Aim instruments

I-prober 520

Positional Current Probe

SERVICE GUIDE

Aim TTi

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Specifications

General specifications apply for the temperature range 5°C to 40°C with the probe connected to a measuring instrument (oscilloscope or DMM) having an input impedance of 1MΩ || <30pF. Accuracy specifications exclude errors of that measuring instrument and apply for the temperature range 18°C to 28°C after 30 minutes warm-up and calibration at 23°C. Specifications quoted without limits are typical characteristics determined by design and are not guaranteed.

Dynamic Characteristics

Bandwidth (small signal):	DC to 5MHz.
Pulse Rise-time (10% - 90%):	<70ns.
Propagation delay:	60ns typical.
Pulse aberrations:	<±5% (<1% at lower bandwidth settings).
Slew Rate (equivalent):	15A/µs
Noise (equivalent in toroid):	$6mA_{rms}$; $1.5mA_{rms}$ at minimum bandwidth setting.
Filter settings:	Full bandwidth, 500kHz or 2Hz.

Magnetic Field Measurement

Scaling factor:	250µT (or 200A/m) per output Volt
Accuracy and linearity:	±3%
Maximum field:	±2·5mT (2000A/m)

Current measurement in wire (with toroid attachment)

Current range:	±10mA to ±10A (DC + peak).
Accuracy and linearity:	±5%
Scaling factor:	1 Amp per output Volt.
Maximum wire diameter:	3.5mm (unbroken) or 6mm (end fed).

Current measurement in PCB track

Scaling factor (with control adjusted to suit track width):	1 Amp per Volt for track widths 0·2mm to 3.5mm (0·007” to 0·14”) or 2 Amp per Volt for track widths 3mm to 6.5mm (0·125” to 0·25”)

General characteristics

Maximum output voltage:	±10V, corresponding to ±2·5mT (field measurement) or ±10A (wire)
Maximum bare-wire voltage:	$300V_{rms}$ CAT II (circuits connected directly to the low voltage mains) or $600V_{rms}$ CAT I (circuits ***not*** connected directly to the low voltage mains). Maximum Permitted Transient Overvoltage: 2500V.
Maximum track temperature:	Probe tip maximum working temperature is 150ºC
Probe dimensions:	155mm x 38mm x 28mm max; 2.8mm x 1.8mm at tip
Cable length:	2m from probe tip to output BNC
Safety:	Complies with EN61010-1 & EN61010-031
EMC:	Complies with EN61326

Current Probe

This instrument is Safety Class III according to IEC classification and has been designed to meet the general requirements of EN61010-1 (Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use) and sub-parts EN61010-2-032 and EN61010-031 as applied to this particular form of current probe.

This instrument has been tested in accordance with EN61010-1, EN61010-2-032 and EN61010-031 and has been supplied in a safe condition. This instruction manual contains essential information and warnings which have to be followed by the user to ensure safe operation and to retain the instrument in a safe condition.

This instrument has been designed for indoor use in a Pollution Degree 2 environment in the temperature range 5°C to 40°C, 20% - 80% RH (non-condensing). It may occasionally be subjected to temperatures between +5° and -10°C without degradation of its safety. Do not operate while condensation is present.

WARNINGS and CAUTIONS

- Use of this instrument in a manner not specified by the user instructions may impair the safety protection provided.
- This probe may only be used by qualified personnel who are aware of the risks associated with probing on or near bare conductors at hazardous voltages, i.e. voltages above 70Vdc or ac voltages exceeding 33Vrms or 46.7Vpeak. The maximum voltage of bare conductors on which it can be used is 300Vrms CAT II or 600Vrms CAT I.
- Connect the AC Power Adaptor to the Base-box and the signal output BNC cable to the oscilloscope before the probe is put in contact with the signal to be measured. Only use the AC Power Adaptor supplied and always use an oscilloscope which has its chassis connected to earth ground.
- Inspect the probe tip, casing and cabling for wear and damage before every use. Safety depends entirely on the integrity of the insulation of that section of the probe shaft forward of the raised safety marker, and of the probe tip in particular.

DO NOT USE THE PROBE IF ANY PART APPEARS TO BE DAMAGED

This service guide describes the procedure for replacing a damaged wear tip. If there is any other damage, the complete unit must be returned to the factory for repair.

