



OPERATING AND INSTRUCTION MANUAL

Electromagnet with 4-Quadrant Power Supply

MODEL EMC2T [Optical access compatibility]



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MAGNET SYSTEM SAFETY DATA SHEETS (SDS)

CRYONANO Magnets are designed in accordance with industry standard Safety standards. Maintenance manuals for our products are typically included along with each product that we manufacture and ship. These manuals are also available online (see our web site www.cryonano.com). For build to order products or when special engineering is required, these manuals are typically emailed along with the certified for construction dimensional drawings. The proper handling of our equipment is required for Safe and Economical operation.

WARNING: FOR SAFE OPERATION OF EQUIPMENT, LIFTING AND SEPARATION MAGNET SYSTEMS MUST BE INSTALLED AND OPERATED BY FULLY TRAINED PERSONNEL ONLY.

Electrical Dangers exist:

Once power is applied to the magnet system, dangerously high voltages are present inside the components. Do not open enclosure doors or remove equipment covers while the power is ON. Make Electrical connections and disconnections ONLY when power is OFF.



DANGER - HAZARDOUS VOLTAGE - placed on covers of the rectifiers and controllers, and inside of rectifiers (WILL CAUSE SEVERE SHOCK OR BURN).

Pacemaker warning: This area is subject to a strong magnetic field. Anyone with a pacemaker should maintain a safe distance of at least 6 m or 20 feet away from the magnet.



WARNING: STRONG MAGNETIC FIELD

The intent of these instructions is to act as a guide and notice of the dangers that may exist in, or around, a magnet system. It is the responsibility of the owner or the operator to properly post warning signs and adequately train all personnel in the safe operation of a magnet system.

1. General Information and Overview

1.1. Purpose and Description of the Equipment

CRYONANO Research Electromagnet **EMC2T** is a high power electromagnet which can produce a maximum axial magnetic field strength of **2.0 Tesla** at maximum pole separation of 20 mm. The magnet is powered by a state of the art bipolar, linear, **true 4-quadrant Power Supply** for smooth change of polarity. This allows one to just vary the output control to seamlessly pass through zero.

It can produce a maximum axial magnetic field strength of **2.0 Tesla** at maximum pole separation of 20 mm for a large pole face of 40 mm. This magnet has water-cooled coils, wide yoke and adjustable pole separation to accommodate different kinds of Cryostat Tails and various sample sizes in different geometries/configurations. The compact, Electro-magnet is ideal for research and various kinds of industrial applications

The compact, Electro-magnet is ideal for small scale laboratory-based, wide range of experiments.

Some possible applications of the Electromagnets are:

Hall/ Spin Hall Effect Measurements

Magnetic susceptibility & Hysteresis Studies

Magneto-transport - Magneto caloric effect, Magneto Resistance Measurements etc.

Magneto-dielectric Studies

Magneto Optical Measurements

Magnetic Resonance Experiments

1.2. Equipment Specifications

High current carrying air/water cooled multiple coils are placed around either soft iron/sintered composite/alloy pole. These magnetic materials have high saturation field and low remenance. Magnetic field produced is governed by faraday laws of magnetics

$B = \text{Ampere.turn} / \text{reluctance} \times \text{pole area}$

1.3 General Specifications of High Power Electromagnets:

Pole face:	40 mm
Pole Gap:	(variable gap setting) 5 – 50 mm
Coil Gap:	140 mm (5.5 inch)
Standard Pole Face:	40 mm tapered
Coils (series connection)	
Coil resistance Nominal (20°C)	0.45 ohm(Each Coil)
Max. Continuous Nominal power (water cooled)	± 50 A/ ±50 V (approx. 2.5 kW)
Ampere-Turns	48000
Current (Maximum operating current)	50 A
Water Cooling (18°C)	8-10 liters/min

*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

Materials Used:

Yoke: Low carbon steel

Pole/Core: Low carbon steel

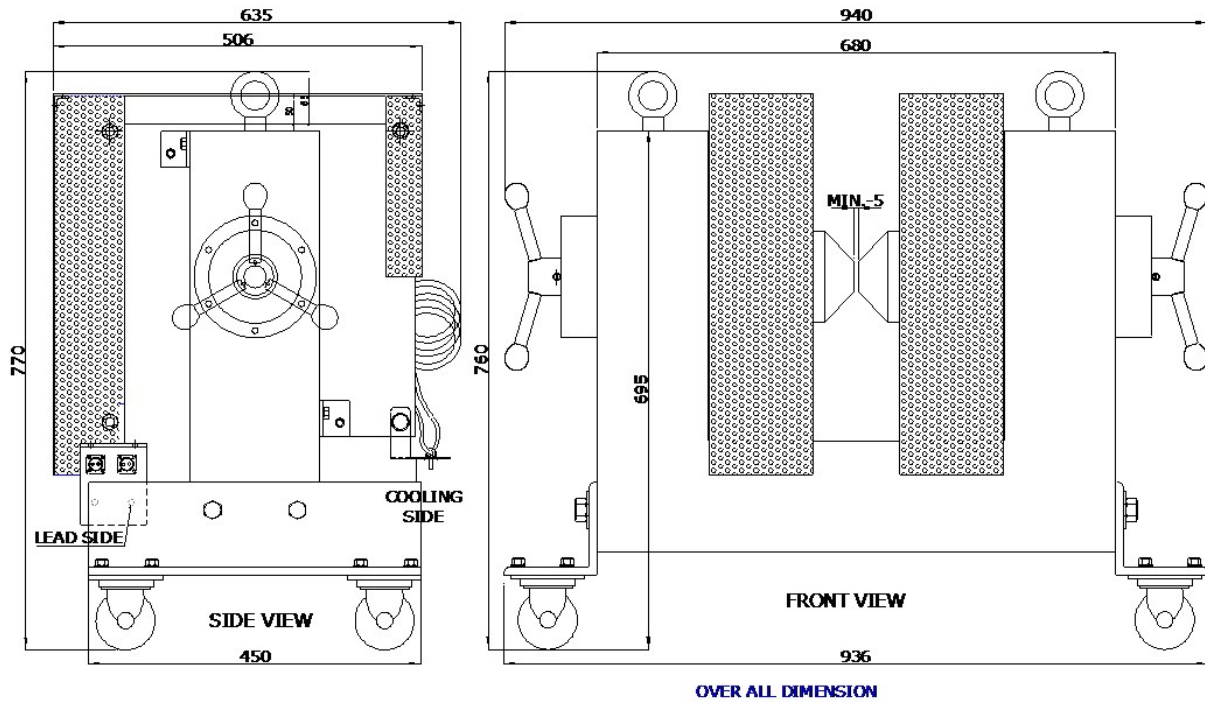
Pole caps: Low carbon steel

Coil conductor: Copper conductor

Coil cooling: Copper tubes

1.4 Dimensions:

In the figure given below the Front and Side views along with the dimensions of the Electromagnet EMC2T are shown. All dimensions are in mm. There is a 4 mm hole in the pole cap for optical access which goes up to 10mm at the end. Not been shown in the figure.



Size magnet only:

94cmx63.5cmx77cm

Approx. weight magnet only

530 Kg

Approx weight of Power Supply

35 Kg

2. Safety Hints

Observe installation, operation, and safety instructions	Read this document before installing and using the hardware unit and any other accessory in this unit.
This equipment must be connected to earth safety ground	This product is grounded through the grounding conductor of the power cord. Please ground the chassis of the Power Supply.
Do not modify the unit	Do not make electrical or mechanical modifications to this unit, which are not authorized by the manufacturer. Misuse of the hardware can result in a hazard. You can compromise the safety protection if the hardware is damaged in any way.
Do not operate in wet/damp conditions	To avoid electric shock hazard, do not operate this product in wet or damp conditions. Protect the device from humidity or direct water contact.
	Do not disconnect I/O side wires or connectors unless the power has been switched off or the area is known to be nonhazardous.
Routinely cleaning from dust	Properly lubricate the pole adjustment mechanism and keep it free from dirt.
No outdoor operation	Outdoor operation of the device is not admissible.

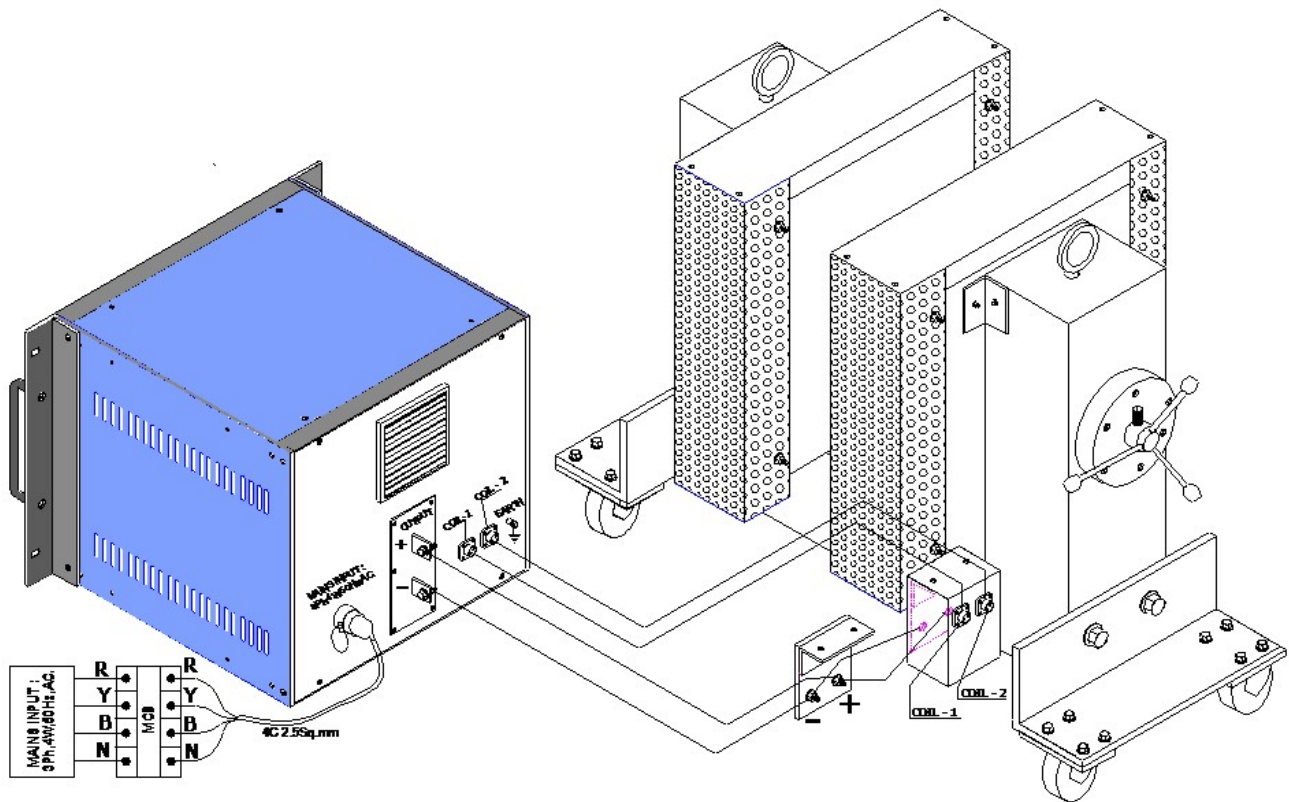
3. Installation, Cooling and Maintenance

