USER'S MANUAL

MODEL: 5453

SHIELDED HELMHOLTZ COIL

Date Sold: _____

Serial number: _____

GMW *955 Industrial Road, San Carlos, CA 94070 Tel: (650) 802-8292 Fax: (650) 802-8298*
Email: tom@gmw.com Web site: http://www.gmw.com

CONTENTS

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.

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.

This product is designed for use in accordance with SOP39. Hazardous voltages are present within this product during normal operation. The product should never be operated with any of the covers removed.

When operated at peak current of 100A the surface temperature of the coils of the electromagnet can rise as high as 50°C. Care must be taken not to touch the coils for extended periods.

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 and simply**

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.**

8. 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.

9. 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

Can 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 his 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, 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

2.1. General Specifications

Magnet Field @ max power (X,Y,Z=0.0)	**264mT (2640Gauss)**
Magnet Inside Diameter:	**260mm (10.2 inch)**
Magnet Length:	**330 mm (13.0 inch)**
Coils (series connection)	
coil Resistance (20°C)	**0.439 Ohm**
max resistance (80°C)	**0.558 Ohm**
Max power (air cooled)	**30A/16V (0.48 kW)**
max power (water cooled @ 4lpm)	**145A/81V (11.7 kW)**
Self Inductance	**65mH**
Calibration Factor (field versus current)	**1.885mT/A**
Calibration Factor (Built in Hall sensor)	**Divide by 0.399378**
Field Uniformity $\Delta B/B$	**less than $\pm$100ppm over a 30mm sphere**
Water Cooling (18°C)	**1.0 bar (15 psid), 4 liters/min (1.05 US gpm)**
Over-temperature Interlock	**Selco OA-150-ST-G Thermal Sensor mounted on each coil cooling plate and wired in series. Contact rating 125VAC,15A. Closed below 65°C**
Dimensions	**Drawing 11807-0000-0_A_S3 400 mm W x 625 mm D x 442 mm H (15.7 inch W x 24.6 inch D x 17.4 inch H)**
Mass	**200 kg (440 lb)**

CAUTION - The value of maximum coil resistance given should not be exceeded. At this resistance the coils are at maximum safe temperature for continuous operation.

2.2. Model 5453 Electrical and Water Connections

DC Current	**(as seen from the rear refer to Drawing 11807-0000-0_A_S2)** **Left hand terminal Negative (Shipped with black cable connected)** **Right hand terminal Positive (Shipped with red cable connected)**
Ground	**The coil cooling plates, the magnet body and the base plate are all earthed through the power supply earth.**
Interlocks (refer Section 7)	**Over-temperature thermostats are installed on each coil cooling plate. These are normally closed for temperatures of less than 65°C. The magnet power supply should be connected so that if any thermostat opens (goes over-temperature) the power supply current will be set to zero. User connections are made directly to the thermostat terminals.**
Water	**outlet 1/4 inch NPT** **inlet 1/4 inch NPT** **(mating couplings for 6.0 mm (1/4 inch) ID hose are provided)**
CAUTION	**Ensure that the high current connections are tight. Loose connections may lead to oxidation and overheating. The field stability may be degraded and the current terminations damaged.**

3. WARNINGS

REFER TO WARNINGS BELOW BEFORE OPERATING ELECTROMAGNET

1 Personnel Safety

The Model 5453 is a shielded electromagnet. In operation the magnet fringing field can be in excess of 0.5mT (5G). This can cause malfunctioning of heart pacemakers and other medical implants. We recommend that the fringing field should be mapped and warning signs be placed outside the 0.5mT (5G) contour. Entry to this region of higher field should be restricted to qualified personnel.

2 Ferromagnetic Objects

During operation the magnet exerts strong magnetic attraction towards ferromagnetic objects in the near vicinity. Loose objects can be accelerated to sufficient velocity to cause severe personnel injury or damage to the coils. Keep ferromagnetic tools clear.

3 Arcing

This magnet stores considerable energy in its field during operation. Do not disconnect any current lead while under load or the magnetic field energy will be discharged across the interruption causing hazardous arcing.

4 Coil Hot Resistance

Do not exceed the maximum coil hot resistance given in the specifications or coil overheating and possible damage may occur.

5 Interlocks

These should always be connected if the magnet is to be operated unattended, to avoid the possibility of coil overheating caused by excessive power dissipation or inadequate cooling. The door latches are included in the interlock sequence. This is to prevent the operation of the magnet with a door open (this would result in the doors slamming closed with considerable force and the potential to cause harm).

6 Watches, Credit Cards, and Magnetic Disks

Do not move magnetically sensitive items into the close vicinity of the magnet. Even some anti-magnetic watches can be damaged when placed in close proximity to the magnet during operation. Credit cards, and magnetic disks are affected by magnetic fields as low as 0.5mT (5G).

7 Trip Hazards

Caution must be taken when moving around the magnet as there are potentially cables on the floor that will present a trip hazard. It is highly advised that floor conduit be purchased that will cover the cables. This will also protect the cables from potential damage.

4. INSTALLATION

Caution: This is a heavy system. All movement, lifting and installation of the 5453 Electromagnet must be under the supervision of an experienced person to prevent the possibility of serious injury or damage to the electromagnet and associated equipment.

4.1. Unpacking Instructions and Damage Inspection

To unpack the electromagnet please use the following procedure.

1. **First remove all of the "Hex Head Screws" 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 "Crate Top Cover" high enough to clear top of electromagnet, walk cover sideways to clear area and place on floor.**

4. **Inspect the magnet to ensure that no damage has occurred to the magnet in shipment. If damage is evident report the damage in detail to the shipper for claim and simultaneously notify GMW in case assessment of the damage must be made. If no damage is found proceed with magnet unpacking and installation.**

5. **With suitable lifting equipment (eg 200kg (440lb) minimum safe lifting rating) lift magnet clear of the shipping crate. Use strops (at least two) around the upper two yoke return arms (Ø2" bars running length of the magnet) to lift the magnet. Make sure that the strops are prevented from sliding together by using the two wooden spacers provided (see figure 1).**

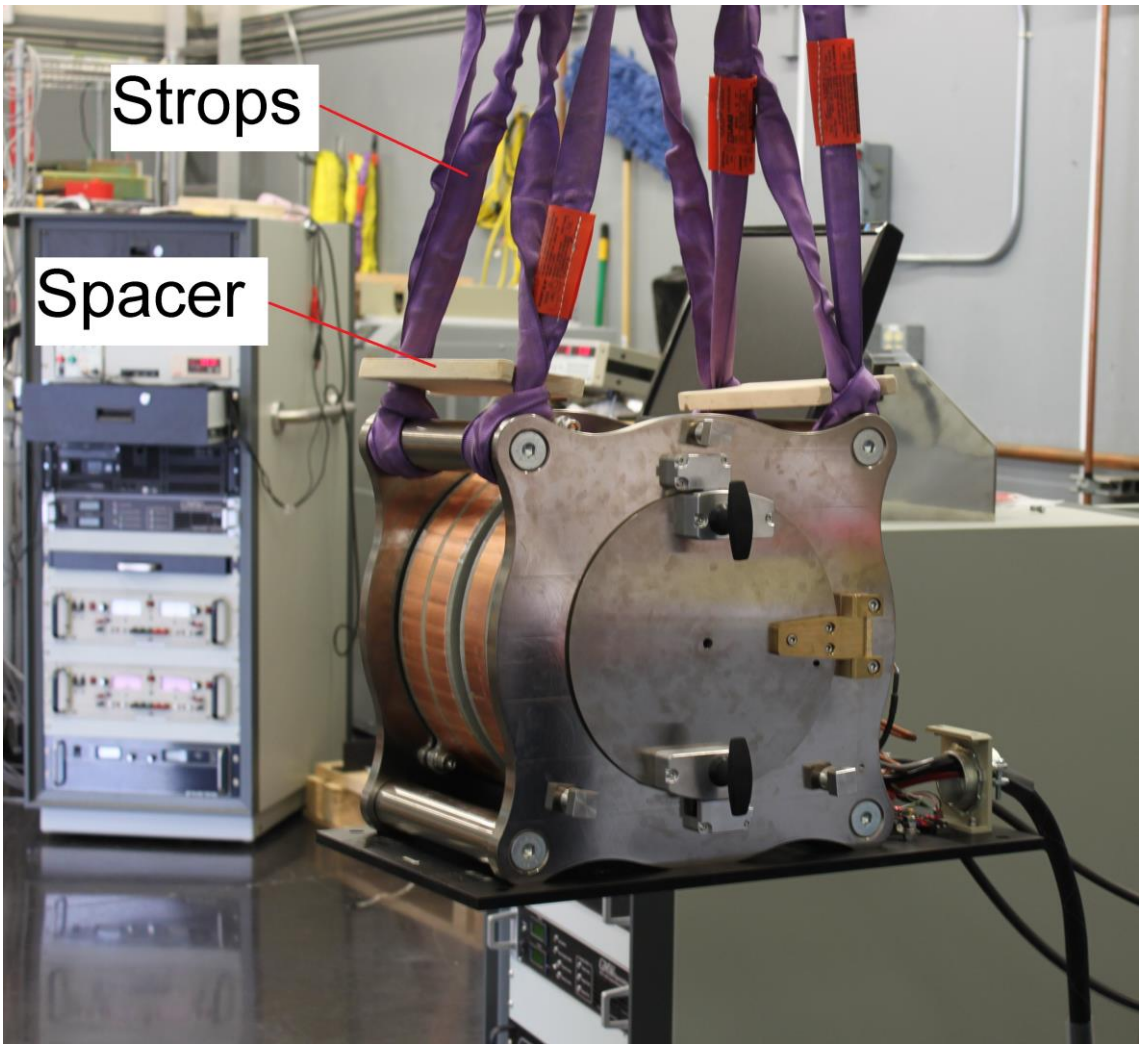


Figure 1: Illustration of the use of strops and spacers to lift the 5453 magnet.

4.2. Siting Considerations

The Model 5453 is partially magnetically shielded. However, ferro-magnetic material in the vicinity of the magnet will modify the magnitude and uniformity of the central region magnetic field. As a general rule avoid magnetic material closer than approximately 1 meter of the central region.

Background fields such as the geomagnetic field and alternating field from 60Hz power sources are partially shielded by the magnet and will add to the field produced by the magnet. If possible these background fields should be measured and their effects evaluated before the Model 5453 magnet is installed. It may be necessary to orient the Model 5453 axis to minimize the effects of external fields, to relocate ac power sources or to install suitable magnetic shielding.

4.3. Electrical Circuit

Never connect or remove cables from the magnet with the power supply connected. The stored energy in the magnet can cause arcing resulting in severe injury to personnel or equipment damage.

The magnet has two coils which are connected in series, (Refer to drawing 11807-0000-0_A_S3). The magnet is shipped with a power and interlock cable attached. The power supply cables should be connected directly to the dc current terminals marked + and -. Recommended current cable for the 5453 is stranded copper of 21.2mm² cross section (4 AWG). Because the magnet stores a significant amount of energy in its magnetic field, special care should be taken to insure that the current terminations are secure and cannot work loose in operation. Local heating at the terminations can cause rapid oxidation leading to a high contact resistance and high power dissipation at the terminals. If left unattended this can cause enough local heating to damage the terminals and the coils.

4.4. The 5453 Interlocks

The Model 5453 has six thermostats, Selco OA-150-ST-G. They are located on the coil cooling plates and wired in series. Each of the door latches (four in total) has an interlock switch to prevent operation when the doors are open. The magnet may be operated with either of the doors remove or both removed but the interlock logic must be changed for these modes of operation. See section 7 for the interlock logic configuration for each door configuration.

4.5. Cooling

The Model 5453 can be operated to an average coil temperature of 80°C. Assuming an ambient laboratory temperature of 20°C and a temperature coefficient of resistivity for copper of 0.0039/°C, the hot resistance of the coil should not exceed 25% more than the ambient temperature "cold" resistance. The coil thermostats will open when any coil cooling plate temperature exceeds approximately 80°C . Clean, cool (16°C - 20°C) water at 4 l/min and 1 bar (15 psid) should be used to cool the 5453 magnet.

The cooling copper tubes are electrically isolated from the coils to avoid electrochemical corrosion. A 50 micron filter should be placed before the input to the magnet to trap particulates.

Configuration Suggestion: For continuous operation of the magnet it may be appropriate to use a recirculating chiller to reduce water and drainage costs. The chiller capacity will depend on whether cooling is required for the magnet alone or magnet and power supply. For the Model 5453 Electromagnet with a Sorenson SGA (50V, 100A) power supply a suitable chiller is the Thermo Fisher TF50 recirculating water chiller (5kW). For the 5453 and Sorenson SGA (100V, 150A) power supply the required Chiller is the Thermo Fisher TF150 recirculating water chiller (15kW).

Do not use corrosion inhibitors in high quality electrical systems since the water conductivity is increased which can result in increased leakage currents and electrochemical corrosion.

At currents of approximately 30A and below the Model 5453 can be operated safely without water cooling. However the coil temperature will vary with the power dissipation. This results in dimensional changes of the magnet and air cooling is not suitable when high field stability is required.

