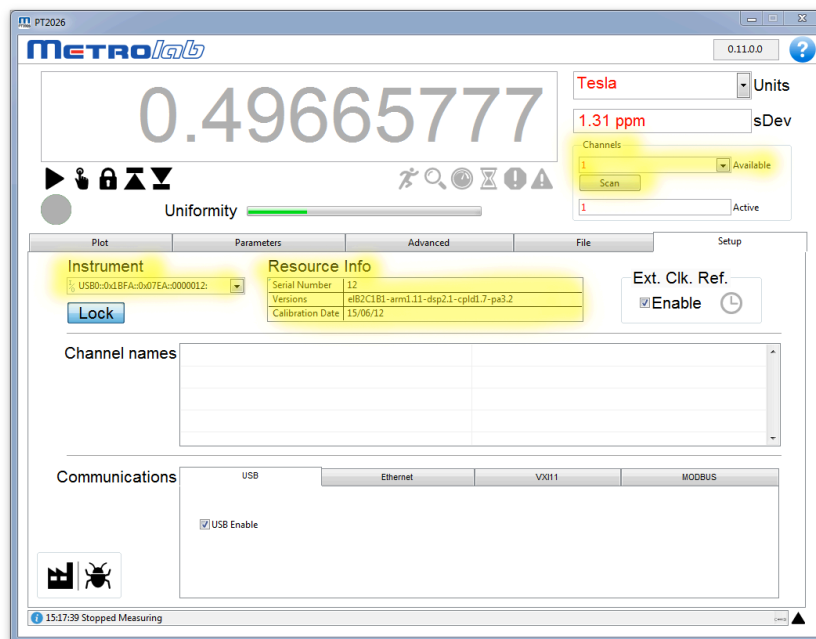
This chapter describes the installation, start-up and shutdown of the PT2026 software. The hardware installation is described in the “PT2026 Installation and Safety Manual.”

2-1 SOFTWARE INSTALLATION – WINDOWS

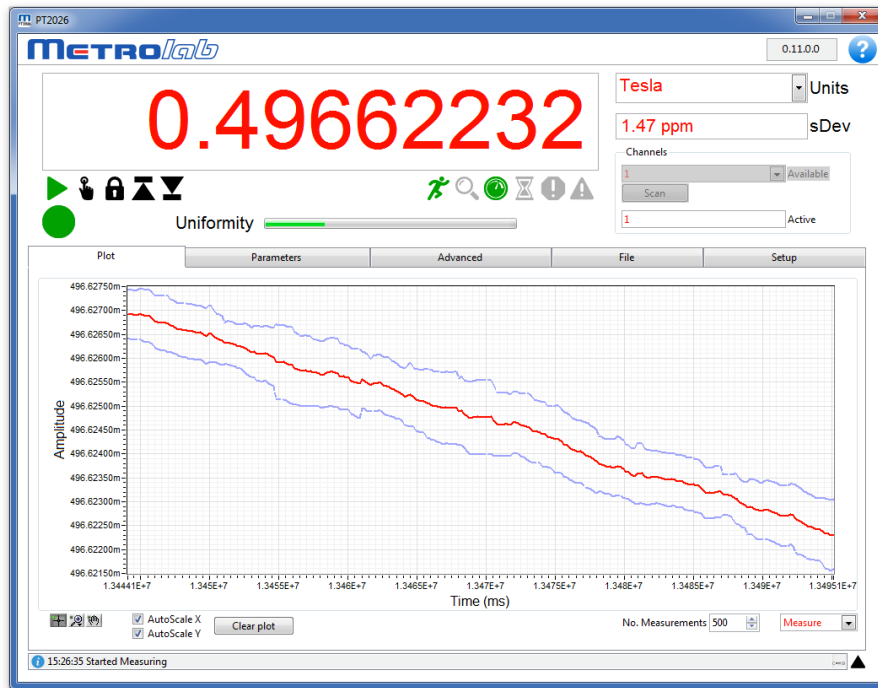
- Plug the USB key.
- Open the ReadMe.md file with your favorite text editor.
Follow the instructions under “PT2026 Software Installation”.

2-2 START-UP

- Power on the PT2026 as described in the PT2026 Installation and Safety Manual.
- Start the PT2026 software from the Windows Start Menu:
Metrolab > PT2026 > Metrolab PT2026
- In the PT2026 software window, click on the “Setup” tab to select the corresponding screen.
With the Instrument pull-down menu, select the VISA resource name that corresponds to your PT2026. This name should look something like “USB0::0x1BFA::0x07EA::xxxxxxx::INSTR”, where “xxxxxxx” represents the serial number written on the back panel of your instrument. Verify that the software has been able to connect to your PT2026, and that the PT2026 has been able to connect to your probe:

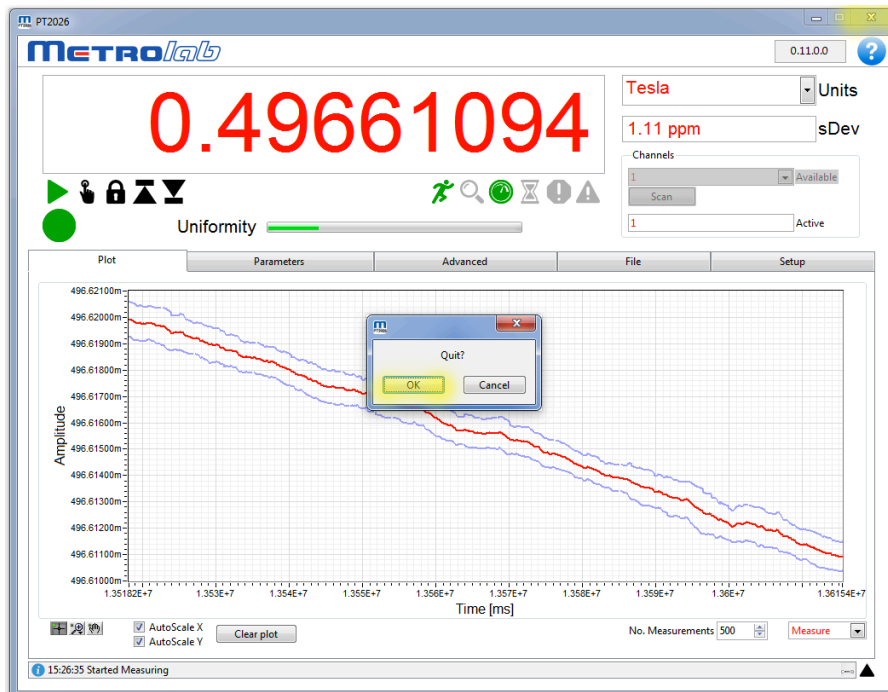


- Using the corresponding tab, return to the Plot screen and click the Measure arrow. The Search Progress bar should show the probe range being swept, searching for the NMR resonance, until your magnetic field value is reached, and the instrument starts measuring:



2-3 SHUT-DOWN

- To stop the software, close the PT2026 window and confirm the “Quit?” dialog:

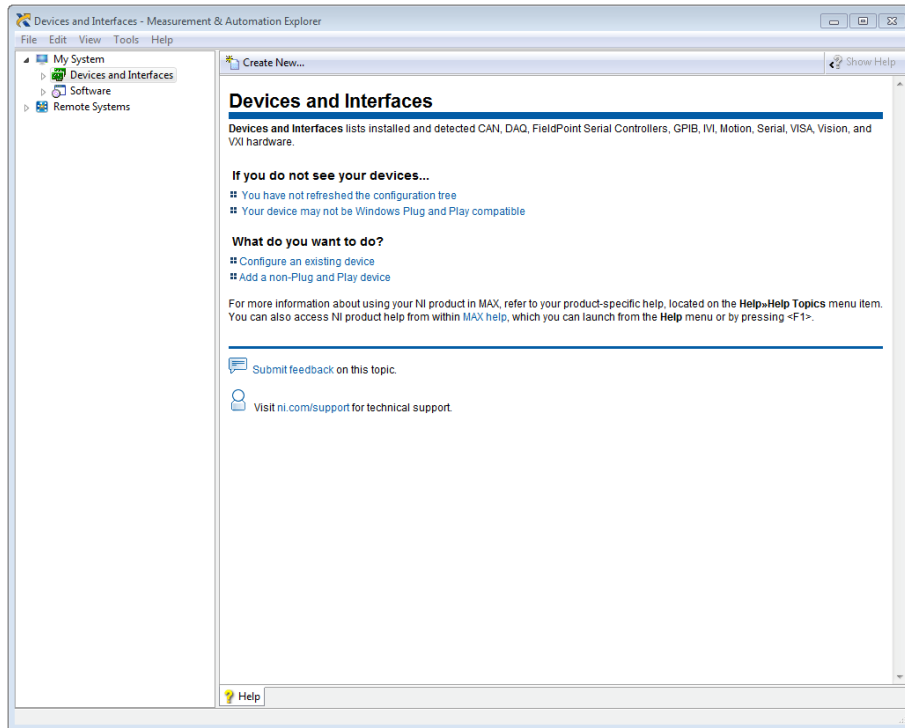


- Power off the PT2026 as described in the PT2026 Installation and Safety Manual.

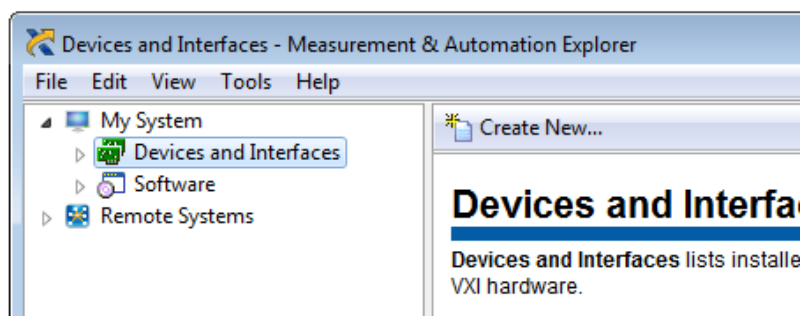
2-4 CONNECT VIA ETHERNET PLUS VERSION OF PT2026 ISN'T CONCERNED

To connect to the PT2026 via Ethernet, you must first create a network instrument entry for the PT2026 in the VISA database. Use the National Instruments utility, “Measurement & Automation Explorer” (MAX) to do this:

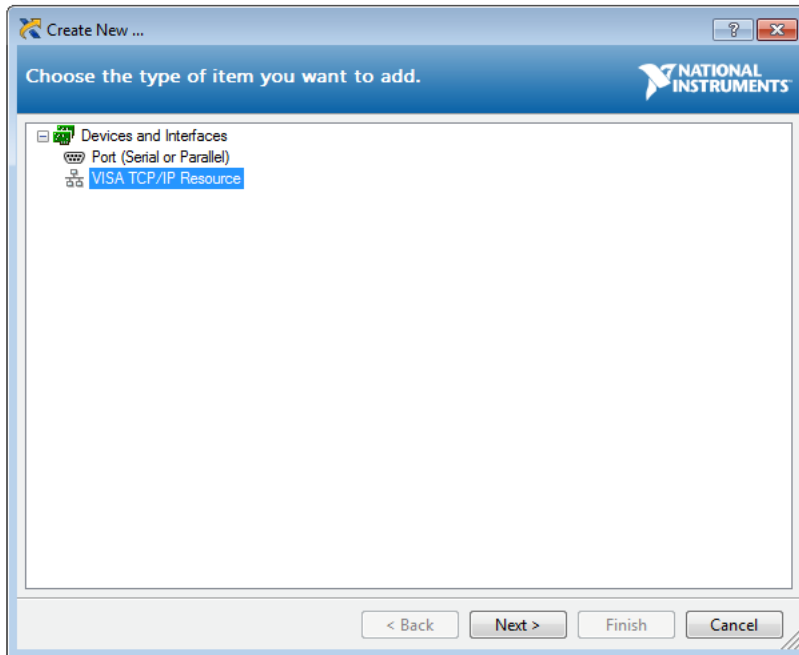
- Launch MAX: Windows Start Menu > All Programs > NI MAX:



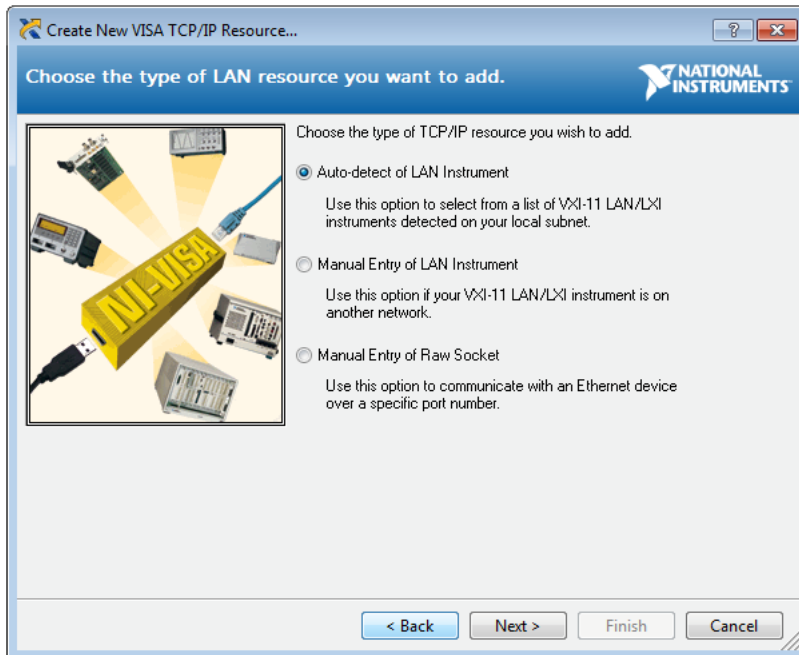
- Select “System > Devices and Interfaces” in the left-hand column, and click on “Create New...”:



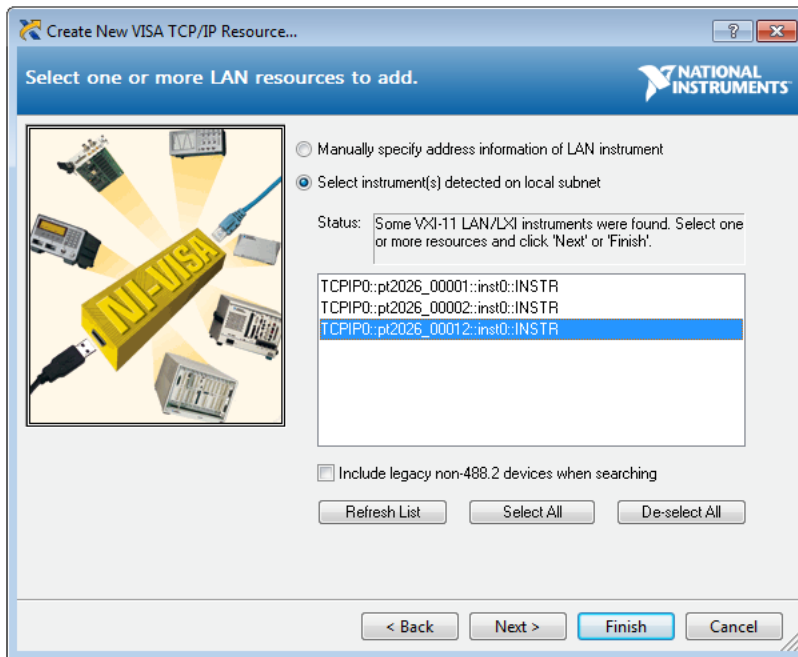
- In the resulting dialogue window, select “VISA TCP/IP Resource” and click “Next”:



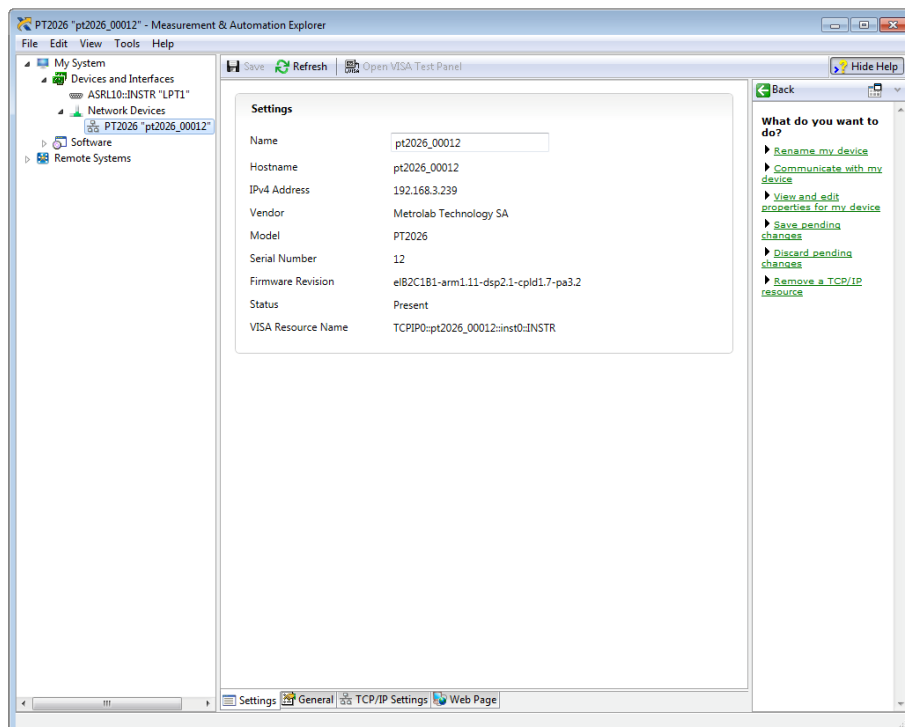
- In the subsequent dialogue, Select “Auto-detect of LAN Instrument” and click “Next”:



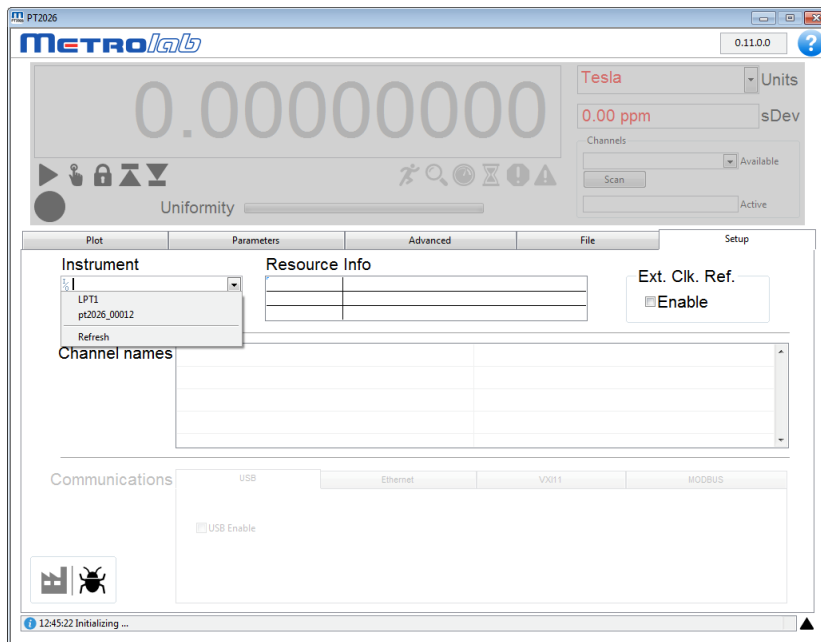
- In the last dialogue, select the entry that corresponds to your PT2026, and click “Finish”:



- In the main MAX window, if you expand the item “Devices and Interfaces”, then the subjacent item “Network Devices”, you will now see an entry for your PT2026. Click on the entry to reveal the Settings panel for your PT2026 network device:



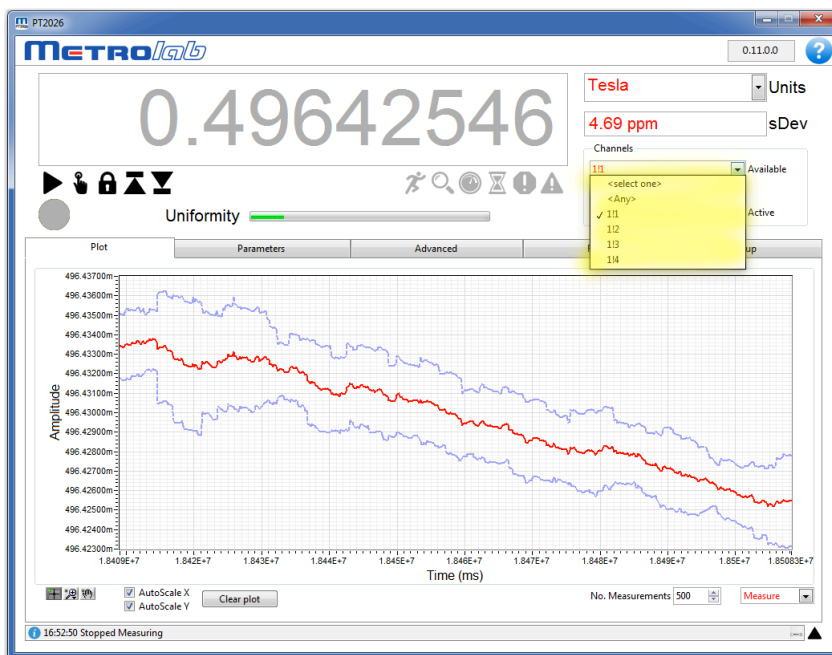
- Now, in the Setup panel of the PT2026 software, if you click on the Instrument pull-down menu, you will see the entry for your PT2026 network device:



Select it and go!

2-5 USING MULTIPLEXERS


- Connect the MUX6026 multiplexer and probes as described in the PT2026 Installation and Safety Manual.
- Select the active probe **from** the Channels pull-down menu:



- Start measuring as described in Section 2-2 .

2-6 USING SOFTWARE EMBEDDED CONTEXTUAL HELP

The PT2026 software is self-documented.

Click on the  button (top right corner of the PT2026 software) to get contextual help.

This opens a help page in your default browser but does not require any internet connection. The page that will be open is related to the current tab opened in your PT2026 software.

USING THE PT2026

3- OVERVIEW

This chapter provides a quick overview of what you can do with the PT2026. Additional details are provided in subsequent chapters. Note that the contextual help in the PT2026 software is very useful.

3-1 MEASUREMENT

- You can measure magnetic flux density with a precision of parts per million (10^{-6}) or even better – but beware of the limitations of NMR magnetometers.
- Before starting to measure the flux density, NMR magnetometers must find the NMR resonance. The software tells you what the PT2026 is doing with a status light, a series of status symbols, a search progress bar, and a message log.
- If for some reason the PT2026 cannot find the NMR resonance, you can limit the search range. If all else fails, you can manually force it to search at a given field strength.
- Once the NMR resonance has been found and the PT2026 is measuring, the search progress bar turns into a field-uniformity display, to help you position the probe in your magnet’s “sweet spot”.
- The software will display the measurements numerically and plot the results on a strip chart. You can freeze the numeric display and change its resolution, and you can manipulate many features of the plot. Some of the plot options, such as the auto-scaling controls, are evident; others, such as the cursor controls, are accessed by right-clicking on the plot.
- You can select the appropriate measurement units, such as Tesla or kGauss. The choices also include some exotic but useful units, such as MHz, MHz-proton and parts per million.
- You can enable measurement averaging and display the standard deviation of the measurements. You can control the averaging method and the filter length.
- If you are using a probe multiplexer, you use the PT2026 software to select which probe to use.
- With a multiplexer, you can also group a set of probes – for example those in a particular magnet – as a single logical channel. The PT2026 will search across the range of each probe in turn and will start measuring with the one where it finds the NMR resonance. The PT2026 comes with one pre-configured logical channel, Any, which includes all probes that are plugged in.

- To help you find the peak field in a volume, you can have the PT2026 software display only maximum or minimum field values.
- You can have the measurements triggered either continuously, at regular intervals, via the software interface, or via a TTL signal.
- You can also have the PT2026 generate an output trigger when a particular field value is attained. The PT2026 only has a single Trigger connector, configured either as input or output, so the output trigger cannot be used at the same time as the TTL measurement trigger.
- If need be, you can optimize the measurements by manipulating a host of internal parameters using the Advanced tab. Unless you are very familiar with the instrument and the principles of NMR, you probably should not touch these. A possible exception is the Advanced > RF Pulse > Period, to increase the measurement rate.
- You can store and recall your favorite settings.
- You can record and play back measurements.
- Finally, the Setup tab embodies a host of useful utility features that deserve browsing.

3-2 INTERFACES

The interfaces are described in detail in Chapter 4- “Host Interfaces”. Generally, you don’t have to know anything about them, since the PT2026 software takes care of it all. If you want to know, the most important point is that the PT2026 adheres closely to industry standards:

- 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).
- Ethernet interface:
Automatically configures itself for 10 or 100 Mbps and Full or Half Duplex operation.
- 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 VXI-11 protocol:
For the Ethernet interface, IEEE488 compatibility is provided by the VXI-11 standard, providing the same advantages as USBTMC for USB.
- 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.

