

Operation Manual for HC1 Helmholtz Coils



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1. *About this Manual*

This manual provides the information necessary to help customers install and operate the HC1 Helmholtz Coil from Bartington Instruments. The HC1 Helmholtz Coil is available in one, two, or three axis versions, with different axes fitted:

- HC1-1X, HC1-1Y, and HC1-1Z Single Axis versions
- HC1-2XY, HC1-2YZ, and HC1-2XZ Two-Axis versions
- HC1-3 Three-Axis version

The HC1 Helmholtz Coil is one component of Bartington Instruments' Helmholtz Coil System. This manual should therefore be read in conjunction with:

- PA1 Control Power Amplifier Manual OM3225
- CU1 Control Unit OM3224
- CU2 Closed-Loop Module (if applicable) OM3999
- Helmholtz Coil Control Software OM3596.

All manuals are available from the Helmholtz Coil System [Operation Manual page](#). The relevant products outline drawings can be found Helmholtz Coil System [outline drawing page](#).

This manual should also be read in conjunction with the product brochure [DS2613](#) which can also be found on the product page.

Photographs of key components are included, labelled with numbers. A number in the text in square brackets [] refers to that label.

Bartington Instruments cannot advise on the integration of this equipment with any third party products.

1.1. *Symbols Glossary*

The following symbols used within this manual call your attention to specific types of information:



WARNING: Indicates a situation in which serious bodily injury or death could result if the warning is ignored.



Caution: Indicates a situation in which bodily injury or damage to your instrument, or both, could result if the caution is ignored.



Identifies items that must be disposed of safely to prevent unnecessary damage to the environment.

Note: Provides useful supporting information on how to make better use of your purchase.

2. Safe Use



WARNING: This product is not qualified for use in explosive atmospheres or life support systems. Consult Bartington Instruments for advice.



WARNING: The electromagnetic field from this product may interfere with the operation of pacemakers and other medical devices. Consult your device's manufacturer before operation.



WARNING: In the UK/EU there is legislation that recommends regulation magnetic field exposure amounts. For this reason safe operation should be observed when using the HC1 by referring to the field/distance graphs in [Appendix B](#).



WARNING: Personal injury may result from lifting the HC1 Helmholtz Coil. Use more than one person to move this device.

3. Introduction

The HC1 Helmholtz Coil is an assembly of up to three pairs of Helmholtz coils and includes the base on which the coils are mounted. The coils produce a magnetic field when a current is circulated through it. The amplitude of the field generated is proportional to the current applied. Both DC and AC magnetic field can be generated. The coils are typically used for the calibration of magnetic field sensors, or to generate a stable, controlled field.

A complete system will include:

- HC1: an assembly of up to three Helmholtz coils.
- PA1 Power Amplifier: See OM3225.
- CU1 Control Unit: the control unit for the system which enables it to interface with a PC-based test, measurement and control system. See OM3224.
- Optional CU2 Closed-Loop Module: allows active cancellation of external DC and AC magnetic field disturbances using the CU2 Reference Magnetometer. See OM3999.

The addition of the acquisition card allows the system to be controlled via a Labview™-based software. A system diagram is shown in [Appendix A](#).

Recommended Accessories:

- Magnetometer and associated mounting jig, which can be supplied in order to check the system at regular intervals.
- Breakout box, enabling access to the signal applied to the coils (Please see [“Appendix C - Helmholtz Coil Breakout Box”](#) for further information). Please contact sales@bartington.com for further information.

As an alternative to the PA1, users with their own power supply can use these with the HC1. Please refer to the product brochure for the maximum current which can be applied to HC1.

