TECHNICAL INFORMATION

LM solenoid magnet systems

Author:	Dr. Taotao Huang	Document Ref:	LM2015v2
Email:	t.huang@hts-110.com	Initial Issue Date:	15/9/2015

Content

Please Note

1 System Description

1.1 Magnet

HTS-110's LM series will provide a maximum field of 1-3T at the centre of the Ø40-80mm room temperature bores. LM series are cryogen-free and are cooled by means of a cryocooler with an associated compressor.

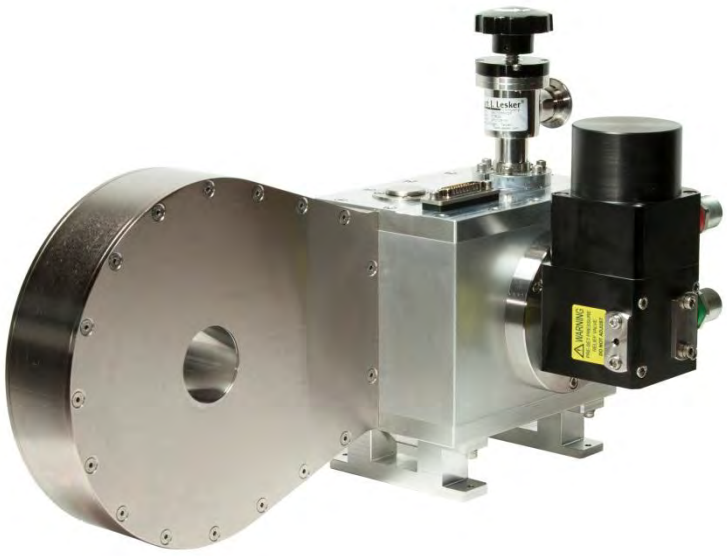
LM series will be provided with a bipolar Kepco power supply which allows the field to be set at any desired level or ramped continuously as required. The power supply is provided with interfaces which allow it to be operated via digital communications from a PC.

LM series are provided with monitoring electronics ("Magnet System Supervisor") to ensure safe, reliable operation.

1.2 Specification

Model	Bore Size (mm)	Peak Field (T)	Height (mm)	Cryostat OD (mm)	Uniformity, 5mm DSV (rms) (%)
LM-40-1T	40	1.4	45	254	0.4
LM-40-2T	40	2	55	254	0.3
LM-40-3T	40	3	100	254	0.2
LM-53-1T	53	1.1	45	254	0.3
LM-53-2T	53	2	65	254	0.2
LM-53-3T	53	3	120	254	0.15
LM-80-1T	80	1	55	254	0.2
LM-80-2T	80	2	100	254	0.15
LM-80-3T	80	3	160	254	0.05
Maximum operating current				125A	

1.3 Magnet Layout & Performance



The magnets can be oriented vertically and horizontally. Please note that support brackets are optional and not included in this supply.

