Operation Manual for
HCS1 Three-Axis Helmholtz Coil System
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1. Legal Notices

1.1. Copyright

The copyright of this document is the property of Bartington Instruments Ltd.

1.2. Trademarks

Bartington® is a trademark in Australia, Canada, China, the European Community, India, Japan, the countries of the Madrid Agreement & Protocol, Norway and the United States of America.

2. How to Use this Manual

This manual provides the information necessary to help customers install and integrate the HCS1 Three-Axis Helmholtz Coil System from Bartington Instruments into their own systems.

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

2.1. 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.
3. Safe Use

**WARNING:** The HCS1 system is powered by mains electricity and contains uninsulated parts. Ensure that the unit is properly earthed at all times. Do not open the casing or have contact with any internal parts except where following a procedure precisely as described in this manual. Only properly trained personnel should carry out procedures in this manual which require the casing of the PA1 power amplifier to be opened.

**WARNING:** These products are not qualified for use in explosive atmospheres or life support systems. Consult Bartington Instruments for advice.

4. Introduction

The HCS1 produces a controllable magnetic field up to 500µT vectored in any orientation, enabling the cancellation of a static (usually geomagnetic) field.

The system consists of:

- **HC1:** an assembly of three pairs of Helmholtz coils. Included in this are the base on which the coils are mounted, and a mounting table to hold the test item inside the homogeneity volume.

- **PA1:** the power amplifier for the system. See Section 6.1 for power requirements.

No magnetometer is supplied as part of this product, but these can be ordered separately from Bartington Instruments.

A signal generator must be used to drive the coils. Bartington Instruments can supply the CU1 control unit for this purpose, or customers can select a signal generator of their own.
4.1. HC1 Helmholtz Coil Assembly

Key

1. X coil pair
2. Y coil pair
3. Z coil pair
4. Reference magnetometer (not supplied)
5. Base
6. Location of HC1 product label, on base of unit
7. Mounting table
4.2 PA1 Power Amplifier

4.2.1. PA1 front view

Key

1. Upper front panel
2. Current control input (takes input from signal generator)
3. Current monitor output
4. Static field offset controls
5. Fastening screws
6. Rocker switch
7. Lower front panel
8. Centre front panel (grille)
4.2.2. PA1 rear view

Key

1. Blank ventilation panel
2. Fastening screws
3. Coil drive output to HC1
4. Lower rear panel
5. Fuse holder
6. Mains power input socket
5. HC1 Helmholtz Coil Assembly Installation

The HC1 assembly should be installed on a non-metallic base or table away from any conductive or magnetic material or metals, or sources of magnetic fields, which will affect the calibration. To connect to the PA1 amplifier, the assembly is fitted with a 5m cable with an 8-pole Speakon plug.

The HC1 assembly has no controls of its own. It activates automatically when the amplifier is switched on.

5.1. HC1 Power

A red LED will appear behind the HC1 label at the base of the assembly [1] to indicate that power is reaching the coils.

No physical adjustment is needed to the coils once the assembly is active.

6. PA1 Power Amplifier Installation

Before the amplifier power is turned on, the PA1 and the HC1 must be connected by plugging the cable attached to the HC1 (supplied) into the coil drive output socket on the rear of the PA1 [1].

Caution: The coil drive output socket is reserved for the cable connecting the HC1 and the PA1. No other connection should be made to this socket.
**Note:** The amplifier and any other control or measuring equipment must be at least 3m away from the coil assembly.

Once the HC1 assembly is installed, the static field compensation will need to be adjusted (see Section 6.3) and the calibration checked (see Section 7).

### 6.1. PA1 Power

The PA1 drive amplifier requires a power supply of 110 to 240V @ 1500W max, and must be earthed/grounded. The supply from a standard wall outlet should be suitable in most countries. A compatible mains cable supplied with a UK 13A connector, an EU (Schuko) connector or bare ends can be specified at the time of ordering.

A 10A time delay fuse is situated on the rear panel [1] which is suitable for a supply of 200 to 240V. Contact Bartington Instruments for advice if a lower voltage is to be used.

⚠️ **Caution:** The time delay fuse must always be replaced by the same type.

To connect the HC1 and the PA1, an IEC C20 inlet is fitted on the rear of the amplifier. The appropriate mating cable is supplied as part of the HC1 assembly.

