Permanent Magnet Synchronous Motor for Rolling Stock (PMSM) and 4-in-1 Variable-Voltage Variable-Frequency (VVVF) Traction Inverter for driving PMSM

Features

◆ The size of the traction inverter has been reduced by integrating the circuits, which drive four permanent magnet synchronous motors (PMSM), into a single power unit, called 4-in-1. (Reduction by 60% and 50% in volume and weight, respectively, compared with previous Toshiba models).
◆ High efficiency has been achieved by applying permanent magnet synchronous motors, instead of conventional induction motors (IM), as the traction motors for rolling stock. (The efficiency of IM: 90% - 92% → efficiency of PMSM: 97%).
In addition, both reduction in maintenance and lower emission or noise have been achieved by the totally enclosed structure (in which outside air is not taken inside for cooling) of the PMSM.

8000-series EMU of Hankyu Corporation

4-in-1 VVVF Traction Inverter for driving PMSM

Energy-Saving Effects and Remarks

◆ Power consumption reduced by more than 50% in comparison with induction motor. (In case of 8000-series EMU of Hankyu Corporation. The actual measurement data of the 8000-series EMU of Hankyu is shown below. The figure includes power obtained from regenerative braking.)
◆ Reduction of emitted noise by 2 - 6dBA thanks to the totally enclosed structure.
◆ External air is not drawn into the motor, eliminating the problem of contamination.
◆ In addition, the construction of the traction motor, which allows replacement of bearings without disassembly of the motor, has reduced maintenance work. (The structure is shown below.)
◆ Certified “Excellent ECP*1” within Toshiba as acknowledgement of an environmentally-friendly product.

*1 Environmentally Conscious Product (environmentally-friendly product)
### Domestic

<table>
<thead>
<tr>
<th>Year</th>
<th>Customer (Car Services)</th>
<th>Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>East Japan Railway Company (E331-series EMU)</td>
<td>Direct Drive Motor (DDM)-version PMSM Propulsion System for Driving PMSM</td>
</tr>
</tbody>
</table>
| 2009 | Tokyo Metro Co., Ltd.  
   Marunouchi Line 02 series in commercial service since Feb. 2010  
   Chiyoda Line 16000 series in commercial service since Nov. 2010  
   Ginza Line 1000 series in commercial service since Apr. 2012  
   Tozai Line 05 series in commercial service since Mar. 2013  
   Hibiya Line 13000 series in commercial service since Dec. 2016 (Only PMSM adopted) | Mass-produced 2-in-1 Traction Inverter Propulsion System for Driving PMSM |
| 2013 | Hankyu Corporation  
   Kobe Line/Takarazuka Line 1000 series in commercial service since Nov. 2013 | Mass-produced 4-in-1 Traction Inverter Propulsion System for Driving PMSM |
| 2015 | Kyushu Railway Company  
   Chikuhi Line 305 series in commercial service since Feb. 2015 | Mass-produced 4-in-1 Traction Inverter Propulsion System for Driving PMSM |
| 2015 | Kita-Osaka Kyuko Railway Co., Ltd.  
   9000 series in commercial service on the Midosuji Line and Kita-Osaka Kyuko Line since Apr. 2014 | Mass-produced 2-in-1 Traction Inverter Propulsion System for Driving PMSM |
| 2009 | Japan Freight Railway Company  
   Prototype HD300 hybrid locomotive in commercial operation since May 2011 | PMSM drive main converter  
*Denotes year it was qualified* |
| 2011 | Japan Freight Railway Company  
   Mass-produced HD300 hybrid locomotive in commercial operation to sequentially start after qualification | Mass-produced PMSM drive main converter  
*Denotes year it was qualified* |
| 2015 | Tobu Railway Co., Ltd.  
   Tobu Main Line 500 series in commercial service since Apr. 2017 | Mass-produced 4-in-1 Traction Inverter Propulsion System for Driving PMSM |
| 2015 | Tobu Railway Co., Ltd.  
   Tobu Skytree Line 70000 series in commercial service since July 2017 (Only PMSM adopted) | Mass-produced System |
| 2013 | Keio Corporation (Advance adoption)  
   Keio Line 8000 series (upgraded cars) in commercial service since Mar. 2013 | 4-in-1 Traction Inverter Propulsion System for Driving PMSM |
| 2015 | Keio Corporation  
   Keio Line 8000 series (upgraded cars) in commercial service since Mar. 2016 or after | Mass-produced 4-in-1 Traction Inverter Propulsion System for Driving PMSM |
| 2014 | Seibu Railway Co., Ltd. (Advance adoption)  
   Ikebukuro Line 6000 series in commercial service since Mar. 2015 | 4-in-1 Traction Inverter Propulsion System for Driving PMSM |
| 2015 | Seibu Railway Co., Ltd.  
   Ikebukuro Line 40000 series in commercial service since Mar. 2017 | Mass-produced 4-in-1 Traction Inverter Propulsion System for Driving PMSM |
| 2013 | Hanshin Electric Railway Co., Ltd.  
   Hanshin Main Line 5700 series (new cars) in commercial service since Aug. 2015 | Mass-produced 4-in-1 Traction Inverter Propulsion System for Driving PMSM |
| 2011 | Hankyu Corporation  
   Kobe Line/Takarazuka Line 7000 series (upgraded cars) in commercial service since May 2016 | Mass-produced 4-in-1 Traction Inverter Propulsion System for Driving PMSM |
| 2012 | Hankyu Corporation (Test implementation)  
   Kobe Line 8000 series (test implementation) in commercial service since Aug. 2012 | 4-in-1 Traction Inverter Propulsion System for Driving PMSM |
| 2015 | Hankyu Corporation  
   Kobe Line/Takarazuka Line 8000 series (upgraded cars) in commercial service since July 2016 | Mass-produced 4-in-1 Traction Inverter Propulsion System for Driving PMSM |

### Overseas

<table>
<thead>
<tr>
<th>Year</th>
<th>Customer (Car Services)</th>
<th>Production</th>
</tr>
</thead>
</table>
| 2013 | Singapore SMRT  
   East-west line/North-south line C151 series (upgraded cars) in commercial service since end of July 2013 | 2-in-1 Traction Inverter Propulsion System for Driving PMSM |
| 2018 | Busan Transport Corporation (Mass adoption)  
   Busan Transport Corporation (South Korea) First subway line (new cars) in commercial service since July 2018 | Mass-produced PMSM and main components for inverter |

---

**Contact:** Toshiba Infrastructure Systems & Solutions Corporation  
Railway Systems Division  
http://www.toshiba.co.jp/sis/railwaysystem/jp/record/index.htm