1.3.1 Magnetic Field Profile

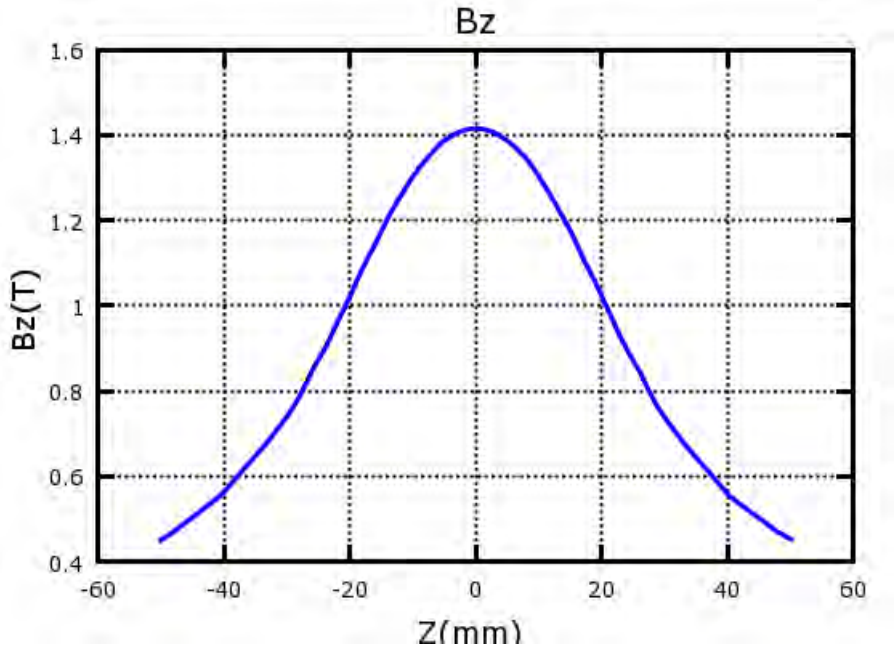


Figure 1 Field profile of LM-40-1T in the axial direction

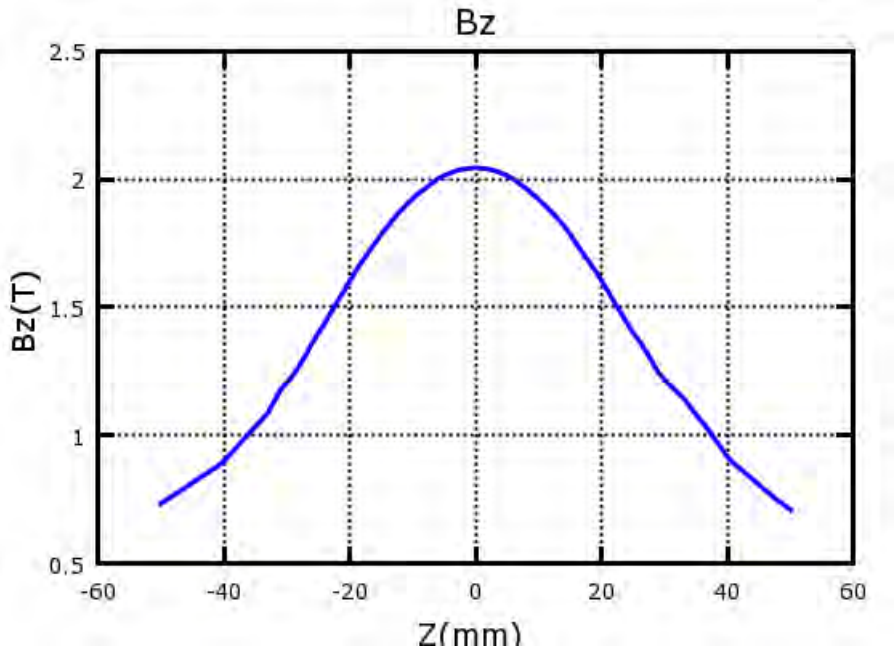


Figure 2 Field profile of LM-40-2T in the axial direction

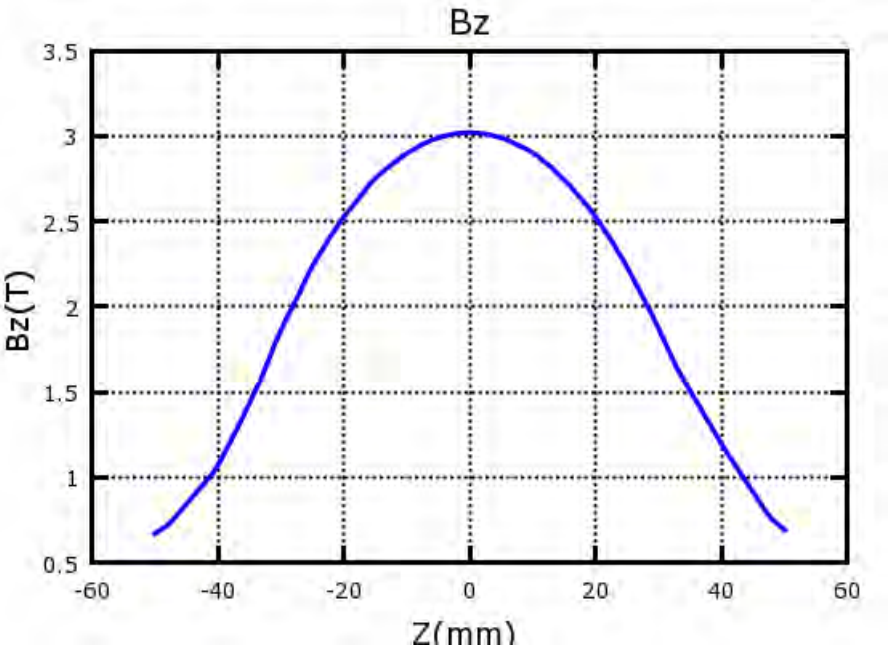


Figure 3 Field profile of LM-40-3T in the axial direction

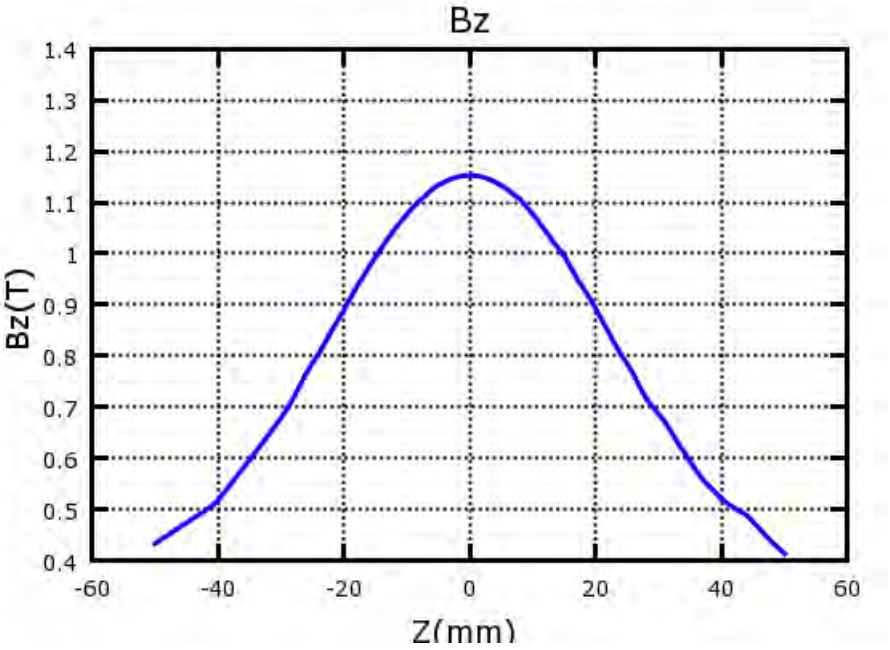


Figure 4 Field profile of LM-53-1T in the axial direction

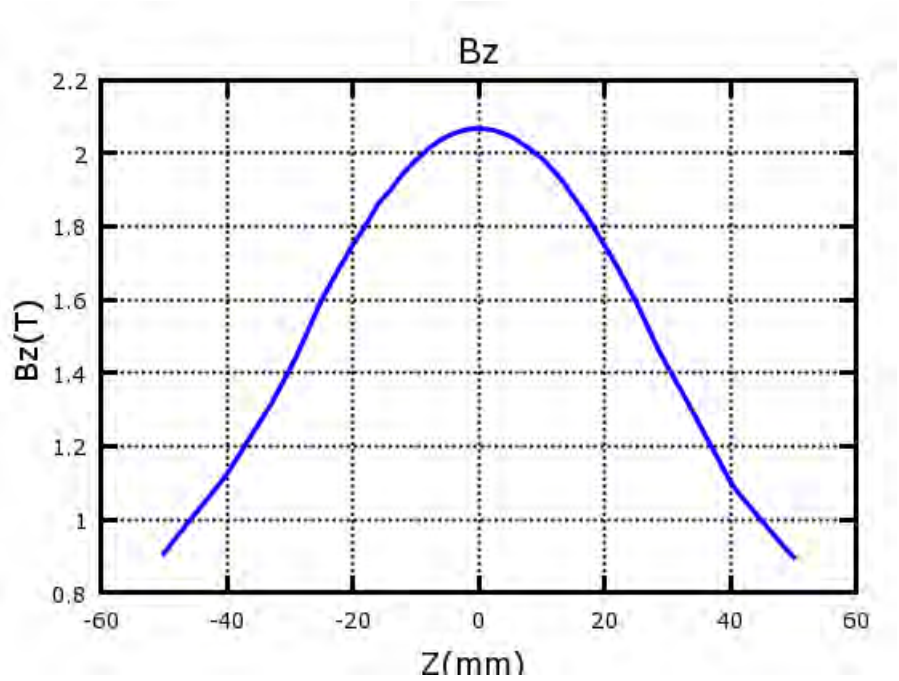


