Introduction to TMEIC Motors

TMEIC combines the best of Toshiba and MitsubishiElectric’s experience in building motors that goes back over 100 years. TMEIC’s motor offering includes induction motors from a few hundred horsepower, up to synchronous motors over 100,000 hp, driving a wide range of industrial applications such as pumps, fans, grinding, conveyors, and compressors.

In addition to applications directly connected to utility power, TMEIC motors can be matched with Variable Frequency Drives for ease of starting and for speed control. The VFD allows motor speeds as high as 12,000 rpm. This chart below and pages 4 & 5 illustrate the range of motors available.

Expansion of the oil and gas industry has created demand for large motors to drive gas compressors and oil pumps. These motors are located in the production areas and on interstate pipelines, and are usually designed with explosion protection. For special applications such as driving large compressors and blowers, motor ratings can reach or exceed 100,000 hp.

Meeting the demand for large motors for the metals industry, TMEIC has produced large synchronous and induction motors for the operation of steel rolling mills. The power levels for these motors go up to about 10 MW. They are covered in a separate brochure.

### Features

- **High Reliability** resulting from use of proven design technology, manufacturing expertise, wide use of robotics, tight quality control, and testing

- **High Efficiency** resulting from detailed analysis of the electromagnetic field patterns and ventilating air flows

- **High Strength Insulation** applied by robotic insulation winding and oversized epoxy resin vacuum impregnation tanks creates strong support and insulation

- **High Mechanical Strength** through use of static and dynamic strength analysis of stator frame, rotor, shaft and bearings. Motor shafts are made of forged steel with high tensile strength

### Benefits

- Many years of excellent trouble-free service under difficult working conditions

- Low electrical losses for high power conversion efficiency

- Withstand surge and minimizes electrical shorts and winding fatigue failure

- Minimizes mechanical deflection and vibration for longer equipment life
High-Quality Design, Manufacturing, and Testing

TMEIC produces high-quality motors by employing the best design, manufacturing, and test procedures. Advanced computer aided design and analysis allows motor performance to be predicted in advance. The world class manufacturing automation system produces high-quality parts, on time, with no exceptions. These automated systems produce components and assemblies meeting the highest quality requirements, delivery schedule, and long life.

Excellent Motor Design Tools – Extensive CAD and Computerized Finite Element Analysis

TMEIC motor engineers make extensive use of computer aided design to produce their detail and assembly drawings, both two-dimensional and three-dimensional.

Continuous Improvement
The manufacturing system has specified standards, and the actual performance is measured against these. Continuous quality improvement is built in, with product quality steadily improving as a natural outcome.

TMEIC's fully instrumented computer automated test (CAT) facilities allow motors to be load and speed tested. The example facility shown here was built to test large motors and drives at high speed. This back-to-back test arrangement used:

- Variable frequency drive to provide power and desired speed to the test motor
- Generator to load the test motor
- Variable frequency drive to recycle power back to the supply

Enhanced computerized Finite Element Analysis is used to analyze and optimize electromagnetic field strength, rotor stress and dynamics, frame natural frequencies, cooling air flow patterns, and internal temperatures.
## TMEIC Motor Product Overview

<table>
<thead>
<tr>
<th>Product</th>
<th>Induction Motors</th>
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<tbody>
<tr>
<td>LV and MV TM21™-FII</td>
<td>MV Motors TM21-MII</td>
</tr>
</tbody>
</table>

### Typical View

- **Power**
  - LV and MV TM21™-FII: 37-1,400 kW (50-1,870 hp)
  - MV Motors TM21-MII: Up to 3,550 kW (4,750 hp)
  - MV Motors TM21-L: Up to 18,500 kW (25,000 hp)

- **Speed**: Up to 3,600 rpm

- **Voltage**: Up to 6,600 V

- **Enclosure**
  - Totally Enclosed
  - Fan Cooled – TEFC/IP55
  - Drip Proof – DP/IP22
  - Weather Protected II-WPII/IP24W
  - Totally Enclosed Air to Air Cooled – TEAAC/IP55
  - Totally Enclosed Water to Air Cooled – TEWAC/IP55
  - Totally Enclosed Separately (Pipe) Ventilated – TESV/IP55

