



USER'S MANUAL

MODEL: 5972

Magnet Control



PROPRIETARY

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CONTENTS

1. SAFETY	3
1.1. Symbols Used In This Manual	3
1.2. Installation, Operation and Service Precautions	4
1.3. Lockout/Tagout Procedures	4
2. SPECIFICATIONS	7
3. INSTALLATION	8
3.1. Unpacking Instructions	8
3.2. Rack Mounting	8
3.3. Electrical Connections	9
4. SOFTWARE	9
4.1. Software Installation	9
4.2. Software Operation	10
5. 5972 OVERVIEW	12
5.1. System Description	12
5.2. 5972 Interlocks	15
5.3. Interlock Operational Checks	15
5.4. Interlock By-Passing	16
5.5. Power Supply Checks	16
6. 5972 OPERATION	17
6.1. Manual Operation	17
6.2. Computer Control	18
7. MAINTENANCE	19
8. ACCESSORIES	19
8.1. Hall Effect Sensors	19
8.2. Temperature Sensors	19
8.3. Water Flow Meters	19
8.4. Power Supply Control Cables	19
8.5. Rack Door Interlock Switch Kit	19
9. CABLE DRAWINGS	20
9.1 16907-0280-1 - Power Supply Control Cable, 3kW DLM	21
9.2 16907-0280-2 - Power Supply Control Cable, SGA	22
9.3 16907-0100-5 - Power Supply Control Cable, IECO BPS	23
9.4 16907-0280-4 - Power Supply Control Cable, Kepco 100W & 400W BOP	24
9.5 16907-0280-5 - Power Supply Control Cable, Kepco 1kW BOP	25

10. TECHNICAL REFERENCE	26
10.1 Drawing 11907-0610-0 - 5972 Magnet Control, Front & Rear Views	27
10.2 Drawing 11907-0610-0 - 5972 Magnet Control, Side View	28
10.3 Drawing 11907-0610-0 - 5972 Magnet Control, Top View	29
10.4. Drawing 13907-0115-0 - 5972 Magnet Control, Internal Block Diagram	30
10.5 USB-6343 DAQ Connections	31
10.6 Interlock Circuits	33
10.7 Connector Pin-outs	34
11. TROUBLESHOOTING	40
12. WARRANTY INFORMATION	41

1. SAFETY

1.1. Symbols Used In This Manual



Important information. This label indicates important information that must be read and understood prior to operation.



Warning relating to the presence of magnetic field.



Warning relating to a trip hazard.



Warning relating to hot surfaces.



Warning relating to the potential for electrical shock.



Warning relating to the potential of injury due to lifting heavy weight.



Warning relating to magnetic fields and medical implants and pacemakers

1.2. Installation, Operation, and Service Precautions



During installation or servicing this magnet must be locked out following the Lockout/Tagout procedure defined in section 1.3.



Hazardous voltages are present within this product during normal operation. This equipment should never be operated with any of the covers removed or interlocks defeated.

Never service alone. The output of this equipment and its DC Power Supply is capable of delivering high voltages at high currents, and is potentially lethal. Do not perform service to this equipment or its associated DC Power Supply unless another person is present who is capable of rendering first aid.

1.3. Lockout/Tagout Procedures

Purpose:

To protect personnel and ensure that machines and equipment are isolated from potentially hazardous electrical energy. Lockout or tagout must occur before employees perform service, maintenance, or renovation. This is important where unexpected start-up could cause personal injury, fire, or equipment damage.

Policy:

All equipment shall be locked out where possible. Where such control is not possible, equipment may be tagged out-of-service. In all instances, equipment shall be made inoperable to protect against possible operation where such operation may cause personal injury or damage. Employees must not attempt to operate any switch or source of energy which is locked out or tagged out.

Procedures:

1. When working on systems which could accidentally be activated, the system shall be locked out or tagged out by use of a safety lockout device and padlock. In addition, a tag shall be used to identify the purpose of the shutdown, the employee involved, the date the unit was removed from service, and when the system may operate again.
2. If more than one source of energy is present, all such sources must be locked out or tagged out. Special procedures must be followed to ensure that the equipment is disconnected from an energy management system or emergency generator system that may start or energize the equipment.
3. A lockout is required on all systems where possible. A tagout is an acceptable means of protection on systems which are less hazardous. An example of less hazardous is a device, if started accidentally, would not cause personal injury.
4. If more than one person is involved in the repair, each person shall install a lock and or tag to the equipment energy source. An employee may not use the tag or lock of another employee.

5. After servicing, renovation, or maintenance is complete, the area must be checked for tools, parts, removed guards, and assurance that no personnel are in the danger zone. Then the lockout or tagout will be removed by the same employee who initially locked it out so energy may be restored to the equipment.
6. If the employee who locked out or tagged out the equipment is unavailable, the supervisor may remove the lock or tag if the following conditions are met:
 1. Verification that the employee who applied the device has left for the duration of the shift and is not at the job site.
 2. Made reasonable efforts to reach the employee.
 3. Inform the employee that the lock or tag has been removed and the system is no longer de-energized, before the employee resumes work.
7. Employee's using lockout/tagout devices shall have training about this program, and shall have annual retraining to ensure that the employee understands and follows this program. The training and retraining shall be documented with the training records maintained by the training coordinator.
8. Outside contractors are required to follow this policy or provide a similar policy that is in compliance with Occupational Safety and Health Administration (OSHA) Standard 1910.147. Under no circumstances are outside contractors authorized to remove a lockout/tagout device nor are they allowed to energize a locked out/tagged out system.

Lockout/Tagout Procedures Checklist:

The following steps must be followed in sequence to properly lockout/tagout and re-establish energy:

I. Understand the hazard:

Electrical

Electrical Shock and or burn could result from contact with the exposed conductors line voltage or high voltage equipment. Flying parts or fire could result if this circuit were shorted. Electricity should be controlled at the circuit breaker, main switch, or fuse box.

Mechanical

Equipment or machinery can inflict tissue or skeletal injury through crushing, laceration or impalement. This can be controlled through the main electrical switch, plug, circuit breaker or anti-motion pin.

Thermal

May cause burns or fires. It can be controlled by the main electrical switch, electrical plug control, electrical circuit breaker, electrical fuse box, steam valve, fluid line valve or shielding.

II. Shutdown:

Know what type of energy the machine uses.

Identify its potential hazards.

Find the switches or other devices that control energy and need to be locked out.

Let employees know that you will be locking or tagging out the equipment and why.

Turn off the machine or equipment.

III. Isolate the source of energy

Electrical

- Locate the main switch box or circuit breaker.
- Open the breaker, open the switch or remove the plug.
- Attach a lockout enabling device if the circuit cannot otherwise accommodate a padlock.
- Place plug in a plug lock box.

Mechanical/Storage Potential Energy

- Lockout enabling device.
- Secure the energy controlling lockout by attaching a personal lock and completed tag to the lockout enabling device. If more than one person will be performing the work, each must apply their own lock to a multiple lock device.
- Release all stored energy.
- If there is a heat exposure, allow to cool.

Release from Lockout/Tagout

1. Inspect the surrounding area following completion of work for loose tools, parts, correct valve settings, system integrity, and exposed conductors.
2. Check that all machine guards are in place and reconnected if applicable.
3. Notify others in the area that the equipment is about to be made operational and returned to service.
4. Remove personal lock, tag, and lockout enabling device. This step must be performed by the same person who applied the tag and lock.

Lockout/Tagout Training

The lockout/tagout program is designed to train employees on disabling powered equipment from their power sources before beginning any servicing or maintenance work. Lockout/tagout training is required for all employees who may possibly need to lockout and tagout equipment.

Employees will receive annual training in the following areas:

1. Recognition of applicable hazardous energy sources.
2. Methods and Means necessary for energy isolation and control.
3. Restrictions and limitations of lockouts.

2. SPECIFICATIONS

Electrical

Power Input: 85-240VAC, 50/60Hz, 2A

Control Modes

Manual Control:

Manual control of the DC current via the DC power supply's front panel controls

Computer Control:

Computer control and monitoring of the electromagnet system is provided by an internal National Instruments USB-6343 multifunction data acquisition module.

Analog current setting resolution: 16 bits/ \pm 10 volts
Analog current & voltage monitor resolution: 16 bits/ \pm 10 volts
Digital monitoring of magnet, power supply, and other interlock inputs
Analog 3-axis magnetic field monitor input resolution: 16 bits
2 x temperature monitor input resolution: 16 bits/10 volts
Analog water flow meter monitor input resolution: 16 bits/10 volts

In addition to the reserved I/O channels listed above, there are several user I/O channels available.

10 Analog I/O Channels (with USB-6343)
8 Digital Channels

Mechanical

Form Factor:

3U fully enclosed rack mount chassis

Overall Dimensions:

482 Wide x 132 High x 581 Deep

Weight:

15.75 kgs (35 lbs)

3. INSTALLATION



In many cases, the 5972 Magnet Control and DC power supply will be pre-installed by GMW into a 19" EIA equipment rack. If it is not, care should be taken during rack mounting to avoid personal injury or damage to the equipment.

3.1. Unpacking Instructions and Damage Inspection

3.1.1 - Systems Shipped with a GMW Supplied Rack:

1. Remove all eight of the lag bolts located at the lower edge of all the side panels of the crate top cover.
2. Gently rock the crate top cover to work it loose from the shipping crate base.
3. Use one person on each side of the shipping crate grip the side panels of the crate top cover. Lift the crate top cover high enough to clear top of the rack, walk the cover sideways to a clear area and place it upon the floor.
4. Inspect the rack and its contents to ensure that no damage has occurred during shipment. If any damage is evident report the damage in detail to the shipper for claim and simultaneously notify GMW in case an assessment of the damage must be made. If no damage is found, proceed with the unpacking and installation.
5. Cut the straps that secure the rack to the pallet base.
6. Remove the wood block at the bottom front edge of the rack.
7. Carefully slide the rack forward and off of the pallet base.
8. Unpack any other system components as per their instruction manuals.

