

MS2/MS3  
Magnetic Susceptibility System

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# MS2/MS3 Magnetic Susceptibility System

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The Bartington MS2/MS3 System is a reliable, high quality instrument that has earned a reputation as the world standard for environmental magnetic susceptibility measurements. It is widely used by academic and research establishments in many countries.

The system comprises a meter with a range of sensors for measuring the magnetic susceptibility of many types of material including soils, rocks, powders and liquids. It is suitable for use in both the laboratory and in the field.

Magnetic susceptibility measurements provide information about the composition and properties of materials. This is valuable in many areas of scientific investigation. For example, in UXO (unexploded ordnance) location, the susceptibility of soil has a strong influence on the efficiency of metal detection techniques; in palaeoclimatology, measurements on sediments can help to determine their origin and the climatic conditions at the time of deposition.

The Bartington MS2/MS3 System is a highly versatile tool that provides the scientist with the ability to perform high precision measurements in a wide variety of different applications, including:

- geological and soil surveys
- palaeomagnetism
- archaeological prospecting
- palaeoclimatic studies
- hydrology
- sedimentology
- core logging and correlation
- soil and airborne pollution surveys
- analysis of ferrites and magnetic inks
- study of micro/nano magnetic particles and fluids

Sensors are available for large area field surveys, core logging, outcrops and small bottled samples in a laboratory. Software is supplied to integrate the system with desktop PCs, laptops and handheld GPS/PDA devices.

A list of academic papers featuring the MS2/MS3 Magnetic Susceptibility System is available on the product page on the Bartington Instruments website at [www.bartington.com/ms3.html](http://www.bartington.com/ms3.html).

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## Principle of operation

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The MS2/MS3 System operates by generating a low frequency, low intensity, AC magnetic field around the sensor. When sample material is placed near the sensor, the resulting change in this field is sensed by the system and converted to magnetic susceptibility readings for both positive and negative (diamagnetic) values, to a resolution of  $2 \times 10^{-6}$  SI units. The measurements are non-destructive, retaining the sample's magnetic characteristics, and relatively unaffected by sample conductivity. The sensors are temperature compensated to minimise drift during use.

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## MS2 Magnetic Susceptibility Meter

The MS2 is a portable meter with an integral four-digit display. It will operate with all MS2 sensors. Powered by internal batteries, it is rechargeable from the mains or a vehicle charging point, with indicators for battery status and charging. Push buttons or a toggle switch are used for zeroing or taking measurements. The serial connection can be used for control and acquisition of data. A range switch allows the user to select high or low resolution. All sockets and switches are environmentally sealed for outdoor use.

The meter is supplied with a carrying bag for field use, an instrument stand for laboratory use, a universal mains adaptor, a vehicle charger and a serial/USB converter.



## MS3 Magnetic Susceptibility Meter

The MS3 is a compact, lightweight meter, offering increased performance over its predecessor, the MS2 Meter. It can measure magnetic susceptibility up to 26 SI (compared to 0.1 SI for the MS2), and the measurement period is selectable down to 0.1s minimum. The MS3 Meter provides significant advantages over the MS2 in terms of portability, configurability and connectivity to a PDA device for GPS-logged field work.

This advanced device offers USB connectivity and is completely software controlled. It must be connected to a compatible PC, laptop, PDA or mobile phone (with USB host capability), which provide all measurement control and display. The Bartsoft software supplied with the unit gives the user control over the measurement protocol and speed. It includes options to display data in both chart and table formats. Full details of Bartsoft are shown at the end of this brochure.

The MS3 operates with all MS2 sensors. The meter is sealed and suitable for both indoor and outdoor use. For outdoor use, a rugged PDA/GPS is recommended (a fully compatible Trimble Nomad 900L PDA can be supplied).