Freon, oil, ethylene glycol or other cooling mediums can be used. The flow required will be approximately inversely proportional to their specific heats. An experimental determination of the flow and pressure required will be necessary.

Avoid cooling the magnet below the dew point of the ambient air. Condensation may cause electrical shorts and corrosion.

During operation the resistance can be checked using a voltmeter across the magnet. The voltage will rise to a constant value once thermal equilibrium has been reached. If it is desired to save water, the flow can be reduced until the hot resistance is approached. NOTE: This adjustment must be made slowly enough to allow for the thermal inertia of the coils.

5. OPERATION

5.1. General

This product is an electromagnet and creates significant magnetic fields both within the magnet and in the surrounding area. Make sure that there are no ferromagnetic items, tools or components loose in a 2 meter diameter area surrounding the magnet.

The Model 5453 is a shielded electromagnet. In operation the magnet fringing field can be in excess of 0.5mT (5G). This can cause malfunctioning of heart pacemakers and other medical implants. We recommend that the fringing field should be mapped and warning signs be placed outside the 0.5mT (5G) contour. Entry to this region of higher field should be restricted to qualified personnel

Do not move magnetically sensitive items into the close vicinity of the magnet. Even some anti-magnetic watches can be damaged when placed in close proximity to the magnet during operation. Credit cards, and magnetic disks are affected by magnetic fields as low as 0.5mT (5G).

The magnet operates as a conventional electromagnet.

1. **Adjust the cooling water flow to about 4 liters/min (1.0 USgpm). For operation at less than maximum power the water flow may be correspondingly reduced. Note that the inlet water temperature will determine the actual flow rate required. The above specified flow rates were determined with a water inlet temperature of approximately 18°C.**
2. **Turn on the power supply and increase the current until the desired field is reached. Note that constant current operation is preferred for stable field performance. Please refer to the User manual of the selected power supply.**

5.2. Calibration

The Calibration factor may be used to convert the operating current to the field in the air gap to within 1 percent. Alternatively the excitation curve shown in Figure 21 may be used. More accurate field determination may be obtained by using the measured calibration curve see Table 1.

Table 1: Measured field versus excitation.

Current [A]	Field [T]
20	0.03581
40	0.07157
60	0.10691
80	0.14142
100	0.17462

This table used with an interpolation routine will eliminate the error associated with reading a graph.

In any event, three points need to be remembered:

1. **A calibration curve or table is only as good as the precision employed in generating it.**
2. **Although this magnet has a large volume of uniform field the field is not uniform over the entire internal volume. If new calibration curves are required the field measurements should be taken in the proper region of interest. Refer to uniformity plots shown in Figure 17 through 20.**
3. **The field is most directly a function of the current in the magnet coils. Voltage across the coils is not a good measure of field since the electrical resistance of the coils depends on the temperature (about 0.4% per degree Celsius).**

5.3. Field Control Operation

The necessity to use calibration curves can be avoided by using a field controller to sense the magnetic field and provide a corresponding power supply control signal through the power supply programming inputs. Contact GMW for suitable instrumentation. This option is described in more detail in section 7.2.

6. MAINTENANCE

Whenever performing maintenance on this magnet all electrical plug socket disconnects must be disconnected and a plug lockout device used to properly shut down the electrical system. Refer to Lockout/Tagout procedure defined in section 2.2 of the "Field Magnet for Drive Testing" User Manual.

6.1. Cooling Circuit

Check the cooling water circuit to ensure the water is clean and free of debris and bacterial growth. If an in-line water filter is used, ensure the filter is clean. If this magnet is used in conjunction with a closed cycle chiller please refer to the User Manual for details specific to that chiller for cleaning and maintenance.

6.2. Strain Relief Check

During the scheduled maintenance it is recommended that cables at the rear of the 5453 Shielded Helmholtz Electromagnet be inspected (Refer to section 12.4 cable 16907-0052-3). In particular the strain relief should be checked to confirm that the cables are properly restrained from movement. The Lockout/Tagout procedure from section 1.3 should be followed during this procedure.

When inspecting cables to the magnet the magnet should be de-energized to zero amps and the power supply switched off. Refer to drawing 16907-0052-3 in section 12.4.

6.3. Hinges

The doors of the 5453 Electromagnet are mounted on brass hinges, refer to Figure 2. The action of these hinges should be firm but smooth. During regular scheduled maintenance these hinges should be inspected for accumulation of dust and swarf. If required these hinges should be cleaned using lint free clean room wipes. It is recommended that the hinges be "greased" with Castrol Optitool 215-2 Cleanroom grade grease.

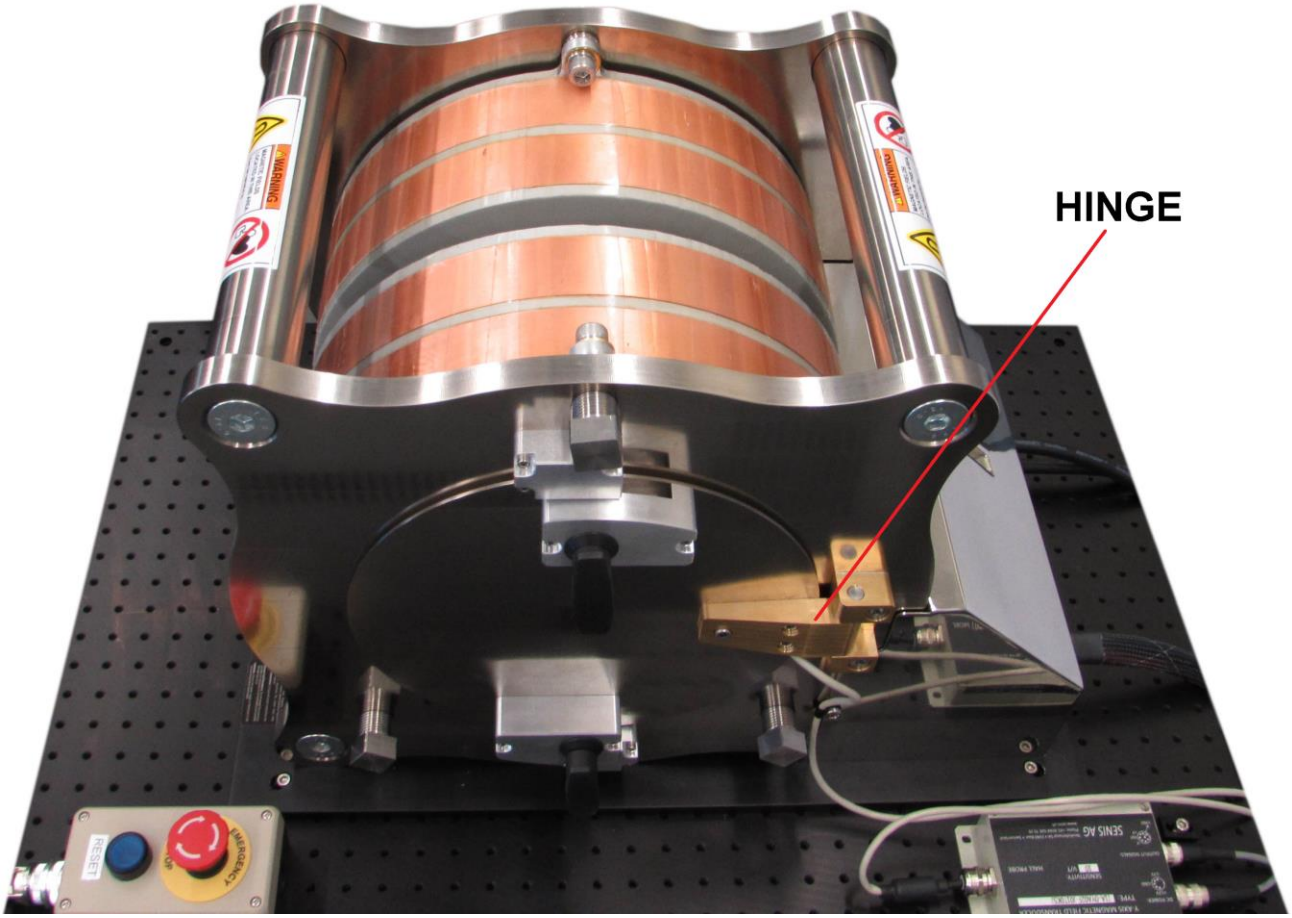


Figure 2: Illustration of the location of the brass hinge. There is a second hinge located on the opposite door.

When cleaning the hinges it should be noted that the action of the hinges represents a pinch hazard. Caution should be taken.

7. STANDARD OPTIONS

7.1. Door Configurations

The 5453 is delivered as standard with two doors at either end of the magnet. Either or both of these may be removed by undoing the two M8 bolts that attach the door hinge to the magnet body. In order to operate in this configuration the latch interlocks must be reconfigured, see section 8. Please contact GMW Associates for instructions for door removal.

7.2. Built-in Hall Sensor

Each of the doors of the 5453 Electromagnet can accommodate a Hall sensor (SENIS Type A head with dimension 16.5 x 5.0 x 2.3mm), refer Figure 3. It is recommended that this option will be delivered installed by GMW Associates. In the event that installation is desired after delivery please contact GMW Associates for detailed instructions regarding installation. Please also refer to Figure 12 for the correlation data relating the field at the built-in sensor to the field in the central volume.

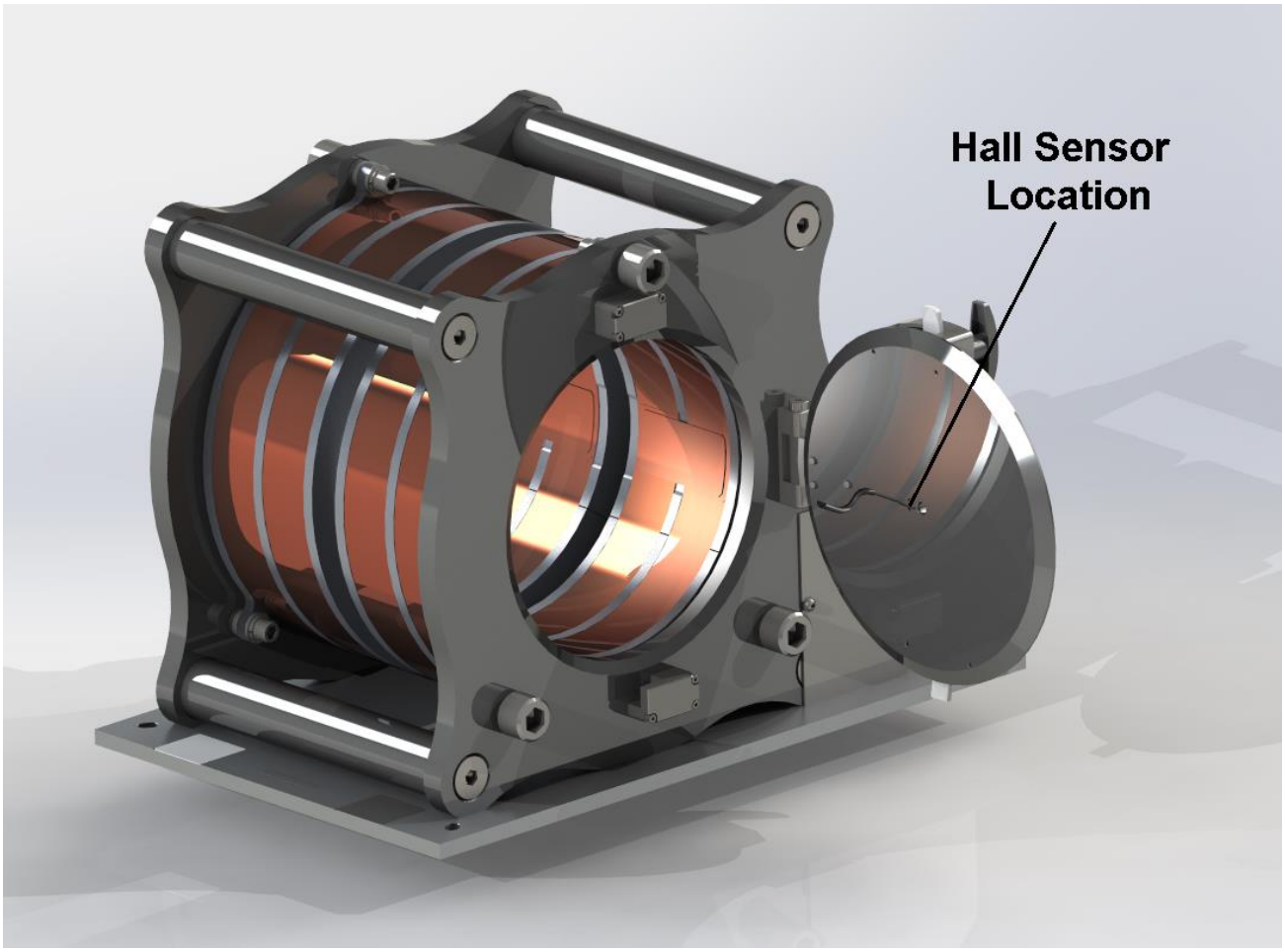


Figure 3: Illustration of the location of the Hall sensor should that option be required. Note that it is possible to locate the sensor in either door.