#### 6.1.1. Coil field determination

The output current of the HC1 assembly is determined by the input voltage. The amplifier output is connected to the assembly with a resistor connected in series on the ground side. To achieve a greater accuracy in determining the coil field, the voltage across the load resistor may be scaled to provide a coil current monitor output. This allows the actual coil current to be measured and the coil field to be determined.
6.2 Cooling

The amplifier is fan-cooled so needs an unimpeded airflow from front to rear. A self-resetting thermal shut-down mechanism will prevent damage through overheating.

Caution: The air filter in the front panel [1] should be inspected regularly, and cleaned or replaced when necessary. See Section 8.

6.3. Static field compensation

The static field is offset by introducing a DC offset into the amplifier input. Lockable controls for static field offset [1] are available on the amplifier upper front panel to set this compensation.

The static field compensation should be set individually for each axis to obtain a minimum field in the centre of the coil. This should be measured by a magnetometer placed in the coil centre. Bartington Instruments can provide a suitable magnetometer.
6.3.1. Method

The controls are locked by the outer hexagonal lock [2] which should be loosened with a spanner. The compensation is adjusted by turning the central shaft [3] with a screwdriver, to obtain a minimum field measured by. A static field of below 100nT should be easily attained. The control should then be locked by tightening down the outer hexagonal lock whilst holding the centre shaft with the screwdriver. Once complete, recheck the offset of each axis.

Note: The compensation current will appear as part of the field current measured by the field monitor. This adjustment should be checked regularly and will certainly need setting on installation, or should the coil or metalwork in the vicinity of the coil be moved, or should other sources of magnetic fields be introduced into the surroundings.

6.4. Connecting the PA1 and the signal generator

The socket that enables the PA1 to be connected to the signal generator is the current control input [1]. The current monitor output [2], located on the upper front panel of the PA1, should be connected to your data acquisition device.

In order to achieve a good noise and hum rejection, the input and current monitor output are differential/balanced signals. Single ended/unbalanced sources may be used by connecting the input negative signals to the source ground. The output may be connected to a single-ended input by using the positive signal and leaving the negative output disconnected; however the output signal will be reduced to half the specified value.

WARNING: Do not connect either positive or negative outputs to ground.
### 6.4.1. Current control input connector pin-out

**HIROSE RM15TRD10S**

Fixed Socket

<table>
<thead>
<tr>
<th>Pin</th>
<th>Function Balanced Input</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>X axis Positive Signal</td>
</tr>
<tr>
<td>2</td>
<td>Y axis Positive Signal</td>
</tr>
<tr>
<td>3</td>
<td>Z axis Positive Signal</td>
</tr>
<tr>
<td>4</td>
<td>Ground</td>
</tr>
<tr>
<td>5</td>
<td>Not used*</td>
</tr>
<tr>
<td>6</td>
<td>Not used*</td>
</tr>
<tr>
<td>7</td>
<td>Not used*</td>
</tr>
<tr>
<td>8</td>
<td>X axis Negative Signal</td>
</tr>
<tr>
<td>9</td>
<td>Y axis Negative Signal</td>
</tr>
<tr>
<td>10</td>
<td>Z axis Negative Signal</td>
</tr>
</tbody>
</table>

**Note:** * Pins 5, 6 and 7 are reserved for future expansion of the system. Do not make any connection to these pins.
6.4.2. Current monitor connector pin-out

<table>
<thead>
<tr>
<th>Pin</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>X axis Positive Signal</td>
</tr>
<tr>
<td>2</td>
<td>Y axis Positive Signal</td>
</tr>
<tr>
<td>3</td>
<td>Z axis Positive Signal</td>
</tr>
<tr>
<td>4</td>
<td>Ground</td>
</tr>
<tr>
<td>5</td>
<td>Not used*</td>
</tr>
<tr>
<td>6</td>
<td>Not used*</td>
</tr>
<tr>
<td>7</td>
<td>Not used*</td>
</tr>
<tr>
<td>8</td>
<td>X axis Negative Signal</td>
</tr>
<tr>
<td>9</td>
<td>Y axis Negative Signal</td>
</tr>
<tr>
<td>10</td>
<td>Z axis Negative Signal</td>
</tr>
</tbody>
</table>

Note: * Pins 5, 6 and 7 are reserved for future expansion of the system. Do not make any connection to these pins.
7. Coil Calibration and Alignment Adjustment

The HC1 assembly is calibrated during manufacture but should be checked on installation. Calibration is usually carried out by placing a reference magnetometer (suited to the range in which the user is working and calibrated by a recognised international standards institution) in the coil and setting the input gains and current monitor output gain accordingly (see Section 7.1). Bartington Instruments can provide a suitable magnetometer.