- Do not hold the probe beyond the finger guard between the body and the probe shaft when making a measurement on a conductor which is at a hazardous voltage, and do not allow any hazardous voltage to approach any closer to the finger guard than the safety marker on the probe shaft. See the diagram opposite.
- Before attaching or detaching the toroid assembly from a bare cable at a hazardous voltage make sure that the conductor is not energized.
- Do not use the probe when wet or if condensation is present. Do not wet the instrument when cleaning it.

AC Power Adaptor

The adaptor/charger supplied has a universal input voltage rating of 100-240VAC, 50/60Hz. It is a Class II (double insulated) device, fully approved to EN 60950-1 (2001) and UL 60950 (UL listing E138754) and AS/NZS CISPR:2002 (C-Tick).

⚠ Use ONLY the AC adaptor/charger provided by TTi with the instrument. Use of any other power source may damage the unit and will void the warranty.

Symbols

The following symbols are used on the current probe and in this manual.

WARNING – Risk of electric shock.

CAUTION – refer to accompanying documentation (this manual).
Damage to the instrument may occur if these precautions are ignored.

Do not apply around or remove from hazardous live conductors.

Application to hazardous live conductors acceptable.

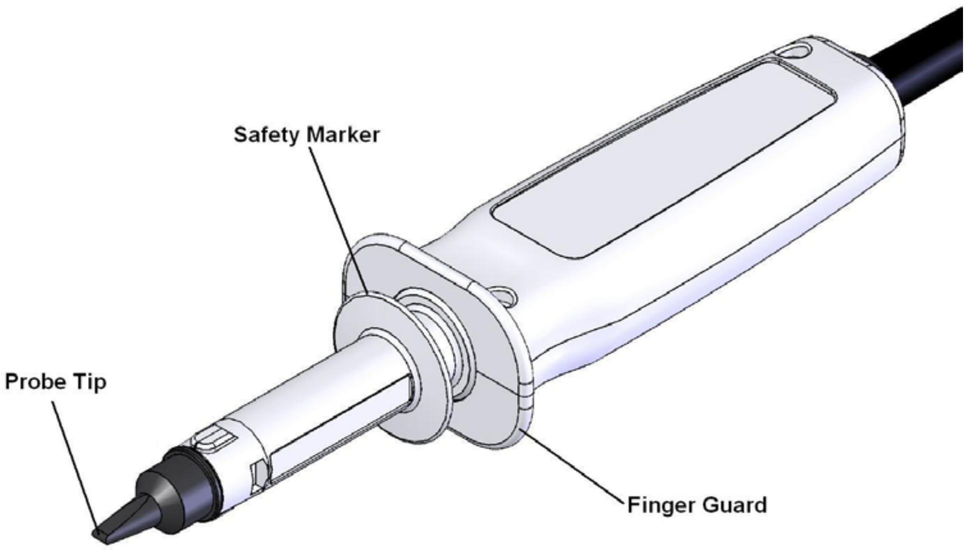
Protected throughout by double insulation or reinforced insulation.

alternating current (ac).

direct current (dc).

CAT II Indicates Measurement Category II; the maximum voltage rating to earth for CAT II measurements is generally shown with the symbol. Measurement Category II applies to measurements performed on circuits directly connected to the low-voltage mains supply, e.g. portable equipment and appliances. CAT II does ***not*** include measurements on distribution level circuits, e.g. distribution boards, circuit-breakers, bus-bars, etc., or industrial installations, all of which are classified as CAT III.

CAT I Indicates Measurement Category I; the maximum voltage rating to earth for CAT I measurements is generally shown with the symbol. Measurement Category I applies to measurements performed on circuits not directly connected to the low-voltage mains supply. This category includes secondary circuits separated from the mains circuits by a transformer and circuits derived from the mains supply in which measures have been taken to limit transient overvoltages to an appropriately lower level. The maximum permitted transient overvoltage for the 600V CAT I rating of this probe is 2500V.



Service Handling Precautions

Service work or calibration should only be carried out by skilled engineers using high quality test equipment. If the user is in any doubt as to his competence to carry out the work, the instrument should be returned to the manufacturer or their agent overseas for the work to be carried out.

This service guide covers two repair possibilities:

1. Recalibration with a different toroid assembly, if the original has been lost or broken.
2. Replacement of the sacrificial wear tip.

