Simulation Study

To better tend to customer’s needs, Toshiba offers a more customer-oriented engineering which includes a simulation study using Toshiba’s advanced traction power simulation software engines. With this, Toshiba can offer a more suitable solution.

Ratings and Specifications

<table>
<thead>
<tr>
<th>Item</th>
<th>Rating / Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated Line Voltage</td>
<td>DC 750V (DC 900V and DC 1000V are also available)</td>
</tr>
<tr>
<td>Rated Power</td>
<td>500kW - 2000kW</td>
</tr>
<tr>
<td>Applicable Load Pattern</td>
<td>Class I, IX (IEC 62924)</td>
</tr>
<tr>
<td></td>
<td>0.75(p.u.) continuous</td>
</tr>
<tr>
<td></td>
<td>Class I, VI - IX (IEC 62924)</td>
</tr>
<tr>
<td></td>
<td>0.5(p.u.) 60s + 0.25(p.u.) 240s (cycle time: 300s)</td>
</tr>
<tr>
<td>Rated Capacity</td>
<td>545kW - 777kW</td>
</tr>
<tr>
<td>Rated Battery Voltage</td>
<td>DC 600V (532V – 713V)</td>
</tr>
<tr>
<td>Operation Mode</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. V-SOC Mode</td>
</tr>
<tr>
<td></td>
<td>- Charge and Discharge corresponding with feeding voltage and SOC. Voltage stabilization of transient fluctuation is also available.</td>
</tr>
<tr>
<td></td>
<td>2. Emergency Power Supply Mode</td>
</tr>
<tr>
<td></td>
<td>- Discharge energy without power from grid.</td>
</tr>
<tr>
<td>Control Function</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. V-SOC Control</td>
</tr>
<tr>
<td></td>
<td>2. Monitoring</td>
</tr>
<tr>
<td></td>
<td>3. Sequence Control</td>
</tr>
<tr>
<td></td>
<td>4. Schedule Control</td>
</tr>
<tr>
<td></td>
<td>5. Data Logging (Option)</td>
</tr>
<tr>
<td></td>
<td>6. Remote Maintenance (Option)</td>
</tr>
<tr>
<td>Applicable Standard</td>
<td>IEC / JEC</td>
</tr>
</tbody>
</table>

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For DC Railway Power Supply Systems

Traction Energy Storage System with SCiB™

For DC Railway Power Supply Systems

http://toshiba-railway.com

Find out more about Toshiba transportation solutions on http://toshiba-railway.com
Traction Energy Storage System with SCiB™

When a train set is braking, it generates energy which can be used by the adjacent accelerating trains. But in most cases, this regenerative energy is not efficiently utilized by the next train and is wasted as heat through onboard or wayside resistors. Such cases does not only incur energy wastage but also likely to cause abrupt shift from regenerative braking to mechanical braking. This sudden change may further cause passenger ride discomfort and degradation of the brake shoe due to abrasion.

Toshiba’s Traction Energy Storage System (TESS) efficiently stores surplus regenerative energy in the SCiB™ and discharges it to another accelerating train. TESS is installed with Toshiba’s patented advance control system which allows flexible control of charge-discharge cycles in accordance to the battery’s State-of-Charge (SOC). This allows significant increase in battery lifetime.

Toshiba developed Traction Energy Storage System (TESS) with SCiB™, a new energy saving solution with Toshiba’s own battery technology of high quality.

Key Benefits

Better Regenerative Braking Operation
Surplus regenerative energy can be efficiently charged and discharged to/from the SCiB™ Battery thus preventing regenerative brake failures.

Energy Saving
SCiB™’s remarkable charge-discharge efficiency characteristics can reduce energy wastage and ultimately, promote power demand peak cut.

Line Voltage Stabilization
Installation of TESS can improve traction power quality through voltage stabilization.

Emergency Power Supply
Stored energy can be utilized to accelerate the trains and safely bring passengers to the nearest station during power failure. This function can be applicable when it is installed in tunnel and bridge sections.