Specifications	MS2 Meter	MS3 Meter
Range	0.09999 SI (volume specific)	26 SI (volume specific)
Maximum resolution	$2 \times 10^{-6}$ SI	$2 \times 10^{-6}$ SI
Units	SI or CGS	SI or CGS
Measurement time	1s or 10s	Selectable to 0.1s minimum
Display	Yes	No (requires PC or PDA)
Laboratory data logging	Yes (with Bartsoft or Multisus)	Yes (with Bartsoft )
Field data logging	Not available	Yes (with Bartsoft for Windows® CE)
Weight	1.9kg	0.13kg
Internal battery	0.7Ah sealed Ni-MH gives 8 hours use before recharge is required	N/A
Enclosure material	High impact ABS	White Acetal
Operating temperature	-10°C to +40°C	-10°C to +40°C
Dimensions (W x H x D)	155 x 50 x 256mm	50 x 25 x 123.5mm
Battery charger inlet	2.1mm socket, 6-18VDC, 100mA maximum, polarity protected	N/A
Battery charge	16 hours full charge	N/A
RS232 interface to PC	1200/9600 baud rate selected on rear panel Pin assignment: 1 = Ground Ov, 2 = MS2 Tx, 3 = MS2 Rx	N1200/9600 baud rate – software selectable
Interface connector	4-way rear panel Fischer socket TNC-TNC	Hirose HR10-7R-6P

A working system comprises a meter unit (either the MS3 or MS2) and one or more sensors.

## Accessories

	MS2 Meter	MS3 Meter
Cables to sensor	Supplied	Supplied
Cables to PC	RS232 supplied Serial/USB adaptor supplied	USB supplied RS232 + 5V mains charger supplied

# MS2B Dual Frequency Sensor

This sensor is primarily used to measure the magnetic susceptibility of soil, rock and sediment samples. It is widely recognised as a standard instrument in the characterisation of the magnetic properties of soil. It can also be used in conjunction with the AMSWIN-BAR software and sample adaptor for measurements of the anisotropy of magnetic susceptibility in rocks.

The dual frequency facility permits identification of superparamagnetic magnetic grains, helping characterise the processes that affect the sample.

The MS2B is also suitable for susceptibility measurements of magnetic fluids, inks and micro/nano particles.

The sensor accepts 10ml and 20ml cylindrical bottles, 25.4mm and 23mm cubic boxes, 35mm pots and 25.4mm cylindrical cores.



Specification	
Calibration accuracy	1% (10ml calibration sample provided)
Measurement period (MS2)*: x 1 range x 0.1 range	1.5s SI (1.2s CGS) 15s SI (12s CGS)
Operating frequencies: LF HF	0.465kHz $\pm$ 1% 4.65kHz $\pm$ 1%
Amplitude of applied field	250 $\mu$ T peak $\pm$ 10% (LF & HF)
Maximum resolution	2 x 10 <sup>-6</sup> SI (vol) (2 x 10 <sup>-7</sup> CGS) (LF & HF)
HF/LF cross calibration	0.1% worst case (can be adjusted using calibration sample)
Drift at room temperature	<2 x 10 <sup>-5</sup> SI (<2 x 10 <sup>-6</sup> CGS) in 3 minutes (after 5 minute warm-up)
Dimensions (W x H x D)	110 x 145 x 210mm
Sample cavity internal diameter	36mm
Weight	0.7kg
Enclosure material	High impact ABS

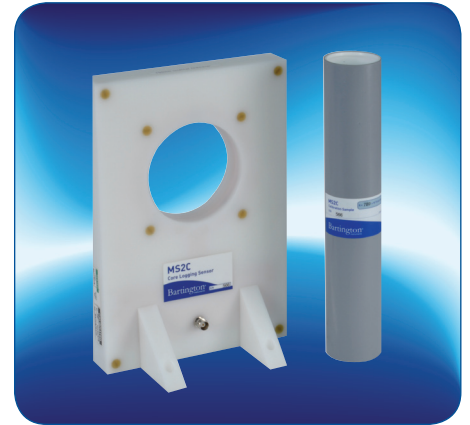
\* MS3 measurement period is software selectable

## MS2C Core Logging Sensor

A series of loop sensors, ranging from 30 to 162mm in diameter, are available for high resolution volume susceptibility measurements on whole cores. They are suitable for measuring any type of peat, lake or marine sediment core, provided it is not metal-clad.

