VOYAGER-5.3

Owner's Manual

MULTIVENDOR MRI SUPERCONDUCTING MAGNET POWER SUPPLY UNIT

Designed and Manufactured by Echo Magnet Services BV.
www.echomagnetservices.com

Echo Magnet Services BV. Middendijk 5a, 5705 CC

Helmond - The Netherlands +31 20 210 34 90

TABLE OF CONTENTS

Operating Procedures

NOTICE

The information contained in this document is subject to change without notice.

ECHO Magnet Services BV shall not be liable for errors contained herein or for incidental or consequential damages in connection with the furnishing, performance or use of this material.

ECHO Magnet Services BV assumes no responsibility for the use or reliability of its software on equipment that is not furnished by ECHO Magnet Services BV

Warranty

The equipment has been tested and inspected. It is warranted for a period of one year, from the date of first shipment. This warranty requires that the equipment was used within its rating.

Equipment that is returned shall be well packaged and shipped freight prepaid.

The company will not be liable for damages including lost profits, down time, or any other incidental or consequential damages arising from the use or inability to use the product.

Safety

Always refer to the appropriate magnet ramp procedures. The power supply is air cooled, make sure that the cooling fans are rotating and are not obstructed. Always feed the MPS from MRI PDU where the cabinet is connected to a proper electrical grounding. Do not operate the unit where there is flammable gases. Do not remove the covers of the equipment to reach internal circuitry. Always connect and use the equipment w.r.t. the users manual. Always turn off the AC supply to isolate the power before connecting or disconnecting the ramp leads and connectors. This MPS unit contains highly ferrous materials, DO NOT bring it into the magnet room. Failure to observe these warnings will result in equipment damage and physical injury.

Overview

This Magnet Power Supply Unit (Voyager - 5.3) is an air-cooled, moveable service tool to energize or de-energize the superconducting magnet coil.

The MPS functions are controlled by a computer with a touch screen integrated to the unit. Additional cable connections have to be established for connecting the MPS to the MR system and for line power supply.

The MPS consists of:

. Universal Magnet Power Supply Unit
. Line power cables for different OEM' s
. Step up transformer located in accessories box
. Ramp probes
. Ramp cables
. Heater cables for different magnets
. Transportation test plugs

A Little Bit of Cryogen Safety

Liquid helium temperature is 4.2K (- 269 °C). It causes burns on the skin due to this extreme temp. Wearing protective gloves, long sleeve non absorbent shirts, face shields help reduce your risk of burning yourself.

In addition to this hazard due to extreme low temperature, expansion rate of liquid helium at room temperature is around 750. So, 1 psi magnet pressure means a way too high pressure when any port on the magnet is opened. Care must be taken to reduce the magnet pressure before opening ramp ports or helium fill ports on the magnet.

Disclaimer

This unit is intended to be used only by qualified personnel who has adequate training on MRI magnets. This manual describes the operation of the MPS but does not include information which could be obtained by trainings on different magnets. Each OEM and sometimes different magnets from the same OEM have different characteristics and requires different trainings on that specific magnet.

Definition of Terms and Some Simple BUT IMPORTANT Explanations

Ramp Lead / Current Lead / Current Probe:
External probes inserted into magnet by the FE to connect MPS current carrying cables with the main coil inside the magnet.

FCL (Fixed Current Lead):
Built in probes already inserted into magnet at the factory to connect MPS current carrying cables with the main coil inside the magnet.

Main Coil Voltage (VCOIL):
Voltage drop observed on main coil ONLY when the main switch heater is ON. This voltage is only available on GE magnets. The measurement taps come from inside the magnet and goes to MPS from within the heater cable. In case of GE LCC, the related pins are 9 & 10 on J5-1 or J5-2 on shim lead. In case of not being able to engage the shim lead properly on an LCC magnet, Main Coil Voltage will NOT be available. Therefore, after engaging the shim lead, it is mandatory to perform an electrical check as described in the OEM manual to ensure a good contact with: Main Heater - pins 1&2, Axial Heater - pins 5&6, Main Coil Voltage - pins 9 & 10 at shim lead J5-1 or J5-2 connector. Optionally, for being able to quench T1 and T2 shim coils to avoid any residual magnetic field left after a ramp down, T1 Heater pins are 6&7, T2 Heater pins are 6&8.

These pin numbers are for reference only, refer to OEM manuals for accurate procedures and pin numbers.

450w/750w magnets do not suffer from this problem as they have a fixed instrumentation cable but no removable shim lead. 450w/750w magnets always have Main Coil Voltage available to MPS when proper cables are connected.

Ramp Lead Voltage / FCL Voltage Drop (VLEAD):
This is the voltage drop observed on the ramp leads whether it is of external or internal type. This voltage can be measured regardless of the main switch heater being ON or OFF. Lead voltage will be something close to main coil voltage in case the main switch heater is ON. Lead voltage measured at 100A (SIEMENS) or at the rated magnet current (PHILIPS / GE) is called ‘’Lead Voltage Check’’ or ‘’Resistance Check’’. OEM manuals give the necessary specs for this lead voltage to insure that the ramp leads have a good contact with the main coil inside the magnet.

Lead voltage reaches the MPS through DVM cables.

Lead Voltage Measurement on PHILIPS Magnets:
A pair of 1.5 mt DVM cable supplied with the kit to be connected from the banana jacks on the ramp leads to the jacks on MEU/MIB is needed. This voltage then reaches the MPS from within the 15-Pin D-SUB heater cable.

Lead Voltage Measurement on GE Magnets:
Lead voltage reaches the MPS unit through a pair of 11 mt DVM cable supplied with the kit to be connected from the banana jacks on the ramp leads to the jacks at the back of the MPS unit.

Lead Voltage Measurement on SIEMENS Magnets:
This voltage reaches the penetration panel (RF WALL) with the pre-connected ramp cables coming from magnet to RF wall. Inside these ‘’BLUE’’ and ‘’GRAY’’ Andersen connectors, there are small pins (red & black) for measuring the lead voltage. Then from this wall panel to the MPS, the kit has ramp cable convertors converting blue and gray Andersen connectors to 500A red and black, round type connectors. There is an 11 mt DVM cable extension supplied with the kit to be connected from the banana jacks on these ramp cable convertors to the jacks at the back of the MPS unit (see diagram on page 23).

A very high or floating lead voltage means that the DVM cable is not connected.

A negative lead voltage measured during Lead Voltage Check / Resistance Check means that the DVM cables are swapped.

Continuing the ramp operation without connecting these DVM cables, OR reversely connecting them, OR improperly connecting them in any way; WILL RESULT IN A MAGNET QUENCH.

Absolute Pressure (psiA) and Gauge Pressure (psig):

Atmospheric pressure at sea level is 1 Bar (absolute) = 14.5 psiA = 0 psig
So, 16 psiA = 1.5 psig = 103 mBar

Whether external or fixed, current leads need cooling during ramp operation to increase their current carrying capacity without overheating.

GE ramp leads have holes in the middle to release cold helium gas through, in order to cool down the external ramp leads.

SIEMENS magnets have 16 psiA valve to open and release cold helium gas through the FCL' s to cool them down.

PHILIPS magnets keep yellow valve (turret gas release or by-pass valve) open and release cold helium gas through the ramp leads to keep them cold.

So, now, we need to over pressurize the magnet so that we can release this over pressure through the ramp leads throughout the ramp operation.

Elements and factors creating pressure inside the magnet are: Main coil switch heater, Axial/B0/EIS switch heater/helium bath heater also called - PRESSURE HEATER.

A green M6 plastic hose is supplied with the kit for measuring magnet pressure. This hose goes to shim lead output on GE magnets. It can be directly connected to brass tee on Philips magnet turrets and there are adapters in the kit for connecting this hose to helium fill port on Siemens magnets. Decrease the magnet pressure to below 0.5 psig before opening helium fill port on Siemens magnets.

SIEMENS magnets have **PRESSURE HEATER** to increase the magnet pressure above 16 psiA (1.5 psig) so that the automatic release valve opens and releases gas helium through the FCL' s to cool them down. This is guaranteed by observing 10K temperature drop on FCL temperatures after powering on the pressure heater.

PHILIPS magnets keep **B0 Heater** ON to over pressurize the magnet throughout the ramp operation. This provides adequate gas flow through the ramp leads provided that the required time limit is not exceeded while parking the magnet during ramp up. This time limit is well explained in OEM manuals.

