The TMdrive-70e2 is a new version of the popular TMdrive-70. The drive offers 4kV class output, and is suitable for induction or synchronous motors. The drive features:

- Smaller size
- Lower weight
- Additional safety features

The new drive provides the same excellent benefits as the original:

- High reliability
- Regenerative converter
- Simple configuration and maintenance
- High energy efficiency and low cost of ownership

**IEGT Technology Dramatically Lowers Cost of Ownership**

The Injection Enhanced Gate Transistor (IEGT) is a breakthrough in power switch technology, providing lower cost of ownership.

**Features**

- Low Voltage Gate Drive
  - Given that the IEGT is a MOS structure, it can be gated (turned on/off) with ±15 V.

- Minimal Snubber Circuitry
  - With the high dV/dt capability of the IEGT, there is only need for a small dc clamp snubber circuit.

- High-Speed Switching
  - The IEGT is switched at a rate of 500 Hz in this application.

**Benefits**

- High Efficiency and Small Size
  - A very compact phase leg assembly is achieved with:
    - A reduction in snubber circuitry
    - Integral forward diodes
    - Integral clamp diodes

- Higher Performance
  - The reduction in snubber circuitry allows a higher chopping frequency, lowering the torque ripple applied to the motor and harmonics fed back into the power system.

- Motor and Power System Friendly
  - The high-speed switching coupled with the three-level power bridge design delivers a smooth sine wave to the motor and power system.

High-power, precision-controlled processes are ideally suited for the TMdrive-70e2 with its efficient high current IEGT power devices and control cards common to the drive family. Flexible arrangement of converter, inverter and cooling units allows for maximum power density, resulting in minimum floor space, and installation cost.

Coordinated drive systems are an integral part of numerous manufacturing processes in the metals industry. TMdrive system drives address all of these applications with a robust control platform and a common Microsoft Windows-based tool. The tool supports local and remote connectivity, and is an invaluable asset for system and process analysis.

Due to its high reliability, simplicity of design and high efficiency, the TMdrive-70e2 is perfect for compressor, fan and pumping applications. It provides accurate speed control and high efficiency while eliminating the need for high maintenance mechanical flow control devices. The TMdrive-70e2 is also well suited for applications like grinding mills and mine hoists, where high overloads and impacts are a part of everyday operations.
The converter generates dc power for the inverter. The inverter then creates variable frequency ac power to control the induction or synchronous motor. The dc power between the converter and inverter is conveyed on a solid copper bus behind the phase leg assemblies in both cabinets. For common bus systems this bus is extended to adjacent cases.

State-of-the-Art Technology:
- Injection Enhanced Gate Transistor (IEGT)-based converter and inverter provides power to the process at near unity power factor with minimum harmonic distortion
- Water-cooling technology for the power bridge reduces the footprint of the equipment saving valuable space in your factory
- Modular design for power bridge minimizes the time required for any maintenance activities

Control Functions
Each inverter and regenerative converter shares a common set of control boards. The primary control board performs several functions:
- Speed and torque regulation
- Sequencing
- I/O mapping
- Diagnostic data gathering
A mounting bracket is provided for an optional LAN interface board.

IEGT Three-Level Phase Leg Assembly
The drive has a total of six identical Injection Enhanced Gate Transistor (IEGT) phase leg assemblies in the converter and inverter. The modular draw-out assembly includes:
- Four IEGT power semiconductors with integrated flyback diodes
- Neutral-point clamp diodes
- Water-cooled piping assembly with quick disconnect fittings
- IEGT gate driver circuit board
- Feedback control circuitry
- dc clamp snubber

Main Capacitors
Film capacitors provide longer life, smaller size, and less weight.

Main Power
3-Phase motor and transformer connections are made in the rear. Both top and bottom are supported.

Cooling Water Interface
150 mm JIS-10K50A fittings are provided for connecting cooling water for de-ionized cooling loop.