PROGRAMMING THE PT2026

4- HOST INTERFACES

4-1 GENERAL

The PT2026 supports two physical host interfaces, USB 2.0 and Ethernet, and two host interface protocols: “native” and “MODBUS.” The native protocol is based on the following standards, very widespread in the instrumentation industry:

- IEEE 488.2: device control,
- VXI-11: Ethernet device control,
- USBTMC-USB488: USB device control, and
- SCPI: command structure.

All these interfaces and protocols are following standards that you may find following these links:

- USB 2.0
See “Universal Serial Bus Specification, Revision 2.0, April 27, 2000,” available from www.usb.org/developers/docs/usb20_docs.
- 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 www.usb.org/developers/docs/devclass_docs.
- SCPI
See “Standard Commands for Programmable Instruments (SCPI), VERSION 1999.0, May, 1999,” available from www.ivifoundation.org/specifications/default.aspx.
- 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 <https://ieeexplore.ieee.org/document/213762..>
- 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 www.ivifoundation.org/specifications/default.aspx.

The native commands provide access to all the features of the PT2026. The same command set is supported on the USB and Ethernet interfaces.

4-1-1 MODBUS

NOTICE

The MODBUS interface protocol is described in another document and, as of June 2025, implemented on “Plus” version of the PT2026 main unit only.

A special case is the MODBUS protocol, which is commonly used in industrial automation applications. The PT2026Plus supports the MODBUS protocol only on the Ethernet interface, and it only provides access to a subset of the instrument’s functionality. The full documentation for this protocol is covered by another document that you may find on our website.

4-1-2 API

Several options are available to communicate with the main unit. As stated before, we offer a full LabVIEW API but we also provide, as an open-source project, a full API written in C++. This API works in conjunction with third-party libraries, also open-source, that allow a seamless integration of the instrument in your code using USB or Ethernet interfaces.

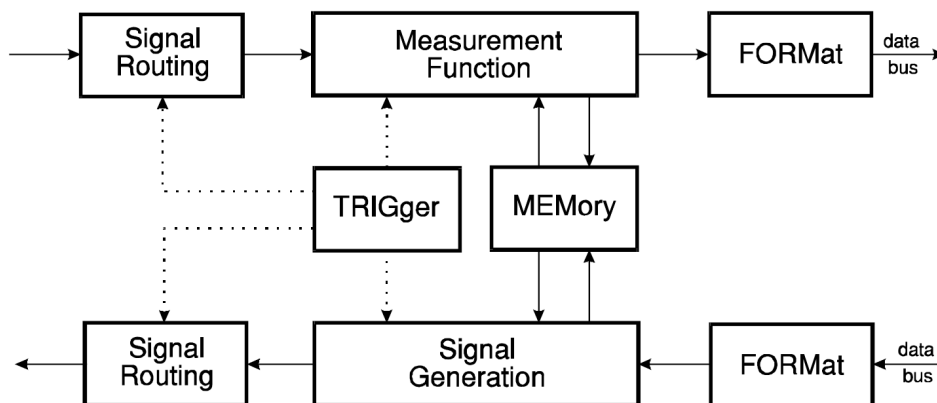
The PT2026 was designed to plug-and-play with a Virtual Instrument Software Architecture (VISA) compliant software library – particularly the NI-VISA library from National Instruments (see www.ni.com) but we also offer a full-featured library that can be used as a substitute for NI-VISA.

For more information about the API and its full documentation and examples, we ask you to visit our website.

4-2 NATIVE INTERFACES

4-2-1 SCPI instrumental model

The PT2026 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 PT2026 capabilities, organized according to the SCPI instrument model. The supported commands include IEEE 488.2 “Common Commands” (start with “*”) as well as SCPI commands – see Sections 0 through 4-2-6 for details. In addition to ASCII commands, the PT2026 also supports certain VXI-11 and USBTMC-USB488 low-level controls, also noted in this table.

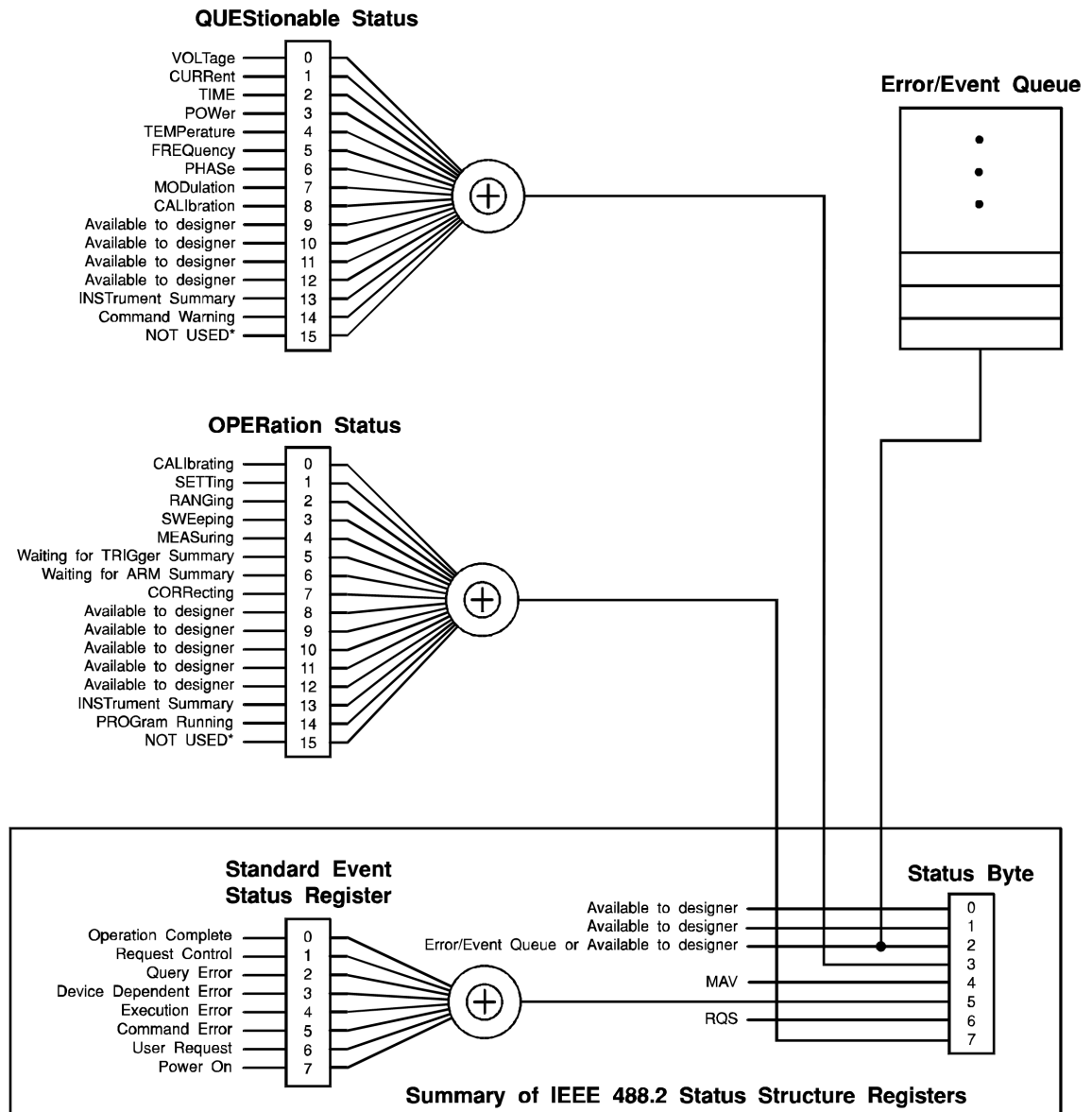
Functional Block	Command(s)	Function
Measurement Function	:MEASure ...	Measure with standard settings. Equivalent to *RST;;READ ...
	:READ ...	Measure with custom settings. Equivalent to :ABORT;;INITiate ...;;FETCh ...
	:FETCh ...	Fetch measurement results previously acquired with MEASure, READ or INITiate
	:CONFigure ...	Configure probe matching/tuning, NMR signal search, measurement and tracking
Signal Routing in	... [, <channel_list>]	Parameter for MEASure and READ
	ROUTE	Explicit ROUTe command
INPut	INPut ...	Configure reference clock
SENSe	:SENSe ...	Configure digitization parameters
CALCulate in	:CALCulate:AVERage1	NMR signal averaging
	:CALCulate:AVERage2	NMR measurement averaging

Functional Block	Command(s)	Function
FORMat	:FORMat ...	Set output format
	:UNIT ...	Set output units
TRIGger	*TRG VXI-11 / USBTMC	Generate a trigger
	:ARM ...	Arm Trigger Out signal
	:INITiate ...	Enable triggers
	:ABORt	Abort triggers
	:TRIGger:SEQuence1 ...	Initiate measurement
	:TRIGger:SEQuence2 ...	Generate Trigger Output signal
MEMory	–	Not used in PT2026
Signal Routing out	–	Not used in PT2026
OUTPut	:OUTPut:TRIGger ...	Configure Trigger Output signal
SOURce	:SOURce:PULSe ...	RF pulse characteristics
CALCulate out	*CLS	Clear status
	*STB?, *SRE VXI-11 / USBTMC	Read / enable bits in Status Byte
	VXI-11 / USBTMC	Request service from host
	*ESR?, *ESE	Read / enable bits in Standard Event Status Register
	*OPC, *WAI	Detect and wait for operation complete
	:STATus ...	Read / enable bits in OPERation and QUEStionable registers
	:SYSTem:ERRor	Query error queue
	VXI-11 / USBTMC	Clear input and output buffers

Functional Block	Command(s)	Function
	VXI-11 / USBTMC	Remote/local control – ineffective since PT2026 has no local controls
	*RST	Perform reset
	*TST?	Perform self-test (not supported by PT2026)
SYSTEM	*IDN?	Return Instrument ID
	:SYSTEM:VERSION	Return SCPI version
	:SYSTEM:HELP ...	Provide command help
	:SYSTEM:COMMUNICATE	Set up Ethernet parameters
	:SYSTEM:LOCK ...	Lock out other host interfaces
MMEMORY	:MMEMORY ...	Manipulate parameter files
DIAGNOSTIC	:DIAGNOSTIC: ...	Initiate firmware upgrade

4-2-2 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 PT2026 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 PT2026 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 PT2026 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 PT2026, including internal errors
4	Execution Error	Error detected during command execution
5	Command Error	Error in preceding command
6	User Request	A parameter has been changed
7	Power On	PT2026 has been powered up

- **QUESTionable Status**

Indicates conditions that may reduce the quality of the measurement. The PT2026 sets the following bits:

Bit	Name	Description
9	Unable to measure	Unable to acquire and measure an NMR signal
10	Ignored setting	A setting was set, but is not taken into account because of other settings
11	Measurement	The quality of the measurement is questionable (e.g. Due to unknown IF in manual search mode)
12	BIT12	Summary Bit: DSP Status

- **QUESTionable:BIT12**

This is a fan-out for bit 12 of the QUESTionable register, a device-specific summary bit.

Bit	Name	Description
0	External Ref Detected	External reference clock is detected
1	External Ref Locked	Locked onto external reference clock
2	Beating Detected	Measurement was rejected as spurious signal (cf. :CONFigure:MEASure:REJect command)
12	Regulator output saturated	The regulation unit isn't regulating anymore due to voltage or current having reached their physical adjustments limits.

- **OPERation Status**

Captures conditions which are part of the instrument's normal operation. The PT2026 uses the following bits:

Bit	Name	Description
2	RANGing	Scanning for available probes
3	SWEeping	Searching for NMR signal
4	MEASuring	Measuring magnetic field strength
5	Waiting for TRIGger	Waiting for trigger
8	New Acq Avail	New Acquisition Data is Available
9	New Meas Avail	New Measurement Available
10	Initiated	Trigger system is initiated
11	BIT11	Summary Bit: A parameter has changed
12	BIT12	Summary Bit: Acquisition status

Note: Bits 8 and 9 are transient pulses (immediately reset to 0 after being set to 1). This means they must be read out of the OPERation:EVENT register rather than the OPERation:CONDition register.

- **OPERation:BIT11**

This is a fan-out for bit 11 of the OPERation register, a device-specific summary bit. It indicates subsystems whose configuration has changed.