It is emphasised that the mechanical positioning of components during assembly of the product is extremely critical, and great attention to detail is required. Also full electrical testing, set-up and calibration requires the use of jigs and very specialist test equipment.

The full calibration procedure is also given, for use in calibration laboratories with the necessary special equipment.

If any other functional fault is suspected, return the complete system to the factory for diagnosis and replacement or repair. It is not possible to localise a fault to an individual PCB assembly.

Basis of the safety insulation

There are no dangerous voltages in the circuits inside the probe. The BNC connector joins these circuits to ground through the attached oscilloscope (the probe may not be used with floating scopes). The potentially dangerous voltage to be considered is the circuit being probed. The user is protected from any such voltage by double insulation in the probe tip and the probe barrel. This is the reason that users are required to check the condition of the probe tip before each use; the two layers of insulation are different colours (black and white) to make it easier to see if the black layer is broken or worn through.

Damage to the Cable

The signal circuits in the cable are surrounded by a lapped sheath which is grounded via the BNC output socket. If the insulation is damaged, this is not in itself dangerous, but the risk exists of contacting some external circuit and causing either a dangerous situation or damage to either the probe or the attached scope.

The cable cannot be replaced in the field, so if a satisfactory repair cannot be made to the insulation then the whole unit must be returned to the factory.

AC Adaptor

The output voltage of the adaptor can be checked with a DVM: the outer sleeve is the negative terminal and the voltage should be around 5.2 to 5.3V.

Toroid Assembly Calibration

This procedure describes the recalibration of the control box to match a new toroid assembly, if the old one has been broken or lost.

Introduction

When the toroid attachment is used with the probe to measure the current in a wire, the calibration factor is nominally 1V/A (with the control box switched to the ‘wire’ mode). There is some variation in this factor depending on the position of the wire in the toroid opening; the calibrated position is with the wire as far away from the sensor tip as possible, as shown in the photograph.

If it is found that the calibration factor is in error by more than a few percent, then it is likely that the ferrite core inside the attachment has been cracked. Typically the reduction is 20%, or even more. If this happens then the whole toroid assembly must be replaced.

Because of mechanical tolerances in grinding the gap in the ferrite toroid, there is a part-to-part variation in the calibration factor required. For this reason toroid assemblies are not simply interchangeable; the adjustment in the control box must be set to suit a particular toroid assembly. This is why they are originally supplied with matching serial numbers.

If facilities are available to perform the calibration procedure described below, then a replacement toroid assembly can be obtained from the manufacturers. If not, then the complete product must be returned to the factory for replacement and recalibration.

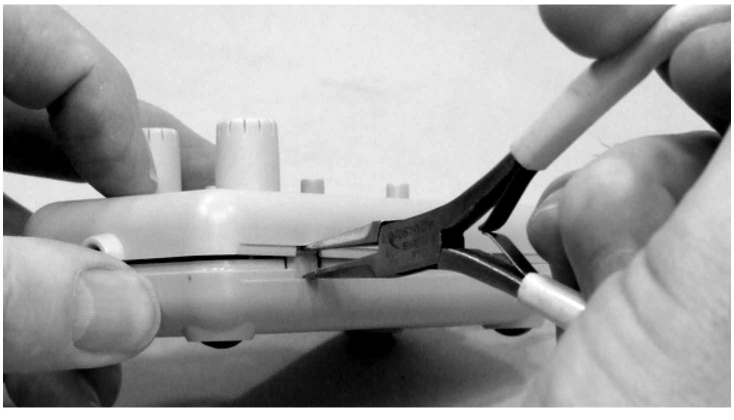
Equipment Required

Calibrated AC current source, to deliver 5A rms at 50 or 60 Hz.
Calibrated AC rms DVM.
Scope (for indication only).
Trimming tool (preferably ceramic) for 2.0 x 0.5 mm slot or 1.5mm cross slot.

Dismantling the Control Box

The PCB in the control box is fixed to the top part of the case. The lower part of the case is held on by four plastic latches. Large slots in the sides of the moulding allow these latches to be pushed apart. Great care is needed to avoid cosmetic damage to the plastic surfaces.

Do not use a twisting action in the slots. Use a pair of pliers with wide flat jaws. Hold the control box in one hand while using the pliers with an opening action to push apart one of the latches. Do not attempt to fully open a latch in the first instance; just open it far enough so that it does not click shut again. Then repeat the action with the other latch on the same side of the box. Revisit all four latches as required until the case lower can be removed.