GE LCC magnets have **AXIAL Switch Heater** where as ''w'' series magnets have **B0 Heater** to pressurize the magnet.

It is very important to keep Axial/B0/EIS Heater ON not only to help pressurize the magnet but also to cancel the effect of induced current on Axial Shim Coils (GE LCC) or shielding coil (magnets equipped with B0/EIS heater) on the main field frequency during ramp up. We want to keep AX(B0/EIS Heater ON during ramp down, too. These coils may be damaged due to excessive amount of induced current or there will be a residual magnetic field left otherwise.
Some versions of **GE** magnet monitors have ‘’Ramp Mode’’ available under ‘’FILL MODE’’. This mode also helps over pressurizing the magnet.

While working on **GE LCC** Magnets, in the case of not being able to engage the shim lead, there will be no axial heater nor a helium bath heater available as you will need to remove the instrumentation cable at the magnet turret and connect Auxiliary Ramp Down cable - or so called Direct Heater Cable. This auxiliary heater cable has the main switch heater connection only. No axial heater, no coil voltage taps are available.

As for normal operation but more importantly in this case (shim lead is not engaged, auxiliary heater cable connected to turret), it is highly recommended to use and adjust the valves provided with the kit for controlling the gas flow through the ramp leads to obtain enough positive pressure inside the magnet. Keeping magnet pressure above 0.3 or 0.5 psi usually provides enough gas flow through the ramp leads. Please observe the frost on the ramp cables close to ramp leads. If the gas flow is inadequate at the present magnet current, the frosted portion will be close to ramp leads where as the frost will extend towards the ramp cables if the flow is good.

Also in the case of not being able to engage the shim lead on a GE LCC magnet, the MPS can NOT ramp down automatically as there will be no Main Coil Voltage available to the MPS to follow. Automatic Resistance Check will still work as the Lead Voltage will be available through the externally connected DVM cables from ramp leads to the back of MPS. The user needs to go into ‘’GE Expert Mode’’ to do the ramp down manually after completing a successful Resistance Check. Enter your customer code at the Teslameter Frequency field to switch the MPS into manual mode of operation. Then, follow the appropriate ramp down table specific to that type of magnet to be used with auxiliary heater cable. The ramp down will be done w.r.t. Lead Voltage instead of Coil Voltage. On the MOS manual control screen, switch the voltmeter to VLEAD (Lead Voltage) if it is in VCOIL (Coil Voltage) mode.

This manual is not intended to tell procedures overriding the ones in OEM manuals. The user needs to strictly follow the OEM manuals for all specs and absolute procedures.

DESCRIPTION OF SYSTEM HARDWARE and OPERATIONAL SCREENS

Main Power Supply

The unit includes a 1000A main power supply. It is fed by 3-phase, 380VAC input. The MPS output current is limited by software depending on the selected magnet type and is fed via a Ramp Down Accelerator to the MPS output connectors. The RDA can be shorted by a contactor.

Actual output current is measured by an internal current transducer connected to the Control Circuit. For service, it can be directly measured at connectors in the front. This is particularly useful when there is a power failure during ramp operation. Magnet current can be measured with a DVM in mV mode (Magnet current = mV x 20 A/mV.

Ramp Down Accelerator

To run down the magnet, the MPS is equipped with a Ramp Down Accelerator (RDA) which consists of heavy-duty diodes embedded in heat sinks and cooled by heavy duty fans.

To activate the RDA, the MPS opens a switch that is connected in parallel. The energy that is stored in the magnet coil is converted into heat inside the RDA and the magnet current is ramped down. During ramp up, the switch is closed to by-pass the RDA.

Shorting contactor

The unit is equipped with shorting contactors that are normally closed. During different phases, the control circuitry will open the contactor when required.

The shorting contactors open when:

- The unit is performing lead check
- The unit is ramping down the magnet
- The unit is ramping up the magnet
- The unit is performing output voltage test during transportation tests

The shorting contactors close when:

- The unit is turned off
- The line power fails (magnet current will safely run down via the ramp cables and closed shorting contactor)
- The unit is performing output current test during transportation tests

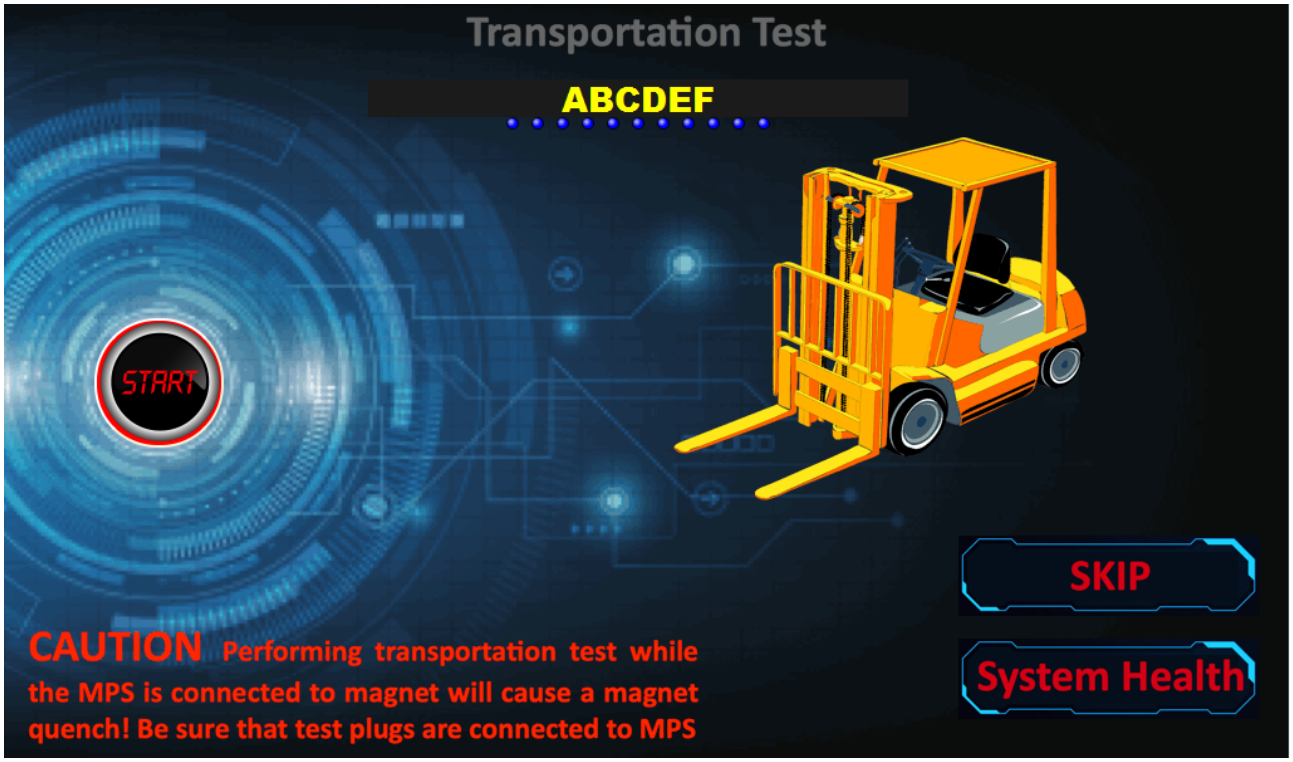
Control circuit

The control circuit monitors and controls the operation of the MPS. Ramping commands are initiated by the operator using the touch screen. The algorithm for ramping is stored in a table at the internal computer. Required magnet specific data are loaded each time a magnet is selected from the menus.