4. HC1 Helmholtz Coil Features

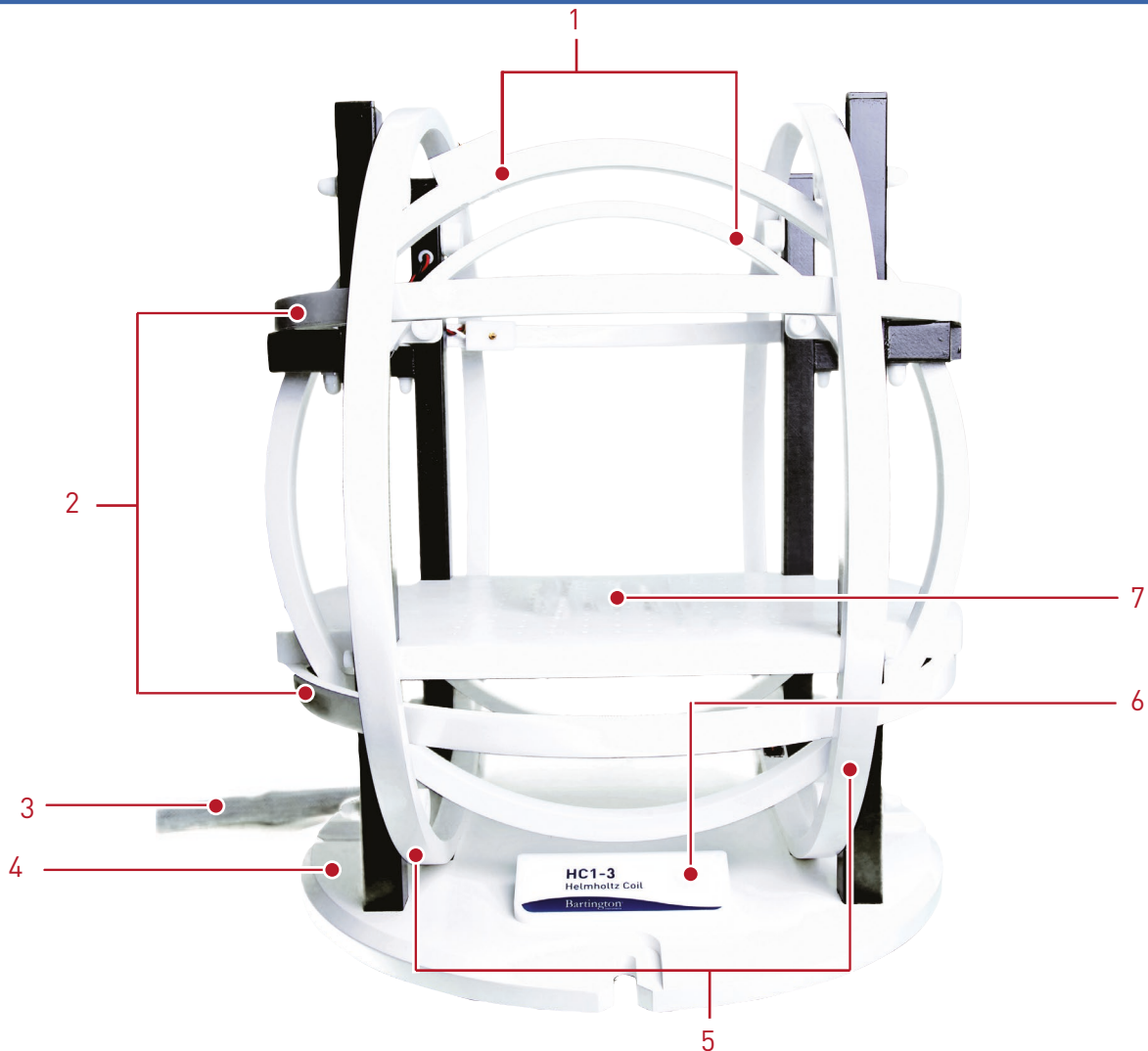


Figure 1. HC1 Three-axis Helmholtz Coils

Key

- | | |
|----------------|-----------------------------------|
| 1. X coil pair | 5. Z coil pair |
| 2. Y coil pair | 6. HC1 label |
| 3. HC1 Cable | 7. Test table with mounting holes |
| 4. Base | |

Note: The test table has threaded holes for the securing of test fixtures.

Note: Figure shows the three axis version of the HC1 Helmholtz coils. Other versions will have a similar appearance, but with fewer axes present.

5. *Compatibility*

The HC1 is compatible for use with Bartington Instruments PA1 Power Amplifier. For a complete system the CU1 Control Unit is also required, and optionally the CU2 Closed-Loop Module. The single axis version of HC1 will require a PA1-1, whilst the two axis version will require the PA1-2.

Mounting accessories for Mag-03MS, Mag-13MS, Mag690, Mag648/649 and Mag678/679 are available as an additional option.