Toroid Calibration procedure

After removing the control box base, connect the output cable to both the scope and the DVM, and connect the AC adaptor.

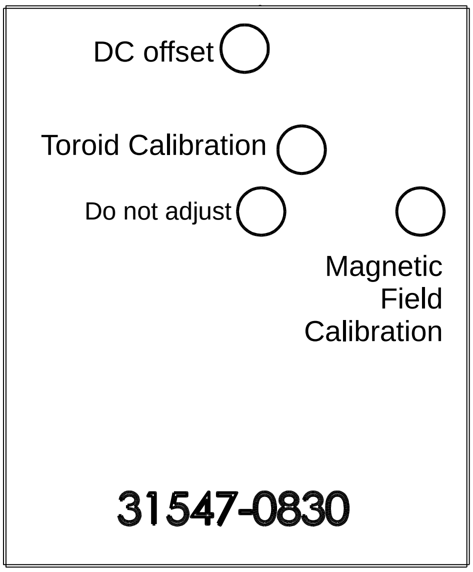
Ensure that the Mode switch is in the wire position.

Pass a standard DVM test lead through the centre of the toroid, and clip the toroid assembly to the probe. Connect the test lead to the current source (initially switched off) and arrange the probe and lead so the lead is as far from the sensor tip as possible within the toroid opening. One simple way to do this is to hang the probe vertically downward from the looped test lead.

Adjust the Trace Position control for zero DC on the scope, and then check, with the scope at high sensitivity, that there is no significant AC magnetic field from objects in the local environment. It is permissible to set the calibrator to a different frequency to the local power mains (e.g. 60Hz in a 50Hz environment, or the reverse) to ensure that any beat frequency does not cause slow variations in the DVM reading.

Switch on the current source at 5·0A rms. Check on the scope that the waveform is a sine wave without any noticeable distortion. The DVM should read 5V rms, within maybe ±10%. If it is significantly different, recheck the setup for errors.

Identify the preset adjustment (inside the screening can) shown on the diagram as Toroid Calibration, and engage the trimming tool carefully (the rotor is quite soft).



Control PCB Adjustments

Adjust carefully until the DVM reads 5·00Vrms ±20mV.

⚠ Do not adjust the preset marked in the diagram as ‘Magnetic Field Calibration’. This adjusts the basic system gain, which will affect all the magnetic field, PCB track and toroid calibrations. There is no way to restore the adjustment without a Helmholtz coil.

Set the current source to 7Arms and check that the DVM reads 6·86 to 7·14Vrms (±2%).

Set the current source to 2Arms and check that the DVM reads 1·96 to 2·04Vrms.

These linearity requirements are the ±2% factory test limits. The specification allows ±5%, so some relaxation is permissible. If the unit does not meet satisfactory linearity requirements, it indicates a fault with the sensor or the probe electronics which cannot be repaired in the field.

Reassembly of the Control Box

Disconnect the AC adaptor.

Take care to identify the correct orientation of the two case parts. The hole for the DC input jack is the easiest feature to identify, but the two cable entries also have different diameters. With the unit upside down, lay the case lower onto the upper part and align the latches. The latches should be clipped together in pairs (not one at a time). Squeeze together both latches on one side of the box simultaneously until they clip together, then repeat with the two latches on the other side of the box.

Mark the new toroid assembly with the serial number of the system that has just been calibrated to match it.

Wear Tip Replacement

⚠ It is an essential requirement of safety legislation that an accredited high voltage insulation (hi-pot) test is carried out after the wear tip is replaced. Users who do not have access to this capability must not attempt to replace the wear tip.

Note also that when the case is opened the internal parts of the probe unit are fragile, and that incorrect handling and reassembly might cause damage that cannot be repaired. Proper operation (particularly the sensitivity to currents in PCB tracks) depends upon physical accuracy in reassembling the unit. In case of doubt, it is strongly recommended that the unit should be returned to the factory for repair.

Dismantling the Probe Unit

A T7 size Torx screwdriver is required.

Identify the + and – indicators on the shaft of the probe, and their relation to the two different labels on the body of the probe. Hold the probe with the + side up, and remove the two Torx screws accessible from that side. Then turn the probe over and remove the two screws on that side. Take care not to lose the screws; they are unusual and hard to replace.