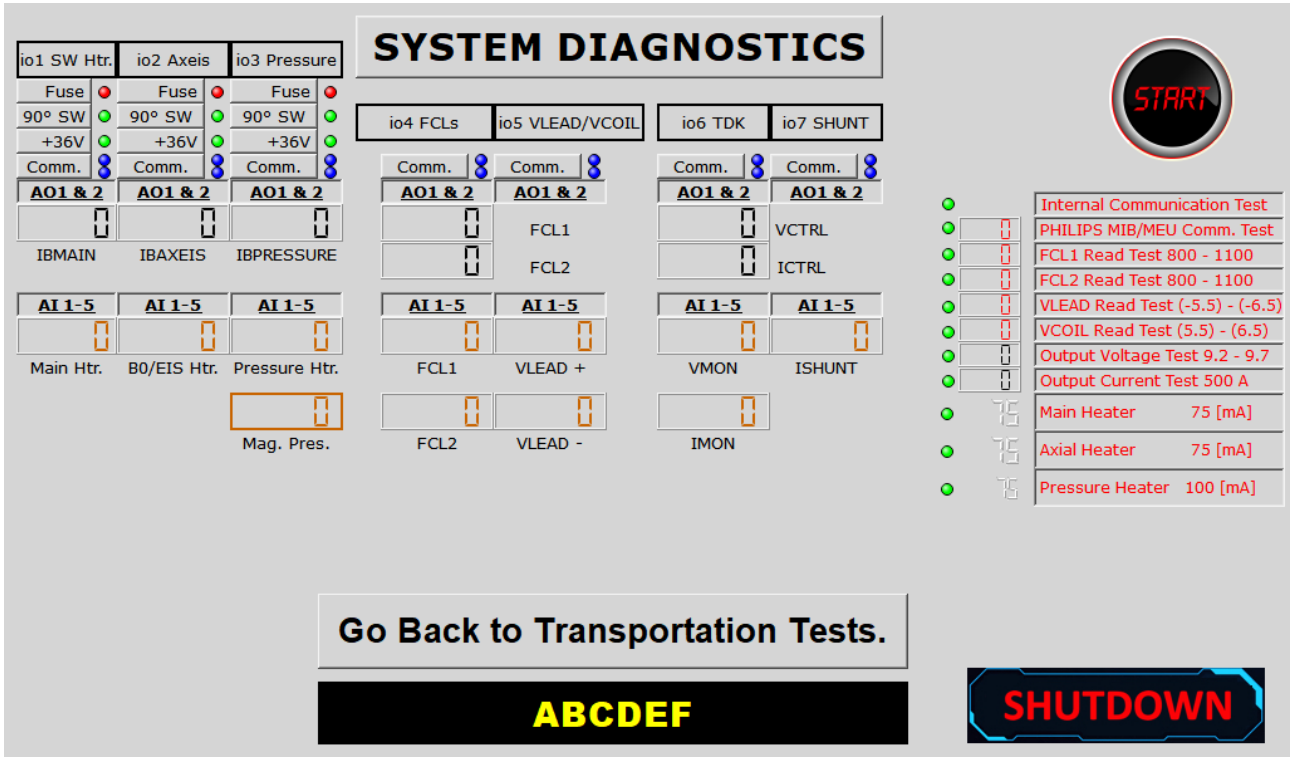
Current and voltage monitoring

The MPS output current and voltage is monitored by the Control Circuit. It is reported via RS 485 to the internal computer. Additionally, a DVM can be connected to the current monitor terminals on the MPS front panel.

Self Test (Transportation Test)



The system self test can be initiated by pressing the ‘’START’’ button on the left (see the picture above). The blue LED’ s start turning on when each corresponding self test is passed. If the related test fails, the corresponding LED stays off. The system goes to next page only if all tests are successful. Otherwise, the system health page is displayed. The software won’ t allow you to continue unless the system succeeds to pass all the diagnostics on this system health page. Please refer to next picture for diagnostics screen.



Internal Communication Test:
The internal computer tests communication to all seven subsystems which are main switch heater, B0/EIS heater, pressure heater, Philips magnet electronics communication unit/FCL temperature reader, lead/coil voltage reader, main power supply communication, output current measurement unit.

Philips MIB/MEU Communication Test:
The MPS communicates to the magnet electronics when the selected OEM is PHILIPS during a ramp operation. This test checks this function with the help of a dummy plug connected to PHILIPS connector at the back of the unit.

FCL1/FCL2, Lead Voltage, Coil Read Tests:
There is a dummy plug set connected to SIEMENS connector and J2/J6 at the back of the MPS. The system software tests the MPS unit' s ability to read FCL temperatures, lead voltage and coil voltage.

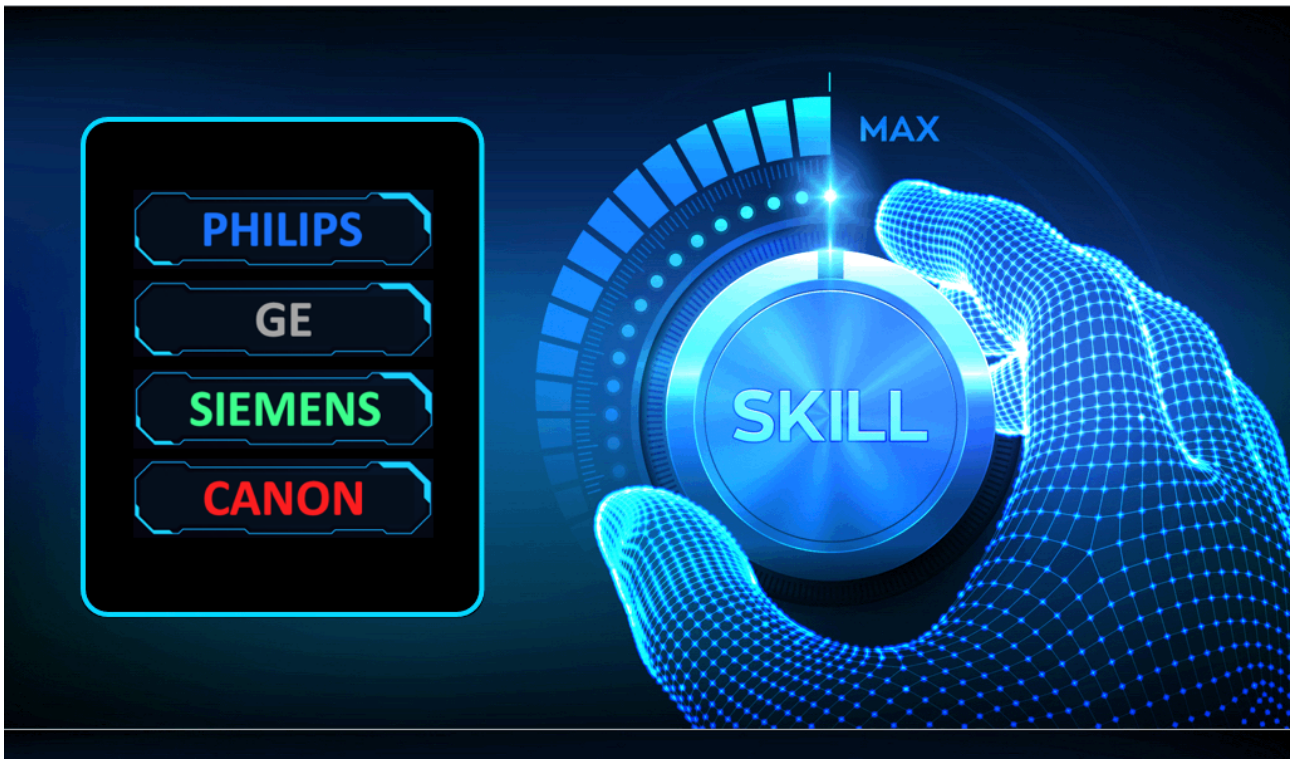
Output Voltage Test:
The output shorting contactor opens and the system software commands the main power supply to go to 9.5 volts and the related I/O unit measures/checks that this voltage is in spec.

Output Current Test:
The output shorting contactor closes, ramp down accelerator contactor opens and the system software commands the main power supply to go to 500 A. The system hardware checks the ramp down accelerator voltages, temperatures and output current.

Heater Tests:
The system software commands the heaters to go to 75mA/100mA. Then the related hardware checks these currents.

