Our Goal
Over 100 years of Toshiba’s experience in railways were put together to design a technologically advanced traction motor; the PMSM. Toshiba started developing the PMSM system in the early 1990s.

The goals have been the following two:
• developing an environment-friendly new system and reducing significantly the running costs for the operator.

Using data accumulated through research, development and field tests during the development phase, we established the PMSM traction system technologies for railway cars. The PMSM’s advantages such as energy savings, noise reduction and easier maintenance were verified through pilot service tests with the customers. Since then, PMSM systems have been deployed in mass produced commuter/subway trains and have been operated since 2007.

Using this technological breakthrough as a starting point, Toshiba continues to innovate and improve this environment-friendly PMSM system to allow its use by more customers.

It also contributes to the larger system called the Energy Management System. By regenerating more energy than conventional traction motors, it allows other trains to receive more regenerated power*. As part of this system, the regenerated energy may also be stored in highly capable batteries or be used by other devices, such as lighting the stations or charging an electric bus.

Toshiba’s commitment to constant, environment-conscious, safe and dream-inspiring innovation for railways is our pledge to ensure that we pass on the beautiful and irreplaceable Earth to future generations.

Driven by Toshiba’s PMSM
Already 3000 PMSM have been delivered.

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*When using regenerative braking, the excess energy is stored as electric energy in the batteries attached to the train. This energy can be used later for traction purposes on the same line.

Find out more on
http://toshiba-railway.com

Toshiba
Permanent Magnet Synchronous Motor for Traction Systems

Efficient
Smarter
Quieter
Reliable
Toshiba’s PMSM (Permanent Magnet Synchronous Motor) offers various benefits to railway services compared to our traditional Induction Motor (IM)™.

**Efficient**

Saving more energy thanks to a high efficiency of 97%©

**Smarter**

Smarter maintenance operations, thanks to the unique structure.

**Quieter**

Reduced by about 1.2dB compared to our conventional open self-ventilating type motors.

Global actions are underway to reduce CO₂ emissions, and railway companies also face considerable expectations to reduce electric consumption of trains (cars). The Toshiba Permanent Magnet Synchronous Motor (PMSM) achieved high-efficiency compared to traditional Induction Motor (IM) due to the extraction of secondary loss. Toshiba's technology approximately exploits the advantages of this IM series, and boosts high-efficiency of 97%.

**Efficient**

**Smarter**

**Quieter**

Reduced by about 1.2dB compared to our conventional open self-ventilating type motors.

Railways systems are currently trying to make periodic maintenance simple and cost-effective, which is essential for railway operators. The maintenance of conventional open self-ventilating type IM systems is tiring, mostly due to the nature of air circulation. For conventional motors, the user has to be operated with a dedicated side to service the motor, then inside cleaned, and the bearing renewed. Toshiba has developed a totally-enclosed structure to make maintenance operations smarter compared to our conventional IM series (less down time and cost). We have successfully eliminated substantial internal contamination, which makes cleaning no longer required through the PMSM’s service life. We have also engineered a structure allowing the bearing to be replaced without dismantling of the entire motor.

Consequently, while improving the maintenance burden for stable operation, Toshiba successfully eliminated the conventional 30-60-day Demanding, and Dangerous maintenance.

![Image of PMSM structure with reduced maintenance steps](image)

**Smartener**

Conventional open self-ventilating type motors require periodic maintenance at intervals, which depend on the motor and the environment of use. Toshiba’s PMSM, on the other hand, offers an extended service life without periodic, maintenance maintenance life can be as long as 10 years, while maintenance costs are considerably lower compared to the IM system.

**Quieter**

Reduced noise due to low rate motor operation have been introduced year by year, especially for the traction of subway trains.

Toshiba has successfully reduced ventilation noise by about 1.2dB throughout all speed ranges compared to our conventional open self-ventilating type.

Additionally, since exhaust air and heat are also reduced as well, this limits the temperature increase in subway tunnels, thereby decreasing power lost by power air conditioning in the tunnels.

![Image of PMSM structure with reduced maintenance steps](image)

**Reliable**

Simple and lightweight

Toshiba’s PMSM has a lighter weight than conventional open self-ventilating type IM as well as simple and lightweight motor structure without radial fans and other components, such as the housing, in order to enhance lightness and save space. The overall size of the motor has been reduced, which makes it lighter and more compact for its equivalent input torque seen to IM. Therefore, in most cases the PMSM can be installed in the existing space without requiring additional space and weight.

Implements permanent magents

Toshiba’s PMSM uses the PMA ( Permanent Magnetic) type, Toshiba’s interior magnets has an improved shape to accomplish a structure that is easy to manufacture, simple and reliable in terms of strength, and is stronger to effectively express the robustness.

High-performance permanent magnets

Since permanent magnets are employed in the rotor core of PMSM, the magnetic force is not faded inside the motor even if the PMSM is damaged. The magnetic force is stronger so it has necessary performance even at the end of the design life. Toshiba’s totally-enclosed structure requires no disassembly through its service life, hence no strong magnet is susceptible to normal handling.

**The simple totally-enclosed structure enhances product reliability:**

- Reduced failure rate due to insulation damage because there is no external wire. Instead all wires are firmly secured, preventing internal contamination and the corogenesis of heat has been eliminated.
- Reduction in the risk of mechanical failure caused by reduced air intake due to dust engulfing.
- Because dust does not attach to the inside of the rotor, it is expected to decrease unbalance vibration due to dust over time.

Almost 3000 IM™© have already been delivered by Toshiba, and so far, no traction motor failure has been reported. It shows the high reliability of Toshiba’s technologically advanced traction motor.

**Driving the PMSM**

Based on our expertise, we have developed an improved traction inverter for the PMSM drive and established PMSM control technology, verified and certified by service operations. Toshiba provides several options for the traction motor. The inverter configuration can be chosen among the following options;

- 1:1 traction inverter: the inverter is integrated in 1 unit driving 4 traction motors at 15 kW.
- 1:2 traction inverter: 22.5 kW/2 in 1 unit driving 2 traction motors at 75kW.
- For the same size, these inverters can be combined, giving a 1:1 in 1 unit at 1.5 MW/2 in 1 unit 2 750 kW.

However, by improving the parts arrangement and developing a highly efficient and compact cooling unit, we have accomplished a size equivalent to conventional Induction motors.

Toshiba will continue to develop our advanced PMSM drive while ensuring a compact and highly reliable traction system suitable for railway applications, offering higher speed and less attenuation.

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- **IM**: Induction Motor
- **PMSM**: Permanent Magnet Synchronous Motor
- **PMA**: Permanent Magnet Assembly
- **IM™**: Induction Motor (Toshiba)™

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