Place the probe on a soft surface and hold down both the barrel of the probe nose and the cable strain relief with one hand. Then gently lift the top case half, starting at the strain relief end. Take careful note of the arrangement of the internal components, and in particular the layout of the flanges that hold the nose barrel to the case halves.

Inspection of the sensor

The safety of the unit depends on double insulation between any external dangerous voltage applied to the probe tip and the internal probe electronics, including the connecting cable and the accessible BNC output connection. The first layer of this insulation is the wear tip being replaced. The inner layer of the insulation is the white plastic of the sensor assembly which encapsulates the sensor coil itself. The thickness of this layer is only 0.25mm and it is essential that it is not damaged in any way.

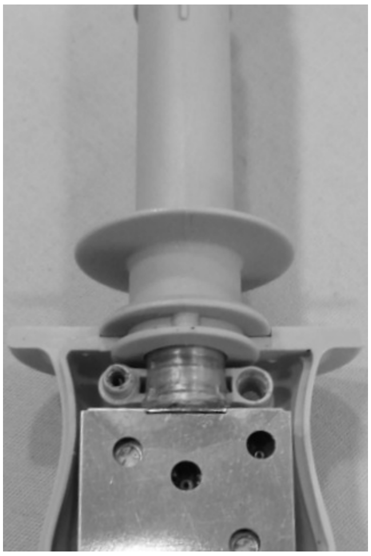
Use a magnifying glass to inspect the tip of the sensor. Move the tip relative to the light source and watch for any reflection. If the tip is flattened at all, or if there is any indication of abrasion, then the sensor is no longer safe and the whole unit should be reassembled and returned to the factory for repair, with a clear indication that a safety replacement of the sensor is needed. The sensor itself cannot be replaced in the field because special test equipment is needed to adjust the circuit.

Reassembly of the Probe unit

Place the case half with the label showing the I-prober logo flat on a soft surface. Take hold of the PCB and cable assembly and slide the ferrite bead over the stripped part of the cable until it touches the rear of the PCB. Orient the screening can and PCB so that the side with the holes for the preset adjustments is uppermost. Lay the can into the case half so that the rear of the PCB is in front of the two thrust ramps moulded into the case. Take great care not to break these – they are fragile. Some units may have a small piece of silicone rubber insulation that fits behind the ferrite bead in the cable clamp section of the moulding. Lay the groove of the strain relief grommet over the back of the case and lower the whole assembly into the case.

Take the new barrel and wear tip assembly with the – sign uppermost and slide it gently over the probe tip. Hold down the strain relief and lift the front of the PCB slightly to allow the flange of the barrel to pass over the case front, while rotating the barrel gently from side to side to feel the probe tip seat inside the wear tip. It is important that the outside of the sensor should touch the inside of the wear tip as any gap here destroys the proper spacing between the sensor and the PCB track being probed. However excessive pressure must be avoided as it is possible to split the end off the wear tip.

Observe that where the barrel sits in the case half there is an anti-rotation pip on the top and bottom of the barrel which sits in a corresponding groove in the case. Lower the barrel into the case, again rocking it rotationally slightly to ensure that these features mate neatly. The photograph shows the arrangement.



It should not be necessary to use force at any point in this procedure; if the components do not appear to fit together properly then investigate the reason and reread these instructions.

Finally place the other case half on top of the assembly, starting with the barrel end. A gently rotation of the cable strain relief will help it to seat, then a last gentle rotation of the barrel as the two case halves come together.

Hold the two case halves together firmly and visually check that the flanges on the case halves have interleaved correctly and that the gap is nearly closed. Then reinsert the two Torx screws visible from this side. When tightening the screws it is desirable to use the existing thread in the plastic rather than cutting a new one. The easiest way to do this is to set the screw at the entry to hole and then turn it anticlockwise until it jumps down into the start of the thread. It can then be tightened, which should only require fingertip torque. Repeat with the two screws on the other side.

Functional test

Attach the AC adaptor and switch on. Place the probe tip in the calibrator recess on the control box with the + sign towards the front. Set the scope to 500mV/div. Switch the calibrator switch to the DC (outermost) position. The scope trace should show a positive output (if not, the unit has been assembled with the barrel upside down).

Switch the calibrator to the AC position and observe the square wave on the scope. Set the mode switch to the PCB track position and turn the PCB Sensitivity control to maximum. Set the scope to 1V/div. The waveform should be at least 3·8V peak to peak between the steady states (ignore any small overshoot on the transitions).