![Image of internal calibration controls]

The internal calibration controls [1] are on a printed circuit board fitted on the inside of the upper front panel of the PA1 amplifier (see Section 4.2). To gain access to the controls, the upper front panel must be carefully removed by unscrewing the four screws, one at each corner.

**WARNING:** Uninsulated live parts are present within this equipment. This procedure must be performed by trained service personnel only.

**WARNING:** Disconnect the power cable from the lower rear panel before removing the upper front panel to expose the amplifier input board.

**WARNING:** Do not reach any further inside the casing of the amplifier once the panel is removed.

**Caution:** Take care not to damage the wiring to the panel. The wiring must remain attached to the amplifier.
The identities and functions of the internal calibration controls are as follows.

<table>
<thead>
<tr>
<th>Image label</th>
<th>Control label</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>[2]</td>
<td>X Trim</td>
<td>X axis gain adjust</td>
</tr>
<tr>
<td>[3]</td>
<td>Y Trim</td>
<td>Y axis gain adjust</td>
</tr>
<tr>
<td>[4]</td>
<td>Z Trim</td>
<td>Z axis gain adjust</td>
</tr>
<tr>
<td>[5]</td>
<td>X&gt;Y</td>
<td>X axis alignment trim in Y axis</td>
</tr>
<tr>
<td>[6]</td>
<td>X&gt;Z</td>
<td>X axis alignment trim in Z axis</td>
</tr>
<tr>
<td>[7]</td>
<td>Y&gt;X</td>
<td>Y axis alignment trim in X axis</td>
</tr>
<tr>
<td>[8]</td>
<td>Y&gt;Z</td>
<td>Y axis alignment trim in Z axis</td>
</tr>
<tr>
<td>[9]</td>
<td>Z&gt;X</td>
<td>Z axis alignment trim in X axis</td>
</tr>
<tr>
<td>[10]</td>
<td>Z&gt;Y</td>
<td>Z axis alignment trim in Y axis</td>
</tr>
<tr>
<td>[11]</td>
<td>X Mon</td>
<td>X axis current monitor gain adjust</td>
</tr>
<tr>
<td>[12]</td>
<td>Y Mon</td>
<td>Y axis current monitor gain adjust</td>
</tr>
<tr>
<td>[13]</td>
<td>Z Mon</td>
<td>Z axis current monitor gain adjust</td>
</tr>
</tbody>
</table>

Place the panel on a suitably supported flat surface in front of the amplifier whilst calibrating.

Adjustments are made with a small screwdriver.

When the panel is safely positioned to make adjustments, reconnect the power supply.
**WARNING:** Ensure that nothing enters the open panel area during the calibration procedure.

When calibration is complete, switch off and disconnect the power before replacing the upper front panel.

**Caution:** Ensure that all the cables, especially the green/yellow earth bonding wire [15], remain connected as the panel is replaced.

### 7.1. Calibration Process

It is recommended that calibration is carried out with an AC signal at 35Hz as this is not affected by any small remaining offset. Use true RMS reading voltmeters which read only the AC component of a signal. The input into the amplifier has a peak value of around 70% of the reference magnetometer maximum, usually 0.5V RMS from a 100µT reference magnetometer or 2.5V RMS for a 500µT magnetometer. The output of the magnetometer may also be monitored on an oscilloscope to ensure that there is no distortion of the waveform.

#### 7.1.1. X Trim, Y Trim & Z Trim

Feed a signal from the signal generator into each axis in turn. Adjust the axis gains until the magnitude of the measured field matches the magnitude expected from the input signal level.

#### 7.1.2. X Mon, Y Mon & Z Mon

Feed a signal from the signal generator into each axis in turn. Adjust the monitor gains until the magnitude of the output matches the magnitude of the measured field.

#### 7.1.3. Alignment trim

In order to compensate for any small alignment inaccuracy in the test magnetometer, two measurements are made, in each axis, with the magnetometer being rotated about the measurement axis by 180 degrees and the average of the two voltages taken. When working with
an AC field, the axis alignment trim control is adjusted until the reading is the same each time the test magnetometer is rotated about the axis being aligned.