6. *HC1 Helmholtz Coil Operation*

6.1. *Installation*

The HC1 Helmholtz Coil should be installed in a magnetically clean area, that is, an area with small magnetic gradient, and with little magnetic disturbances.

The HC1 should be installed on a non-metallic base and kept away from:

- Large conductive objects which may induce currents, and therefore secondary magnetic fields, when generating AC magnetic fields.
- Sources of magnetic field, either DC (e.g. large objects made of magnetic materials) or AC (e.g. mains powered equipment) as these will distort the magnetic field around them, and may affect the shape and extent of the homogeneous area.

The PA1 includes 3 DC offset controls which are used to compensate for the local DC magnetic field. These will not be able to compensate for large objects which may create a strong localised gradient.

Note: The HC1 should be kept a minimum of 3 metres from any potential magnetic interference.

Ideally a magnetic field survey should be carried out to assess the suitability of the site. This can be carried out using a Mag-03 Three-axis fluxgate magnetometer connected to a Spectramag-6 Data Acquisition Unit. Please contact support@bartington.com for further assistance.

Note: The largest coil of the Helmholtz Coil should be positioned so that the field it generates is in the direction of the lowest ambient field strength. This will reduce the level of DC offset applied, and optimise the maximum field which can be generated in that direction.

Note: Do not place the HC2 on the floor, as there may be unknown elements in or below it that will affect its operation.

6.2. *Connecting the HC1*

The HC1 is a passive coil with no controls of its own. When connected to the PA1 (or any other power supply) and current is circulated through the coils, a magnetic field is induced.

The HC1 connects to the PA1 via the cable attached to the coils [6]. This 5m length cable allows the positioning of the PA1 away from the coils to prevent any interferences. It should be placed in such a way as to not present a trip hazard. The cable is terminated with an 8-way plug that should be connected to the Coil Drive Output Socket on the back of the PA1 Power Amplifier (see OM3225, Connecting the Helmholtz Coil System).

Note: A diagram showing the interconnection of components of the Helmholtz Coil System is given in [“Appendix A: Connecting the Components of the Helmholtz Coil System”](#).

Note: The PA1 Power Amplifier is available in a number of configuration with changing numbers of channels (1, 2 or 3). If the HC1 has a greater number of axes than the PA1 then only the number of axes corresponding to the PA1 can be used.

6.3. *System Checks*

Once the HC1 is connected, no mechanical adjustments are needed. Helmholtz Coil System setup, including DC offset adjustments, are done via the PA1 Power Amplifier, using a reference magnetometer (suited to the range in which the user is working and calibrated by or traceable to a recognised international standards institution) mounted in the homogeneous area of the coil. If using the CU1 and a Bartington Instruments magnetometer, the reference sensor can be directly connected to the CU1.

For further details, please refer to PA1 Power Amplifier operation manual OM3225.

7. *Absolute Maximum Power*

When using the PA1, or an alternate power supply, the maximum current that may be applied to the HC1 Helmholtz Coil (shown in the product brochure), should not be exceeded.

8. *Mounting Accessories*

A range of mounting accessories are available to mount some of Bartington Instruments sensors in the middle of the homogeneous area. The Mag-13MS and associated mounting plate is recommended to be used as a reference sensor for periodic checks of the HC1.

Mounting points on the test table are shown in [Figure 1](#) and DR3205.

9. Troubleshooting, Care and Maintenance

In the event of any apparent malfunction, please email: service@bartington.com or telephone the Bartington Instruments service team on: +44 (0)1993 706565.

10. Storage and Transport



WARNING: Do not lift by the coils as this may cause mechanical damage to the assembly. Lift only by the base or by using the pillars.

The HC1 Assembly is a precision electronic instrument and should be treated as such.

Bartington Instruments has supplied this product in appropriate packaging for transportation. It is recommended that this packaging is used for any future transport.

Refer to the product brochure for this product's maximum environmental, electrical and mechanical ratings.



Caution: Exceeding the maximum environmental ratings may cause irreparable damage to the equipment.