Figure 5 Field profile of LM-53-2T in the axial direction

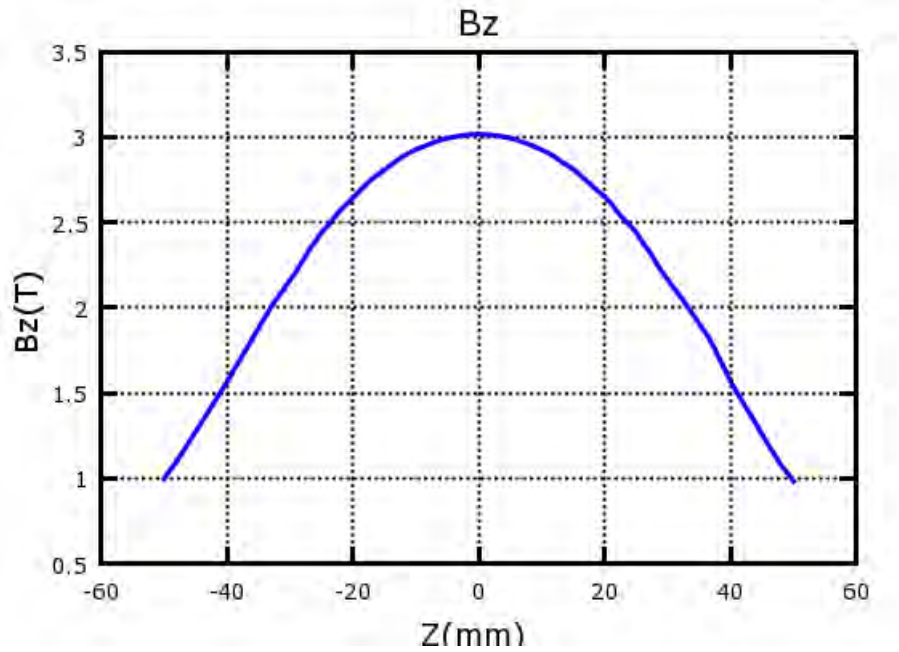


Figure 6 Field profile of LM-53-3T in the axial direction

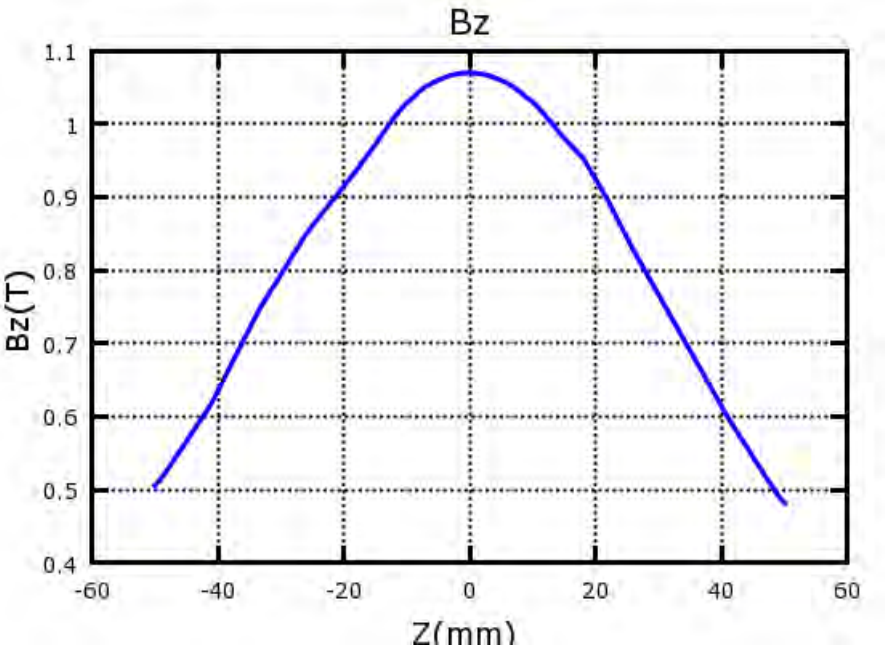


Figure 7 Field profile of LM-80-1T in the axial direction

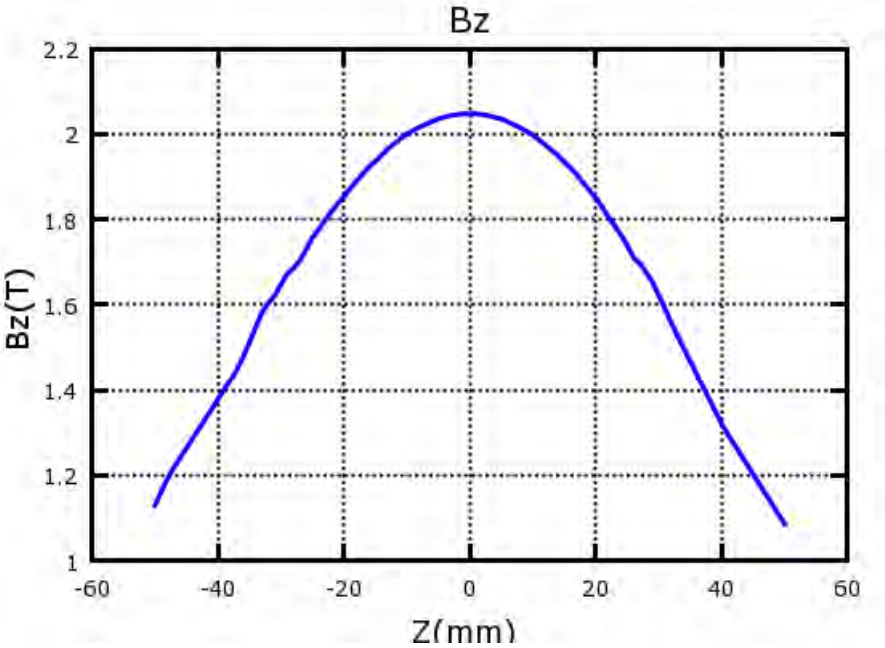


Figure 8 Field profile of LM-80-2T in the axial direction

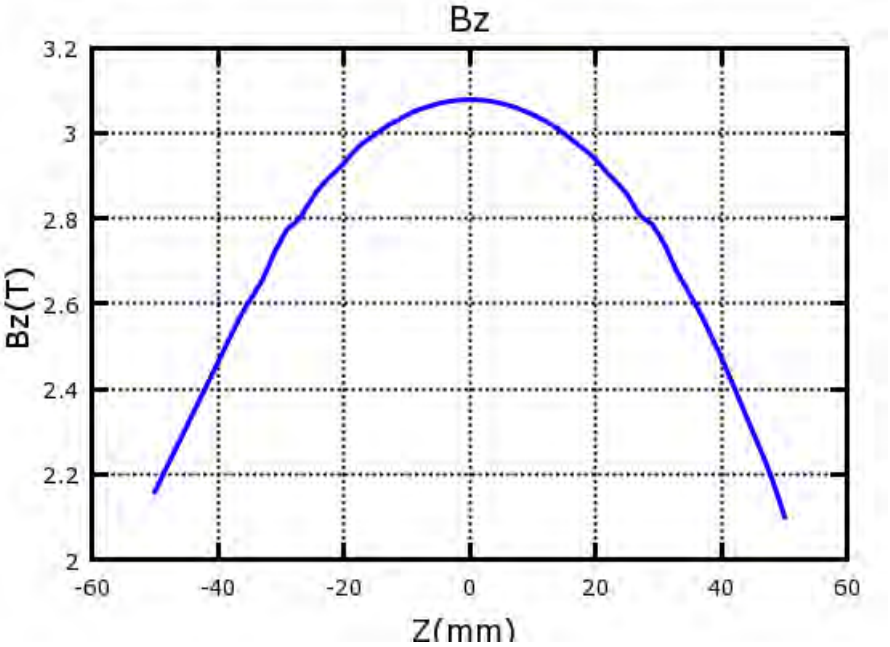


Figure 9 Field profile of LM-80-3T in the axial direction

Figure 1-9 shows the fields in the axial direction.

