We drive industry

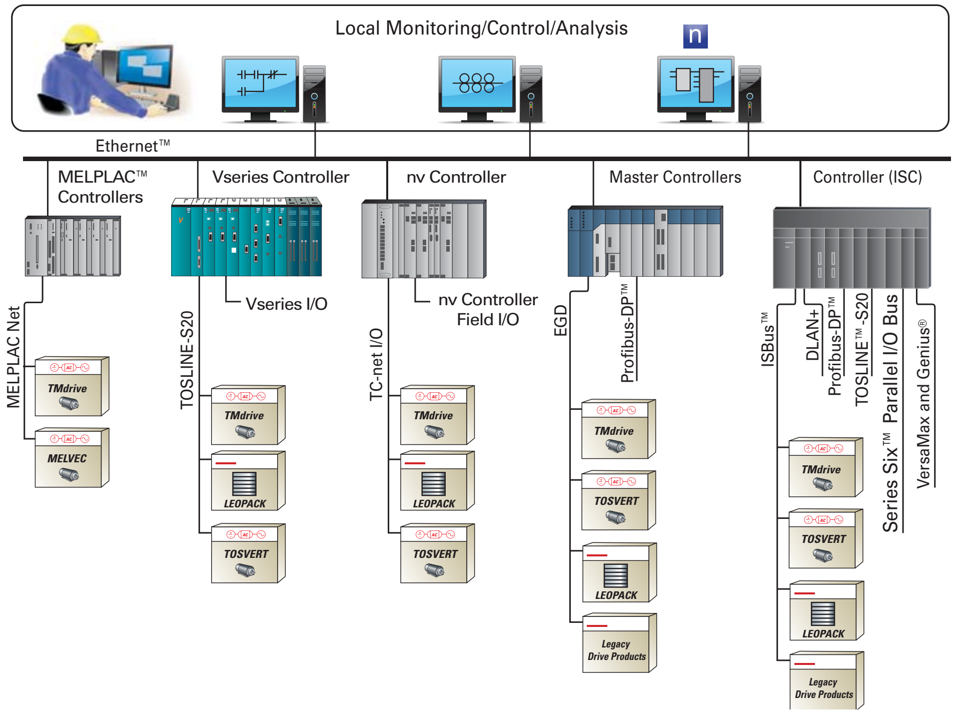
TMdrive®-10e2 Product Application Guide

Low Voltage IGBT System Drive

metals | cranes | mining | testing | oil & gas | renewable energy | power generation | cement

TMdrive-10e2 is an evolution in the family of TMdrive ac system drives offering:

- **High reliability**
- **Simple configuration and maintenance**
- **Low cost of ownership**
- **Compact design**



TMdrive-10e2

Features	Benefits
State-of-the-art microprocessors including floating point calculation.	Higher processing speed and communications for next generation control system. Per unit calculations are easy to understand.
Heat pipe cooling technology. The IGBT power bridges use heat pipe cooling technology.	Reduces footprint and lowers audible noise. This technology saves valuable floor space and lowers the required cooling-air flow, reducing the associated audible noise.
Microsoft® Windows®-based configuration. The TMdrive-Navigator is used to configure, install, and maintain the TMdrive-10e2 drives.	World-class tool across all system drives. Flexible tool connectivity. Native Ethernet drive interface allows flexible point-to-point TMdrive-Navigator communication over control LAN or even via your factory LAN.
LAN options: • TC-net™ I/O • Profibus™-DP • DeviceNet™ • Modbus™ RTU • Ethernet Global Data (EGD) • ControlNet™	Multiple controller platforms supported. For virtually all controller platforms, these LAN options provide seamless integration with the rest of your factory. Connectivity to legacy equipment. Existing equipment can be seamlessly integrated into new systems.
Safety features according to: • ISO 13849-1 (Category 3) • IEC 61800-5-2 (Safety Integration Level 2)	Risk is defined and analysis simplified according to these standards. Integrated hardware removes the requirement for external components to meet standards. The system is simplified and reliability improved.

Bringing Reliable Control To System Applications

In the automation of container cranes, tight integration between the system drive and the controller is a requirement. TMdrive-10e2's compact and efficient design together with a multitude of LAN options enhance yard and dock side crane productivity. The high-performance networks provide:

- High-speed real-time control
- Full automation with no operator
- Remote connectivity for configuration and monitoring

Coordinated drive systems are an integral part of manufacturing processes in the metals industry. TMdrive-10e2 system drives address all of these applications by providing:

- High reliability, low maintenance, compact design
- Low voltage application from a few to hundreds of drives
- High-speed communication featuring robust control and diagnostics
- Strip transport or Auxiliary applications
- Continuous or batch operations

In the pulp and paper industry, uninterrupted operation is priority one. The robust design of the TMdrive–10e2 heat pipe-cooled power bridges provides superior reliability and maintainability for paper mill applications.

A Look Inside

Two-Level Phase Leg Assembly

The cabinet style inverters have modular two-level phase leg assemblies, which weigh less than 30 kg (66 lbs) each for easy handling. Each phase leg includes:

- IGBTs with flyback diodes
- Heat pipe assembly
- IGBT gate driver circuit board

Control Functions

The primary control board performs several functions:

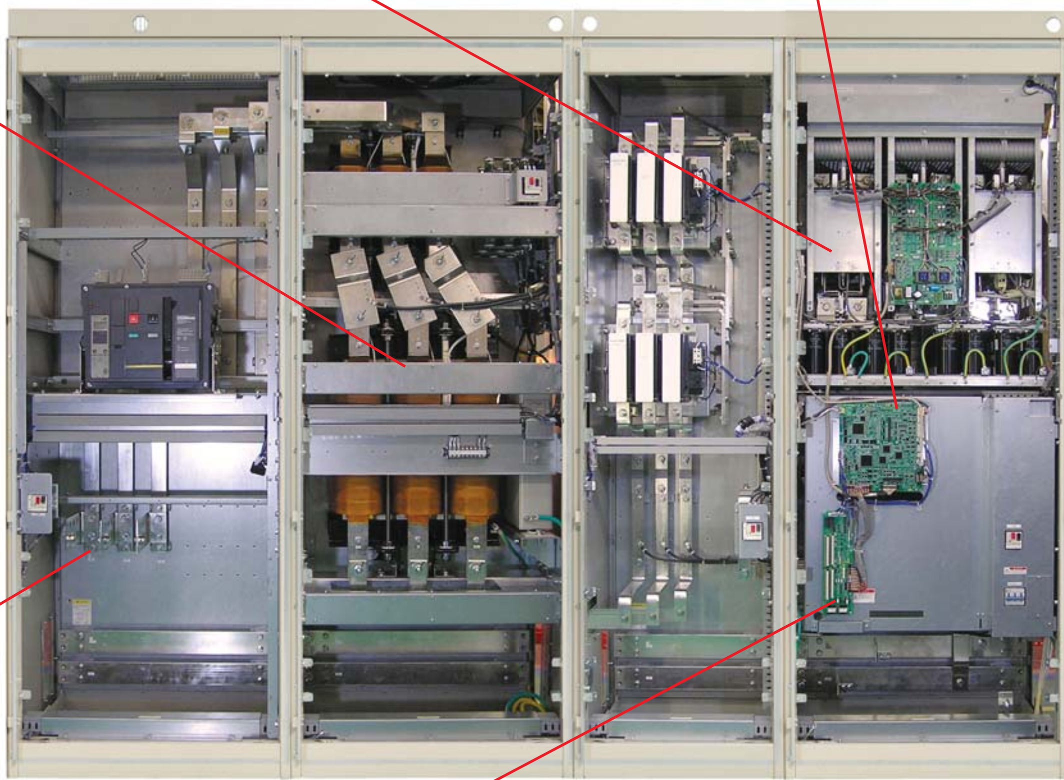
- Speed and torque regulation
- Sequencing
- I/O mapping
- Diagnostic data gathering

A mounting bracket is provided for an optional LAN interface board.

Harmonic Filter

Optional advanced harmonic filter panel can be integrated into the lineup. The filter is arranged in an LCL configuration.

1200 Frame Converter



Incoming Power (Main and Control)

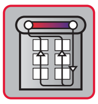
The converter in each lineup is fed 3-phase ac power. AC entry panels contain main AC breaker and support both top and bottom entry. In addition, 3-phase ac control power is fed to each converter and inverter in the lineup. A control power disconnect is provided in each cabinet.

I/O Board

All TMdrive–10e2 products include standard I/O, which supports an encoder, 24V dc and analog I/O. In addition, a resolver interface option can be provided. All I/O's are terminated to a two-piece modular terminal block for easy maintenance. Either screw or spring terminal blocks can be provided.

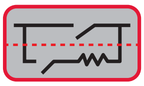
Motor Connections and Optional Output Contactor

Cabinet style inverters include bus tabs for easy motor connection. Both JEM and NEMA drilling patterns are provided. Bottom cable entry is standard, and top entry is accomplished using an additional cable cabinet. A galvanized steel plate is provided in the bottom for termination of motor cable shields. An optional ac output contactor (shown) can be supplied.



Heat Pipe Cooling Technology

The cabinet style inverters and regenerative converters use heat pipes to cool the IGBT power switches and capacitors. This technology reduces the footprint of the power bridge as well as the airflow requirements, saving valuable floor space and reducing the audible noise.



Motor Isolation Switch

The draw-out style inverters can be equipped with optional AC disconnect and cabinet style inverters with optional DC disconnect to allow safe servicing of the motor.