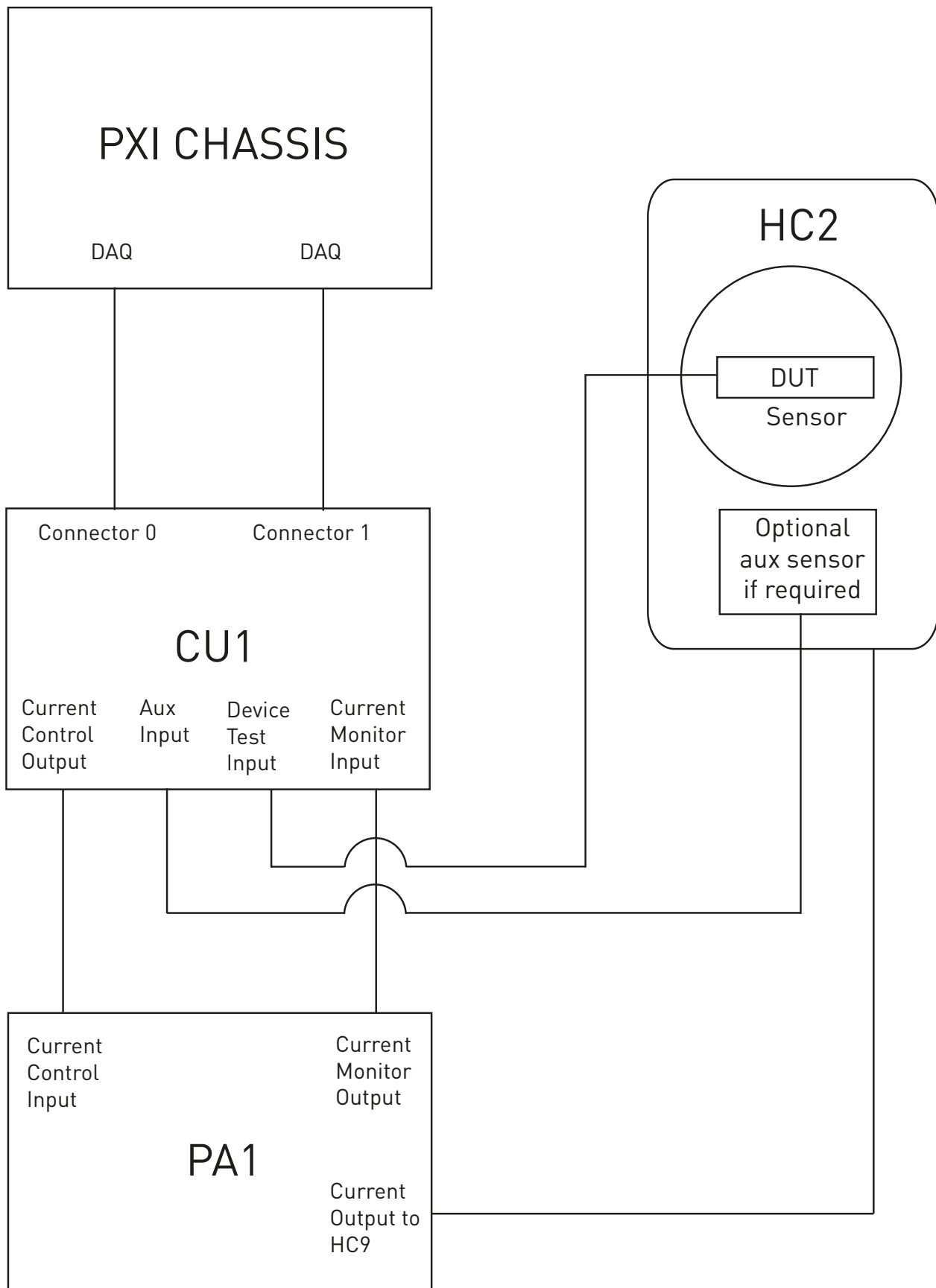
11. Disposal

This product should not be disposed of in domestic or municipal waste. For information about disposing of this product safely, check local regulations for disposal of electrical / electronic products.

11.1. Waste Electrical and Electronic Equipment (WEEE) Regulations



This product complies fully with Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment (RoHS) and WEEE Regulations current at the time of printing.

Appendix A: Connecting the Components of the Helmholtz Coil System

Appendix B - Magnetic field B magnitude with Distance from the HC1

Single channel: The current of PA1 is limited by series resistance.