Optional Remote Control
Modular construction allows the power converter and control cabinets to be installed up to 100 m (330 ft) apart. This optimizes the use of space in your equipment room.

dc Bus
The converter generates dc power for the inverter. The inverter then creates variable frequency ac power to control the induction or synchronous motor. The dc power between the converter and inverter is conveyed on a solid copper bus behind the phase leg assemblies in both cabinets. For common bus systems this bus is extended to adjacent cases.

A Look Inside the 9 MVA Drive

Interface Board
The interface board supports encoder or resolver, 24 V dc I/O and analog I/O. All I/O are terminated to a two-piece modular terminal block for ease of maintenance.

Control Cabinet
Converter Front View
Inverter Front View

Inverter Back View
Converter Back View

Output Voltage
Output Current
Regenerative Systems

Three-Level Phase Leg Assembly for 9 MVA Converter and Inverter

- Quick disconnect fittings for the cooling system reduce mean time to repair
- DC clamp snubber circuit absorbs the energy generated in turning off the IEGTs
- Compact gate drive assemblies due to low power switching requirements of the IEGT devices
- IEGT devices with integral forward and clamp diodes allow a very compact phase leg stack, reducing the footprint versus previous technology. (Note: the 6 MVA stack is completely different.)

Flexible Topologies To Match Your Needs

Configuration Options

1 Converter
1 Inverter

1 Converter
2x1 Inverters

3 Converter
3 Inverter

2 Converter
2 Inverter

4 Converter
4 Inverter

2 Converter
3x1 Inverters

Flexible Topologies To Match Your Needs

TMdrive-P70e2 Regenerative IEGT Converter

- 6000 Frame
- 9000 Frame

- High Speed Fuses
- Circuits Shock

TMdrive-70e2 IEGT Inverter

- 6000 Frame
- 9000 Frame

- High Speed Fuses
- Discharge Resistors

AC Input

3800 V ac

Control

AC Input

3800 V ac

Control

AC Input

2600 V dc

Discharge Resistors

2600 V dc

Discharge Resistors
<table>
<thead>
<tr>
<th>Banks</th>
<th>Frame (kVA)</th>
<th>Losses to Air (kW)</th>
<th>Losses to Water (kW)</th>
<th>Weight kg (lbs)</th>
<th>Control Power kVA</th>
<th>Motor Current A ac</th>
<th>Allowable Overload %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6,000</td>
<td>5</td>
<td>62</td>
<td>3,500 (7,700)</td>
<td>950</td>
<td>150</td>
<td>3.0</td>
</tr>
<tr>
<td>2</td>
<td>12,000</td>
<td>10</td>
<td>124</td>
<td>6,700 (14,740)</td>
<td>1900</td>
<td>150</td>
<td>6.0</td>
</tr>
<tr>
<td>3</td>
<td>24,000</td>
<td>20</td>
<td>248</td>
<td>13,100 (28,820)</td>
<td>3800</td>
<td>150</td>
<td>12.0</td>
</tr>
<tr>
<td>4</td>
<td>36,000</td>
<td>40</td>
<td>380</td>
<td>15,760 (34,672)</td>
<td>5700</td>
<td>150</td>
<td>12.0</td>
</tr>
</tbody>
</table>

**Notes:**
1. Front and rear access doors: 1000 mm overhead clearance and 1500 mm front and rear access clearance recommended. Frame 6000 does not require rear access when configured in end to end arrangement.
2. Bottom cable entry is standard, top is optional.
Water Conditioning Equipment

Water conditioning control panel continuously monitors the status of the water system. Separate fault indications help find and fix problems fast.

Integrated water system has internal plumbing for de-ionized cooling loop.

Separate type cooling has field-installed plumbing for de-ionized cooling loop.

Water to water heat exchanger keeps the de-ionized system isolated from the plant water supply.

Surge tank absorbs water during pump transients and indicates the internal cooling loop water level.

De-ionizer removes contaminants for the internal cooling loop.

Redundant pumps keep the system running even if one pump fails.