Reliable low voltage ac system drive technology designed to **reduce cost of ownership:**

- **Heat pipe cooling technology** that reduces the size of the power bridge and audible noise generated by the cooling fans
- **Draw-out style inverters** for low hp applications
- **Advanced IGBTs** increase efficiency

1200 Frame Inverter

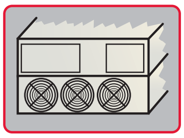
400 Frame Inverter

Draw-Out Style Inverters

Frame 15-100

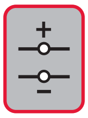
Frame 150

Frame 250



Draw-Out Style Inverters

For applications up to 193 kW (259 hp), draw-out style inverters are available in a very compact package. Draw-out inverters are mounted on heavy-duty slides with staggered connectors on the back that connect with the bus when slid into the cabinet. Motor cables are terminated at a common terminal block in the bottom of the cabinet. I/O and incoming ac power are mounted on modular terminal blocks for ease of maintenance.



DC Bus

The converter in each lineup generates dc power for each of the inverters. The inverters then create variable frequency ac power to control the induction motors. This dc power for the lineup is conveyed on a solid tin-plated copper bus near the bottom of the cabinets.

Equipment Safety Covers

Equipment ships from the factory with steel safety covers. These covers provide personal safety even in the event that a cabinet door is opened eliminating the need for door interlock devices.

Flexible I/O Interface

TMdrive-10e2 features a flexible I/O system allowing a variety of I/O to connect directly to each inverter. Standard I/O shown below is always supplied. Additionally, either option unit A or B may be specified to extend I/O capability.

Standard I/O

Digital Inputs	+24 V dc, 10 mA	• Quantity 2 for UVS (SIL 2) • Quantity 4 configurable mapping
Digital Outputs	24 V dc, 50 mA	• Quantity 2 for UVS (SIL 2) • Quantity 4 user defined • Open Collector
Analog Inputs	+/- 10 V dc, 4-20 mA, A/D	• Quantity 1 configurable • Differential • 13-bit resolution
Analog Outputs	D/A, +/- 10 V dc, 1 mA	• Quantity 1 user defined • Non-Isolated • 10-bit resolution
(Optional) Speed Feedback Resolver Input	Sin, Cos (Excitn); Sin, Cos (Fdbk)	• Excitation frequency of 1 or 4 kHz • Source for resolvers is Tamagawa: www.tamagawa-seiki.co.jp
Speed Feedback Encoder Input	A, B, Z (Excitn); Supply	• A quad B with marker • Maximum frequency of 100 kHz • Differential or single-ended 5 or 15 V dc
Speed Tach Follower Output	A, B, Z, 25 mA, 12-24 V dc	• A quad B with marker • Maximum frequency of 100 kHz
Motor Temperature Feedback	M	• High-resolution torque motor temperature feedback • 1 kΩ positive temperature coefficient RTD or other sensor requires selecting Option Unit

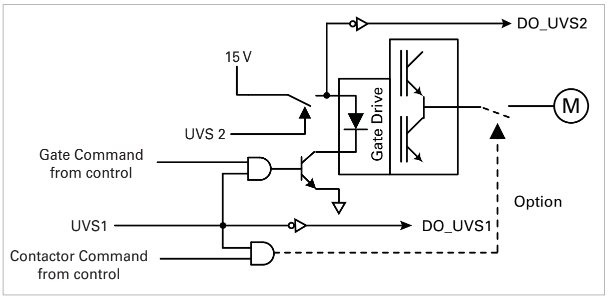
LAN Interface Options

TC-net I/O	• 8 words in/out
Ethernet Global Data (EGD)	• 10 words in/out
Profibus-DP	• 10 words in/out
Modbus RTU	• 10 words in/out
ControlNet	• 10 words in/out
DeviceNet	• 4 words in, 10 words out

TOSLINE-S20 and ISBus legacy LANs can also be supported on request.

Safety Integrity

Safety features according to IEC 618005-2 (Safety Integration Level 2) and ISO 13849-1 (Category 3). Safety integrity level 2/category 3 is insured by independent gate command lockout via two hardware inputs; UVS1 and UVS2. In addition, when the optional output contactor is supplied it is also disabled by the UVS1 signal providing additional protection.

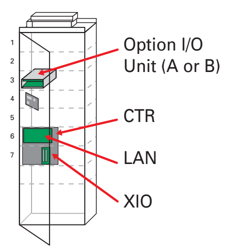


Option I/O Unit A

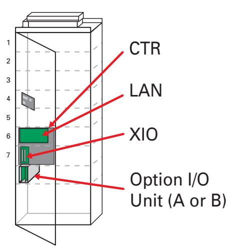
Digital Inputs	24 V dc, 10 mA	• Adds Quantity 5 configurable • Relay or solid state
Digital Outputs	24 V dc	• Adds Quantity 5 user defined • Relay (1 A) or solid state (70 mA)
Analog Inputs	±10 V, 4-20 mA, A/D	• Adds one isolated channel
Analog Outputs	D/A, ±10 V	• Adds one isolated channel

Option I/O Unit B

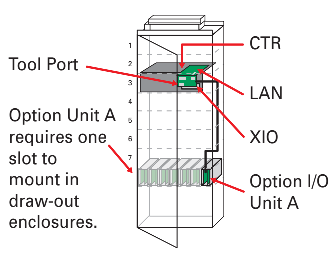
Digital Inputs	24 V dc, 10 mA	• Adds Quantity 6 configurable • Relay or solid state
Digital Outputs	24 V dc	• Adds Quantity 6 user defined • Relay (1A) or solid state (70mA))
Analog Inputs	±10 V, 4-20 mA, A/D	• Adds two isolated channels
Analog Outputs	D/A, ±10 V	• Adds two isolated channels



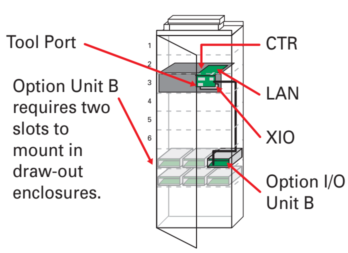
Cubicle Panel (600 mm)



Cubicle Panel (800 mm)



Draw-out Panel (Option A)



Draw-out Panel (Option B)

Operator Interfaces

Cabinet Enclosure Displays

Three-digit display alternates between speed and current while running, or a fault code when there is an error.

Standard Display

RJ-45 Ethernet port is used for local tool connection

Interlock button disables the drive

LEDs give a quick indication of the status of the unit.

LED Indication

Ready	On when the unit is ready to run
Running	On when the unit is running
Alarm/Fault	Blinking LED indicates alarm condition, while solid LED indicates a fault
DC Bus Discharged	On when the DC Bus is discharged

Optional Enhanced Keypad

Navigation
Allows adjustment of drive parameters from the front of the equipment.

Controls
Allow the equipment to be controlled in local mode from the front of the equipment.

- Reset faults, reverse direction, inc./dec. speed, jog, run and stop are available.
- Switch to local mode to allow operation at this control panel.

Optional analog meters can be supplied in addition to either the standard or enhanced display. Standard inverter I/O includes meter driver outputs that are +/- 10 V with 10-bit resolution. For cabinet style equipment, four meters are provided. For draw-out style, two meters are provided for each inverter.

Draw-out Enclosure Display

LEDs give a quick indication of the status of the unit.

LED Indication

DC Bus Discharged	On when the DC Bus is discharged
Ready	On when the unit is ready to run
Running	On when the unit is running
Alarm/Fault	Blinking LED indicates alarm condition, while solid LED indicates a fault

Control Functions

The TMdrive-10e2 has a wide array of control functions to suit any application:

I/O Functions

Analog input conditioning:
- Offset for each
- Gain for each
- Rollover protection

Analog output conditioning:
- Offset for each
- Gain for each
- Rollover protection

Digital position instrument with high-speed latches

High-resolution motor temperature feedback:
- Torque accuracy
- Motor protection

Diagnostic and Protective Functions

Simulation mode for testing and training:
- Motor simulator
- Load simulator

High-speed data capture buffer:
- Configurable trigger data capture (8 channels)
- Fault data capture (90 channels, 7 fault history, Total 1MB of data)

Protection:
- Over speed
- Over frequency
- Cooling fan failure
- Stall
- Speed error
- Timed overcurrent
- Motor overheat

Speed/Torque Regulator Functions

Outer regulator with 4 modes:
- Speed
- Speed with droop
- Torque
- Saturated speed with torque control

Current limits:
- di/dt
- Speed dependent
- Inverting

Automatic field adjustments:
- Field weakening
- Saturation compensation

Four forms of load compensation:
- Inertia
- Windage
- Friction
- Impact

Wizard functions:
- Commissioning
- Automatic motor control tuning
- Automatic speed control tuning

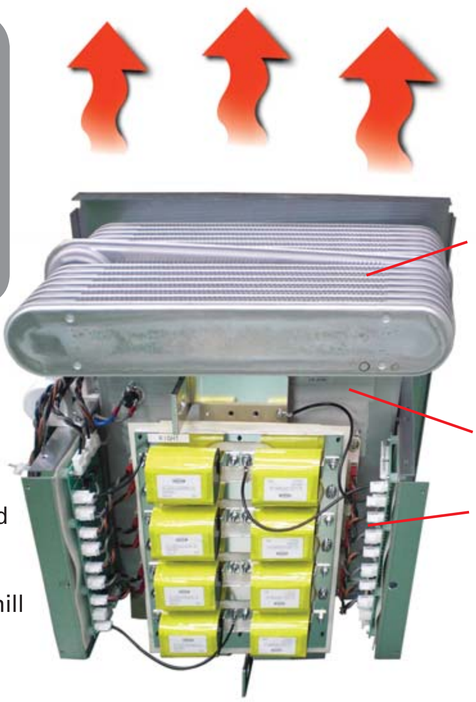
Reference model:
- Model following control to eliminate mechanical resonance problems

Inner regulator with 3 modes:
- Vector with speed feedback
- Sensorless vector
- Sensorless scaler (Volts/Hz)

Configurable sequential functions:
- Start
- Stop
- Alarm
- Trip, etc.

Heat Pipe Technology Used In TMdrive-10e2

This dramatic advance in power bridge cooling design provides:
- **Significant reduction in the footprint of the power bridge**
- **Lower audible noise**



1 Condensate To Vapor

The thermal cycle starts with the refrigerant in condensate form at the bottom of the chill plate. IGBTs are mounted to the multi-channeled chill plate. The heat generated by these IGBTs vaporizes (heats) the refrigerant, moving it up through the chill plate to the bottom of the condensing unit.

1 2 3 Thermal Cycle

Condensing unit with several fins for the flow of refrigerant

2 Vapor To Condensate

The refrigerant cools while moving through the condensing unit.

Cooling air is pulled vertically through the power bridge and then the condensing unit by both convection and fans mounted in the top of the cabinet.

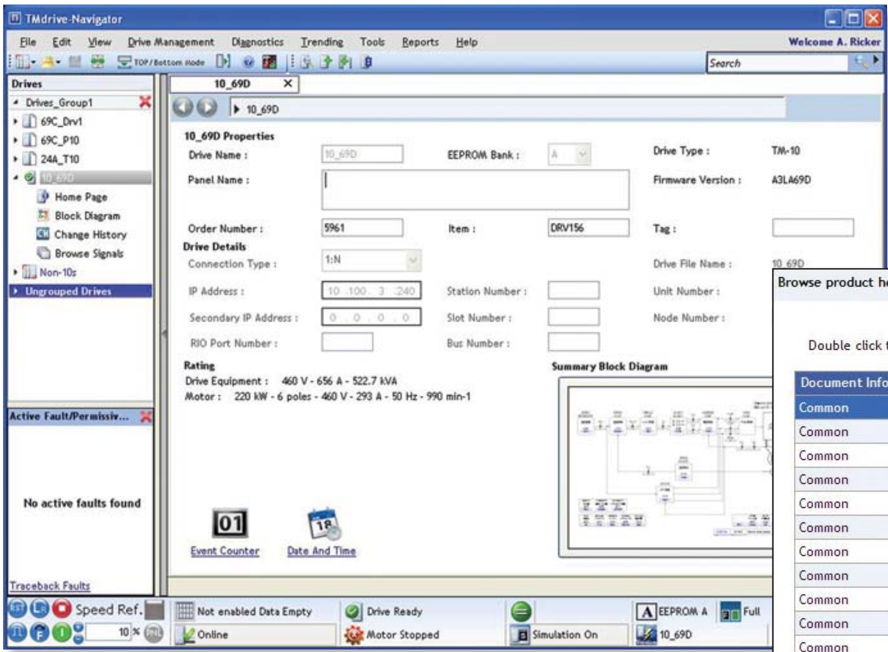
The multi-channeled chill plate contains a CFC free refrigerant which is practically non-toxic to humans and ozone friendly.

IGBT power switches.

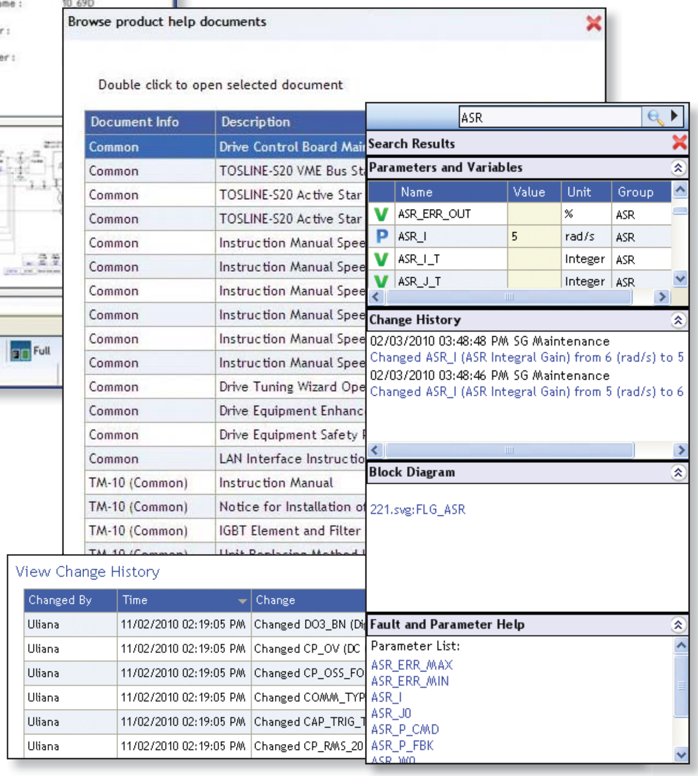
3 Return Of Condensate

The condensate (refrigerant in liquid form) returns to the bottom of the multi-channeled chill plate for the beginning of another thermal cycle.

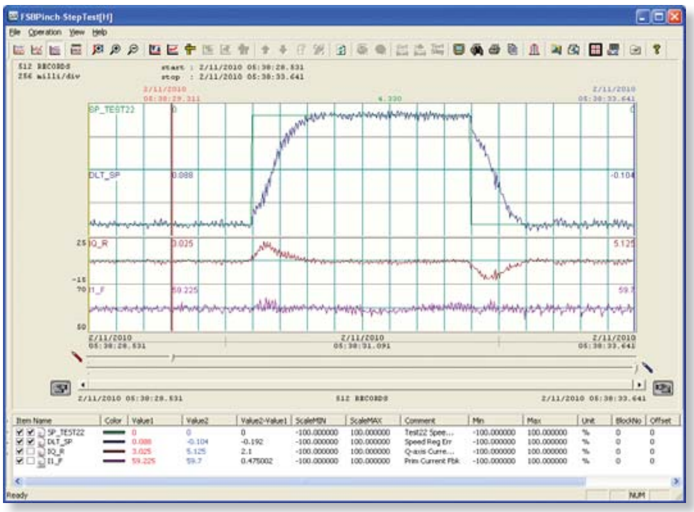
TMdrive-Navigator – Simple Configuration & Maintenance



The TMdrive-Navigator tool helps you maintain TMEIC drives yourself. Engineers and technicians are empowered to understand how the drive works and what the drive is doing. Any user can easily access current drive expertise and know-how.



Desktop-like search technology links topical signal lists, block diagrams, help files, product documentation, change history, and user notes. Windows techniques facilitate navigation within a drive and across the system. The status of all drives is always in view.



High speed data is automatically captured and saved in the event of a drive fault. Users can also capture high speed data based on their own trigger conditions or perform high resolution real-time trending.

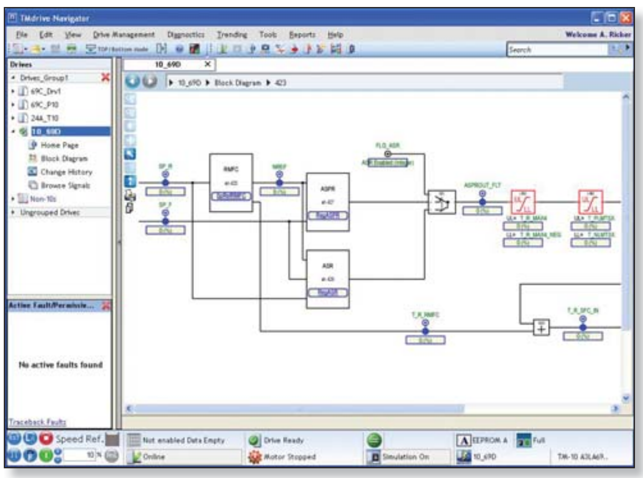
Fault data can be automatically "pushed" to key users. The client-server architecture allows access to high performance data from remote locations – with the same resolution as if you were in the plant.

Wizards support tuning of drive functions.

Live block diagrams provide a real-time graphical view of drive functions. Functions can be configured directly from the graphical view.

Product documentation is integrated right into the tool. Users can even capture their own notes to benefit future troubleshooting.

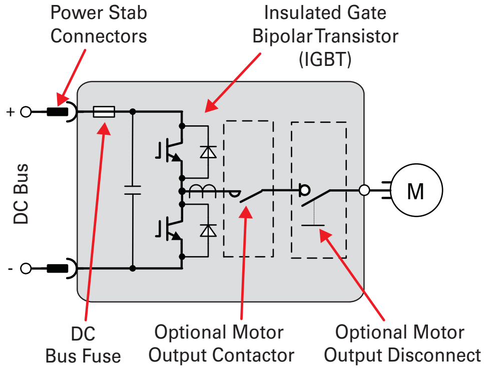
Compatible with:
- Windows XP, Vista, 7
- Windows Server 2003, 2008



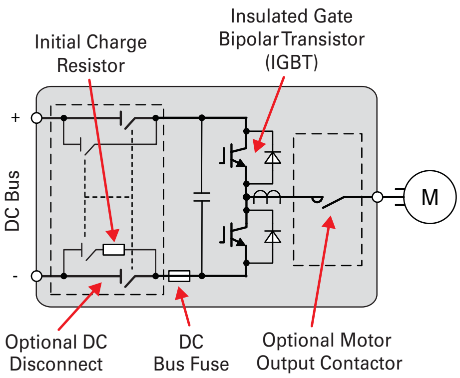
A Low Voltage Power Bridge Topology To Fit Your Application