These rugged sensors, with a very low temperature induced drift, are designed for laboratory, field or shipboard use. They can be used with manual or automated core analysis systems (details can be provided).

The MS2C Sensors are used in prospection, core correlation and the identification of palaeoclimatic sequences. Optimum measurement accuracy is achieved with 5 to 10mm core clearance. Calibration graphs are provided for varying core to sensor diameter.



### Specification

Loop internal diameter	30, 36, 40, 45, 47, 50, 60, 70, 72, 80, 85, 90, 93, 100, 110, 120, 125, 130, 135, 140, 145, 146, 150, 160 or 162mm (Intermediate sizes can be provided at an additional charge)
Calibration accuracy	5% (calibration sample provided)
Measurement period (MS2)*: x 1 range x 0.1 range	1.1s SI (0.9s CGS) 11s SI (9s CGS)
Operating frequency	0.565kHz
Spatial resolution	20mm
Drift at room temperature	$<2 \times 10^{-5}$ SI (vol) [ $<2 \times 10^{-6}$ CGS] in 10 minutes (after 5 minutes' warm-up)
Dimensions (W x H x D)	200 x 290 x 162mm (with feet)
Weight	2 to 2.7kg depending on diameter
Enclosure material	White polyacetal

\* MS3 measurement period is software selectable

## MS2D Surface Scanning Probe

This loop probe is designed for rapid assessment of the content of magnetic materials in the top 100mm of the land surface. It is used in studies of slope processes and in archaeological prospecting. The probe can only be operated in conjunction with the MS2 Probe Handle.



### Specification

Depth of response	50% at 15mm, 10% at 60mm
Measurement period (MS2)*: x 1 range x 0.1 range	0.6s SI (0.5s CGS) 6s SI (5s CGS)
Operating frequency	950 ± 60Hz
Drift at room temperature	$<10 \times 10^{-5}$ SI (vol) [ $<10 \times 10^{-6}$ CGS] in 20 minutes (after 20 minutes' warm-up)
Dimensions (∅ x H): overall coil	208mm x 104mm 185mm mean diameter
Weight	0.5kg
Enclosure material	Reinforced epoxy

\* MS3 measurement period is software selectable

## MS2E Core Logging Sensor

This sensor is designed to perform high resolution measurements on the surface of split drill or soft sediment cores. The sensitive area of the probe (i.e. the area receiving 50% maximum response) is in the form of a rectangle of 3.8mm x 10.5mm, allowing very fine resolution surface measurements. The position of the long axis is identified by marks on the circumference of the sensor. The MS2E is supplied in a protective case.

### Specification

Calibration accuracy	2% (calibration sample provided)
Area of response	3.8mm x 10.5mm at the end of the ceramic cylinder
Depth of response	50% at 1mm, 10% at 3.5mm
Measurement period (MS2)*: x 1 range x 0.1 range	1.5s SI (1.2s CGS) 15s SI (12s CGS)
Operating frequency	2kHz
Drift at room temperature	<2.3 x 10 <sup>-5</sup> SI (vol) (<2 x 10 <sup>-6</sup> CGS) in 10 minutes (after 5 minutes' warm-up)
Dimensions (W x H x D)	50 x 25 x 149mm
Weight	0.22kg
Enclosure material	Diecast aluminium and ceramic

\* MS3 measurement period is software selectable



## MS2F Surface Point Probe

This miniature probe is ideal for the stratigraphic study of exposed geological and archaeological sections. It is also used where uneven surface conditions prevent good contact with the MS2D loop. The MS2F can only be operated when connected to the MS2 Probe Handle.