Safety test

Disconnect the AC adaptor.

⚠ This test must be performed by an operator trained in the use of the equipment required and knowledgeable of the dangers of the high voltages used.

The safety test must measure the leakage between the outer surface of the whole of the probe tip and the BNC output connector.

Use thin aluminium foil to surround the probe from the tip back past the joint between the black tip and the grey barrel. Form the foil carefully to make close contact with the outside of the tip. Any air gap here will invalidate the test.

⚠ Do not use conductive liquids or gels to make contact with the tip. They will leave a conductive residue on the surface which cannot reliably be completely removed.

Join the inner and outer of the BNC connector together.

Connect the foil to the high voltage terminal of the tester and the BNC to the low voltage (current sensing) terminal of the tester. Arrange the unit on an insulating bench, so that it does not need to be manually held during the test.

Set the tester to 2.2kVrms AC (50 or 60 Hz) and the current trip at 1mA. The voltage should ramp up over 5 seconds and then be held for 5 seconds. Ensuring the safety of the operator, apply the test voltage for at least 5 seconds and check that the leakage current to the BNC socket is less than 100µA. Note that because of capacitance to the environment the current drawn from the high voltage terminal will be higher.

Before performing a calibration, carefully inspect the insulation of the probe tip for any wear or damage. If there is any doubt, replace the wear tip (as described above) first.

The probe fundamentally measures magnetic field, so full calibration (or even calibration check) requires access to a known, calibrated magnetic field. This field must be uniform over a sufficient volume in space to ensure that reasonably small errors in the positioning of the sensor do not impair the results. This is provided by a device known as a Helmholtz coil, which is an arrangement of two coils spaced by a distance exactly related to their diameter.

Equipment Required

Helmholtz coil e.g. Lake Shore MH-2.5, with known mT/Amp calibration constant.
Calibrated constant current calibrator producing 50 or 60 Hz sinewave at about 500mA.
Calibrated AC voltage DVM.
Scope (for indication only).

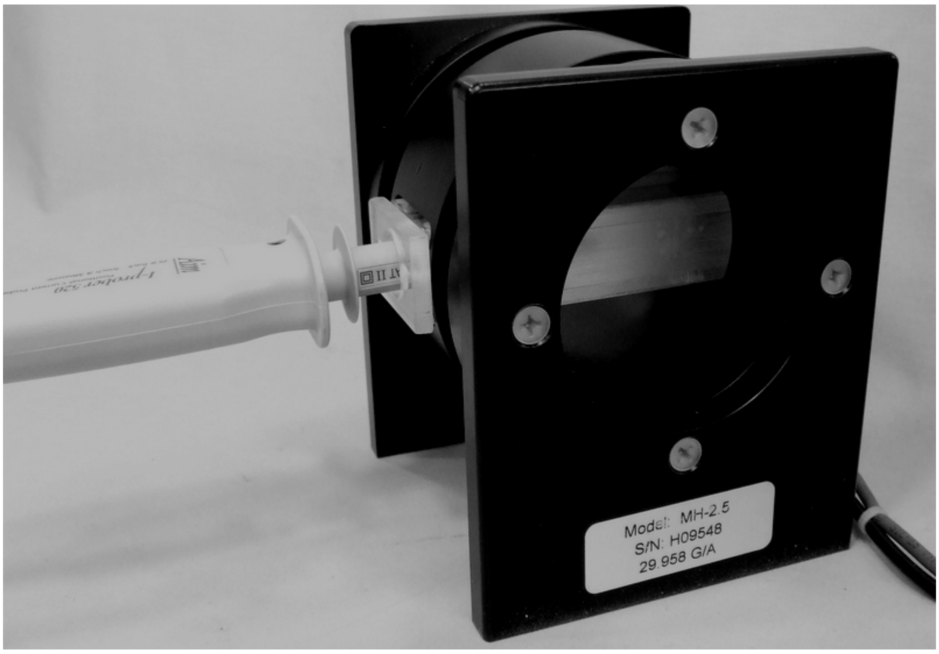
Establishing the magnetic field

The probe is calibrated at a field of 1·25mT (which is the same as 12·5 Gauss). The current through the Helmholtz coil must be set to produce this value. The calibration constant relating field to current is provided by the manufacturer of the coil; it is nominally 3·0 mT/Amp (30 Gauss/Amp) for the recommended coil (the one in the photograph is 29·958 Gauss/Amp), which therefore requires 417mA. The current must be provided by a calibration grade constant current source, so variations in the resistance of the coil do not affect the results.