Bit	Name	Description
0	SYSTEM	System: system ID, communications, lock
1	STATus	Status: enable bits
2	MEMory	Memory: parameter file loaded
3	MMEMory	Mass memory: parameters saved, created, deleted
4	CONFigure	Measurement: matching/tuning, search, tracking
5	ROUTE	Route: channel selection
6	INPut	Input: reference clock
7	OUTPut	Output: trigger output signal
8	SENse	Sense: digitization
9	SOURce	Source: pulse
10	TRIGger	Trigger: measurement trigger, output trigger
11	CALCulate	Calculate: signal & measurement averaging
12	FORMat	Format: output format

13	UNIT	Units: output units
14	REGulation	Regulation: parameter changed (needs RG8026 option)

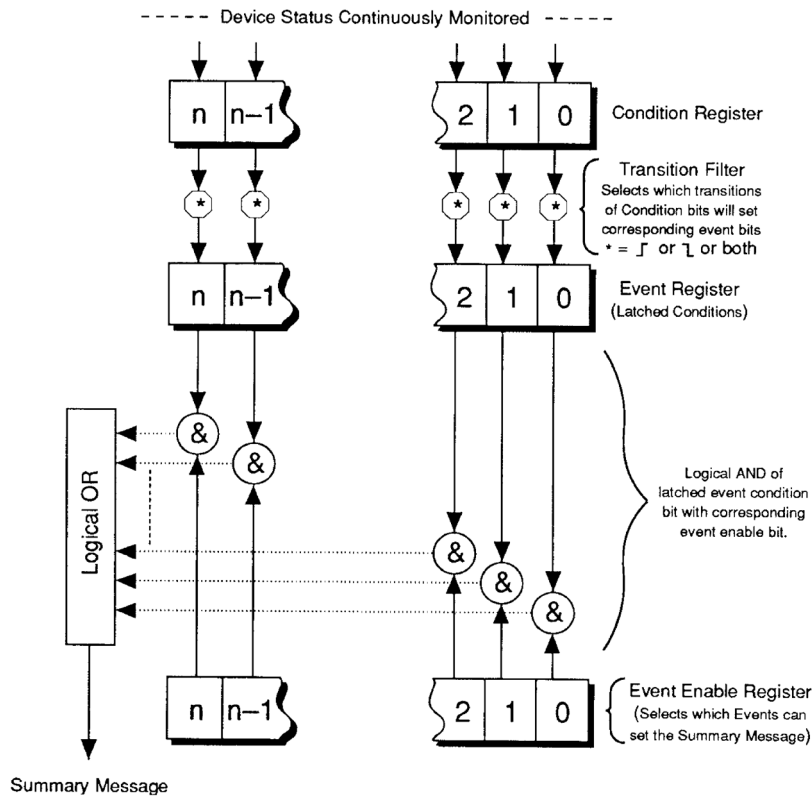
- OPERation:BIT12

This is a fan-out for bit 12 of the OPERation register, a device-specific summary bit.

Bit	Name	Description
0	DSP_CPLD Fatal Error	Unable to use DSP and/or CPLD
3	Acquisition overrun	DSP's acquisition buffer is full
4	Trigger overrun	Trigger arrived before previous acquisition complete
5	NMR Path Broken	Active probe was unplugged
6	Peripheral Plugged	A peripheral was plugged into the PT2026
7	Remote Box Start	The start button of the remote box was pressed.
12	Regulator active	The regulation unit is active
13	Regulator error	The regulation unit is in error
14	Regulation on hold	The regulation unit is active but holds the correction value.
15	Regulation Filter active	The regulation filter is active.

Needs RG8026 Option

As shown in the figure below, taken from the IEEE 488.2 standard, each of the registers above is 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. 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).

In addition, transition filters are supported for the following register sets: QUESTIONable, QUESTIONable:BIT12, OPERation, OPERation:BIT11, and OPERation:BIT12. Transition filters are used to detect events with positive transitions (false to true) and/or negative transitions (true to false). By default, only positive transitions are detected.

Note that some Condition Register bits signal permanent conditions – for example Power On – and others signal transient events – for example, Command Error. Reading a Condition Register will provide no indication of transient events; only the corresponding Event Register will catch such events.

Also note that for efficiency reasons, status register updates are deferred to the extent possible, and are normally performed only at end of each sequence of commands separated by semicolons. This also means that a ReQuest for Service (RQS) is normally generated only at the end of such a sequence. There are exceptions to this deferral rule, for example if the command sequence includes a status-query command.

Finally, remark that the PT2026 supports multiple IEEE 488.2 connections, and that each connection uses its own set of status registers. Thus status bits that only affect one interface – for example Command Error – are not seen by the other interfaces. However, status bits that indicate general instrument status – in particular the QUEStionable and OPERation registers – are propagated to all interfaces. Using this feature, the OPERation:BIT11 registers can serve to broadcast parameter changes caused by any one interface.

4-2-3 IEEE 488.2 controls

The following low-level functions are defined by the VXI-11 and USBTMC-USB488 protocols. Excluded are the functions that are fundamental to the operation – e.g. in VXI-11: `create_link`, `destroy_link`, `device_write`, `device_read`, `create_intr_chan`, `destroy_intr_chan`, `device_enable_srq`, `device_intr_srq`, and `device_abort`.

Historically, the functions listed below correspond to dedicated hardware signals in IEEE 488.1 (HPIB or GPIB). Not all functions are supported in both VXI-11 and USBTMC-USB488. In addition, some of these functions are not supported on the PT2026; the Description column will note whether the function has no effect or whether it returns an error.

VXI-11	USBTMC-USB488	Description
<code>device_clear</code>	<code>INITIATE_CLEAR</code>	Clears the device input and output buffers
<code>device_trigger</code>	<code>TRIGGER</code>	Assert bus trigger
	<code>SRQ</code>	Requests service from host
<code>device_readstb</code>	<code>READ_STATUS_BYTE</code>	Read status byte
<code>device_remote</code>	<code>REN_CONTROL</code>	Remote Enable – no effect
<code>device_local</code>	<code>GO_TO_LOCAL</code>	Enable local controls – no effect
–	<code>LOCAL_LOCKOUT</code>	Disable local controls – no effect

device_lock	-	Acquire or release the device's lock
device_unlock	-	
device_docmd	-	Do special command – unsupported, returns error

4-2-4 IEEE 488.2 common commands

As any IEEE 488.2 compliant instrument, the PT2026 supports the following commands.

Command	Name	Description
*CLS	Clear status	Clear all event registers and queues (not enable registers) and error buffer
*ESE <value>	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; versions of hardware and firmware; and purchased options. Note: 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 <value>	Program status enable	Program status enable register Important: you must also enable service requests on the host. See Section 0 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

4-2-5 SCPI command syntax

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] ?	[<digits>]	Measured flux density
:SIGMa?	[<digits>]	Measurement deviation

According to this table, the following commands are legal:

:FETC:SCAL:FLUX?

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

:FETC:SIGM? (fetches measurement deviation)

The following special parameters are recognized:

MINimum

MAXimum

DEFault

The command syntax

<command>? MAXimum/MINimum[,...]

can be used to query the maximum or minimum values for all parameters of a command.

Some commands take a channel list parameter, to specify the probes to be used. The syntax of a channel list is specified in Section 8.3.2 of Volume 1 of the SCPI standard. In brief:

- Each channel is specified as a list of multiplexer ports separated by exclamation marks. For example “1!2” refers to the probe plugged into channel 2 of a second-level multiplexer plugged into channel 1 of the top-level multiplexer.
- A range of channels can be specified by separating the starting and ending channels with a colon. For example, “1!4:1!6” specifies channels 4 through 6 on the second-level multiplexer.
- An arbitrary list of channels and channel ranges can be specified by separating them with commas. For example, “1!2,1!4:1!6” specifies channels 2, 4, 5 and 6 on the second-level multiplexer.
- The channel list is opened by “(@” and closed by “)”. For example: “(@1!2,1!4:1!6)”.

Command parameters may be set to their default values by omitting them. To use a parameter after an omitted parameter, keep the commas as placeholders. For example, to measure channels 1 and 2 with the default search range:

MEASURE? „(@1,2)

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)

G = giga (10^9)

The PT2026 recognizes the following units:

Base unit	Multiplier	Description
T	N, U, M	Tesla (default for magnetic field strength)
GAUSS	U, M, K	Gauss
PPM		Parts Per Million deviation: magnetic field strength, relative to a reference value set with the :UNIT:PPMReference command
HZP	K, MA, G	Magnetic field strength measurements: equivalent proton NMR resonant frequency
HZ	K, MA, G	Frequency. For magnetic field strength measurements: NMR resonant frequency for the probe being used.
S	M, U, N	Seconds
V	M	Volts

Any parameters whose units indicate magnetic field strength (T, GAUSS, PPM, HZP, HZ) use the units currently selected by the UNIT command.

4-2-6 SCPI command summary

The following tables list the legal commands for the PT2026, in alphabetical order:

Command	Parameters	Description
:ABORt		Stop execution of a command
[:CALCulate]		Averaging control.
:AVERage1		NMR signal averaging. This is intended to reduce noise in the NMR signal. Measurements are performed on the averaged NMR signal. All subcommands are as for :CALCulate:AVERage2. Note: This command should only be used with very stable fields. Averaging signals with different frequencies can lead to very confusing behavior.
:AVERage2		NMR measurement averaging. This permits an estimate of the measurement stability. Without measurement averaging, :FETCh:SIGMa? returns NaN (“Not a Number”). A measurement is returned only after averaging.
:COUNT?	[MINimum MAXimum DEFault]	Query averaging count.

:COUNT	<value> MINimum MAXimum DEFault	Set number of signals in average. The measurement is performed after this number of acquisitions. min = 1; max = 1000; default = 1.
[:STATe]?	[DEFault]	Query averaging enabled/disabled.
[:STATe]	<boolean> DEFault	Enable/disable averaging. The default state is OFF.
:TCONtrol?		Query the termination control setting.
		Specify action after <avg_count> signals: - EXPonential: $AVG_n = \frac{1}{k} X_n + \frac{k-1}{k} AVG_{n-1}$ where k = <avg_count> - MOVing: Moving window: oldest measurement is subtracted from average, and newest measurement is added. This action is not supported for :AVERage1. - REPeat: Clear the average and repeat. This is the default action.
:TCONtrol	EXPonential MOVing REPeat	
:CONFigure?		Returns string “<function><parameters>” with configuration set by the last CONF command or MEAS? query.
:CONFigure		Configure measurement and search parameters
[:MEASure]		
:MODE?		Query measure mode.
:MODE	AUTO MANual	- Automatic measure mode uses the default measurement settings. - Manual mode uses the values set with the :CONFigure[:MEASure] commands.
:REJect?	[DEFault]	Query reject setting
:REJect	<boolean> DEFault	Enable or disable spurious signal rejection. The default state is ON.
:LEVel?	[MINimum MAXimum DEFault]	Query detection level [V].

:LEVel	<value> MINimum MAXimum DEFault	Minimum level of NMR peak relative to average spectral noise [V]. min = 0, default = probe dependent, max = 32V.
:BANDwidth?	[MINimum MAXimum DEFault]	Query frequency range [Hz].
:BANDwidth	<value> MINimum MAXimum DEFault	Frequency range around peak value used to fit response [Hz].
:POINTs?	[MINimum MAXimum DEFault]	Query number of fit points
:POINTs	<value> MINimum MAXimum DEFault	Number of points used to fit the response. min = 3, default = 8, max = 32.
:HYSTeresis?	[MINimum MAXimum DEFault]	Query measurement hysteresis
:HYSTeresis	<value> MINimum MAXimum DEFault	How many missing measurements to allow before aborting measurement mode. min = 0, max = 100, default = 5.
:PROBE		
:MODE?		Query matching/tuning mode.
:MODE	AUTO MANual	- Automatic matching/tuning uses the probe's characteristic curves. - Manual matching/tuning sets the voltages manually
:MATChing?	[MINimum MAXimum DEFault]	Query matching voltage [V].
:MATChing	<value> MINimum MAXimum DEFault	Set matching voltage [V]. min = 0, max = 30, default = 15.
:TUNing?	[MINimum MAXimum DEFault]	Query tuning voltage [V].
:TUNing	<value> MINimum MAXimum DEFault	Set tuning voltage [V]. min = 0, max = 30, default = 15.
:SEARCh		Configure search parameters.
:ENABle?	[DEFault]	Query search enable.
:ENABle	<boolean>	Enable or disable search. When enabled, the system sweeps frequency until it found an NMR signal. When disabled, the system operates at fixed frequency defined by :CONFigure:SEARCh[:LIMit]:VALue. default = true.
:MODE?		Query search mode.