- **Classified Area (optional)**
  - Exn, Extc, Exd
  - Exn, Exe, Exp, ExtD
  - Exn, Exe, Exp, ExtD

- **Rotor**
  - Aluminum die cast rotor, or Copper rotor bars
  - Aluminum die cast rotor Optional copper rotor bars
  - Copper rotor bars

- **Bearing Options**
  - Ball and roller bearings, grease lubrication
  - Ball and roller bearings, grease lubrication
  - Ball and roller bearings, grease lubrication
  - Sleeve bearings

- **Available Standards**
  - IEC, NEMA, BS, AS, CSA, API
  - IEC, NEMA, BS, AS, CSA, API
  - IEC, NEMA, BS, AS, CSA, API

- **Major Applications**
  - Fans, Blowers, Compressors, Conveyors
  - Fans, Blowers, Compressors, Mills, Conveyors
  - Fans, Blowers, Compressors, Mills, Conveyors
<table>
<thead>
<tr>
<th>Induction Motors</th>
<th>Synchronous Motors</th>
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</thead>
<tbody>
<tr>
<td><strong>High Speed</strong> (Custom design)</td>
<td><strong>Vertical Motors</strong> TM21-VL &amp; VLL</td>
</tr>
<tr>
<td>Up to 8,000 kW (10,720 hp)</td>
<td>300-6,500 kW (8,700 hp)</td>
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<tr>
<td>Up to 11,900 rpm on VFD power</td>
<td>Up to 28 poles, option &gt; than 30 poles</td>
</tr>
<tr>
<td>2.3 –11 kV</td>
<td>2.3 –13.8 kV</td>
</tr>
<tr>
<td>Totally Enclosed Water to Air Cooled – TEWAC/IP55 (Blower ventilated)</td>
<td>Weather Protected II-WPII/IP24W</td>
</tr>
<tr>
<td>Totally Enclosed Water to Air Cooled – TEWAC/IP55</td>
<td>Cylindrical solid rotor for two-pole, salient pole all others</td>
</tr>
<tr>
<td>Aluminum alloy rotor bars</td>
<td>Copper rotor bars</td>
</tr>
<tr>
<td>Magnetic bearings</td>
<td>Antifriction bearings</td>
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<tr>
<td>Tilting pad bearings</td>
<td>Tilting pad bearings</td>
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<tr>
<td>IEC, NEMA, BS, AS</td>
<td>IEC, NEMA, BS, AS</td>
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<tr>
<td>Gearless Compressors</td>
<td>Pumps</td>
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</tbody>
</table>
TMEIC’s totally enclosed fan-cooled motors for low and medium voltage are widely applied in industrial applications such as small and medium size fans, blowers, compressors, pumps, and conveyors. They are tough and suitable for harsh conditions.

**Power** – The TM21-FII series power output ranges from 37 kW (50 hp) to 1400 kW (1,850 hp). With a choice of poles, the series provides a selection of speeds from 720 rpm up to 3,600 rpm.

**Frame** – The TM21-FII series have a cast iron fin frame with improved ventilation flow.

**Rotor** – The squirrel cage rotor is a highly-reliable aluminum die-casting.

**Bearings and Maintenance** – Ball and roller bearings or oil lubricated sleeve bearings are applied based on rating and application requirements. Optimized design makes re-greasing simple.

**Quality Manufacturing and Standards** – TMEIC manufacturing is certified to ISO 9001 and ISO 14001. Motors can be certified by third party agencies such as Lloyd’s, CSA, Baseefa, and etc.

Motors can be designed to international standards such as IEC, NEMA, BS, AS, etc.
TM21-M and TM21-L Series Induction Motors

TMEIC offers a range of medium voltage induction motors for larger industrial applications such as fans, blowers, pumps, mills, compressors and conveyors. These motors offer higher efficiency and higher power factor than any previous design. The TM21-M and TM21-L have rugged fabricated steel frames.