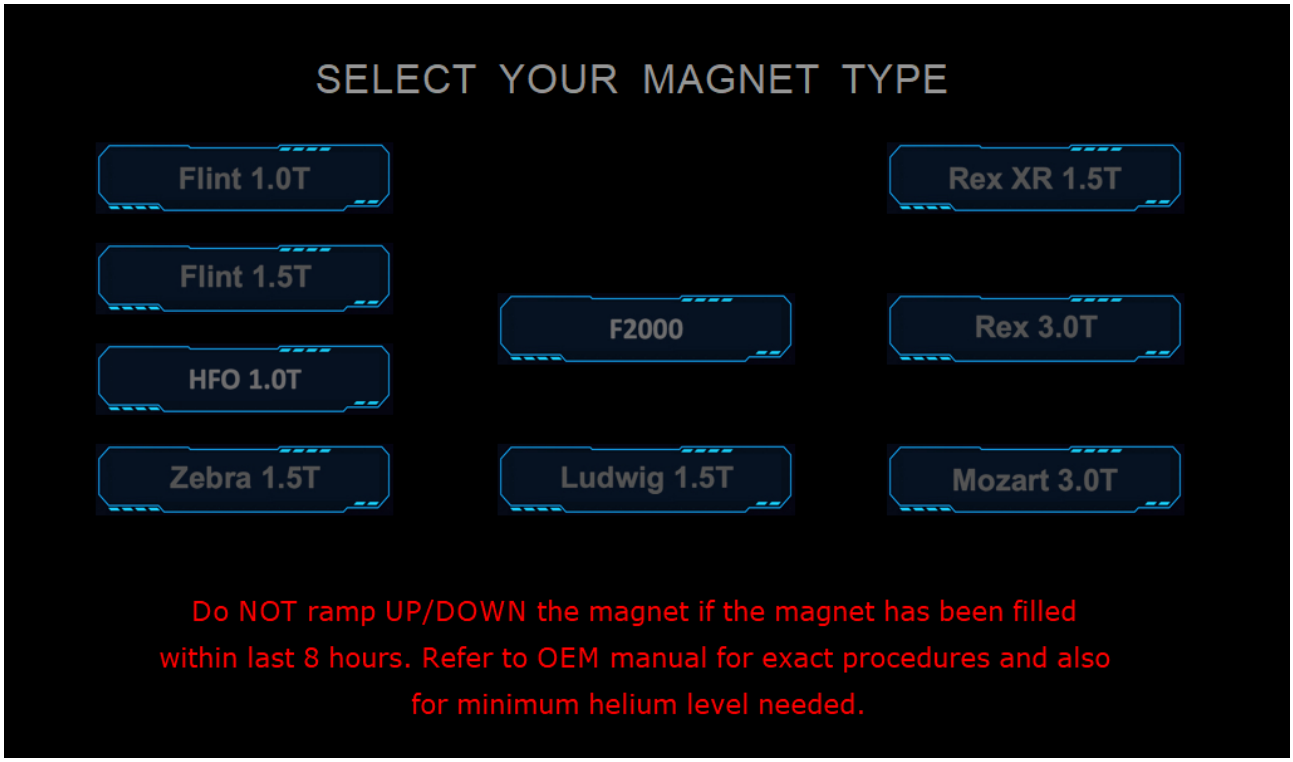
The software won’ t allow you to continue unless the system succeeds to pass all the diagnostics on system health page. If all the tests pass, ‘’GO BACK TO TRANSPORTATION TESTS’’ button will appear. It is then mandatory to run the transportation tests. Connect the test plugs as shown in the picture. 25-pin DSUB connector may be connected to J2 or J6 depending on the hardware version of your system before beginning the transportation tests.

OEM SELECTION SCREEN



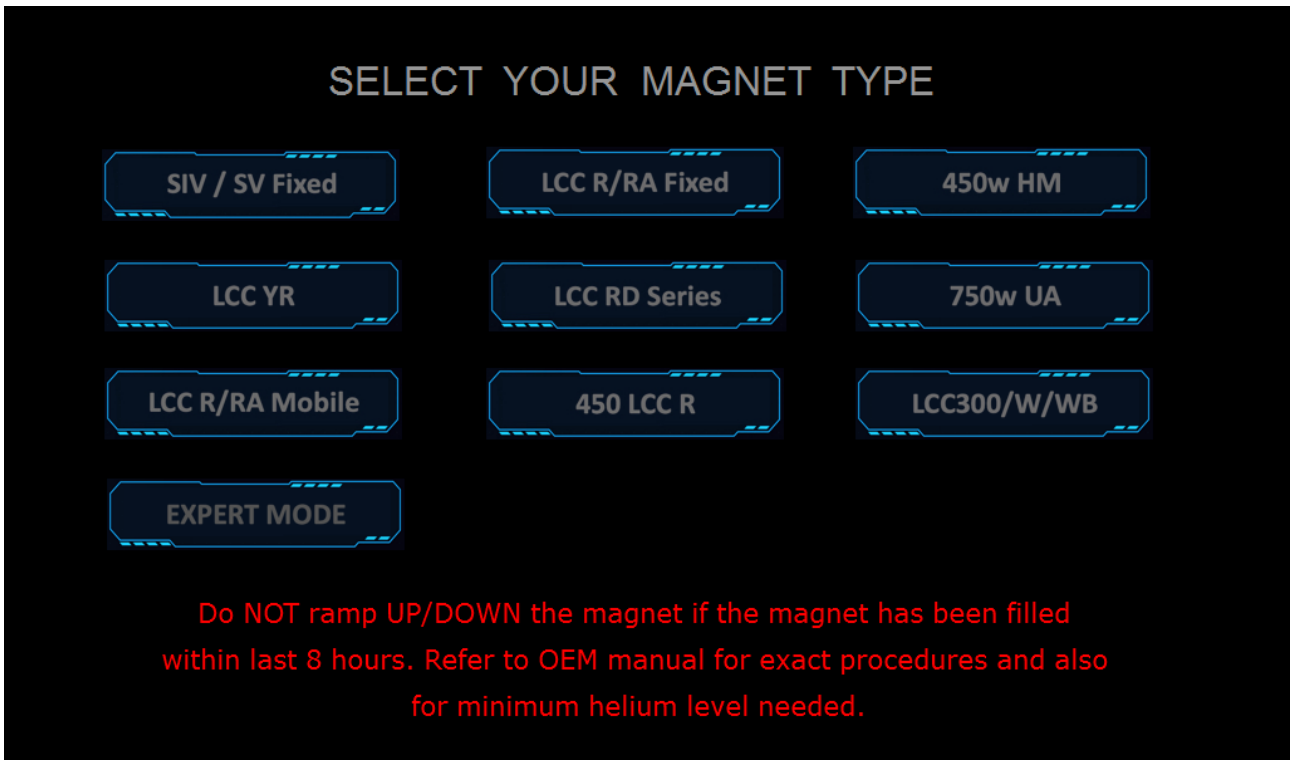
The hardware of this MPS is capable of doing ramp operations theoretically on any superconducting magnet. Current version of software allows the OEM options listed in the above picture. Your exact kit may have only one or more OEM' s depending on the options of your purchase agreement. Selecting PHILIPS on this page will initiate a communication check with the magnet electronics. So, make sure that the heater cable is connected to MIB/MEU on the magnet before selecting PHILIPS on this page.