TMdrive-10e2 Inverter Topologies

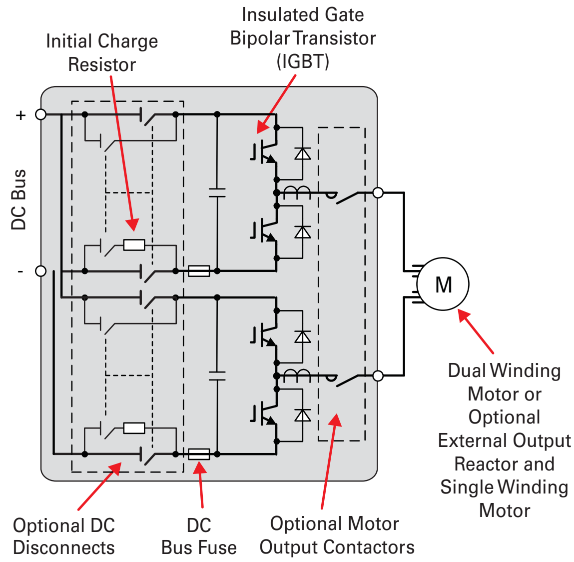
460 V Frames 15-250
690 V Frames 30-250



460 V Frames 400-900
690 V Frames 400-1200



460 V Frames 1200-1800
690 V Frames 1500-2400



TMdrive-10e2 Inverter Enclosures

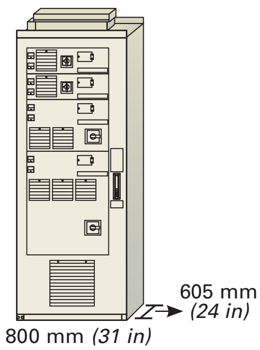


Fig. 1

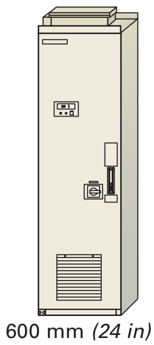


Fig. 2

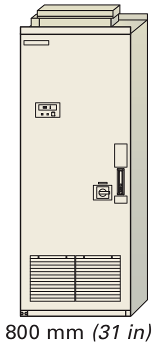


Fig. 3

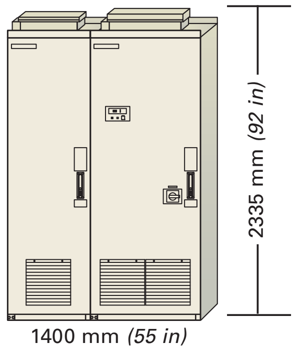


Fig. 4

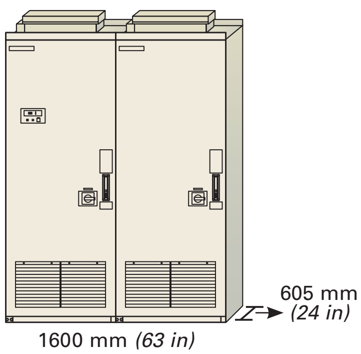


Fig. 5

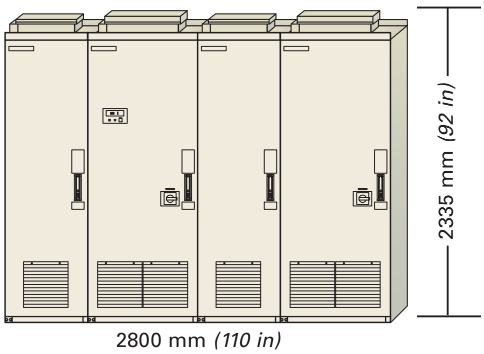


Fig. 6

Inverter Specifications

Inverter Power Output

Output Voltage	**460 V design** supports motor voltages up to 460 V, including 230 V, 380 V, 415 V, 440 V and 460 V **690 V design** supports motor voltages up to 690 V, including 575 V and 690 V
Output Frequency	0-200 Hz (0-400 Hz Optional) Continuous operation below 0.4 Hz requires derate
Output Chopping Frequency	1.5 kHz for all frames Up to 3 kHz available with derating
Inverter Type Modulation	Two-level voltage converter Pulse Width Modulation (PWM)
Power Semiconductor Technology	Low Loss Trench IGBT
Inverter Efficiency	98.5%

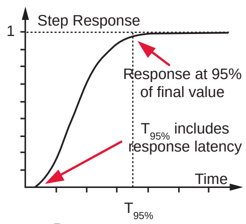
Motor Control

With Speed Sensor (Resolver or Encoder)
- Speed regulator accuracy: +/- 0.01%
- Maximum speed response: 60 rad/sec
- Torque linearity: +/- 3% with temperature sensor
  +/- 10% without temperature sensor
- Maximum Torque current response: 1000 rad/sec
- Torque range: 0-400% of rated motor torque
- Maximum flux control range: 20%-100%

Without Speed Sensor
- Speed regulator accuracy:
  +/- 0.1% with temperature sensor
  +/- 0.2% without temperature sensor
  (Using 1% slip motor at rated flux)
- Maximum speed regulator response: 20 rad/sec
- Minimum continuous speed: 3%
- Torque linearity: +/-10%
- Maximum Torque current response: 1000 rad/sec
- Torque range: 0-150% of rated motor torque
- Maximum flux control range: 75%-100%

Inverter Notes

1. All inverter cabinets are 605 mm (24 in) in depth. All equipment requires a steel support of at least 50 mm (2 in) under the panel (not included in these dimensions). All shipping splits are 2.4 m maximum.
2. A minimum of 500 mm (20 in) should be allocated above cabinet for fan maintenance. No back access is required. A minimum of 500mm (20 in) front clearance is required and 1500 mm (59 in) of front clearance is recommended.
3. Motor power ratings assume no options, 150% overloads, motor efficiency of 95%, motor power factor of 0.85, ambient temperature 0-40˚C (32-104˚F), and altitude below 1000 m (3280 ft) above sea level. Use actual motor data for final inverter selection.
4. The specified current ratings are continuous to which the referenced overload can be applied for a maximum of 60 seconds. Refer to application example on page 14.
5. Inverters support bottom cable entry. Top cable entry is supported with one 600 mm (24 in) auxiliary cabinet between every two inverter cabinets.
6. Each of the inverters requires 3-phase control power.
7. For high-performance torque regulation, a temperature sensor is mounted in the motor.
8. Speed and current regulator responses are computed per the adjacent figure in radians/s. 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. Air is pulled in through the front and out through the top for all cabinets.
10. The dc bus for the lineup has a maximum current capacity of 2350 amps.
11. For frames 2-250, add 500 VA of control power for inverter enclosure.



Response = $3/T_{95\%}$ (radians/s)

Environmental (Inverters and Converters)

Operating Temperature	0 to 40°C (32 to 104°F) at rated load 20 to 50°C (-4 to 122°F) with derating Derate current -2.5% per ˚C above 40˚C, all frames Derate current -2.5% per ˚C below 0˚C, frames 400 and larger
Storage Temperature	-25 to 55°C (-13 to 131°F)
Temperature Humidity	5 to 95% relative humidity Non-condensing
Altitude	0 to 5000 m (16400 ft) above sea level Derate current ratings: 1% per 200 m (656 ft) altitude above 1000 m (3280 ft) Derate voltage 2.25% per 200 m (656 ft) for 460 V inverters above 4000 m (13120 ft) for 690 V inverters above 2000 m (6560 ft)
Vibration	IEC60721-3-3 Class 3M2 2 Hz<f<9 Hz: Half amplitude sine wave is within 1.5 mm 9 Hz<f<200 Hz: Vibration acceleration is 5 m/s^2 or less

Single DC disconnect
Inverter Lockout

Cabinet Lockout
(control power)

Mechanical (Inverters and Converters)

Enclosure	IP20 (NEMA 1). IP32 is optional
Cable Entrance	Bottom is standard Top with optional auxiliary cabinet
Wire Colors	Per CSA/UL and CE
Short Circuit Ratings	100 kA for ac and dc buswork 10 kA for control power (UL) 15 kA (IEC)
Acoustic Noise	70 dB (78 dB for TMdrive-P10e2 690 V 1200F/2400F Type F Frames)
Mean Time to Repair	30 minutes to replace power bridge phase-leg
MTBF	> 41,000 hours
Code Conformance	Applicable IEC, JIS, JEM, UL, CSA and NEMA standards
Equipment Markings	E221104 Canada United States European Union

Inverter Specifications

460 V Design

Frame†	Encl. Fig. #* (Control Power)	Weight kg (lbs)	Losses kW	Motor kW (hp)	Inverter kVA				Motor Current A				Allowable Overload %
					No Options	Both Options	Only Contactor	Only Disconnect	No Options	Both Options	Only Contactor	Only Disconnect	
15	1 Single (200 VA)	23 (51)	0.3	11.6 (15.5)	18		16	18	23		20	23	100
							14				18		150
							9				11		300
30		25 (55)	0.6	22.5 (30)			36				45		100
							28				35		150
							18				22		300
60		28 (62)	1	48 (64)			76				95		100
							60				75		150
							34				43		300
100		28 (62)	1.7	82 (110)	108	100/80	108/80	100	136	125/100	135/100	125	100
					102	100/80	102/80	100	128	125/100	128/100	125	150
							60				75		300
150	1 Double (300 VA)	53 (117)	2.6	131 (176)	163	159	163	159	204	200	204	200	100
					163	159	163	159	204	200	204	200	150
							96				120		300
250	1 Quad (300 VA)	83 (183)	3.6	174 (233)	257	251/239	257/239	251/239	322	315/300	322/300	315/300	100
							215				270		150
							123				155		300
400	2 (350 VA)	280 (617)	5.4	293 (392)			402				504		100
							363				455		150
							210				263		300
600	3 (650 VA)	460 (1014)	10.2	450 (604)			664				833		100
							558				700		150
							335				420		300
750		470 (1036)	10.8	602 (806)	829		797	829/819	1040		1000	1040/1028	100
							745				935		150
							382				479		300
900		480 (1058)	13.8	740 (992)	1020		797	1020	1280		1000	1280	100
					916		797	916	1150		1000	1150	150
							492				617		300
900[1]	4 (770 VA)	790 (1741)	13.8	740 (992)			1020				1280		100
							916				1150		150
							492				617		300
1200	5 (1.3 kVA)	920 (2028)	20.4	900 (1207)	1327		1323	1327			1666		100
							1115				1400		150
							669				840		300
1500		940 (2072)	21.6	1203 (1612)	1657		1593	1657/1638	2080		2000	2080/2056	100
							1490				1870		150
							763				958		300
1800		960 (2116)	27.6	1479 (1983)	2040		1593	2040	2560		2000	2560	100
					1833		1593	1833	2300		2000	2300	150
							983				1234		300
1800[1]	6 (1.54 kVA)	1580 (3483)	27.6	1479 (1983)			2040				2560		100
							1833				2300		150
							983				1234		300