8. Interlock Connections for Various Door Configurations

Whenever changing the interlock settings, or removing the terminal cover for any other reason, all electrical plug socket disconnects must be disconnected and a plug lockout device used to properly shut down the electrical system. Refer to Lockout/Tagout procedure defined in section 1.3.

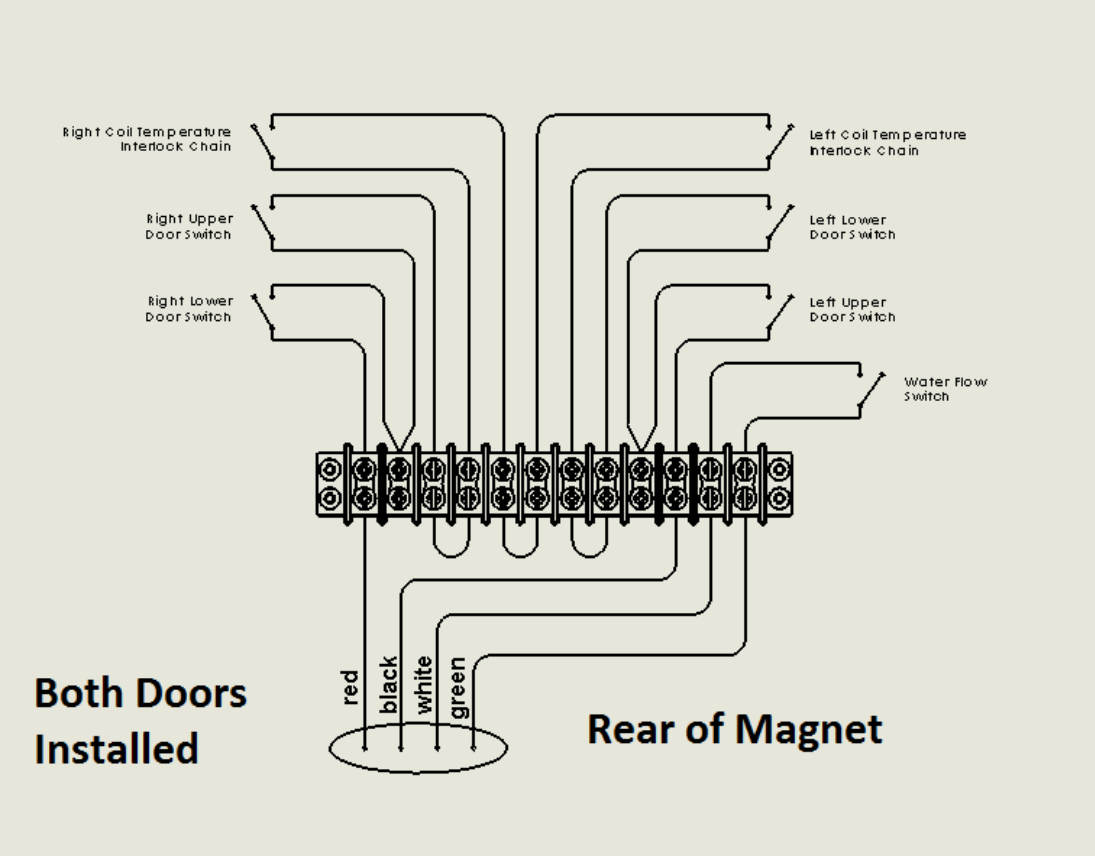


Figure 4: Interlock configuration with both doors installed (default).

Ex-factory configuration: Door switch and temperature interlocks are wired in series (red and black wires from cable 16907-0052-3). The water flow switch is separate (white and green wires of cable 16907-0052-3).

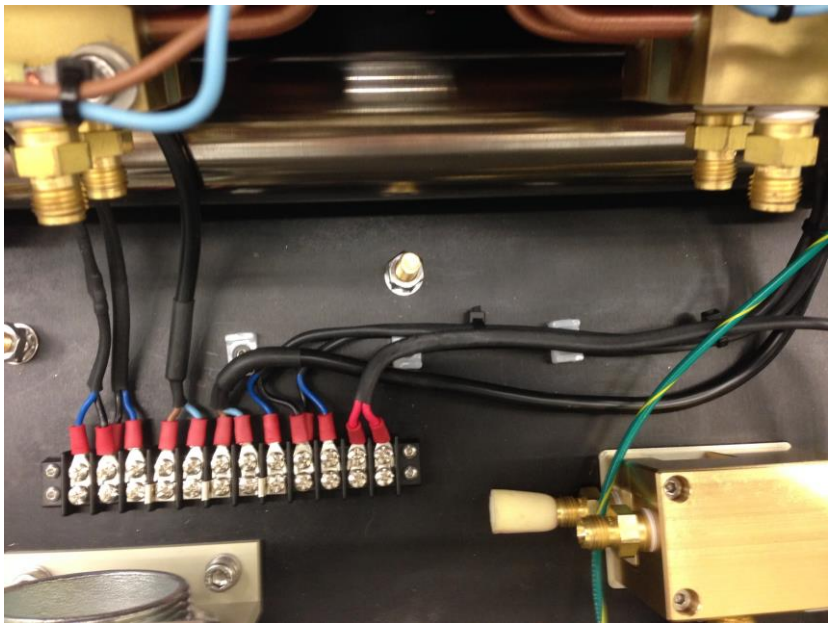


Figure 5: Image of the interlock connections beneath the terminal cover (cover removed in this photograph) showing the default connections.

Door Interlock – Switch closed when door is fixed.
Temperature Interlock – Switch is closed below 80°C
Water Flow Interlock – Switch is closed when flow is greater than 2 lpm.

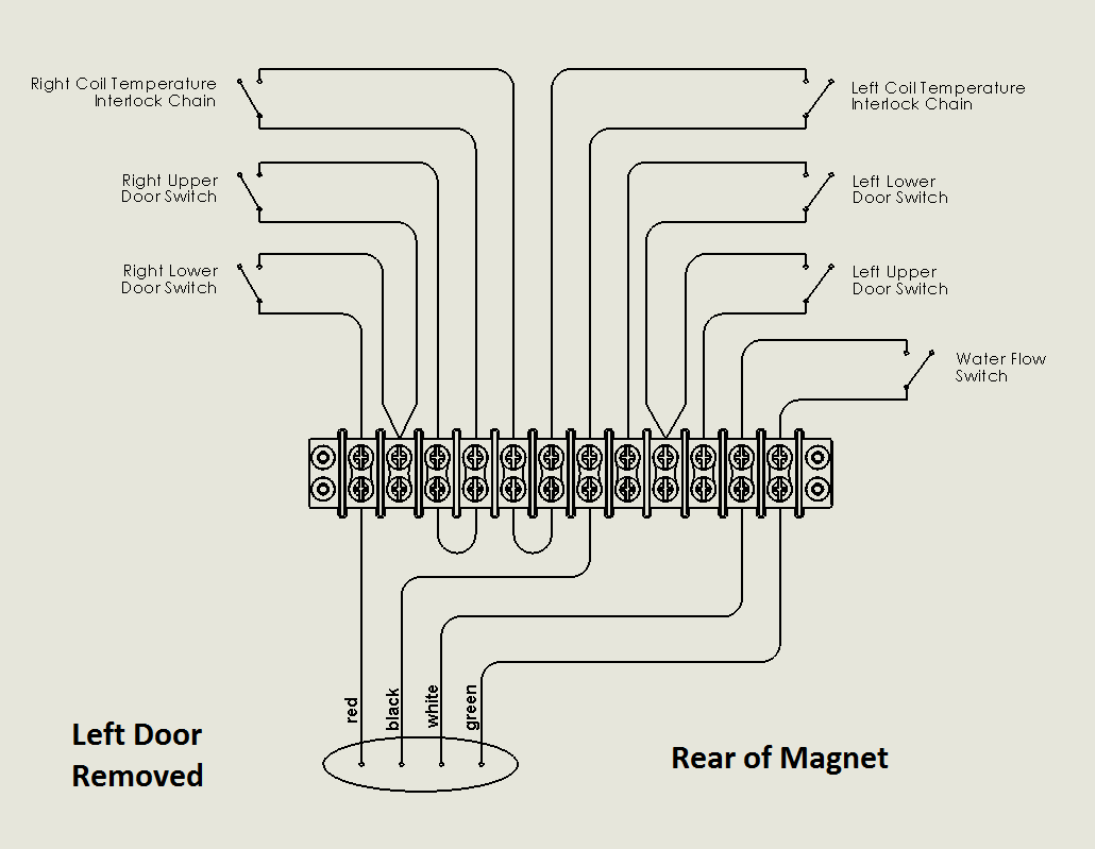


Figure 6: Interlock configuration with left door installed.

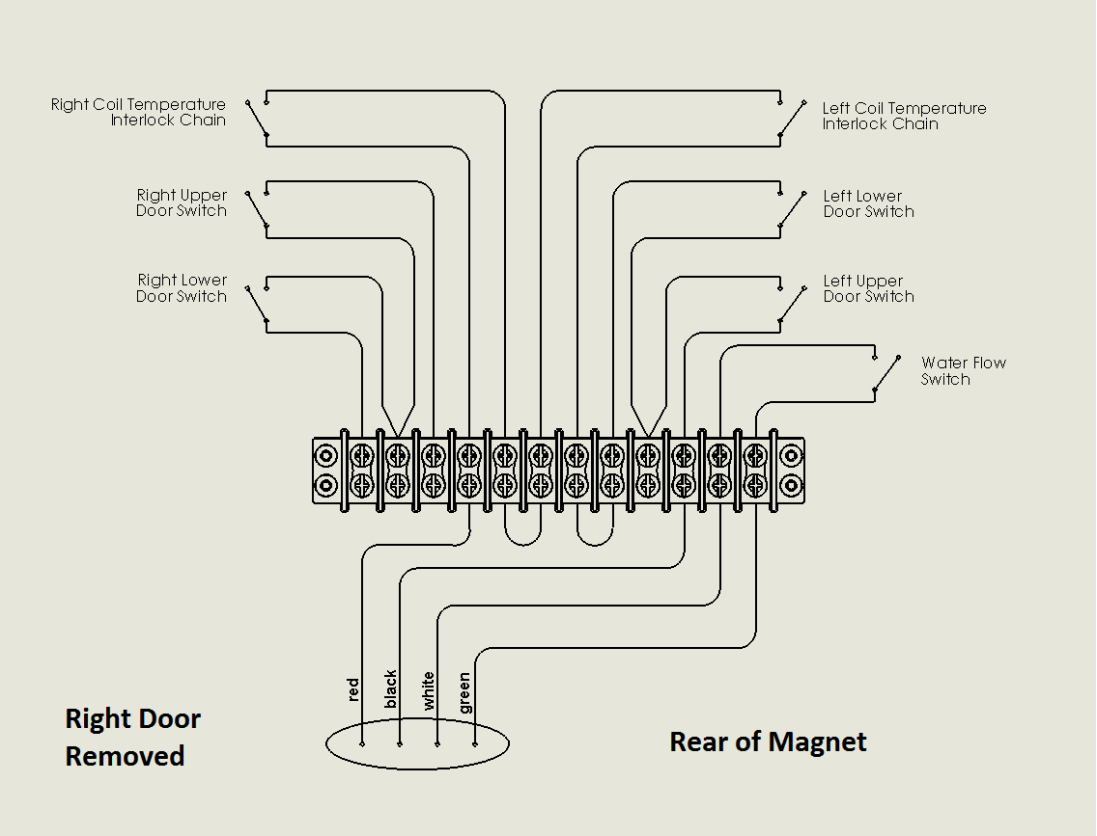


Figure 7: Interlock configuration with right door installed.