PHILPS MAGNETS SCREEN



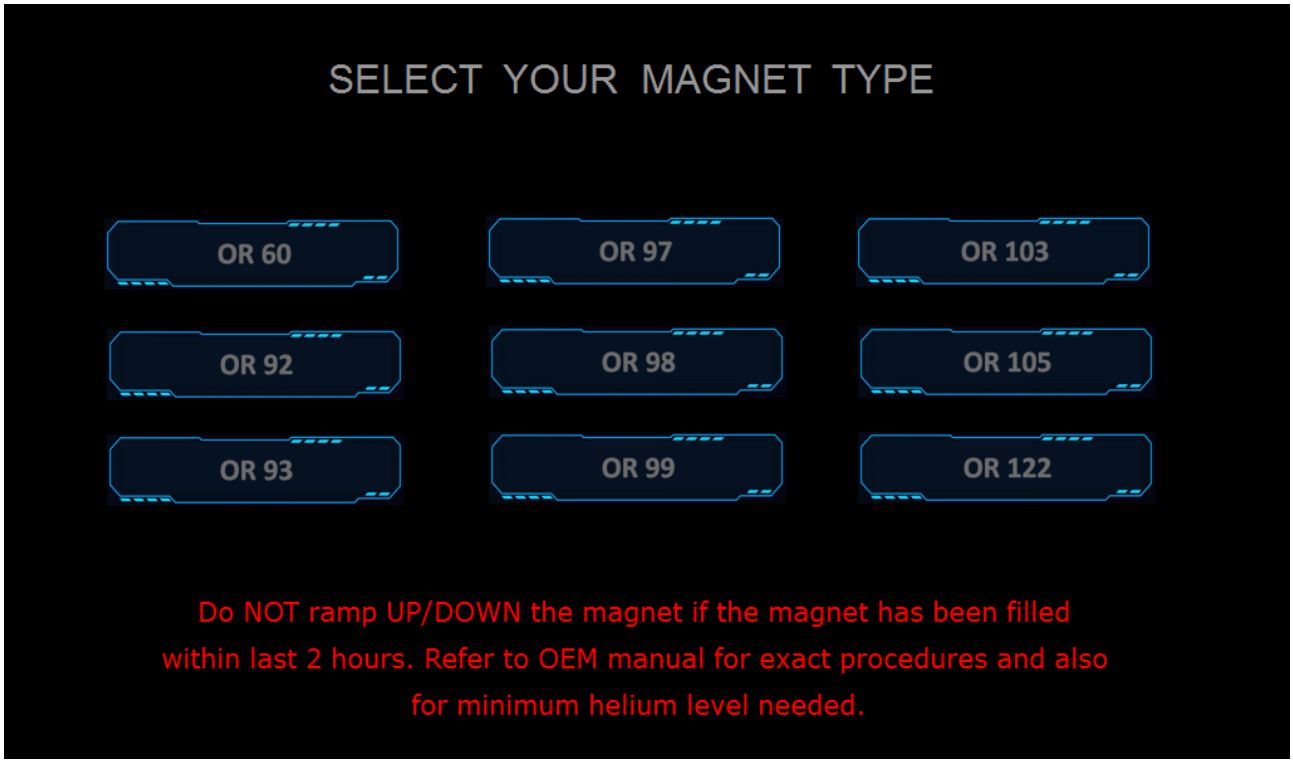
Magnets have different ramp profiles in general. These ramp profiles are stored in system software. So, selecting the correct magnet type is essential at this stage. The system hardware does NOT know the connected magnet type. It trusts that you know what you are doing. Please be sure that you know the magnet type and select the magnet type from the above menu accordingly.

GE MAGNETS SCREEN



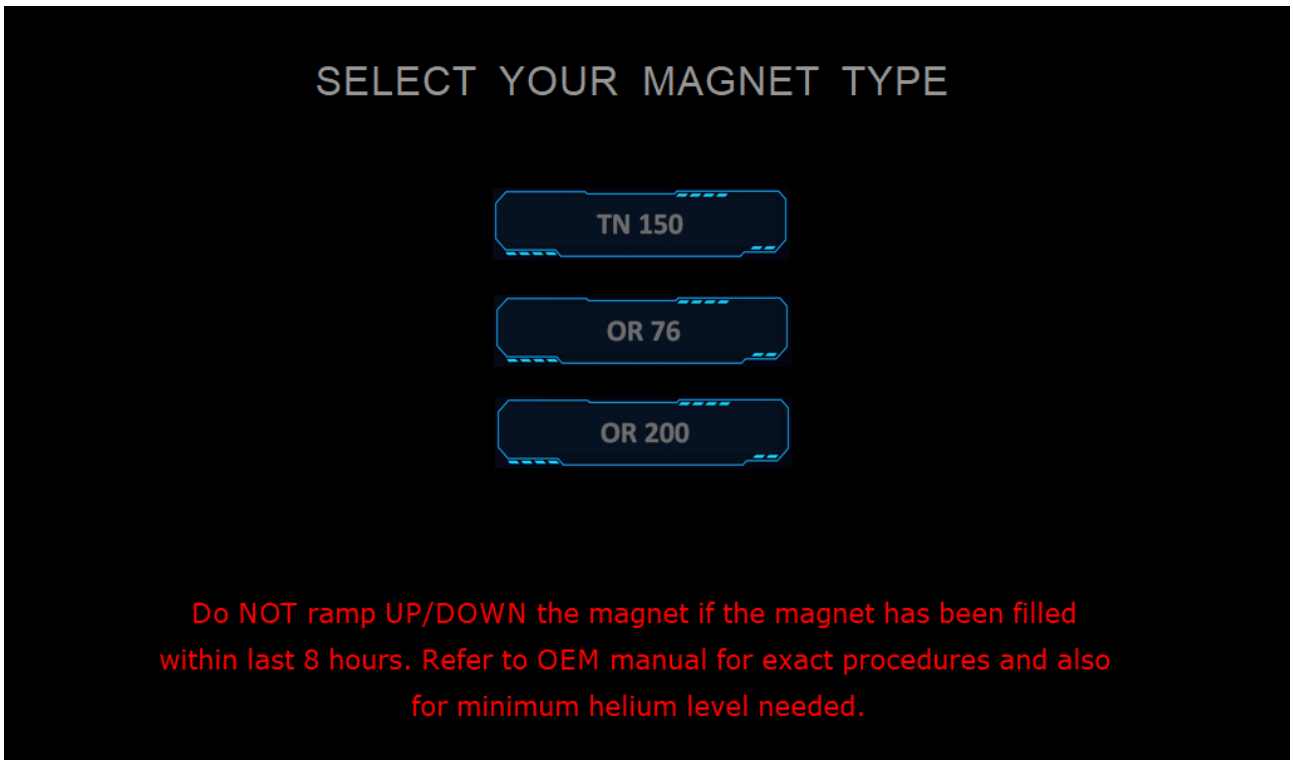
Magnets have different ramp profiles in general. These ramp profiles are stored in system software. So, selecting the correct magnet type is essential at this stage. The system hardware does NOT know the connected magnet type. It trusts that you know what you are doing. Please be sure that you know the magnet type and select the magnet type from the above menu accordingly.

SIEMENS MAGNETS SCREEN



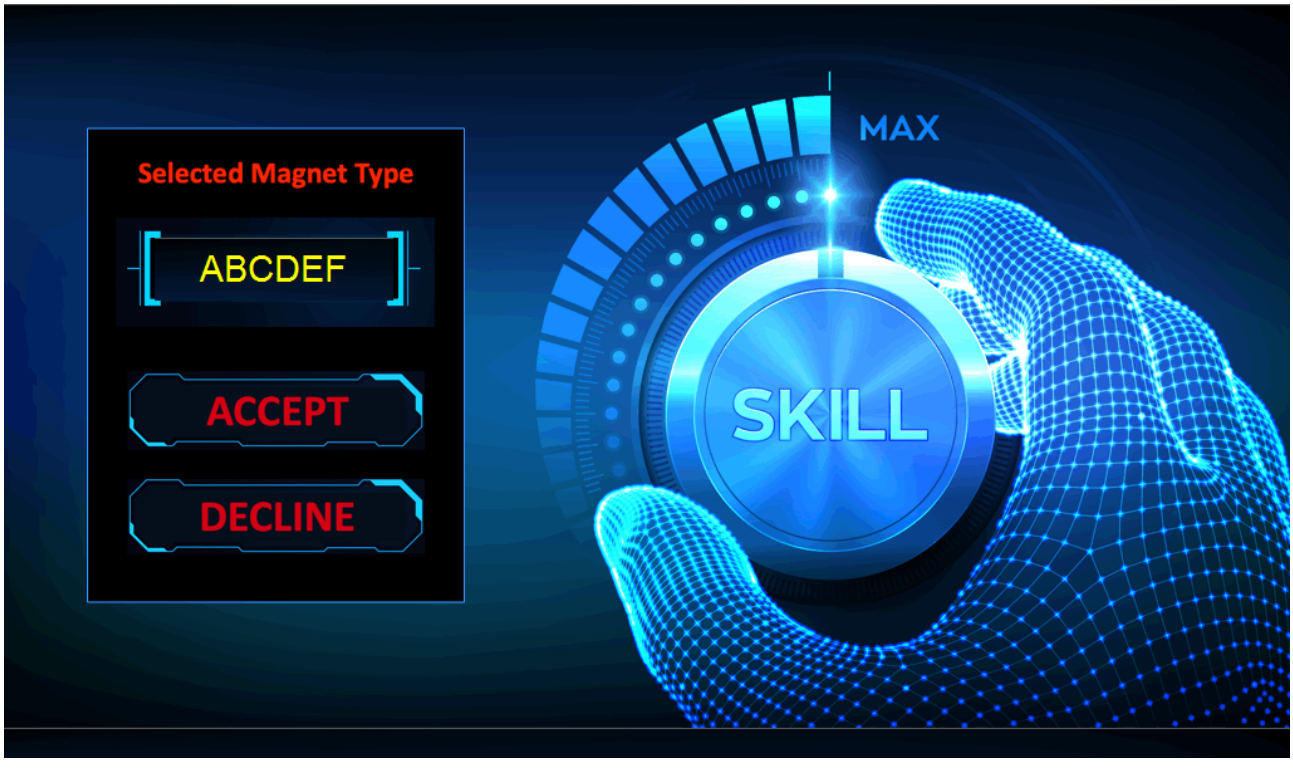
Magnets have different ramp profiles in general. These ramp profiles are stored in system software. So, selecting the correct magnet type is essential at this stage. The system hardware does NOT know the connected magnet type. It trusts that you know what you are doing. Please be sure that you know the magnet type and select the magnet type from the above menu accordingly.

