Operation Manual for PA1 Power Amplifier





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Table of Contents

1.	About this Manual		3		
	1.1.	Symbols Glossary	3		
2.	Safe Us	e	4		
3.	Introduction		4		
4.	PA1 Power Amplifier Features				
	4.1.	PA1 Power Amplifier Front Panel	5		
	4.2.	PA1 Power Amplifier Rear Panel	6		
5.	Compat	ibility	6		
6.	PA1 Power Amplifier Operation				
	6.1.	PA1 Location and Ventilation Requirements	7		
	6.2.	Connecting to the Helmholtz Coils	7		
	6.3.	Connecting to the CU1 Control Unit and CU2 Closed-Loop M	odule 8		
		6.3.1. Pin-Outs	8		
	6.4.	PA1 Power Amplifier Connection to Mains Power	9		
	6.5.	PA1 Power Amplifier Output Circuit Breakers	9		
	6.6.	Cooling	9		
7.	Powerir	ng Sequence	10		
8.	System Calibration 11				
	8.1.	Static Field Compensation	11		
	8.2.	Scaling	12		
	8.3.	Orthogonality	12		
9.	Air Intal	ke Filter Cleaning and Replacement	12		
10.	. Absolu	Absolute Maximum Voltages and Ratings 13			
11.	. Troubl	eshooting, Care and Maintenance	13		
12.	. Storag	e and Transport	14		
13.	. Dispos	al	14		
	13.1	. Waste Electrical and Electronic Equipment (WEEE) Regulat	ions 14		
Ap	pendix A:	Connecting the Components of the Helmholtz Coil System	15		
Ap	Appendix B: Guidance for Connection to Mains Supply 16				

1. About this Manual

This manual provides the information necessary to help customers install and operate the PA1 Power Amplifier. The PA1 Power Amplifier is one component of Bartington Instruments' One, Two or Three-Axis Helmholtz Coil System. This manual should therefore be read in conjunction with:

- Compatible Helmholtz Coils Operation Manuals
- CU1 Control Unit Operation Manual OM3224
- CU2 Closed-Loop Module (if applicable) OM3999
- Helmholtz Coil Control Software 0M3596.

All manuals are available from the Helmholtz Coil System <u>Operation Manual page</u>. The relevant products outline drawings can be found Helmholtz Coil System <u>outline drawing page</u>.

This manual should also be read in conjunction with the product brochure <u>DS2613</u> 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: A paragraph in this format provides useful supporting information on how to make better use of your purchase.

2. Safe Use

WARNING: The PA1 Power Amplifier 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. Safety protection will be impaired if the unit is used in a manner not specified in this manual.



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

WARNING: Personal injury may result from lifting the PA1 Power Amplifier. Use more than one person to move this device. It should be carried by each of the four lower corners.



CAUTION: When operated at full power for extended periods of time, thermal cut-out may be activated to protect the equipment from overheating. Should this occur, the power to the PA1 will be cut. In such event, it is advised to allow the unit to cool down before restarting it. To prevent the thermal cut-out from activating, the equipment should be used in a cooled temperature controlled environment (refer to Section 6.6)

3. Introduction

The PA1 Power Amplifier is the power amplifier for our Helmholtz Coil System. It delivers power to the coil so as to generate the appropriate the required field. Additionally a permanent DC offset can be applied to the Helmholtz Coils via the PA1 front panel DC offset potentiometers.

The following items allow to consitute a complete Helmholtz Coil System:

- HC1, HC2, HC9 or HC16 Helmholtz Coils: an assembly of up to three Helmholtz coils. See related operation manuals. Ferronato Helmholtz Coils can also be operated through this system.
- PA1 Power Amplifier.
- CU1 Control Unit: the control unit for the system which enables it to interface with a PCbased 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.
- A National Instrument acquisition card or PXI system.

BARTINGTON INSTRUMENTS

A diagram showing the connection of these separate items into one system is given in <u>"Appendix</u> <u>A: Connecting the Components of the Helmholtz Coil System"</u>.