Aluminum rotor bars are standard on the TM21-M, and copper rotor bars are standard on the TM21-L. Both series can be customized with different top enclosures for selected types of protection and cooling. The arrows in the illustrations below indicate airflow.

**Totally-Enclosed Air-Water-Cooled Type TEWAC/IP55**
Includes an air-to-water heat exchanger in the air housing above the motor.
A drain in the air housing protects the motor from damage caused by water leakage.

**Totally-Enclosed Air-Air Cooled Type TEAAC/IP55**
In a corrosive or harmful environment, a totally-enclosed fan-cooled motor can be applied. An external fan directs fresh air through the pipes in the air housing above the motor. The pipes serve as a heat exchanger in which outside fresh air passing through cools the hot air inside.

**Drip Proof Type DP/IP22**
A drip-proof type motor has a cooling air intake and hot air exhaust window located at the top of the hood.
Openings are covered by screens and enclosure is constructed to prevent intrusion of water drips and other foreign materials into the motor and meets NEMA WP-I requirements.

**NEMA Weather-Protected WPII/IP24**
This motor is designed for outdoor operation. The air housing is in accordance with NEMA WPII, and features three right-angled turns for air intake, dropping velocity below 3 m/sec (600 ft/min.), trapping water, dust, and foreign materials.

### Fundamental Building Block 21-M and 21-L
- C01, IC61 and IC81W cooling per IEC Standard construction are available by changing the top-mounted air housing.
- The main terminal box can be rotated every 90°, and is large enough for easy cable connection.
- International standards such as IEC, NEMA, BS, AS, etc.
- Optional classified areas: Exn, Exe, Exp, Extd
- Insulation Class F, B Rise design is standard

<table>
<thead>
<tr>
<th></th>
<th>TM21-M</th>
<th>TM21-L</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Power 50 HZ</strong></td>
<td>160 - 2,800 kW (210 - 3,750 hp)</td>
<td>450 - 16,500 kW (600 - 22,000 hp)</td>
</tr>
<tr>
<td><strong>60 HZ</strong></td>
<td>200 - 3,550 kW (270 - 4,750 hp)</td>
<td>450 - 18,500 kW (600 - 25,000 hp)</td>
</tr>
<tr>
<td><strong>Voltage</strong></td>
<td>2.3 kV - 11 kV</td>
<td>2.3 kV - 13.8 kV</td>
</tr>
<tr>
<td><strong>Speed</strong></td>
<td>Up to 3,600 rpm</td>
<td>Up to 3,600 rpm</td>
</tr>
<tr>
<td><strong>Poles</strong></td>
<td>From 2 up to 10</td>
<td>From 2 up to 24</td>
</tr>
</tbody>
</table>
High-speed Induction and Medium-High Power Synchronous Motors

High-Speed Induction Motors

For very high speeds, induction motors are used. These are custom designed for special applications such as driving gearless compressors. The example shown here runs at up to 11,900 rpm and develops 1.8 MW for driving a compressor.

Data for typical high speed induction motors are shown below.

Motor Speed – Up to 12,000 rpm
Rotor – Squirrel cage with aluminum rotor bars
Stator – Two pole windings, spring mounted for low vibration
Bearings – Oil-fed sleeve bearings or Magnetic bearings

Motor Speed
Supply Voltage
Poles
Enclosure
Classified Areas
Available Standards

Power | Up to 8000 kW
Supply Voltage | 2.3-11 kV
Poles | 2 Poles
Enclosure | Totally Enclosed Water to Air Cooling TEWAC/IP55 or Air to Air TEAAC/IP55
Classified Areas | Exn, Exe, or Exp Protection
Available Standards | IEC, NEMA, BS, AS

Medium-High Power Synchronous Motors

TMEIC custom designs and builds medium and high power synchronous motors for special applications such as driving mills, blowers, pumps and compressors. The example shown here is a 53 MW synchronous motor for a steel mill blower. It runs at 3,000 rpm with a 10 kV supply. Data for typical synchronous motors are shown below.