CANON MAGNETS SCREEN



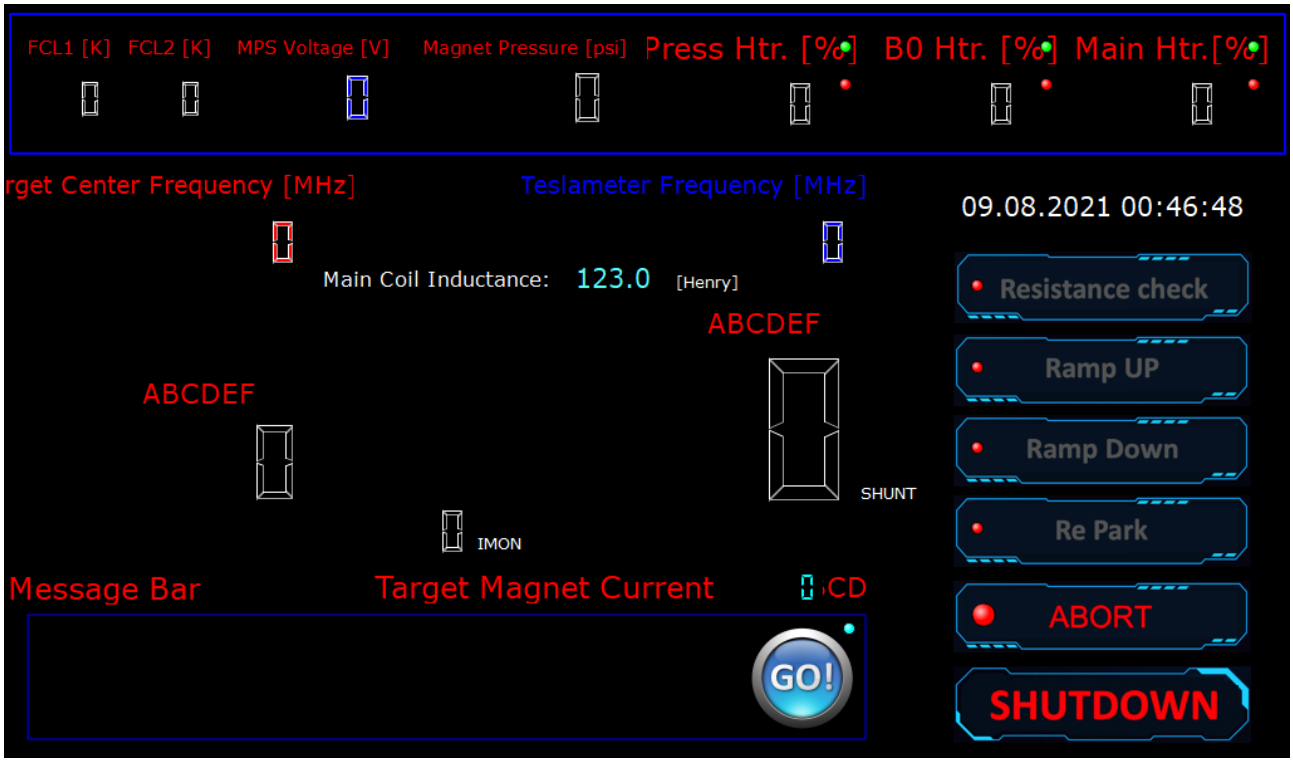
Magnets have different ramp profiles in general. These ramp profiles are stored in system software. So, selecting the correct magnet type is essential at this stage. The system hardware does NOT know the connected magnet type. It trusts that you know what you are doing. Please be sure that you know the magnet type and select the magnet type from the above menu accordingly.

CONFIRMATION SCREEN



Magnets have different ramp profiles in general. These ramp profiles are stored in system software. So, selecting the correct magnet type is essential at this stage. The system hardware does NOT know the connected magnet type. It trusts that you know what you are doing. Please be sure that you know the magnet type and confirm the selected magnet type accordingly.

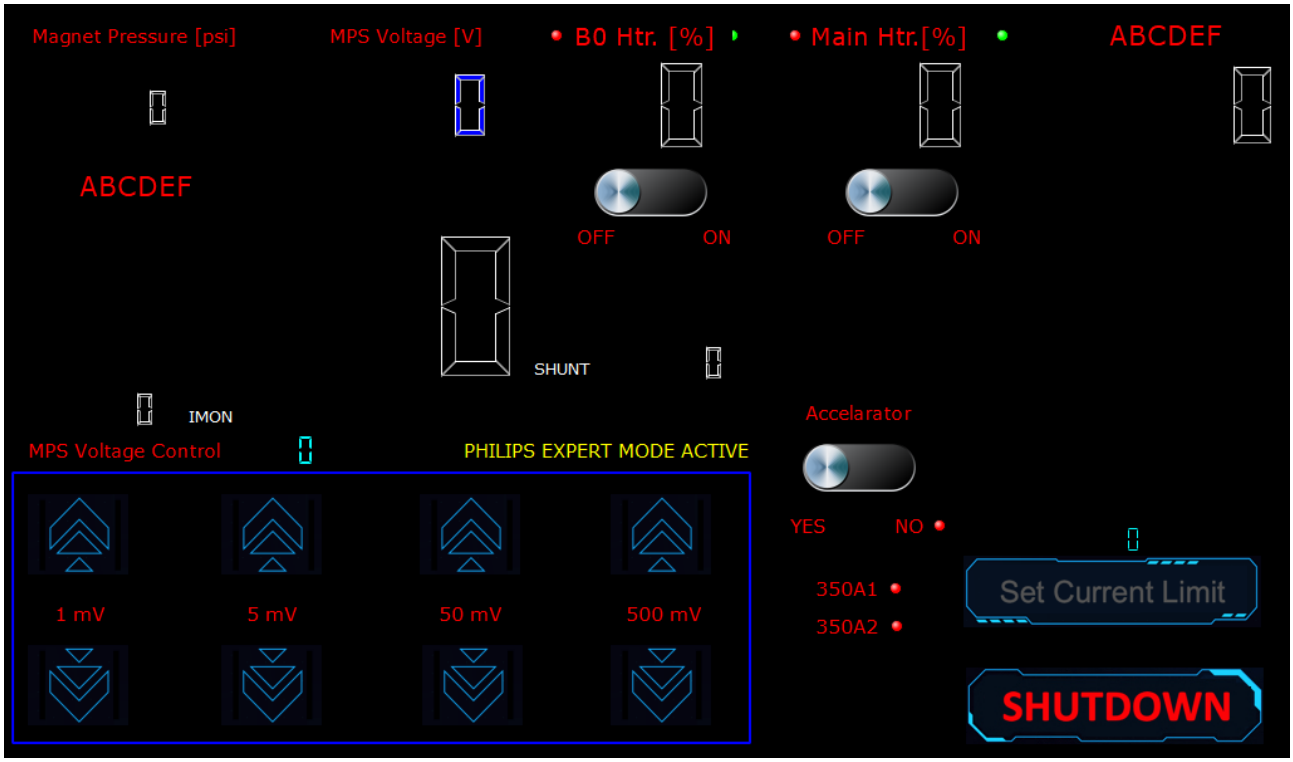
MAIN OPERATION CONTROL SCREEN



FCL temperatures (in case of Siemens or Canon magnets), MPS output voltage, magnet pressure (provided that you have connected the M6 hose to the magnet), heater currents (in %), MPS output/magnet current, lead/coil voltage is displayed on this screen. Current version of the software does not allow the following button operations: Equalize and Park, Re-Park. These may become available with later versions or may be omitted depending on the test results and complexities. Target center frequency display/button is also for future use in case the company decides to make the MPS communicate with the teslameter and make park the magnet to the desired frequency option available. Teslameter frequency display/ button however has some functions besides it will be reading the teslameter frequency in future products.