The PA1 Power Amplifier is available in a number of variants to match the coil assembly it is being used with:

- PA1-1X, PA-1Y, and PA1-1Z Single Axis versions
- PA1-2XY, PA1-2YZ, and PA1-2XZ Two Axes versions
- PA1-3 Three Axes version

4. PA1 Power Amplifier Features



Figure 1. PA1 Power Amplifier Front Panel

Key

- 1. Upper front panel
- 2. Current control input
- 3. Calibration controls
- 4. Current monitor output
- 5. Static field offset controls

- 6. Fastening screws
- 7. On/Off rocker switch
- 8. Lower front panel
- 9. Centre front panel (grille)
- 10. Amplifier O/P circuit breakers

Current Control Input [2]: three differential analogue inputs from the CU1 Control Unit which control the power to be applied to the Helmholtz Coil in order to generate and regulate the required DC or AC magnetic field.

Calibration Controls [3]: a set of potentiometers which are used for fine adjustment of the calibration of the system, 3 potentiometers for gain (X, Y and Z), 3 potentiometers for current monitor gain (X, Y and Z) and 6 potentiometers for Orthogonality corrections (Xy, Xz, Yx, Yz, Zx, Zy). These are behind a cover to prevent accidental changes.

Current Monitor Output [4]: this is a differential output for monitoring the current in the Helmholtz Coil. This should be connected to the Current Monitor Input of the CU1 Control Unit.

Static field offset controls [5]: a set of three potentiometers (X, Y and Z) used to back-off the local DC magnetic field present around the coil. They create a DC bias on the field applied which is always present as soon as the PA1 is switched on.

Fastening screws [6]: fixing points for the front upper, centre and lower panel. Only the middle panel may require disassembly for cleaning of the air filter.

On/Off switch [7]: Enable powering on/off of the PA1. The switch is illuminated when the unit is switched on.

Centre fron panel [9]: Grille with air filter providing ventilation to the PA1

Amplifier O/P Circuit Breaker [10]: Protect the system in the event of a fault. If tripped, these can be reset (see <u>"PA1 Power Amplifier Output Circuit Breakers"</u>.



Figure 2. PA1 Power Amplifier Rear Panel

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- 11. Blank ventilation panel
- 12. Fastening screws
- 13. Coil drive output to Helmholtz Coils
- 14. Lower rear panel
- 15. Circuit breaker
- 16. Mains power input socket

Blank ventilation panel [11]: Grille to provide air input for cooling of the PA1.

Coil drive output to Helmholtz Coils [13]: Connector for pluging of compatible Helmholtz coil cable.

Circuit breaker [15]: Protects the unit from use of a higher current mains source.

Mains power input socket [16]: IEC input for connection to mains supply.

5. Compatibility

The PA1 is compatible to use with Bartington Instruments Helmholtz Coils HC1, HC2, HC9 and HC16. It is also suitable for use with a range of Ferronato[™] Helmholtz Coils. Refer to the Ferronato Coils datasheet or the <u>Ferronato Coil product page</u> for further details. The PA1 can also be connected to our CU1 Control Unit and/or CU2 Closed-Loop Module.

6. PA1 Power Amplifier Operation

6.1. PA1 Location and Ventilation Requirements

The PA1 has ventilation panels on the front, back and on either side. These should remain unobstructed to allow air movement through the PA1.

Note: The PA1 should be positioned around 3m away from the Helmholtz Coils to reduce PA1 distorting and interfering with the magnetic field generated by the Helmholtz Coils.

Note: For optimum results the ambient temperature should not exceed the maximum specified in the datasheet.

6.2. Connecting to the Helmholtz Coils

The compatible Helmholtz Coils are fitted with a cable with a plug for connection to the PA1 Power Amplifier.

Note: The PA1 Power Amplifier and the Helmholtz Coil must be connected before the PA1 is turned on.



Figure 3. Output to Helmholtz Coils

The supplied cable is plugged into the Output socket to the Helmholtz Coil on the rear of the PA1 Power Amplifier [13].



Caution: The coil drive output socket is reserved for the cable connecting the Helmholtz Coil and the PA1 Power Amplifier. 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 Helmholtz Coils.

Note: The PA1 Power Amplifier varies for Helmholtz Coils with different numbers of axes. One, two, and three axis PA1 versions are available. If an HC1 has a greater number of axes than the PA1 then only the number of axes corresponding to the PA1 can be used.