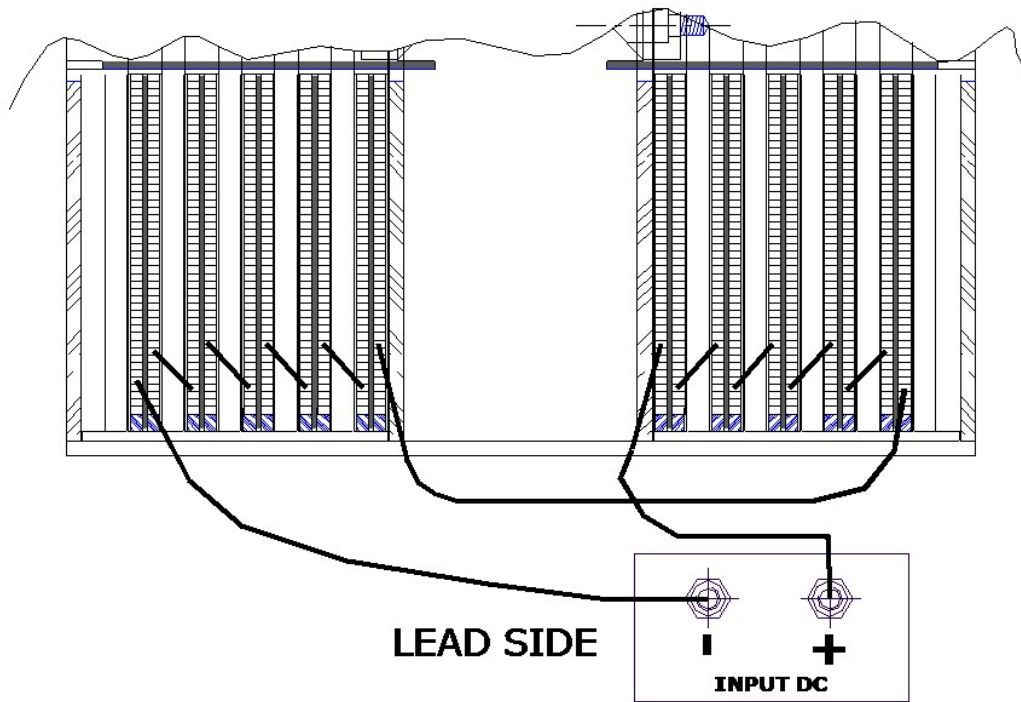
This is a heavy system. All movement, lifting and installation of the EMC2T Electromagnet must be under the supervision of an experienced person to prevent the possibility of serious injury or damage to the Electromagnet and associated equipment.

Site readiness: The following considerations are necessary for site readiness. It is required to minimize stray environmental magnetic fields such as emanating from transformers, heavy duty motors etc. The structural support of the floor needs to support the weight of the magnet and power supply. Check with your civil department for adequate load bearing capability.

Electrical readiness: The power supply the Main Input Supply requirements are 3 -phase 4-wire 415 VAC, 50 Hz connection with grounding which implies that a 30 Amp (per phase 10Amp current- > 2.5 sq mm wire) power connection with MCB connection will work. The wiring diagram for the power supply with electromagnet connection is shown in the following figure.

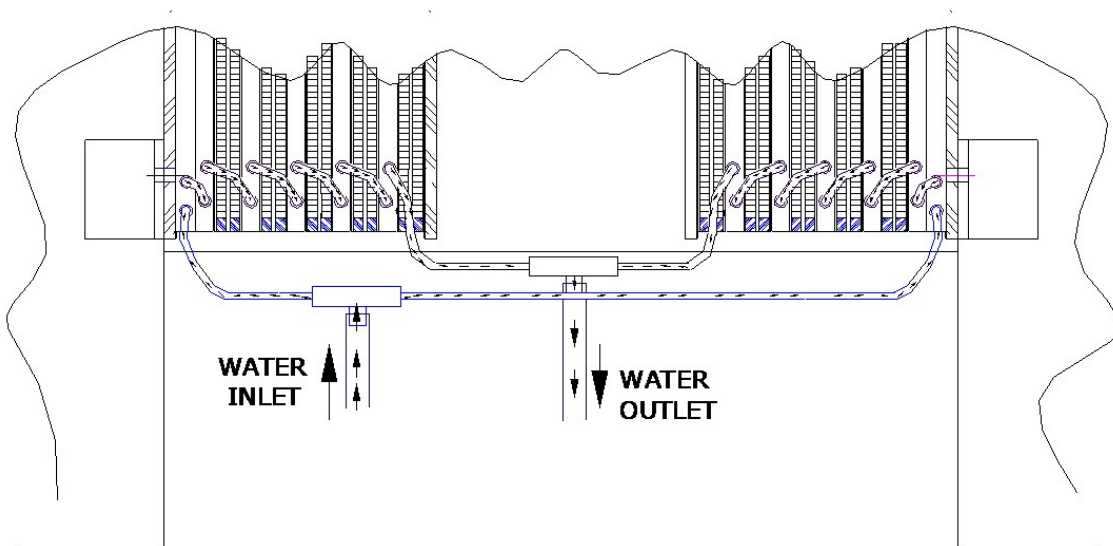
Important Note: It is very essential to ground the body of the power supply.



