THOMAS JEFFERSON NATIONAL ACCELERATOR FACILITY
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HALL B PROCEDURE NO.:
B000000401-P020 Rev - C

TITLE: **Hall B Torus Power-Up and Power-Down Procedure**

BY: R. Fair

DATE: 12 / 08 / 2016

Intended Checker and Approvers:
CHK: R. Rajput-Ghoshal
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3. APP: 3rd Approver (if necessary)

REV.	ECO#	DESCRIPTION	BY	CHK.	APP.	APP.	DATE
C		Changed authorship from C. Luongo to R. Fair. Added Renuka Rajput-Ghoshal as checker and moved Probir Ghoshal to Approver. Updated Tables III and B.1 and the Interlock Status screenshot	RF	RRG	PG		01/18/17
B		Added section with simplified instructions for shift workers and made it central to document. Moved commissioning procedure to Appendix	RF				12/08/16
A		Fixed typo in page 9 (step 19)	CL	PG	RF		10/19/16

SUMMARY OF CHANGES FROM PREVIOUS REVISION:

1. Scope and Requirements

This document describes the power up and power down procedure for the Hall B CLAS12 Torus superconducting magnet.

This document is organized as follows:

- Operations Manual for the magnet/power supply, based on the commissioning experience
- An appendix containing the Power-up sequence followed during 12 GeV commissioning, at the conclusion of which the project transferred operational responsibility to Hall B
- Power-up sequence for post-commissioning phase (but prior to regular operations) as envisioned during commissioning (but open to modifications based on Hall B priorities)

2. Magnet/Power Supply Operation (Regular Physics Operations)

Introduction

This section summarizes the power up (energization) and power down (de-energization) procedure for the Hall B CLAS12 Torus superconducting magnet. It is primarily a guide for shift workers.

Emergency Contact Names

Should the need arise, first call the 'ENGINEER ON CALL' – his/her name and contact telephone number should be on the white board in the Hall B Counting Room.

The ENGINEER ON CALL will then (if necessary) call in the relevant Subject Matter Experts (SME).

Table I – Contact Names

Sub-System	SME
Magnet Power Supply	Krister Bruhwel
Magnet Fast Dump / Quench	Dave Kashy
Cryogenics System	Dave Kashy, Denny Insley
Vacuum System	Dave Anderson
Instrumentation and Control	Nick Sandoval

Pre-Energization Checklists

The following checks should already have been completed.

IF IN DOUBT PLEASE CONTACT THE 'ENGINEER ON CALL'

1. *B000000401-P021 Hall B Torus Operations Power Up Checklists*
2. *B000000402-P002 Hall B Superconducting Magnets Power Supply Maintenance Turn-On Checklist*
3. *B000000402-P001 Hall B Superconducting Magnets Pre-Power-Up Power Supply Internal Interlock Checklist*
4. *B000000401-P022 Hall B Torus Pre-Power-Up Water-Cooled Leads Checkout Procedure*
5. *B000000401-P023 Hall B Torus Pre-Power-Up Vapor-Cooled Leads Checkout Procedure*
6. *B000000401-P025 Hall B Pre-Power-Up Instrument Checkout Procedure*
7. *B000000401-P026 Hall B Pre-Power-Up Quench Detector Tuning Procedure*
8. *B000000401-P027 Hall B Pre-Power-Up Interlock Checkout Procedure*

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Magnet Operation

The Operator controls the Magnet Power Supply (MPS) for the magnet and monitors the magnet and its sub-systems via a PLC using a series of EPICS screens. Bringing the Torus to operating field is done in a series of current steps at differing current ramp rates. Each time the operator establishes the desired current on the EPICS screen and clicks anywhere outside the 'Set point' box, the power supply automatically begins the ramp to the set point current at a pre-programmed slew rate (Ramp rate). This slew rate is set within the PLC code and is not accessible to the operator.

Shift workers will typically operate the magnet using the Magnet Power Supply (MPS) Control Screen shown in Figure 1 below.