### Specification

Area of response	End face and cylinder wall up to the shoulder
Depth of response	10% at 6mm from end face and 4.5mm from outer diameter of end cap
Measurement period (MS2)*: x 1 range x 0.1 range	1.1s SI (0.9s CGS) 11s SI (9s CGS)
Operating frequency	0.58kHz
Drift at room temperature	<10 x 10 <sup>-5</sup> SI (vol) (<5 x 10 <sup>-6</sup> CGS) in 20 minutes (after 20 minutes' warm-up)
Dimensions: sensitive volume overall	15mm diameter x 20mm 35mm diameter x 85mm
Weight	0.05kg
Enclosure material	Nylon 66

\* MS3 measurement period is software selectable



## MS2G Single Frequency Sensor

This sensor is designed for magnetic susceptibility measurements of 1ml liquid or powder samples. Calibrated volume is 1ml but scaling correction values allow volumes down to 0.2ml to be measured. The sensor operates at a low frequency and has excellent temperature stability.

The MS2G is used for susceptibility measurements where only very small samples of homogeneous fine-grained material are available. Examples are airborne particulates collected in filter papers or particles in colloidal suspension.

The sensor accepts commercially available polythene vials with a diameter of 8mm and a length of 30mm. The sample holder is compatible with other rock measuring equipment, allowing a comprehensive range of measurements to be taken without the need for re-packing the sample. The sample cavity is situated at the tip of a boom mounted on the aluminium electronics enclosure.



### Specification

Calibration accuracy	2% (1ml calibration check sample provided)
Measurement period (MS2)*: x 1 range x 0.1 range	0.9s SI (0.7s CGS) 9s SI (7s CGS)
Operating frequency	1.3kHz
Drift at room temperature	$<2 \times 10^{-5}$ SI (vol) ( $<2 \times 10^{-6}$ CGS) in 5 minutes (after 5 minutes' warm-up)
Sample cavity dimensions	8.5mm diameter x 28mm in height
Sensitive region	5mm height at centre of cavity
Dimensions (W x H x D)	91 x 67 x 184mm
Weight	0.67kg
Enclosure material	Aluminium and ceramic

\* MS3 measurement period is software selectable



## MS2K Surface Sensor

This handheld sensor is designed to provide highly repeatable measurements of the volume magnetic susceptibility of moderately smooth surfaces. Applications include description of magnetic stratigraphy and identification of horizons. It can also be used for characterisation of outcrops and logging split cores, with the exception of metal-clad cores. The sensor has applications in materials testing where the relatively low operating frequency permits measurement on some of the less electrically conductive metal alloys, for example stainless steel, without magnetisation.



Specification	
Calibration accuracy	1% (calibration sample provided)
Area of response	25.4mm diameter (full-width, half-maximum)
Depth of response	50% at 3mm, 10% at 8mm
Measurement period (MS2)*: x 1 range x 0.1 range	1.2s SI (1s CGS) 12s SI (10s CGS)
Operating frequency	0.93kHz
Drift at room temperature	$<2 \times 10^{-5}$ SI (vol) [ $<2 \times 10^{-6}$ CGS] in 5 minutes (after 5 minutes' warm-up)
Environmental	May be used under wet conditions: not suitable for immersion
Dimensions (W x H x D)	50 x 170 x 165mm
Weight	0.32kg (1.20kg with carrying case)

\* MS3 measurement period is software selectable

## MS2H Downhole Sensor

The MS2H is a downhole sensor for profiling the magnetic susceptibility of strata in 25mm nominal diameter auger holes. The detachable probe is fitted to the lower end of a push-tube to give an assembled length of 1 metre. Waterproof screw couplings allow further 1-metre extension tubes to be added to achieve any practical length. The probe assembly is hand guided within the hole during logging. Graduations ensure depth control to a resolution of 1cm. The probe connects to the meter via a 5mm diameter cable, which may be extended to any practical length up to 100m.