Note: When two values exist, IEC/JEM value precedes UL value.
1 – Twin Contactor
* – Refer to Page 10
† – Inverters are also available in Frames 2, 4 and 8

690 V Design

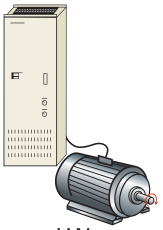
<table>
<tr><th rowspan="2">Frame</th><th rowspan="2">Encl. Fig. #* (Control Power)</th><th rowspan="2">Weight kg (lbs)</th><th rowspan="2">Losses kW</th><th rowspan="2">Motor kW (hp)</th><th colspan="4">Inverter kVA</th><th colspan="4">Motor Current A</th><th rowspan="2">Allowable Overload %</th></tr>
<tr><th>No Options</th><th>Both Options</th><th>Only Contactor</th><th>Only Disconnect</th><th>No Options</th><th>Both Options</th><th>Only Contactor</th><th>Only Disconnect</th></tr>
<tr><td rowspan="3">30</td><td rowspan="9">1 Single (200 VA)</td><td rowspan="3">25 (55)</td><td rowspan="3">0.6</td><td rowspan="3">25 (34)</td><td colspan="4">31</td><td colspan="4">26</td><td>100</td></tr>
<tr><td colspan="4">31</td><td colspan="4">26</td><td>150</td></tr>
<tr><td colspan="4">22</td><td colspan="4">18</td><td>300</td></tr>
<tr><td rowspan="3">60</td><td rowspan="3">28 (62)</td><td rowspan="3">0.9</td><td rowspan="3">46 (62)</td><td colspan="4">69</td><td colspan="4">58</td><td>100</td></tr>
<tr><td colspan="4">57</td><td colspan="4">48</td><td>150</td></tr>
<tr><td colspan="4">31</td><td colspan="4">26</td><td>300</td></tr>
<tr><td rowspan="3">100</td><td rowspan="3">28 (62)</td><td rowspan="3">1.5</td><td rowspan="3">69 (93)</td><td colspan="4">102</td><td colspan="4">85</td><td>100</td></tr>
<tr><td colspan="4">86</td><td colspan="4">72</td><td>150</td></tr>
<tr><td colspan="4">48</td><td colspan="4">40</td><td>300</td></tr>
<tr><td rowspan="3">150</td><td rowspan="3">1 Double (300 VA)</td><td rowspan="3">53 (117)</td><td rowspan="3">2.7</td><td rowspan="3">114 (152)</td><td colspan="4">141</td><td colspan="4">118</td><td>100</td></tr>
<tr><td colspan="4">141</td><td colspan="4">118</td><td>150</td></tr>
<tr><td colspan="4">102</td><td colspan="4">85</td><td>300</td></tr>
<tr><td rowspan="3">250</td><td rowspan="3">1 Quad (300 VA)</td><td rowspan="3">83 (183)</td><td rowspan="3">3.9</td><td rowspan="3">193 (259)</td><td colspan="4">239</td><td colspan="4">200</td><td>100</td></tr>
<tr><td colspan="4">239</td><td colspan="4">200</td><td>150</td></tr>
<tr><td colspan="4">139</td><td colspan="4">116</td><td>300</td></tr>
<tr><td rowspan="3">400</td><td rowspan="3">2 (350 VA)</td><td rowspan="3">280 (617)</td><td rowspan="3">5.4</td><td rowspan="3">313 (420)</td><td colspan="4">442</td><td colspan="4">370</td><td>100</td></tr>
<tr><td colspan="4">388</td><td colspan="4">325</td><td>150</td></tr>
<tr><td colspan="4">213</td><td colspan="4">178</td><td>300</td></tr>
<tr><td rowspan="3">600</td><td rowspan="12">3 (650 VA)</td><td rowspan="3">460 (1014)</td><td rowspan="3">9.6</td><td rowspan="3">511 (685)</td><td colspan="4">789</td><td colspan="4">660</td><td>100</td></tr>
<tr><td colspan="4">633</td><td colspan="4">530</td><td>150</td></tr>
<tr><td colspan="4">339</td><td colspan="4">284</td><td>300</td></tr>
<tr><td rowspan="3">750</td><td rowspan="3">470 (1036)</td><td rowspan="3">12</td><td rowspan="3">627 (841)</td><td colspan="4">944</td><td colspan="4">790</td><td>100</td></tr>
<tr><td colspan="4">777</td><td colspan="4">650</td><td>150</td></tr>
<tr><td colspan="4">430</td><td colspan="4">360</td><td>300</td></tr>
<tr><td rowspan="3">900</td><td rowspan="6">480 (1058)</td><td rowspan="3">13.2</td><td rowspan="3">723 (970)</td><td colspan="4">1052</td><td colspan="4">880</td><td>100</td></tr>
<tr><td colspan="4">896</td><td colspan="4">750</td><td>150</td></tr>
<tr><td colspan="4">490</td><td colspan="4">410</td><td>300</td></tr>
<tr><td rowspan="3">1200</td><td rowspan="3">16.2</td><td rowspan="3">974 (1306)</td><td>1374</td><td colspan="2">1195</td><td>1374</td><td>1150</td><td colspan="2">1000</td><td>1150</td><td>100</td></tr>
<tr><td>1207</td><td colspan="2">1195</td><td>1207</td><td>1010</td><td colspan="2">1000</td><td>1010</td><td>150</td></tr>
<tr><td colspan="4">639</td><td colspan="4">535</td><td>300</td></tr>
<tr><td rowspan="3">1200[1]</td><td rowspan="3">4 (770 VA)</td><td rowspan="3">790 (1741)</td><td rowspan="3">16.2</td><td rowspan="3">974 (1306)</td><td colspan="3">1374</td><td></td><td></td><td colspan="2">1150</td><td></td><td>100</td></tr>
<tr><td colspan="3">1207</td><td></td><td></td><td colspan="2">1010</td><td></td><td>150</td></tr>
<tr><td colspan="3">639</td><td></td><td></td><td colspan="2">535</td><td></td><td>300</td></tr>
<tr><td rowspan="3">1500</td><td rowspan="9">5 (1.3 kVA)</td><td rowspan="3">940 (2072)</td><td rowspan="3">24</td><td rowspan="3">1254 (1681)</td><td colspan="4">1888</td><td colspan="4">1580</td><td>100</td></tr>
<tr><td colspan="4">1554</td><td colspan="4">1300</td><td>150</td></tr>
<tr><td colspan="4">860</td><td colspan="4">720</td><td>300</td></tr>
<tr><td rowspan="3">1800</td><td rowspan="3">960 (2116)</td><td rowspan="3">26.4</td><td rowspan="3">1447 (1940)</td><td colspan="4">2103</td><td colspan="4">1760</td><td>100</td></tr>
<tr><td colspan="4">1793</td><td colspan="4">1500</td><td>150</td></tr>
<tr><td colspan="4">980</td><td colspan="4">820</td><td>300</td></tr>
<tr><td rowspan="3">2400</td><td rowspan="3">960 (2116)</td><td rowspan="3">32.4</td><td rowspan="3">1949 (2613)</td><td>2749</td><td colspan="2">2390</td><td>2749</td><td>2300</td><td colspan="2">2000</td><td>2300</td><td>100</td></tr>
<tr><td>2414</td><td colspan="2">2390</td><td>2414</td><td>2020</td><td colspan="2">2000</td><td>2020</td><td>150</td></tr>
<tr><td colspan="4">1279</td><td colspan="4">1070</td><td>300</td></tr>
<tr><td rowspan="3">2400[1]</td><td rowspan="3">6 (1.54 kVA)</td><td rowspan="3">1580 (3483)</td><td rowspan="3">32.4</td><td rowspan="3">1949 (2613)</td><td></td><td colspan="2">2749</td><td></td><td></td><td colspan="2">2300</td><td></td><td>100</td></tr>
<tr><td></td><td colspan="2">2414</td><td></td><td></td><td colspan="2">2020</td><td></td><td>150</td></tr>
<tr><td></td><td colspan="2">1279</td><td></td><td></td><td colspan="2">1070</td><td></td><td>300</td></tr>
</table>

Application Examples

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.



$kW_{Shaft} = 150\ kW$ *(201 hp)*

The motor delivers constant torque from zero to base speed of 900 rpm and 150 kW *(201 hp)*.

Duty cycle requires 150% for 10 sec, but has a rms duty cycle of 150 kW *(201 hp)*.