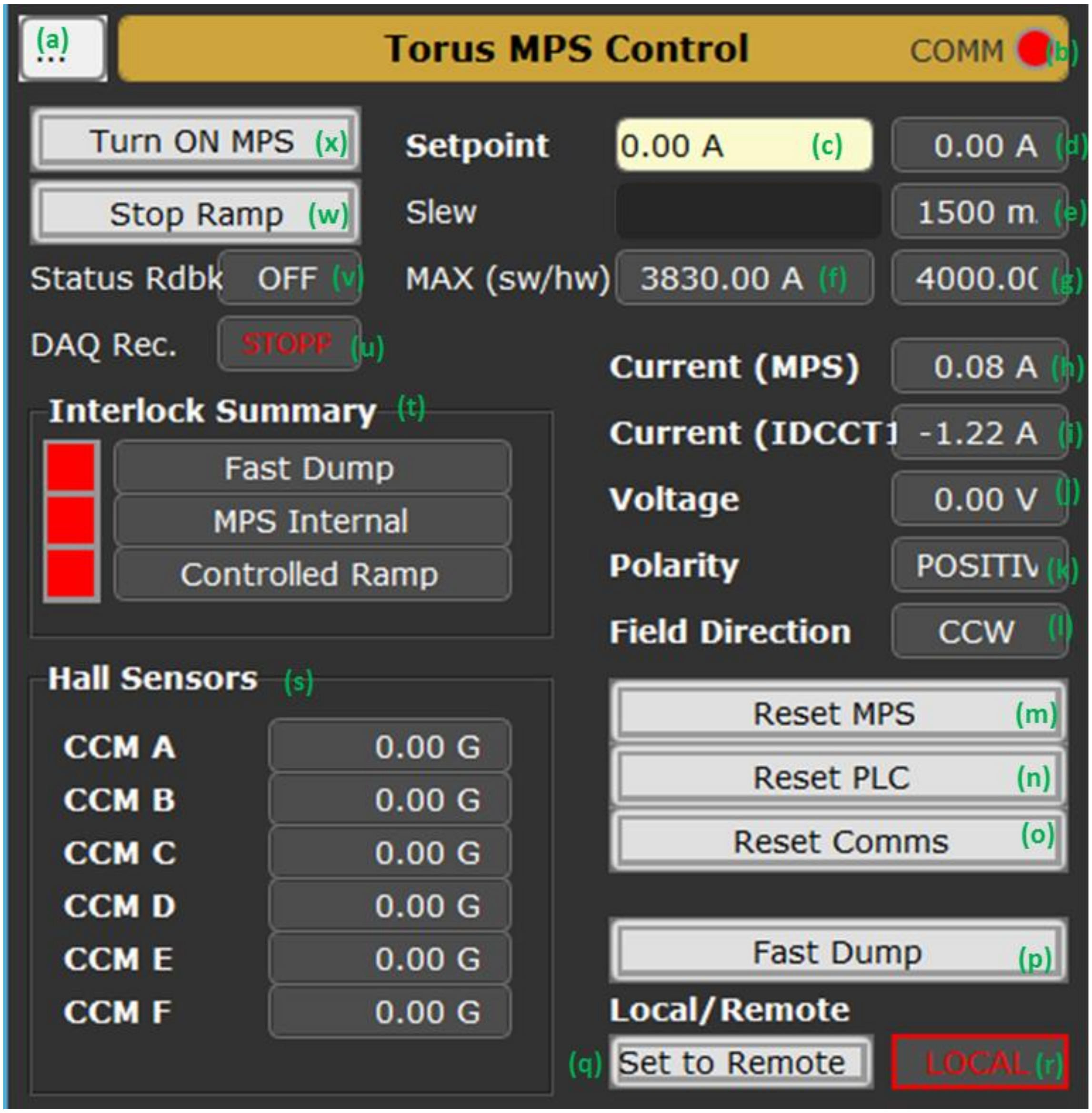

Figure 1 - JLab MPS Control – EPICS

Table II – Definition of items on MPS EPICS Control Screen

	Description	Expected value
(a)	Launches 3 additional windows: (i) Interlock Status (ii) Fast DAQ recording control (iii) Fast DAQ live data	N/A
(b)	Ethernet to RS232 communication between Torus PLC, 435NBX, and Magnet Power Supply	GREEN
(c)	Desired target current. User types value into the field shown and presses enter. Use a negative value if ramping to a negative polarity is required. User only needs to enter a number (no units are required). If the user enters a number greater than the software limit (see (g) below), the target current (c) will automatically be set to (g)	User Defined
(d)	Present target current.	Defined in (c)
(e)	Present slew rate	Refer to sub-section 4.1 Step 8
(f)	Software (SW) magnet current limit set within the PLC code	3830 A
(g)	Hardware (HW) Power Supply Current Limit. This value will never change as long as the same power supply is used. (This value is needed to get PPM conversion from set point to PSU correct)	4000 A
(h)	Magnet current read back from magnet power supply, A/D 16 bit	Actual value
(i)	Magnet current read back from buffered analog output of control crate (through cRIO)	Actual value
(j)	Magnet Power Supply output voltage	Actual value
(k)	Magnetic polarity (and therefore magnet current polarity).	POSITIVE or NEGATIVE
(l)	Magnetic field direction. Positive field direction is CCW when looking downstream.	CCW or CW
(m)	Resets only the MPS internal interlocks	N/A
(n)	Resets only PLC interlocks	N/A
(o)	Resets only communications between the magnet power supply and PLC	N/A
(p)	Initiates a fast dump of the magnet current through the dump resistor. On clicking this button, the user will be prompted to confirm the action.	N/A
(q)	Used to switch between local and remote mode on the MPS display unit	N/A
(r)	Read back of MPS control state: will display 'LOCAL' in local mode, and 'REMOTE' in remote mode. Must be set to 'REMOTE' to allow changes on the MPS EPICS screen to affect the power supply.	LOCAL or REMOTE
(s)	Read backs from the 6 hall sensors mounted on the outside of the vacuum jackets of the individual coils	20000 Gauss @ 3770 A
(t)	Sum status of the three sets of interlocks	GREEN
(u)	Indicates whether the Fast DAQ system is writing data to disk. Always ensure this is 'RECORDING' before energizing the magnet	RECORDING or STOPPED
(v)	Magnet Power Supply On/Off status	ON
(w)	Stops the ramping of the magnet by EPICs changing the set point to a value close to the current read back	N/A
(x)	Button to turn on MPS after communications has been established (Enables output). On clicking this button, the user will be prompted to confirm the action.	ON

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Power Up

Reference should be made to Figure 1 and Table II.