The area of sensitivity for magnetic investigation radiates uniformly from the end of the probe, resulting in tolerance to inhomogeneities. Strata as narrow as 12.5mm in thickness can be discriminated. Measurements to a resolution of  $1 \times 10^{-5}$  SI (volume) are obtained in less than one second. A low operating frequency of 1.3kHz ensures immunity to electrical conductivity effects.

Suitable augers can be supplied. More information is available on request.

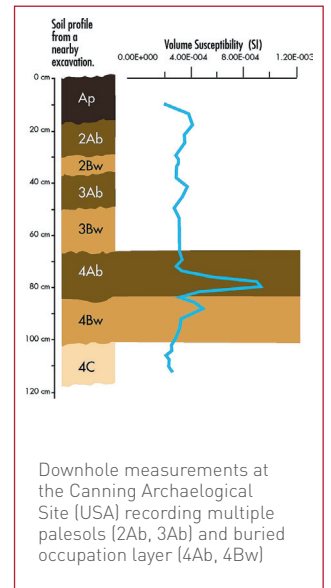
Applications include cultural stratigraphy in archaeology, geomorphology, landslide characterisation, paleosol identification, pedology, erosion studies and stratigraphic correlation.



### Specification - MS2H Sensor

Calibration accuracy	1% (calibration sample provided)
Spatial resolution (vertical)	12.5mm (full-width, half-maximum)
Depth of horizontal penetration	50%/2mm, 10%/5.5mm, 1%/13mm
Operating frequency	1.3kHz
Calibration accuracy	5% in ø22mm sample
Measurement period (MS2)*: x 1 range x 0.1 range	0.9s SI (0.7s CGS) 9s SI (7s CGS)
Thermal drift (typical)	$2 \times 10^{-5}$ SI/°C (below 20°C) $-1 \times 10^{-5}$ SI/°C (above 20°C)
Thermal setting time (typical)	30s/°C (step change)
Markings for plane of sensitivity	Lowest graduation
Dimensions (Ø x L)	21.5 x 153mm
Weight	0.13kg

\* MS3 measurement period is software selectable



### Specification - Push tubes

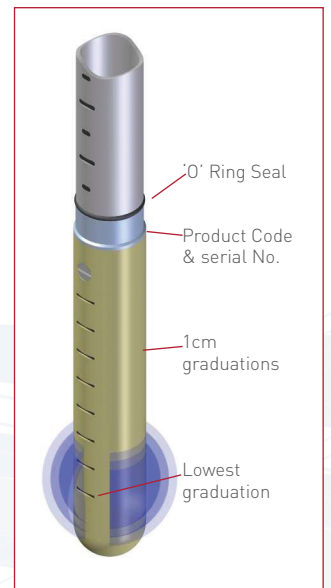
Construction	Anodised aluminium alloy with BS015 'O' ring seal and stainless steel threaded couplings
Lengths including union: extension primary	101.5cm 91.5cm
Weight	0.35kg each

### Specification - Connecting cable

Construction	10m length, 5mm diameter co-axial (may be extended to 100m max)
Weight	0.4kg/10m

### Specification - Carrying case

Dimensions (W x H x D)	380 x 140 x 138mm
Weight (full)	10kg



## MS2 Probe Handle

This device incorporates the electronics for both the MS2D and MS2F and is required for connection of these sensors to the meter. The handle is submersible to the depth of the electronics unit (0.6m).

Specification	
Dimensions: upper section lower section	430mm length 360mm length
Weight	0.6kg
Connections: mechanical electrical	11TPI 'O' ring sealed screw coupling 50 ohms TNC



## MS2 Equipment Carrying Cases

Tough, lockable cases are available in a variety of sizes and carrying weights, to suit the combination of instruments ordered. Interior cut-outs provide maximum protection for the equipment.

Specification	
Maximum dimensions (W x H x D)	710 x 310 x 570mm
Maximum weight	18.6kg including equipment



## MS2/MS3 Susceptibility/Temperature System

This system measures the magnetic susceptibility of samples over the temperature range -200°C to +850°C. It is used in the investigation of the magnetic properties of minerals and for the determination of Curie transition temperatures.