2 Select motor based on process requirements and compute required inverter kVA.

- 150 kW *(201 hp)*
- 900 rpm, 460 V
- Efficiency = 0.954
- Power factor = 0.765
- Service factor = 1.15

3 Compute continuous current requirements for the inverter based on the selected motor.

$$I_{ac\ Inverter} = \frac{kW_{Shaft} \times 1000 \times SF_{Mtr}}{Eff_{Mtr} \times PF_{Mtr} \times \sqrt{3} \times V_{Motor\ rated\ voltage}}$$

$$= \frac{150 \times 1000 \times 1.15}{0.954 \times 0.765 \times \sqrt{3} \times 460\ V}$$

$$= 297\ amps$$

4 Select inverter based on continuous current and overload requirements.

Scan the 150% entries in the inverter tables for a frame where the continuous current rating exceeds 297 amps. The **400 frame** meets this criterion (**455 amps**) and is appropriate for this application.

<table>
<tr><th rowspan="2">Frame</th><th colspan="4">Motor Current A</th><th rowspan="2">Allowable Overload %</th></tr>
<tr><th>No Options</th><th>Both Options</th><th>Only Contactor</th><th>Only Disconnect</th></tr>
<tr><td rowspan="3">400</td><td colspan="4">504</td><td>100</td></tr>
<tr><td colspan="4">455</td><td>150</td></tr>
<tr><td colspan="2">263</td><td colspan="2"></td><td>300</td></tr>
</table>

Regenerative Converter (TMdrive-P10e2) 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 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.

$$kW_{dc} = \frac{kW_{Shaft}}{Eff_{Mtr} \times Eff_{Inv} \times Eff_{Conv}}$$

$$= \frac{150\ kW}{0.954 \times .985 \times .985}$$

$$= 162\ kW$$

2 Compute continuous ac current requirement of the converter based on its power requirements.

$$I_{ac\ Converter} = \frac{kW_{dc} \times 1000}{\sqrt{3} \times V_{Converter\ line\text{-}to\text{-}line\ voltage}}$$

$$= \frac{162\ kW \times 1000}{\sqrt{3} \times 460\ V}$$

$$= 203\ amps$$

Note: For sizing systems with peak powers in regenerative mode, a different equation is used to compute power requirements.

$$kW_{dc} = kW_{Shaft} \times (Eff_{Mtr} \times Eff_{Inverter} \times Eff_{Conv})$$

3 Scan the 150% for 60 sec entries in the regenerative converter tables for a frame where the continuous current rating exceeds 203 amps.

Non-Regenerative Converter (TMdrive-D10e2) 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 on top of page).

1 Compute the operating voltage of the dc bus. It is assumed that the converter is dedicated to the inverter specified in the application example above.

$$V_{dc\ Bus} = 1.35 \times V_{Converter\ line\text{-}to\text{-}line}$$

$$= 1.35 \times 460 \times 1.05$$

$$= 652\ V$$

Assumptions:

- Converter at 100% of current rating
- Transformer sized for converter
- 5% high transformer tap is used

2 Compute the continuous dc current requirement of the converter based on its power requirement.

$$I_{dc\ Converter} = \frac{kW_{Shaft} \times 1000}{Eff_{Mtr} \times Eff_{Inv} \times V_{dc\ Bus}}$$

$$= \frac{150\ kW \times 1000}{0.954 \times 0.985 \times 652}$$

$$= 245\ amps$$

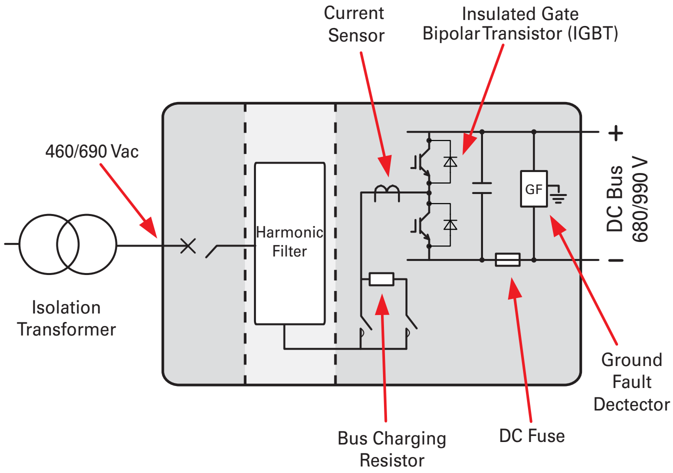
3 Scan the specifications in the non-regenerative converter tables at the top of this page for a frame where the continuous current rating exceeds 245 amps.

Flexible Converter Topologies To Fit Your Application

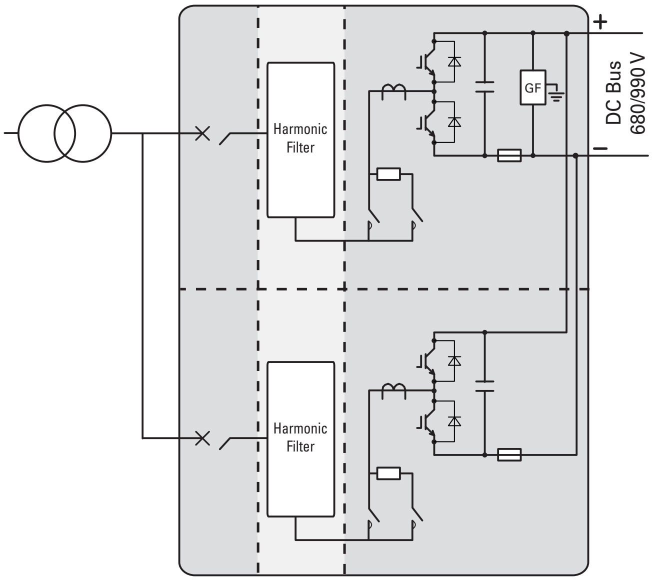
TMdrive-P10e2 Converter Topologies

The TMdrive-P10e2 converter introduces a modular and flexible design. These converters require an AC entry section, a filter section and an IGBT power bridge. The AC entry section and the filter may be integrated in a single lineup with the power bridges or they can be mounted in a remote location and cabled.

Frames 150-1200

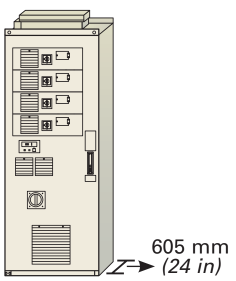


Frames 1500-2400



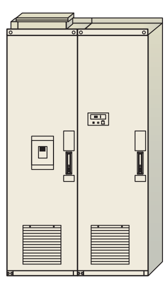
The required harmonic filter can be separately mounted and is not shown in the figures below.

TMdrive-P10e2 Converter Enclosures



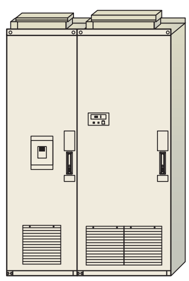
800 mm *(31 in)*

Fig. 1



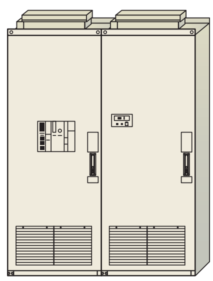
1200 mm *(47 in)*

Fig. 2



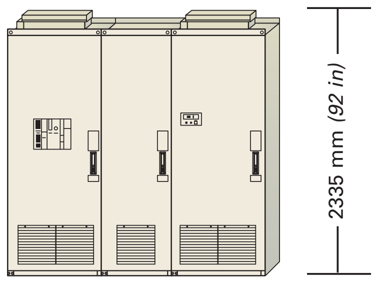
1400 mm *(55 in)*

Fig. 3



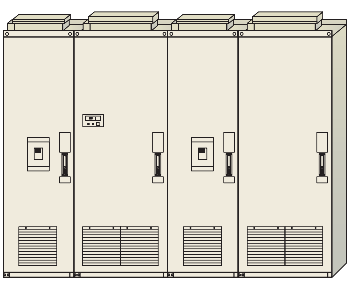
1600 mm *(63 in)*

Fig. 4



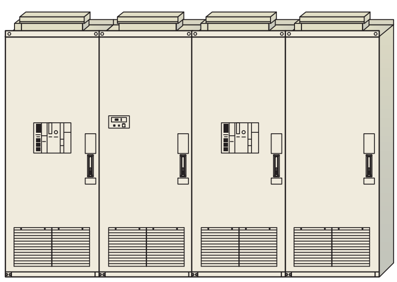
2200 mm *(87 in)*

Fig. 5



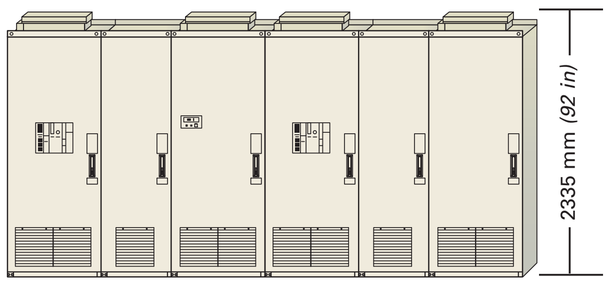
2800 mm *(110 in)*

Fig. 6



3200 mm *(126 in)*

Fig. 7



4400 mm *(173 in)*

Fig. 8

The figures shown include AC breakers.