3.1.2 - Systems Shipped without a GMW Supplied Rack:

1. Open the shipping crate by removing the screws in the top panel.
2. Unstrap the 5972 Magnet Control from the crate.
3. Carefully lift the Magnet Control clear of the shipping carton.
4. Inspect the Magnet Control for any damage.
5. Retain all packing materials for future shipping needs.

3.2. Rack Mounting



When rack mounting the 5972 Magnet Control it is important to note that the vertical mounting flanges alone are not strong enough to support the weight of the 5972 Magnet Control. Support angles on each side, beneath the 5972 must also be used. Failure to use adequate support angles will result in equipment damage.

Take care when selecting a rack that it has enough depth to completely house the Magnet Control and DC Supply. The GMW-RC-1920 Bench Height Rack offered by GMW has an internal depth of 762mm (30"). Typical installations would put the DC supply at the bottom of the rack, with the Magnet Control just above, thus keeping the center of gravity as low as possible in the rack. Other instrumentation may then be installed in to the upper sections of the rack.

Note: Telco style racks are NOT appropriate for the Magnet Control and DC supply.

3.3 - Electrical Connections

Even if the 5972 Magnet Control was ordered as a complete system and assembled into a rack by GMW, it is still recommended to follow and verify the following section as connections may have loosened during shipment.

3.3.1 - DC Supply, Magnet Control, and Electromagnet Connections

1. Connect the DC Supply to Magnet Cable to the input +, input – and ground. This cable provides the DC power and ground between the DC power supply and the Magnet. Ensure that ALL connections are tight and that the polarity is correct.
2. Connect the Magnet Cable interlock plug to the Magnet Control.
3. Connect the Magnet Control to DC supply interface cable between the Magnet Control and the DC supply.

3.3.2 – Magnet Control Power

Connect an appropriate AC mains power cord to the Magnet Control.

3.3.1 - Magnet Supply Main Power

This procedure should be carried out by a qualified electrician.

1. Connect the DC Supply to the AC Mains service via an appropriate three-phase AC power disconnect / breaker panel.
2. Ensure that the Electromagnet and DC power supply grounds are connected. The DC power supply must be connected to the local service ground.

4. SOFTWARE

The 5972 Magnet Control is provided with basic control and monitoring software. This section covers the installation and basic operation of the software.

4.1 - Software Installation

Install the software packages in the order below. This should ensure that all components are correctly installed and working.

1. Install the National Instruments software and driver package, NI-DAQmx, according to the instructions in the National Instruments software manual. If the software is not included, it may be downloaded from the National Instruments web site.
2. Connect the Magnet Control to the computer.
3. Using the National Instruments software, Measurement and Automation Explorer, verify communication between the computer and the Magnet Control.
4. Install the GMW 5972 Magnet Control software.

There are two options when installing the software. The first is a basic run-time version that does not allow modification of the software. The second option is a set of virtual instruments (VIs) that may be modified to suite a custom application. Note that the ability to use the VI version requires the purchase of the complete National Instruments LabVIEW software package.

4.1.1 - Installing the Run Time software version

1. Insert the GMW supplied software disc in to the CD or DVD drive.
2. Run the setup.exe located in the directory \Installer\Volume.
This will install both the runtime and source VIs and by default, the installer will place the files in the directory c:\program files\GMW 597X\. You may change this at the time of installation.
3. After the setup has completed, read the readme file for any last minute changes or notes.

4.2 - Software Operation

Once the software is installed, it will be possible to control and monitor the magnet system using the supplied software.

4.2.1 - Running the software

1. The runtime version is accessed via the start menu:
Start > All Programs > GMW 597X > GMW_597X.exe
2. The source VIs are located in the directory c:\program files\GMW 597X\Source VI\
Note that LabVIEW 8.6.1 or later is required to run, view or modify the source VIs.

4.2.2 - Software Configuration

Upon the first run of the software, a simple configuration screen will be presented. Select the Voltage and current monitor ranges, and the programming voltage of either 5V or 10V full scale. If the power supply that is being used is not listed, enter the maximum voltage and current of the DC power supply that you have. Then select the address of the USB-6343 DAQ from the list. You may also enter the default directory to be used for storing data generated from the data logger.

Save and exit the configuration screen.

4.2.3 - Basic Operation

Once configured, the normal operation screen will be presented. This screen provides control of current and monitoring of the DC power supply's output voltage and current. It also provides status read back of the Electromagnet interlock status.

It is important to note that when operating remotely, the DC Power Supply front panel controls be set as follows: Voltage to Maximum, Current to zero. If this is not done, the DC Power Supply will be voltage limited and full output current may not be achieved.

4.2.4 - Local / Remote

The 5972 Magnet Control software defaults to local operation. In order to control the DC power supply it must first be placed into the 'Remote' mode. This is done by clicking on the Local / Remote' Control. This control will change its state depending on what mode it is in. The two states are:

'Local' - The control is green and displays the legend 'Push for Remote'

'Remote' - The control is yellow and displays the legend 'Push for Local'

4.2.5 - Setting the output current

The output current is simply set by entering the desired output current in the current control box.

4.2.6 - Data Logging

There are a few things to set up in order to use the data logger:

1. Push the 'Create Log File' button. This will open a dialog box that will prompt for the file name of the log file. If the file exists, it will prompt for confirmation to over write the existing file.
2. Enter a log file sample interval (in mili-seconds). Set to 0 to log every sample.

Note at this time, data is NOT being logged.

3. To start the logging, click on the green 'Start Logging' button. The button will then change to a red 'Pause Logging' Button.
4. To stop or pause the logging, click on the red 'Pause Logging' button. The button will change back to the green 'Start Logging' button.
5. To close the log file, click on the 'Close Log File' button.

4.2.7 - Status Read Back

This software will read back the 5972 Magnet Control status regardless of its Local / Remote status. The status read back consists of three interlock indicators and the general status indicators.

If any one of the interlock conditions exists, the corresponding indicator will flash on the screen and the DC power supply's output will be disabled.

5. 5972 OVERVIEW

5.1 - Description

The 5972 Magnet Control is comprised of several sections: The display and interlock control electronics, a National Instruments USB-6343 Control with USB interface and an auxiliary power supply all integrated into a single 19" rack mounting chassis. Refer to drawing no. 13907-0115-0, Rev. B for an internal block diagram.

The internal power supply provides power for the display, interlock control circuitry, and the NI USB-6343. It also provides power on the rear panel for an optional external Senis Magnetic Field Transducer, Temperature Monitors, and Flow Meter power.

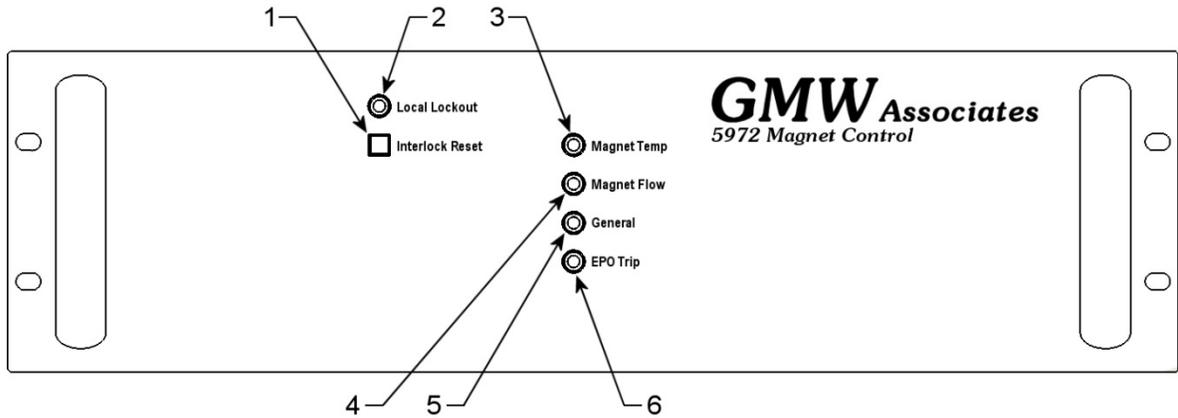
The interlock circuit for the magnet requires a 'closed contact' connection. Provision for both the magnet over temperature and water flow switches are provided. An open circuit on either of the magnet interlocks of either circuit is indicated on the front panel of the Magnet Control. When using the NI USB-6343, this information is available via the computer control software. In the event of a magnet interlock fault, the DC supply is placed in a standby mode and the output is inhibited.

A General interlock input has been provided and is available for user connection. If the 5972 Magnet Control has been installed into a rack by GMW, this input will be connected to the rear door switch of the rack. Opening the rear door will open the interlock circuit and the DC power supply output will be inhibited. It is possible to connect other user interlock switches IN SERIES on this interlock circuit. All switches should be 'Normally Open' and configured to OPEN on the fault condition.

An external interlock is provided as a monitor of an Emergency Off system. It is included in the 5972 Magnet Control interlock chain to provide positive latching to inhibit the DC power supply output once the EMO has been reset and power restored. This is a 'Normally Open' input and the circuit must be CLOSED to satisfy the interlock logic. Opening the circuit will disable the DC power supply output.