Figure 4. Zoom on PA1 Front Panel Input and Output

The PA1 Power Amplifier is connected to the CU1 Control Unit via the current control input [2]. The current monitor output [4], located on the upper front panel of the PA1 Power Amplifier, is also connected to the CU1.

When using the optional CU2 Closed-Loop Module, the PA1 Power Amplifier is connected to the CU2 Closed-loop module via the current control input [2]. The current monitor output [4], located on the upper front panel of the PA1 Power Amplifier, remains directly connected to the CU1.

Note: A diagram showing the interconnection of components of the Helmholtz Coi System is given in <u>"Appendix A: Connecting the Components of the Helmholtz Coil System"</u>.

Note: When using CU2 Closed-Loop Module, please refer to the CU2 operation manual for connections.

Current Control Input and Current Monitor Output are both differential for increased noise rejection. Ensure to use the interconnecting cables provided with the PA1 and CU1.

WARNING: Do not connect either current control differential inputs or current monitor differential outputs to ground.

Pin-out information for the current control input and the current monitor output can be found on the PA1 Outline Drawing DR3047 available on our website.

6.4. PA1 Power Amplifier Connection to Mains Power

Details of suitable power supply for the PA1 Power Amplifier are provided in the product brochure, with the supply being earthed/grounded. The supply from a standard wall outlet should be suitable in most countries. A compatible mains cable supplied with a UK 13A plug, an EU plug or bare ends can be specified at the time of ordering. In the latter case, refer to <u>"Appendix B:</u> <u>Guidance for Connection to Mains Supply"</u>.

A 16A circuit breaker is situated on the rear panel [15] which is suitable for the supply stated in the product brochure. Contact Bartington Instruments for advice if a lower voltage is to be used.



Figure 5. Mains Circuit Breaker on back panel

6.5. PA1 Power Amplifier Output Circuit Breakers

Each amplifier output is fitted with a resettable 20A circuit breaker [10], which protects both the amplifiers and the coil assembly in the event of a fault. The breakers are normally in the reset position. If a breaker trips, it can be reset by pressing in the appropriate button on the front panel. Repeated tripping may be an indication of a system fault.



Figure 6. Amplifier Output circuit breakers

6.6. 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.



Figure 7. Centre Front Panel - Ventilation Grille

Caution: If used on full power ensure that the equipment is placed in a cool, controlled environment to prevent activation of the thermal cut-out.



Caution: The air filter in the front panel [9] should be inspected regularly, and cleaned or replaced when necessary. See Section <u>9</u>.

7. Powering Sequence

Before powering the system, you should ensure that all the connections between the Helmholtz Coil and the PA1, the PA1 and the CU1 and/or CU2 as well as the CU1 to a suitable National Instruments acquisition card (or PXI-system) are done.

Once all connections are done, the following sequence should be used:

- Power the PC and National Instruments acquisition card or PXI system
- If using a CU2, ensure that the CU2 Reference Magnetometer is connected to the CU2 Module
- Power the CU1
- Power the PA1

To power down the system, the reverse sequence should be followed.

Please note that the equipment should be left to warm up for at least 12 hours before any of the calibration is undertaken.

8. System Calibration

The complete calibration document is available on request. Please contact <u>sales@bartington</u>. <u>com</u> for further information.

8.1. Static Field Compensation

The ambient DC magnetic field can be compensated for by introducing a DC offset into the amplifier input. The level of offset applied is set by lockable potentiometers [5] present on the amplifier upper front panel. This will enable a user to measure a 0 magnetic field when generating a 0 magnetic field in the software.



Figure 8. DC Field Offset Potentiometers

This adjustment is done one axis at a time using the Static Field Offset potentiometers. Additional equipment required include a suitable magnetometer, and a mounting jig to position the magnetometer in the centre of the coils, with the sensor's axes mechanically aligned to the axes of the Helmholtz Coil. A suitable magnetometer and mounting jig are both available from Bartington Instruments. Please contact <u>sales@bartington.com</u> for further information.