$I_{DCmax}=20A$, the maximum magnetic field in the centre of the coils is respectively 592uT for the large coil, 644uT for the Medium coil and 715uT for the small coil.

The curve of magnetic field (DC) along each axis versus distance from centre of the coils is shown in [“Figure 2. B versus Distance from the centre for DC current”](#).

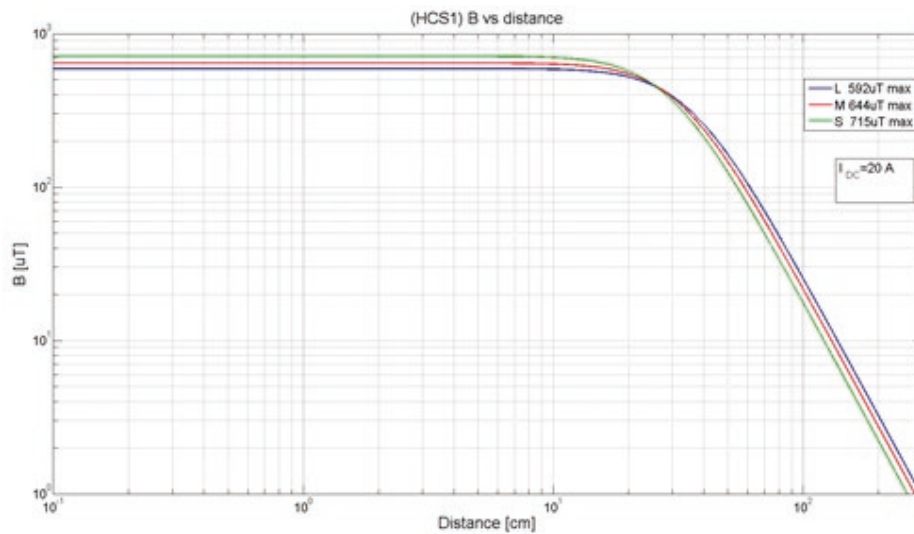


Figure 2. B versus Distance from the centre for DC current

At 3kHz, the maximum current of each coil is limited by series R and L. At 3kHz, $I_{max}=7.7A$, the maximum magnetic field in centre of the coils is respectively 228uT for the large coil, 248uT for the Medium coil, and 275uT for the small coil.

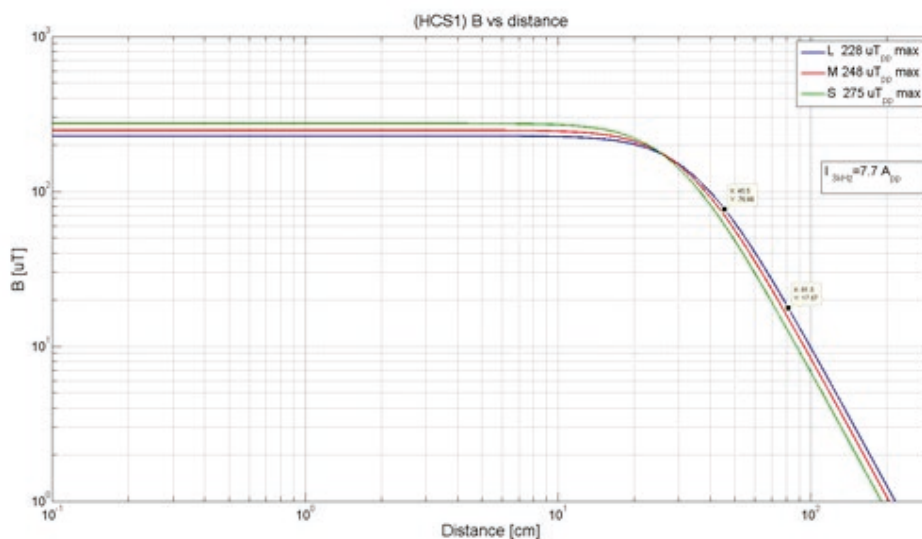


Figure 3. B versus Distance from the centre at 3kHz.

From [“Figure 3. B versus Distance from the centre at 3kHz.”](#), it can be seen that at a distance of 45.5 cm from the centre, the field is 27 μ Trms . At 81.5 cm from the centre, the field is 6.2 μ Trms .