1.3.2 Fringe Field

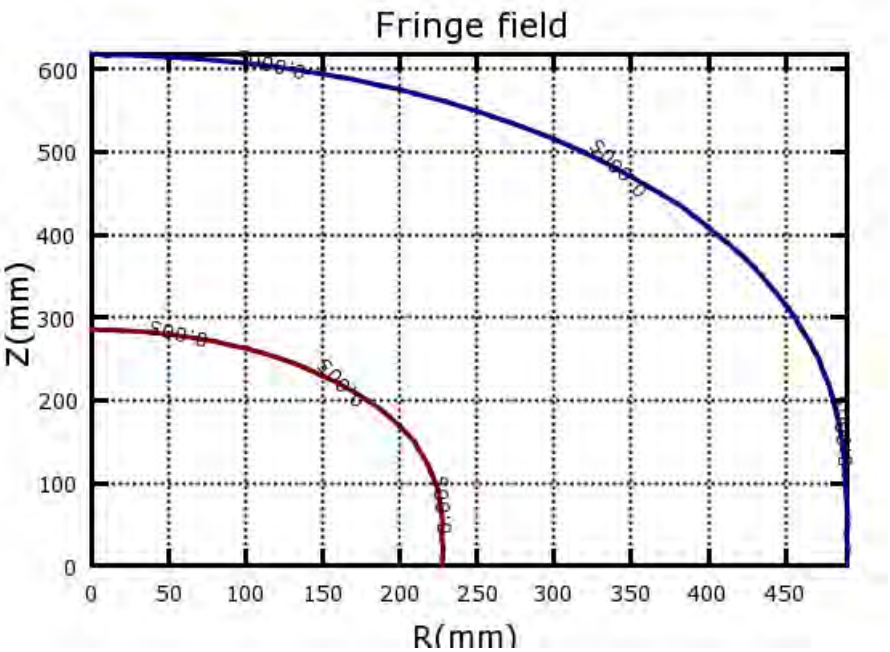


Figure 10 Fringe field of LM-40-1T

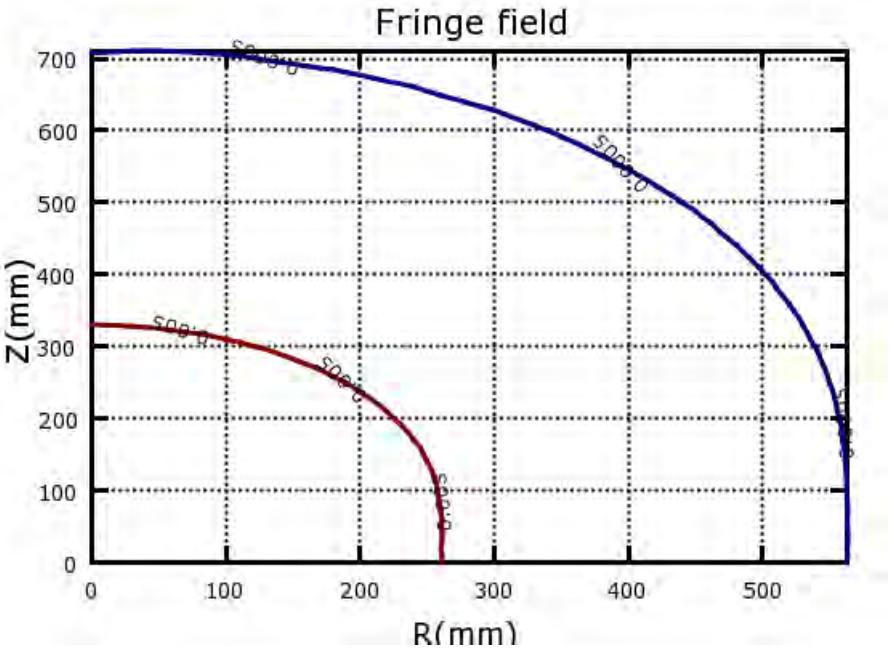


Figure 11 Fringe field of LM-40-2T

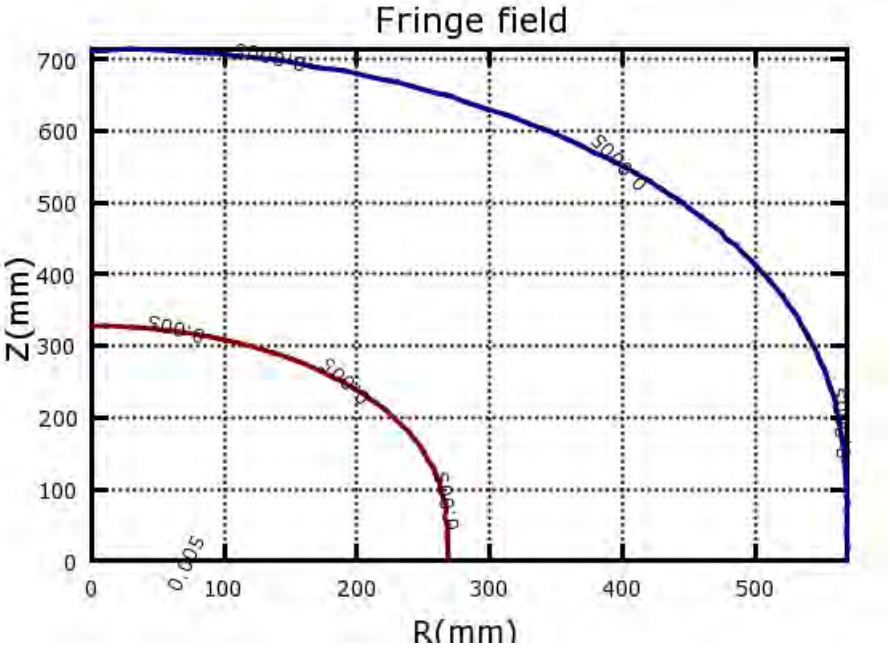


Figure 12 Fringe field of LM-40-3T

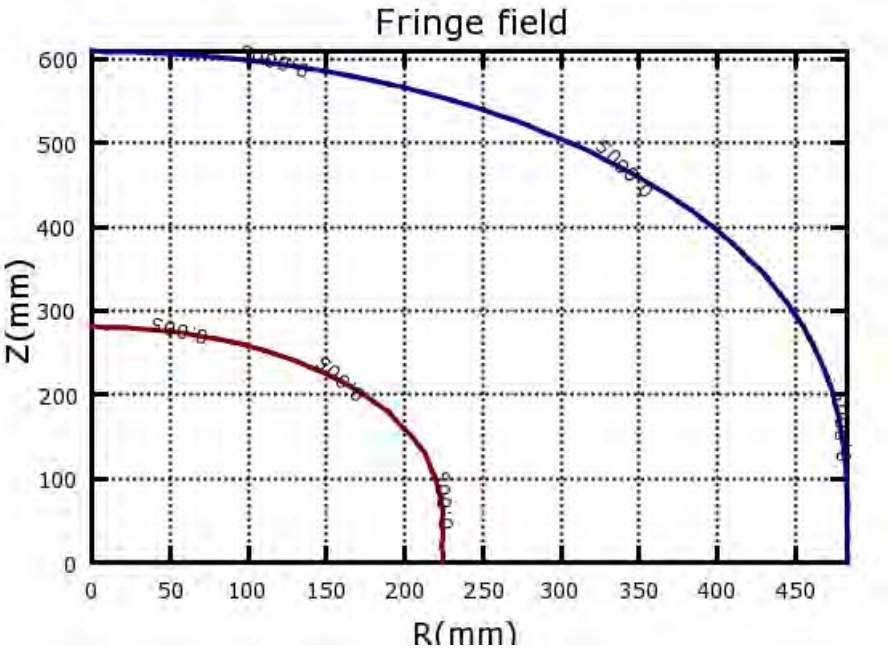


Figure 13 Fringe field of LM-53-1T

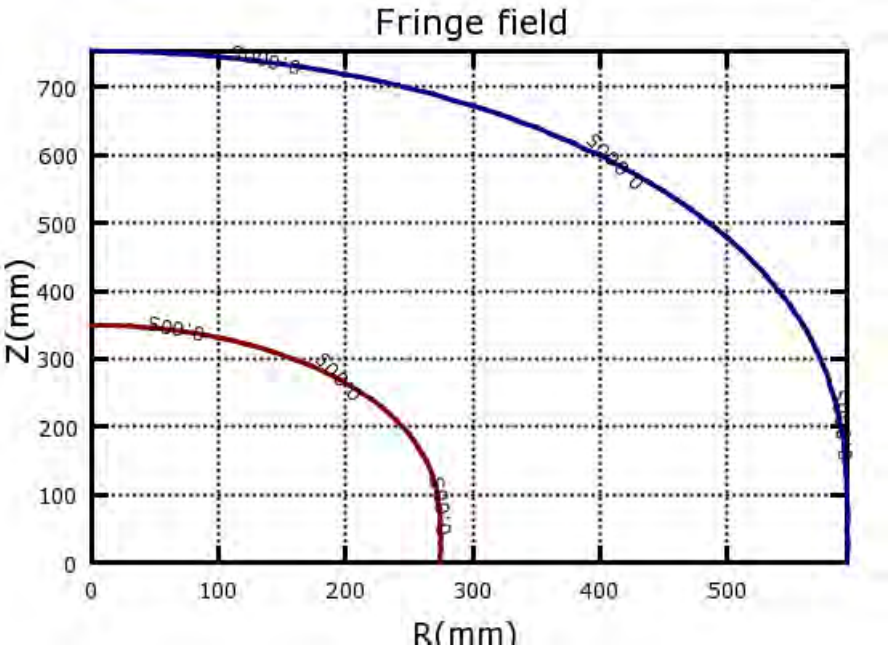


Figure 14 Fringe field of LM-53-2T

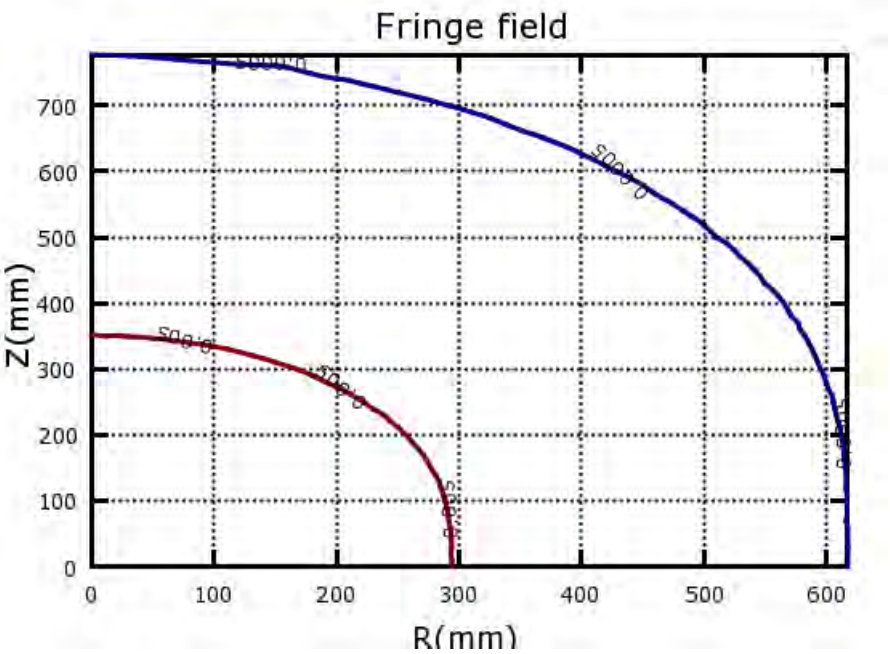


Figure 15 Fringe field of LM-53-3T

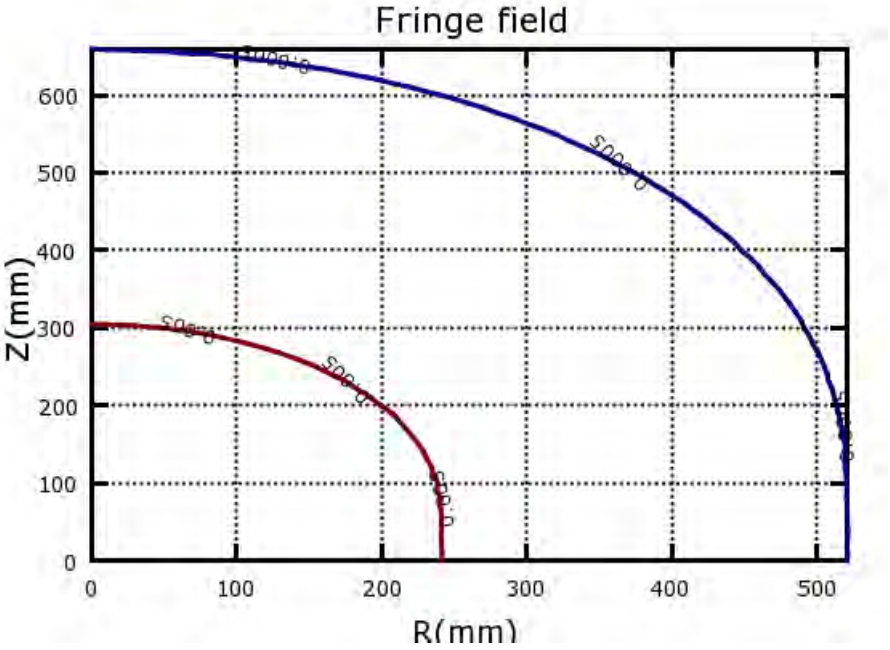