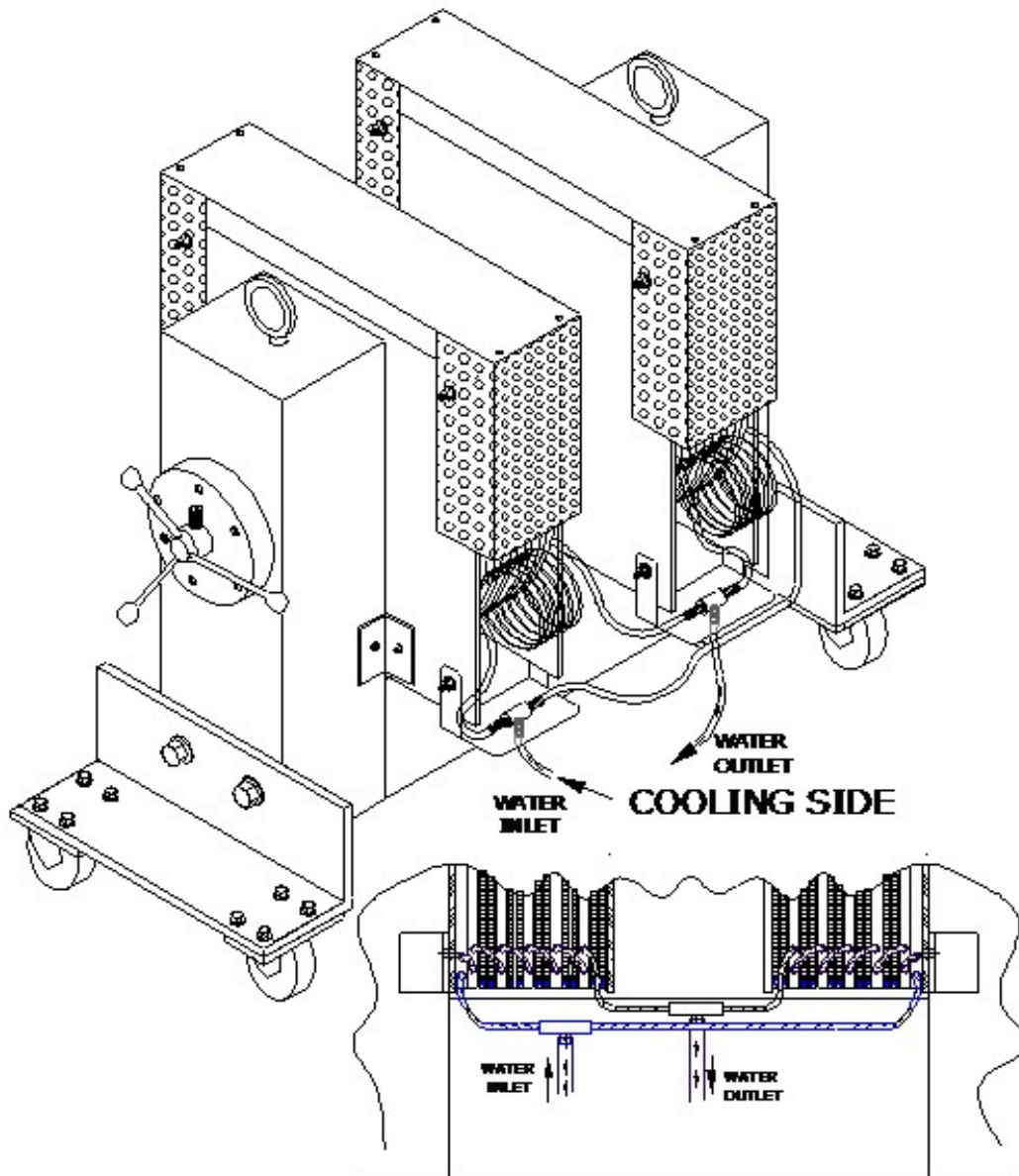


The coils are wound in series with two wires from the electromagnet connects to the back output power lugs of the electromagnet power supply.

Cooling water Requirement: EMC2T can be operated to an average coil temperature of 70°C. The cooling copper tubes are electrically isolated from the coils to avoid electrochemical corrosion. It is desirable to place a filter for trapping particulate matter for maintaining reliable water flow. For continuous operation of the magnet it is highly recommended to use a recirculation chiller. For recirculating cooling systems please use distilled or deionized water with a biocide to prevent bacterial growth and corrosion.