At 5kHz, the maximum current of each coil is limited by series R and L. At 5kHz, $I_{max}=5A$, the maximum magnetic field in the centre of the coils is respectively 148 μ T for the large coil, 161 μ T for the Medium coil, and 179 μ T for the small coil.

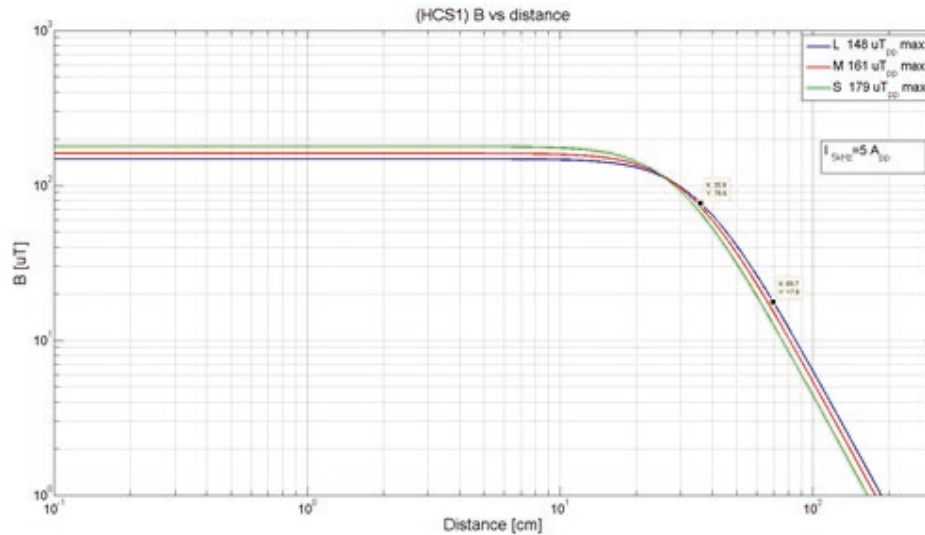


Figure 4. B versus Distance from the centre at 5kHz.

From [“Figure 4. B versus Distance from the centre at 5kHz.”](#), at a distance of 35.9 cm from centre, the field is 27 μ Trms . At 69.7 cm from the centre, the field is 6.2 μ Trms.

When the HCS1 is used in the 2 coil configuration, the maximum current in each coil is limited by series resistance, which will be 18.71A DC max per coil, 7.7App at 3kHz per coil ,or 5App at 5kHz per coil.

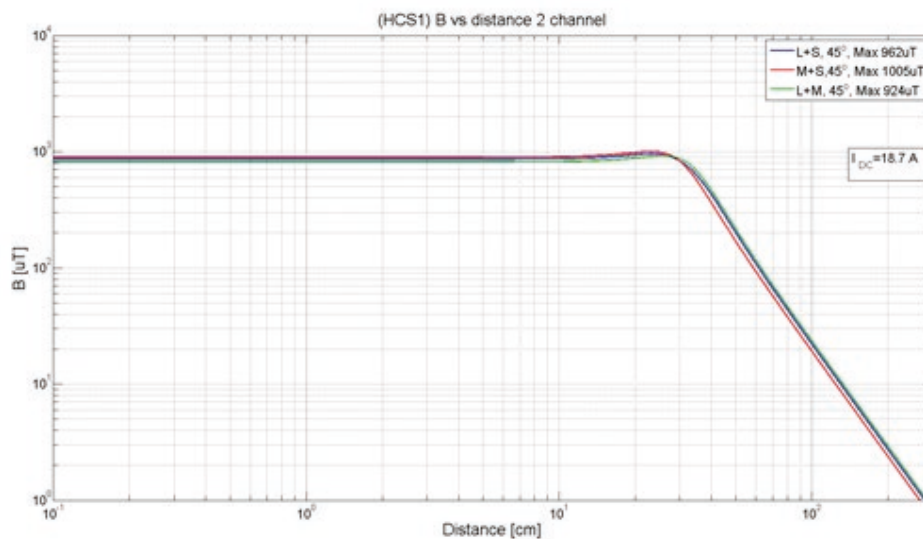


Figure 5. B versus distance from the centre of the coils at 45° between 2 axes at DC.