<table>
<tr><th></th><th>Instruction</th><th>Action</th></tr>
<tr><td colspan="3">CHECKS AND INITIAL SETTINGS ON THE MPS CONTROL SCREEN BEFORE ENERGIZING MAGNET</td></tr>
<tr><td>1</td><td>Set the (c) Setpoint to 0 (zero) A. Do this by typing in the field and clicking anywhere outside the field. [This is to avoid any unintentional current ramps before all checks have been completed].</td><td>• If the control screen does not allow you to do this, call the ENGINEER ON CALL</td></tr>
<tr><td>2</td><td>Check that (b) COMM is GREEN</td><td>• If it is RED, click (p) Reset Comms
• If it does not turn GREEN, call the ENGINEER ON CALL</td></tr>
<tr><td>3</td><td>Check that (g) MAX sw (software) limit is set to a value higher than the final target current.</td><td>• If it isn’t, call the ENGINEER ON CALL</td></tr>
<tr><td>4</td><td>Check that (h) MAX hw (hardware) limit is set to a value higher than the final target current.</td><td>• If it isn’t, call the ENGINEER ON CALL</td></tr>
<tr><td>5</td><td>Check that (s) is displaying REMOTE.</td><td>• If it isn’t, click (r) Set to Remote to set it to REMOTE
• If it does not switch to REMOTE, call the ENGINEER ON CALL</td></tr>
<tr><td>6</td><td>Check that all the (u) Interlock Summary indicators are GREEN.</td><td>• If any of the indicators are RED, call the ENGINEER ON CALL
• From the pull-down menu: Select Interlock Status
• This will bring up another window (Torus MPS Interlock Status - PLC).
• Report to the ENGINEER ON CALL which indicators are RED.
• Go back to the MPS Control screen</td></tr>
<tr><td>7</td><td>Check that (v) DAQ Rec is displaying RECORDING</td><td>• If it says STOPPED, click (a) (upper left of screen).
• From the pull-down menu: Select Fast DAQ Recording Ctrl.
• This will bring up another window (Torus Fast DAQ ROOT File).
• Click the ‘Start Recording’ button.
• Check that a filename is displayed below and that the file size is increasing before continuing with magnet energization.
• Go back to the MPS Control screen</td></tr>
<tr><td colspan="3">ENERGIZING (POWERING UP) THE MAGNET</td></tr>
<tr><td>8</td><td colspan="2">The following ramp rates and target currents to power up the magnet to full field (3770 A) are pre-programmed in the PLC. Simply type in the ‘Target Current’ in the (c) Setpoint field and click anywhere outside the field to start the ramp up.
<table>
<tr><th>From Current (A)</th><th>To Target Current (A)</th><th>Slew rate (mA/s)</th></tr>
<tr><td>0</td><td>2000</td><td>1500</td></tr>
<tr><td>2000</td><td>2500</td><td>800</td></tr>
<tr><td>2500</td><td>3000</td><td>500</td></tr>
<tr><td>3000</td><td>3770</td><td>400</td></tr>
</table></td></tr>
<tr><td>9</td><td colspan="2">If there are any trips (magnet, cryogenics, control, communications etc), one of more of the (u) Interlock Summary indicators will turn RED and the magnet with either Fast Dump or initiate a Controlled Ramp Down. If this happens call the ENGINEER ON CALL.</td></tr>
</table>

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Power Down

Table III provided the nomenclature for magnet discharge modes.

Table III – Definition of Magnet Discharge Modes

Type of discharge	Definition	Discharge time
Normal ramp down	Discharge following the prescribed maximum ramp rate at a given current, through the Power Supply	~ 4920 sec (82 min) from full current (3770 A)
Controlled ramp down	Discharge at 1 A/sec irrespective of magnet current, through the Power Supply	3770 sec (63 min) from full current (3770 A)
Fast Dump	Discharge (emergency) through the Dump Resistor (dump switch) – this is also the discharge mode during a magnet quench	80 sec from full current (3770 A) to zero (16 sec time constant)

Note: Torus Magnet inductance = 2 Henries, Dump resistor = 0.124 Ohms

Reference should be made to Figure 1 and Table IV.

	Instruction	Action
DE-ENERGIZING (POWERING DOWN) THE MAGNET		
1	The power down process is simply a reverse of the power up process. The following ramp rates and target currents to power down the magnet from full field (3770 A) are pre-programmed in the PLC. Simply type in the 'Target Current' in the *(c) Setpoint* field and click anywhere outside the field to start the ramp down.	
11	If there are any trips (magnet, cryogenics, control, communications etc), one of more of the *(u) Interlock Summary* indicators will turn RED and the magnet with either Fast Dump or initiate a Controlled Ramp Down. If this happens call the ENGINEER ON CALL.	

From Current (A)	To Target Current (A)	Slew rate (mA/s)
3770	3000	400
3000	2500	500
2500	2000	800
2000	0	1500

Reversing Polarity

Reference should be made to Figure 1 and Table II.

	Instruction	Action
REVERSING POLARITY		
1	• Note that POLARITY is defined as follows: CCW Field Direction (looking downstream) = POSITIVE POLARITY CW Field Direction (looking downstream) = NEGATIVE POLARITY • Typing a POSITIVE number in *(c) Setpoint* will cause the magnet to ramp in POSITIVE POLARITY MODE • Typing a NEGATIVE number in *(c) Setpoint* will cause the magnet to ramp in NEGATIVE POLARITY MODE • Note: If the magnet is in POSITIVE POLARITY MODE and you wish to run it in NEGATIVE POLARITY MODE, simply type in a NEGATIVE number in *(c) Setpoint.* The magnet will then ramp down to zero (0) Amps at whatever slew rate is presently active, the polarity reversal switch within the magnet power supply will activate and the magnet will then ramp up in the opposite direction to the target current that you have selected. And vice versa, if the magnet was originally in NEGATIVE POLARITY MODE.	
2	If there are any trips (magnet, cryogenics, control, communications etc), one of more of the *(u) Interlock Summary* indicators will turn RED and the magnet with either Fast Dump or initiate a Controlled Ramp Down. If this happens call the ENGINEER ON CALL.	

Appendix A – Magnet Power Supply Control Screens (EPICS)