The electromagnet is cooled by using **8 mm pipes** samples of which are provided with the electromagnet.



The image above describes the cooling circuit of the electromagnet.

If the magnet is mainly operated at lower Fields then the water flow rate can be reduced. Please be careful about the inlet temperature to the electromagnet as this will determine the actual flow rate. Turn on the power supply and increase the current until the desired field is reached.

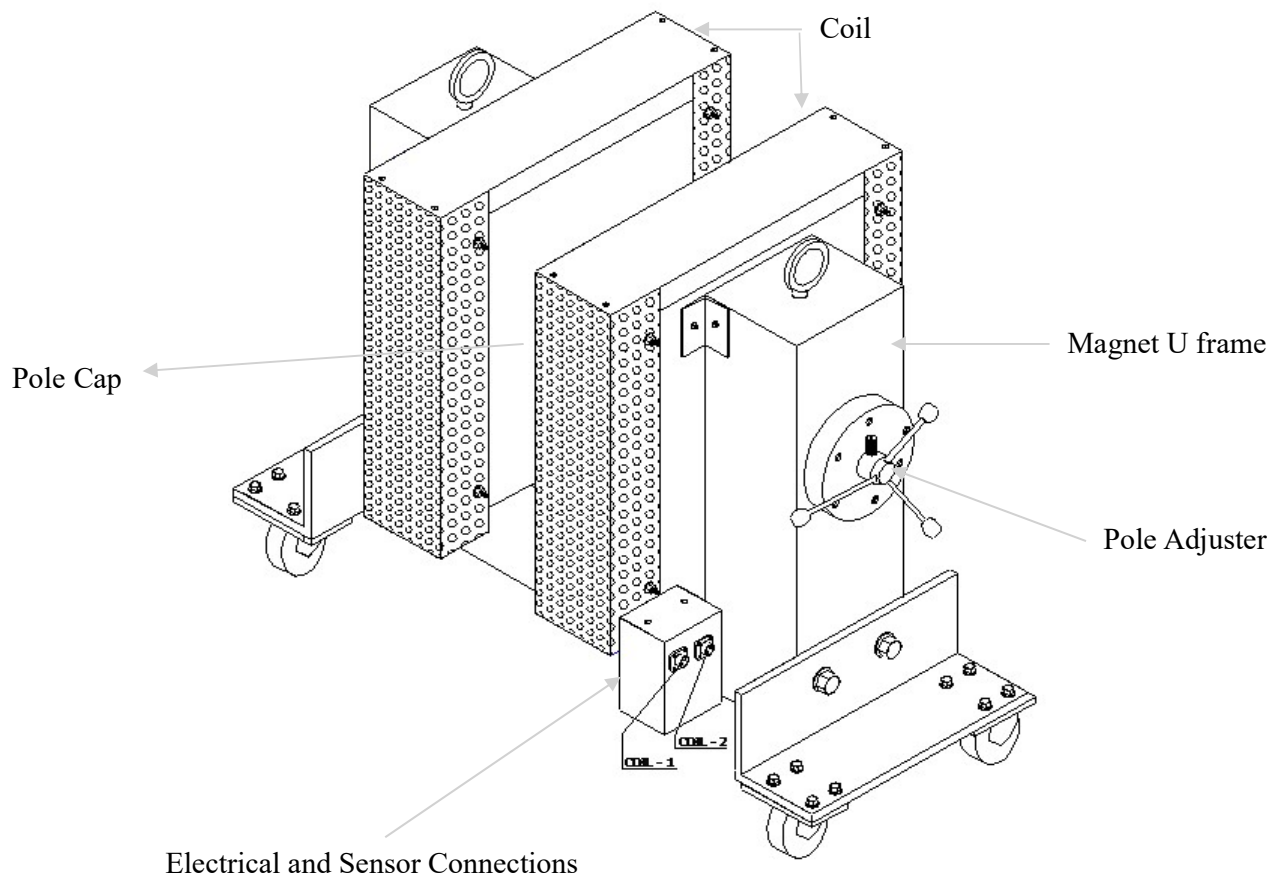
Properly lubricate the pole adjustment mechanism and keep it free from dirt. Take good care of the soft core as any damage may degrade the magnetic field uniformity of the gap. Ensure the in-line water filter is clean.