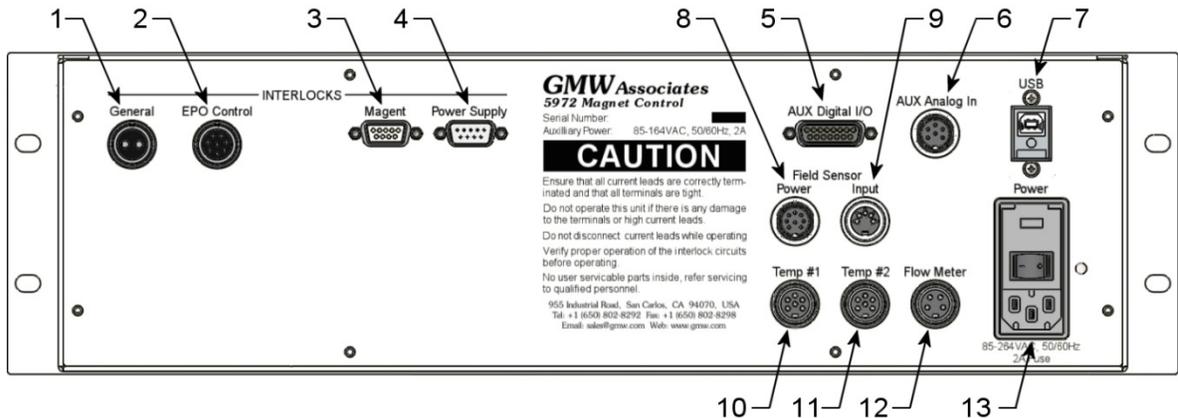
The NI USB-6343 interface provides computer control and monitoring of the system. It provides a 16-bit analog output ($\pm 10V$) as a programming signal to the DC supply. The output voltage and current are monitored by two 16-bit input channels. The magnet interlock status is also monitored via its digital input channels. Additional analog channels are used for monitoring optional Senis single or three-axis field transducers. An Auxiliary Analog Input connector allows for up to ten additional analog inputs with user settable full-scale inputs from $\pm 2V$ to $\pm 10V$. For more information, please refer to the NI USB-6343 Manual and section 4.5 of this manual.

5.1.1 - Figure 1 - Front Panel - Standard Version



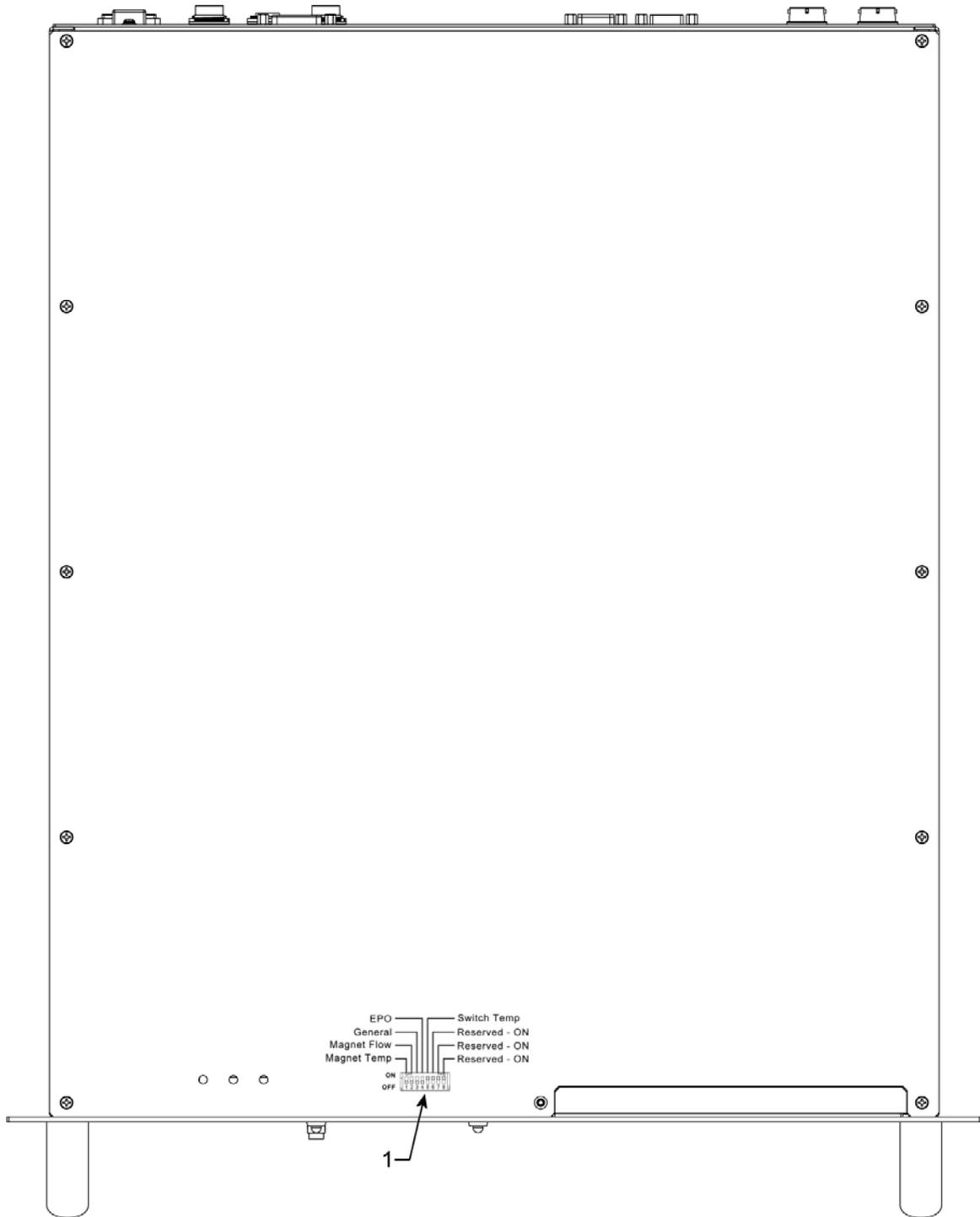
1. Interlock Reset Switch
2. Local Lockout Indicator
3. Magnet Over Temperature Indicator
4. Magnet Water Flow Failure Indicator
5. General Interlock Indicator
6. EPO Trip Indicator

5.1.2 - Figure 2 - Rear Panel - Standard Version



1. General Interlock input - Normally closed - Open on fault.
2. EPO Control I/O
3. Magnet Interlock Connection
4. Power Supply Interlock Connection
5. Aux DAQ Digital I/O.
6. Auxiliary Analog Inputs:
7. USB Port - Type B USB connection for computer control
8. Sensor Power - $\pm 12V$ power for Senis Magnetic Field Transducer
9. Sensor Input - Senis analog Magnetic Field Transducer input
10. Temperature Monitors 1 and 2 input
11. Temperature Monitors 3 and 4 input
12. Flow Meter input
13. AC Mains Input, Power Switch, & Fuse Holder - 115 - 220VAC, 2A

5.1.3 - Figure 3 - Top Cover



1. Interlock By-Pass Switch (SW1)

5.2 - 5972 Interlock

The interlock logic of the 5972 has been updated and now includes a latching DC power supply inhibit circuit. When an interlock event occurs, the circuit will latch the DC power supply in to a 'standby' state. This prevents the output of the DC power supply from automatically resuming its output when the interlock condition clears. To resume the DC power supply output, the 'Standby Reset' button on the front panel of the 5972 must be pressed to reset the latch. Each time the 5972 is powered 'On' the DC power supply standby is latched, requiring the 'standby Reset' to be pressed to enable the DC power supply output.

Before using the 5972 Magnet Control, the interlocks should be configured. If the Magnet Control is part of a complete system provided by GMW, this procedure will most likely have been done for you.



If the 5972 is being operated in the REMOTE mode, the interlock reset button on the front panel of the 5972 is disabled, and a reset of the 5972 interlocks may be accomplished via the USB interface.

5.2.1 - Temperature and Water Flow Interlocks:

This interlock activates on an open circuit. All GMW electromagnets will provide an over temperature interlock circuit, and most will also provide a water flow switch interlock circuit. These interlock circuits are monitored separately. If the water flow switch circuit is not provided, the interlock must be bypassed.

5.2.2 - General Interlock:

This interlock activates on an open circuit. The General Interlock input provides for an additional external interlock input. On rack-mounted systems provided by GMW, this input will be connected to the rear door. Interlock switches may be added in series to this circuit.

5.2.3 - EMO Interlock:

This interlock requires an external DC voltage (12v, nominal, 48V max.) to activate. The EMO interlock input provides for monitoring of the EMO controlling the AC mains power input of the DC power supply. If the EMO is tripped and power is removed from the DC supply, the 5972 Magnet Control will enter an interlocked state, inhibiting the DC power supply output. This will prevent the power supply from returning to its last set output when AC main power is restored. By default, this interlock is bypassed.

5.3 - Interlock Operational Checks



Before beginning this procedure first verify that the DC output cables between the DC Power Supply and the electromagnet are correctly connected and the connections are tight. Also ensure that the DC output controls of the DC power supply for voltage and current are set to zero.

Once the interlocks are configured and connected, it is recommended that the interlock functionality be verified for proper function prior to operation of the magnet system. The procedure below should be followed to verify the interlock chain is working correctly.

1. If the electromagnet is water cooled, verify that the cooling water is flowing at the correct flow rate.
2. Switch the 5972 Magnet Control on, but leave the DC power supply unpowered.

All interlock indicators should show a green aspect, and the 'Interlock Reset' switch should be illuminated. When the 'Interlock Reset' button is pressed, its light should go out and enable the DC power supply.

