Magnet power supply system for J-PARC main ring upgrade

Yuichi Morita
J-PARC/KEK
Contents

- Introduction
- Present PS system
- PS system after upgrade
- Present status
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J-PARC Main Ring (MR) Specifications

Proton synchrotron
2 experimental facilities (Neutrino, Hadron)
Acceleration: 3 GeV to 30 GeV, 3 GeV to 8 GeV
Beam power: 470 kW for Neutrino facility (present)
Beam upgrade

In order to achieve the MR beam power of $> 750 \text{ kW}$,

the scheme of Increasing Repetition Rate is adopted.

Required Performance of PS for MR Main Magnets

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Present PS</td>
<td>2.48</td>
<td>1600</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>New PS</td>
<td>1.3</td>
<td>1600</td>
<td>~6</td>
<td>~10</td>
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<tr>
<td>Power Supply</td>
<td>Number of Magnets</td>
<td>Total Inductance at 30 GeV [H]</td>
<td>Flat Base Current [A]</td>
<td>Flat Top Current [A]</td>
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<td>--------------</td>
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<tr>
<td>BM1~6</td>
<td>16</td>
<td>1.47</td>
<td>190</td>
<td>1570</td>
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<tr>
<td>QFN</td>
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<td>2.93</td>
<td>86</td>
<td>710</td>
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<tr>
<td>QDN</td>
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<td>QDX</td>
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<td>QFR</td>
<td>9</td>
<td>0.57</td>
<td>77</td>
<td>640</td>
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<tr>
<td>QDR</td>
<td>6</td>
<td>0.44</td>
<td>75</td>
<td>620</td>
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<tr>
<td>QFP</td>
<td>6</td>
<td>0.20</td>
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<tr>
<td>QFS</td>
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<td>0.30</td>
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<td>QDS</td>
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<td>0.35</td>
<td>110</td>
<td>890</td>
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<tr>
<td>QFT</td>
<td>6</td>
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<tr>
<td>SDB</td>
<td>24</td>
<td>0.41</td>
<td>19</td>
<td>160</td>
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</table>

**List of MR Main Magnets and PSs**

- **B Magnets**
- **Q Magnets at Arc Sections**
- **Q Magnets at Linear Sections**
- **S Magnets**

**Power variation at electrical system**

- **2.48 sec cycle**
  - ~60 MVA (peak to peak)
  - Forbidden by electrical power company
- **1.3 sec cycle**
  - w/o Capacitor Bank: > 100 MVA
  - w/ Capacitor Bank: lower than the present value
B and Arc-Q magnets are the primary power variation sources.

Capacitor banks will be installed.

### List of MR Main Magnets and PSs

<table>
<thead>
<tr>
<th>Power</th>
<th>Number of Magnets</th>
<th>Total Inductance at 30 GeV [H]</th>
<th>Flat Base Current [A]</th>
<th>Flat Top Current [A]</th>
<th>Output Voltage [kV]</th>
<th>2.5 sec / 1 sec</th>
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<tr>
<td>BM1~6</td>
<td>16</td>
<td>1.47</td>
<td>190</td>
<td>1570</td>
<td>2.6 / 5.8</td>
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<td>2.93</td>
<td>86</td>
<td>710</td>
<td>2.7 / 5.6</td>
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<tr>
<td>QDN</td>
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<td>3.46</td>
<td>86</td>
<td>710</td>
<td>3.1 / 6.7</td>
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<td>88</td>
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<tr>
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- Present status
Present system

Schematic circuit of PS

Current source converter

Hybrid passive and active filters

Three buildings for present PSs
Electrical connection of PS system

Present system

D1

D2

D3

Tunnel

22kV 50Hz

6.6kV

VCB
Present system

**Electrical connection of PS system**

- Large PSs are connected to 22 kV line.
- Small PSs are connected to 6.6 kV line. All of them are in D1.
- Alarm monitor panel exists in each building.
- Alarm monitor panels receive the commands from the terminal.
- Alarm monitor panels distribute the commands to the target PSs or VCBs.
Connection for alarms

D1
- 22kV 50Hz
- VCB
- Magnets around D1
- Tunnel

D2
- 22kV 50Hz
- Alarm Monitor Panel
- Magnets around D2

D3
- 22kV 50Hz
- Alarm Monitor Panel
- Magnets around D3

Terminal
- Optical
- Metal

Present system

Connection for alarms
- Metal + Optical
- Optical
- Metal
- Alarm monitor panels receive the alarm signals from the PSs, VCBs, transformers and magnets.
- The terminal can detect the alarms via the alarm monitor panels.
- Alarm information of magnets are shared among the three alarm monitor panels.
Example of magnet distribution (QFN, 48 magnets)
Contents

- Introduction
- Present PS system
- PS system after upgrade
- Present status
After upgrade

### New PS for BM

- Voltage source converters.
- Six choppers are connected in series.
- Each chopper is connected to a CB.

Details will be presented by Daichi Naito in the tomorrow session.