Figure 16 Fringe field of LM-80-1T

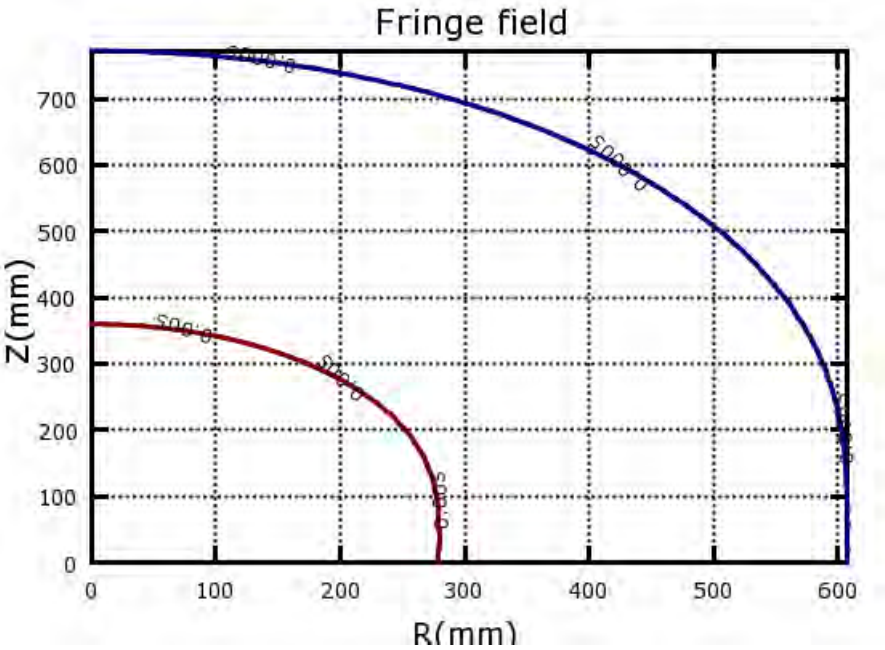


Figure 17 Fringe field of LM-80-2T

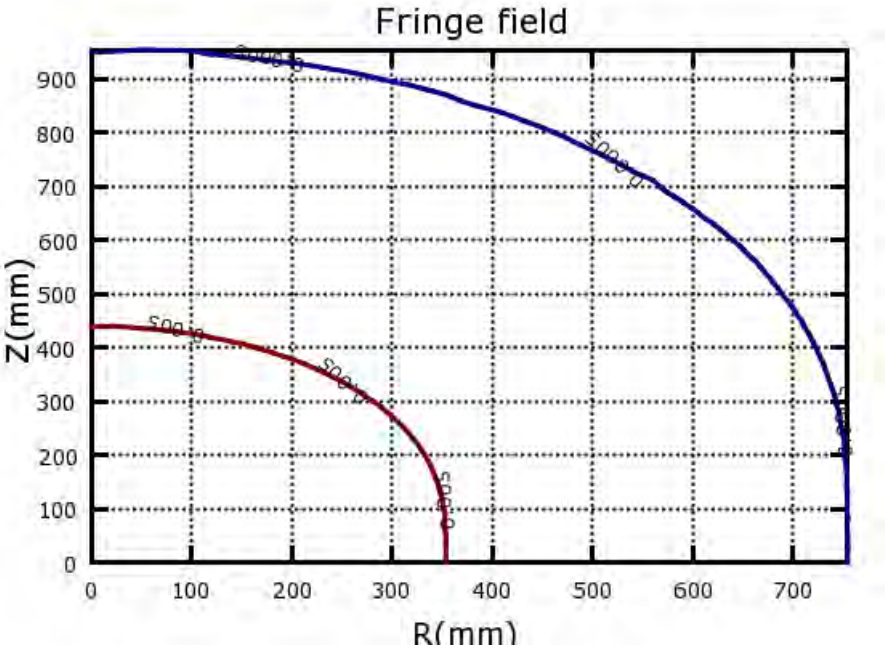


Figure 18 Fringe field of LM-80-3T

50 Gauss (red) and 5 Gauss (blue) lines of the magnets are shown in Figure 10-18.

1.4 Power Supply

KEPCO BOP power supplies are normally used with HTS-110 magnets. These are 4-quadrant supplies offering smooth sweeps through a zero field (no switching). The power supplies have communication interfaces for remote operation and are connected to the Magnet System Supervisor for safety shut-down. The magnets are driven by one KEPCO BOP 6-125MG power supply.

1.5 Cryocooler

The magnet coils are kept at operating temperature using a cryocooler and associated compressor. Specifications of this cooler are included in the Technical Information Section.

1.6 Magnet Field Control Software

The relationship between field and current is determined when the magnets are tested at HTS-110. The power supply can be controlled from a PC on which the client can run its own programs to control the magnet field.