- Test each of the interlock inputs in turn. When an interlock connection is broken, its corresponding indicator will show red and the Interlock Reset switch will illuminate. Reconnecting the interlock will cause its indicator to show green. Pressing the 'Interlock Reset' switch will enable the DC power supply.

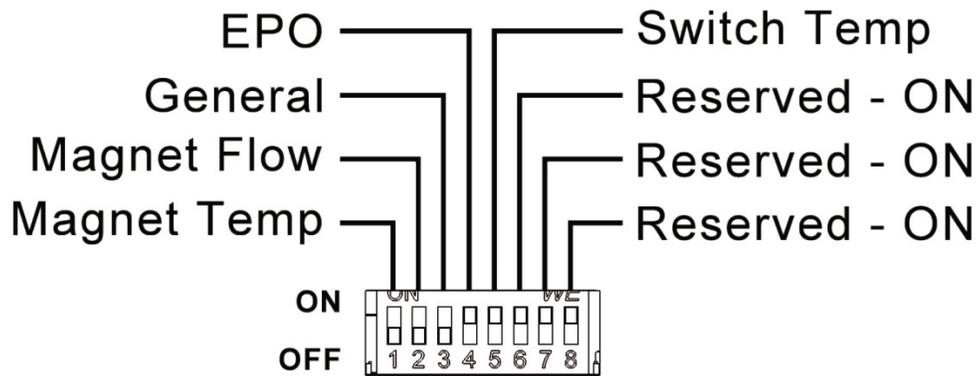
5.4 - Interlock By-Pass



If an interlock is not used, it must be by-passed. It is important to only bypass the interlocks that are not being used or damage to the electromagnet and other equipment may occur.

The interlock bypass switch access is located at the front, center of the top cover of the 5972.

5.4.1 - Figure 4 - Interlock By-Pass Switch



5.4.2 - SW1, Interlock By-Pass Switch - Default Positions

SW1-1	Magnet Temp	OFF	SW1-5	Switch Temp	ON
SW1-2	Magnet Flow	OFF	SW1-6	RESERVED	ON
SW1-3	General	OFF	SW1-7	RESERVED	ON
SW1-4	EPO	ON	SW1-8	RESERVED	ON

To by-pass an interlock, move its switch to the 'ON' position. Note that the last four switch sections (SW1-5 to SW1-8) are not used on the 5972 and must remain in the 'ON' position

5.4.3 - Power Supply Checks

Once the interlocks have been verified as operational, it is time to check that power supply functions as expected. Insure that the 'Voltage' and 'Current' controls on the DC supply are turned down to their minimum values and switch on the DC power supply. Slowly turn up the voltage and current controls until about 5 amps is indicated on the DC supply display. Refer to the power supply operators manual for more details.

It is important to note that for normal operation, the DC power supply voltage be set at Maximum. If this is not done, the DC power supply will be voltage limited and full output current may not be achieved.

With Kepco Bipolar power supplies, typically only the current control need be operated.

6. 5972 OPERATION

6.1 - In manual operation, the 5972 Magnet Control without a computer and provides basic monitoring of the magnet systems interlock status only. All other features such as current and voltage monitoring, magnet field monitoring, and access to the auxiliary digital and analog channels require an external control computer.



Most magnet power supply's (both DC and AC) will have controls for both voltage and current output limits. It is recommended to operate the power supply in CURRENT mode. To accomplish this, the voltage control is typically set to its maximum, and the power supply output is controlled by the current control. Some magnet power supplies are configured to operate in current mode exclusively, and have no voltage control.

Certain power supplies have no manual controls and may only be controlled via a $\pm 10V$ current programming input. One such power supply is the IECO MPS-400-200-GSG.

6.1.1 - System Startup - Manual Operation

1. Prior to applying AC mains power, ensure that the DC power supply's voltage and current controls are at their minimum settings.
2. Turn on the 5972 Magnet Control and DC power supply. At this point the DC power supply output will be inhibited by the 5972 Magnet Control's interlock circuits. Set the DC power supply's VOLTAGE control to maximum. Leave the CURRENT control at its minimum.
3. Turn ON the electromagnet's cooling water supply.
4. Verify that all interlock status lights on the 5972 Magnet Control are green, indicating that no faults are present. The 'Interlock Reset' switch should be illuminated, indicating that the DC power supply's output is inhibited.
5. Enable the DC power supply's output by pressing the 'Interlock Reset' button on the 5972 Magnet Control. The light should go out.

Note that when the 5972 is operating in REMOTE mode, the Interlock Reset button is inhibited and the reset must be accomplished via the USB interface.

6. Adjust the DC power supply's current to the desired levels.

6.1.2 - System Shut Down - Manual Operation

1. Set the DC power supply's voltage and current controls are at their minimum settings.

2. Turn OFF the electromagnet's cooling water supply.
3. Turn the DC power supply's mains input.
4. Turn off the 5972 Magnet Control.

6.2 - In remote, computer controlled operation the 5972 Magnet Control provides access to all of its features. The interface of the 5972 is accomplished utilizing a National Instruments USB-6343. A simple and easy to use LabVIEW program allows access to functions of the 5972 as well as the three axis field transducer (ordered separately), temperature monitor inputs, and the flow meter input. Auxiliary analog and digital channels for user allocation are supported as well.

On systems that are delivered as fully configured with a computer, the required software will already have been installed and set up.

6.2.1 - System Startup - Computer Control

1. Prior to applying AC mains power, ensure that the DC power supply's voltage and current controls are at their minimum settings.
2. Turn on the control computer.
3. Turn on the 5972 Magnet Control and DC power supply. Set the DC power supply's voltage output to maximum and leave the current control at its minimum. At this point the DC power supply output will be inhibited by the 5972 Magnet Control's interlock circuits.
4. Launch the 597X control software, and set the 5972 Magnet Control into 'Remote' mode by clicking on the 'Press for Remote' button on the screen. The various status indicators on the screen should mirror the status indicators on the 5972 Magnet Control's front panel
5. Turn ON the electromagnet's cooling water supply.
6. Verify that all interlock status lights on the 5972 Magnet Control are green, indicating that no faults are present. The 'Interlock Reset' switch should be illuminated, indicating that the DC power supply's output is inhibited. The 'Interlock Reset' button on the computer screen should also be active.
8. Enable the DC power supply's output by pressing the 'Standby Reset' button on the 5972 Magnet Control software. The light should go out.
9. Set the DC Power Supply's output current to the desired levels using the computer interface.

6.2.2 - System Shut Down - Computer Control

1. Set the DC power supply's voltage and current controls are to their minimum settings.
2. Turn OFF the electromagnet's cooling water supply.

3. Turn the DC power supply's mains input.
4. Turn off the 5972 Magnet Control.

7. MAINTENANCE

The 5972 is designed to be as maintenance free as possible. There are no user serviceable components inside the 5972 case. Maintenance should be limited to periodically wiping the front panel down with a soft cloth.

8. ACCESSORIES

GMW offers several accessories to expand upon the capabilities of the 5972 Magnet Control.

8.1. - Hall Effect Sensor

For Magnetic Field Measurement, GMW offers the I1A series from Senis (various sensitivities and packages available) as single axis probe or F3A series for three-axis solutions.

8.2. - Temperature Sensors

The 5972 has four channels dedicated for temperature measurements, a dual channel K-type thermocouple amplifier module is available. Order part number: 11907-0670-0. If two channels are required, order two.

8.3. - Water Flow Sensors

A water flow meter input is available for use with SMC PF3W Series Digital Flow Meters. Other flow meters are not supported.

8.4. - Power Supply Control Cables

Power supply control cables are offered for power supplies from Ametek, IECO, Kepco, and Sorensen. Cables are 2.5 meters long.

8.5. - Rack Door Interlock Switch Kit

The addition of a rack door interlock switch can provide added safety to a magnet system by inhibiting the output of the DC power supply to the magnet when the rack rear door is opened. This kit consists of a connecting cable and a door frame mounted switch. It is included in systems that are ordered with a rack.