:MODE	AUTO CUSTom MANual	<p>- Auto search mode steps through the specified search range with default search parameters.</p> <p>- Custom search mode is as the Auto mode but uses the custom user search level and frequency step parameters.</p> <p>- Manual search mode sets the RF frequency where a search is to be performed.</p>
:FSTep?	[MINimum MAXimum DEFault]	Query frequency step [Hz].
:FSTep	<value> MINimum MAXimum DEFault	<p>Frequency step, used in CUSTom search mode [Hz]. Zero indicates default step size, as computed from probe data.</p> <p>min = 1e3, max = 60e3, default = 10e3, digits = 3</p>
:HALLenable?	[DEFault]	Query Hall enable.
:HALLenable	<boolean>	<p>Enable or disable using the Hall value to assist the NMR resonance search.</p> <p>default = true.</p>
[:LIMit]		min, max, default: those for the active probe.
:HIGH?	[MINimum MAXimum DEFault]	Query maximum field value [UNIT?].
:HIGH	<value> MINimum MAXimum DEFault	Maximum field value [UNIT?].
:LOW?	[MINimum MAXimum DEFault]	Query minimum field value [UNIT?].
:LOW	<value> MINimum MAXimum DEFault	Minimum field value [UNIT?].
:VALue?	[MINimum MAXimum DEFault]	Query fixed field value [UNIT?].
:VALue	<value> MINimum MAXimum DEFault	Fixed field value, when search is disabled [UNIT?].
:TRACking		Field-tracking parameters.
[:LIMit]		min, max, default: those for the active probe.
:HIGH?	[MINimum MAXimum DEFault]	Query maximum IF [Hz].
:HIGH	<value> MINimum MAXimum DEFault	<p>Max intermediate frequency [Hz].</p> <p>min = 800, max = 150e3, default = 150e3</p>
:LOW?	[MINimum MAXimum DEFault]	Query minimum IF [Hz].

<code>:LOW</code>	<code><value> MINimum MAXimum DEFault</code>	Min intermediate frequency [Hz]. min = 800, max = 150e3, default = 800
<code>:HYSTeresis?</code>	<code>[MINimum MAXimum DEFault]</code>	Query tracking hysteresis.
<code>:HYSTeresis</code>	<code><value> MINimum MAXimum DEFault</code>	How many measurements to allow outside the range before correcting the RF frequency. min = 0, max = 1000, default = 0.
<code>:DIAGnostic :UPGRade [:INITiate]</code>		Initiate a firmware upgrade. The PT2026 will disconnect from the USB bus and reconnect as a DFU (Device Firmware Upgrade) device, ² with the following alternate settings: CODE, DATA, CPLD and HWINFO.
<code>:LOG[:DATA]?</code>		Read the debug log. Note: if the PT2026 detects an irrecoverable error, it attempts to write the debug log to non-volatile memory. (/yaffs/user/DebugLog.txt).

NOTICE

The `:DIAGnostic` commands are intended for use by the manufacturer only. They can cause your PT2026 to become nonoperational.

² See “Universal Serial Bus Device Class Specification for Device Firmware Upgrade,” Version 1.1, Aug 5, 2004, available from www.usb.org/developers/devclass_docs/DFU_1.1.pdf.

Command	Parameters	Description	Binary Format
:FETCh		Fetch data values acquired during last MEASure, READ or INITiate. The following actions invalidate previously acquired data: - Reset; - Continuous trigger initiation; and - Changing trigger parameters. <digits>: return at least the requested number of significant digits. min = 1, max = 16, default = Flux 9, Sigma 4, Uniformity 3	
[:SCALar]			
[:FLUX]?	[<digits>]	Measured flux density [UNIT?].	f64
:SIGMa?	[<digits>]	Standard deviation of measurement [ppm]. Standard deviation of measurement. [ppm]. Note: Returns NaN (“Not a Number”) if :CALCulate:AVERage2 is not enabled.	f32
:UNIFormity?	[<digits>]	Rough measure of field uniformity (0 to 1).	f32
:CHANnel?		Channel selected for measurement [FORMat?].	u8, 0 separated
:TIMEstamp?		Time stamp [ms].	u64
:STATus?		1 if measurement was questionable, 0 otherwise.	u8
:IFRequency?	[<digits>]	Measured intermediate frequency [Hz]	f64
:RELaxation?	[<digits>]	Measured relaxation time [s]	f32
:RFFRequency?	[<digits>]	Radio frequency [Hz]	f64
:SPRogress?		Search progress: percentage done, and Hall value if present, -1 otherwise. Only useful when a search is initiated. [%, UNIT?].	u8, f32
: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] ?	<size>[, <digits>]	Measured flux density [UNIT?].	f64
:SIGMa?	<size>[, <digits>]	Standard deviation of measurement. [ppm]. Note: Returns NaN (“Not a Number”) if :CALCulate:AVERAge2 is not enabled.	f32
:UNIFormity?	<size>[, <digits>]	Rough measure of field uniformity (0 to 1).	f32
:CHANnel?	<size>	Channel selected for measurement [FORMat?].	u8, 0 separated
:TIMEstamp?	<size>	Time stamp [ms].	u64
:STATus?	<size>	For each measurement: 1 if questionable, 0 otherwise.	u8
:NMRSignal?	<size>	Return <size> samples of the last NMR IF signal acquired. The first datum returned is the sample period in seconds.	Period: f32 Sample: f32
:FFTBuffer?	<size>	Return <size> samples of the last FFT buffer. The first datum returned is the frequency resolution in Hz.	Resolution: f32 Sample: f32
:SPECTrum?	<size>	Return <size> samples of the peak spectrum. The first two data returned are the center frequency and the frequency resolution in Hz.	Center: f32 Resolution: f32 Sample: f32
:FIT?	<size>	Return <size> polynomial coefficients, starting at degree 0. The first datum returned is the residue.	Residue: f32 Coeffs: f32

Command	Parameters	Description
:FORMat		
[:DATA] ?		Query data output format
[:DATA]	ASCIi INTeger	<p>Set format for returned data. ASCIi by default.</p> <p>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.</p> <p>For the flux density and standard deviation, binary data consists of 64-bit little-endian floating-point values.</p> <p>The binary representation of a channel is a 16-bit little-endian unsigned integer, with channel numbers as defined in Section 4-3-2. The relevant commands are flagged with “[FORMat?]”.</p> <p>The binary representation of a timestamp is a 64-bit unsigned integer [ms].</p>
:INITiate		<p>Start measurements.</p> <p>Note: This command is overlapped; in other words, other commands can be processed while initiated. Moreover, it does not affect the No Operation Pending Flag; in other words, it does not force *OPC, *OPC? and *WAI to wait for the INITiate to complete.</p>
[:IMMEDIATE]		
[:ALL]		Enable trigger with trigger source, trigger count and trigger period set by TRIGger commands
:CONTinuous?	[DEFault]	Query continuous-trigger state
:CONTinuous	<boolean> DEFault	<p>Set continuous-trigger state, where the trigger is automatically re-enabled after each acquisition.</p> <p>OFF by default.</p>
:INPut		
:CLOCK [:SOURce] ?		Queries the clock source.
:CLOCK [:SOURce]	INTernal EXTernal	Selects the source of the reference clock. If configured as INTernal, the output from the OCXO, divided by 2, is presented at the Clock connector. For EXTernal, the Clock connector is configured as input. The default is EXTernal;

		thus if an external clock is connected, it is used; otherwise the OCXO is used.
:MEASure		Abort any pending triggers and perform measurements using the default search and measurement parameters.
[:SCALar]		
[:FLUX]?	[<expected_value> [,<digits> [,<channel_list>]	Perform a single measurement. <expected_value> serves to constrain the NMR signal search; by default the full range of all active probes is searched [UNIT?]. <digits> defines the number of significant digits to return for ASCII FORMat; the default is 9. The PT2026 searches for an NMR signal on each channel in <channel_list>, in order, and will start measuring on the first channel where it finds a signal. The default channel list is defined by the ROUTe command, or else contains all connected probes.
:ARRay		
[:FLUX]?	<size> [,<expected_value> [,<digits> [,<channel_list>]	Perform a series of <size> measurements. The other parameters are as for the :MEASure:SCALar command.
:MMEMory		Manipulate parameter files.
[:CATalog]?		Read the file directory. Returns: - Total bytes used - Total bytes available - File entries consisting of: - File name - File type - File size
:DATA?	<filename>	Read the contents of the given file.
:DATA	<filename>,<data>	Write the contents of the given file. Note: <filename> must be a path starting with "/yaffs/user/".
:DELete	<filename>	Delete the given file.
:LOAD		
[:STATe]	<value>,<filename>	Load the given parameter file. Since the PT2026 does not support the *SAV/*RCL commands, <value> must be 0.

:STORE		
[:STATe]	<value>, <filename>, ALL COMMunication MEASure TRIGger REFClk UNITS	Store the specified subset of the current parameters. <value> must be 0.
:OUTPut [:TRIGger]		Configure Trigger Output signal. The output is initiated by TRIGger:SEquence2.
[:STATe]?	[DEFault]	Query the Trigger Output state.
[:STATe]	<boolean> DEFault	Enable or disable the Trigger Output signal.
:IMMediate		Force Trigger Output signal, as if the field had gone above the threshold.
:SHAPE?	[DEFault]	Query Trigger Output shape
:SHAPE	DC PULSE DEFault	Set Trigger Output signal shape: - DC: Logic level, depending on POLarity - PULSE: Pulse at transition, as defined by WIDTH and POLarity
:POLarity?	[DEFault]	Query trigger polarity
:POLarity	NORMAL INVERTed	Set the polarity of the trigger signal. For pulse output, NORMAL is a positive-going pulse. For DC output, NORMAL is low level when the field is below the threshold, high level when it is above.
:WIDTH?	[MINimum MAXimum DEFault]	Query trigger pulse width [s]. Valid only if SHAPE = PULSE.
:WIDTH	<value> MINimum MAXimum DEFault	Pulse width [s]. min = default = 1 ms, max = $2^{32} - 1$ ms
:DELay?	[MINimum MAXimum DEFault]	Query trigger output signal hold-off [s]
:DELay	<value> MINimum MAXimum DEFault	Output signal hold-off [s]. min = default = 0 ms, max = $2^{32} - 1$ ms
:READ		
[:SCALar]		
[:FLUX]?	[<expected_value> [, <digits>] [, <channel_list>]	Perform a single measurement. <expected_value> serves to constrain

the NMR signal search; by default the full range of all active probes is searched [UNIT?]. <digits> defines the number of significant digits to return for ASCII FORMat; the default is 6.

The PT2026 searches for an NMR signal on each channel in <channel_list>, in order, and will start measuring on the first channel where it finds a signal. The default channel list is defined by the ROUTe command, or else contains all connected probes.

:ARRay		
[:FLUX] ?	<size> [, <expected_value>] [, <digits>] [, <channel_list>]	Perform a series of <size> measurements. The other parameters are as for the :READ:SCALAr command.
:REGUlation Regulation unit related commands are described in the RG8026 User Manual . The Regulation unit is an option that isn't part of the standard PT2026 and must be ordered separately.		
:MODEl?	<channel_list>	Model
:SERialno?	<channel_list>	Serial number
:DESignation?	<channel_list>	Designation
:MINimum?	<channel_list>	Minimum field [UNIT?].
:MAXimum?	<channel_list>	Maximum field [UNIT?].
:SCAN?		Returns an array of all channels which have a probe connected [FORMat?].
:HALL		Return the Hall sensor reading. If the probe has no Hall sensor, this command returns an error.
[:CALibrated] ?		Return Bx, By, Bz, B, calibrated
:RAW?		Return Bx, By, Bz, B, uncalibrated
:LOWLevel?	<message>	Send the given message to the probe/multiplexer system, and return the response. The message is encoded as "arbitrary block program data" (see Section 7.7.6 of IEEE 488.2 standard). The first byte of the response is the returned status: 0 = No error

		11 = Write error 12 = Read error 47 = Firmware failure
:MMEMory:DATA?	<channel_list>	Read a peripheral's rewritable memory. Note: channel list must contain exactly one channel.
:MMEMory:DATA	<channel_list>, <data>	Write a peripheral's rewritable memory. The data is encoded as "arbitrary block program data" (see Section 7.7.6 of IEEE 488.2 standard). Note: channel list must contain exactly one channel.

