BARTINGTON

MAG-03SCU

SIGNAL CONDITIONING UNIT

OPERATION MANUAL

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OPERATION MANUAL
FOR *Mag*-03SCU
SIGNAL CONDITIONING UNIT

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DESIGN CHANGES

In the interest of product improvement, Bartington Instruments Ltd., reserve the right to change any part of the design of this product without prior notice.

1.0. INTRODUCTION

It is a frequent requirement, when performing magnetic measurements using the *Mag*-03 range of sensitive magnetometers, to condition the signals prior to analysis and have some means of supplying power to the magnetometer. To a limited extent these requirements are satisfied through the use of the *Mag*-03 power supply unit and, where very slowly varying signals are to be processed, the 24-bit *Mag*-03DAM data acquisition module may be used.

The mains powered signal conditioning unit described here is intended for use where simultaneous visual display, together with analog data, is required. Very wide range high and low pass filters, together with a gain control and an adjustable supply voltage, enable the user to configure the system to suit a variety of operational requirements.

2.0. GENERAL DESCRIPTION

See Figures 1 and 2

The signal conditioning unit, the *Mag*-03SCU, is a mains powered unit, housed in a 19" rack-mountable enclosure. Function controls and LCD displays for the three axes are mounted on the front panel with connectors on the rear panel.

The unit functions in the following way:-

2.1. Power supplies

2.1.1. Mains inlet

The a.c. mains supply is connected to the unit via the IEC inlet on the rear panel. The inlet contains two 1 A quick blow fuses which may be 20 mm or 3/4 inches in length. The fuse carrier also acts as a mains voltage selector by appropriate orientation. The unit is switched on and off by a rear panel switch, integral with the IEC mains inlet. Radio frequency filtering is incorporated in the connector assembly.

2.1.2. Low voltage supplies

Low voltage supplies are derived from transformers which possess low input to output coupling capacitance. From the transformers, rectified, but unregulated, d.c. supplies are derived. The supplies are regulated to produce four d.c. supplies. These are:

(a) Supply to the magnetometer - this supply can be set to either ±12 V, ±15 V or ±17 V under control of the SUPPLY voltage selector on the front panel.

(b) ±15 V supply to the internal analog circuitry

(c) +5 V supply to the LCD panel meters and logic

(d) ±10 V high stability precision supply for offset reference

All supplies, including the magnetometer supply, are taken, together with the external line supply ground, to a common earthing point on the chassis of the unit.
All power supplies have very low ripple and are short circuit protected for indefinite time.

2.2. Analog signal processing

2.2.1. The differential amplifier

Power is supplied to, and analog signals received from, the magnetometer via the 10-way rear panel connector. All lines pass via an 18 V surge arrestor which provides limited protection against voltage surges due, for example, to indirect lightning strikes. The low resistance magnetometer cable shield acts as the power return line and is connected within the
Mag-03SCU to the common earth point.

Analog signals on the X, Y and Z axes are referenced to a common signal return line and this, together with the signals, is connected to the input terminals of the differential amplifier. The ultra low drift amplifier is based on the ADOPO3 and provides less than 1 μV/°C input offset drift, together with an input impedance of 50 kohms. The output of the amplifier is referenced to the local 0 V analog reference and is available as an unconditioned output on the rear panel.

This amplifier ensures very high immunity to errors arising from the presence of common mode voltages. These can be due to voltage differentials in the power supply return line and external noise. The theoretical common mode range is ±18 V.

2.2.2. The filter See Figure 2

High and low pass filters are incorporated to provide 18 dB/octave roll-off characteristics outside the pass band. The -3 dB frequency response point for the filters for all channels is set via front panel controls. The high and low pass filters are in two sections situated before and after a variable gain amplifier. The section before the amplifier has a roll-off of -12 dB/octave and a Q factor of 0.85. The section after the amplifier has a roll-off of -6 dB/octave and a Q factor of 0.5. In this way a maximally flat response is achieved with the desired roll-off characteristics and freedom from overload problems.

The filters are built around the ADOP270 low noise, high stability op amp and have a dynamic range of ±13 V.

When the high pass filter is set to 0 Hz, d.c. operation is enabled and the high pass filter sections are bypassed.

