“Series EV-E301” Rolling Stock
Catenary and Battery-Powered Hybrid Railcar

10 September 2014
Rolling Stock Technology Center, Transport and Rolling Stock DEPT,
East Japan Railway Company
Hiroshi TAKIGUCHI
Agenda

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2 Catenary and Battery-Powered Hybrid Railcar System

3 Unique Mechanism of Series EV-E301

4 Main Specifications

5 Design Concept

6 Outline of Series EV-E301

7 Future Effort
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Background
1-1 Purpose of Development

- In non-electrified section,
  - The improvement of energy efficiency
    - Effective use of regenerative power
  - Reducing the environmental impact
    - Reducing CO$_2$ emissions
    - Eliminating exhaust gases and noise from diesel engine
  - Reduction in maintenance of the cars by reducing laborious mechanical parts (such as engines and transmissions)
  - The improvement of rolling stock operation efficiency
    - The cars can run on both electrified and non-electrified sections.
  - The improvement of acceleration and deceleration performance of cars
1-2 Hybrid Railcars of JR EAST

- **Diesel Hybrid Railcar**
  - **Kiha E200 Type**
  - Commercial operation: 2007
  - Line: Koumi Line

- **Series HB-E300**
  - Commercial operation: 2010
  - Line: Gono Line, Tsugaru Line, Ominato Line etc.
Development of Catenary and Battery-Powered Hybrid Railcar

R&D Period (2008—2012)

Commercial Development Period (2012—2014)

15 March 2014 Commercial Operation Start

2012

2008

Series EV-E301 ‘ACCUM’

Test car ‘NE(New Energy) Train’
1-4 Operation Area of Series EV-E301

- Electrified section (Tohoku Line) between Utsunomiya and Hoshakuji
  Distance: 11.7km

- Non-electrified section (Karasuyama Line) between Hoshakuji and Karasuyama
  Distance: 22.4km
2

Catenary and Battery-Powered Hybrid Railcar System
Overall Composition of Catenary and Battery-powered Hybrid Railcar System

Overview of rolling stock system:
- 1500V DC
- Converter
- 600V DC
- Inverter
- Battery

1. Charges battery from catenary via pantograph
2. Drives motor by either catenary or battery
3. Charges battery with regenerative energy
   (Regeneration to catenary possible in electrified sections.)

Overview of charging facilities system:
- Overhead conductor rail
- 1500V DC
- Voltage converter
- 6600V AC

1. Power received from power company distribution line instead of dedicated power lines
2. Stepping down and rectification at voltage converter and power feeding to car from overhead conductor rail

In electrified sections:
- Power lines
- Substation
- Runs as ordinary EMU while charging

In non-electrified sections:
- Runs on power from batteries

Turn-back station:
- Distribution line
- Charging facility
- Overhead conductor rail
3

Unique Mechanism of Series EV-E301
3-1 Main Circuit System Composition

Overall composition of main circuit system

Series EV-E301

■ Pantograph

DC1500V → DC/DC converter → DC630V → VVVF inverter → Main motor → Wheels

Battery for main circuit

■ Typical DC train

Pantograph

DC1500V → DC/DC converter → VVVF inverter → Main motor → Wheels

 Auxiliary power source

Photo: Power converter
3-2 Setting Battery Capacity

Setting Battery Capacity

- Drive load (Powered running/regeneration)
- Auxiliary power unit load
- Rolling stock power consumption
- Leeway for stops/delays
- Allowance for deterioration over time
- Unable to use range
- Necessary capacity of battery (at the time of start operation)
- Capacity of onboard battery

SOC [%] = State of Charge

190 kWh
Series EV-E301 has equipment to automatically identify overhead line type.

- **Case 1**: Catenary → **Electrified section**
- **Case 2**: Without Overhead Line → **Non-electrified section**
- **Case 2**: Overhead Conductor Rail → **Turn-back Station (Charging Facility)**

- **Pantograph Control**
- **Powering and Braking Control**
- **Limit of value of collected current through pantograph**
3-3 Equipment for Identifying Type of Overhead Lines

Example of the car control

Electrified section

- Raising pantograph ⇒ possible
- Powering ⇒ possible
- Value of collected current ⇒ normal current

Non-electrified section

- Raising pantograph ⇒ impossible
- Powering ⇒ possible

If the pantograph is raised,

- Powering is impossible
- Apply the emergency brake

Charging facility (Turn-back station)

- Raising pantograph ⇒ possible
- Powering ⇒ impossible
- Value of collected current ⇒ large current

- Large current NG

- OK
3-4 Method of Mounting Batteries

1 module (0.864 Wh) × 22 module

1 box
Passenger cabin of Series EV-E301 has a monitor display showing energy flow between the equipment.