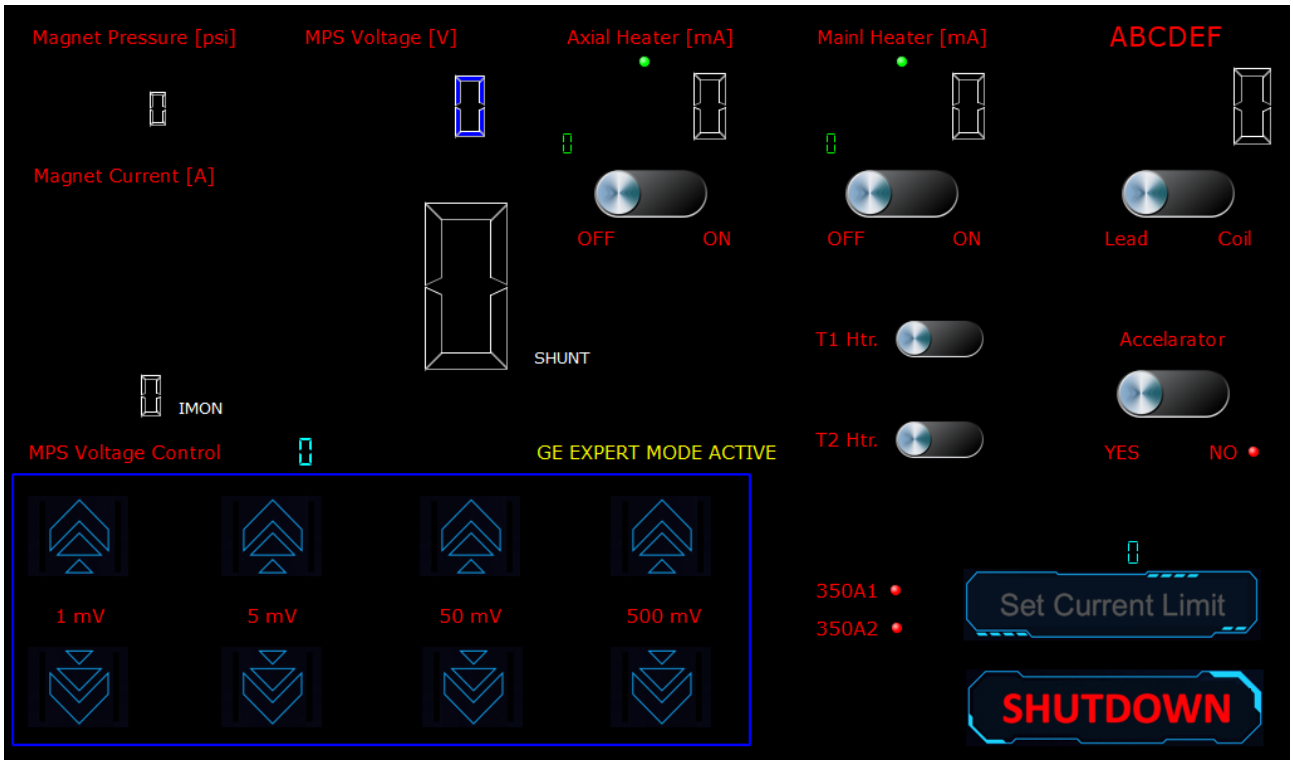
The system software allows you to switch to manual mode during a ramp operation if you enter your customer code to ‘’Teslameter Frequency’’ button then press ‘’GO’’ and hold it until you see the manual control screen. A screen shot of these manual pages is displayed on the next page.

PHILIPS MANUAL/EXPERT CONTROL SCREEN



MPS output voltage control is possible with the buttons at the lower left corner. Each button will increase or decrease the output voltage by 1 mV, 5 mV, 50 mV, 500 mV. This allows the user to park the magnet at the desired frequency during ramp up. Manual control buttons for B0 and main heaters are also available on this mode of operation.

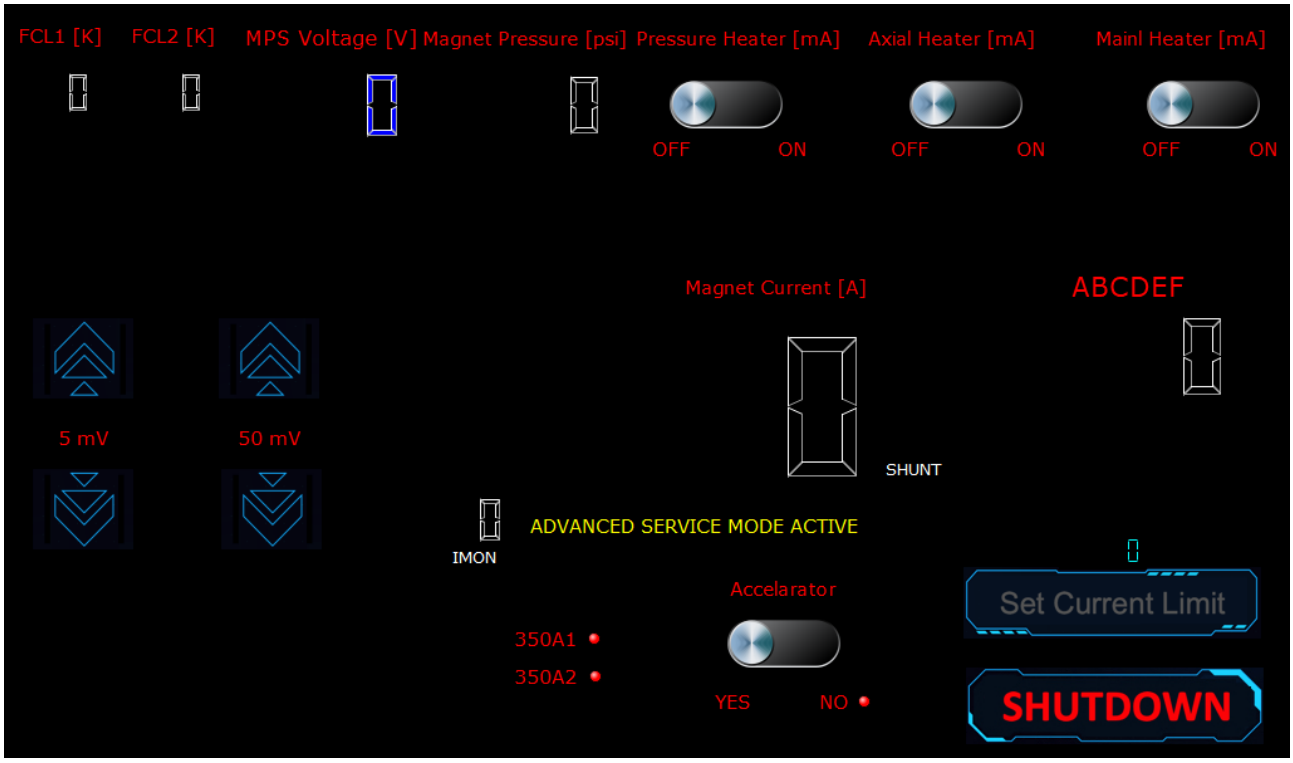
GE MANUAL/EXPERT CONTROL SCREEN



MPS output voltage control is possible with the buttons at the lower left corner. Each button will increase or decrease the output voltage by 1 mV, 5 mV, 50 mV, 500 mV. This allows the user to park the magnet at the desired frequency during ramp up. Manual control buttons for Axial/B0, T1, T2 and main heaters are also available on this mode of operation. Accelerator by-pass button needs to be on YES for manual ramp down and needs to be on NO side for manual ramp up. The voltmeter on the upper right corner have two selections to display the lead voltage or the main coil voltage.

SIEMENS MANUAL/EXPERT CONTROL SCREEN

FCL temperatures, MPS output voltage, magnet pressure (provided that you have connected the M6 hose to the magnet), heater currents (in %), MPS output/ magnet current, lead/coil voltage is displayed on this screen. Manual control buttons for pressure, EIS, and main heaters are also available on this mode of operation. As Siemens magnets are parked to current but not to frequency, this manual mode is almost never needed. It is made available for just incase situations.