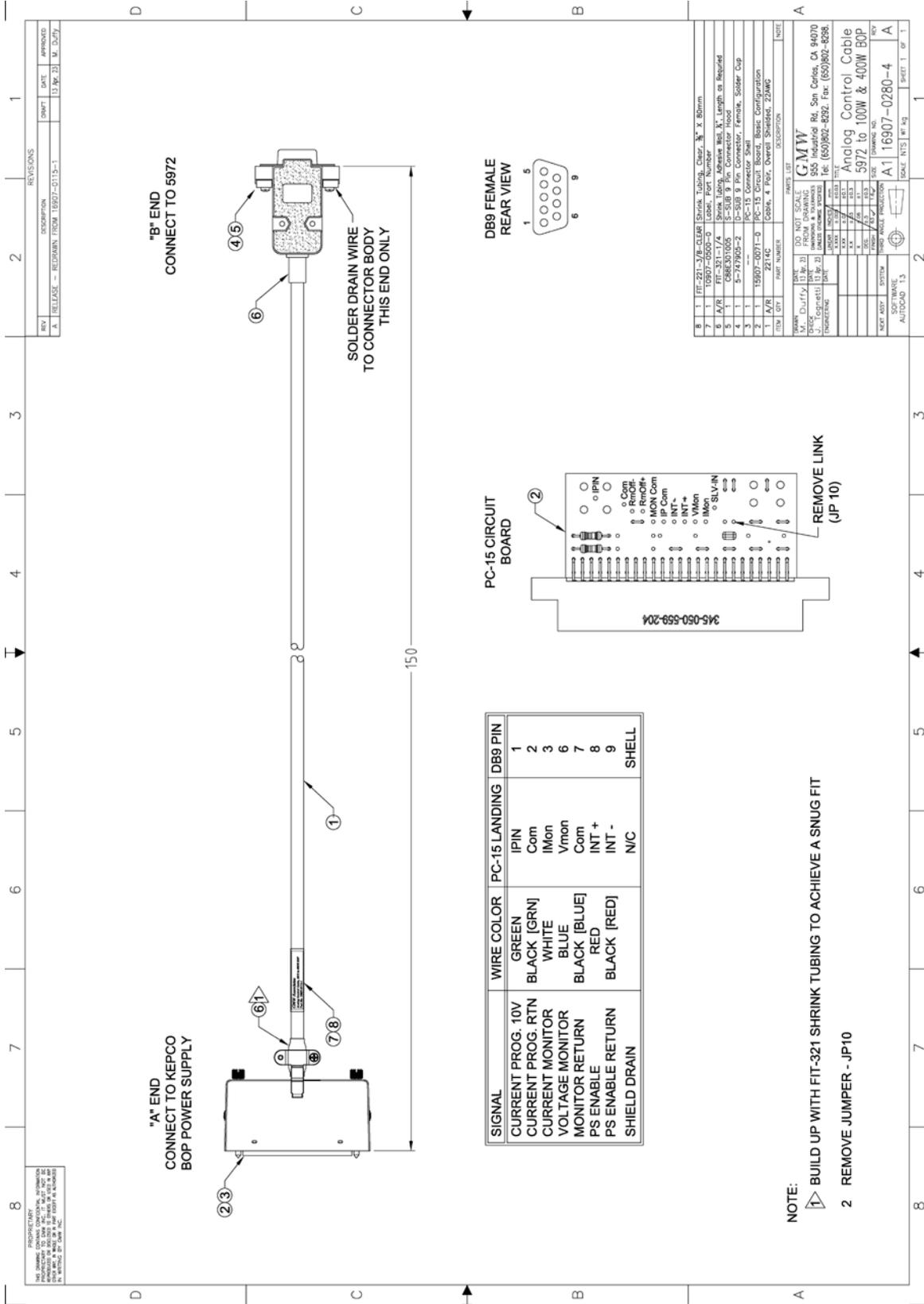
Note that this option does NOT remove the AC mains power from the power supply. If it is a requirement to remove the AC mains power from the DC power supply, an additional Emergency Off system (EMO) would be needed.

Please contact GMW for more information sales@gmw.com.

9. CABLE DRAWINGS

9.1.	Drawing 16907-0280-1 - Power Supply Control Cable, 3kW DLM	22
9.2.	Drawing 16907-0280-2 - Power Supply Control Cable, SGA	23
9.3.	Drawing 16907-0100-5 - Power Supply Control Cable, IECO BPS	24
9.4.	Drawing 16907-0280-4 - Power Supply Control Cable, Kepco 400W BOP	25
9.5.	Drawing 16907-0280-5 - Power Supply Control Cable, Kepco 1kW BOP	26

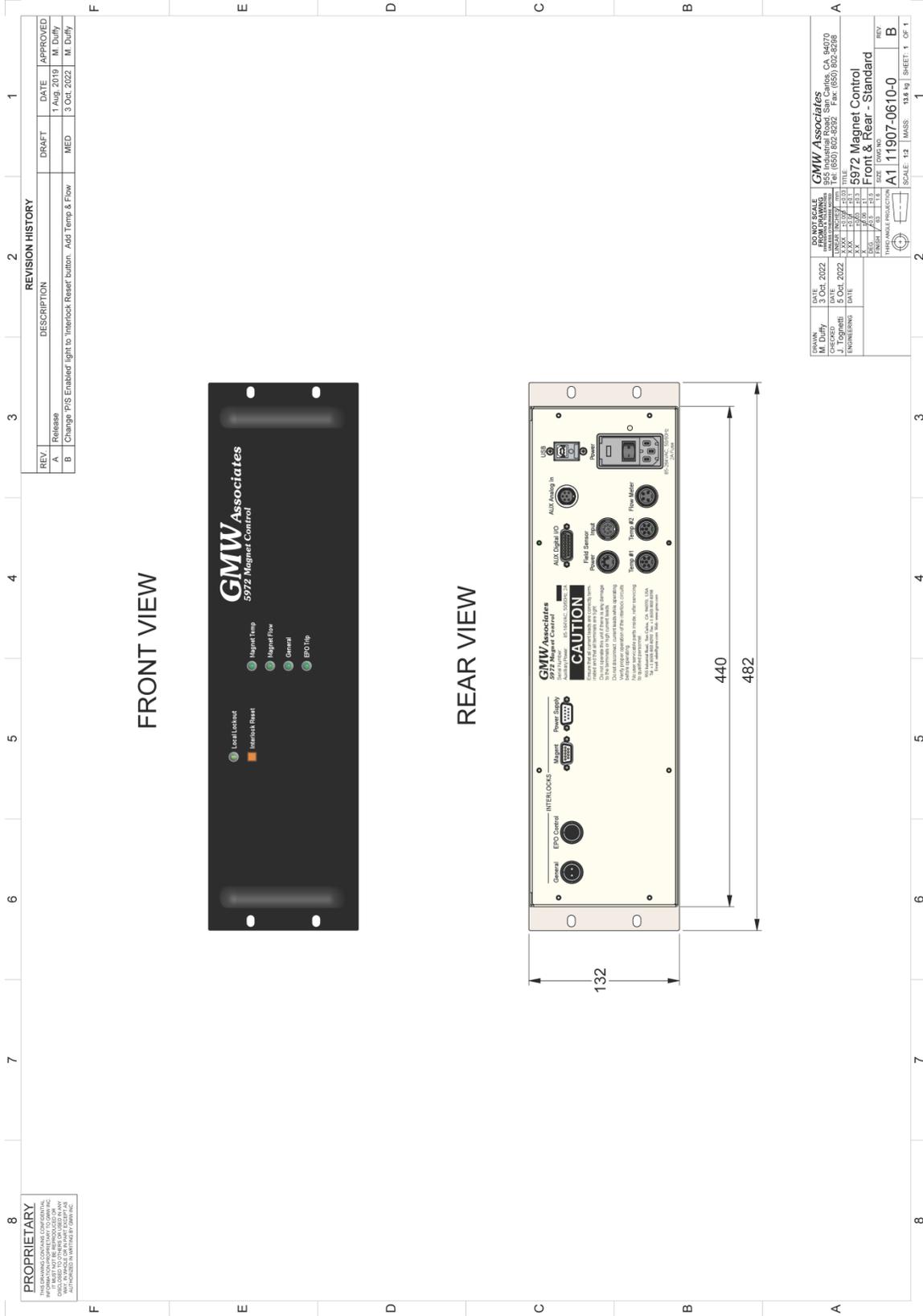
9.4. Drawing 16907-0280-4, Power Supply Control Cable 5972 to 100 & 400W Kepco BOP



10. TECHNICAL REFERENCE

10.1	Drawing 11907-0610-0 - 5972 Magnet Control, Front & Rear Views	27
10.2	Drawing 11907-0610-1 - 5972 Magnet Control, Side View	28
10.3	Drawing 11907-0610-2 - 5972 Magnet Control, Top View	29
10.4.	Drawing 13907-0115-0 - 5972 Magnet Control, Internal Block Diagram	30
10.5.	USB-6343 DAQ Connections	31
10.6	Interlock Circuits	33
10.7	Connector Pin-outs	34

10.1. Drawing 11907-0610-0 - 5972 Magnet Control Front and Rear Views



REV	DESCRIPTION	DRAFT	DATE	APPROVED
A	Release		1 Aug. 2019	M. Duffy
B	Change PDS Enabled light to "Interlock Reset" button. Add Temp & Flow	MED	3 Oct. 2022	M. Duffy

REVISION HISTORY

8 7 6 5 4 3 2 1

PROPRIETARY
 THIS DRAWING IS CONFIDENTIAL AND NOT BE LOANED, REPRODUCED, COPIED, OR IN ANY MANNER DISCLOSED TO ANY OTHER PERSON WITHOUT THE WRITTEN PERMISSION OF GMW ASSOCIATES. UNAUTHORIZED REVISIONS BY OTHERS ARE PROHIBITED.