1.7 Magnet System Supervisor

All HTS-110 magnets are supplied with an in-house magnet system supervisor (MSS). The MSS monitors temperature at several points within each coil pack as well as voltage across the coils. Given the high thermal stability of HTS magnets, abnormal operating condition can be readily detected and acted on before a quench occurs. If a pre-quench condition is detected a shut-down command is sent to the power supply and the stored energy dumped through a resistor based dump circuit.

The dump circuit is sized to ensure complete energy dump within the required time from the sequence trigger. Approximate decay time in case of dump is in the range 1-5 seconds.

1.8 Yoke

An aluminium cryostat integrated with returning yoke forms the mechanical chassis for the system. This outer yoke is manufactured from low carbon steel (AISI 1006) with a nickel coating for corrosion resistance.

2 Infrastructure requirements (expected)

For installation an oil-free vacuum pump (not supplied by HTS-110) is required. It is also recommended that a vacuum pump is available on site so that the magnet vacuum can be reconditioned from time to time.

Cryocooler & Compressor	1 phase 200V, 220V,240V, 50Hz or 200V, 208V, 220V 60Hz, 11A (Max)
Cooling Water	5 litre per minute @ 18°C
Magnet System Supervisor	100-240 VAC,47/63HZ, 1ph 0.25A (Max)
Magnet Power Supply	176-264 VAC, 47/63 Hz, 1ph, 9.5 A (Max)
Current Terminal Heaters	110-230 V : 50/60 Hz, 1ph 0.1A (Max)

3 Pre-delivery Tests

1. Vacuum integrity
2. Cool-down time
3. Static monitor tests
    a. Disable signal correctly switches off the power supply
    b. Power-supply disabled when voltage limits exceeded
    c. Power-supply disabled when temperature limits exceeded
    d. Power supply disabled if magnet monitor cable is removed/monitor switched off
4. High current monitor/dump-circuit test - Power supply disabled and magnet safely ramps down
5. Fringe field - Radial and axial 5 gauss line
6. B vs I excitation curves for magnet
7. Field maps if required
8. Single non-linear cycle at fastest stable rate.
   -Cycle time and maximum temperature excursion recorded.

4 Technical Information

4.1 Magnet System Supervisor (MSS)

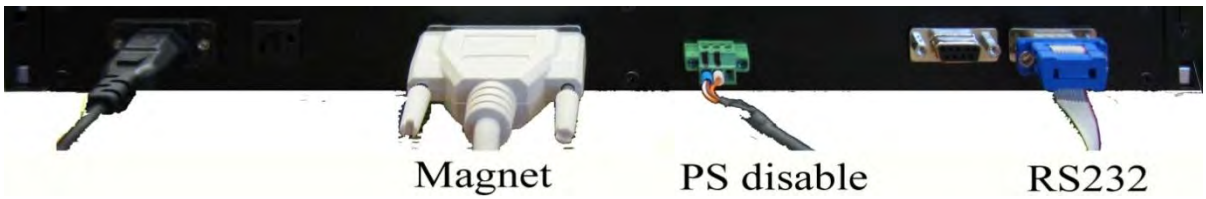
The Magnetic System Supervisor (MSS) is designed to monitor the conditions of the HTS magnet and automatically disable the power supply if the magnet begins to operate abnormally. The MSS can control the power supply attached to the magnet system via the auxiliary communication port using a standard RS-232 cable to create a fully autonomous system.

The MSS fits inside 19" Rack, it is 1U tall, 10" deep and weighs 3kg. The MSS requires 47/63Hz 100-240V, 0.4A max, single-phase power.

Features

- Five dedicated temperature channels: for simultaneously measuring up to five cryogenic temperature sensors.
- Two dedicated voltage channels: for simultaneously measuring up to two fully differential voltages.
- PC communication output: for remote control/monitoring of the system via a computer.
- Interlock relay output: for disabling the power supply in the event of a quench.
- Aux relay output: for switched control output. (optional)
- Status lamp: a multi-colour led for visual status update.

4.2 Key MSS Interfaces



AC in	Data line x <10' (from magnet)	Safety interlock x <10' (to power supply)	Data logging port (to PC) – usage optional

4.3 Power Supply Data Sheet

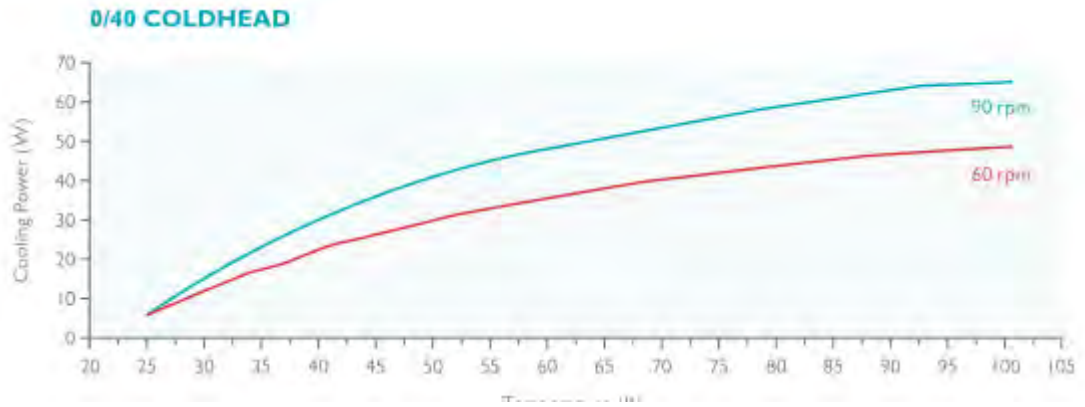
Detailed input characteristics:

SPECIFICATIONS		RATING/DESCRIPTION	CONDITION
a-c Voltage	nominal	230V a-c	Single phase
	range	176-264V a-c	
Frequency	nominal	50/60 Hz	
	range	47-63 Hz	
Current	176V a-c	9.5A (7.5A)*	Maximum
	264V a-c	6.4A (4.4A)*	Maximum
Power Factor	source	0.99	Nominal output power
	sink	0.97	
Efficiency		65% (56%)*	Minimum when sourcing
Switching Frequency		70 KHz ±5% (50KHz ±5%)*	Active PFC for source and sink
EMC Compliance		EN61326-1 (1997)	Class A equipment
EMC Immunity	ESD	EN61000-4-2	Electrostatic discharge
	Radiated RF	EN61000-4-3	
	EFT	EN61000-4-4	Electrical fast transient/burst
	Surges	EN61000-4-5	
	Conducted RF	EN61000-4-6	
EMC Emissions	Conducted	EN61000-3-2	Harmonics
		EN61000-3-3	Fluctuation and flicker
	Conducted	EN55011/CISPR11	0.15 to 30 MHz
	Radiated	EN55011/CISPR11	30 to 1000 MHz
Leakage Current		3.5 mA	230V a-c, 47-63 Hz
Insulation Coordination	Input	Installation Category II	For TN or TT power system
		Overvoltage Category II	
	Output	Installation Category II	Maximum 300V common mode voltage between output terminals and chassis ground
		Overvoltage Category II	
	Pollution Degree	2	