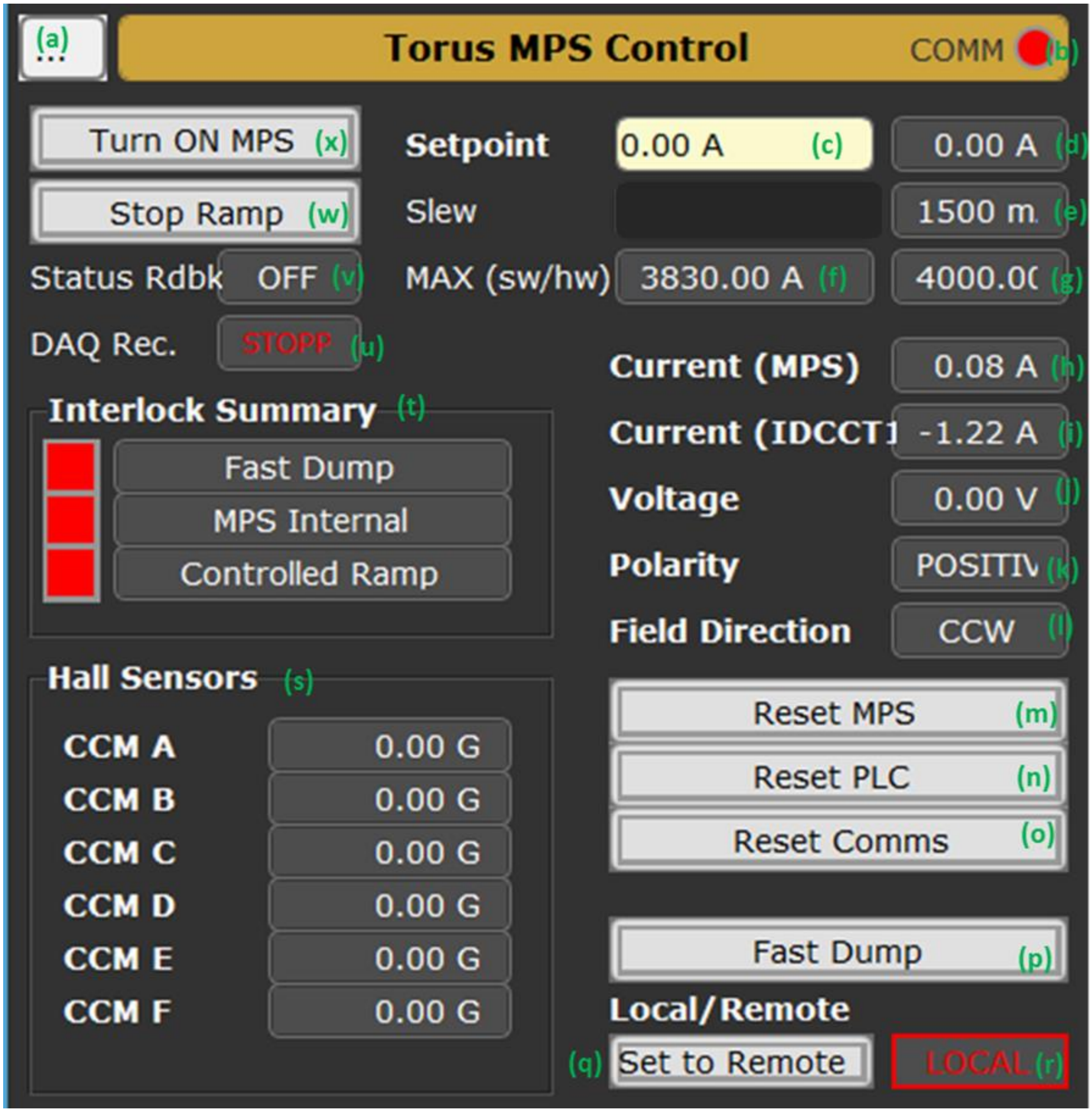

Figure A.1 - JLab MPS Control – EPICS

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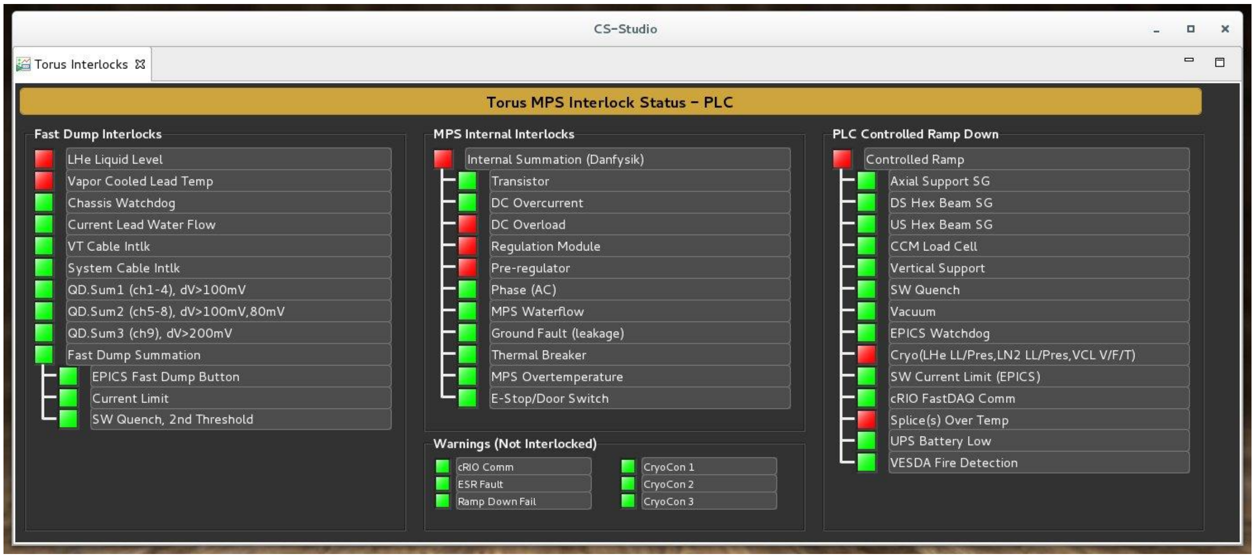
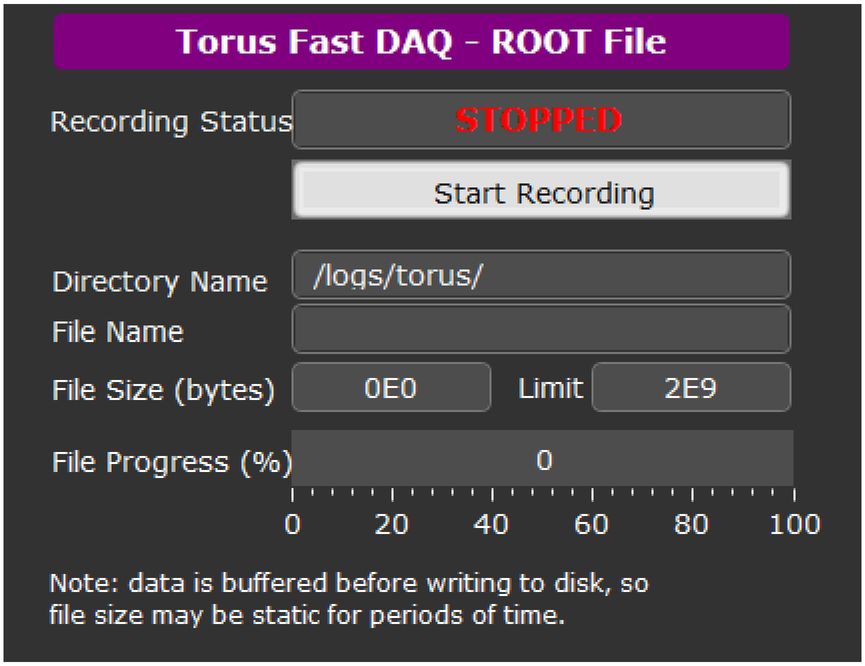
Clicking on Item (a) (Figure A.1), will provide the user with access to three further EPICS screens as follows:

Interlock Status
All interlock indicators should be GREEN before start of magnet energization



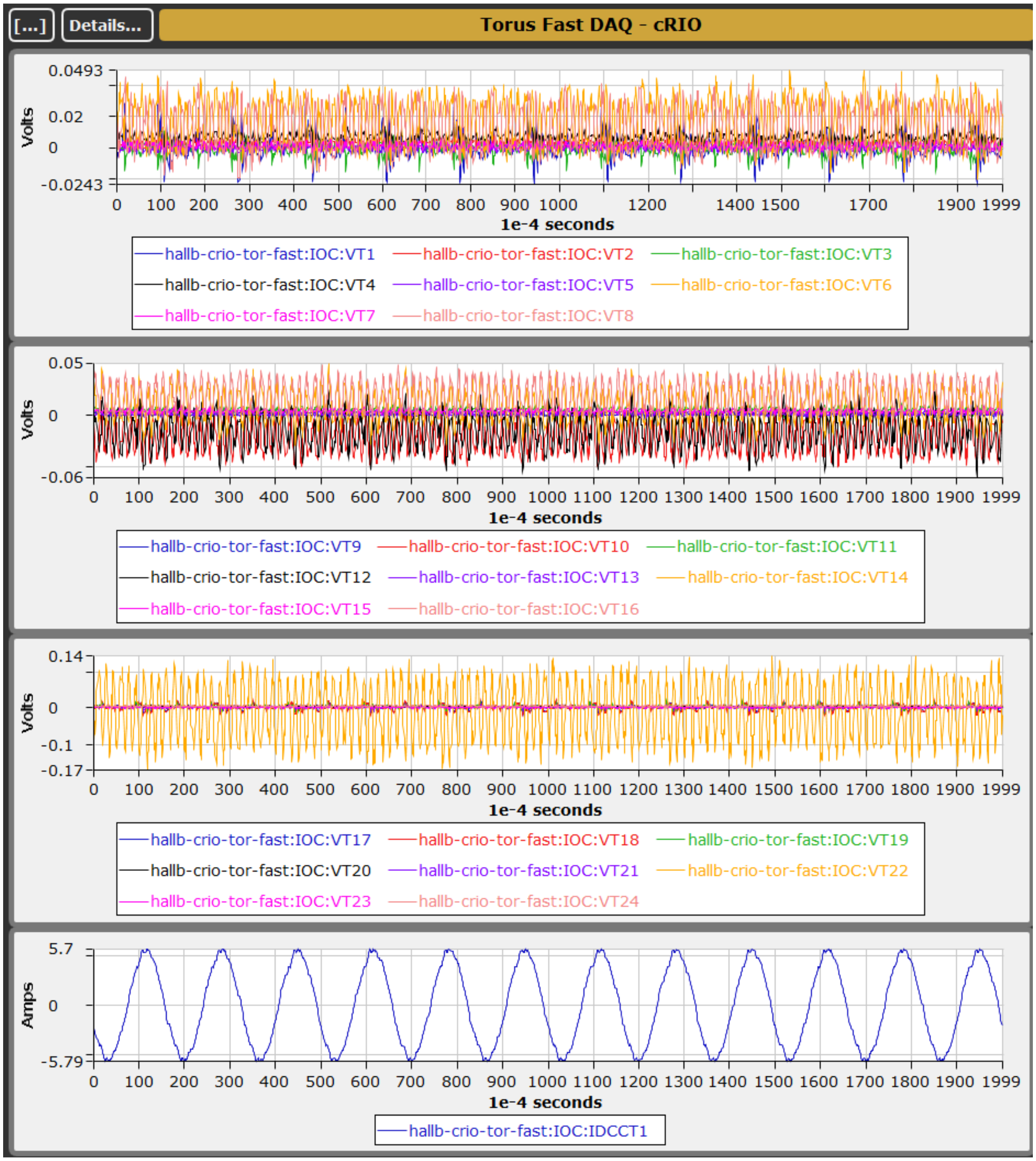
Fast DAQ Recording Status
The Recording Status should be RECORDING before start of magnet energization. Click the ‘Start Recording’ button if necessary. Check that a filename is displayed below and that the file size is increasing before continuing with magnet energization.



Fast DAQ Live Voltage Data

This displays live voltage tap data for all the voltage channels as well as the magnet current IDCCT1 – i.e. as read by the Fast DAQ National Instruments cRIO modules.

The screens below (without the magnet in operation) are an indication of the noise levels to be expected for each of the voltage channels. Noise levels typically vary from ±10 mV to ±60 mV for individual channels and can be as high as ±170 mV across the whole magnet.



Appendix B - 12 GeV Commissioning Power Up & Power Down

This is the procedure followed for magnet commissioning.