The system comprises the MS2 or MS3 Meter, MS2W Water Jacketed Sensor, MS2WF Furnace, MS2WFP Power Supply Unit and a self-contained water coolant supply, fully interlocked to prevent the MS2WF Furnace operating without coolant flow. The Geolabsoft software package (running under Windows®) collects data and displays the results during the measurement sequence.



## MS2W Water Jacketed Sensor

This water jacketed sensor has a 30mm diameter sample cavity. The temperature stability of the sensor is excellent and drift during the measurement sequence is exceptionally low, as the water jacket thermally isolates the electronics from the sample cavity. The sensor can be used without the furnace or power supply, in conjunction with the MS2/MS3 Meter and a non-magnetic type T thermocouple (Cu/Cu-Ni), for measurements on 10ml cylindrical samples over the temperature range -200°C to room temperature. The sample is cooled in liquid nitrogen and allowed to warm slowly to room temperature while measurements are taken.

For high temperature measurements to +850°C, the MS2WF Furnace and MS2WFP Power Supply Unit are required.



Specification	
Calibration accuracy	1% [calibrated for 10ml sample]
Measurement period [MS2]*: x 1 range x 0.1 range	2.4s SI (1.9s CGS) 24s SI (19s CGS)
Operating frequency	0.348kHz
Drift during measurement	$<2 \times 10^{-5}$ SI [vol] [ $<2 \times 10^{-6}$ CGS]/30 minutes with 2l/minute water flow through sensor
Dimensions: probe internal $\varnothing$ overall (W x H x D)	31mm 96 x 65 x 255mm
Weight	0.85kg
Sensitive area	15 mm height – centre of cavity
Coolant (water) flow rate	2 litres/min minimum recommended
Maximum water pressure	300cm Hg
Connectors: water electrical	6m TNC
Mounting	13mm rod
Materials	Glass filled polycarbonate/glass

\* MS3 measurement period is software selectable

# MS2WF Furnace

The MS2WF Furnace is installed inside the cavity of the MS2W Water Jacketed Sensor, for heating samples from room temperature to +850°C. The non-inductively wound platinum heating element on a quartz cylinder ensures uniform heating of the sample, while insulation reduces the maximum external temperature to around 100°C.

The sample temperature is displayed on a digital panel meter to a resolution of 0.1°C when connected to a thermocouple, either type S (Pt/Pt-Rh: for measurements up to +850°C) or type T (Cu/Cu-Ni: for measurement in the range -200°C to +350°C). The sample temperature is also available as an analogue voltage.

The sample diameter is restricted to 15mm maximum or circa 2.5ml volume. A ceramic crucible, specially designed to fit onto the thermocouple, is provided for granular or powder samples.



## Specifications

Dimensions: overall (W x H x D) heating cavity ceramic crucible cavity	135 x 350 x 235mm 17mm Ø 25mm usable height 13mm Ø 20mm usable height
Weight	2kg
Materials	Silica/platinum/alumina/stainless steel
Electrical resistance	3Ω at room temperature
Power requirements	100W max. 28V DC at 3A
Internal magnetic field	measured less than 0.05A/m
Operating temperature	850°C maximum intermittent use
Voltage/Temperature ratio	approx. 0.027V/°C with good thermal insulation
<b>Fixed thermocouple (non magnetic, high temperature)</b>	
Type	'S' (Pt/Pt. 10%Rh) built-in and permanently wired to base electronics unit with adjustable height
Calibrated range	-50°C to 850°C
<b>Separate thermocouple (non magnetic, low temperature)</b>	
Type	'T' (Cu/Cu Ni) Remote connection via polarised plug and socket
Calibrated range	-250°C to +400°C
<b>Base</b>	
Materials	Aluminium
Dimensions	235 x 135 x 90mm
Retort stand dimensions	260 x 9.5mm
<b>Digital thermometer</b>	
Type	4 digit display with polarity
Output	1 mV/oC via 4mm sockets
Serial output	RS232 via RS485/RS232 converter
Bits per character	1 start, 8 data, 2 stop, no parity
Baud rate	1200
Trigger	from GeoLabsoft program
Output	ASCII string
Sockets	2 x 4mm Va out 1 x 8-way polarised MS2WFP to MS2WF connection (Trident ringlock) 1 x polarised Cu/Cu.Ni. thermocouple connector