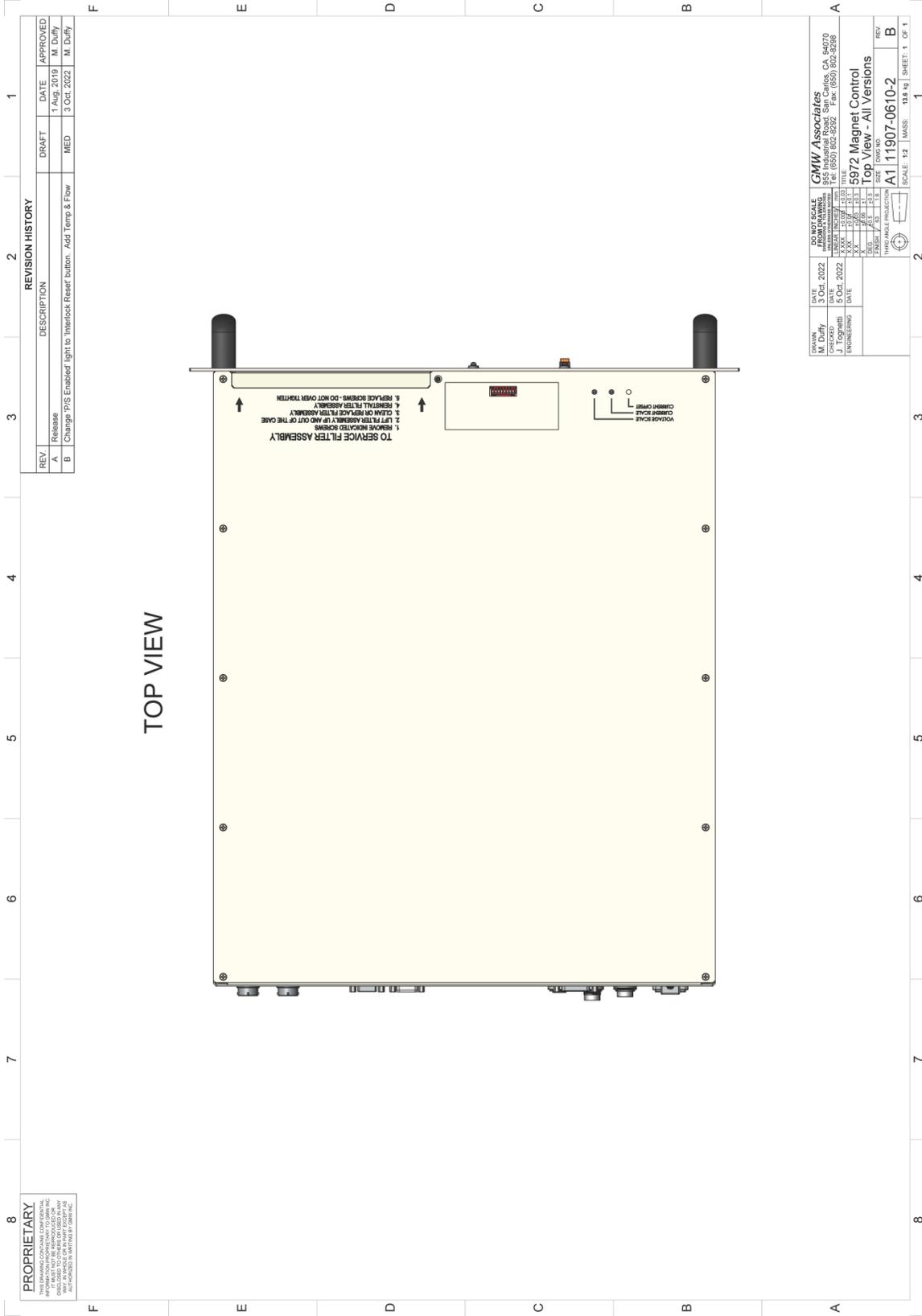
DATE	BY	REVISION
3 Oct. 2022	M. Duffy	Release
5 Oct. 2022	J. Tognarelli	Change PDS Enabled light to "Interlock Reset" button. Add Temp & Flow

DATE	BY	REVISION
3 Oct. 2022	M. Duffy	Release
5 Oct. 2022	J. Tognarelli	Change PDS Enabled light to "Interlock Reset" button. Add Temp & Flow

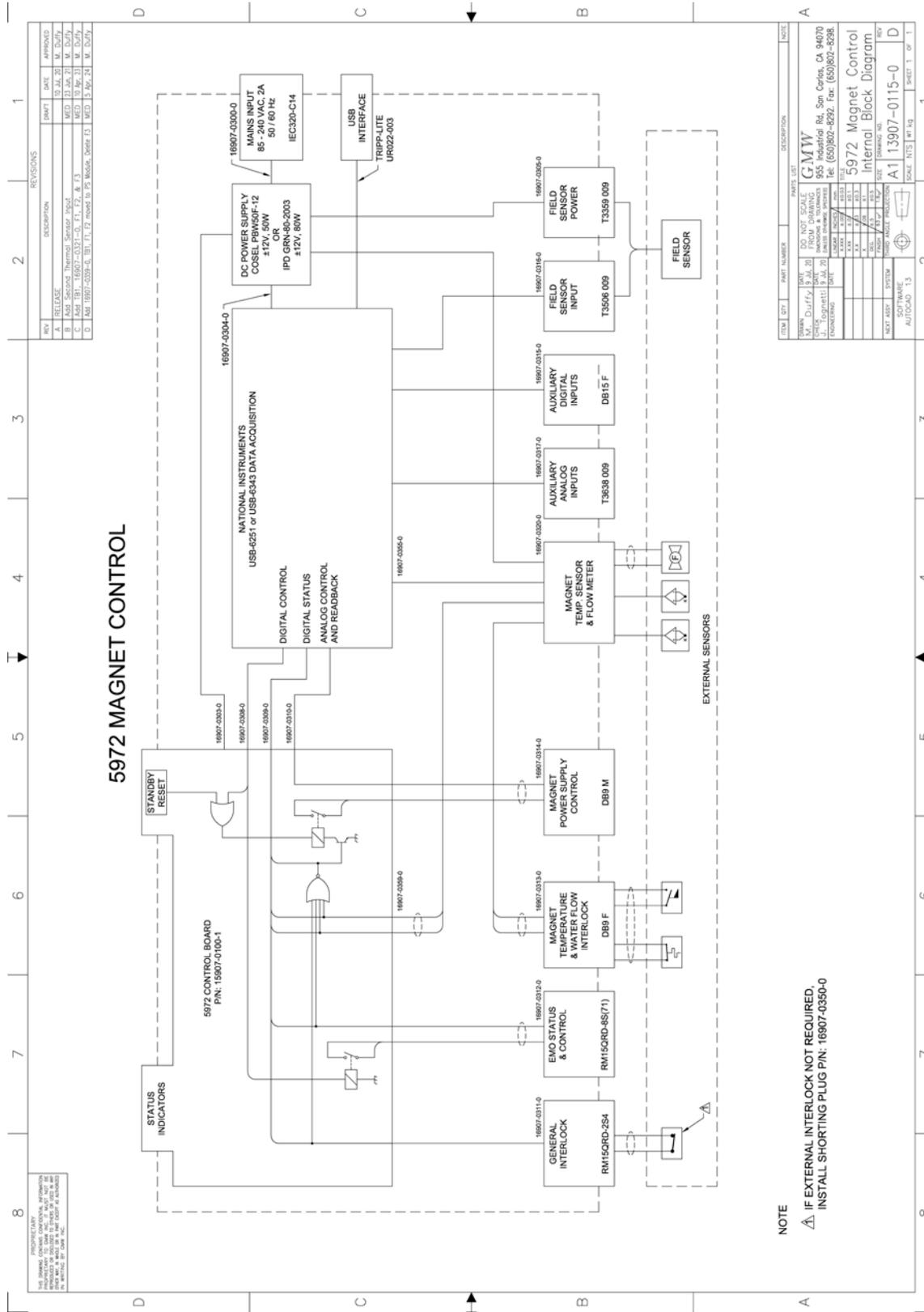
GMW Associates
 11907-0610-0
 5972 Magnet Control
 Front & Rear - Standard

SCALE: 12 | MASS: 13.6 lb | SHEET: 1 OF 1

10.3. Drawing 11907-0610-2 - 5972 Magnet Control Top View



10.4. Drawing 13907-0115-0, 5972 Magnet Control Internal Block Diagram



REV	DESCRIPTION	DATE	BY	APP'D
A	RELEASE	03 JAN 20	M. DUFFY	
B	ADD Second Thermal Sensor Input	23 JAN 21	M. DUFFY	
C	ADD 1B1 - 16907-0337-0, F1, F2, & F3	09 MAR 21	M. DUFFY	
D	ADD 16907-0309-0, 1B1, F1, F2 moved to TP Module, Delete 13	10 SEP 20	M. DUFFY	

ITEM	QTY	PART NUMBER	DESCRIPTION	NOTE
1	1	16907-0304-0	NATIONAL INSTRUMENTS USB-6251 or USB-6340 DATA ACQUISITION	
2	1	16907-0300-0	DC POWER SUPPLY COSELE 16905F-12 24VDC 1.5A 30W OR IPD GRN-80-2003 ±12V, 80W	
3	1	16907-0306-0	FIELD SENSOR POWER T3359 009	
4	1	16907-0316-0	FIELD SENSOR INPUT T3506 009	
5	1	16907-0316-0	AUXILIARY DIGITAL INPUTS DB15 F	
6	1	16907-0317-0	AUXILIARY ANALOG INPUTS T3638 009	
7	1	16907-0300-0	MAGNET TEMP. SENSOR & FLOW METER	
8	1	16907-0314-0	MAGNET POWER SUPPLY CONTROL DB9 M	
9	1	16907-0313-0	MAGNET TEMPERATURE & WATER FLOW INTERLOCK DB9 F	
10	1	16907-0312-0	EWO STATUS & CONTROL RM15QRD-4S(71)	
11	1	16907-0311-0	GENERAL INTERLOCK RM15QRD-2S4	
12	1	16907-0302-0	USB INTERFACE TRIPP-LITE UR0322-003	

DO NOT SCALE FROM DRAWING CHECK DIMENSIONS FROM PARTS LIST

SCALE: 1:1

DATE: 10/20/20

BY: M. DUFFY

APP'D: M. DUFFY

PROJECT: 5972 Magnet Control Internal Block Diagram

SCALE: 1:1

SHEET 1 OF 1

10.5. USB DAQ Connections

GMW offers the National Instruments USB-6343 DAQ. This together with GMW's Magnet Control software provides control and monitoring of the 5972 Magnet Control. Custom software may be used to control the 5972 with the USB DAQ. The tables below describe the channels used and their functions for the two different DAQ models.