Resistance Check (Lead Check)/Ramp UP/Ramp DOWN

PHILIPS

Insert the ramp leads as described in the OEM manuals. Connect the ramp cables, 15 pin DSUB control cable, DVM cables and M6 hose for monitoring the magnet pressure. Press ‘’Resistance Check’’ button on the main control screen. The system will initiate an automatic sequence and will display MPS output voltage and lead voltage on the message bar at the end of this sequence. Continue with ramp up or ramp down only if these voltages are in OEM specs for the specific magnet you are working on.

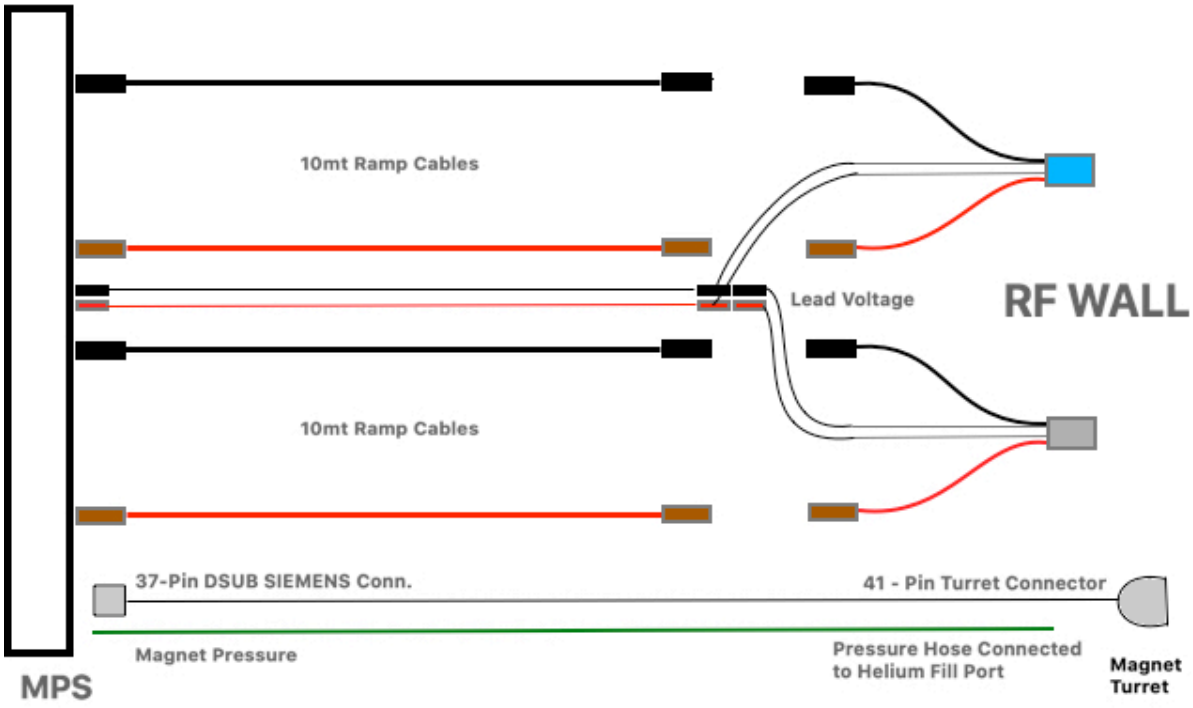
GE

Insert the ramp leads as described in the OEM manuals. Connect the ramp cables, heater cable, DVM cables and M6 hose to nupro valve on shim lead or to magnet turret in case of HM series magnet for monitoring the magnet pressure. Press ‘’Resistance Check’’ button on the main control screen. The system will initiate an automatic sequence and will display MPS output voltage and lead voltage on the message bar at the end of this sequence. Continue with ramp up or ramp down only if these voltages are in OEM specs for the specific magnet you are working on. If you are doing an Automatic Ramp DOWN, The MPS will remove T1, T2 and Axial shim currents at the beginning of the procedure automatically only if the shim lead is engaged properly.

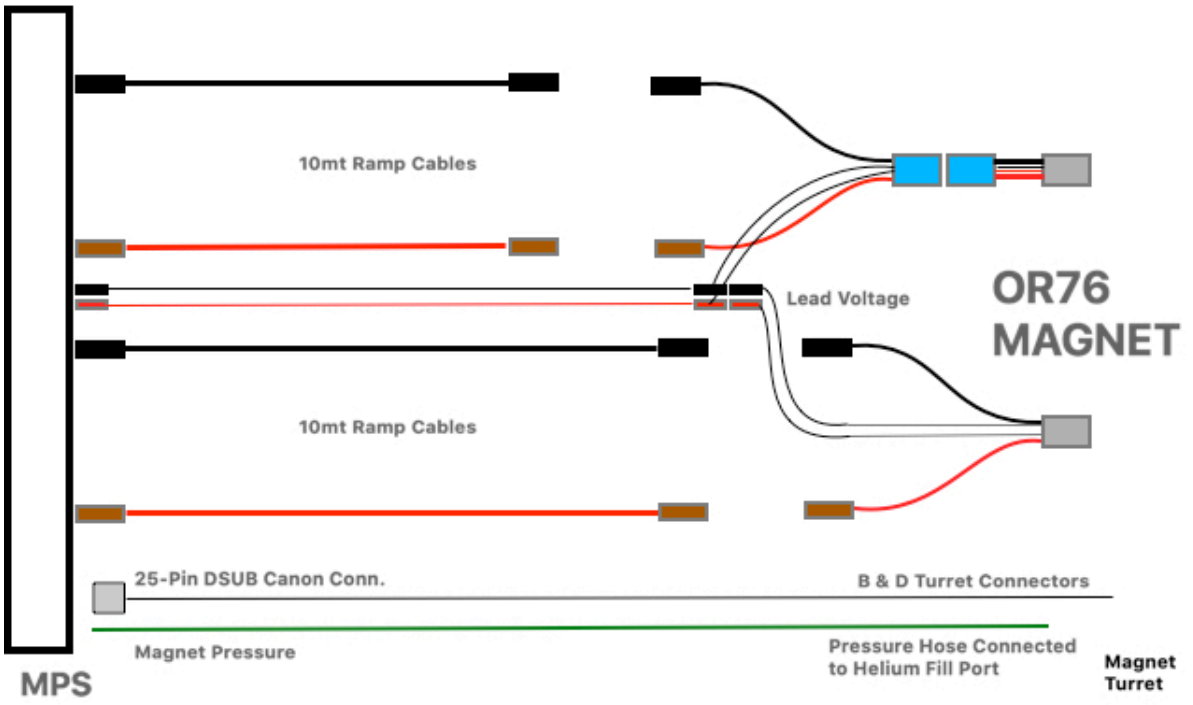
In the case of not being able to engage the shim lead and using auxiliary ramp down cable, DO NOT use automatic ramp down as the MPS will not be able to read the ‘’Main Coil Voltage’’. Instead, switch to manual mode after having completed the resistance check. Select ‘’Lead’’ voltage at the voltmeter on the upper right of the ‘’GE Expert Mode’’ screen. Shim lead not engaged means there is no main coil voltage available. Use the appropriate ramp down table in the related magnet manual when using auxiliary ramp down cable.

Connect the ramp cables as described in the OEM manuals. Connect 37 pin DSUB control cable to magnet turret, you need to remove the system cable coming from MSUP to this turret connector. Connect the M6 hose to helium fill port via the supplied adapter for monitoring the magnet pressure. Press ‘’Resistance Check’’ button on the main control screen. The system will initiate an automatic sequence and will display MPS output voltage and lead voltage on the message bar at the end of this sequence. Continue with ramp up or ramp down only if these voltages are in OEM specs for the specific magnet you are working on. Consider the OEM note about quenching the Z2 heater in case of working on an OR122 magnet.

In the case of having trouble with 10K drop on FCL’ s like when they are cold already and no more drop is possible but you are sure that 16 psi valve has opened and FCL’ s are cooled down, there is a way to by pass ‘’Waiting for 10K drop on FCL' s.”; Enter 123456 to ‘’Teslameter Frequency’’ then press ‘’GO’’ and hold it until you see the following message: "10K temperature drop is observed on FCL' s.”; " 5 minute vent delay has started. Remaining time: 5 [min]”.



SIEMENS RAMP CONFIGURATION



OR76 RAMP CONFIGURATION

Z2 Heater Power Supply Connection Diagram for OR122: