TORUS

Jefferson Lab

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HALL B PROCEDURE NO.:
B000000401 –P026 Rev -0

TITLE: **Hall B Torus Pre-Power-Up Quench Detector Tuning Procedure**

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DATE: 07 /14 /2016

Intended Checker and Approvers:
CHK: K. Bruhwel
1. APP: R. Fair
2. APP. 2nd Approver (if necessary)
3. APP: 3rd Approver (if necessary)

Complete and recorded online in the Network

P Ghoshal
13th July 2020

REV.	ECO#	DESCRIPTION	BY	CHK.	APP.	APP.	DATE

SUMMARY OF CHANGES FROM PREVIOUS REVISION:

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Introduction

The Danfysik System 8500 Multi Quench Detector (QD) detects quenches within the Hall B Torus superconducting magnet and is considered as part of the hard-wired protection system

Each QD unit works by comparing:

1. The voltage drops across a pair of coils + splice and triggering a fast dump whenever the voltage imbalance is higher than a pre-set threshold and,
2. Measuring voltage across Vapor Cooled Leads in two separate channels compared to a fixed minimum set threshold voltage.

Since the torus magnet has coils with near-identical inductances, during normal current ramp up or ramp down there will be little to no voltage difference between different coils. The coil voltage drop is envisaged to be equal, thus making the QD units 'blind' to the inductive voltage. In addition, during steady current conditions there will be no voltage imbalance.

The measured inductances at room temperature have been measured and are available as an Excel file stored on a shared server as follows:

M:\hallb_eng\CLAS12\Magnets\Torus\JLabTorus\C&I_Torus\Installation_HallB\Tests in Hall\Inductance &Res Measurement_HallB\Hall Torus Voltage Tap Wiring Checkouts v1_Low current measurement.xlsx

Channel Assignments

- The total calculated Magnet inductance is ~2.0 H and was measured to be ~1.8 H.
- The QD system has NINE independent channels.
  - The first 5 channels are used to compare the following coils and also include any splices between coils:
    - A-B, B-C, C-D, D-E, E-F
  - The 6th channel compares:
    - (A+B+C)-(D+E+F)
  - The 7th and 8th channels are independent channels which are individually compared to the pre-set quench voltage detection threshold value (e.g. 200 mV).
  - The 9th channel compares the whole magnet to half of the magnet (in order to protect against a simultaneous, full-magnet quench). The whole magnet voltage is compared to 2 X half of the magnet voltage (both inductive and resistive components). During charging, $V_{Upper} = 2 * V_{Lower}$

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Tuning Procedure

1. The initial quench voltage detection threshold will be pre-set to 200 mV + ½ of the nominal inductive voltage across the magnet (determined at maximum ramp rate): This works out to be 2.45 V for example.
2. In other words, we won't use the balance pot and will include the offset into the threshold. This allows us to use a threshold which is not ramp-rate dependent. Lower ramp rates will have less sensitivity to a simultaneous, full-magnet quench. In a full magnet quench, the difference between the upper and lower voltage will be much greater than the 2.45 V thresholds (Max of 250 V).
3. Each channel has to be adjusted for ZERO balance and then tuned to set the gain to achieve a threshold equivalent to 1.28 V max (trip set by Manufacturer and internal to the circuit board) to account for any imbalance of the channel pair (this should normally be ZERO or in practice may reflect the inherent noise level within the experimental hall itself). The pairs of coils that are being compared are defined by drawing *DRG#B00000-09-01-0180 Rev A*. The procedure below describes how to perform this adjustment for a given channel. This procedure is then repeated for all the channels since all the coils are exactly the same with an exception to channel #9 as discussed earlier.
4. **Note the adjustments per channel**: balance, gain and offset are set to have a trip at 1.28V across the amplified comparator.
    a. The balance adjustment accounts for the imbalance between compared coils.
    b. The gain adjustment sets the trip sensitivity.
    c. The offset adjustment ensures that the channel behaves symmetrically during ramp up vs. ramp down. Also note that the offset potentiometer may need to be adjusted to null out induced voltages (not envisaged for the Torus magnet) from the magnet power supply.
5. Use *DRG#B00000-09-01-0180 RevA* to check that that you are clear which channel has been assigned to each coil.
6. Calculate the maximum coil voltages for the channel at the highest ramp rate based on calculated inductances (See EXCEL file above). Note that the actual inductances will be re-measured during the commissioning of the Torus so this procedure may need to be repeated if the difference between the calculated and measured inductances is too large.
7. Turn ON all the QD units.
8. Zero out the channel offset by measuring the voltage at the rear test points and adjusting the rear offset potentiometer until the measured voltage is zero.
9. Using two DC power supplies apply voltage to the high and low channels across the QD unit on the front panel connectors according to the expected maximum voltages during ramp up (none for torus).
10. Measure the voltage on the front-panel leads and input to the QD (orange

connector) and measure the imbalance through the BNC connector on the front of the QD (numbered 1-9). With injection of 100 mV across the paired channel (set both +100 mV) the BNC output should ideally read ZERO).

11. If the read out is not ZERO, adjust the front-panel balance potentiometer until the voltage drop is zero. At this point the channel is adjusted for the unequal inductances of the coils (if any).
12. Also confirm this adjusted setting by applying a range of other voltages for example 50 mV and 500 mV (to characterize any drift or noise) as reference points only
13. From this point onwards, the balance potentiometer should not need to be adjusted again unless the measured inductance ratio differs significantly from the calculated values.
14. Increase the voltage on one of the power supplies injecting into the upper channel on the front panel, to the point where you want the channel to trip (e.g. at the 200 mV level). Adjust the front panel gain potentiometer so that the channel just trips at this offset (voltage measured on the BNC on the front of the QD unit should be 1.28 V).
15. Restore the voltage to the first channel and offset the second channel by the same amount. The QD should trip or be very close to tripping.
16. Now restore and reverse the polarity of both voltages to simulate ramping in the other direction (e.g. ramp down instead of up). Check if both channels trip at the same voltages. If not, adjust the back-panel offset potentiometer to split the difference.
17. Repeat steps 4-16 until the channel trips at the required offsets and trips symmetrically for positive and negative voltages.
18. Repeat the procedure for all the other channels.

Record all the ultimate trip voltages on the Excel spread sheet stored on the shared server at the following location:

M:\hallb_eng\CLAS12\Magnets\Torus\JLabTorus\C&I_Torus\Installation_HallB\Tests in Hall\Inductance &Res Measurement_HallB\Hall Torus Voltage Tap Wiring Checkouts v1_Low current measurement.xlsx.

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