**X axis alignment trim in Y axis**

Feed a signal from the signal generator into the X axis. Monitor the Y axis output of the calibration magnetometer. Initially adjust the trim control until a minimum is obtained. Then rotate the test magnetometer through 180° about the Y axis. If a signal is found then adjust the trim control until the same level is observed when the magnetometer is in the normal position and rotated position.

**X axis alignment trim in Z axis**

Feed a signal from the signal generator into the X axis. Monitor the Z axis output of the calibration magnetometer. Initially adjust the trim control until a minimum is obtained. Then rotate the test magnetometer through 180° about the Z axis. If a signal is found then adjust the trim control until the same level is observed when the magnetometer is in the normal position and rotated position.

**Y axis alignment trim in X axis**

Feed a signal from the signal generator into the Y axis. Monitor the X axis output of the calibration magnetometer. Initially adjust the trim control until a minimum is obtained. Then rotate the test magnetometer through 180° about the X axis. If a signal is found then adjust the trim control until the same level is observed when the magnetometer is in the normal position and rotated position.

**Y axis alignment trim in Z axis**

Feed a signal from the signal generator into the X axis. Monitor the Z axis output of the calibration magnetometer. Initially adjust the trim control until a minimum is obtained. Then rotate the test magnetometer through 180° about the Z axis. If a signal is found then adjust the trim control until the same level is observed when the magnetometer is in the normal position and rotated position.

**Z axis alignment trim in X axis**

Feed a signal from the signal generator into the Z axis. Monitor the X axis output of the calibration magnetometer. Initially adjust the trim control until a minimum is obtained. Then rotate the test magnetometer through 180° about the X axis. If a signal is found then adjust the trim control until the same level is observed when the magnetometer is in the normal position and rotated position.

**Z axis alignment trim in Y axis**

Feed a signal from the signal generator into the Z axis. Monitor the Y axis output of the calibration magnetometer. Initially adjust the trim control until a minimum is obtained. Then
rotate the test magnetometer through 180° about the Y axis. If a signal is found then adjust the trim control until the same level is observed when the magnetometer is in the normal position and rotated position.

8. Air Intake Filter Cleaning and Replacement

The air filter [1] is fitted behind the centre front panel of the PA1 and should be cleaned or replaced when necessary.

**WARNING:** Disconnect the power cable from the lower rear panel before removing the centre front panel by loosening the four large screws in the corners [2].

The filter may be cleaned by brushing off any dust from the front and blowing through from the inside surface.

**Caution:** Air should be blown with a low pressure air line. Use appropriate personal protective equipment (PPE).

Should the filter need replacing, the old filter may be removed from the panel and replaced with a filter cut from loose woven (rayon or cellulose) fibre filter sheet. The filter should be attached to the panel by a non-corrosive silicon rubber adhesive.

When filter maintenance is complete, replace the centre front panel.
9. Absolute Maximum Voltages

The maximum voltages that may be applied to any part of the HCS1 equipment are shown below. These figures are provided for information and safety regarding the voltages that may be used in local connections in the user’s laboratory.

**Caution:** If these voltages are exceeded, this may cause damage to the equipment.

<table>
<thead>
<tr>
<th>Port</th>
<th>Maximum voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>PA1 control input</td>
<td>± 10V</td>
</tr>
<tr>
<td>PA1 current monitor output</td>
<td>± 15V</td>
</tr>
<tr>
<td>PA1 coil drive output</td>
<td>± 30V @ 20A*</td>
</tr>
<tr>
<td>HC1 LED power indicator</td>
<td>12V 100mA*</td>
</tr>
</tbody>
</table>

**Caution:** * Do not make any other connection to these ports.

10. 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.

11. Storage and Transport

The HCS1 is a precision electronic instrument and should be treated as such.

Bartington Instruments has supplied this product in appropriate packaging for transporting. This packaging should be used for any future transport.

Refer to the product datasheet available on the Bartington Instruments website at [www.bartington.com/helmholtz-coil-three-axis-system](http://www.bartington.com/helmholtz-coil-three-axis-system) for this product’s maximum environmental, electrical and mechanical ratings.

**Caution:** Exceeding the maximum environmental ratings may cause irreparable damage to the equipment.
12. 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.

12.1. 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.