Operation Manual for

Mag639 Wide Bandwidth Three-Axis Magnetic Field Sensor

Bartington® Instruments

Table of Contents

1. About this Manual

This manual describes the installation, operation and maintenance of the Mag639 three-axis magnetic field sensor. It should be read in conjunction with product brochure DS2240, which can be found on the product page on the Bartington Instruments website at www.bartington.com. An outline drawing (DR2839) is also available on the product page.

Note that failure to follow the instructions in this manual may invalidate your product's warranty. If in doubt, do not hesitate to contact Bartington Instruments.

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.

This symbol identifies items that must be disposed of safely to prevent unnecessary damage to the environment.

Note: A note provides useful supporting information and sometimes suggests how to make better use of your purchase.

2. Safe Use

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

3. Introduction to the Mag639

The Mag639 is a magnetometer consisting of a cluster of three feedback stabilised fluxgate sensors arranged along X, Y and Z axes. Each axis provides a highly linear magnetic response with low hysteresis and low cross talk between axes.

Mag639 is ideal for use in electromagnetic (EM) survey systems (e.g. TDEM and MT) where its extra frequency response can increase overall system sensitivity.

The standard Mag639 has a pre-fitted circular connector on a 2.5m lead. A mating connector is supplied for the customer to connect to their own equipment

3.1. Vector Measurements and Conventions

The magnetometer produces three independent analogue output voltages in response to the magnitude and direction of the orthogonal components of a magnetic field. A 'right-hand' co-ordinate system is adopted. In this system, the X, Y and Z axis correspond to the thumb, first finger and second finger respectively of the right hand. By convention, the magnetometer should be installed so that the X axis is arranged to point North, the Y axis to point East and the Z axis to point down (see Figure 1).

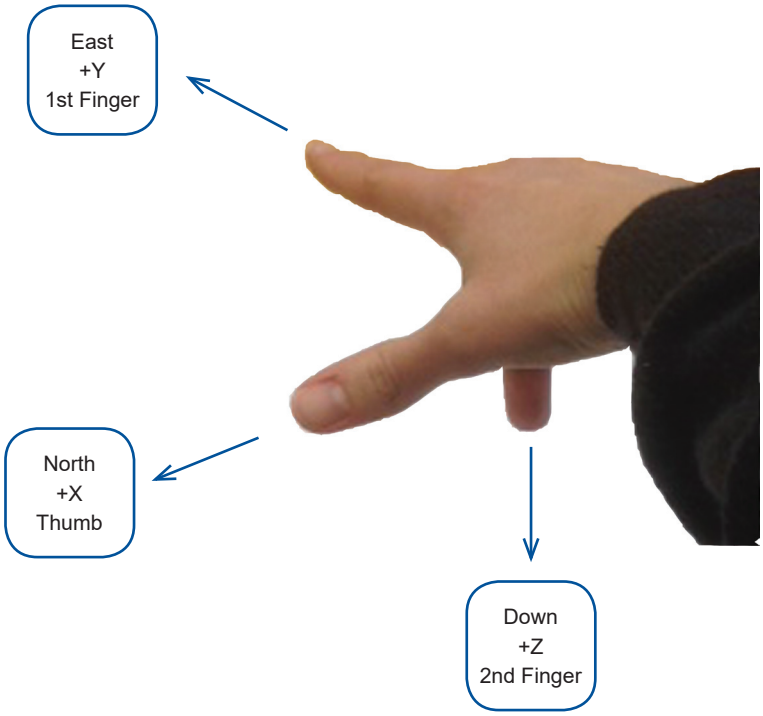

Figure 1. The right-hand rule.

The centres of the three vector sensors are superimposed; each orientation is denoted on the magnetometer's label. The point of each vector arrow indicates the positive direction of each axis.

4. Installing the Mag639

4.1. Siting the Magnetometer

Note: In whatever situation the Mag639 is to be installed, it is important to avoid or compensate for local magnetic effects. In general:

- Site the magnetometer several metres from any magnetic base rock to avoid compromising measurements.
- Site the magnetometer several tens of metres from very large ferromagnetic objects that could become magnetised and create fields that exceed the measuring range of the sensor.
- Avoid siting the sensor near any ferromagnetic objects that may be subjected to the effects of magnetic hysteresis, which would affect the sensor in an unpredictable manner.

Note: For these reasons, a magnetic evaluation of any proposed installation site should be conducted to establish that it is free from magnetic contaminants. It is recommended that such an evaluation be carried out using total field or resonance magnetometers.

4.2. Connection Recommendations

4.2.1. Connector Pin Allocation

The connector pin or cable colour allocation for the connection to each package type is shown in outline drawing DR2839.

4.2.2. Interface

Caution: There is no protection against reverse polarity power connection. Users must observe the correct polarity to prevent permanent damage to the sensor if the supplies are connected incorrectly.

Caution: Short circuits from outputs to either power rail may result in permanent damage to the sensor. Limiting the power supply current to 100mA is recommended to minimise risk of damage caused by incorrect connection.

The analogue outputs for the X, Y and Z axes are buffered to give a low output impedance, enabling the unit to be operated over long cables and interfaced to low impedance data acquisition systems.

4.2.3. Power Supplies

Note: The Bartington PSU1, Magmeter, SCU1 and Spectramag-6 are suitable power supply units, but low-pass filters fitted within these units may restrict bandwidth. Refer to the product brochure for details of filter cut-off frequencies.

Note: Power supplies that do not have adjustable voltages may limit the available output to less than that specified for the Mag639.

Alternatively, users may wish to provide their own supply. Refer to Appendix 1 for further information.

4.3. Pre-Installation Tests

Prior to the installation of the system, the magnetometer, cable and power supply must be fully tested to ensure correct function, as follows.

Caution: Take care to avoid bending or otherwise damaging the contacts whilst conducting the tests.

Caution: Carefully check for correct connection before applying power. Applying incorrect polarity or power to output connections may cause irreparable damage to the sensor.

1. Test the cables for continuity (using an electrical continuity tester or ohmmeter).
    a. Test the cables end to end at the connectors to ensure that the correct pins have been allocated to the conductors, and that there are no open or high resistance circuits.
    b. Test the cables at the connectors to ensure that there are no short circuits between the conductors.
3. Check the power supply output voltage using a voltmeter. Refer to the product brochure for the required values.

Caution: Switch off the power supply before connecting to the Mag639.

4. Connect the magnetometer to the cable connector.
5. Connect the power supply to the other cable connector.
6. Switch on the power supply and wait until the magnetometer has stabilised. Refer to the product brochure for warm-up times.

4.4. Mounting Recommendations

Mag639 comes in a circular enclosure which may be clamped using Bartington Instruments' Mag-TA Universal Tripod adaptor or similar.

4.5. Post-Installation Testing

1. Site the magnetometer, and install the power supply and cabling.
2. Switch on the power supply and wait until the magnetometer has stabilised. Refer to the product brochure for warm-up times.
3. Confirm no magnetic objects are moving in the vicinity.
4. Monitor the sensor outputs.
5. Confirm that the sum of the measured magnetic field vectors is similar to the expected local earth field.

5. Using the Mag639

5.1. Cabling

Note: Use an eight-core screened cable to connect to the sensor. Two cores will be used for positive and negative power supply lines, three cores for output signals, one core for signal common and one for power supply ground.

Note: The screen should be connected to supply ground at the supply end only.

Note: The capacitance between cores should be less than 200pF per metre.

Note: A cable with individually shielded cores should be considered for long cable applications.

Note: Leads are susceptible to EM interference and should be screened wherever possible.

Note: The length of the cable is limited by the voltage drop in the power supply lines and the capacitance between the cores. Long cables will limit both the bandwidth and the full-scale range of the Mag639.

5.2. Connecting Power

Caution: Check that the polarity of the supply is correct. The power supply should be connected to the sensor before the supply is energised as this prevents high inrush currents which could cause damage. Apply the positive and negative supplies simultaneously and avoid leaving the sensor connected to one polarity only.

5.3. Response

The analogue output V, for any channel, is proportional to the axial component b of the total field F. If θ is the angle subtended between the direction of F and sensing axis of the fluxgate element, then:

$b = F \cos\theta$ and $V \propto F \cos\theta$

5.4. Electromagnetic Compatibility

Note: The Mag639 is not shielded for immunity from, or emission of, electromagnetic fields. Any shield placed around the sensor will limit the bandwidth of the sensor response. The emissions generated are at a low level with a primary frequency matching the frequency of the energising field of the sensor. The sensor is required to respond to magnetic fields within the specified frequency band.

Note: Ensure that the sensor is not operated in areas where a high electromagnetic field exists, even if the frequency is above the bandwidth of the sensor, as false information may appear due to aliasing. This effect is seen in data acquisition systems when the frequency of sampling is lower than the frequency of the signal which is being sampled. It may produce apparent signals at lower frequencies than the noise, which may be within the frequency band of the sensor.

Note: Similarly, do not place the sensor near to any equipment which may be affected by the fields produced by the sensor excitation.

5.5. Signal Processing

For different applications, it may be necessary to process the signal from the sensor in different ways.

In order to increase the sensitivity of the recording system, it may be necessary to back-off the earth's field and amplify only the changes in the field from the current value. This requires a high-pass filter, which could be a simple capacitively coupled arrangement or a multi-pole filter to provide a steep roll off characteristic. These features are all present in the SCU1 signal conditioning unit.

Note: The output from all fluxgate sensors will contain noise from the driving electronics. For the Mag639 this noise is at 32kHz, which is well above the bandwidth of the sensors. Where low noise operation is required, a filter should always be provided to reject the noise which lies outside the band of interest.

When the sensor output is digitized it may be necessary to include an analogue low-pass anti-alias filter to prevent the creation of in-band noise by beating the 32kHz excitation with the sampling clock of the digitizer.

The level of unwanted breakthrough at 32kHz has been minimized in the Mag639 but may still cause an apparently raised noise level when sampled at low sampling frequencies without further analogue filtering.

5.6. Magnetic Hysteresis

Note: The Mag639 is designed to have an extremely low magnetic hysteresis. However, Bartington Instruments recommends your magnetometer is not subjected to magnetic fields greater than their stated measuring range for extended periods as this could alter the DC offset. If this occurs, the offset will exhibit drift as it returns to its original offset specification.

Caution: Subjecting the magnetometer to fields in excess of 2 x the nominal range may cause inaccuracy in future measurements. Degaussing the magnetometer can reverse such an effect.

5.7. Environmental Precautions

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

Caution: Exceeding the maximum ratings may cause irreparable damage to your sensor.

6. Troubleshooting

The sensor is unlikely to suffer any defects in normal use: no internal components are serviceable. The most likely causes of failure, and their solutions, are detailed in the following table.

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

Cause of failure	Solution
Power supply	Check the power supply as detailed in Pre-Installation Tests.

Cables	Check the cables as detailed in Pre-Installation Tests.
Power input	If no fault can be found in the power supply or cables, ensure the cable length is not too long, causing excessive voltage drop between the power supply and magnetometer. Refer to the specifications defined in the product brochure.
Magnetometer	No physical damage to the Mag639 can be repaired. Replace with a new unit. For information about disposal of the damaged unit, refer to End of Life Disposal.

7. Care and Maintenance

Beyond the procedures described below and in Troubleshooting, no user repair or servicing is possible with the Mag639. No routine maintenance should be required.

7.1. Cleaning the Mag639

Use water and mild soap to remove grime from external enclosures.

Caution: Never use chemicals, such as solvents, when cleaning the Mag639.

Caution: Take particular care when cleaning around electrical connections. Bent or damaged pins may cause the magnetometer to malfunction.

7.2. Calibration

Return the Mag639 to Bartington Instruments for calibration at the recommended intervals. Refer to the Calibration Certificate for further details.

8. Storage and Transport

Your sensor is a precision electronic instrument and should be treated as such.

Note: Avoid exposing this instrument to shocks or continuous vibration.

Note: Store only within the temperature range specified in the product brochure.

Note: Do not expose this instrument to strong magnetic fields while being stored.

9. End of Life Disposal

This product should not be disposed of in domestic or municipal waste. For information about disposing of your sensor safely, check local regulations for disposal of electrical / electronic products. Alternatively, contact Bartington Instruments to arrange the return of products for disposal. Where returning the instruments is not possible, check local regulations for disposal of electronic products.

9.1. Waste Electrical and Electronic Equipment (WEEE) Regulations

The Bartington D/I System complies fully with RoHS (Reduction of Hazardous Substances) legislation. However, electronic equipment should never be disposed of in normal waste.

Appendix 1

A1. Use of Alternative Power Supplies

Bartington power supplies provide the most suitable methods for connecting to and operating your sensor. Refer to www.bartington.com/data-acquisition-and-conditioning-units.html for details of Bartington Instruments power supply units and data acquisition units that are compatible with this product.

If you have decided to use an alternative then the information in this Appendix is important.

Caution: Failure to follow these instructions may result in incorrect sensor readings and in some circumstances may cause irreparable damage to your sensor. Mag639 does not incorporate any reverse supply polarity protection.

Power supplies should normally provide ±15V and, for the lowest noise applications, ripple in the output should be in the mV region. The nominal current requirements are +60 mA and -35 mA with an additional current in proportion to the measured field. The additional current is 1.4mA per 100µT per axis and will be drawn from the positive or negative supply, depending on the direction of the field.

The maximum output voltage swing from the sensor will always be less than the supply voltage. In the temperature range -40°C to +70°C, and with an external load of 10kΩ, the maximum output voltage will be less than each supply voltage by up to 3V. All parameters other than the output voltage range remain unaffected for supply voltage changes in the range from ±12 to ±18V.

The current drain is independent of the power supply voltage and the unit will operate with input voltages down to ±12V. As the output voltage swing is limited to 3V less than the supply voltage, for a supply of ±12V the output will operate normally with any output between +9V and -9V, representing a field of 90% of the full scale value in each direction. The scaling factor and linearity will remain at the normal value up to this saturation point. The output will remain at the saturation level if the field is increased beyond this point. Asymmetric supplies may be used provided that the minimum and maximum voltages are not exceeded for either polarity.

A2. Signal/Power Ground

The two signal/power ground conductors are connected to a common point within the sensor and the power supply common (power 0V) should be connected to only one of them, which becomes the power ground. The other conductor becomes the signal ground and is used as the 0V output from the sensor. Each signal is then measured between the X, Y and Z output conductors and the signal ground output. In this way, the signal ground carries no power supply currents.

The minimum current in the power ground conductor is approximately 35mA. On long cables, this will give rise to an appreciable potential difference between the power supply end and the sensor end of the power ground conductor. The use of separate power and signal ground conductors will ensure that this voltage is not included in the voltage measured between the signal outputs and the signal ground.

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