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TMdrive[®]-10e2

Product Application Guide

Low Voltage IGBT System Drive

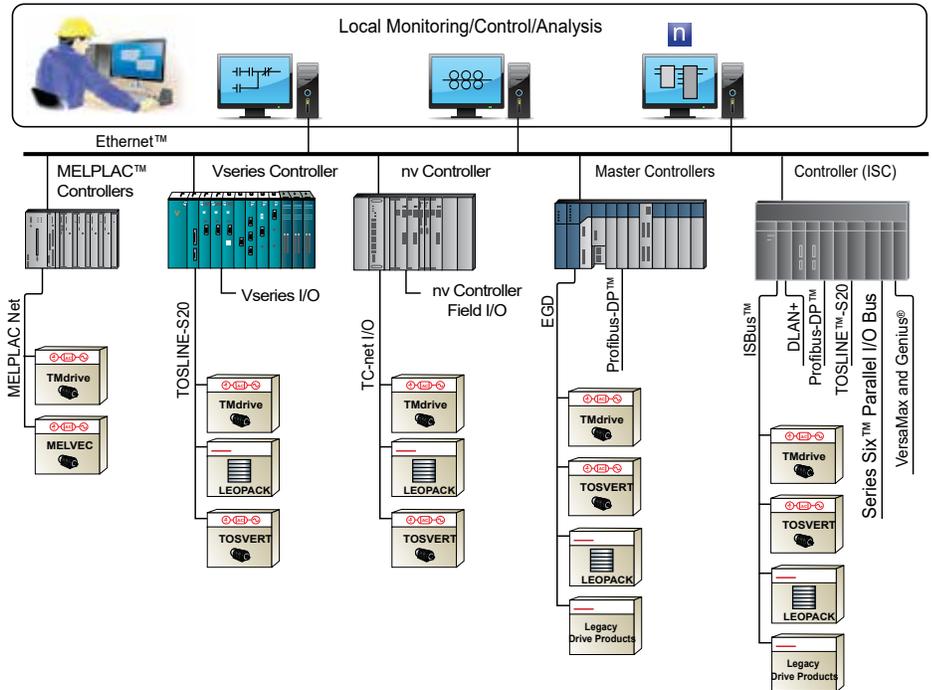


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TMdrive-10e2 is an evolution in the family of TMdrive ac system drives offering:

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



TMdrive-10e2

Features

State-of-the-art microprocessors including floating point calculation.

Heat pipe cooling technology. The IGBT power bridges use heat pipe cooling technology.

Microsoft® Windows®-based configuration. The TMdrive-Navigator is used to configure, install, and maintain the TMdrive-10e2 drives.

LAN options:

- TC-net™ I/O
- Profibus™-DP
- DeviceNet™
- Modbus™ RTU
- Ethernet Global Data (EGD)
- ControlNet™

Safety features according to:

- ISO 13849-1 (Category 3)
- IEC 61800-5-2 (Safety Integration Level 2)

Benefits

Higher processing speed and communications for next generation control system.

Per unit calculations are easy to understand.

Reduces footprint and lowers audible noise. This technology saves valuable floor space and lowers the required cooling-air flow, reducing the associated audible noise.

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.

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.

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

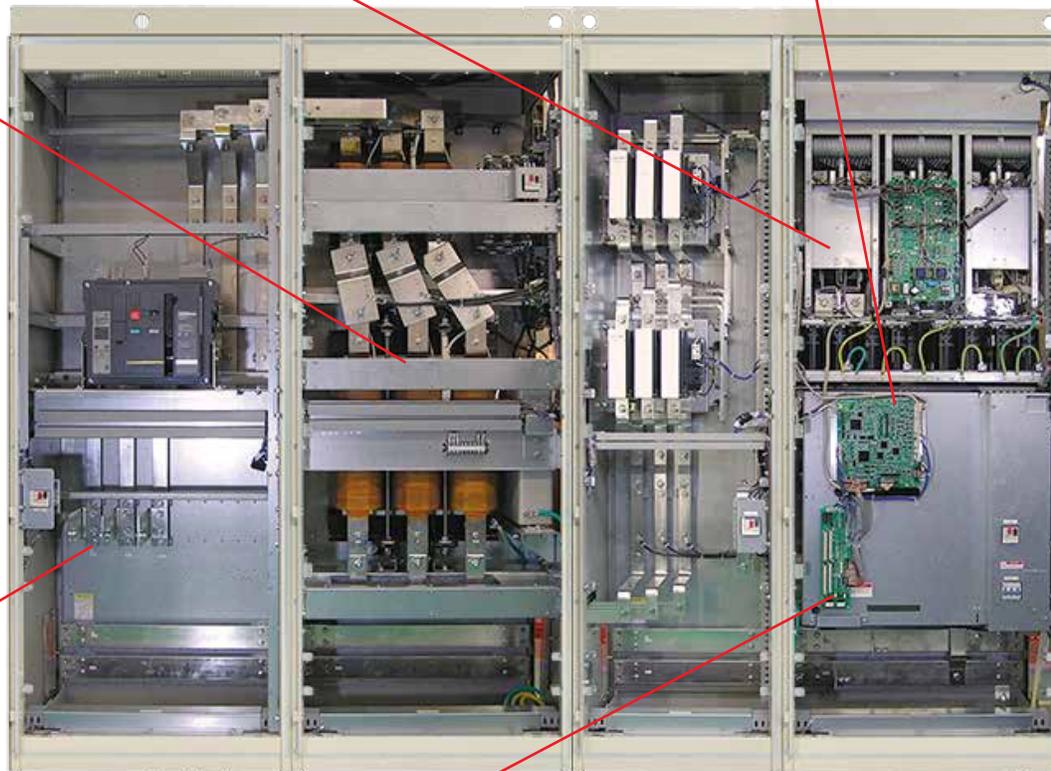
A mounting bracket is provided for an optional LAN interface board.