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Advanced PWM Technology

Advanced PWM control brings enhanced efficiency and reduced harmonics to TMdrive-70e2 systems. Fixed pulse pattern gate control uses optimum gating sequences to almost eliminate switching losses in the IEGT device. Gating sequences are pre-computed for the control rather than computed at runtime. The result is performance that reduces losses and harmonics.

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Synchronous Motor Exciter

Synchronous Motor Field Exciter
- Microprocessor-based fully digital control
- One direction, full wave bridge thyristor rectification
- Current control following main speed/torque regulator commands
- Air cooled
- Maintenance from front
- Bottom cable entry
- Required free-standing indoor cubicle, totally enclosed IP20

AC Leg Fuses protect power bridge from faults on the ac line

Autonomous Crowbar prevents dangerous motor voltages from developing under certain fault conditions

Enhanced Converter Technology

The TMdrive-P70e2 converter can be configured in two modes, providing VAR Control within the limits of its current capacity.

One mode is the conventional PWM type normally set to unity power factor for all load conditions. (Shown in red)

Another mode is the Fixed Pulse Pattern type, providing unity power factor for all load conditions. (Shown in red)

Synchronous Motor Exciter

AC Leg Fuses protect power bridge from faults on the ac line

Enhanced Converter Technology

The TMdrive-P70e2 converter can be configured in two modes, providing VAR Control within the limits of its current capacity.

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Another mode is the Fixed Pulse Pattern type, providing unity power factor for all load conditions. (Shown in red)

MVA vs. MW and Voltage

Frame 1200 Field Supply

Main Power module. One module is applied for the 1200A supply and two modules for the 2100A model.

Ground Fault detection module provides indication of insulation failure

Enhanced Converter Technology

TMdrive-P70e2VAR Control

The TMdrive-P70e2 converter can be configured in two modes, providing VAR Control within the limits of its current capacity.

One mode is the conventional PWM type normally set to hold unity power factor for all load conditions. (Shown in red)

Another mode is the Fixed Pulse Pattern type, providing voltage stability, improved harmonics and efficiency. The Fixed Pulse Pattern mode stabilizes line voltage by providing system VARs when line voltage is low and drawing VARs from the system when the voltage is high. By convention, VARs from the system are (+) and cause the line voltage to drop while VARs from the converter are (-) and cause the line voltage to rise. The relationship of line voltage, loads MW and converter MVAR is shown by the blue voltage lines depending on the measured line voltage.
Application Examples

Applying the TMdrive-70e2 Starts With the Motor Design

Consideration must be given to motor design when applying the TMdrive-70e2. A primary constraint is the motor terminal voltage. It is important that the motor terminal voltage does not exceed 3650 Vac under any operating condition. Reserving voltage margin correctly is critical to success. Detailed motor design data is needed for correct application.

OL_V Overload derate. The rated motor voltage over the terminal voltage of the motor at maximum applied overload. Motors with no overload use 1.0.

ST_V Field forcing margin needed when applying synchronous motors. Apply 0.94 for synchronous motor systems.

RP_V Reduction in maximum voltage due to the dc bus ripple of the drive at low frequencies. If the base frequency is below 5 Hz then this derate is 0.97, otherwise it is 1.0.

SP_V Speed margin. For motors that run above base speed this is the ratio of the terminal voltage at base speed over the terminal voltage at top speed under maximum overload at each point. Other motors use 1.0.

Maximum Rated Motor Voltage = 3650 x OL_V x RP_V x ST_V x SP_V

Experience has shown that the following maximum rated motor voltages apply based on the type of motor and the application.

<table>
<thead>
<tr>
<th>Induction (Maximum Voltage at max OL and top speed)</th>
<th>Synchronous Maximum Rated Motor Volts</th>
<th>Rated Motor Frequency</th>
<th>Overload Requirement</th>
<th>Example Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>3650</td>
<td>3500</td>
<td>60 Hz</td>
<td>100%</td>
<td>Pump or Fan</td>
</tr>
<tr>
<td>3500</td>
<td>3400</td>
<td>30 Hz</td>
<td>200%</td>
<td>Mine Hoist</td>
</tr>
<tr>
<td>3400</td>
<td>3300</td>
<td>5 Hz</td>
<td>225%</td>
<td>Mill Stand</td>
</tr>
</tbody>
</table>

TMdrive-70e2 Notes

1. Allocate a minimum of 1000 mm (40 in) above cabinet for fan maintenance.
2. Power rating data assumes ambient temperature of 5-40°C (41-104°F), altitude up to 1000 m (3280 ft) above sea level.
3. The specified current ratings are continuous to which the indicated overload may be applied for a maximum of 60 seconds.
4. Each cabinet requires 3-phase control power.
5. For high performance torque regulation, a temperature sensor is mounted in the motor (induction motor only).
6. All TMdrive-70e2 cabinets require 1500 mm (60 in) front access for connections and maintenance.
7. Water connections for separate type cooling systems are located near the floor of the rear of power converter cabinets. The flange is 150 mm JIS-10K50A. Stainless piping is required for plumbing of the de-ionized loop. Secondary cooling water temperature supplied by customer 10°C-32°C (50-90°F).
8. Speed and current regulator responses are computed per the adjacent figure in radians/Sec. Speed regulator responses shown are maximum available. Actual response will be limited by drive train mechanical conditions. Accuracy and linearity specifications shown are as measured under controlled conditions in our lab and while typical may not be achievable in all systems.
9. dc Bus bar included in lineups is rated for one cabinet for fan maintenance. Secondary required for plumbing of the de-ionized loop. Secondary cooling water temperature supplied by customer 10°C-32°C (50-90°F).
10. Field supply enclosures are typically installed directly behind control enclosures within the lineup.
11. Systems that share a common dc Bus must have the same winding configuration for their converter transformer secondaries.
12. Field supply enclosures are typically installed directly behind control enclosures within the lineup.
13. TMdrive-70e2 converters require a minimum of 15% total input impedance.
14. Systems with a base frequency below 5 Hz may require additional 800 mm (32 in) capacitor panels for each dc link, 1800 kg weight.

Inverter Example

When specifying an inverter, start from the process requirements and work through the motor to the inverter. The following example illustrates this process.

1. Define process requirements.
2. Select motor based on process requirements and compute required inverter kW.
   - 7500 kW (10,000 hp)
   - 500 rpm, 3300 V
   - Efficiency = 0.965
   - Power factor = 1.0
   - Service factor = 1.0
   - Synchronous

3. Compute continuous current requirements for the inverter based on the selected motor.
   \[ \text{I}_{\text{cont, inverter}} = \frac{\text{kw}_{\text{ac}}}{1.732 \times \text{eff}_{\text{inverter}}} \]
   - \( \text{kw}_{\text{ac}} = 7500 \times 1000 \times \frac{1}{1.0} \)
   - \( \text{I}_{\text{cont, inverter}} = \frac{7500 \times 1000}{1.732 \times 0.965} \)
   - \( \text{I}_{\text{cont, inverter}} = 7762 \text{ A} \)

4. Select inverter based on continuous current and overload requirements.

Regenerative Converter (TMdrive-70e2) Example

When specifying a converter, start from the process requirements and work through the motor to the inverter, and then the associated converter. The following example illustrates this process (continuation of inverter application example from above):

1. Compute kW requirements into the inverter. It is assumed that the converter is dedicated to the inverter specified in the application example above. It is also assumed that the converter is controlled to unity power factor.
   \[ \text{kw}_{\text{inverter}} = \frac{\text{kw}_{\text{ac}}}{1.732 \times \text{eff}_{\text{inverter}}} \]
   - \( \text{kw}_{\text{inverter}} = \frac{7500 \times 1000}{1.732 \times 0.965} \)
   - \( \text{kw}_{\text{inverter}} = 7762 \text{ kW} \)

2. Compute continuous ac current requirement of the converter based on its power requirements.
   \[ \text{I}_{\text{cont, converter}} = \frac{\text{kw}_{\text{inverter}}}{1.732 \times \text{eff}_{\text{inverter}}} \]
   - \( \text{I}_{\text{cont, converter}} = \frac{7762 \times 1000}{1.732 \times 0.965} \)
   - \( \text{I}_{\text{cont, converter}} = 7762 \text{ A} \)