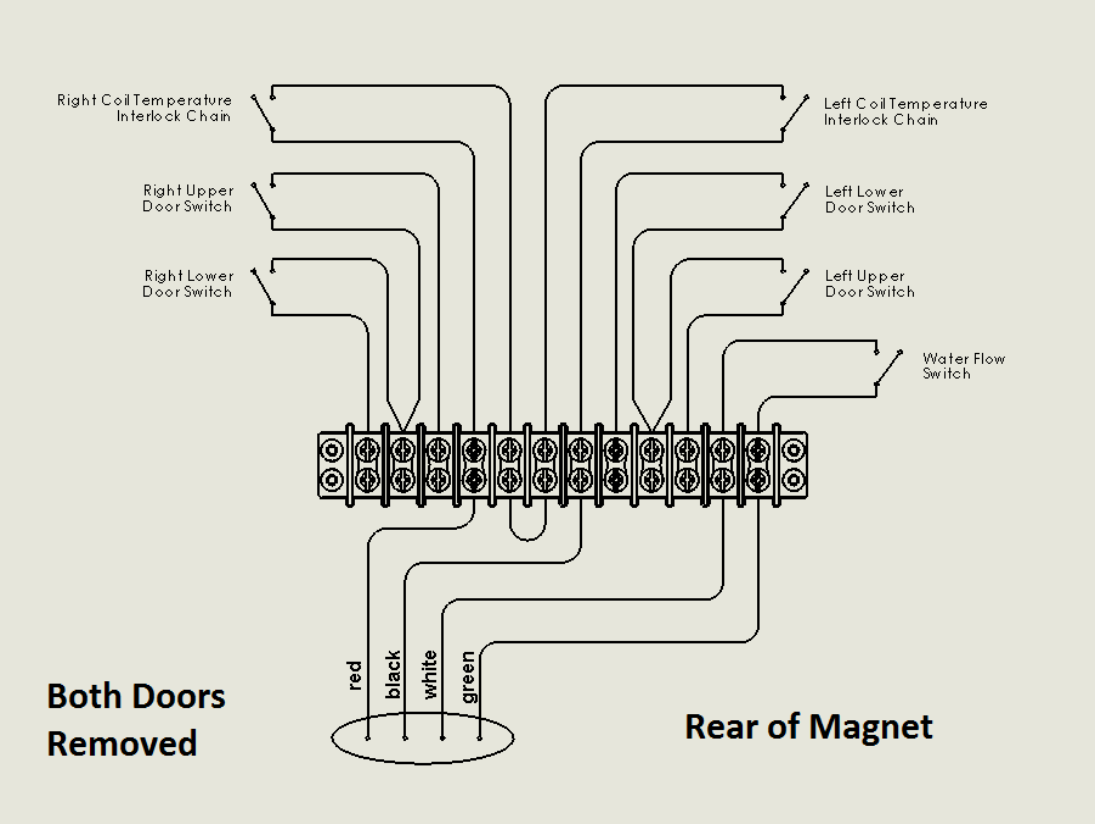


Figure 8: Interlock configuration with both no doors installed.

Note that the magnet's doors represent the only moving part of the magnet and are a potential source of physical injury. In the event that a door latch is left open prior to operation the magnet will not energize. In the event that the door latch is opened during operation the magnet will de-energize.

NOTE THAT IF A DOOR LATCH IS OPENED WHILE THE MAGNET IS ENERGISED THE MAGNET WILL IMMEDIATELY RAMP TO ZERO FIELD – WHEN THE DOOR LATCH IS CLOSED THE MAGNET WILL IMMEDIATELY RE-ENERGISE. THIS POSES NO RISK OF INJURY. THE USER SHOULD BE AWARE THAT THERE IS NO NEED FOR A MANUAL RESET.

9. CUSTOM OPTIONS

10. EXCITATION CURVES AND FIELD UNIFORMITY

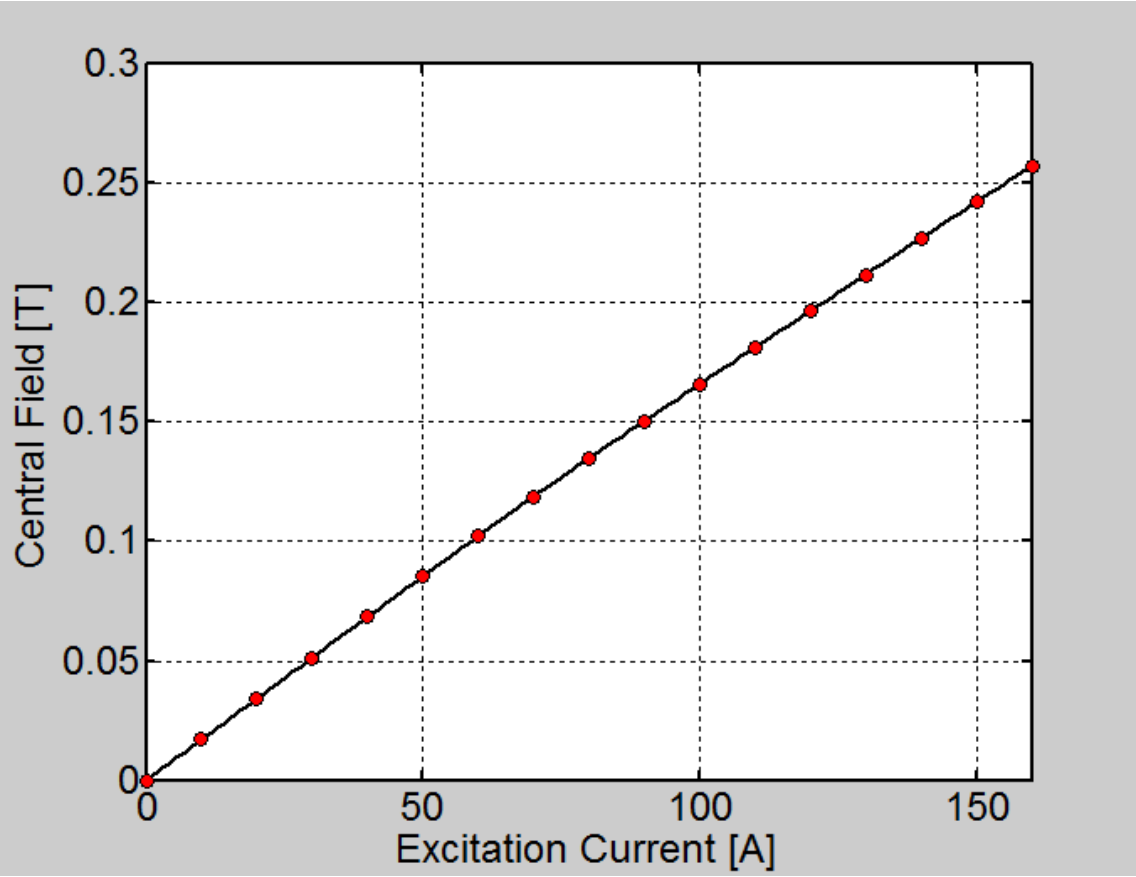


Figure 9: Modelled excitation with both doors installed. Field is approximately 1.83 mT/A.

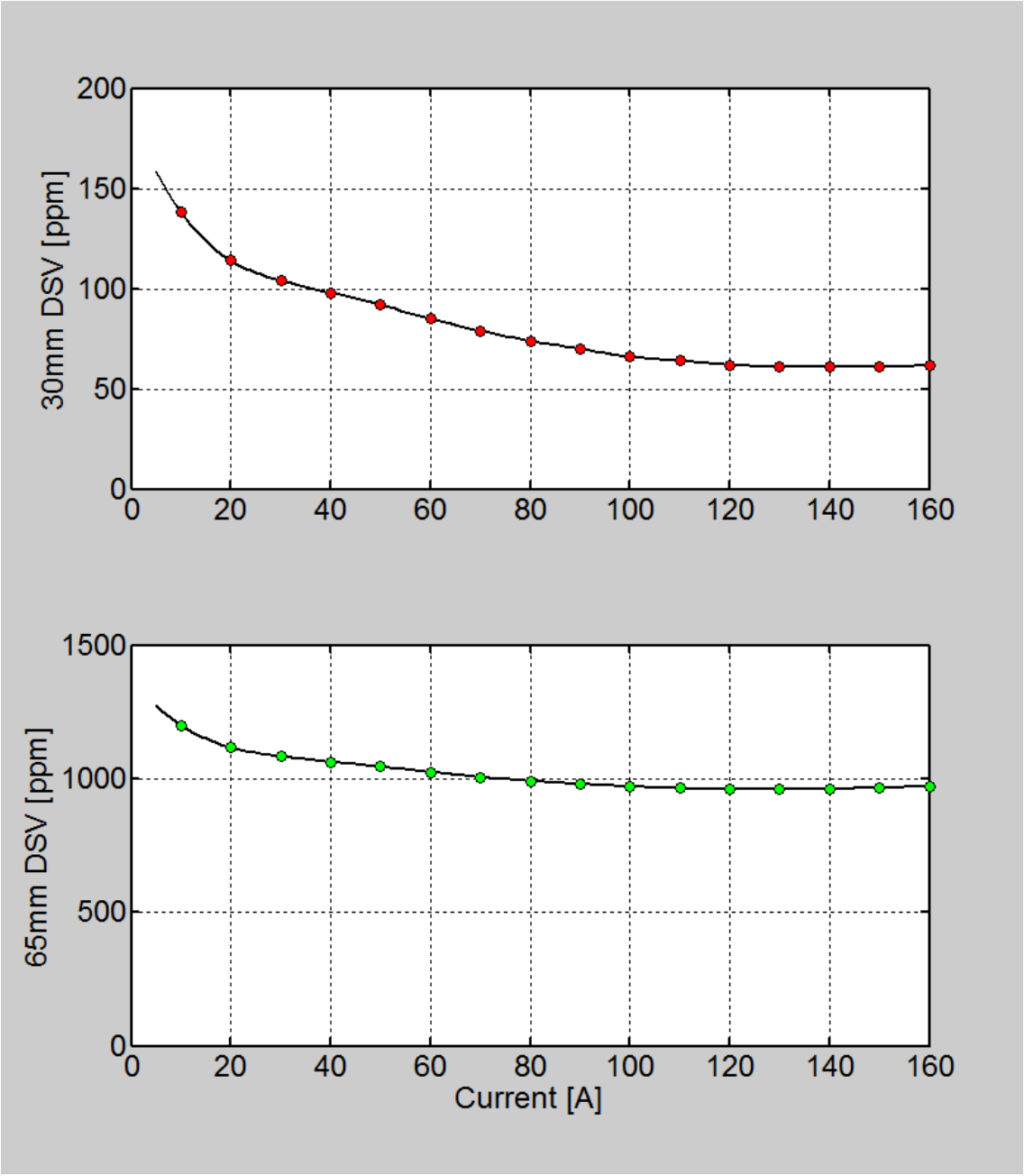


Figure 10: Modelled field Uniformity against excitation with both doors installed and for 30mm DSV and 65mm DSV.

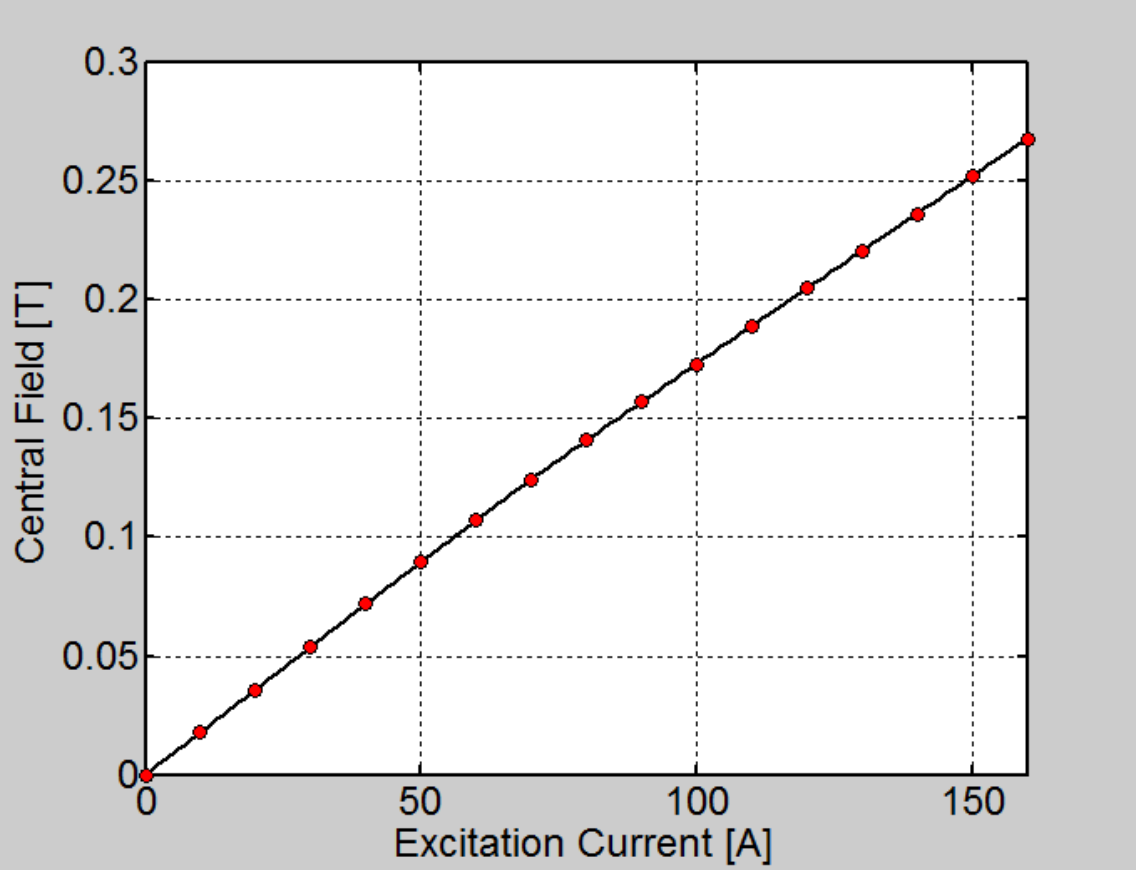


Figure 11: Modelled excitation with one door installed. Field is approximately 1.73 mT/A.