2.2.3. The variable gain amplifier

The gain of the X, Y and Z channels can be individually set using three front panel controls. This section is based on the AMP01 instrumentation amplifier. Input and output offset error is individually trimmed. The input drift, which will be amplified, is less than 0.5 μV/°C. The input to the amplifier is fully differential over a ±12 V common mode range and permits the precision offset to be introduced at this point.

2.2.4. Offset

Small signal variations can be measured in the presence of a high background value by using the offset controls on the front panel. The reference signal for this is derived from the precision reference which is based on the ADREF01 ultra high stability 10 V reference. A coarse offset control is provided by a three position, centre off switch to set the polarity of the offset required together with and a 10-turn precision potentiometer. A fine offset control with a centre off position provides a continuous fine adjustment of the offset.

2.2.5. Panel meter

The conditioned signals for the three channels are available as analog outputs on the rear panel and are also displayed numerically on the three LCD meters on the front panel. The meters are set to read directly in volts and the least significant digit has a resolution of 10 mV. The meters display results at three readings per second and will therefore not indicate a meaningful result for a.c. signals. For a.c. measurements the analog signals from the rear panel connector should be viewed with an a.c. meter, oscilloscope or output to a data acquisition system.

3.0. OPERATING INSTRUCTIONS

3.1. Connecting up

3.1.1. Mains power supply - earthing and safety

WARNING: THIS UNIT IS MAINS POWERED AND THE FOLLOWING INSTRUCTIONS SHOULD BE STUDIED CAREFULLY

The following safety precautions should be observed before connecting the unit to a mains supply:

(a) The unit MUST be earthed. For this reason a 3-core connecting cable is supplied. The centre pin of the IEC inlet on the rear panel is internally connected to all the metal panels of the unit. The correct mains cable should possess three conductors and a three pin plug. The earth pin of the plug, which is usually the central one, connects electrically with the centre pin of the IEC inlet. A supply connection should be selected such that the IEC inlet centre pin is connected to a safety earth point.

(b) When viewed from the rear the right hand pin of the IEC inlet is mains LIVE and the left hand side one is NEUTRAL. Although, in practice, these can be reversed, for reasons of safety correct connection should be observed.

(c) This unit is not sealed against the ingress of water and should be operated only under dry conditions.

If in doubt about any of the above a qualified electrician or safety officer should be consulted before making connection to the mains power supply.

3.1.2. Mains voltage selection

It is important that the unit is set to operate on the local a.c. voltage. To accomplish this, the fuse holder within the IEC connector can be removed and inserted so that the arrow on the body of the connector aligns with the arrow on the fuse carrier which is adjacent to the correct voltage.

SET TO 220-240V OR 110-120V

3.1.3. Fuses

1 Amp capacity fuses are fitted with a voltage rating of 250 V. The fuses may be either 20 mm European or 3/4 inch US style. No other rating of fuse should be fitted.

3.2. Switching on

Ideally, the magnetometer should be connected prior to switching on the *Mag*-03SCU. In this way, power supplies to the magnetometer are switched on simultaneously and intermittent connections are avoided. However, failure to do this is unlikely to cause any problems.

The unit is switched on by selecting the "1" position on the rocker switch on the IEC inlet. The LCD displays should immediately become illuminated.

3.2.1. Magnetometer supply voltage

The front panel control should be set to supply the appropriate voltage to the magnetometer. For very short cables, a few metres or so, use 12 V setting. Between 100 and 300 metres, use 15 V setting and above this length use the 17 V setting.

3.2.2. Preliminary set-up - d.c. measurements

Following switch-on, the unit requires approximately 10 minutes to achieve full stability whilst the internal circuitry warms to its operational temperature. Ideally the ambient temperature should not vary more than 2 or 3^{o} C per hour if full stability is to be achieved. For this reason the unit should be operated out of direct sunlight.

Set the high pass filter to d.c. 0 Hz position and set each of the individual gain controls to the lowest setting. Set each of the coarse offset switches to the centre (OFF) position and the 10-turn coarse offset controls fully counter clockwise. Set the fine offset controls to the centre zero position. It will then be possible to observe the major static field present at the sensor axes.

Note: Any channel which displays a value above 10 V should be considered to be approaching overload and at 12 V the channel is overloaded.

A decision can now be made, depending on the type of measurements to be performed, whether higher gain settings are permissible, operation of the offset control is appropriate or whether the high pass filter function should be enabled.

If the conditioned or unconditioned analog outputs are to be used, they should be loaded by an impedance of not less than 50 kohms for the greatest accuracy.

3.2.3. Offset

The variable gain amplifier is subsequent to the offset facility. Therefore, if it is desired to use this facility, remember that the difference between the offset value and the current field value for each channel will be multiplied by the gain. The offset facility will usually be used in the following way:

Set the coarse offset 10-turn control fully counter-clockwise and select an offset polarity which is of opposite sign to the value to be nulled. Rotate the offset control clockwise until the value displayed reduces to zero or some small value. The fine offset control may then be set to reduce the offset to zero. It is now possible to increase the gain to the required value for the investigation and adjust the fine control again as necessary.

3.2.4. Gain setting

The gain of each channel may be individually set to a value of either 1, 50, 100, 300, 500 or 1000.

The maximum gain permitted will be limited by considerations of maximum signal excursion over a measurement sequence and the degree of precision required in setting the offset. The coarse offset can, with care, be set to zero the signal within the ±5mV range of the fine offset control.

3.2.5. Scaling

Note: 1 Gauss = 100 mT

Magnetometers in the *Mag*-03 series are available in range settings of 70, 100, 250, 500 and 1000µT per 10 V output full scale. The scaling at the output of the *Mag*-03SCU will therefore be equal to the scale factor divided by the gain. For example, for the *Mag*-03MC100 and a gain setting of 1000, the analog output scale factor will be

10/1000 = 0.01 μT/V or 10 nT/V

3.2.6. A.C. coupling - high pass filter

Sometimes, where the background field is dominant but is changing at a rate slower than the field to be studied, it is more convenient to use a.c. coupling. Two high pass filter settings for this purpose are provided, having values of 0.01 Hz and 1.0 Hz. Select the frequency which is substantially lower than the frequency of the field under investigation but higher than the frequency at which the background field may be varying.

Sufficient time should be allowed, especially at the lowest frequency setting, for the filter to settle. Momentary selection of the higher frequency, 1 Hz setting, will assist in settling the lower frequency filter, 0.01 Hz setting.

The offset controls remain operational when the a.c. coupling is implemented and could be used to assist in shortening the settling time. However, it is usual that the central position of the offset polarity switch will be selected, the 10-turn control set fully counter clockwise and the fine control set to the centre position to disable this facility during a.c. measurements.

3.2.7. Low pass filter

The low pass filters are enabled at all times and may be set to reject frequency components above a value of either 1, 10, 100, 1000 or 10,000 Hz.

3.3. Electromagnetic compatibility

The *Mag*-03SCU instrument contains no high frequency electronics likely to cause emissions which could cause interference with other apparatus. The design includes decoupling of internal power supplies and mains filters to minimise any emissions.

The unit is also unlikely to be affected by interference from other equipment in the normal operating environment. However, the sensors used with this unit, being designed to measure the magnetic field, are susceptible to electromagnetic interference and operation close to a high frequency sources of radiation should be avoided. Interference is indicated by instability in the reading when the sensor is maintained in a fixed position.

4.0 TECHNICAL SPECIFICATIONS

Mechanical

Enclosure	:	483 mm width (19”) 88 mm height (2U) 300 mm depth Rack mountable
Weight	:	5.5 kg
Markings	:	product code, serial no., supply voltage

Environmental

Operating temperature range	:	-20°C to +70°C
Humidity	:	0-50% (non-condensing)

Electrical

Power input	:	110/220 V ac selectable
Fuses	:	1 A, 250 V rating, 20 mm or 3/4 inch
Power output	:	±12 V, ±15 V and ± 17V dc at 1 A short circuit protected surge protection provided with ±18 V clamp
Ripple	:	<1 mV p-p

Performance

Input channels	:	3 from *MAG*-03 three axis magnetic sensor (X, Y and Z)
Input signal range	:	±18 V maximum - surge protection with ±18 V clamp
Signal output	:	three unfiltered analog three filtered analog
Signal coupling	:	a.c. or d.c. depending on filter selection
Low pass filter	:	1, 10, 100, 1000 or 10000 Hz switch selected
High pass filter	:	0 (d.c.), 0.01 or 1.0 Hz switch selected
Filter roll-off	:	-18 dB/octave for low and high pass
Gain	:	1, 50, 100, 300, 500 or 1000 switch selected for each channel.
Offset -Coarse	:	0 to ±10 V for each channel
-Fine	:	0 to ±5 mV for each channel
CMRR	:	> 60 dB
Offset control	:	10 turn potentiometer with polarity switch for each channel
Thermal drift	:	≤6 mV/hour for filtered/nulled signal output with gain=300
System noise	:	minimum discernible input signal variation of ±0.1 mV with signal/noise ratio of ≥10 dB at all gain settings
Display	:	3 x 3½ digit LCD
Controls	:	Power on, low pass filter, high pass filter, supply voltage, gain (3), offset (3), polarity (3)
Connectors	:	power in - 3 way IEC with integral filter (power cable supplied) sensor - 10 way Hirose RM15TRD10P analog outputs - 6 x BNC

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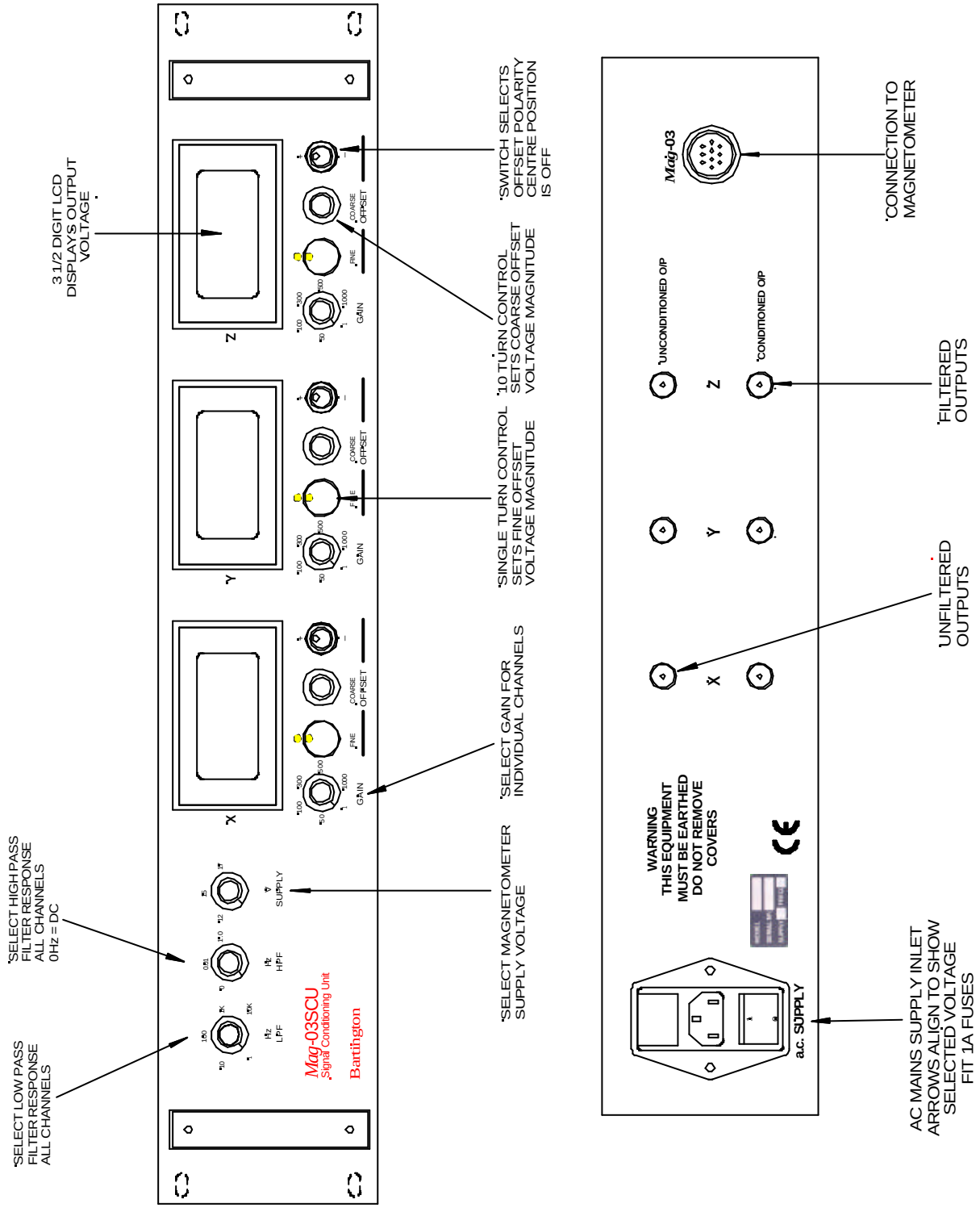

FIGURE 1 *Mag*-03 SIGNAL CONDITIONING UNIT
FRONT & REAR PANELS

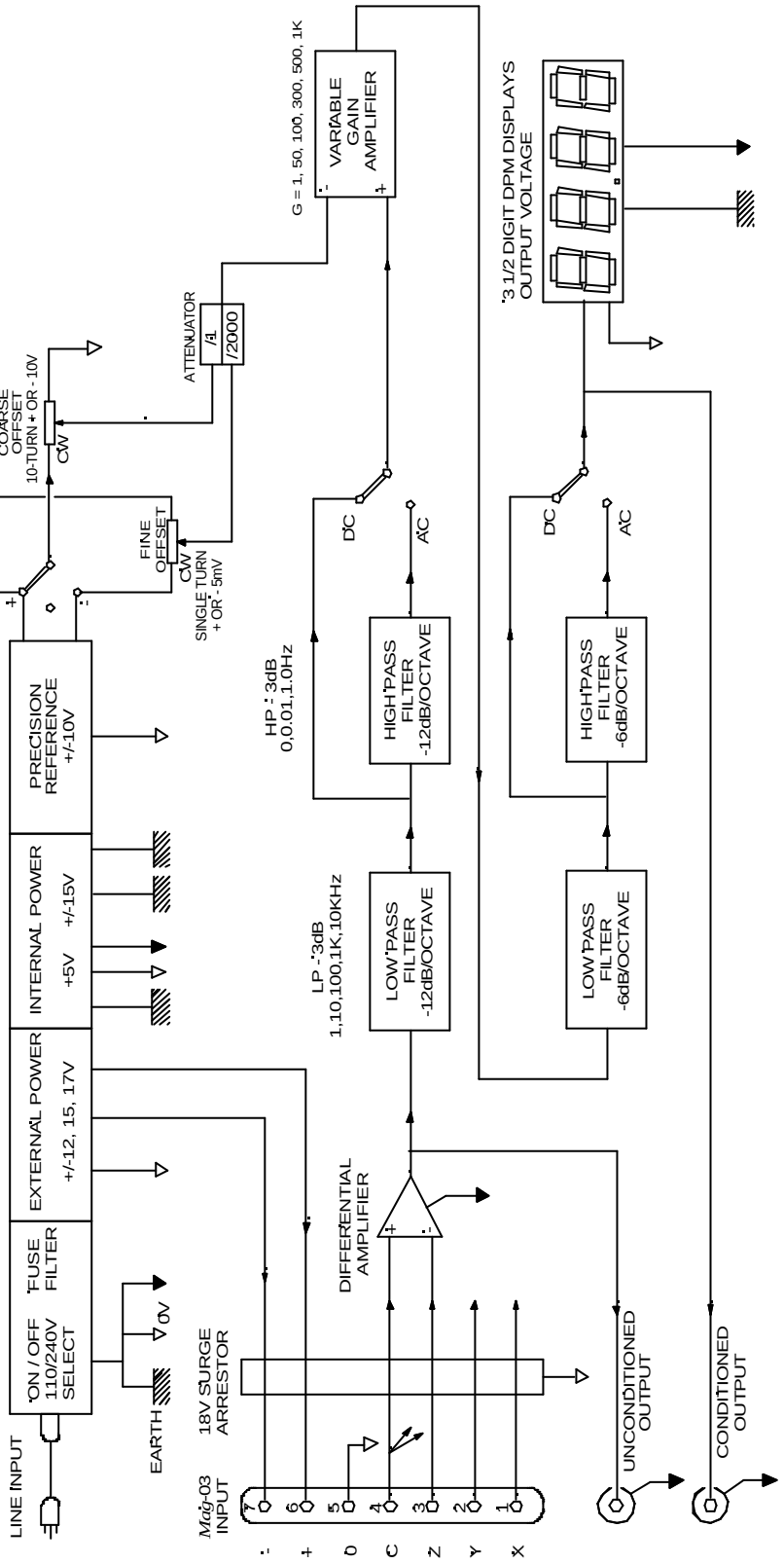

FIGURE 2 *Mag*-03 SIGNAL CONDITIONING UNIT BLOCK SCHEMATIC - ONE AXIS (Z) OF THREE SHOWN