Motor Speed – Very low speed up to 3,600 rpm
Rotor – Cylindrical solid rotor for 2 pole, salient pole for 4 to 34 poles
Bearings – Oil-fed sleeve bearings

Power
Supply Voltage
Poles
Enclosure
Classified Areas
Available Sync Field Designs

2000 kW up to 80 MW, either Utility Fed or VFD Powered
3.3-13.8 kV
Up to 34 Poles
Totally Enclosed Water to Air Cooling TEWAC/IP55 or TEAAC/IP55 – Other Enclosures Available
Exn/Exp Protection Available
Brush Type, DC Brushless, AC Brushless
TMEIC builds a range of custom designed, high-speed, high-power synchronous motors for driving large compressors.

The example on the left shows a 25 MW synchronous motor designed for variable speed operation from 2,500 to 3,780 rpm with a 7 kV variable frequency drive.

Other TMEIC designs are available for synchronous motor top speeds up to 6200 rpm. This can allow large compressors to be driven without a gearbox.

### Large High-Speed 2-Pole Synchronous Motors

**Power** – Motor output levels up to 80 MW (107,200 hp) are available, and speeds up to 6,200 rpm when used with a matched variable frequency drive such as the TMEIC TMdrive®-XL85.

**Rotor** – The rotor is a two pole, cylindrical design with a shaft mounted brushless exciter.

**Bearings and Maintenance** – Oil lubricated sleeve bearings are used. No slip rings are required with the brushless exciter.

**Quality Manufacturing and Standards** – TMEIC’s motor manufacturing is certified to ISO 9001 and ISO 14001. Motors can be certified by third party agencies such as CSA, Lloyd’s and Baseefa. Motors can be designed to international standards such as IEC, NEMA, BS, and AS.

<table>
<thead>
<tr>
<th>Power 60 HZ</th>
<th>15 MW (20,100 hp) up to 80 MW (107,200 hp)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Voltage</td>
<td>3.3 kV to 13.8 kV</td>
</tr>
<tr>
<td>Enclosure</td>
<td>Totally Enclosed Water to Air Cooled – TEWAC/IP55</td>
</tr>
<tr>
<td>Classified Areas</td>
<td>Exp certification for use in hazardous areas Zone 1 &amp; 2, using an internal pressurization system</td>
</tr>
<tr>
<td>Motor Speed</td>
<td>Up to 6,200 rpm</td>
</tr>
<tr>
<td>Insulation Class</td>
<td>Class F</td>
</tr>
</tbody>
</table>

Motor Cooling uses a water-air heat exchanger with two shaft-mounted fans forcing cool air inwards through the rotor and windings.

Brushless Exciter has a rotor mounted three-phase winding, which feeds high reliability diodes on the shaft supplying DC power to the rotor field winding.
TMEIC produces a range of high-quality, custom designed generators for power by turbines or diesels. The four-pole designs provide power levels up to 50,000 kVA at 50 or 60 Hz, 1500 rpm or 1800 rpm. Higher speed two-pole generators provide power levels up to 100,000 kVA.

Reliability - All generators are built in the same plant as, and to the same high standards as the large motors. Manufacturing procedures to obtain the highest reliability include Vacuum Pressure Impregnation of the insulation, employing a forged rotor with integral pole bodies for the maximum shaft rigidity and higher critical speed, and accurate rotor shaft balancing.

Maintenance - Easy maintenance is realized using a brushless AC exciter with a permanent magnet generator. The oil-fed sleeve bearings employ a floating labyrinth seal to prevent leakage, and positive internal pressure to prevent oil entering the generator.

The cutaway drawing in the upper left shows a typical four-pole generator with top mounted air cooler and water heat exchanger.

<table>
<thead>
<tr>
<th>Type</th>
<th>Two-pole, 5,000 to 100,000 kVA power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotor</td>
<td>Solid cylindrical rotor</td>
</tr>
<tr>
<td>Voltage</td>
<td>Rated 11 kV, 13.8 kV</td>
</tr>
<tr>
<td>Speed</td>
<td>3,000 rpm or 3,600 rpm</td>
</tr>
<tr>
<td>Frequency</td>
<td>50 or 60 Hz</td>
</tr>
<tr>
<td>Power Factor</td>
<td>85% lagging</td>
</tr>
<tr>
<td>Enclosure</td>
<td>Totally enclosed, water to air cooled (TEWAC)</td>
</tr>
<tr>
<td>Insulation</td>
<td>Rating F-Class insulation</td>
</tr>
<tr>
<td>Excitation</td>
<td>Brushless exciter with PMG</td>
</tr>
<tr>
<td>Bearings</td>
<td>Sleeve bearings, oil lubricated</td>
</tr>
<tr>
<td>Oil</td>
<td>0.1 Mpa bearing pressure</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type</th>
<th>Four-pole, 10,000 to 50,000 kVA power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotor</td>
<td>Salient pole solid rotor</td>
</tr>
<tr>
<td>Voltage</td>
<td>Rated 6.6, 11 kV, 13.8 kV</td>
</tr>
<tr>
<td>Speed</td>
<td>1,500 rpm or 1,800 rpm</td>
</tr>
<tr>
<td>Frequency</td>
<td>50 or 60 Hz</td>
</tr>
<tr>
<td>Power Factor</td>
<td>80–90% lagging</td>
</tr>
<tr>
<td>Enclosure</td>
<td>Totally enclosed, water to air cooled (TEWAC)</td>
</tr>
<tr>
<td>Insulation</td>
<td>Rating F-Class insulation</td>
</tr>
<tr>
<td>Excitation</td>
<td>Brushless exciter with PMG</td>
</tr>
<tr>
<td>Bearings</td>
<td>Sleeve bearings, oil lubricated</td>
</tr>
<tr>
<td>Oil</td>
<td>0.1 Mpa bearing pressure</td>
</tr>
</tbody>
</table>
Hazardous Area Protection

Types of Explosion Protected Machines

TMEIC provides motors with different levels of explosion protection for a range of operating environments found in the process industries, in particular the Oil & Gas industry. Protection in dust environments, Zone 22, is available as ExtD according to IEC61241-1.

Exn – Non-Sparking

Machines which, in normal operation, are not capable of igniting a surrounding explosive atmosphere.

Exe – Increased Safety

Machines that do not produce dangerous sparks or temperatures in normal service or starting. Special increased safety measures are taken.

Exp – Inner Pressurized

Explosive gas is excluded from the inside of the machine that may cause ignition. The motor housing is pressurized with air to ensure no gases enter.

Exd – Flame Proof Enclosure

Machines are constructed to contain an internal explosion and prevent the transmission of flame to the external atmosphere. The temperature of operation is such that it cannot ignite the surrounding gas.

Global Protection and Certification

Explosion protection certification for TMEIC’s motors has been obtained in most areas of the world, as illustrated in this table.

<table>
<thead>
<tr>
<th>USA</th>
<th>UK</th>
<th>Europe</th>
<th>China</th>
<th>Korea</th>
<th>Russia</th>
<th>Australia</th>
<th>Canada</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEC</td>
<td>EN</td>
<td>EN + ATEX</td>
<td>GB</td>
<td>IEC or KS</td>
<td>IEC or AS</td>
<td>IEC or GOST</td>
<td>CSA</td>
<td>IEC or EN</td>
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<tr>
<td>FM, UL, etc.</td>
<td>Baseefa</td>
<td>Baseefa, PTB, etc.</td>
<td>COST</td>
<td>KOSHA</td>
<td>CCVE</td>
<td>TestSafe or Baseefa</td>
<td>CSA</td>
<td>Baseefa</td>
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</tbody>
</table>

<table>
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<tr>
<th>Records</th>
<th>USA</th>
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</table>
Global Support

Wherever You Are, We Are Right Next Door

TMEIC has the capability to provide world-wide service support with trained field service engineers. Spare parts depots are strategically located close to main industrial centers.

In Asia & Pacific: Customers are supported by TMEIC service personnel and the TMEIC factory in Japan.

In North America: Customers are supported by TMEIC factory service personnel from Roanoke, Virginia.

In Europe: Customers are supported by TMEIC European service personnel.

Motor and Generator Service: EASA Service Centers support TMEIC motors and generators across North America.