The static offset potentiometers are locked by the outer hexagonal lock [17]. This should be loosened with a spanner. The compensation is adjusted by turning the central shaft [18] with a screwdriver.

Place first a suitable magnetometer in it's mounting jig, with the X, Y and Z axis of the sensor aligned with the X, Y and Z axes of the Helmholtz Coil. The magnetometer's sensing element should be located in the centre of the coils in the area of highest homogeneity. The sensor can be typically connected via the DUT or AUX connection of the CU1 (when no CU2 is connected).

Once the system is powered and has been left to warm-up for a recommended period of at least 12 hours, turn off the field generation (using the Generate tab of the software - see Helmholtz Coil Control Software operation manual). Using the Measure tab of the Helmholtz Coil Control Software, take readings from the sensor (in DC setup). Turn the front panel Static Field Offset potentiometers until the readings of the magnetometer are as close to 0 as possible. A residual DC magnetic field field of below 100nT should be easily attained. The Static Field Offsets potentiometers locking rings should then be tightened 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, and be checked after moving the coils or placing magnetic objects nearby.

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 overtighten the locking rings.

8.2. Scaling

When supplied as a pair, the PA1 and Helmholtz Coil will have been factory set up. Description for the scaling adjustment procedure is available on request from Bartington Instruments - please contact <u>sales@bartington.com</u>.

Scaling should be checked on installation as the presence of metal nearby the coil may interfere with the field generated.

8.3. Orthogonality

In order to check and adjust for orthogonality, a suitable magnetometer and mounting jig is required. For information about a suitable magnetometer and the orthogonality adjustment procedure, please contact <u>sales@bartington.com</u>.



Figure 9. Internal view of ventilated front panel.

The air filter consists a 440x85mm (approx.) foam pad [32] fitted behind the centre front panel of the PA1 Power Amplifier. It should be cleaned or replaced when necessary.



WARNING: Remove the power connector from the lower rear panel before removing the centre front panel. The earth bonding connector can then be disconnected if required. Fan filter maintenance must be performed by suitably trained personnel only.

The centre front panel can be removed by loosening the four fastening screws in the corners of the panel [33].

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 can be removed by taking out the six screws [34] holding the filter retaining bracket. Replace the filters with appropriate flame retardant filter material (contact Bartington Instruments for details). Replace the filter retention bracket and screws.

When filter maintenance is complete, replace the earth bonding wire connector (if disconnected), before replacing the centre front panel.



WARNING: Ensure the earth bonding wire is firmly re-attached to the panel before refitting.

10. Absolute Maximum Voltages and Ratings

See the product brochure for the maximum voltages that may be applied to the PA1 Power Amplifier control input, and mains power inlet.

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.



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

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

11. Troubleshooting, Care and Maintenance

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

12. Storage and Transport

The PA1 Power Amplifier is a precision electronic instrument and should be treated as such.

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

Due to the weight of the equipment it should be moved by at least two people and carried by each of the four lower corners.

13. 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.

13.1. 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: Guidance for Connection to Mains Supply

1. Ensure that the mains feed is from a clean AC supply with the following characteristics:-

Voltage Range	100V to 240V AC
Frequency	47 – 63Hz

It is highly recommended that this mains feed is via an appropriate Residual Current Circuit Breaker, rated at 30mA trip current. This must comply with local regulations.

2. The mains input connectors are as follows:-

Device	Input Connector	Mating Cable Connector
Power Amplifier PA1	IEC C20	IEC C19
Control Unit CU1	IEC C14	IEC C13

These cables are available in specific versions for most countries.

3. If an un-terminated IEC connector lead is supplied with the equipment, the wires must be wired accordingly:-

BROWN	LIVE	
BLUE	NEUTRAL	
GREEN/YELLOW	EARTH	

4. It is essential that the control unit CU1 and the Power Amplifier PA1 are properly earthed at all times.

5. It is recommended that the mains to each unit is supplied via an appropriate mains fuse:-

Power Amplifier PA1	13A
Control Unit CU1	13A

This is appropriate for the use over the whole supply voltage range.

6. This installation MUST be carried out by a trained, competent person.

7. Before initial switch-on, an appropriate earth bonding test should be performed to ensure a robust earth connection.

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