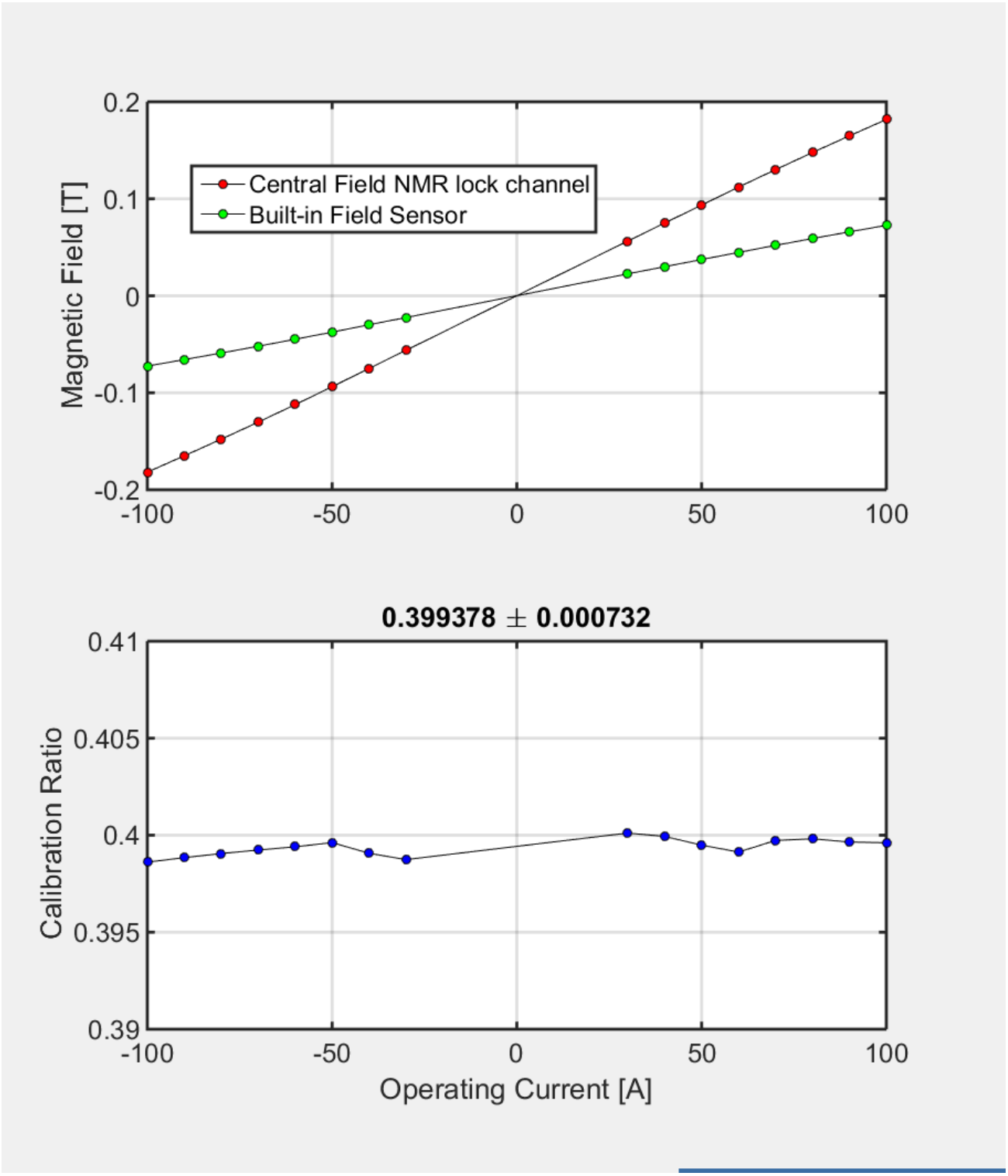


Figure 12: Calibration curve for the built-in Hall sensor. This calibration is made between the Hall sensor and a Metrolab PT2025 Precision Teslameter.

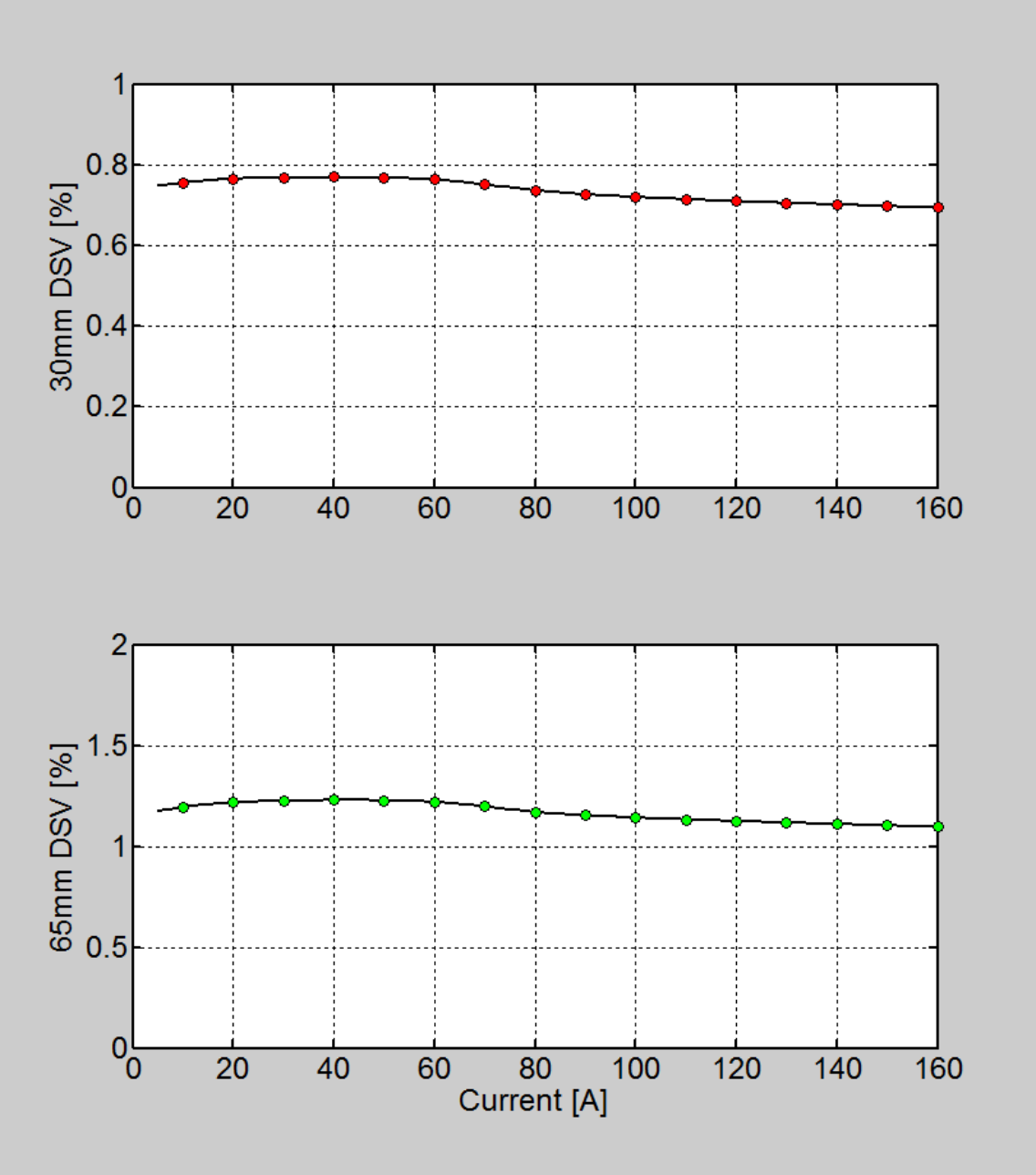


Figure 13: Modelled field Uniformity against excitation with one door installed and for 30mm DSV and 65mm DSV.

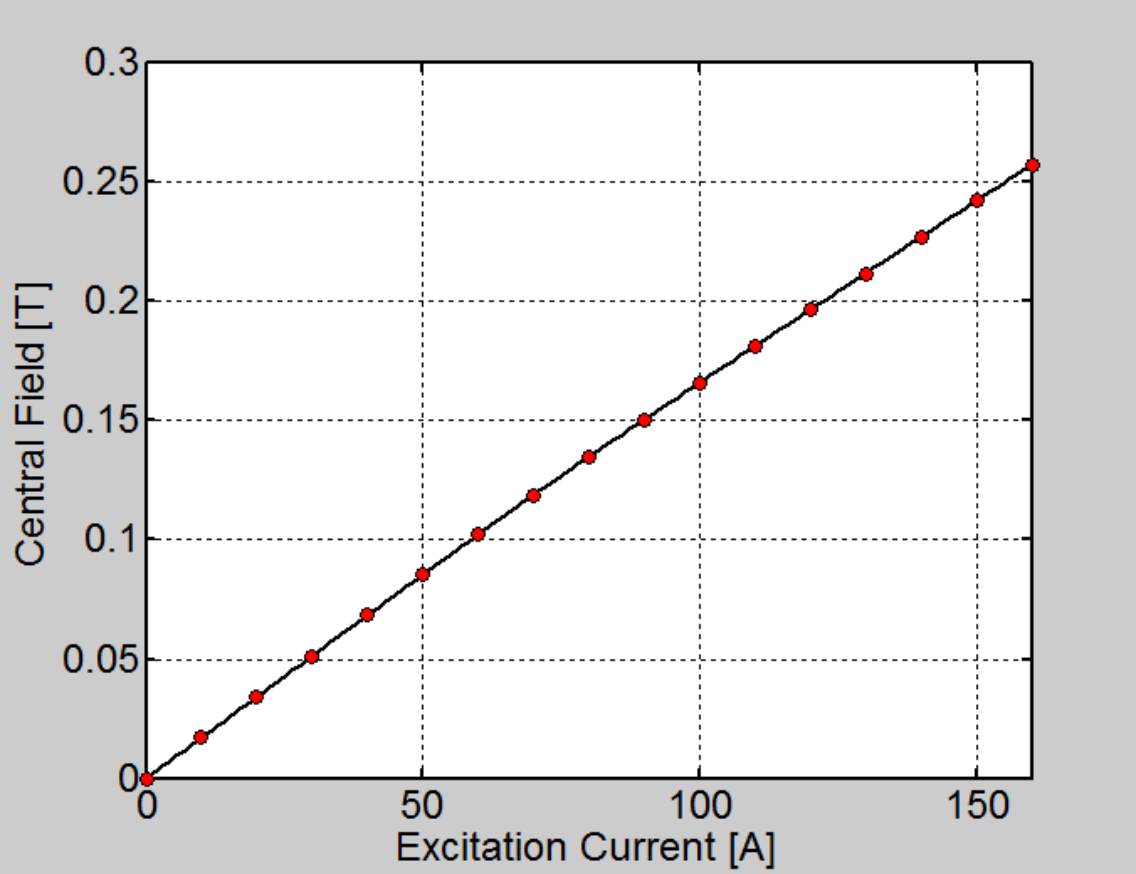


Figure 14: Modelled excitation with no doors installed. Field is approximately 1.66 mT/A.

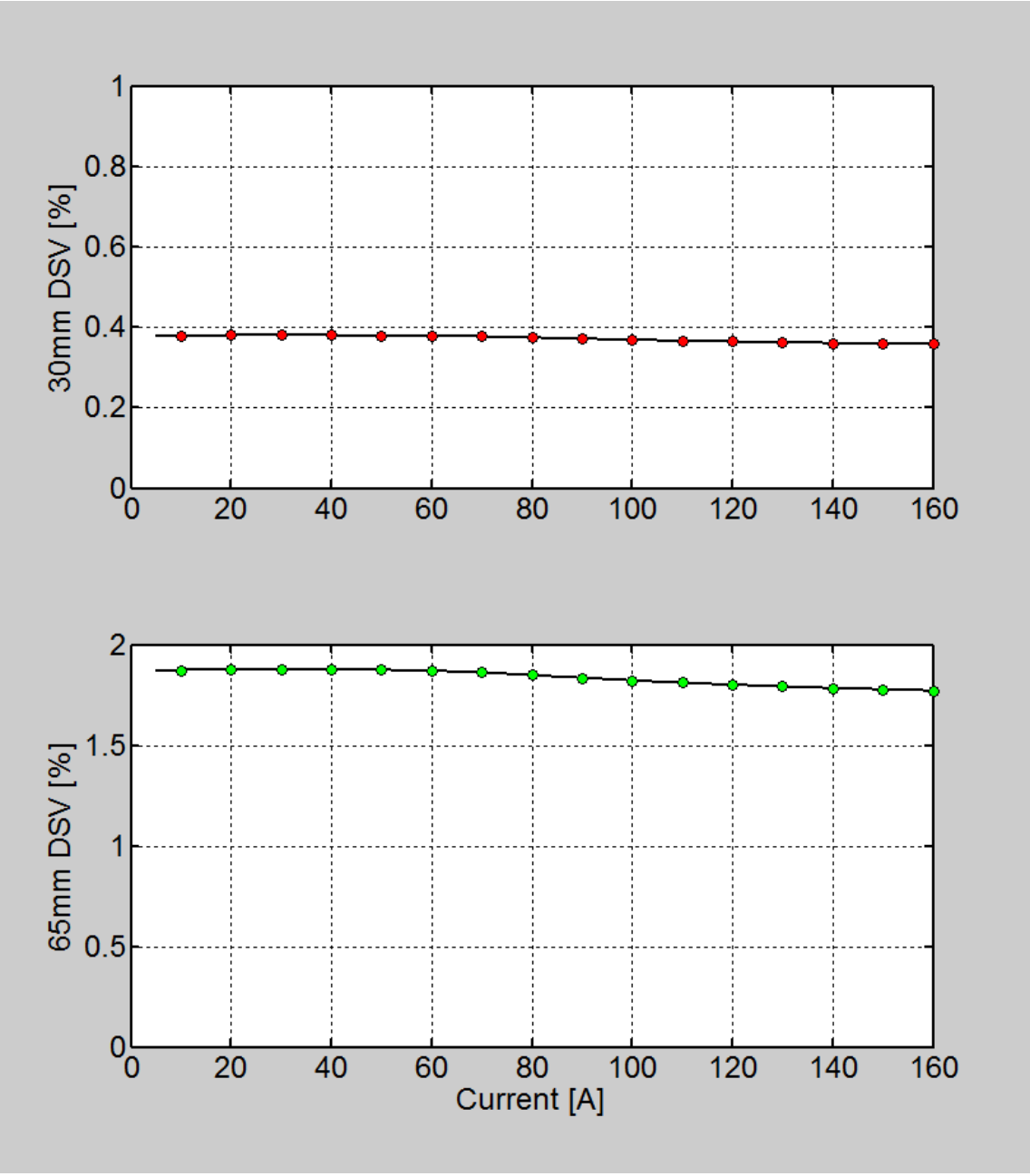


Figure 15: Modelled field Uniformity against excitation with no doors installed and for 30mm DSV and 65mm DSV.

