LQ

Instrumentation

and Quench Protection
Trace Design Summary

Layer 1: *design presented at CM 10*
- 13 voltage taps on the trace
- 4 strain gages stations (azim, and axial) wired externally
- 1 external spot heater

Layer 2: *design presented at CM 10*
- 7 voltage taps on the trace
- 1 strain gages stations (azim, and axial) on the trace => optional
Trace fabrication: 1st set

Artwork

Traces

R measured

Layer 1 = 6.78 lead / 6.79 W return

Layer 2 = 6.78 lead / 6.67 W return
CM11 Status

- Fabrication of 6 sets of traces
  - 1 sets of traces not used
  ⇒ modification of the voltage taps circuits to accommodate the lifting holes
  ⇒ introduction of a cutout in the heaters to accommodate the pockets in the outer layer
  ⇒ boxes on the traces to indicate the location of the strain gages

5 sets of traces used in coils #3 to #7
Trace Design: improvements since CM 11

- Modifications in the end region of the heaters have been requested to better fit in the pocket (based on coil #4 and #5 fabrication)

  Modification required based on coils #4 and #5 feedback implemented in coil #8 and subsequent coils

- Increase of spacing between vtaps to allow a hole for the fixation of a G10 strain relief piece on the inner layer return end

  Modifications implemented in traces for coil #8 to #11
Trace improvements for next coils

- Request for coil #12 and subsequent coils: to increase the spacing between the coil pole and the heaters

During potting, the trace tends to be sucked by the groove in the pole of the outer layer

Additional feedback expected from fabrication of coils #8 to #11
Heaters Powering

- All the coils have to be wired the same way

- Need to have the outer and inner layer powered with opposite current to cancel flux change

Inner layer seen from the bore

Outer layer seen from outside
Heaters Connections

-4 circuits:
- 4 inner layer RE heaters in parallel powered by 1 heater firing unit (HFU)
- 4 inner layer LE heaters in parallel powered by 1 HFU
- 4 outer layer LE heaters in parallel powered by 1 HFU
- 4 outer layer RE heaters in parallel powered by 1 HFU

IHFU = 4 X 60 A = 240 A

VHFU = 288 V
C_HFU = 19.2 mF => RC = 23 ms

R equivalent 4.2 K = 1.2 ohm

Rstrip 300K = 7 ohm
Rstrip 4.2 K = 4.8 ohm

Question: what is the maximum current which can be delivered by each HFU?
Coil #5 Heaters Test Motivation and Set up

- Coil #5 => practice coil

- Opportunity
  - to check the reliability of the heaters after several discharges => in particular the inner layer heaters
    - by visual inspection
    - by Hipot at 1 kV
  - to check the HFU performances for currents above 200 A

- Heater test in Liquid Nitrogen
  - 2 configurations: 1 strip or 4 strips in parallel connected to HFU
  - Capacitor bank range: 2.4, 4.8, 9.6 and 19.2 mF
  - Max voltage: 450 V
Coil #5 Heaters Test at FNAL

Before the test:
- Hipot of the coil at 1 kV at 300 K and 77 K

During the test:
- Heater resistance measurement
- Hipot of the coil
- Maximum current delivered by HFU during the test: 285 A
- Maximum current in the heaters: 90 A (450 V single strip \(\Rightarrow\) 195 W/cm²)

Visual inspection: no damage

Hipot test: ok at each step (leak current below 0.02 µA)

FNAL – coil #5 – Guram Chlachidze
Coils Instrumentation Plan

1 to 1.5 meter of wire needed

Outer layer is instrumented at BNL and FNAL

Different potting fixture at BNL and FNAL

⇒ FNAL can impregnate the coil with the wires

⇒ BNL has to solder the wires after potting

Inner layer is instrumented at LBNL

13 Vtaps + 1 Spot heater + 8 strain gauges

- Install outer layer strain gauge and solder wires
  - This is an option
- Install inner layer strain gauges and solder wires
- Install spot heaters
- Wire all instrumentation to the connectors at the top of the shell
- Install pig tails from shell-connectors to VMTF connectors

<table>
<thead>
<tr>
<th>Task:</th>
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<tbody>
<tr>
<td>- Design and procure traces</td>
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<tr>
<td>- Prep traces (inner and outer layers) before impregnation:</td>
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<tr>
<td>- Pre-tin trace soldering areas (for heater wires, voltage tap wires, and voltage tap flags)</td>
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<tr>
<td>- Place mold release on trace soldering areas (for inner layer heater wires, voltage tap wires)</td>
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<tr>
<td>- Cut windows for strain gauges</td>
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<tr>
<td>- Punch holes for epoxy flow:</td>
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<tr>
<td>- Diameter: 1/8 inch</td>
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<tr>
<td>- Minimum distance from heater and VT traces: 3.5 mm</td>
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<tr>
<td>- Pre-tin trace soldering areas for strain gauges on outer layer</td>
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<td>- This is an option</td>
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<tr>
<td>- Install traces on inner and outer layers</td>
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<tr>
<td>- Solder voltage tap flags to traces</td>
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<tr>
<td>- Solder wires for protection heaters and voltage taps on the outer layer</td>
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<tr>
<td>- VTaps: Optic Inner and outer layers</td>
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<tr>
<td>- Should be 1.5 m long (1)</td>
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<tr>
<td>- Gauges and colors <a href="https://plan4.fnal.gov/P1/USLARP/MagnetRD/longquad/meetings/06/09/22/dec08">See</a></td>
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<tr>
<td>- During coil prep for impregnation</td>
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<tr>
<td>- Cut windows in the S2-glass over soldering areas and over strain-gauge areas</td>
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<td>- Put teflon tape or kapton tape with mold release over soldering areas and over strain-gauge areas</td>
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<td>- After impregnation</td>
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<tr>
<td>- Remove the tapes and perform the standard electrical checks of coil, voltage taps and heaters</td>
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<tr>
<td>- Provide holes for fixing strain relieve G10 blocks:</td>
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<tr>
<td>- Add tapped hole to IL LE saddle ext. at 0.4 inch (2) from edge</td>
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<tr>
<td>- Fill hole in IL RE saddle with S2-glass, punch 1/8 inch hole in trace at same location</td>
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<td>- Solder wires for protection heaters and voltage taps on the inner layer</td>
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<td>- LBNL</td>
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<td>- BNL &amp; FNAL</td>
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<th>Not used in coils 6-9</th>
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04/09/2009 Collaboration Meeting 12 Napa LQ IQP

Helene Felice
Connectors

Connectors for instrumentation located on the shell
Instrumentation wires exiting from Lead end and Return end

LQSD – B. Bingham
Issues encountered

On coil #7 (BNL)
⇒ a short was detected between the heaters and the end saddles => pocket
⇒ no coil/heater short

Hipot of the traces before installation on the coil performed
Review of the wiring procedures in all labs

OL Traces for coils #8 and 10 (FNAL)
⇒ Hipot ok

OL Traces for coils #9 (BNL)
⇒ Hipot detected 4 pinholes: 1st failure of the heaters

Additional insulation between saddles and trace (Nomex at BNL, kapton at FNAL) under discussion
Status

Coil Instrumentation

- Coils #5 and #6 received at LBNL
  - Electrical checks performed on Monday
- Coils #4 and #7 expected at LBNL this week
- Instrumentation of the inner layer to be completed
  - 13 Vtaps
  - 8 Strain gages (4 stations per coil)
- Schematic in preparation for connection of the instrumentation to the top of the shell

Trace fabrication

Feedback from coils #8 to 11 before artwork revision