## MS2WFP Power Supply Unit

This unit supplies power to the MS2WF Furnace to heat the sample. The sample temperature can be increased or decreased at a pre-selected linear rate, or maintained at a pre-set level using manual controls.



Specification	
Dimensions (W x H x D)	260 x 143 x 360mm
Weight	7kg
Power input (rear panel IEC inlet)	110V or 220V AC selectable, 200W max.
Power output	150W max.
Power lead colour code	Brown – LIVE Blue – NEUTRAL Green/Yellow – EARTH
Line fuse	2 A anti-surge 20 x 5mm
Output voltage	±20V max.
Minimum load resistance	3Ω
Maximum output current	4A
Maximum ripple voltage	0.2V p-p
Serial data I/O	9-way 'D' connectors : RS232
Output data format temperature susceptibility	see MS2WF specification see MS2 specifications
8-way socket connections	A 0 V power B +ve furnace (active) C -ve furnace D 0 V signal E 1 mV/oC in F Rx data G Tx data H +15V out
9-way plug (MS2 Meter) connections	2 Tx 3 Rx 5 0V
9-way skt (Computer) connections	2 Tx 3 Rx 4 DTR link to 6 DSR 7 RTS Link to 8 CTS 5 0V
3-way skt (water cooling system)	1 +ve 2 -ve 3 Signal

# Software

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## Bartsoft

The MS3 Meter has no display or controls because it is designed to be connected to a PC, laptop or PDA running the supplied Bartsoft software. This provides a range of features to control the meter and display the measured results.

### Main Features

- Adjustable measurement period to optimise the overall time taken and the required data resolution. This can more than halve the overall experimental time, compared to older MS2 Meter systems.
- User-definable measurement protocols can be used to provide a level of automation in the measurement process. Predefined protocols are available for tasks such as individual sample tests, core logging, two-dimensional X-Y surveys and one-dimensional downhole surveys.
- Data display options including tabular format, with selectable data columns and X-Y chart plots.
- Automatic correction factors for non-standard sample volume, mass specific results and temperature drift.

Data collected can be saved in Bartsoft's native format or copied into other applications (e.g. spreadsheets) for further analysis.

### Versions available

- Bartsoft for Windows requires Windows 2000/XP/Vista or Windows 7 (both 32-bit and 64-bit).
- Bartsoft for Windows CE runs under Windows Mobile 6 and includes GPS compatibility, enabling magnetic susceptibility data to be tagged with a GPS location (this requires a Windows Mobile device with internal or external GPS).

Note that Bartsoft for Windows can be used with the MS2 Meter. Most features will function, although the measurement period is fixed at 1.0s or 0.1s by the meter. Bartsoft for Windows CE will not operate with the MS2 Meter.

## AMSWIN-BAR

This package is used with the MS2 Meter, MS2B Sensor and MS3 Meter to measure the anisotropy of magnetic susceptibility for magnetic fabric analysis. A sample adaptor designed for 25mm diameter palaeomagnetic samples is supplied with the software. The software operates under Windows 2000/XP/Vista.

## Geolabsoft software

This software for the MS2/MS3 Susceptibility/Temperature System runs under Windows 95/98/2000/NT/XP/Vista. Data is collected via a single RS232 serial interface and plotted in real time. Drift correction is applied at the end of the measurement sequence.



**Bartington**<sup>®</sup>  
Instruments

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