4.4 Cryocooler Data Sheet

Coolstar 0/40 cold head

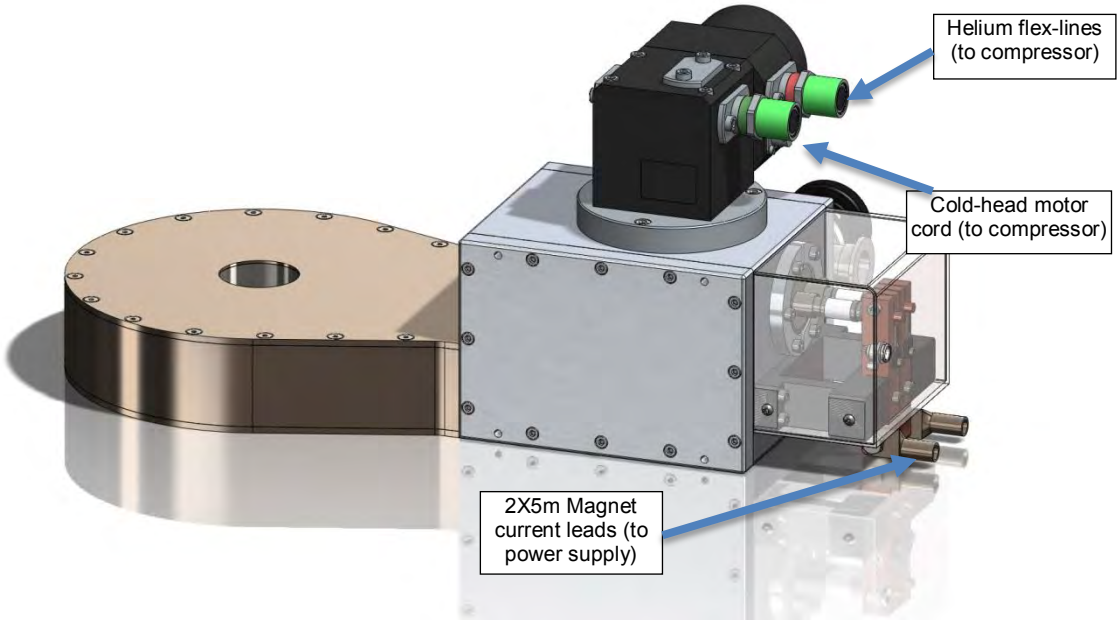
	Coolstar 2/9	Coolstar 6/30	Coolstar 0/12	Coolstar 0/40
Base Temperature (Unloaded)	10 K	10 K	30 K	30 K
Nominal Cooling Power at 20 K			-	-
Normal Speed (72 rpm)	2 W	6 W	-	-
High Speed (90 rpm)	2.4 W	7 W	-	-
Nominal Cooling Power at 77 K				
Normal Speed (72 rpm)	9 W	28 W	12 W	42 W
High Speed (90 rpm)	11 W	30 W	17 W	57 W
Time to cooldown bare coldhead				
to 20 K	<18 min	<18 min		
to 77 K			<11 min	<11 min
Increase in cooldown time for each 100 g Copper added	14 min	5.2 min	6 min	2 min
Weight	2.5 kg	6.1 kg	2.4 kg	5.6 kg
Dimensions	278 x 129 x 150mm	344 x 155 x 207mm	185 x 123 x 150mm	219 x 155 x 207mm

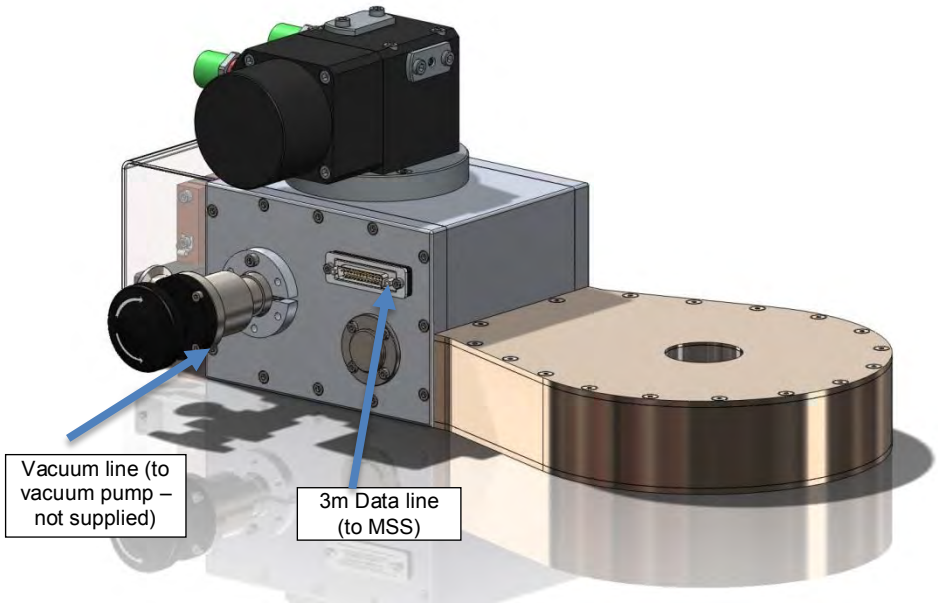


Cryodrive 2.0 compressor

Electrical Power (±6%)	Only single-phase power required 200 V, 220 V, 240 V 50 Hz or 200 V, 208 V, 220 V, 60 Hz
Typical Running current:	
Cryodrive 2.0	11 A
Cryodrive 3.0	13 A
Typical Helium Pressure	
Running	22.5 Bar
Static	16.5 Bar
Operating Temperature	4-38°C
Typical Cooling Water Flow	5 l/min at 18°C
Weight + Dimensions	80 kg, 451 x 556 x 448mm
Standard Helium Hose and Coldhead Cable Length	3 m
Cooling Water Connection	½" ID nozzle

4.5 Key Magnet Interfaces





4.6 Outline drawing (LM-53-2T)