This procedure:

- Picks up where the power supply checklists end (B000000401-P027)
- Ends when magnet is brought to operating current and is ready for field mapping
- Distinguishes between "first ramp up" (commissioning), pre-operational ramps done after 12 GeV project commissioning but prior to regular operation, and subsequent ramp ups during regular operations
- During first ramp up (12 GeV commissioning):
    - Going up in current in steps
    - Reversing after each ramp to observe behavior of instruments (strain gages in particular); watching OOPS loads and adjusting if necessary
    - Exercising the fast dump capability of the power supply at least once (at partial current)
    - Reverse the magnet polarity (at partial current) to ensure instruments and controls, power supply, and other systems, can operate in reverse polarity
- A sub-procedure (checklist) to be followed in the event of quench

Pre-Energization Checklists

In the Intervening time between start of cool-down and complete helium fill, many of the system operation controls as well as interlocks can be tested and verified using the following set of checklists:

10. *B000000401-P021 Hall B Torus Operations Power Up Checklists*
11. *B000000402-P002 Hall B Superconducting Magnets Power Supply Maintenance Turn-On Checklist*
12. *B000000402-P001 Hall B Superconducting Magnets Pre-Power-Up Power Supply Internal Interlock Checklist*
13. *B000000401-P022 Hall B Torus Pre-Power-Up Water-Cooled Leads Checkout Procedure*
14. *B000000401-P023 Hall B Torus Pre-Power-Up Vapor-Cooled Leads Checkout Procedure*
15. *B000000401-P025 Hall B Pre-Power-Up Instrument Checkout Procedure*
16. *B000000401-P026 Hall B Pre-Power-Up Quench Detector Tuning Procedure*
17. *B000000401-P027 Hall B Pre-Power-Up Interlock Checkout Procedure*

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12 GeV Commissioning Power Up & Power Down

The Operator controls the Magnet Power Supply (MPS) for the magnet and monitors the magnet and its sub-systems via a PLC using a series of EPICS screens. Bringing the Torus to operating field is done in a series of current steps at differing current ramp rates.

Each time the operator establishes the desired current on the EPICS screen and clicks anywhere outside the 'Set point' box, the power supply begins the ramp to the setpoint current at the specified slew rate (Ramp rate).

The power supply can either be controlled via its own remote control interface (mounted in a rack within the hall itself), see Fig. B.1 below; or via a JLab-developed EPICS screen, see Fig. B.2.

Figure B.1 - Danfysik Remote Control Crate

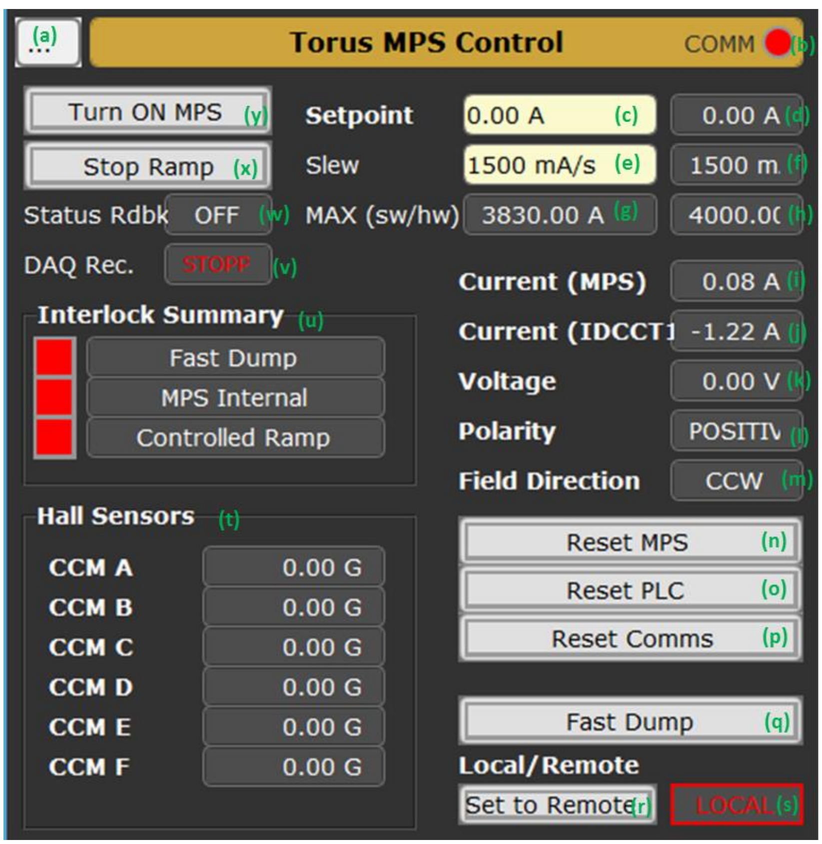

Figure B.2 - JLab MPS Control – EPICS

For the power-up procedure, the following nomenclature will be used for a magnet discharge:

Table B.I – Definition of discharge mode

Type of discharge	Definition	Discharge time
Normal ramp down	Discharge following the prescribed maximum ramp rate at a given current (see Table II), through the Power Supply	~ 4000 sec (65 min) from full current (3770 A)
Controlled ramp down	Discharge at 1 A/sec irrespective of magnet current, through the Power Supply	3770 sec (63 min) from full current (3770 A)
Fast Dump	Discharge (emergency) through the Dump Resistor (dump switch) – discharge mode during quench	80 sec from full current (3770 A) to zero (16 sec time constant)

Note: Torus Magnet inductance = 2 Henries, Dump resistor = 0.124 Ohms

Power-Up Sequence (12 GeV Commissioning)

During commissioning ramp-up certain parameters will be monitored and recorded (aside from the EPICS logs). Values are to be monitored and compared during the stops between ramps to ensure behavior is as expected before moving on to the next step. A spreadsheet with what is being recorded at each step is a companion to this procedure, and will be filled out both on paper and electronically as the power-up proceeds. Final spreadsheet will be placed on the Hall B log.

Before defining the steps of commissioning ramp-up, it is useful to define magnet polarity. We define polarity as the direction of the toroidal field when looking downstream at the magnet from the current leads; clockwise or anti-clockwise. Determination of polarity is done as part of the pre-power up checklist.

The commissioning power-up will start with the magnet connected in the ***clockwise*** polarity.