NOTICE

The :ROUTE:LOWLevel?, :ROUTE:MMEMory:DATA?, and :ROUTE:MMEMory:DATA commands are intended for use by the manufacturer only. It can cause your PT2026 to become nonoperational.

[:SENSE]

:SWEep		Set/query digitization parameters
[:MODE] ?		Query sweep mode
[:MODE]	AUTO MANual	Compute the sweep time automatically, or set it manually.
:OFFSet		Set/query offset used to mask the transient at the beginning of the NMR signal, caused by the transmit pulse.
:TIME?	[MINimum MAXimum DEFault]	Query offset [s].
:TIME	<value> MINimum MAXimum DEFault	Set offset [s]. min = 0, max = 100 ms, default = 70 us
:TIME?	[MINimum MAXimum DEFault]	Query sweep time [s].
:TIME	<value> MINimum MAXimum DEFault	Set sweep time [s]. min = 1 μ s, max = 100 ms, default = 10 ms
:FREQuency?	[MINimum MAXimum DEFault]	Query digitization rate [Hz].
:FREQuency	<value> MINimum MAXimum DEFault	Set digitization rate [Hz]. min = 1 kHz, max = 1 MHz, default = 1 MHz

[:SOURCE]

:PULSe		Set/query the RF pulse parameters
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<code>[:MODE] ?</code>		Query pulse mode.
<code>[:MODE]</code>	AUTO MANual	Determines whether the pulse width and period are calculated automatically from the probe information, or set manually.
<code>:PERiod?</code>	[MINimum MAXimum DEFault]	Query RF pulse period [s].
<code>:PERiod</code>	<value> MINimum MAXimum DEFault	Set RF pulse period [s]. min = 30 ms, max = 5 s, default = 100 ms
<code>:WIDTh?</code>	[MINimum MAXimum DEFault]	Query RF pulse width [s].
<code>:WIDTh</code>	<value> MINimum MAXimum DEFault	Set RF pulse width [s]. min = 1 μ s, max = 200 μ s, default = 25 μ s
<code>:STATus</code>		
<code>:OPERation </code>	Register set to query/set	
<code>:OPERation:BIT<n> </code>		
<code>> </code>		
<code>:QUEStionable </code>		
<code>:QUEStionable:BIT<n></code>		
<code>[:EVENT] ?</code>		Read and clear event register
<code>:CONDition?</code>		Read condition register
<code>:ENABle?</code>		Query enable register
<code>:ENABle</code>	<numeric_value>	Set enable register
<code>:NTRansition?</code>		Query negative transition filter
<code>:NTRansition</code>	<numeric_value>	Set negative transition filter
<code>:PTRansition?</code>		Query positive transition filter
<code>:PTRansition</code>	<numeric_value>	Set positive transition filter
<code>:PRESet</code>		Reset OPERation and QUEStionable enable registers
<code>:SYSTem</code>		
<code>:CDATe?</code>		Return calibration date in the following: YYMMDD
<code>:CDATe</code>	<date>	Set new calibration date, given in the following format: YYMMDD
<code>:COMMunicate</code>		Definitions for communication

:ETHERnet		Ethernet parameters
[:ENABle]?	[DEFault]	Query whether Ethernet is enabled
[:ENABle]	<boolean> DEFault	Enable or disable Ethernet default = enabled
:IDENtifier?		Query system identifier
:IDENtifier	<string>	Set system identifier, used for DNS and NBNS
:ADDRes?		Query IP network address
:ADDRes	AUTO <IP_address>	Set IP network address If AUTO, use DHCP to obtain the IP address, network mask, broadcast address, gateway address, and DNS server address.
:MASk?		Query IP network mask
:MASk	<network_mask>	Set IP network mask
:BROadcast?		Query IP broadcast address
:BROadcast	<broadcast_address>	Set IP broadcast address
:GATeway?		Query IP gateway address
:GATeway	<gateway_address>	Set IP gateway address
:DNSServer?		Query DNS server IP address
:DNSServer	<DNS_server_address>	Set DNS server IP address
:DOMain?		Query domain name
:DOMain	<domain_name>	Set domain name
:NBNS?	[DEFault]	Query whether NBNS is enabled
:NBNS	<boolean> DEFault	Enable or disable NBNS default = enabled
:REStart		Restart with new parameters
:MODBus		
[:ENABle]?	[DEFault]	Query whether the MODBUS interface is enabled.
[:ENABle]	<boolean> DEFault	Enable or disable the MODBUS interface. default = disabled
:HOSTs?		Query allowed host IP numbers
:HOSTs	<string>	Set allowed host IP numbers. List separated by spaces.
:NCONnections?	[MINimum MAXimum DEFault]	Query allowed number of connections

:NCONnections	<value> MINimum MAXimum DEF ault	Set allowed number of connections default = 1
:F32?	[DEFault]	Query whether 32-bit floating-point numbers are returned.
:F32	<bool> DEFault	Select whether 32-bit floating-point numbers are returned. default = false
:USBTmc		
[:ENABle] ?	[DEFault]	Query whether the USBTMC-USB488 interface is enabled.
[:ENABle]	<boolean> DEFault	Enable or disable the USBTMC-USB488 interface. This interface is always enabled at system startup. default = enabled.
:VXI11		
[:ENABle] ?	[DEFault]	Query whether the VXI-11 interface is enabled.
[:ENABle]	<boolean> DEFault	Enable or disable the VXI-11 protocol on the Ethernet interface. default = enabled
:ERRor		
[:NEXT] ?		Query error queue
:HELP		Instrument's help utilities for programmer
:HEADers?		Lists all available commands
:SYNTax?	<command_header>	Lists syntax for a command
:LOCK		Lock out other host interfaces
:REQuest?		Attempts lock and returns 1 if successful, 0 if it fails
:RELease		Release lock
:MDATe?		Return manufacturing date in the following: YYMMDD
:POFF	<boolean> DEFault	If true, reboot the system; if false, power it off. default = false.
:TEMPerature?		Query the temperature inside the instrument case
:VERSion?		Query SCPI version (e.g. 1999.0)
:TRIGger		
[:SEQuence1]		TRIGger:SEQuence1 initiates a measurement.

:COUNT?	[MINimum MAXimum DE Fault]	Query trigger count
:SOURce?	[DEFault]	Query trigger source
:SOURce	IMMediate TIMer BUS EXTernal DEFault	Trigger source: - IMMEDIATE = no wait - TIMer = periodic trigger - BUS = VXI-11 or USB488 - EXTernal = trigger input default = IMMEDIATE Note: Resets the trigger system.
:TIMer?	[MINimum MAXimum DEF ault]	Query trigger timer [s].
:TIMer	<value> MINimum MAXimum DEF ault	Set period for Timer trigger [s]. min = 1 ms; max = 86400 ms; default = 200 ms; resolution = 1 ms Note: Resets the trigger system.
:TRIGger		
:SEQuence2		TRIGger:SEQuence2 generates a Trigger Output signal. Note: TRIGger:SEQuence2 (Trigger Out) is mutually exclusive with TRIGger:SEQuence1:SOURce = EXTernal (Trigger In).
:LEVel?	[MINimum MAXimum DE Fault]	Query the trigger level [UNIT?].
:LEVel	<value> MINimum MAXimum DEF ault	The measurement value at which Trigger Output is activated [UNIT?]. min = 0, max = 100, default = 0
:SLOPe?		Query the trigger slope.
:SLOPe	POSitive NEGative E ITHer	Select Trigger Output on a rising measurement, a falling measurement, or either.
:UNIT?	[DEFault]	Query units
:UNIT	T MT GAUSS KGAUSS P PM MAHZP MAHZ DEFault	Set units for the measurement results, or any flux-density parameter (marked as “[UNIT?]”). Supported units: T: Tesla mT: mTesla (1T=10 ³ mT) G: Gauss (1T=10 ⁴ G) kG: kGauss (1T=10 kG)

		ppm: parts per million (relative to value set in “Configure PPM Reference.vi”)
		MHz: NMR frequency (depends on gyromagnetic ratio of sample material)
		MHz-p: proton equivalent NMR frequency (1T ≈ 42.5775 MHz-p)
		default = T
:ALL?		Return a list of all the units supported by this instrument, followed by the divisor for each set of units. The divisor converts T to the associated units.

:PPMReference?	[MINimum MAXimum DEFAULT]	Query reference value for ppm [UNIT?].
----------------	---------------------------	--

:PPMReference	<value> MINimum MAXimum DEFAULT	Set reference value for ppm [UNIT?]. min = 0, max = 100, default = 1
---------------	---------------------------------	---

4-2-7 Programming hints

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

- For simple measurements with the standard settings, use the MEASURE? command. MEASURE:ARRAY? is the same, except it returns a time series.
- The “expected value” parameter can be used to minimize the search.
- When given a channel list, MEASURE? tries to measure on each of the specified channels. This is useful for groups of probes with different field ranges used to measure a single magnet. Preference is given to channels with previous successful measurements, and the result from the first channel with a successful measurement is returned. Use :FETCH:CHANNEL? to know which channel was measured.
- Use the UNIT command to set the units in which the results are returned, and the “digits” parameter to control the number of significant figures returned (assuming FORMAT is ASCII).
- For measurements with non-standard parameters, do a CONFIGure, INPUT, ROUTe, SWEep, SOURCE and/or PULSE, followed by a READ. As with MEASURE, READ:ARRAY? returns a time series. The optional parameters act as for MEASURE.
- Use the TRIGGER:SEQUENCE1 commands to control the measurement timing. As trigger source, you can select “IMMEDIATE”, an internal timer, a trigger command sent from the host, or an external Trigger In signal. After setting up the trigger source, you initiate a measurement using

the INITiate command. The CONTinuous option immediately re-initiates an acquisition when the previous one has completed.

- Use the :CALCulate:AVERage commands to control averaging. The PT2026 supports averaging of the NMR signal, or averaging of the resulting measurement. Any combination of signal- and measurement averaging is supported. Averaging is only effective for a stable field.
- The measurement integration time depends on the trigger and the measurement averaging options:
- If CALCulate:AVERage2:TCONTROL = REPEAT, the measurement average is computed from a block of new measurements initiated by the trigger.
- Otherwise, for EXPonential and MOVing mode averaging, the average is computed from one new measurement, initiated by the trigger, plus older measurements that have been acquired in the course of signal tracking (and may never have been returned to the user).
- Use the :OUTPut[:TRIGger] commands to configure an output trigger signal when the measured field value crosses a certain threshold. Use the TRIGger:SEQUence2 commands to initiate the output trigger. Note that the Trigger In function (TRIGger:SEQUence1:SOURce = EXTERNAL) is mutually exclusive with the Trigger Out function.
- 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. The NMR signal and intermediate signal analysis results corresponding to the last measurement can be retrieved with the FETCh:ARRay:NMRSignal? / FFTBuffer? / SPECtrum? / FIT? commands.
- The ROUTe:CLOSe command does the same thing as the channel list in the MEASure and READ commands. The syntax of the channel list is specified by Volume 1 of the SCPI standard, Section 8.3.2. For example, ROUTe:CLOSe (@1) selects channel 1, and ROUTe:CLOSe (@2!3) selects channel 3 on a secondary mux attached to channel 2 of the primary mux. Colons are used for ranges of channels; for example, ROUTe:CLOSe (@3:5) sets up to measure channel 3, 4 or 5. Commas are used to enumerate several channels or channel ranges; for example, ROUTe:CLOSe (@1,2) sets up to measure channel 1 or channel 2.
- Use ROUTe:SCAN? to find all channels with a probe attached. Use ROUTe:PROBe to retrieve information about a probe.

- To determine whether an NMR signal has been found, check the OPERation status register. By setting the appropriate Operation Status Enable bit, plus the OSB (Operation Summary Bit) in the Status Enable register, you can generate a ReQuest for Service (RQS) when the PT2026 enters a given state.
- Using the *OPC command, you can also 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.
- Be sure to check the status after every command. The Standard Event Status register provides a general idea of what went wrong, and the message on the Error/Event Queue (retrieved by SYSTem:ERRor?) provides a detailed diagnostic. See Section 4-2-8 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.
- On the USBTMC host interface, 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.
- The MMEMory commands are used to manipulate XML-format parameter files. The user can store custom parameters – e.g. user-friendly channel names – that they would like to store with the instrument.
- Two host interfaces can be synchronized using the STATus:OPERation:BIT11 register. Enable the bits of interest in STATus:OPERation:BIT11, bit 11 in STATus:OPERation, and the OSB in the Status Byte; now, a Service Request (SRQ) will be generated whenever the configuration of one of the corresponding subsystems changes. The application must then read STATus:OPERation:BIT11 to identify which subsystem is affected. Finally, the updated value of these parameters can be read back using the appropriate query. Note that since reading the STATus:OPERation:BIT11 register also resets it, this technique does not work for more than two host interfaces.

4-2-8 Error codes

Error codes returned by the native host interfaces are numbered according to the SCPI standard.

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 PT2026, and the circumstances that might produce each error.

0	NO ERROR	Zero indicates no error.
-100	COMMAND ERRORS	
-102	Syntax error	The command header did not match any of the known commands.
-104	Data type error	A parameter within the command was of a type invalid for the command.
-115	Unexpected number of parameters	The wrong number of parameters was given in the command.
-120	Numeric data error	<value> parameter to :MMEMory:LOAD or STORE is non-zero.
-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 .
-151	Invalid string data	The parameters in the command contain an unmatched single or double quote, or invalid setting type in :MMEMory:STORE.
-171	Invalid expression	The parameters in the command contain an unmatched bracket.
-200	EXECUTION ERRORS	
-200	Execution error	*CLR or :ABORT has failed, for an unknown reason.
-210	Trigger error	Input trigger failed, for an unknown reason.
-221	Settings conflict	Indicates that a legal program data element was parsed but could not be executed due to the current device state: <ul style="list-style-type: none"> • Conflicting parameters – see Figure 1. • Received bus trigger, but not in bus trigger mode. • Changing Trigger Out parameters while measuring. • Changing clock source while measuring. • Starting a measurement while already measuring. • Changing measurement parameters while measuring. • Loading new parameters while measuring. • Scanning probes or changing channels while measuring. • Disabling the active interface. • Setting ppm reference in ppm units.
-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.

-225	Out of memory	The device has insufficient memory to perform the requested operation.
-240	Hardware error	DSP firmware failed to boot.
-257	File name error	<ul style="list-style-type: none"> • Filename parameter of :MMEMory:DATA? query is empty. • Filename parameter of :MMEMory:DATA command does not start with “/yaffs/user/”. • Filename parameter of :MMEMory:DELeTe command does not start with “/yaffs/”. • Filename parameter of :MMEMory:LOAD command does not start with “/yaffs/settings/”. • Filename parameter of :MMEMory:STORe command is a path.
-300	DEVICE-DEPENDENT ERRORS	
-350	Queue overflow	A specific code entered into the queue in lieu of the code that caused the error. This code indicates that there is no room in the queue and an error occurred but was not recorded.
-365	Time out error	DSP is not responding.
-400	QUERY ERRORS	
-400	Query error	Generic query error: reset in progress?
-410	Query INTERRUPTED	The host has sent a new command before finishing reading the response to a preceding query.
-420	Query UNTERMINATED	The host is trying to read a response without having sent a complete query.
-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 PT2026, the only command returning an indefinite response (“Arbitrary ASCII Response Data”) is *IDN.
100	INSTRUMENT-DEPENDENT COMMAND ERRORS	
101	Invalid value in list	One or more values in a numeric list parameter are invalid, e.g. floating point when not allowed.
102	Wrong units for parameter	A parameter within the command has the wrong type of units for the command.
103	Invalid number of dimensions in channel	The channel list provided refers to more layers of multiplexers than allowed.
104	Error in channel list	The channel list provided is not valid.
105	Numeric suffix invalid	Too many numeric suffixes, or one or more numeric suffix in the command is invalid, e.g. out of range.

200 INSTRUMENT-DEPENDENT EXECUTION ERRORS

200	Software Error	The firmware has encountered an unexpected error.
201	No probe	No probe is plugged in.
202	No selected channel	No channel has been specified.
203	Invalid channel list	Channel specification is invalid.
204	Data not all available	The user is trying to fetch more data than was acquired.
205	Topology changed	The channel topology has changed: probes and/or multiplexers have been plugged or unplugged.

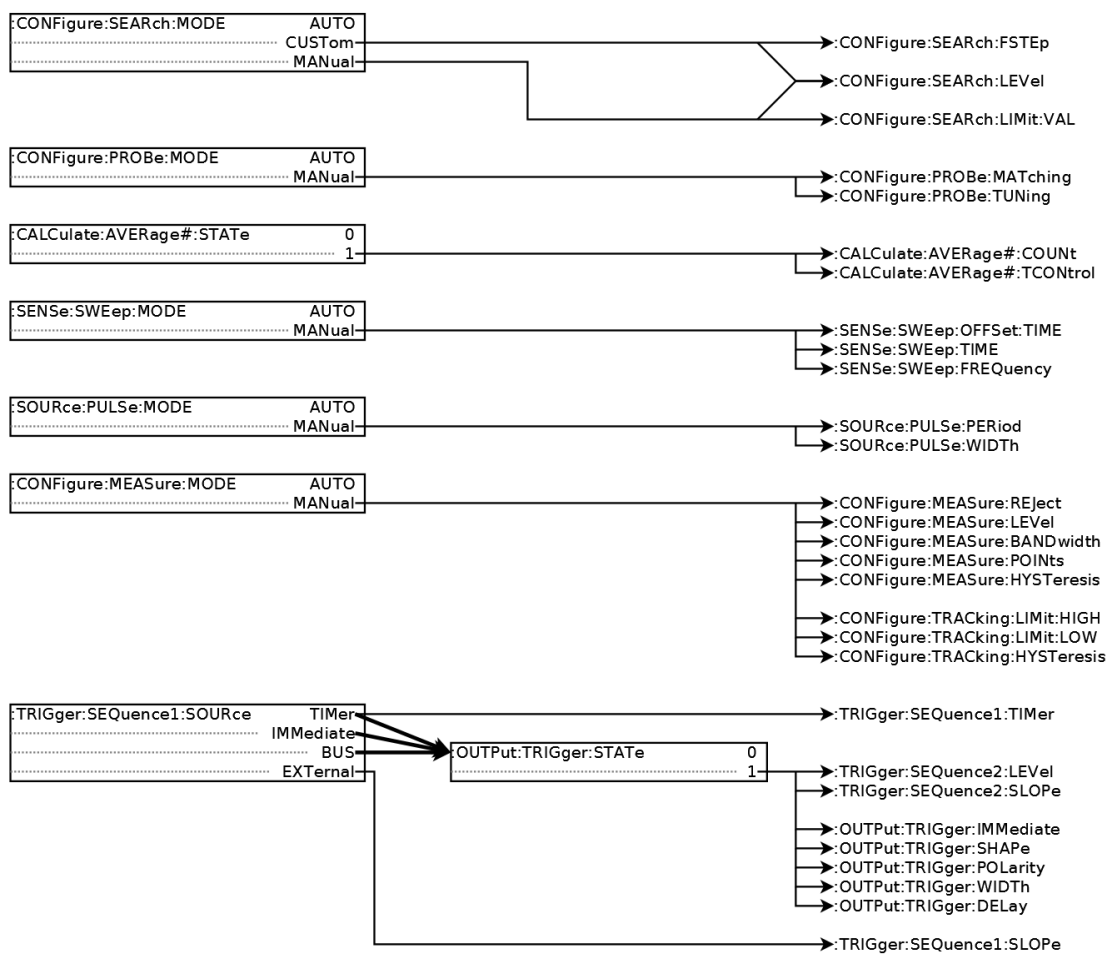


Figure 1. Parameter compatibility matrix.

5- KEY SPECIFICATIONS

See the PT2026 Installation and Safety Manual for Dimensions, Ratings and Back Panel Connections.

5-1 DIMENSIONS

PT2026 Main Unit	210 X 125 X 324 mm
PT2126 Main Unit	483 X 125 X 324 mm



Figure 2 - PT2026 desktop main unit, front and back panel



Figure 3 - PT2126 19” Rack mounting main unit, front panel

5-2 MEASUREMENT

Measurement principle: pulsed wave Nuclear Magnetic Resonance

Frequency range	1 MHz – 1 GHz
Resolution	± 0.1 Hz (stable field, low gradient, no averaging) < 0.01 ppm (10 ppb) in uniform 3 T field
Accuracy	± 5 ppm, independent of temperature
Max gradient	> 1000 ppm/cm
Measurement rate	Up to 33 Hz
Trigger modes	Immediate, Timed, Bus, External

5-3 RATINGS

Power	55 VA, 100 – 240 VAC, 50-60 Hz
Overvoltage	Accepts temporary overvoltage occurring on the mains supply— transient overvoltage up to the levels of overvoltage category II.
Fuse	3.15 A (T), 5x20 mm, 250 V
Environment	Indoor use; no air inlet (IP 50)
Operating temperature	10 – 40 °C
Storage / transport temperature	Deuterium probes: 0 – 80 °C Other: -25 – 80 °C
Altitude	≤ 2000 m
Relative humidity	Maximum 80 % for temperatures up to 31 °C, decreasing linearly to 50 % relative humidity at 40 °C
Pollution	Pollution degree 2: only non-conductive pollution occurs, except that occasionally a temporary conductivity caused by condensation is to be expected.
Magnetic environment	< 0.2 T (PT2026 Main Unit)
Electromagnetic environment	Equipment intended to be used in an industrial electromagnetic environment, class A.

5-4 SOFTWARE

Supported platforms	Microsoft Windows
API	Access to all system features; LabVIEW® or C++ API
Licenses	Metrolab (including source code for LabVIEW & C++ API) National Instruments (LabVIEW® and NI-VISA run-times)

6- PROBE SPECIFICATIONS

6-1 PROBE MODEL 1326

Heavy-duty probe, suited for most measurements.

A single connector makes it easy to plug and unplug. An integrated 3-axis Hall probe speeds up the search for the NMR signal.



6-1-1 Ranges

Model designation	Range minimum (T)	Range Maximum (T)	Sample diameter, material
1326-0.038-0.14	0.038	0.14	7.45 mm, Hydrogen / synthetic rubber
1326-0.13-0.48	0.13	0.48	5.1 mm, Hydrogen / synthetic rubber
1326-0.46-1.5	0.46	1.5	2.9 mm, Hydrogen / synthetic rubber
1326-0.9-3.2	0.90	3.2	2.9 mm, Hydrogen / synthetic rubber
1326-1.4-4.8	1.4	4.8	2.9 mm, Hydrogen / synthetic rubber
1326-4.35-11.7	4.35	11.7	1.8 mm, Hydrogen / natural rubber
1326-10-32	10	32	3.6 mm, Deuterium / heavy water
1326-0.1-3	0.094	3.05	7.35 mm, Hydrogen / synthetic rubber

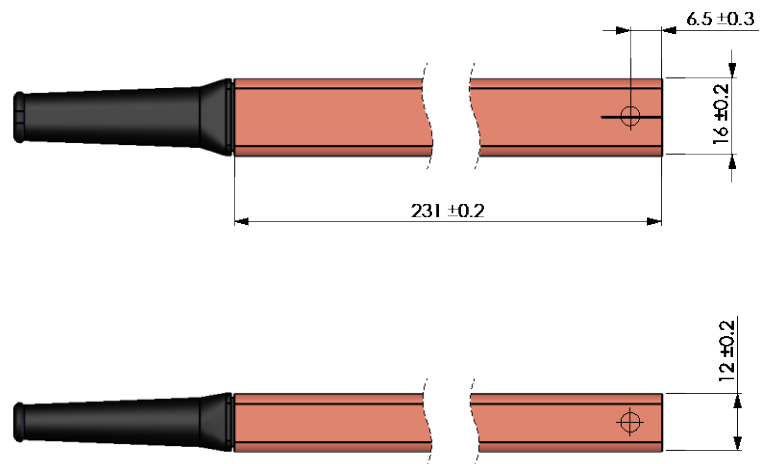
Note that model 1326-0.1-3 is a specialty probe, suitable only for applications where a highly uniform field can be guaranteed, such as calibration magnets.

Custom ranges are available upon request.

6-1-2 Dimensions

16 x 12 x 231 mm (same as PT2025 model 1062 probes)

Probe, model 1326



Probe cable length

10 m as a standard; custom length upon request
100 m max total length (incl. multiplexers)

6-2 PROBE MODEL 1426

Model 1426 probes have a remote passive measurement head that fits into small gaps and is ideal for high-radiation environments that would damage electronic components.



6-2-1 Ranges

Model designation	Range minimum (T)	Range maximum (T)	Sample diameter, material
1426-0.19-0.52	0.19	0.52	4.0 mm, Hydrogen / synthetic rubber
1426-0.42-1.29	0.42	1.29	3.0 mm, Hydrogen / synthetic rubber
1426-1.13-3.52	1.13	3.52	3.0 mm, Hydrogen / synthetic rubber
1426-3.17-10.69	3.17	10.69	1.8 mm, Hydrogen / natural rubber
1426-8.00-22.80	8.0	22.8	3.6 mm, Deuterium / heavy water

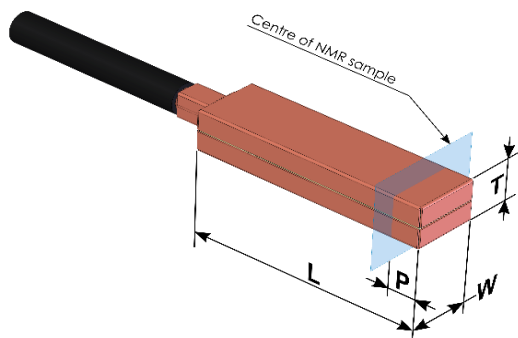
6-2-2 Dimensions

Probe, model 1426
Electronics

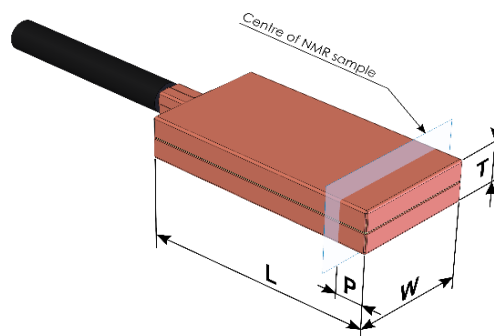
16 x 12 x 231 mm

Measurement head	L [mm]	W [mm]	T [mm]	P [mm]
	Proton sample	31.9 ±0.5	9.6 ±0.5	5.9 ±0.5
Deuterium sample	31.9 ±0.5	16.9 ±0.2	6.2 ±0.5	4.0 ±0.3

PWP1426 Remote Head for Medium and High Field



PWP1426 Remote Head for D2O sample



Electronics – head:

50 cm, Ø 4.3 mm

Cable Length

Probe- Electronics

10 m; custom upon request

100 m max total length (incl. multiplexers)

6-3 PROBE MODEL 1426-THIN

Model 1426-Thin probes have a remote passive measurement head that fits into gaps as small as 1.5 mm and is ideal for high-radiation environments that would damage electronic components.



6-3-1 Ranges

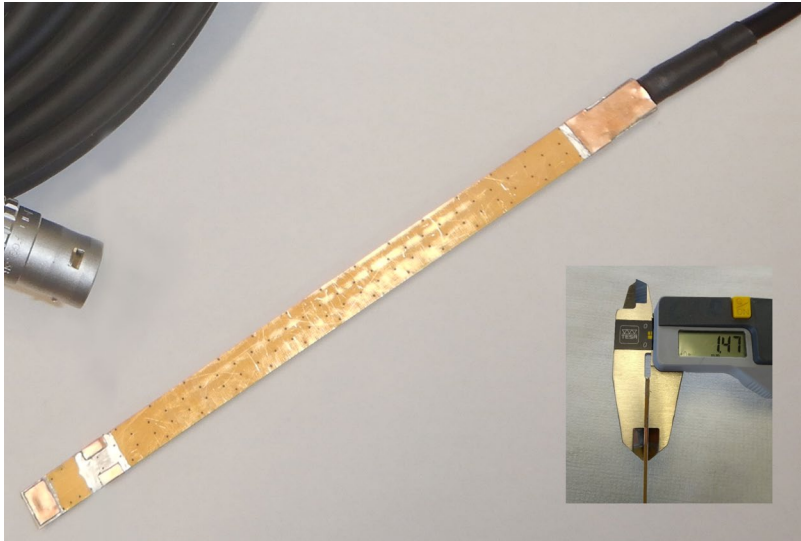
Model designation	Range minimum (T)	Range maximum (T)	Sample diameter, material
1426T-0.19-0.58	0.19	0.58	3.6 mm, Hydrogen / synthetic rubber
1426-0.45-1.50	0.45	1.50	3.0 mm, Hydrogen / synthetic rubber
1426-1.4-4.2*	1.4	4.2	3.0 mm, Hydrogen / synthetic rubber
1426-3.5-10.5*	3.5	10.5	1.8 mm, Hydrogen / natural rubber

* Subject to change, ranges to be confirmed

6-3-2 Dimensions

Probe, model 1426-thin Electronics 16 x 12 x 231 mm

Measurement head	L [mm]	W [mm]	T [mm]
	Proton sample	179.0 ±0.5	9.4 ±0.2



Cable Length

Electronics – head:

50 cm, Ø 4.3 mm

Probe- Electronics

10 m; custom upon request

100 m max total length (incl. multiplexers)

6-4 PROBE MODEL 1526

Model 1526 probes have a remote active measurement head that fits into small gaps. The local treatment of the NMR signal improves the signal-to-noise ratio and allows for longer cables.



6-4-1 Ranges

Model designation	Range minimum (T)	Range maximum (T)	Sample diameter, material
1526-0.038-0.14	0.038	0.14	7.45 mm, Hydrogen / synthetic rubber
1526-0.13-0.48	0.13	0.48	4.0 mm, Hydrogen / synthetic rubber
1526-0.46-1.5	0.46	1.5	2.9 mm, Hydrogen / synthetic rubber
1526-0.9-3.2	0.9	3.2	2.9 mm, Hydrogen / synthetic rubber
1526-1.4-4.8	1.4	4.8	2.9 mm, Hydrogen / synthetic rubber
1526-4.35-11.7	4.35	11.7	1.8 mm, Hydrogen / natural rubber
1526-9.5-32	9.5	32.0	3.6 mm, Deuterium / heavy water
1526-0.1-3	0.094	3.05	7.35 mm, Hydrogen / synthetic rubber
1526-0.65-2.4	0.65	2.4	2.9 mm, Hydrogen / synthetic rubber

Note that model 1526-0.1-3 is a specialty probe, suitable only for applications where a highly uniform field can be guaranteed, such as calibration magnets.

Custom ranges are available upon request.

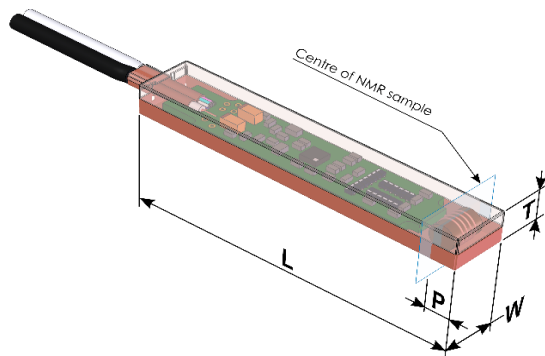
6-4-2 Dimensions

Probe, model 1526
Electronics

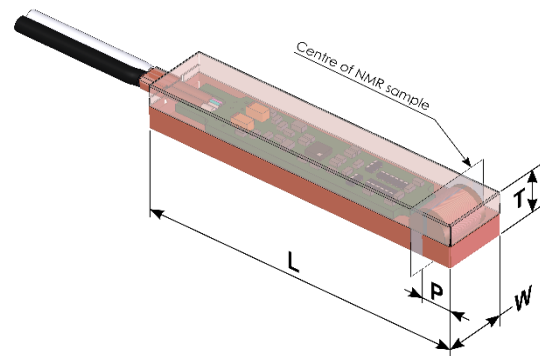
16 x 12 x 231 mm

	L [mm]	W [mm]	T [mm]	P [mm]
Measurement head	Head MF-HF	60.5 ±0.5	10.8 ±0.2	6.0 ±0.2
	Head LF	63 ±0.5	12.8 ±0.2	9.1 ±0.2
	Head D ₂ O	60.5 ±0.5	15.8 ±0.2	6.0 ±0.2

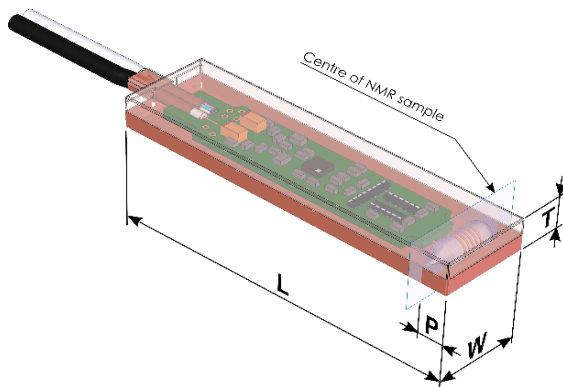
PWP1526 Remote Head for Medium and High Field



PWP1526 Remote Head for Low Field



PWP1526 Remote Head for D2O sample



Electronics – head:

150 cm, up to 10 m, Ø 4.3 mm

Probe cable length

Probe- Electronics

10 m; custom upon request

100 m max total length (incl. multiplexers)

6-5 INTEGRATED HALL PROBE

The integrated hall probe is meant to accelerate the process of finding the NMR signal, as such it isn't calibrated but uses a standard compensation curve, based on statistics over several sensors. As such, it can lead to measurements being off by several percents.

Be aware that the Hall probe that comes along the 1526 probe is not attached to the NMR sensor allowing the user to put it in the position of his choosing. As such, it can lead to dramatic differences when located in an area that isn't related to the magnetic field that is meant to be measured by the NMR sensor. Right now, there is no way to inform the main unit of a relation between the Hall value measured by the probe and the one that should be seen by the NMR sensor. Allowing the use of the Hall probe

6-5-1 Availability

	Hall probe
Model 1326 probe	Included
Model 1426 probe	Not available
Model 1526 probe	Optional

6-5-2 Measurement

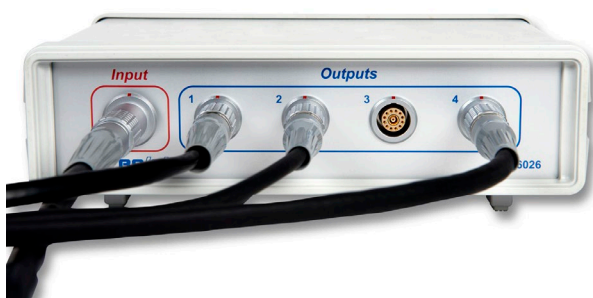
	Hall and NMR signals acquired non simultaneously to avoid signal disruption
Acquisition	Hall signal measured until NMR search range is reached
	Hall probe can be deactivated
Color of the display of the measured field strength	Orange during Hall measurement
	Green during NMR measurement
Precision (Hall)	5%

7- OPTIONS AND ACCESSORIES

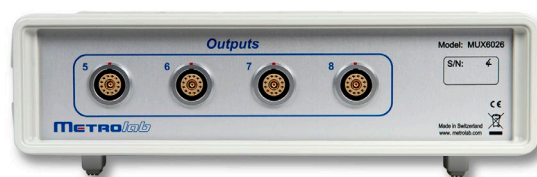
7-1 MULTIPLEXER

MUX6026-4 Multiplexer 250 X 80 X 180 mm

MUX6026-8 Multiplexer 250 X 80 X 180 mm



MUX6026-4 NMR probe multiplexer & MUX6026-8 NMR probe multiplexer front panel



MUX6026-8 NMR probe multiplexer back panel

7-1-1 MUX6026-4 4-CHANNEL MULTIPLEXER

For up to 4 channels. For direct connection of any combination of 1326 -1426 -1526 NMR Probes or 6026 Multiplexers, up to 3 levels of multiplexers.

7-1-2 MUX6026-8 8-CHANNEL MULTIPLEXER

For up to 8 channels. For direct connection of any combination of 1326 -1426 -1526 NMR Probes or 6026 Multiplexers, up to 3 levels of multiplexers.

7-2 FIELD REGULATION UNIT FOR PT2026 AND PT2126



RG8026 Magnetic Field Regulation Unit (board, back panel and cable).

Stabilizes the field of resistive, superconducting or permanent magnets by continuously measuring the field. The RG8026 can generate a correction voltage or current for an MPS with analog fine control, directly drive a small correction coil, or drive an auxiliary coil power supply.

7-3 PROBE-EXTENSION/MULTIPLEXER CABLES

3026-10M	1 - 10 m long	Cable diameter 13 mm*
3026-11M	11 - 50 m long	Cable diameter 15 mm*
3026-51M	51 - 100 m long	Cable diameter 20 mm*

Cables between NMR Teslameter Main Unit / 6026 Multiplexer, or cable extension for any 1326 -1426 - 1526 NMR Probes.

- We recommend using the highest rating of the total cable length, not of the individual segments.