4. Operation

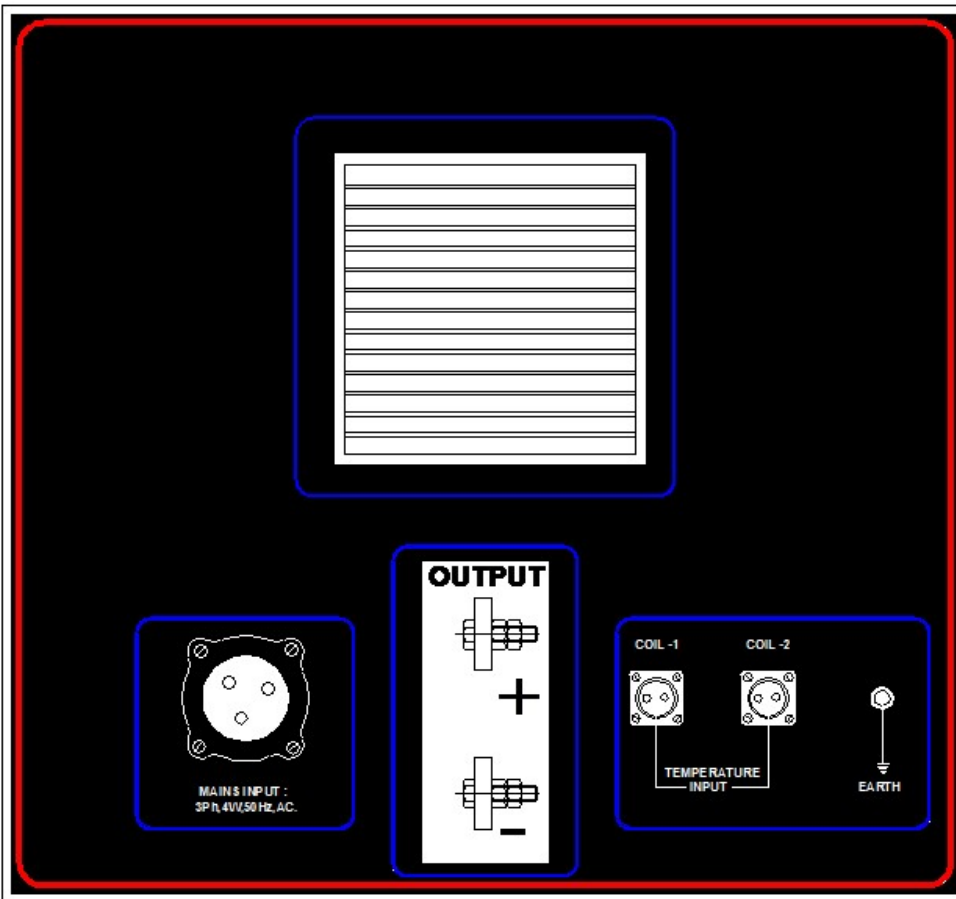
4.1 Adjusting the Magnet Air Gap

The electromagnet air gap or pole gap is the distance between the left and right polecap, at the center of the electromagnet. The EMC2T has a continuously adjustable air gap. For a given set of pole caps, increasing the magnet's air gap decreases magnetic field intensity while decreasing the magnet's air gap increases magnetic field intensity.

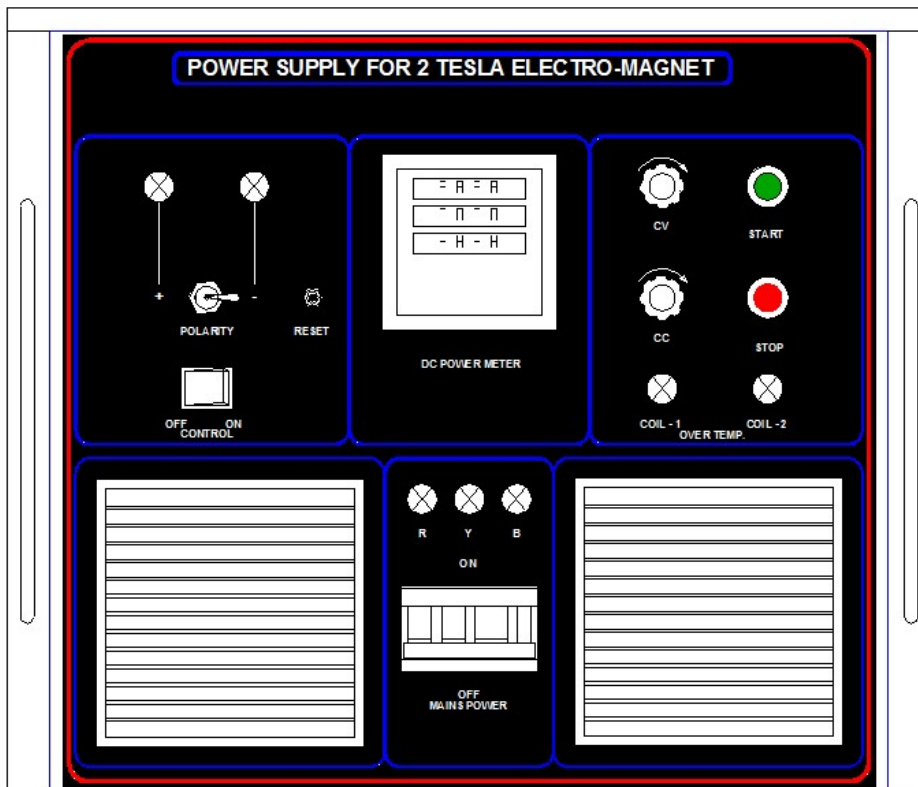
It is best to set the poles by increasing the gap to reduce mechanical backlash. Rotate the pole adjuster spokes equally on both sides [gradual one turn on each side] to move the poles to set the air gap.



4.2 Operating the power supply



- Check the DC current lugs from the electromagnet are tightly connected with OUTPUT connection.
- Check if the coil-1 and coil-2 over temperature sensors are connected.
- Ground the chassis from the EARTH connection
- Connect the 3 phase power supply plug provided to the mains input.