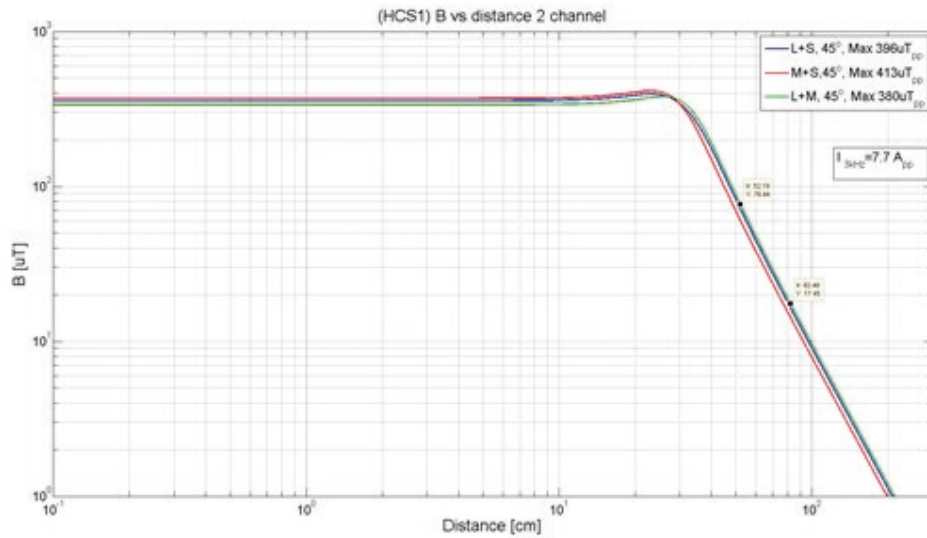


Figure 6. B versus distance from the centre of the coils at 45° between 2 axes at 3kHz.

From [“Figure 6. B versus distance from the centre of the coils at 45° between 2 axes at 3kHz.”](#),

at a distance of 52.2 cm from centre, the field is 27uTrms. At 82.5 cm from the centre, the field is 6.2 uTrms

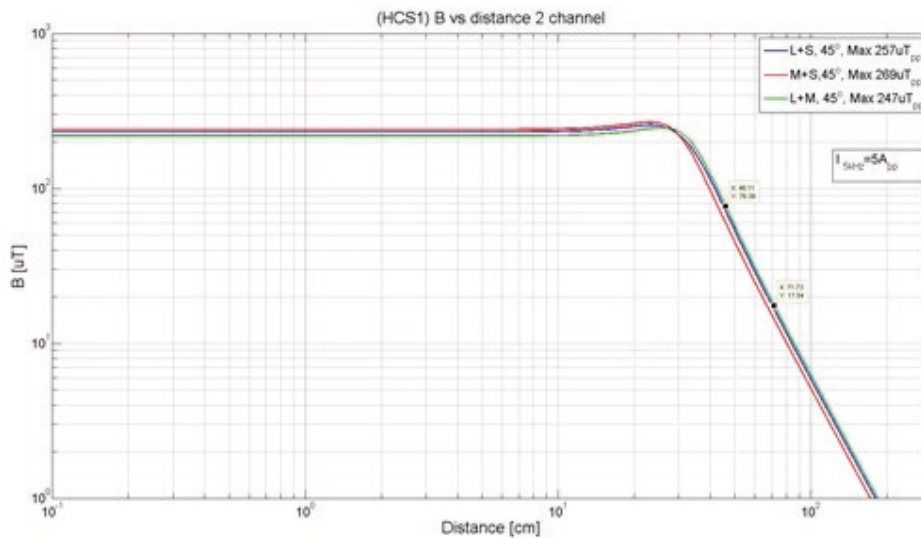


Figure 7. B versus distance from the centre of the coils at 45° between 2 axes at 5kHz.