11. TEST DATA

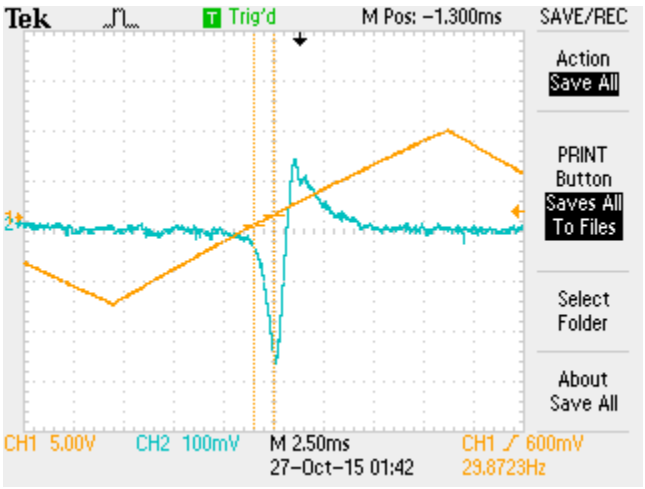


Figure 16: Output from the Metrolab PT 2025 showing a strong lock signal derived from the 5453 uniform field.

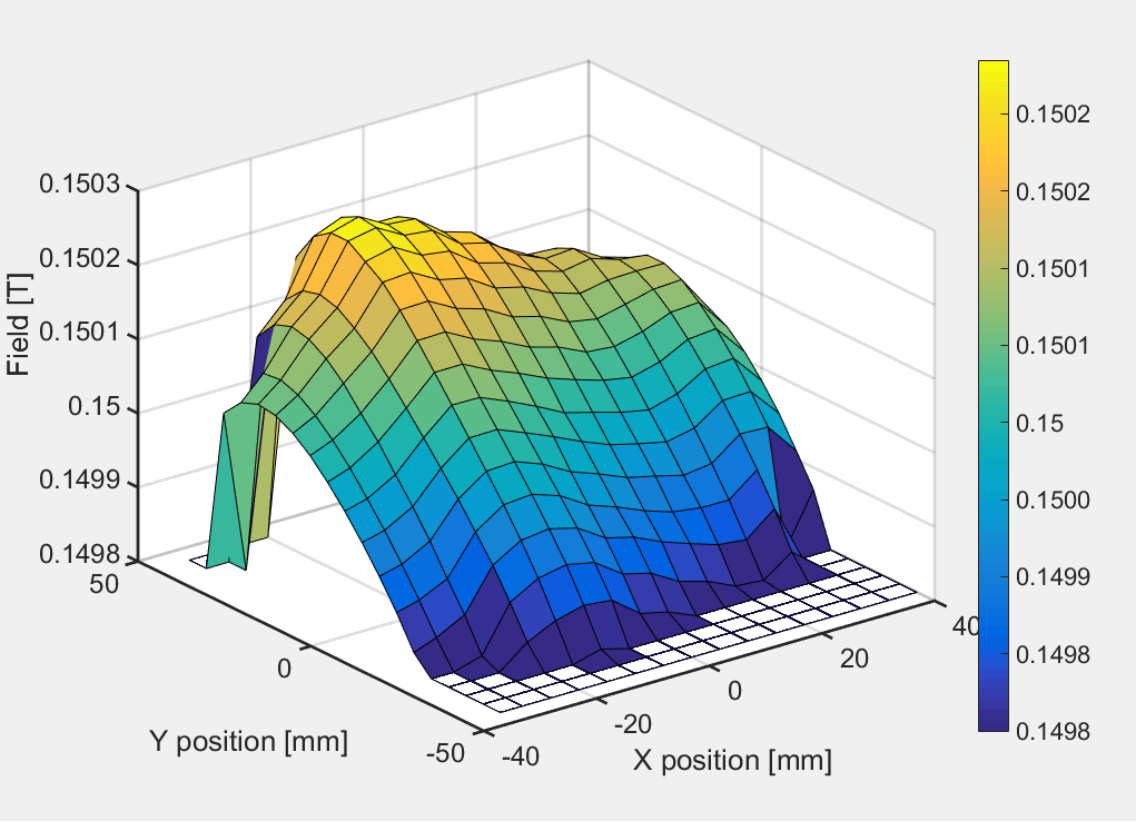


Figure 17: Measured surface plot of the field uniformity in the median plane. The squares coloured white indicate where the NMR lock channel failed to lock on to the NMR signal. (Metrolab PT 2025).

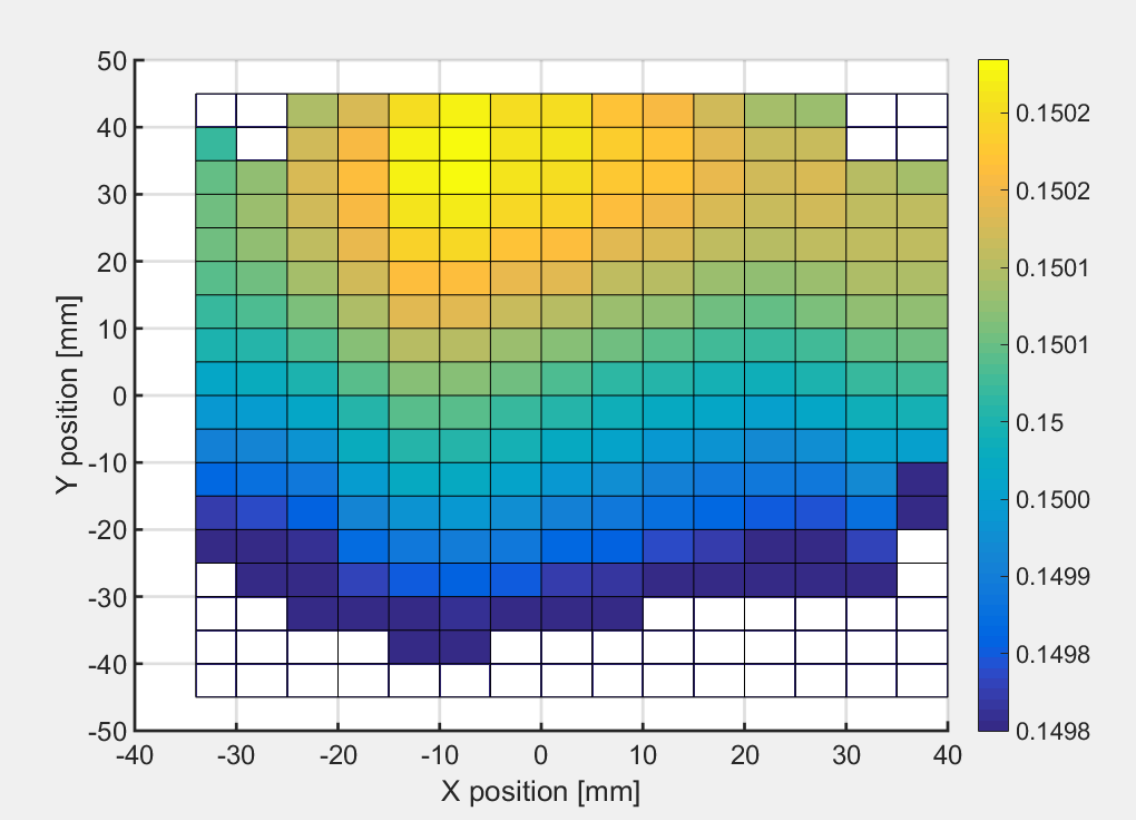


Figure 18: Previous plot viewed from above and showing the field uniformity in the median plane. The squares coloured white indicate where the NMR lock channel failed to lock on to the NMR signal. (Metrolab PT 2025).

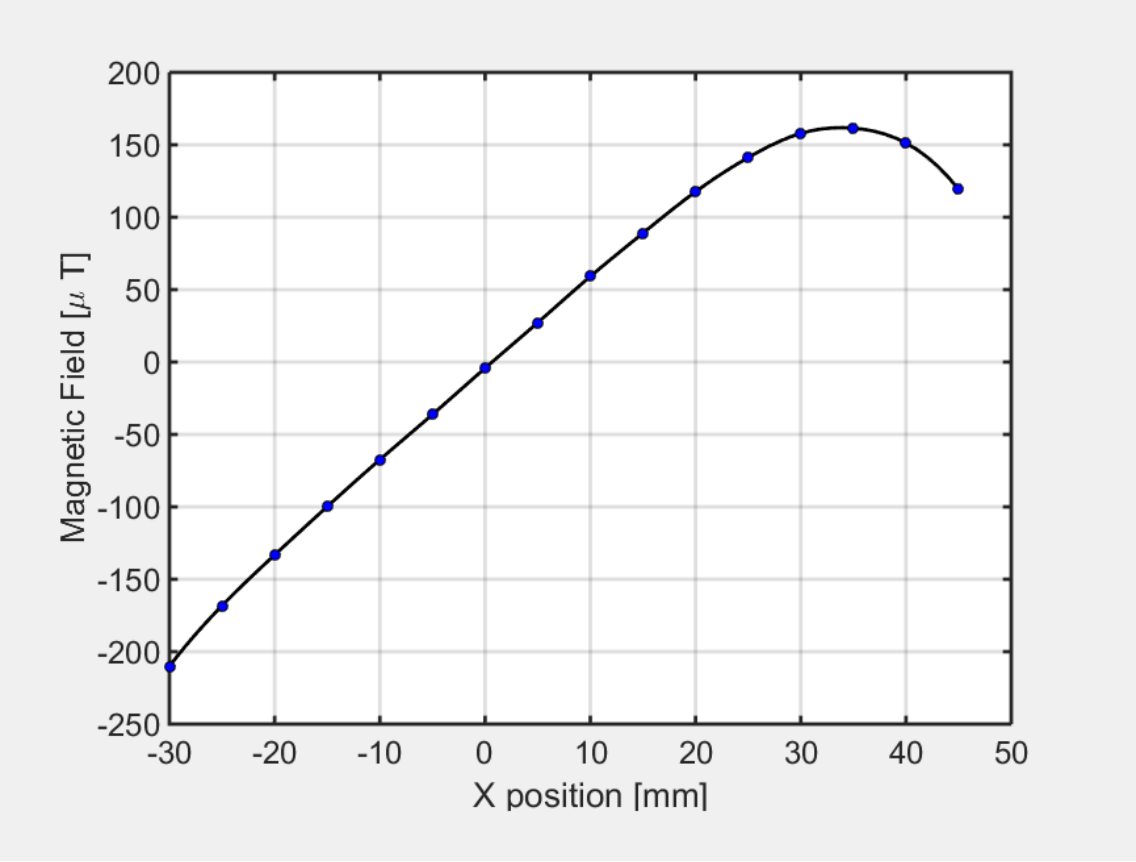


Figure 19: Field across the lateral axis of the magnet along the x-direction.