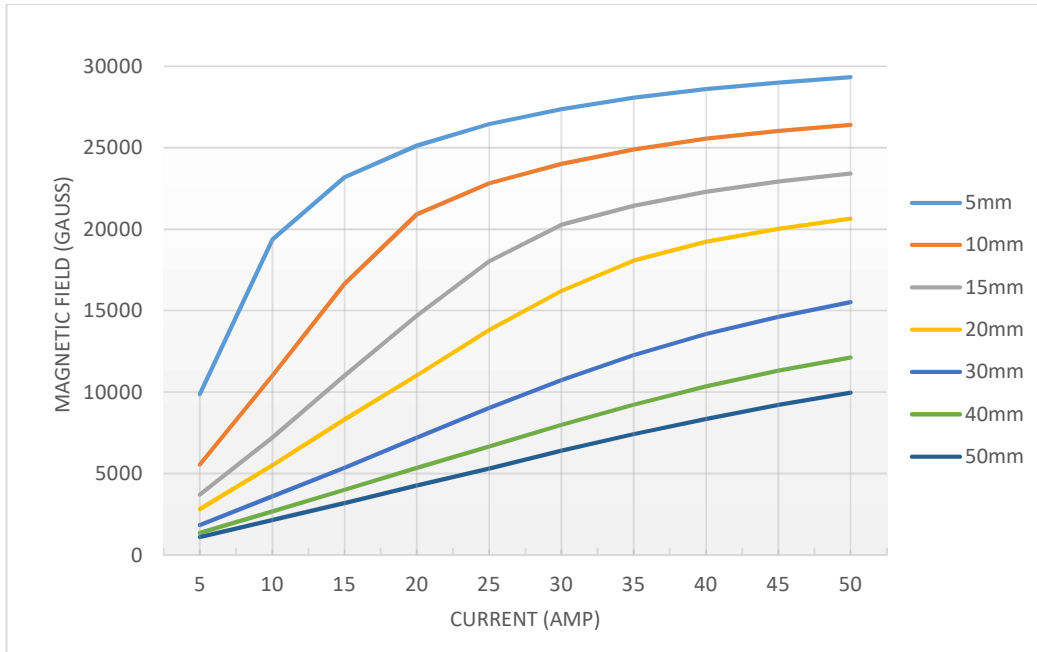


- Switch on the MAINS POWER MCB ON. The RYB phase indicators should light on. The DC power meter as indicated in the figure should also light on.
- Switch on the control ON switch on top left with user selected polarity.
- Press the Start button ON.
- Start increasing the CC knob to increase the current to set the desired current. The CV knob has been set at a higher voltage to allow the current to reach 50Amp – 44Amp is the current required to set the Magnetic field at 2 Tesla at 20 mm separation.
- If due to any reason the current is not increasing try increasing the CV knob.
- To change polarity of the Magnetic Field - Reduce the current to zero. Press STOP. Change polarity switch. Press the RESET button. SWITCH START and start increasing the current gradually again.
- To de energise the system press STOP button and power down the MCB to OFF.

5. Electromagnet Excitation Plot

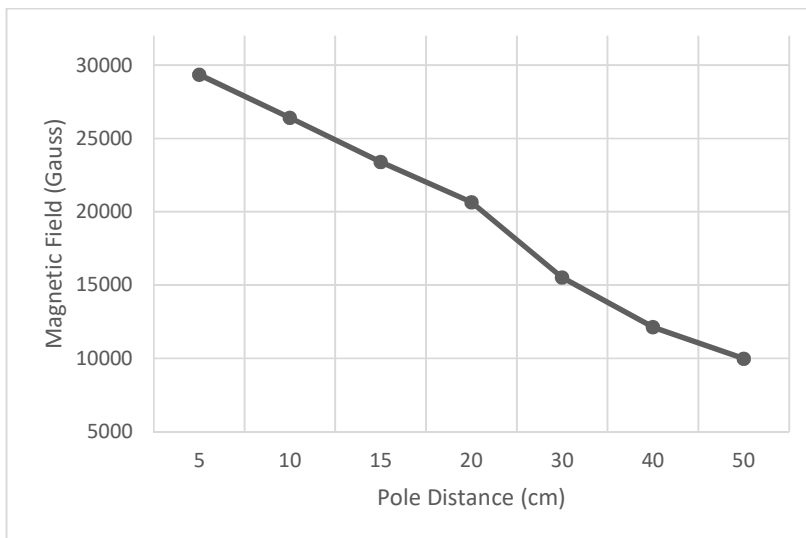
5.1 Field Vs Current at different pole separations.

The Magnetic field plots described in this manual are the typical response curves for this particular unit with 4mm hole in the pole pieces. The max. Magnetic Fields achieved as a function of current at various pole gaps is one of the most useful data for the user for operating the electromagnet. At maximum pole gap the electromagnet has a response typical of air core ones. Use this curve for your experiments.