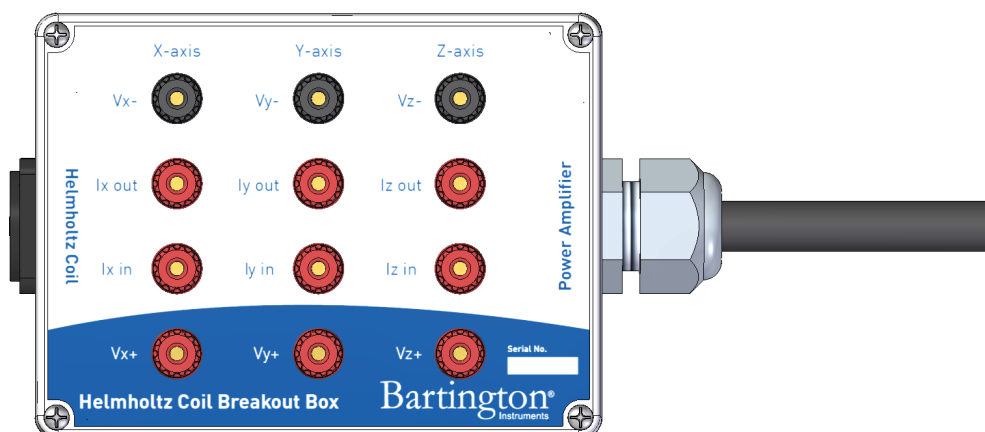
From [“Figure 7. B versus distance from the centre of the coils at 45° between 2 axes at 5kHz.”](#),

at a distance of 46.2 cm from centre, the field is 27uTrms. At 71.8 cm from the centre, the field is 6.2 uTrms

Appendix C - Helmholtz Coil Breakout Box

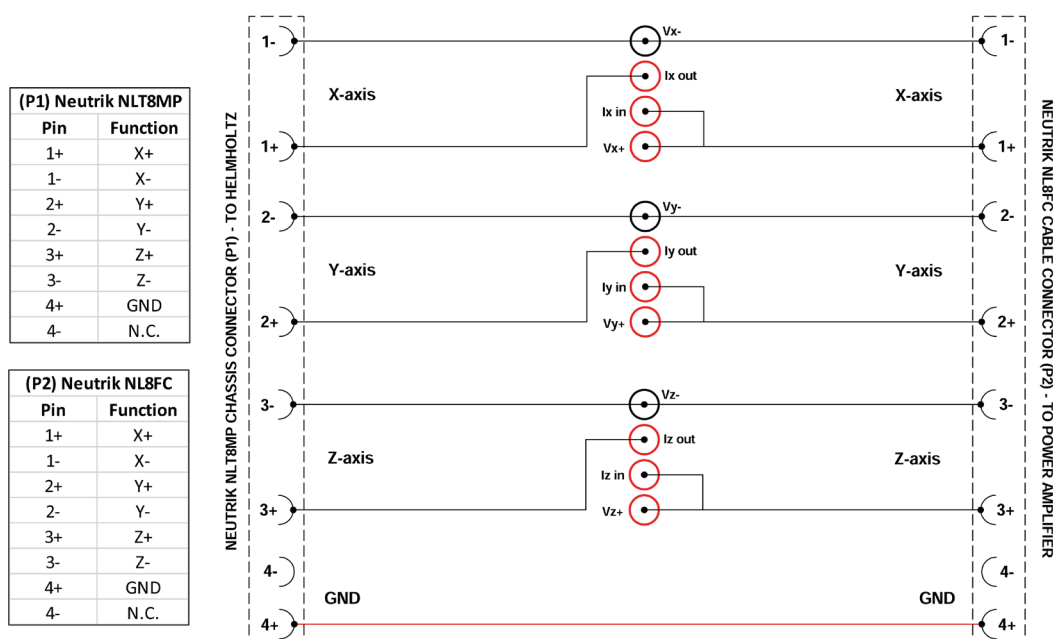
The Helmholtz Coil Breakout Box can be purchased separately for use between the HC1 Helmholtz Coil and the PA1 Power Amplifier. It is used to monitor the current and voltage from each axis. This can be done separately or in conjunction with the other axes.

The box consists of 12 terminals; positive and negative voltage terminals, and current in and out terminals, for each axis. Connections can be made using 4mm banana plugs.



The voltage can be measured across the **Vx+** and **Vx-** terminals on each axis. During normal operation the **I in** and **I out** terminals will be connected together by a short wire link. To measure the current, the appropriate link should be removed and replaced with an ammeter.

The connection diagram for the breakout box can be found below. See also the outline drawing on the [Bartington Instruments website](#).



Caution: Do not interconnect the negative return signals.

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