**Example of the display**

- **Electrified section**
  - pantograph raised
  - powering

- **Non-electrified section**
  - pantograph lowered
  - powering
4  
Main specifications
## 4-1 Main specifications

**EV=Energy storage Vehicle**

<table>
<thead>
<tr>
<th>Car type</th>
<th>EV-E301</th>
<th>EV-E300</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classification code</td>
<td>Mc</td>
<td>Mc'</td>
</tr>
<tr>
<td>Passenger capacity (number of seats)</td>
<td>133(48)</td>
<td>133(48)</td>
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<tr>
<td>Weight (t)</td>
<td>40.2</td>
<td>37.7</td>
</tr>
<tr>
<td>Car body length × Width × Height (mm)</td>
<td>19,570 × 2,800 × 3,620</td>
<td></td>
</tr>
<tr>
<td>Bogie center distance (mm)</td>
<td>13,800</td>
<td></td>
</tr>
<tr>
<td>Bogies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gauge (mm)</td>
<td>1,067</td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td>Bolsterless</td>
<td></td>
</tr>
<tr>
<td>Wheel base (mm)</td>
<td>2,100</td>
<td></td>
</tr>
<tr>
<td>Wheel diameter (mm)</td>
<td>φ860</td>
<td></td>
</tr>
<tr>
<td>Drive system</td>
<td>Parallel cardan system</td>
<td></td>
</tr>
<tr>
<td>Electric system</td>
<td>1,500V DC / 630V DC</td>
<td></td>
</tr>
<tr>
<td>Train performance</td>
<td>Maximum running speed 100km/h, Starting acceleration 0.556m/s² (2.0km/h/s)</td>
<td></td>
</tr>
<tr>
<td>Control system</td>
<td>VVVF inverter control</td>
<td></td>
</tr>
<tr>
<td>Main circuit battery</td>
<td>Lithium-ion battery 95kWh</td>
<td>Lithium-ion battery 95kWh</td>
</tr>
<tr>
<td>Brake system</td>
<td>Electric command air brakes with regenerative braking (with load compensating control)</td>
<td></td>
</tr>
<tr>
<td>Traction motor</td>
<td>3-phase squirrel-cage induction motor</td>
<td></td>
</tr>
<tr>
<td>Continuous rated output: 95kW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Auxiliary power supply</td>
<td>Static inverter; Auxiliary rectifier</td>
<td></td>
</tr>
<tr>
<td>Safety devices</td>
<td>ATS-P</td>
<td></td>
</tr>
</tbody>
</table>
Why was the car nicknamed ‘ACCUM’?

The nickname was chosen by the public.

ACCUM = Accumulator

Symbol mark

Imaging the flow of energy between ‘Overhead line’, ‘Battery’ and ‘Main motor’
5

Design concept
5-1 Exterior Design

Total Concept: “Spirit of Innovation” “Environmentally Friendliness”

- Spirit of innovation
  The new car head shape/Stripe coloring creates a sharp impression
- Eco-friendliness
  The silver/green coloring combination on the car body
5-2 Interior Design

Total Concept: “Spirit of Innovation” “Environmentally Friendliness”

- **Spirit of innovation**
  - Indirect LED lighting arranged continuously / New ceiling shape

- **People-friendliness**
  - Sufficient space for wheelchair user /
  - Color combination for separating information area

- **Features of the Karasuyama Line**
  - “Green” of seat: The landscape of the four seasons along the line
  - “Orange” of floor: The vibrancy of “Yamaage Festival”
6

Outline of Series EV-E301
6-1 Car Body

Light-Weight Stainless Steel Construction

- Straight body
- The reinforced head structure
- Weight reduction structure
  (Replacing stainless steel parts with aluminium alloy)
6-2 Passenger Cabin

- Same layout for each car
- Long seats
- Universal design
- One man operation equipment
6-2 Passenger Cabin

- LED Room Light
- Wheelchair Space
- LCD-type information display
6-3 Crew Cabin

- Completely partitioned structure from the passenger cabin
- No corridor connection
- The reinforced head structure
- Rescue port for the crew
- LED headlamp
6-3 Crew Cabin

- Trolley Voltmeter (DC1500V)
- Battery Voltmeter (DC630V)
- Control Line Voltmeter (DC100V)
- Quick Charge Start Switch
- Quick Charge Stop Switch
6-4 Equipment Layout on Roof

- **Train Radio Antenna**
- **Air-conditioner**
- **Pantograph** (Only Car 2)
6-5 Equipment Layout under Floor

Car 1

- Battery Box
- Compressor Unit
- Auxiliary power source
- Battery (DC100V for control)
6-5 Equipment Layout under Floor

- Car 2

- Filter Reactor

- Battery Box

- Power Converter
Future Effort
7-1 Assumed Effect

- **Effect of reducing CO₂ emissions**
  - Diesel car: 100
  - Diesel Hybrid Railcar: 90
  - EV-E301: 40

- **Effect of reducing noise**
  (When the car stopped at the station.)
  - Diesel car: 90dB
  - Diesel Hybrid Railcar: 60dB
  - EV-E301: 60dB
7-2 Future Effort

- Acquiring data about the battery in the summer and winter season (temperature, SOC, etc.)
- Replacing all diesel cars running Karasuyama Line with Series EV-E301