The windings of the Helmholtz coil have significant inductance, which may affect the stability of the current source. Series or parallel damping resistance may be needed, or possibly a parallel capacitance. If any network is used in parallel with the coil, then the current setting on the source will need to be adjusted to account for the current passing through this network so that the current passing through the Helmholtz coil itself meets the required value.

Mounting the probe

The probe must be mounted to that its sensor is positioned in the centre of the Helmoltz coil (within the region of uniform field), aligned with the field and held reasonably rigidly. In the factory a jig is used, but for occasional field use a temporary construction of cardboard and bubble wrap or expanded polystyrene can be used. The photograph gives an indication of the orientation and position required. All material must be non-magnetic.



Initial Checks

Connect the output of the control box to both the DVM and a scope, attach the AC adaptor and switch on. Set the controls to:

Calibrator:	Off.
Bandwidth :	Full.
Mode:	Field.

With the scope AC coupled and at high sensitivity, search for any 50 or 60Hz magnetic fields in the environment. Rotate and move the Helmholtz coil with the probe inside it to the position of minimum interference. It will probably be necessary for the sensor to be at least 500mm away from any equipment containing a laminated core mains transformer. If there is a noticeable field at the local mains frequency, it can be helpful to set the calibrator to the alternative frequency.

Set the scope to DC coupling and adjust the Trace Position control for zero DC out.

Field Calibration

Switch on the AC current from the calibrator to the current source and check on the scope for an undistorted sinewave. Check that there is no sign of high frequency oscillation.

Identify the adjustment marked Magnetic Field Calibration in the diagram on page 7 and adjust it for a reading of 5·00Vrms ±10mV on the DVM.

Switch off the current and remove the probe from the Helmholtz coil.

Toroid calibration

Check that the serial number marked on the toroid matches that on the underside of the control box. Perform the toroid calibration as directed in the procedure on page 7 above.

PCB Calibration

There is no exact calibration for measurements on PCB tracks, but perform the functional check described on page 9 above to ensure that the system is working normally.

DC Offset

This setting is optional. The intention is that when the Trace Position control is at its physical centre, with the indicator line on the knob pointing to the front of the control box, then the probe should give zero volts DC out when oriented to a position of zero net magnetic field (i.e. East – West in an open environment).

Obtain a mumetal screening can of at least 25mm in each dimension. The type used with microphone transformers in professional audio equipment is suitable. Place the probe tip deep into the can, and experiment with moving the probe and can around in the Earth’s magnetic field. If the screening can is sufficient, there should be no noticeable variation of DC output voltage with either position or orientation. Adjust the Trace Position control for 0V DC on the scope. Look at the position of this control – it should be at the physical centre of rotation with the indicator mark pointing to the front of the box. If it is noticeably different, then set the control to that centre position and adjust the internal preset marked DC offset to bring the trace to 0V.

Parts List

Part Number	Description		Position
Standard Items			
51151-0820	AC ADAPTOR UNIV 5.2V/1A DC		(WITH CONNECTORS)
38637-0430	CARRY CASE – I-prober 520		
48582-0010	Instruction Book	I-prober 520	
48582-0011	Calibration Graph	I-prober 520	
Service Items			
48582-0030	Service Guide	I-prober 520	(This document)
58250-2100	TOROID ASSEMBLY UN-CAL I-PROBER		
58250-2110	WEAR TIP SERVICE KIT I-PROBER		
20065-0172	SCREW M2.5x10 PNHD TORX BLACK		For probe case halves
33536-4610	CASE UPPER – BASEBOX		
33536-4620	CASE LOWER – BASEBOX		
37113-2120	CAP – SLIDE SWITCH GREY3		
37151-0493	KNOB 12.5mm D-SHAFT GREY3		
20662-0550	FOOT – RUBBER		
43171-0021	CABLE & CONN ASSY BASEBOX-SCOPE		
20653-0270	CABLE TIE 71 x 1.7mm		Output cable to PCB
20065-0020	SCREW M2.2x8 PLAS PNHD		Control box PCB to cover.

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