The steps to follow during commissioning power-up are:

STEP 1a

Purpose:

- To check on inductance of coils and magnet
- To allow 'tuning' of quench detector circuits
- To check for signs of eddy-current heating in CCMs and thermal shields
- To check for signs of stress in coil cases

- To check for load unbalances on OOPs and supports
- To verify correct Gauss/Amp for each coil
- To verify integrity of coil splices
- To check for hysteresis in instrumentation

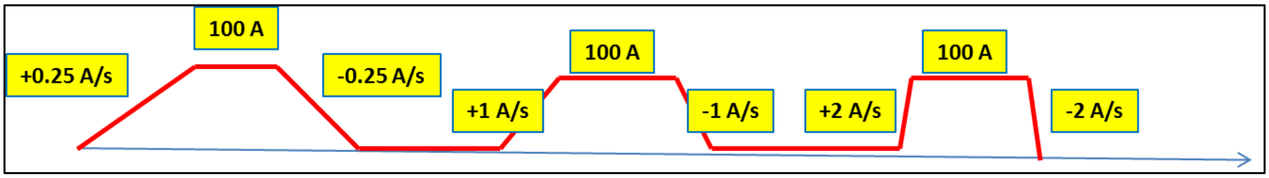

Figure B.3 - Ramp-up schedule for Step 1a

(1) Pre-Power-Up Checklist complete

(2) Verify magnet polarity is clockwise

(3) Ramp up current from 0 to 100A, stay at 100A at least 10 minutes, and then decrease back to zero at the same ramp rate. Repeat three times at increasing ramp rates (0.25, 1, and 2 A/s) and staying at 0 A at least 10 minutes each time

(4) During ramp up or ramp down monitor:

   a. Voltages across coils (and entire magnet)

   b. Voltages in current leads (and stop ramping if abnormal)

(5) During stay at 100A check, record and evaluate:

   a. Strain gages

   b. Load cells (OOPS + supports)

   c. Hall probes

   d. CCM and shield temperature

   e. Splice voltages (especially when we are at high current)

   f. VCL voltage

(6) Upon cycles completion, check for consistent behavior, signs of hysteresis in the instrumentation

STEP 1b

Purpose:

- To verify all instruments and controls, power supply, and magnet, can operate in reverse polarity
- To verify that all the checks done on Step 1a are still valid in reverse polarity mode

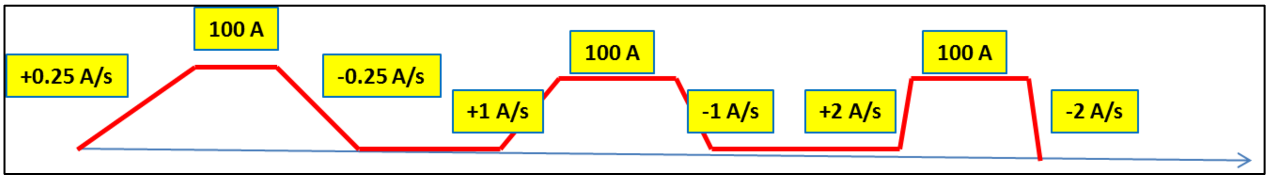

Figure B.4 - Ramp-up schedule for Step 1b

(7) Reverse polarity to ***counter-clockwise***

(8) Verify all instruments and controls are operational

(9) Proceed with a similar ramp and same steps as in Step 1a (but now in reverse polarity)

(10) Ramp up current from 0 to 100A, stay at 100A and then decrease back to zero at the same ramp rate. Repeat three times at increasing ramp rates (0.25, 1, and 2 A/s)

(11) During ramp up or ramp down monitor:

a. CCM and shield temperatures

b. Voltages across coils (and entire magnet)

(12) During stay at 100A check, record and evaluate:

a. Strain gages

b. Load cells (OOPS + supports)

c. Hall probes

d. CCM and shield temperature

e. Splice voltages (especially when we are at high current)

f. VCL voltage

(13) Upon cycles completion, check for consistent behavior, signs of hysteresis in the instrumentation

(14) Compare findings of Step 1b with those of Step 1a and check for consistency

For all the next steps, the polarity of the magnet is NOT changed, it remains ***counter-clockwise***.

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STEP 2

Purpose:

- As for Step 1b but at higher currents
- To test the Fast Dump process

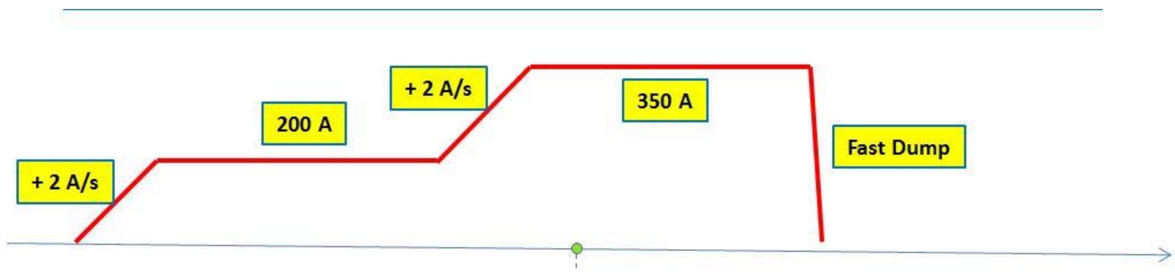

Figure B.5 - Ramp-up schedule for Step 2

(15) Ramp up current from 0 to 200A at +2 A/sec, wait at 200 A (time needed to do the checks below)

(16) Proceed to 350 A at the same ramp rate, wait and record

(17) During ramp-ups monitor:

a. CCM and shield Temperatures

b. Voltages across coils (and entire magnet)

(18) During stays check:

a. Strain gages

b. Load cells (OOPS + supports)

c. Hall probes

d. CCM and shield temperature

e. Splice voltages (especially when we are at high current)

f. VCL voltage

(19) From 350 A level, trip Fast Discharge (by soft or hard button). After Fast Discharge, stay discharged:

a. Collect data and look at voltages,

b. If anything trips, why

c. Look at all mechanical sensors (are they back to values at 0 A?)