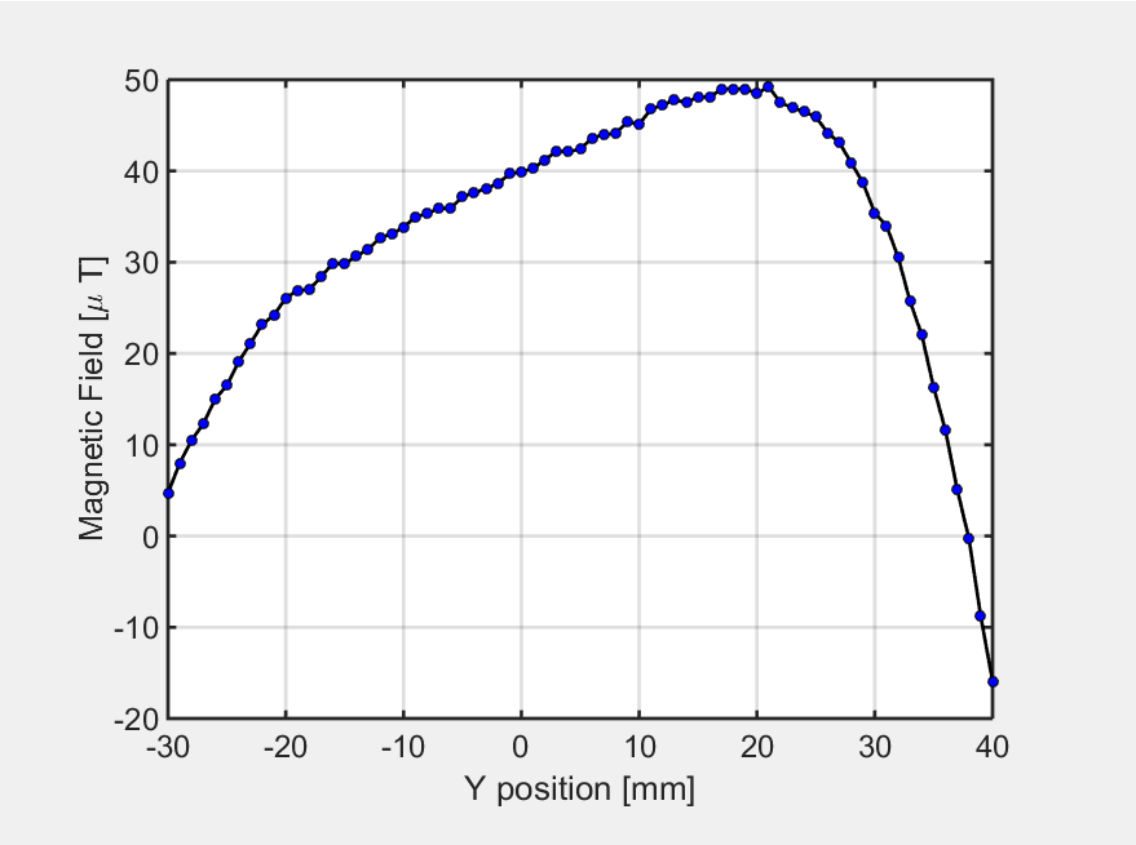


Figure 20: Field across the vertical axis of the magnet along the y-direction.

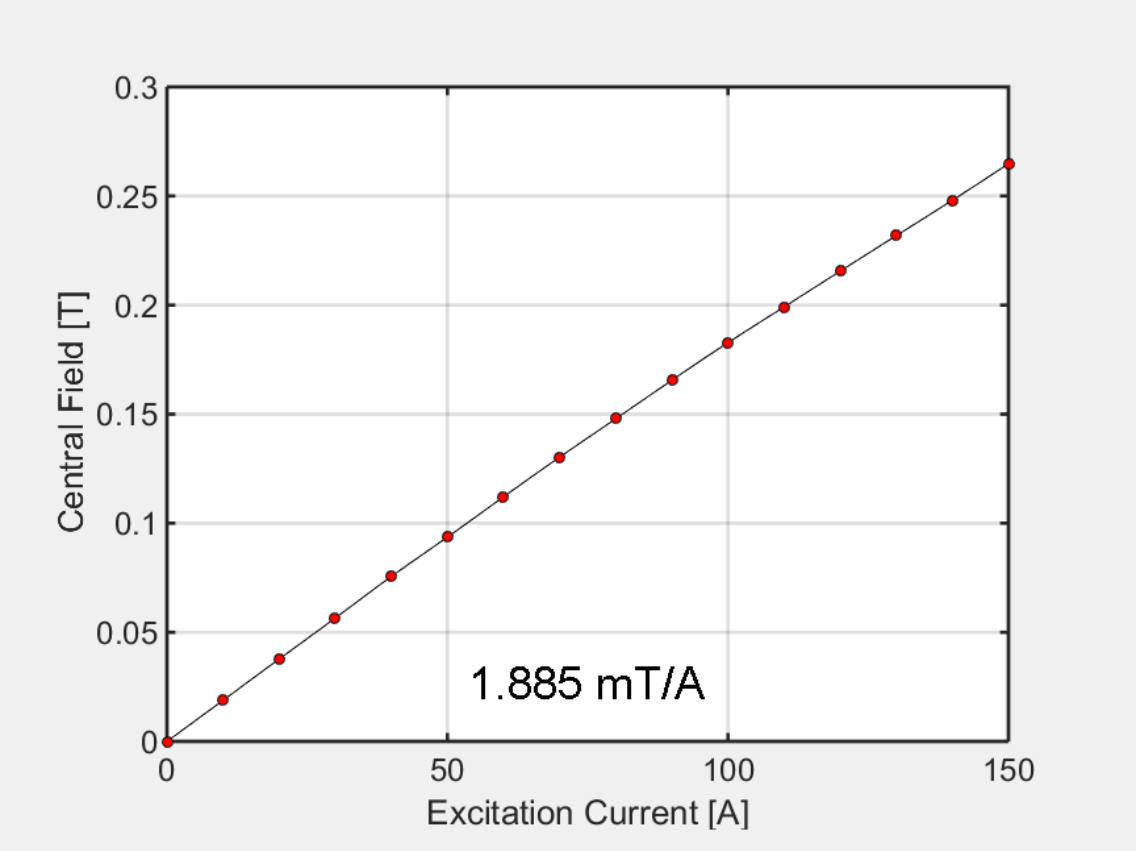


Figure 21: Measured excitation curve up to 150A.

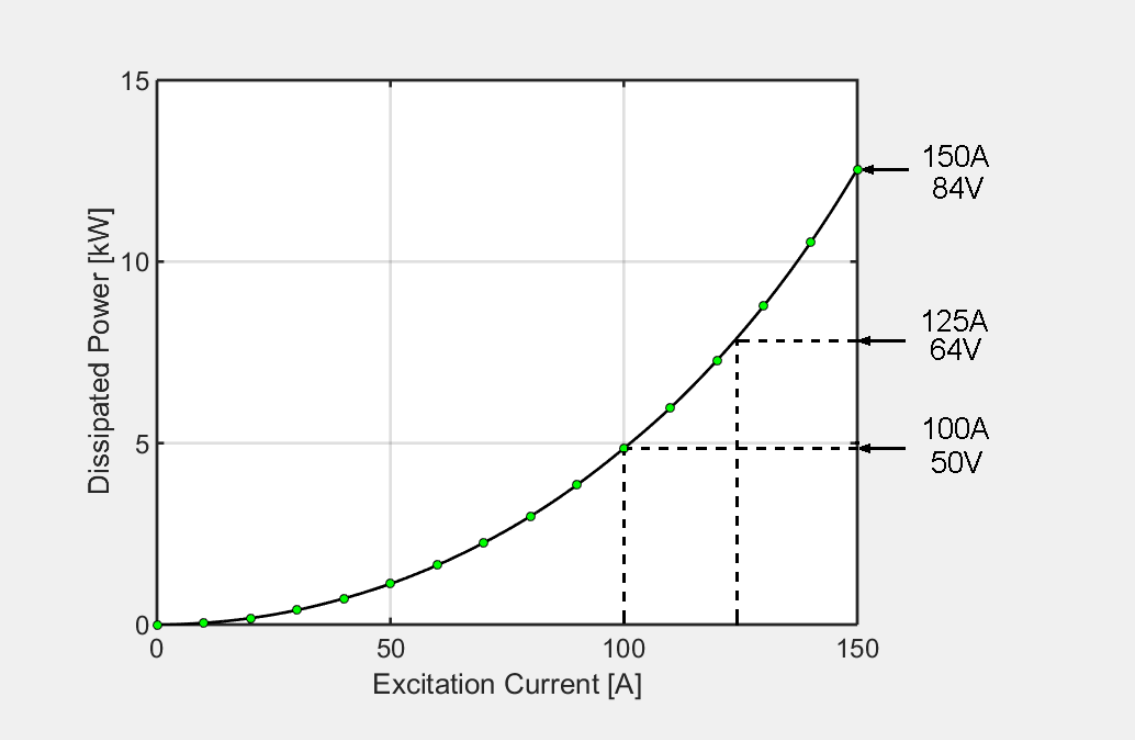
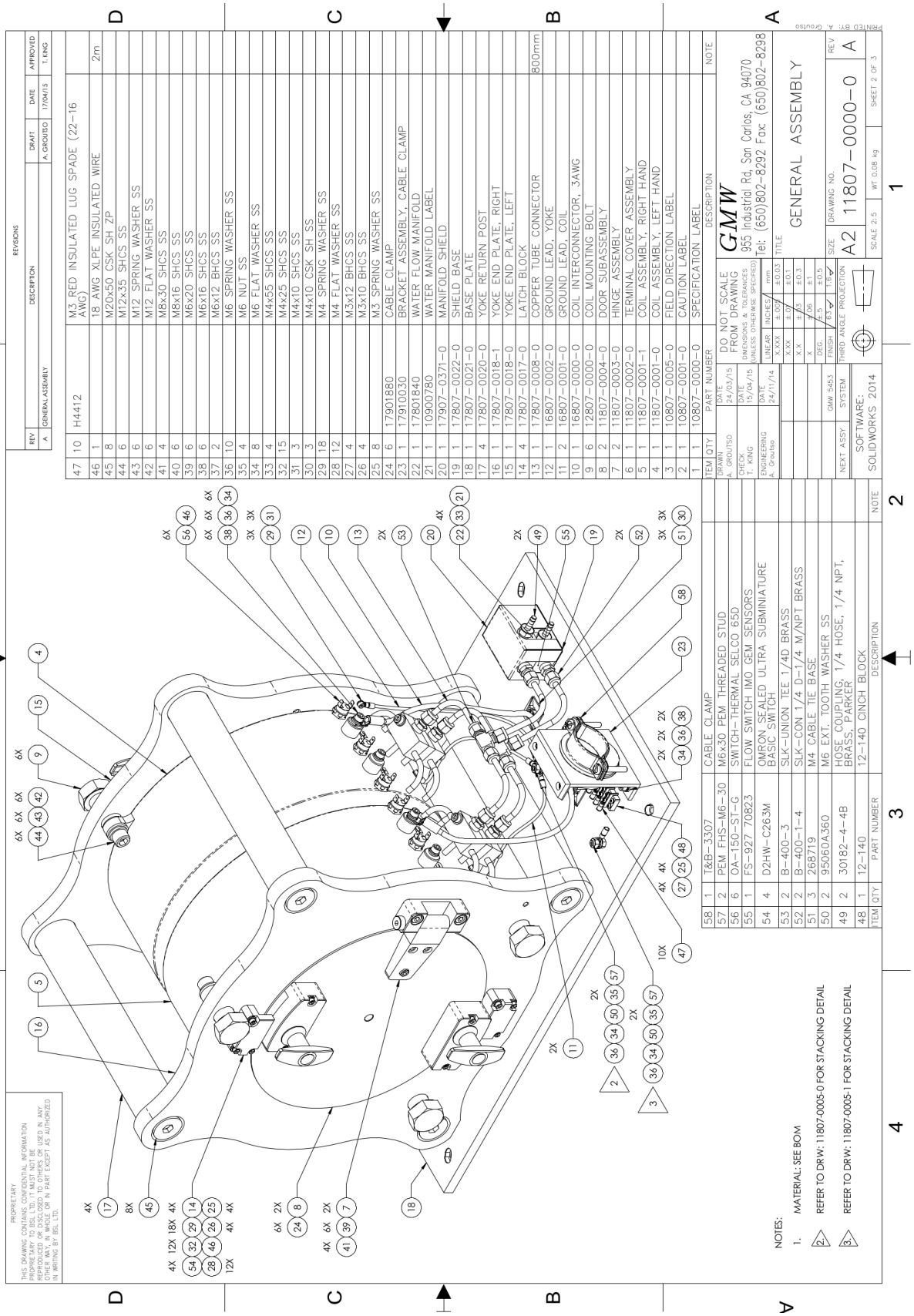