5.2 Field vs. Pole Air Gap

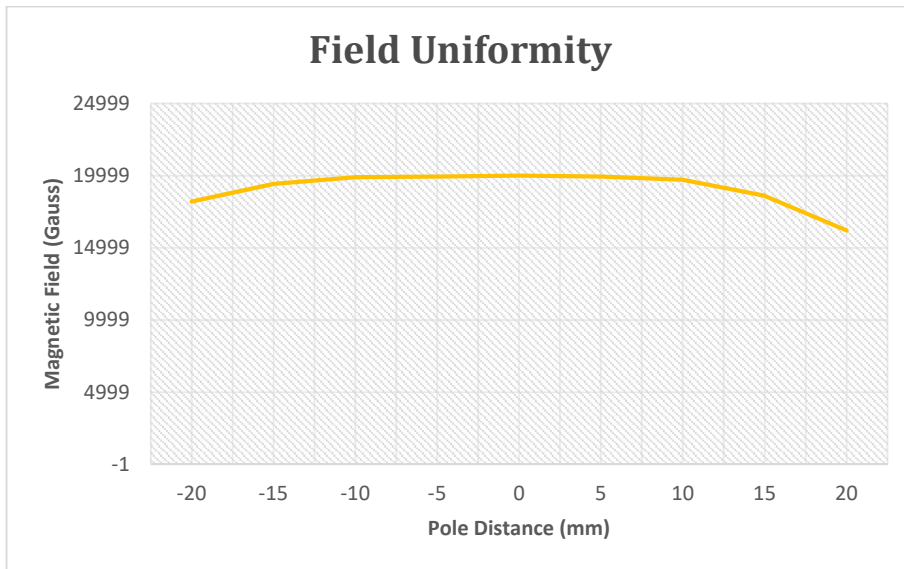
To understand the response of the magnet at 2T of field at 44A of current the following curve can be used.



5.3 Field vs Position

It is important to understand the Field Profile of the magnetic field across the Pole Face.. We provide this data for experimentalists take better decisions about the area of samples that can be measured accurately inside the Magnet.

Parameter: Pole gap = 20 mm, Current= 44 Ampere, Magnetic Field at center=2 Tesla
The Field is slightly asymmetric after 20mm cross section due to the holes drilled for Optical Access.



BIPOLAR POWER SUPPLY EMP40

The magnet is powered by a state of the art bipolar, 4-quadrant voltage and current Power Supply that can source or sink power. It is critical for driving large inductive loads like magnets and motors. These supplies can go through smooth change of polarity which can vary the output control to seamlessly pass through zero. These supplies are based on IGBT technology and are optimized for low ripple and noise even while using switch mode technology acting as regenerative loads. As the active load is regenerative, instead of heat dissipation the energy goes back to the mains increasing the efficiency of the supply. These supply can be used as either constant voltage or constant type electronic loads.

Features:

3 ψ 4-wire I Y 340~ 530VAC wide input range

Operating Modes: Voltage Mode with Current Limit or Current Mode with Voltage Limit

Rejection of line-related ripple/noise from digital readback for 50Hz and 60Hz.

High efficiency up to 91% for switch mode operation

Forced air cooling by built-in DC fan

Protections: Short circuit | Overload | Over voltage | Over temperature | Fan fail

The detailed specifications are as follows:

Main Input Supply requirements	3 ψ 4-wire / Y 340 VAC, optimum 415 VAC	
Frequency Range	47 ~ 63Hz	
Power Factor (Typ.)	0.95/230VAC(400VAC) at full load	
Efficiency (Typ.)	91 %	
Output:	Bipolar, linear, 4-quadrant DC power supply operation	
Type of Stabilizer:	Constant Voltage (CV) / Constant Current (CC), automatic crossover, Electronic regulation of current and voltage limit	
Line Regulation, Load Regulation	< \pm 0.5%, < \pm 0.5 %	
Adjustment Range:	Voltage 0-100 % of rated voltage Current 0-100 % of rated voltage	
Stability	0.01% or better considering external parameters unchanged	
Cooling	Forced air cooling with replaceable Removable dust filter	
Protection	Overload	User adjustable continuous constant current limiting or constant current limiting with delay shutdown after 5 seconds, re-power on to recover
	Over Voltage	Protection type : Shut down o/p voltage, re-power on to recover
	Over Temperature	Shut down o/p voltage, recovers automatically after temperature goes down
		Built in diodes and snubber protection for the output
		Protection against kick back due to breakage of connection to the magnetic coil
Environment	Working Temp.	-30 ~+70°C
	Working Humidity	20 ~ 90% RH non-condensing
	Temp. Coefficient	0.03%/°C(0 ~ 50°C)

6. Warranty

WARRANTY PERIOD: One (1) year

CRYONANO assures that products will be free from manufactured defects (either material or electrical) for one year from the date of delivery. If CRYONANO receives intimation of any malfunctioning during the covered period and the defective Product is shipped back to CRYONANO, it will repair without charge for parts, service labor and associated customary return shipping cost to the customer. Replacement for the product may be equivalent in performance to new. Repaired parts/ product, will be warranted for only the unexpired portion of the original warranty or 1 year (whichever is later).

CRYONANO warrants the Product only if the Product has been sold by an authorized sales representative or CRYONANO itself.

The Warranty Period begins on the date of delivery of the product.

This limited warranty does not apply to defects in the Product resulting from (a) improper maintenance, unauthorized repair, (b) power surges, lightning, (c) parts or other supplies not provided by CRYONANO, (d) unauthorized modification or misuse, (e) operation outside lab environment and without using chiller, (f) site maintenance/ renovation, (g) any kind of natural disasters such as tsunami, flood, fire, wind, or earthquake.

This limited warranty does not cover: non- CRYONANO branded Products that are integrated with the Product.

CRYONANO is not responsible whether the products will be fit for any particular purpose for which you may be buying it. Any implied warranty is limited in duration to the warranty period. No oral or written information or advice given by its Agents shall create a warranty or in any way increase the scope of this limited warranty. Buyer may have other rights that vary from country to country, state to state.