Improvements in the T2K Primary Beamline Control System

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• Current Status
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• A Prototype of Power Supply Control System for Steering Magnets
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T2K (Tokai to Kamioka) Experiment

A long-baseline neutrino oscillation experiment at J-PARC

SK@Kamioka

J-PARC@Tokai
T2K Primary Beamline

To the Target

10 NC Magnets

Final-Focusing section

14 SC Doublets

Arc section

11 NC Magnets

Preparation section
Current Status

Under MW-class beam operation, ONE MISS SHOT can destroy beamline equipment

Taken from Y. Ikeda, Address from J-PARC Center, 17th J-PARC PAC meeting, Sep. 2013.
Machine Protection for Beams

MPS (Machine Protection System)
   – An interlock to protect beamline equipment from high intensity beams

In the T2K the healthiness of extracted beam and beamline equipment is assessed shot by shot

If beam loss increases, equips troubles, etc.

→ Abort beam by MPS activation

In MW-Class beam operation, MPS will become even more important
NEW INTERLOCK SYSTEM FOR NC MAGNET POWER SUPPLIES
Interlock System for Power Supply of Normal-Conducting (NC) Magnets

We have developed a new interlock system using Digital-Panel-Meters (DPMs) and PLC

DPM continuously samples and digitizes the DCCT output of NC PS. DPM allows 4 warning thresholds, HH, HI, LO and LL.

<table>
<thead>
<tr>
<th>Item</th>
<th>Spec.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input</td>
<td>DC -9.999 to 9.999 V</td>
</tr>
<tr>
<td>Display</td>
<td>-9999 to 9999</td>
</tr>
<tr>
<td>Samp. rate</td>
<td>1 kHz</td>
</tr>
<tr>
<td>Comm.</td>
<td>RS485/RS232C</td>
</tr>
</tbody>
</table>

YOKOGAWA FA-M3

Watanabe Elec. Ind. A7111-C
Interlock System for PS of NC Magnets (Contd.)

NC PS (x 22) -> DCCT Output

DPMs

RS485 -> PLC

HI/LO Status

Network

MPS

GUI

EPICS IOC

HI/LO Thr. Setting
Interlock System for Power Supply of NC Magnets (contd.)

Power Supplies @Preparation Section

Power Supplies @Final-Focusing Section
Performance measurement

We made some *preliminary investigations* of the performance measurement. We measured *the latency time* of the interlock system by changing *the number of averaging times* in the DPM.

- Increasing no. of avr.  =>  removing elec. noises/latency worse
- Decreasing no. of avr. =>  latency better/increasing fake MPSs

Operation: 100 A
LO Limit: 80 A
No. of Avr: 1, 4, 10, 100
Performance measurement (Contd.)

Need further study

\[ \Delta T_{\text{Panel+PLC}} \]

\[ \Delta T_{\text{Panel}} \]

\[ \Delta T_{\text{Plc}} : 14\text{msec} \]

Slow

Preliminary
We caught 3 failures by this system from March 2012 to the present

<table>
<thead>
<tr>
<th>Date</th>
<th>Magnet</th>
<th>Operation</th>
<th>HI / LO</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 May 2012</td>
<td>PQ2</td>
<td>485.0 A</td>
<td>490.0 / 480.0 A</td>
<td>485.0 -&gt; 462.0 A</td>
</tr>
<tr>
<td>24 Nov. 2012</td>
<td>PV2</td>
<td>-2.0 A</td>
<td>3.0 /-5.0 A</td>
<td>-2.0 -&gt; 14.6 A</td>
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<tr>
<td>21 Jan. 2013</td>
<td>PD2</td>
<td>1206.9 A</td>
<td>1211.9/1201.9 A</td>
<td>1206.9 -&gt; 60.5 A</td>
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</table>
NEW POWER SUPPLY AND CONTROL SYSTEM
New PS and Control System

- We plan to replace all the PSs for NC magnets and modernize its control system
- We developed a prototype of control system
New PS and Control System (Contd.)

Magnet

DCCTs

Danfysik SYSTEM9100

RS485

ILKs of Magnet and PS

PLC for PS Ctrl.

Current monitoring

Network

DPM-based ILK System

HI/LO from Panel

RS485

MPS

EPICS IOC

GUI

DCCT for Interlock

DCCT for Curr. Monitoring

EPICS IOC

GuI
New PS and Control System (Contd.)

### Supported Commands

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
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<tbody>
<tr>
<td>N</td>
<td>Power ON</td>
</tr>
<tr>
<td>F</td>
<td>Power OFF</td>
</tr>
<tr>
<td>RS</td>
<td>Reset Interlocks</td>
</tr>
<tr>
<td>AD</td>
<td>Read Monitor Channel</td>
</tr>
<tr>
<td>DA</td>
<td>Set Output Current</td>
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<tr>
<td>REM</td>
<td>Set Remote Mode</td>
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<tr>
<td>LOC</td>
<td>Set Local Mode</td>
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<td>ASW</td>
<td>Set Answer Mode</td>
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<tr>
<td>CMD</td>
<td>Read Command Mode</td>
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<tr>
<td>S1</td>
<td>Read Status</td>
</tr>
</tbody>
</table>

**Control Panel (EDM) for the New PS**
Summary

• We developed DPM-based interlock system for NC magnet PSs applied in March 2012.

• We measured the latency of DPM interlock system
  – The latency of PLC: ~14 msec
  – The latency of MPS increases in proportion to no. of avr. times of DPM
  – We need more investigation of latency improvement

• We developed a prototype of power supply control system for steering magnets. They have been used successfully since Oct. 2012. Based on this system, we will install new PSs and control system in fall 2014
Backup Slides
Neutrino Facility at J-PARC
Interlock System for Power Supply of NC Magnets
Interlock System for Power Supply of NC Magnets

[Diagram of interlock system with labels such as DCCT out: Voltage, Ethernet: data, PS ON status: Contact in, etc., and connections to panel-meter and PLC modules]