

## 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



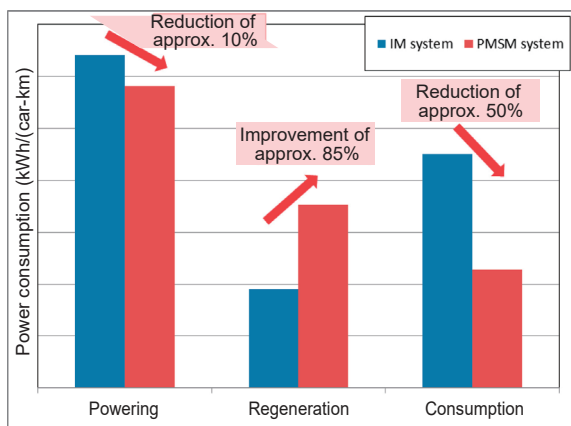
Permanent Magnet Synchronous Motor (PMSM) for Rolling Stock



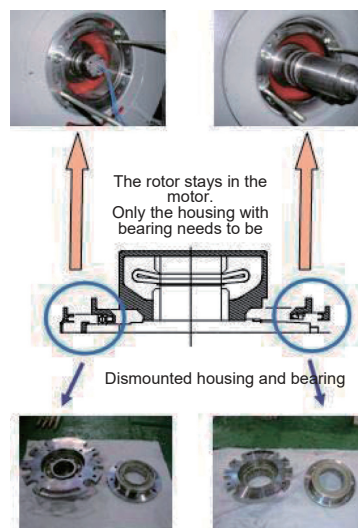
4-in-1 VVVF Traction Inverter for driving PMSM

### 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.)



Energy consumption measurement results



<b>Domestic</b>	<b>Year</b>	<b>Customer (Car Services)</b>	<b>Production</b>
	2006	East Japan Railway Company (E331-series EMU)	Direct Drive Motor (DDM)-version PMSM Propulsion System for Driving PMSM
	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) Marunouchi Line 2000 series in commercial service since Feb. 2019	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

<b>Overseas</b>	<b>Year</b>	<b>Customer (Car Services)</b>	<b>Production</b>
	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
	2019	Seoul Metro (Mass adoption) Seoul Metro Line 5 and Line 7 (new cars) in commercial service since April 2022	Mass-produced PMSM and main components for inverter

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