3. Scan the regenerative converter table for entries that exceed your overload (150%, time [60 sec] and continuous current requirements [1192 amps]). In this case the 9000 frame TMdrive-P70e2 meets the requirement and is appropriate for this application.
A Common Control to Reduce Cost of Ownership

Operator Interfaces

Instrumentation Interface

Power Input/Output

Input Voltage 3800 V for Fixed Pulse Pattern type
3300 V for Carrier Comparison type

Input Voltage Variation ±5% for fixed pulse pattern+
-10% for conventional PWM, continuous operation below nominal requires derate

Input Frequency 50/60 Hz

Input Chopping 450/540 Hz

Input Harmonics Compliant TMdrive-70e2 – IEEE 519

Control Power Control and Blowers 180-220 Vac, 50 Hz 3-Phase
118-242 Vac, 60 Hz 3-Phase

Pumps and Precharge 380-460 Vac, 50/60 Hz 3-Phase

Analog Inputs

10 V, 4-20 mA

12 bit resolution

Digital Inputs

-24 V dc

24-110 V dc

49-120 V dc

Opto-coupled 10mA

Quantity 5 user defined

Digital Outputs

+24 V dc

-24 V dc

Opto-coupled 10mA

Quantity 5 user defined

Analog Outputs

10 V

4-20 mA

Motor Control

With Speed Sensor (Resolver or Encoder)

Speed regulator accuracy: ±0.01%

Maximum speed response: 60 rad/sec (without coupling)

Torque linearity: ±10% Synchronous motors

Induction Motor

Without Speed Sensor (Induction Motor Only)

Speed regulator accuracy: ±0.1% with temperature sensor

±0.2% without temperature sensor

(Using 1% slip motor at rated flux)

Maximum speed regulator response: 30 rad/sec

Minimum continuous speed: 3%

Torque linearity: ±10%

Maximum Torque current response: 600 rad/sec

Operator Water

Temperature 10°C – 32°C at inlet

10°C – 35°C at inlet with derate

Outlet temperature is inlet + 72°C

Inverter and Regenerative Converters

Keypad

High Function Display

- LCD backlight gives great visibility and long life

- Bar graphs, icons, menus, and digital values combine to provide concise status information, often eliminating the need for traditional analog meters

Easy-to-understand navigation buttons allow quick access to information without resorting to a PC-based tool

Operator Interfaces

Mechanical (Inverters & Converters)

Enclosure IP 20 (NEMA 1); IP43 option

Cable Entry Bottom, top is optional

Wire Colors Per CSA/UL and CI

Short Circuit Ratings 100 kA for ac and dc buswork

50 kA for control power

Acoustic Noise 66-68 dB @ 150% OL

1 m from cabinet in all directions

1.5 m in height above floor

Environmental (Inverters & Converters)

Operating Air Temp. 5°C to 40°C (41°C to 104°F) at rated load

9°C to 50°C (41°C to 121°F) with derating

Storage Temperature -20°C to 55°C (-13°F to 131°F)

Humidity 5% to 85% relative humidity

Non-condensing

Altitude 0 to 1000 m above sea level

Vibration 10-50 Hz, ±0.5 g

Operating Water Temperature 10°C – 32°C at inlet

10°C – 35°C at inlet with derate

Outlet temperature is inlet + 72°C

Operator Interfaces

Safety Integrity

Safety features according to IEC 61800-5-2 (Safety Integrity Level 2) is insured by independent gate command lockout via two hardware inputs: UV51 and UV52.

LAN Interface Options

TC-net I/O

8 words IN/OUT

Ethernet Global Data (EGD)

10 words IN/OUT

Modbus RTU

10 words IN/OUT

ControlNet

10 words IN/OUT

DeviceNet

4 words IN, 10 words OUT

Remote Terminal: TOSLINE-520 and 1980 legacy LANs can also be supported on request. Note: 1 word = 16 bits