System Outline

<table>
<thead>
<tr>
<th>Substation</th>
<th>TESS</th>
<th>Substation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regenerative Power</td>
<td>Charge</td>
<td>Discharge</td>
</tr>
</tbody>
</table>

Conventional Control
- Discharge Area
- Charge Area
- Charge Start Voltage
- Discharge Start Voltage
- Line Voltage

Advanced V-SOC Control
- Discharge Area
- Charge Area
- Start Voltage
- Charge Start Voltage
- Discharge Start Voltage
- Line Voltage

Advanced V-SOC Battery Control

Toshiba also developed a completely new and advanced Charge-Discharge algorithm for the efficient control of TESS. For conventional energy storage systems, battery is charged and discharged to keep specified SOC (State of Charge). Thus, battery is charged and discharged regardless of the feeding voltage. There will be instances when the battery will be unnecessarily charged/discharged even at rated line voltage (area between the Charge Start Voltage and Discharge Start Voltage). Thus causing feeding voltage imbalance and shortened battery lifetime.

As for Toshiba’s advance V-SOC control method, charge and discharge characteristics automatically shifts depending on SOC. When SOC is high, charge-discharge characteristic will shift to the lower voltage side thus, battery shall perform more charging. The lifetime of a battery strongly depends on the charge-discharge times and current. By using this control algorithm, unnecessary charge and discharge can be greatly reduced.

Toshiba’s system does not define any certain SOC which means that charge and discharge will be performed dynamically within a wide range of SOC.

High performance SCiB™

TESS utilizes Toshiba’s own high performance SCiB™

This battery has various outstanding characteristics

By using unique oxide materials, SCiB™ holds high resistance against thermal runaway caused by internal short circuiting brought about by physical stresses.

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Performance Record

TESS for Line Voltage Stabilization

Tobu Railway – Unga Battery Post
During the adaptation of new type of cars, significant loss in line voltage was expected to occur between Noda Substation and Toyoshiki Substation (11.65km distance). To stabilize line voltage in this section and avoid building new substation, 1000kW TESS was installed as a battery post.

TESS was able to stabilize line voltage fluctuation without having to build a new substation. Furthermore, power peak cut was also achieved through the effective use of regenerative energy.

Voltage Fluctuation Stabilization Results during Morning Rush Hour

<table>
<thead>
<tr>
<th>Line Voltage (V)</th>
<th>Without TESS</th>
<th>With TESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1800</td>
<td>6:00 ~ 7:00</td>
<td>1742V</td>
</tr>
<tr>
<td>1600</td>
<td>7:00 ~ 8:00</td>
<td>1502V</td>
</tr>
<tr>
<td>1400</td>
<td>8:00 ~ 9:00</td>
<td>1362V</td>
</tr>
</tbody>
</table>

TESS for Energy Saving

Okinawa Urban Monorail – Sueyoshi Substation Field Test Result
500kW TESS was installed in Sueyoshi Substation of Okinawa City Monorail. With TESS operation, 10% power peak cut was achieved in Sueyoshi SS power consumption alone. Significant power peak cut was also achieved in total power consumption in all substations.

With TESS, daily traction energy consumption was reduced to 575kWh/day (-17%) during weekday and 883kWh/day (-32%) during weekend while reducing the adjacent substation energy consumption as well.

Voltage Fluctuation Stabilization Results

<table>
<thead>
<tr>
<th>Substation</th>
<th>Peak Value (Without TESS)</th>
<th>Peak Value (With TESS)</th>
<th>Peak Cut Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sueyoshi SS</td>
<td>830 kWh/0.5h</td>
<td>310 kWh/0.5h</td>
<td>10%</td>
</tr>
<tr>
<td>All SS (Total)</td>
<td>6000 kWh/0.5h</td>
<td>360 kWh/0.5h</td>
<td>3.6%</td>
</tr>
</tbody>
</table>

TESS for Emergency Power Supply

Tokyo Metro – Ayase Substation Field Test Results
500kW TESS was installed in Ayase Substation of Tokyo Metro for energy saving and emergency power supply. TESS was able to independently power a 10-Car Train including all its auxiliary equipment (air conditioners, etc.) through a 2.4-kilometer distance from Ayase Station to Kita-Senju Station. This distance has a section with steep gradient of up to +33‰. Even at this stringent condition, TESS was able to safely power the train in a power failure condition.

Field Test Conditions

- **TESS Capacity**: 194kWh
- **TESS Output**: 500kW
- **Train Speed**: 15km/h
- **Auxiliary Power**: In Use