Converter Power Input

Mains Input Voltage	460 V design supports line voltages up to 460 V, including 230 380 V, 415 V, 440 V and 460 V
Input Frequency	40-90 Hz
Mains Short Circuit	Up to 100 kA may be specified
Power Factor	Unity at all loads
Modulation Type	Two-level voltage source converter featuring Intelligent Current Control or PWM modulation
Power Semiconductor Technology	Low Loss Trench IGBT
Output Chopping Frequency	Intelligent Current Control – Average 2150 Hz Standard PWM – 2048 Hz
Control Power	200/220 Vac 50 Hz +/- 10% 220/230 Vac 60 Hz +/- 10%
Converter Efficiency	98.5% at full load

Converter Notes

1. TMdrive-P10e2 cabinets are 605 mm (24 in) in depth. All equipment requires a steel support of at least 50 mm (2 in) under the panel, which is not included in these dimenstions. Height of all panels are shown includes lifting means and fans. Reserve an additional 115 mm (5 in) in height for equipment requiring a debris hood (UL).
2. Allocate a minimum of 500 mm (20 in) above the cabinet for fan maintenance. A minimum of 800 mm (32 in) front access should be reserved for maintenance. No back access required.
3. Air is pulled in through the front and out through the top for all cabinets.
4. DC bus is limited to 2340 A. Position converters within lineups so that this limit is not exceeded.
5. There are no restrictions on total dc bus length or the minimum capacitance connected to any of these converters. However, due to bus charging constraints you should consult the factory if the combined rating of all connected inverters exceeds 3 times the converter rating.
6. Maximum shipping split from the factory is 2.4 m. Equipment longer than this must be split for shipment.
7. The TMdrive-P10e2 converter can be equipped with the standard or optional enhanced keypad shown on page 7.
8. Enclosures shown on page 15 include AC circuit breakers but do not include required harmonic filters.
9. The specified current ratings are continuous, to which the referenced overload can be applied for a maximum of 60 seconds.

TMdrive-P10e2 Intelligent Current Control

The TMdrive-P10e2 converter introduces a new modulation strategy that improves harmonic performance when compared to standard PWM control. The Intelligent Current Control generates a PWM signal utilizing the current deviation vector derived from current feedback and current reference. Figure 1 is a block diagram representation of the control. When combined with a simple harmonic filter, compliance with IEEE-519 harmonic limits is achieved with the Intelligent Current Control.

Intelligent Current Control Advantages

- Meets IEEE-519 requirement at all loads
- Simple and compact filters minimizes footprint

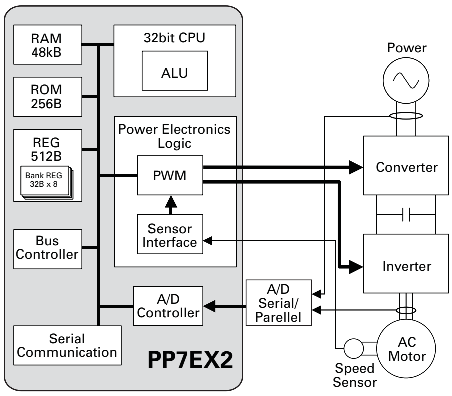
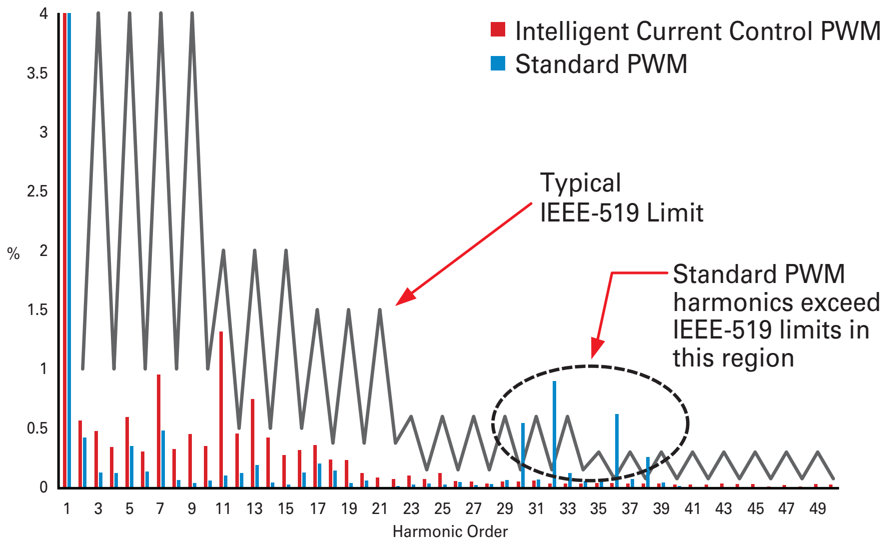


Fig. 1. Functional control block diagram.



Reduced harmonics mean a simple filter can achieve IEEE-519 standard.

TMdrive-P10e2 Converter Specifications

460 V Design

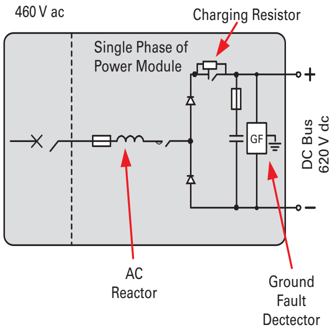
Frame	Voltage V	AC Current A	Allowable Overload %	Control Power kVA	Losses kW	Capacity kW	IEC Design				UL Design			
							Encl. Fig. #	MCCB Short Circuit kA	Weight kg (lbs)	Width mm (in)	Encl. Fig. #	MCCB Short Circuit kA	Weight kg (lbs)	Width mm (in)
150	460	170	150	0.2	2.3	130	1	50	540 (1190)	800 (31)	1	50	540 (1190)	800 (31)
		140	200											
		100	300											
400	460	390	150	0.55	4.3	298	2	30	550 (1213)	1200 (47)	2	35	550 (1213)	1200 (47)
		308	200											
		205	300											
750	460	825	150	0.8	10.6	631	3	40	740 (1631)	1400 (55)	3	50	740 (1631)	1400 (55)
		650	200											
		460	300											
900	460	1000	150	0.8	12.7	765	3	65	780 (1720)	1400 (55)	4	100	870 (1918)	1600 (63)
		790	200											
		555	300											
1200	460	1260	150	1	14.7	964	5	85	1170 (2579)	2200 (87)	5	100	1170 (2579)	2200 (87)
		975	200											
		650	300											
1500	460	1650	150	1.6	21.2	1263	6	40	1480 (3263)	2800 (110)	6	50	1480 (3263)	2800 (110)
		1300	200											
		920	300											
1800	460	2000	150	1.6	25.4	1530	6	65	1560 (3439)	2800 (110)	7	100	1740 (3836)	3200 (126)
		1580	200											
		1110	300											
2400	460	2520	150	2	29.4	1928	8	85	2340 (5159)	4400 (173)	8	100	2340 (5159)	4400 (173)
		1950	200											
		1300	300											

690 V Design

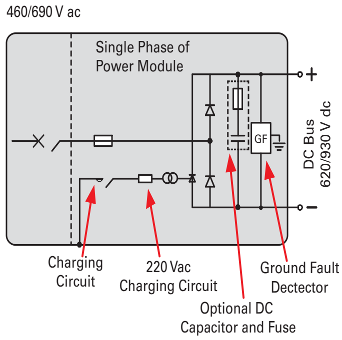
Frame	Voltage V	AC Current A	Allowable Overload %	Control Power kVA	Losses kW	Capacity kW	IEC Design				UL Design (575 V)			
							Encl. Fig. #	MCCB Short Circuit kA	Weight kg (lbs)	Width mm (in)	Encl. Fig. #	MCCB Short Circuit kA	Weight kg (lbs)	Width mm (in)
150	690	110	150	0.2	2.2	126	1	10	540 (1190)	800 (31)	1	18	540 (1190)	800 (31)
		80	200											
		60	300											
400	690	240	150	0.55	4.5	275	2	35	550 (1213)	1200 (47)	2	18	550 (1213)	1200 (47)
		194	200											
		129	300											
750	690	550	150	0.8	10.1	631	3	30	740 (1631)	1400 (55)	3	50	740 (1631)	1400 (55)
		431	200											
		287	300											
900	690	640	150	0.8	12.2	735	3	25	780 (1720)	1400 (55)	4	85	870 (1918)	1600 (63)
		500	200											
		345	300											
1200	690	800	150	0.8	15.2	918	4	85	870 (1918)	1600 (63)	4	85	870 (1918)	1600 (63)
		640	200											
		445	300											
1500	690	1100	150	1.6	20.2	1263	6	30	1480 (3263)	2800 (110)	6	50	1480 (3263)	2800 (110)
		862	200											
		574	300											
1800	690	1280	150	1.6	24.4	1469	6	25	1560 (3439)	2800 (110)	7	85	1740 (3836)	3200 (126)
		1000	200											
		690	300											
2400	690	1600	150	1.6	30.4	1836	7	85	1740 (3836)	3200 (126)	7	85	1740 (3836)	3200 (126)
		1280	200											
		890	300											

TMdrive-D10e2 Converter Specifications

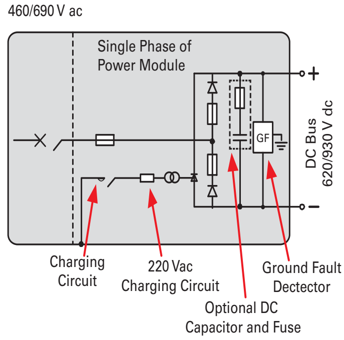
TMdrive-D10e2 Converter Topologies



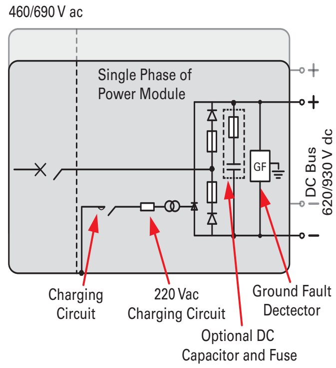
150 Frame (460 V only)