STEP 3

Purpose:

- To stress and de-stress the coils and structural members during ramp-up
- To test the Controlled Ramp Down process from full operating current

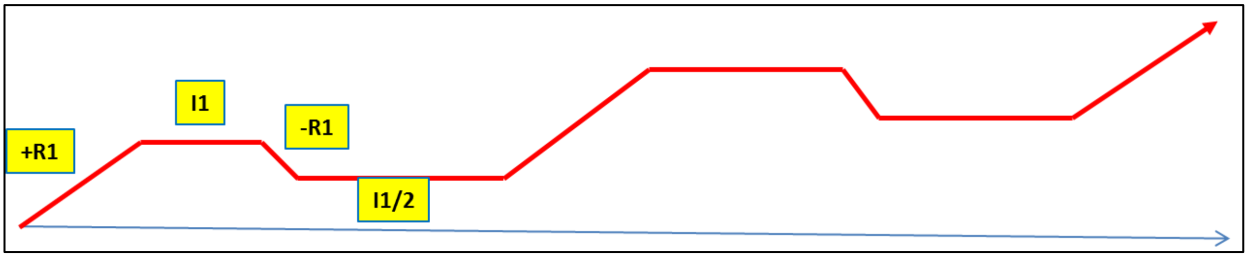

Figure B.6 - Ramp-up schedule for Step 3 (illustration)

(20) After Fast Dump checklist is complete, commence ramp-up to slightly above nominal current (3800 A) following a pattern:

1. Ramp current up to I1 at a rate +R1
2. Stay at I1 to conduct checks (30-60 minutes)
3. Decrease current to I1/2 at a rate –R1
4. Stay at I1/2 for checks (30-60 minutes)

(21) Continue this process of ramp up/wait/ramp down/wait to increasing levels of current at the appropriate ramp rates. The levels and rates are the same used during a regular ramp up, as follows:

Table B.II - Maximum ramp rate as a function of current, schedule of current ramps for Step 3[1]

Current (A)	Ramp rate (A/sec)
0 - 500	2
500 - 1000	2
1000 - 2000	2
2000 - 2500	1.5
2500 - 3000	1
3000 - 3500	0.5
3500 - 3770	0.25

(A)	(A/sec)
500	2
250	-2
1000	2
500	-2
2000	2
1000	-2
2500	1.5
1250	-1.5
3000	1
1500	-1
3500	0.5
1750	-0.5
3770	0.25

Wait

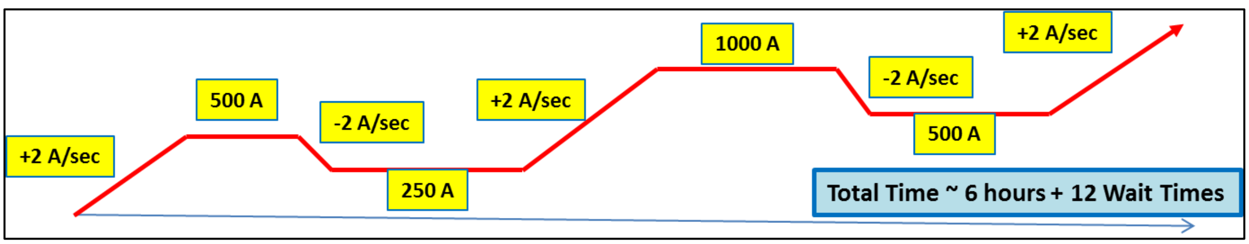

Figure B.7 - Ramp-up schedule for Step 3 (showing ramp rates)

(22) During ramp-ups monitor:

c. CCM and shield Temperatures

d. Voltages across coils (and entire magnet)

(23) During stays check:

g. Strain gages

h. Load cells (OOPS + supports)

i. Hall probes

j. CCM and shield temperature

k. Splice voltages (especially when we are at high current)

l. VCL voltage

[1] Note that these values for ramp rates were determined BEFORE the start of commissioning. Observation of thermal transients (AC losses) during magnet ramping led us to decrease the maximum ramp rate as a function of current. Lower values were used during the remaining steps of commissioning, the values given in the Operations Manual section were determined during commissioning

(24) It is important to record and evaluate the VCL voltage during ramping-up, as values may be incorporated to the control system in the form of an alarm on deviations from expected trend

(25) At 3000A, and AFTER lowering the current to 1500A, stop the process, evaluate all the data collected up to this point, and only proceed with this step if no anomalies in magnet behavior are noted.

(26) After evaluation, resume the step, and charge magnet to 3800 A (0.8% above nominal).

(27) From the final current of 3800 A, come down to nominal current of 3770 A, and then perform a Controlled Ramp Down using a ramp rate of -2 A/s all the way down to 0 A while monitoring all instrumentation – in particular temperature sensors to identify any eddy current issues (both in shields and coils).

Actions in the event of training quench

1. In the event of a training quench during power up, the step will be stopped to investigate and try to localize where the quench originated, and if data permits, identify a root cause for the quench. The steps are:
    a. Analyze all temperature, pressure, mechanical, and voltage fast DAQ data to determine location, and if possible, source of the quench
    b. Check the interlock SOE (sequence of events)
    c. Attempt to isolate location and root cause of quench
    d. From the voltage tap data estimate quench propagation velocity, and use the information to validate assumptions of quench propagation modeling (in particular, if quench originates in splice region, confirm that quench propagates into the coils)
    e. Do a visual inspection of all magnet, power supply, and cryo systems
    f. Unless investigation uncovers a problem, then:
2. Re-start by following the cooldown check list (as per appropriate section in the Cooldown Procedure B00000901-P007)
3. Proceed to cooldown (as per appropriate section in the Cooldown Procedure B00000901-P007)
4. Go through procedure B000000402-P001 Hall B Superconducting Magnets Pre-Power-Up Power Supply Internal Interlock Checklist
5. Re-start the power up step at which the quench occurred (1a or 1b, 2, or 3), going back to the beginning of the step

Power-Up Sequence (Post-Commissioning)

After taking the magnet to 3800 A, and a Controlled Ramp Down from 3770 A, the 12 GeV commissioning phase is considered complete. Post-commissioning operation begins, and is intended to further exercise certain features prior to unrestricted operation. There are two steps in this post-commissioning phase:

(1) Exercise a reverse polarity ramp-up to high current
   a. Reverse the polarity from counter-clockwise to clockwise
   b. Proceed to execute Step 3 from the Commissioning Power-Up (Section 4), but only up to a current of 2665 A

(2) Exercise a fast Dump from high current
   a. After stopping at 2665 A and recording data, exercise a Fast Dump (via soft or hard button) from this level back to 0 A
   b. Analyze the data from the ramp-up and Fast Dump, in particular, any indication that the coils may have quenched during the Fast Dump

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