USB-6343 Connections - RESERVED			
Signal	Type	Direction	6343 Terminal
Current Control Output 10V output proportional to 100% current output	Analog S.E.	Output	AO-0
Current Control Common	Ground	Ground	AO-GND
Voltage Monitor 10V / 100% of the power supply's rated output voltage	Analog S.E.	Input	AI-0
Voltage Monitor Common	Analog	Input	AI-GND
Current Monitor (+) 10V / 100% of the power supply's rated output current	Analog S.E.	Input	AI-1
- Reserved -	Analog	Input	AI-9
Current Monitor Common	Analog	Input	AI-GND
Analog Flow Meter	Analog	Input	AI-8
Y-Axis Field Monitor +	Analog	Input	AI-2
Y-Axis Field Monitor -	Analog	Input	AI-10
X-Axis Field Monitor +	Analog	Input	AI-3
X-Axis Field Monitor -	Analog	Input	AI-11
Z-Axis Field Monitor +	Analog	Input	AI-4
Z-Axis Field Monitor -	Analog	Input	AI-12
Field Monitor Common	Ground	Ground	AI-GND
Temperature Monitor #1	Analog	Input	AI-7
Temperature Monitor #2	Analog	Input	AI-15
Temperature Monitor #3	Analog	Input	AI-16
Temperature Monitor #4	Analog	Input	AI-24
- Reserved -	Digital	-	P0.0
Switch Temp - Low = Okay	Digital	Input	P0.1
Magnet Flow - Low = Okay	Digital	Input	P0.2
Magnet Temperature - Low = Okay	Digital	Input	P0.3
P/S Standby - Low = On Standby	Digital	Input	P0.4
Polarity Status - High = Forward	Digital	Input	P0.5
Local Lockout - High = Remote	Digital	Output	P0.6
Polarity Control - High = Forward	Digital	Output	P0.7
General Interlock - Low = Okay	Digital	Input	P1.0
EPO Trip - Low = Okay	Digital	Input	P1.1
EPO Control - High = Shut down	Digital	Output	P1.2
Standby Reset = Reset Standby	Digital	Output	P1.3
- Reserved -	Digital	-	P1.4 - P1.7
Interlock Status Common	Ground	Ground	DGND

USB-6343 Connections - USER ACCESSABLE

The unused analog input and digital I/O channels below are available on the rear panel of the 5972 for user connection. The analog channels may be configured as single-ended or differential inputs.

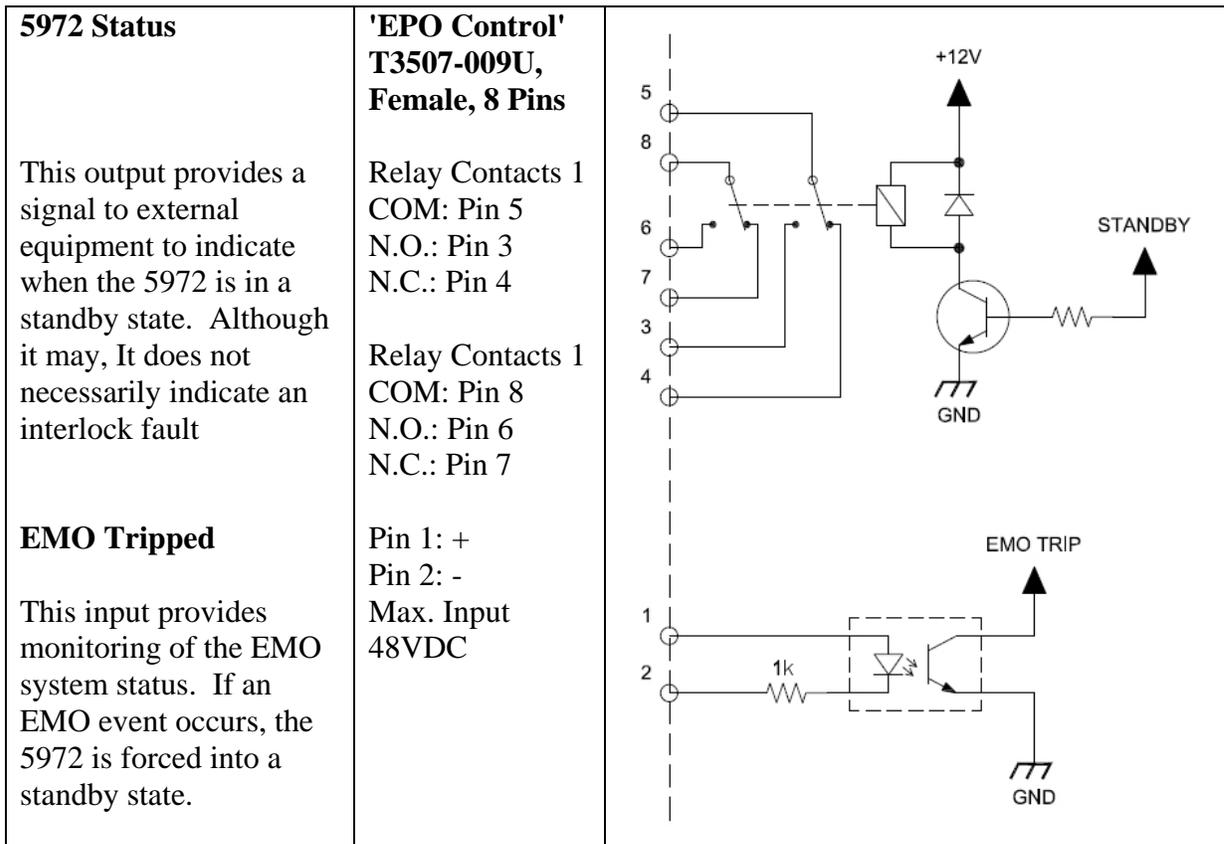
The full-scale ranges of the analog input channels may be configured as $\pm 2V$, $\pm 5V$, or $\pm 10V$. The digital channels may be configured as either input or output.

Signal	Type	Direction	6343 Terminal
Analog Channel 19	Analog	Input	AI-19
Analog Channel 20	Analog	Input	AI-20
Analog Channel 21	Analog	Input	AI-21
Analog Channel 22	Analog	Input	AI-22
Analog Channel 23	Analog	Input	AI-23
Analog Channel 27	Analog	Input	AI-27
Analog Channel 28	Analog	Input	AI-28
Analog Channel 29	Analog	Input	AI-29
Analog Channel 30	Analog	Input	AI-30
Analog Channel 31	Analog	Input	AI-31
Digital Channel P.0	Digital	Input or Output	P2.0
Digital Channel P.1	Digital	Input or Output	P2.1
Digital Channel P.2	Digital	Input or Output	P2.2
Digital Channel P.3	Digital	Input or Output	P2.3
Digital Channel P.4	Digital	Input or Output	P2.4
Digital Channel P.5	Digital	Input or Output	P2.5
Digital Channel P.6	Digital	Input or Output	P2.6
Digital Channel P.7	Digital	Input or Output	P2.7
Digital Common	Ground	-	DGND
+5V Power	Power	-	+5V

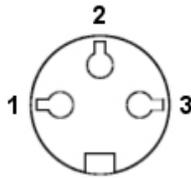
Please refer to the National Instruments USB-6343 DAQ manual for configuring the analog and digital channel inputs.

10.6. Interlock Circuits

Interlock	Connector	Circuit
<p>Magnet Temperature</p> <p>Thermal switches OPEN on magnet coil over temperature</p>	<p>'Magnet' DB9, Female</p> <p>Pins 6 & 9</p>	
<p>Magnet Flow</p> <p>Flow switch OPENS when water flow rate is below acceptable limits</p>	<p>'Magnet' DB9, Female</p> <p>Pins 1 & 5</p>	
<p>General</p> <p>Auxiliary interlock input, switches OPEN on fault. More than one switch may be daisy-chained.</p>	<p>'General' T3263-009, Female, 3 Pins</p> <p>Pins 1 & 3</p>	

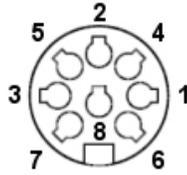


10.7. Connector Pin-Outs



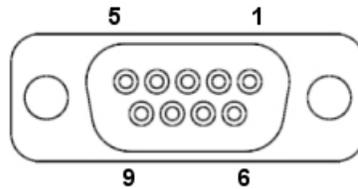
GENERAL INTERLOCK CONNECTOR, Amphenol T3263-009, Female Mating Connector: Amphenol T3260-001U

Pin	Function	Description
1	General Interlock Out	Source of General Interlock Switch, Connect to Pin 3 to satisfy the general interlock
2	NO CONNECTION	
3	General Interlock Return	Isolated Ground



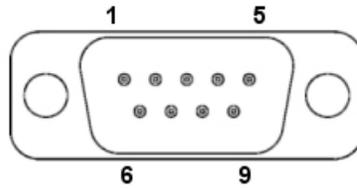
STATUS CONNECTOR, Amphenol T3507-009, Female
Mating Connector: Amphenol T3504-001U

Pin	Function	Description
1		
2		
3		
4		
5		
6		
7		
8		



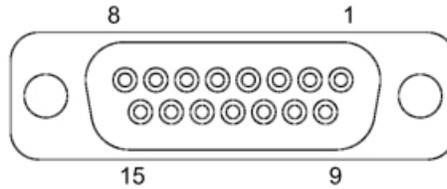
MAGNET INTERLOCK CONNECTOR, DB9, Female

Pin	Function	Description
1	Flow Interlock Out	Source for Flow Interlock Switch, Connect to Pin 5 to satisfy the flow interlock
2 - 4	NO CONNECTION	
5	Flow Interlock Return	Isolated Ground
6	Temp Interlock Out	Source for Temp Interlock Switch, Connect to Pin 9 to satisfy the flow interlock
7, 8	NO CONNECTION	
9	Temp Interlock Return	Isolated Ground
9	PS ENABLE RETURN	Power Supply Enable Return



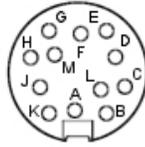
POWER SUPPLY CONTROL CONNECTOR, DB9, Male

Pin	Function	Description
1	IP 10V	Power Supply Current Control output, $\pm 10V$
2	IP 10V Return	Return for Power Supply Current Control output
3	I MON +	Power Supply Current Monitor input, 10V = full scale
4	REMOTE	Power Supply Remote, connect to pin 5 for remote
5	REMOTE RETURN	Power Supply Remote Return
6	V MON+	Power Supply Voltage Monitor input, 10V = full scale
7	COM	Power Supply Analog Common
8	PS ENABLE	Power Supply Enable, connect to pin 9 to enable



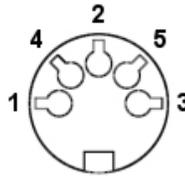
DIGITAL I/O CONNECTOR, DB15, Female

Pin	Function	Description
1	+5V OUTPUT	+5V Output available for user connection, tied to Pin 2
2	+5V OUTPUT	+5V Output available for user connection, tied to Pin 1
3	D I/O CH 1	Digitail I/O, channel 1, DAQ P1.6
4	D I/O CH	Digitail I/O, channel 2, DAQ P1.7
5	D I/O CH	Digitail I/O, channel 3, DAQ P2.0
6	D I/O CH	Digitail I/O, channel 4, DAQ P2.1
7	D I/O CH	Digitail I/O, channel 5, DAQ P2.2
8	D I/O CH	Digitail I/O, channel 6, DAQ P2.3
9	D I/O CH	Digitail I/O, channel 7, DAQ P2.4
10	D I/O CH	Digitail I/O, channel 8, DAQ P2.5
11	D I/O CH	Digitail I/O, channel 9, DAQ P2.6
12	D I/O CH	Digitail I/O, channel 10, DAQ P2.7
13	DGND	Digital Ground, tied to pins 14 & 15
14	DGND	Digital Ground, tied to pins 13 & 15
15	DGND	Digital Ground, tied to pins 13 & 14



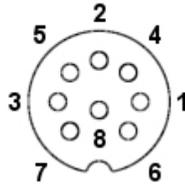
HALL PROBE POWER CONNECTOR, Amphenol T3638-009, Female
Mating Connector: Amphenol T3635-001U

Pin	Function	Description
A	ANALOG I/O CH. A+	Analog I/O, Channel A+, DAQ AI-19
B	ANALOG I/O CH. A-	Analog I/O, Channel A-, DAQ AI-27
C	ANALOG I/O CH. B+	Analog I/O, Channel B+, DAQ AI-20
D	ANALOG I/O CH. B-	Analog I/O, Channel B-, DAQ AI-28
E	ANALOG I/O CH. C+	Analog I/O, Channel C+, DAQ AI-21
F	ANALOG I/O CH. C-	Analog I/O, Channel C-, DAQ AI-29
G	ANALOG I/O CH. D+	Analog I/O, Channel D+, DAQ AI-22
H	ANALOG I/O CH. D-	Analog I/O, Channel D-, DAQ AI-30
L	ANALOG I/O CH. E+	Analog I/O, Channel E+, DAQ AI-23
M	ANALOG I/O CH. E-	Analog I/O, Channel E-, DAQ AI-31
J	AGND	Analog Ground
K	SHIELD	Cable shield, connect cable drain wire here.



HALL PROBE POWER CONNECTOR, Amphenol T3359-400, Female
Mating Connector: Amphenol T3360-010U

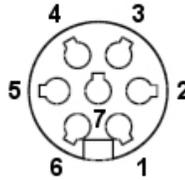
Pin	Function	Description
1	-12V	-12V power to hall probe transducer
2	GND	Power Common
3	-12V	+12V power to hall probe transducer
4	NO CONNECTION	
5	NO CONNECTION	



HALL PROBE SIGNAL CONNECTOR, Amphenol T3506-400, Male

Mating Connector: Amphenol T3505-001U

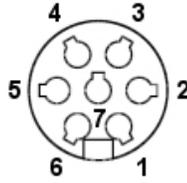
Pin	Function	Description
1	X+ IN	X-Axis positive input
2	TEMP	Hall Probe Temperature - NOT SUPPORTED
3	Z+ IN	Z-Axis positive input
4	Y- IN	Y-Axis negative input
5	Y+ IN	Y-Axis positive input
6	X- IN	X-Axis negative input
7	Z- IN	Z-Axis negative input
8	GND	Analog Ground



THERMOCOUPLE #1 CONNECTOR, Amphenol T3478-400, Female

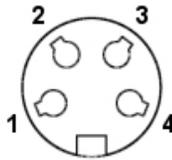
Mating Connector: Amphenol T3475-001U

Pin	Function	Description
1	T3+	Temp sensor #4 input
2	T3GND	Temp sensor #4 ground
3	+12V	+12V power to thermocouple board
4	-12V	-12V power to thermocouple board
5	T4-	Temp sensor #4 ground
6	T4+	Temp sensor #4 input
7	GND	Common Ground



THERMOCOUPLE #2 CONNECTOR, Amphenol T3478-400, Female
Mating Connector: Amphenol T3475-001U

Pin	Function	Description
1	T1+	Temp sensor #1 input
2	T1GND	Temp sensor #1 ground
3	+12V	+12V power to thermocouple board
4	-12V	-12V power to thermocouple board
5	T2-	Temp sensor #2 ground
6	T2+	Temp sensor #2 input
7	GND	Common Ground



FLOW METER CONNECTOR, Amphenol T3303-400, Female
Mating Connector: Amphenol T3300-001U

Pin	Function	Description
1	+12V	Flow meter power, +12VDC
2	GND	Common Ground
3	FLOW	Flow meter analog flow rate
4	FLOWSW	Flow meter O.C. output switch

11. TROUBLESHOOTING

Problem	Possible Causes	Solution
5972 will not power up.	No power on input Fuses blown Internal power supply has failed	Verify AC mains power Check fuses in power input module Contact GMW for assistance
No communications with DAQ	USB cable is unplugged or damaged Incorrect device selected in control software DAQ has failed	Verify USB cable is plugged in / replace cable Verify the device in the software configuration Contact GMW for assistance
Voltage / Current Monitor read-back does not match the power supply meters	Software control or read-back scaling incorrectly configured	Verify the power supply control and monitor voltage scales are correct, and that the power supply maximum current and voltage is correctly set
Cannot control the system (DC Power Supply output current) with the computer	No communications with the DAQ System is not in 'Remote' mode DC Power Supply voltage and current not correctly set	Verify DAQ Communications Enable 'Remote' mode in the software Set DC Power Supply voltage to maximum, and current to minimum.
Cannot control the system locally	System is not in 'Local' mode	Disable 'Remote' mode in the software
The interlocks do not seem to be working correctly	Faulty interlock on magnet Magnet interlock cable unplugged Incorrectly set interlock bypass switch	Manually test magnet interlocks Plug in magnet interlock cable Verify interlock bypass switches are correctly setup
The interlock reset light is on	There is an active interlock	Correct the interlock issue and press the interlock reset

The above table covers the most common issues, but by no means includes all possible faults that may be encountered. If there is a problem that is not covered, please contact GMW associates for technical support.

12. WARRANTY INFORMATION

GMW Associates warrants that Laboratory Electromagnets and Laboratory Electromagnet Systems and components supplied by GMW Associates will be free of defects in materials or workmanship for a period of 12 months from the date of installation or 15 months from the date of shipment whichever is the shorter.

Within this period GMW Associates will repair or replace defective parts free of charge either at the end user's site or at GMW Associates location at GMW's choice.

GMW Associates will reimburse or pay the lowest two way freight charges on items returned to GMW Associates or our authorized agent provided prior authorization for shipment has been given by GMW Associates.

This warranty shall not apply to any equipment which our inspection shows to have become defective due to mishandling, misuse, improper maintenance or any other damage not generally acceptable for equipment of a similar type.

GMW Associates reserves the right to make changes in product or system design without incurring any obligation to modify previously delivered equipment.

The foregoing is the full extent of the GMW Associates warranty. No other warranty is expressed or implied. In no event shall GMW Associates be liable for damage arising from late delivery or misuse of the equipment. GMW Associates makes no warranty of the fitness of the equipment for the intended end-use other than the equipment meets the written specifications presented to the purchaser by GMW Associates.

If any defect or fault in the equipment is discovered the end-user should notify GMW Associates of the problem including details of Model numbers and serial numbers. GMW Associates will either make arrangements for service by the end-user or GMW Associates, or give authorization for return shipment to GMW Associates.

All return shipments must be made according to GMW Associates instructions with adequate packaging and documentation identifying the shipment including the GMW Associates Return Material Authorization (RMA) number. GMW Associates will not accept responsibility for equipment damaged in return shipment and thus all shipments should be properly packed and adequately insured by the customer.

To request warranty service, please contact the GMW representative nearest you.

GMW Associates

Web: www.gmw.com/help/

Email: engineering@gmw.com

India: Magnergy Technology.

Web: www.magnergy.com

Email: info@magnergy.com

Japan: TOYO Corporation.

Web: www.toyo.co.jp/English/

Email: magne@toyo.co.jp