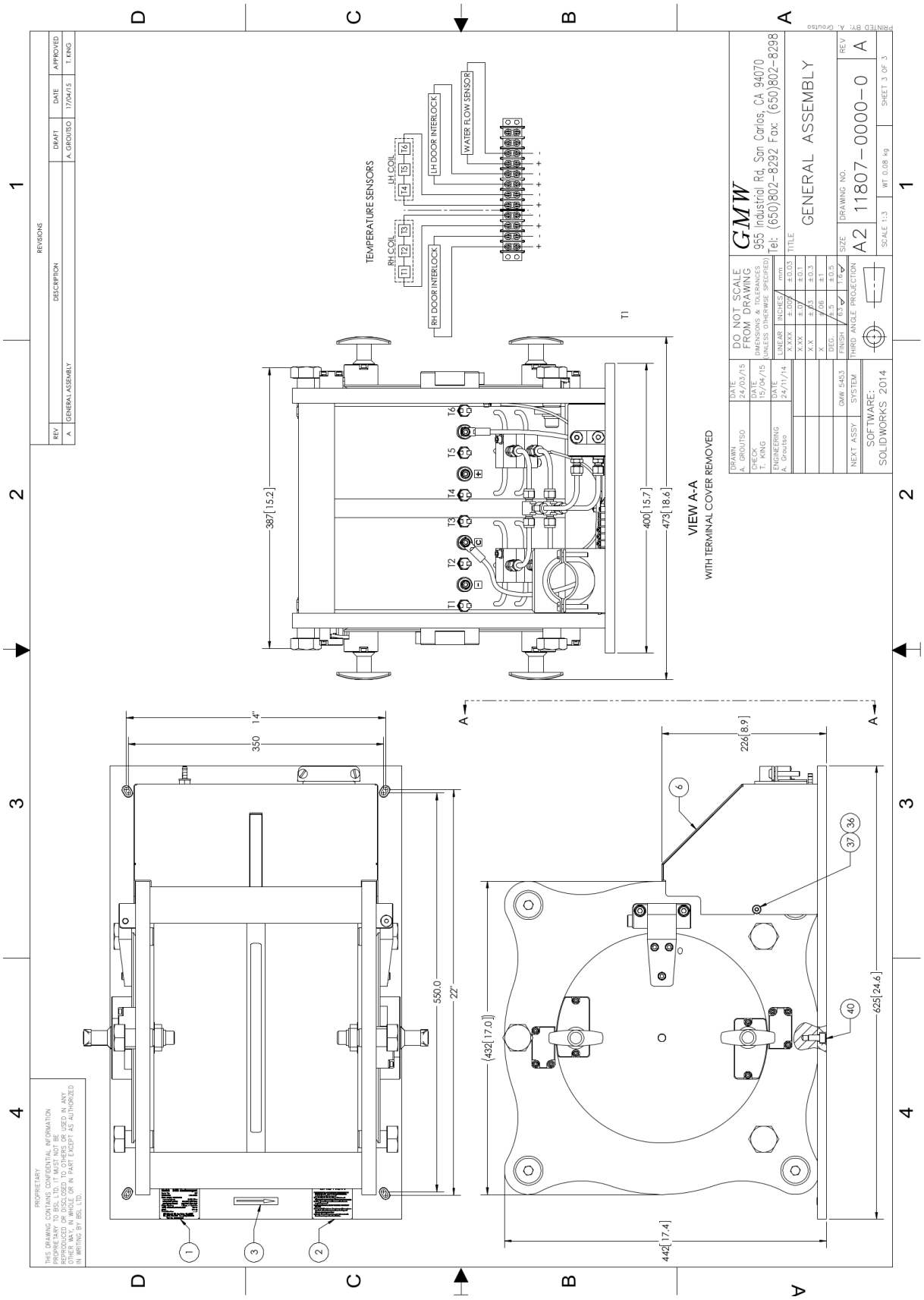
Figure 22: Measured power dissipation curve with DC power supply requirements @ 4 lpm cooling water.

12. DRAWINGS

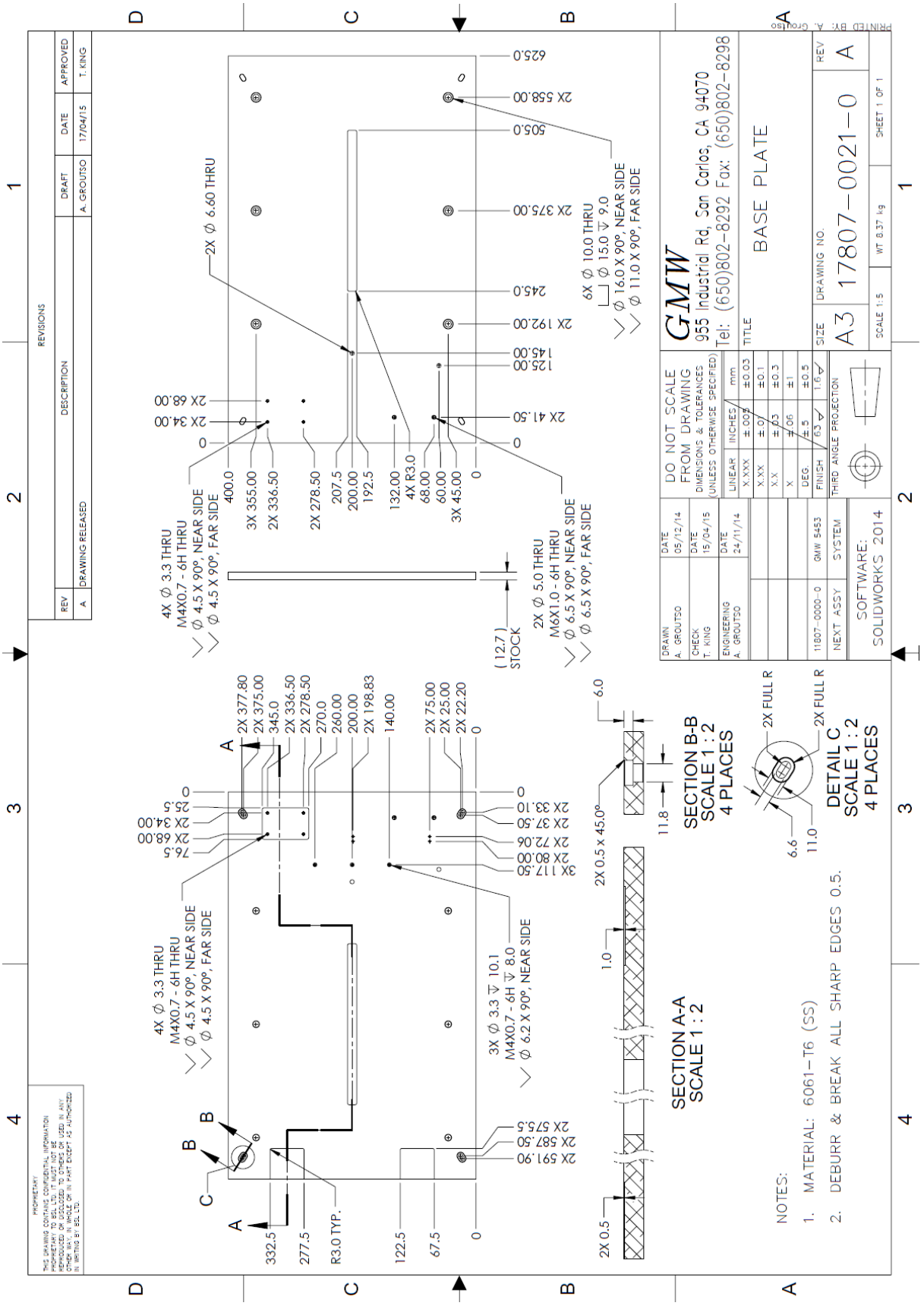
12.1. Drawing 11807-0000-0_A_S2 General Assembly – No terminal cover



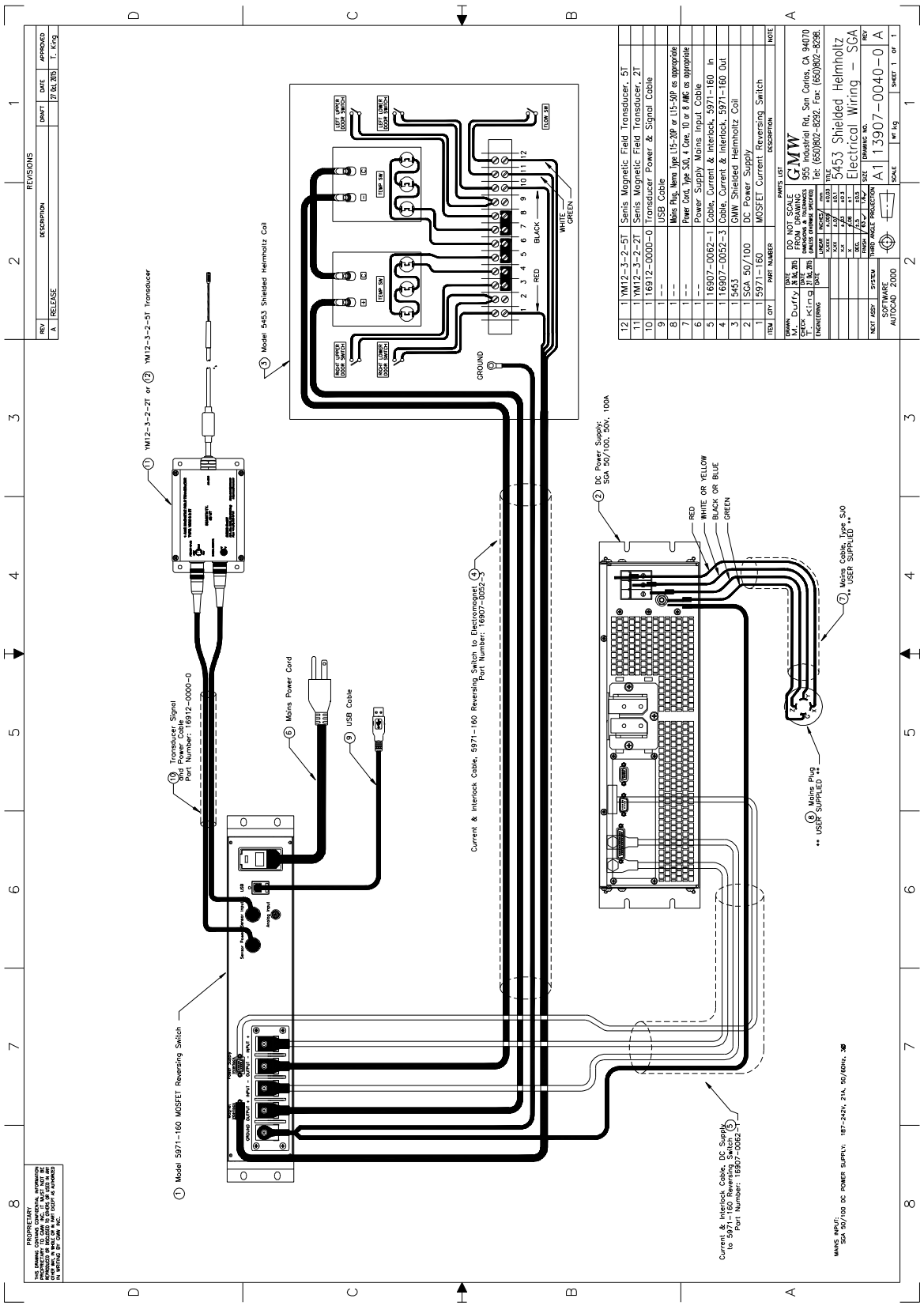
12.2. Drawing 11807-0000-0_A_S3 General Assembly



12.3. Drawing 17807-0021-0_A Base Plate



12.4. Drawing 13907-0040-0_A 5453 Electrical Wiring



ITEM	QTY	PART NUMBER	DESCRIPTION	NOTE
12	1	YM12-3-2-5T	Senis Magnetic Field Transducer, 5T	
11	1	YM12-3-2-2T	Senis Magnetic Field Transducer, 2T	
10	1	16912-0000-0	Transducer Power & Signal Cable	
9	1	--	USB Cable	
8	1	--	Mains Plug, Nema Type L15-20P or L15-30P as appropriate	
7	1	--	Power Cord, Type SJO, 4 Core, 10 or 8 AWG as appropriate	
6	1	--	Power Supply Mains Input Cable	
5	1	16907-0062-1	Cable, Current & Interlock, 5971-160 In	
4	1	16907-0052-3	Cable, Current & Interlock, 5971-160 Out	
3	1	5453	GMW Shielded Helmholtz Coil	
2	1	SGA 50/100	DC Power Supply	
1	1	5971-160	MOSFET Current Reversing Switch	

PARTS LIST

REVISIONS

REV	DESCRIPTION	DRAFT	DATE	APPROVED
A	RELEASE		27 JUL 2015	T. King

DRAWN M. Duffy 28 JUL 2015
CHECK T. King 28 JUL 2015
ENGINEERING DATE

DO NOT SCALE FROM DRAWING
UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES; TOLERANCES ARE: FRACT ±1/64; DECIMAL X ±0.03; XX ±0.01; XXX ±0.007; ANGLES ±2°; BEND RADIUS .06; FINISH 63; THIRD ANGLE PROJECTION

GMW
955 Industrial Rd, San Carlos, CA 94070
Tel: (650)802-8292, Fax: (650)802-8298

NEXT ASSY | SYSTEM
SOFTWARE AUTOCAD 2000
SCALE | WT kg
SIZE A1 | DWG NO. 13907-0040-0 | REV A
SHEET 1 OF 1

12.4. Drawing 13907-0040-0_A 5453 Electrical Wiring