Frames 600 - 1400



Frames 1800 - 2800



Frames 2x1800 - 2x2800

Preliminary TMdrive-D10e2 Diode Converter Ratings

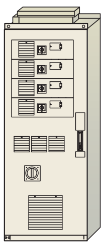


Fig. 1

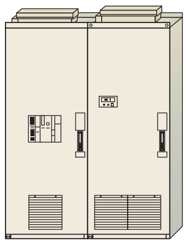


Fig. 2

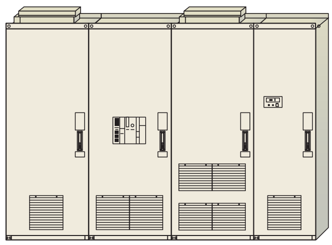


Fig. 3

Fig. 4

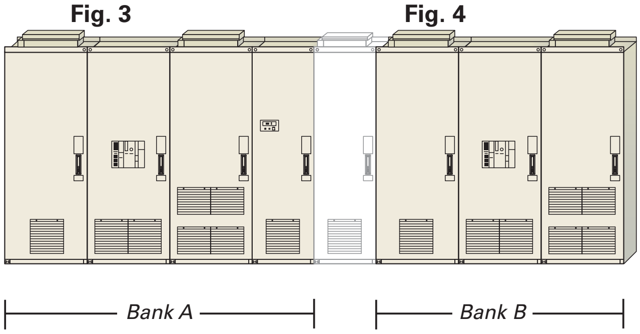


Fig. 5

460 V Design

Frame	Encl. Fig. #	Voltage	Current A dc (A ac)	Power kW	Losses kW	Width mm (in)
150	1	460	250 (204)	155	0.8	800 (31)
600	2	460	966 (788)	600	6.0	1600 (63)
1200	2	460	1932 (1577)	1200	9.0	1600 (63)
1800	3	460	2898 (2365)	1800	12.0	3000 (118)
2400	3	460	3864 (3153)	2400	15.0	3000 (118)
2 x 1800	4	460	5796 (4730)	3600	24.0	5400 (213)
2 x 2400	4	460	7728 (6306)	4800	30.0	5400 (213)

690 V Design

Frame	Encl. Fig. #	Voltage	Current A dc (A ac)	Power kW	Losses kW	Width mm (in)
700	2	690	773 (631)	720	3.0	1600 (63)
1400	2	690	1546 (1262)	1440	6.0	1600 (63)
2100	3	690	2319 (1892)	2160	9.0	3000 (118)
2800	3	690	3092 (2523)	2880	12.0	3000 (118)
2 x 2100	4	690	4638 (3784)	4320	18.0	5400 (213)
2 x 2800	4	690	6184 (5046)	5760	24.0	5400 (213)

TMdrive-D10e2 Diode Converter Notes

1. Enclosures shown on this page are not more than 2335mm (92 in) tall and 605mm (24 in) deep. For Figure 4 the width shown in the table includes bank A & B but does not include any inverters inserted between.
2. Converters larger than frame 150 require external reactance of 3% minimum. Normally, a dedicated transformer is sufficient to satisfy this requirement.
3. Dual bank converters require separate transformer windings for each half bridge.
4. The currents ratings shown allow 150% overloads for 60 seconds.
5. The 460Vac 150 frame converters include an IGBT braking module rated for 400 A. Resistors with the ratings appropriate for the application must be supplied and externally mounted to use this function.
6. Enclosures shown on this page include option of circuit breaker, but without built-in ACL (except Frame 150).
7. For converters larger than 150 frame, DC capacitors internal to the converter are optional. This option should be used if the sum of all inverters frames sizes without DC disconnects connected to converter is less than 500.
8. TMdrive-D10e2 converters are not available with UL labels. Applications which require UL labeled converters should use TMdrive-D10.

TMdrive-10e2 Hybrid Converter System

The TMdrive-10e2 platform introduces the ability to combine diode converters with PWM converters.

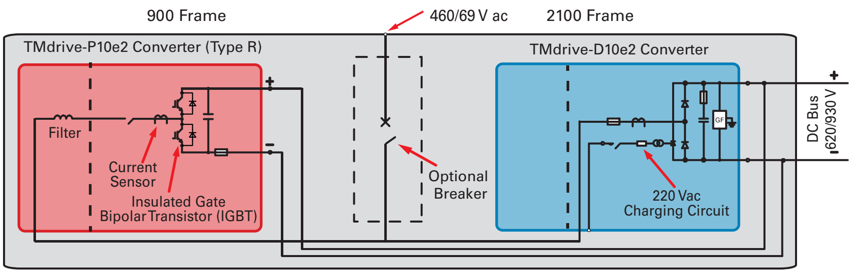
In situations where the regenerative power requirement is significantly different from motoring power requirement, hybrid converters offer a cost effective solution by using a diode converter for motoring and PWM converter for regeneration.

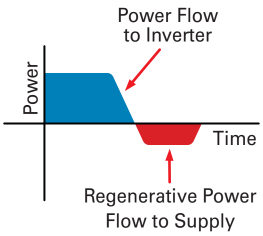
To apply Hybrid converter, follow the 2-step process:

1. Select diode converter using the **Non-Regenerative converter** example on **page 14** using the required motoring power.
2. Select the PWM converter using the **Regenerative converter** example on **page 14** and the required regenerative power.

TMdrive-P10e2 converters for these applications are ordered in a special configuration, which deletes the breaker panels and adds a filter panel when compared to lineups of page 15. This configuration is designated the “Type R” configuration. Only frames 400-1200 are available in this configuration with lineup dimensions as shown at the bottom of this page.

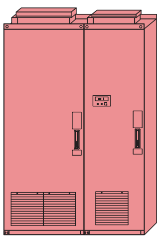
TMdrive-10e2 Hybrid Converter System Application One-line



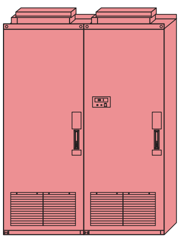


Hybrid Converter Lineup Example

TMdrive-P10e2 (Type R) Enclosures + **TMdrive-D10e2 Converter Enclosures** = **Hybrid Converter Enclosure**

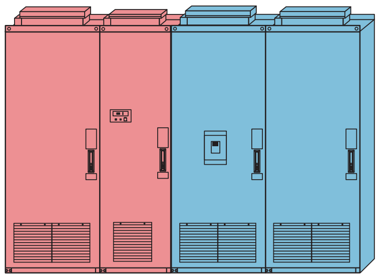


1400 mm *(55 in)*
Frame 400



1600 mm *(63 in)*
Frames 750/900/1200

(see page 18)

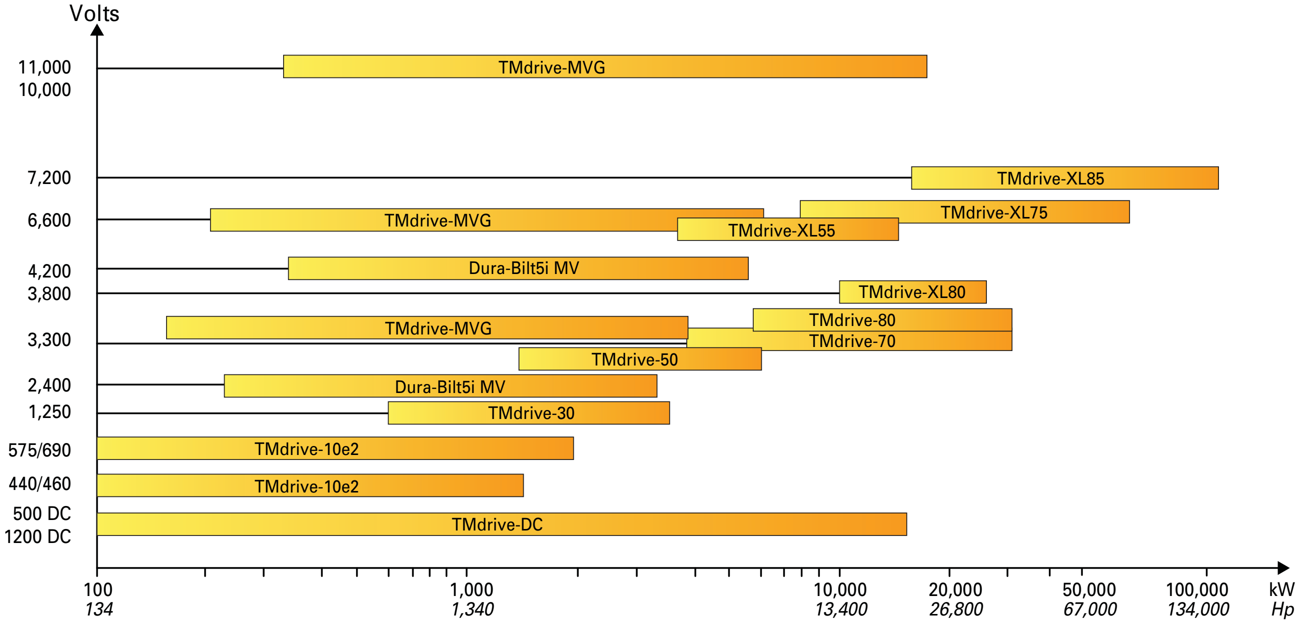


Frame 400 TMdrive-P10e2 Type R Converter

Frame 600 TMdrive-D10e2 Converter

Any TMdrive-P10e2 / TMdrive-D10e2 Type R Converters are combined to form a Hybrid Converter.

TMEIC AC Drives Offer Complete Coverage



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