#### Specifications

<table>
<thead>
<tr>
<th>Specifications</th>
<th>Value</th>
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<tbody>
<tr>
<td>Load</td>
<td>1.5H, 750mΩ</td>
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<td>Output Current [A]</td>
<td>1600</td>
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<tr>
<td>Output Voltage [V]</td>
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<tr>
<td>Capacitance / CB [mF]</td>
<td>480</td>
</tr>
<tr>
<td>Capacitor voltage [V]</td>
<td>1700 maximum</td>
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</table>
New buildings for upgrade

Three new buildings were constructed.
The constructions were completed last year.
New buildings for upgrade

Three new buildings were constructed.
The constructions were completed last year.
After upgrade

Electrical connection of PS system

D4

D1

22kV 50Hz

Tunnel

BM3 with CB

BM4 with CB

0.6kV

6.6kV

VCB

6.6kV

0.4kV

6.6kV

QFP

QDR

QFS

QFT

QDS

QDT

SFA

SDB

SDA
- New BM PSs with capacitor banks are installed in D4.
- New BM PSs are connected to the present system.
- QFR PS has already been upgraded.
- QDT magnets of larger aperture are required.
- Present systems are sufficient for SDA and SDB.
After upgrade

Connection for control

Tunnel

BM3 with CB

BM4 with CB

22kV 50Hz

6.6kV

VCB

Optical

Metal

Alarm Monitor Panel

Terminal

D4

D1

22kV 50Hz

6.6kV

Optical

From D3

Optical

Metal

Connection for control

From D3

Optical

Metal

Alarm Monitor Panel

Terminal

D4

D1

22kV 50Hz

6.6kV

VCB

Optical

Metal

Alarm Monitor Panel

Terminal

D4

D1

22kV 50Hz

6.6kV

VCB

Optical

Metal

Alarm Monitor Panel

Terminal

D4

D1

22kV 50Hz

6.6kV

VCB

Optical

Metal

Alarm Monitor Panel

Terminal

D4

D1

22kV 50Hz

6.6kV

VCB

Optical

Metal

Alarm Monitor Panel

Terminal

D4
- Connections for control of new BM PSs are isolated from other PSs. Make system simple
- No alarm monitor panel exists in D4. The terminal directly contacts the new BM PSs.
Connection for alarms

After upgrade

Terminal

D4

BM3 with CB

BM4 with CB

6.6kV

Optical

Metal

Alarm Monitor Panel

Metal (magnet alarm)

22kV 50Hz

VCB

Optical + Metal

To D3

Optical

Metal

Magnets around D1

D1

QFP

QFR

QFS

QFT

SFA

SDA

SDB

QDP

QDS

QDT

D1

To D3

Optical + Metal

Metal (magnet alarm)

Metal

Magnets around D1

D1

Optical

Metal

Alarm Monitor Panel

Metal (magnet alarm)
Connections for alarms of new BM PSs are isolated from other PSs. ➔ Make system simple
- Alarm information of magnets are shared among new BM PSs and the alarm monitor panels.
New buildings for upgrade

Three new buildings were constructed. The constructions were completed last year.
Electrical connection of PS system

After upgrade

Tunnel
After upgrade

- New BM PSs with capacitor banks are installed in D5.
- New BM PSs are connected to the present system.
Connection for control

After upgrade

Terminal

Tunnel

D5

D2

BM5 with CB

BM6 with CB

QDN with CB

QFN with CB

22kV 50Hz

6.6kV

0.6kV

From D3

Optical

Metal

Alarm Monitor Panel

Optical

Terminal Connection for control
- Connections for control of new BM PSs are isolated from other PSs. Make system simple.
- No alarm monitor panel exists in D5. The terminal directly contacts the new BM PSs.
After upgrade

Connections for alarms of new BM PSs are isolated from other PSs. Make system simple
- Alarm information of magnets are shared among new BM PSs and the alarm monitor panels.
After upgrade

Connection for alarms

Configuration of D3 and D6 is almost identical to that of D5 and D2
Contents

- Introduction
- Present PS system
- PS system after upgrade
- Present status
### Present status

<table>
<thead>
<tr>
<th>Family</th>
<th>status</th>
</tr>
</thead>
<tbody>
<tr>
<td>BM1</td>
<td></td>
</tr>
<tr>
<td>BM2</td>
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<td>BM3</td>
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<td>BM4</td>
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</tr>
<tr>
<td>BM5</td>
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</tr>
<tr>
<td>BM6</td>
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<tr>
<td>QFN</td>
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<td>QDN</td>
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<td>Converter</td>
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<tr>
<td>SDA</td>
<td>Converter</td>
</tr>
<tr>
<td>SDB</td>
<td>Converter</td>
</tr>
</tbody>
</table>

Components that will be installed next January:
- Two sets of converters
- Three containers for CB

The new QFR PS has been used for the beam operation since 2016.

~35% of the installation will be finished next January.

No technical issue is remained.
The production of rest of PSs will start as soon as the budget is approved.

Product was delivered in 2014.

Present systems are sufficient.
The end of slides
Management for key of container

The conditions for the permission of the use of the key.

- The discharger “CLOSE” AND
- All of 6 banks complete the discharges (lower than 10 V). AND
- 5 minutes after the discharger closed.

PLC monitors the conditions.

The key is common for the three containers. (It is not common among the different families.)

All PLCs are connected with optical links each other. All voltages of 6 banks are included the management sequence.