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.

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.

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.



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.

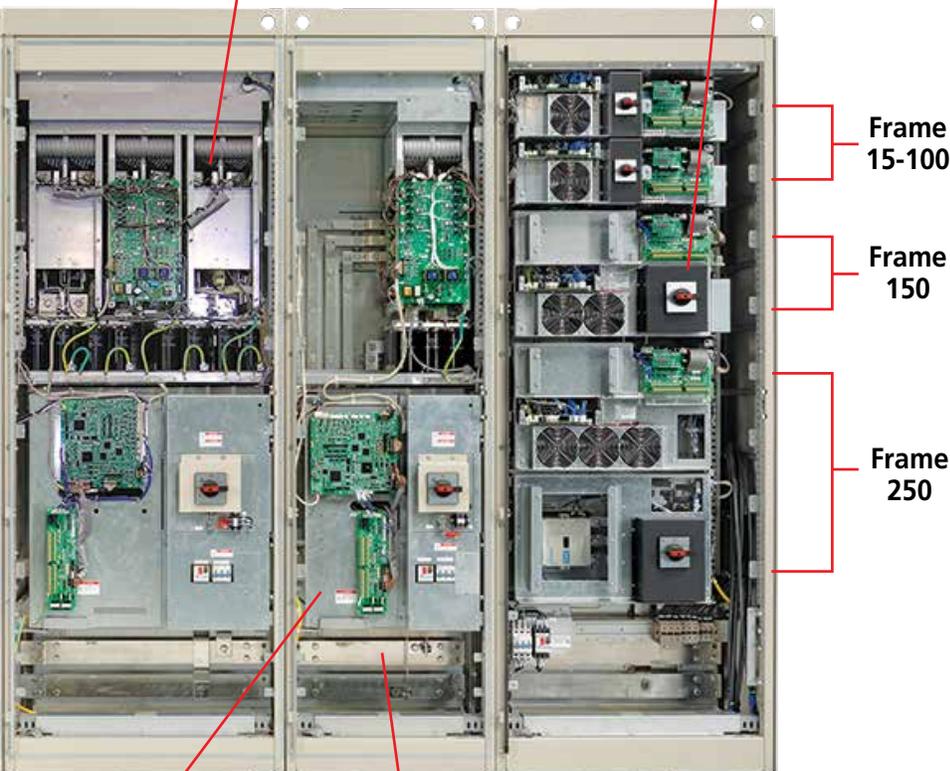
Reliable low voltage ac system drive technology designed to reduce cost of ownership:

- 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

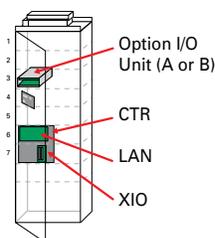
TMdrive-10e2 features a flexible I/O system allowing a variety of I/O to connect directly to each inverter. Standard I/O shown below is always supplied. Additionally, either option unit A or B may be specified to extend I/O capability.

Standard I/O

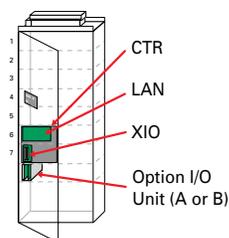
Digital Inputs	<ul style="list-style-type: none"> Quantity 2 for UVS (SIL 2) Quantity 4 configurable mapping
Digital Outputs	<ul style="list-style-type: none"> Quantity 2 for UVS (SIL 2) Quantity 4 user defined Open Collector
Analog Inputs	<ul style="list-style-type: none"> Quantity 1 configurable Differential 13-bit resolution
Analog Outputs	<ul style="list-style-type: none"> Quantity 1 user defined Non-Isolated 10-bit resolution
(Optional) Speed Feedback Resolver Input	<ul style="list-style-type: none"> Excitation frequency of 1 or 4 kHz Source for resolvers is Tamagawa: www.tamagawa-seiki.co.jp
Speed Feedback Encoder Input	<ul style="list-style-type: none"> A quad B with marker Maximum frequency of 100 kHz Differential or single-ended 5 or 15 V dc
Speed Tach Follower Output	<ul style="list-style-type: none"> A quad B with marker Maximum frequency of 100 kHz
Motor Temperature Feedback	<ul style="list-style-type: none"> High-resolution torque motor temperature feedback 1 kΩ positive temperature coefficient RTD or other sensor requires selecting Option Unit

Option I/O Unit A

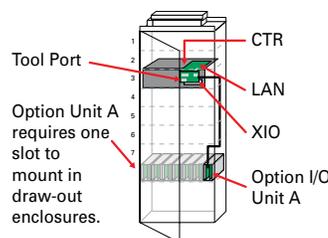
Digital Inputs	<ul style="list-style-type: none"> Adds Quantity 5 configurable Relay or solid state
Digital Outputs	<ul style="list-style-type: none"> Adds Quantity 5 user defined Relay (1 A) or solid state (70 mA)
Analog Inputs	<ul style="list-style-type: none"> Adds one isolated channel
Analog Outputs	<ul style="list-style-type: none"> Adds one isolated channel



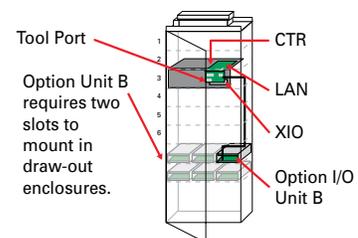
Cubicle Panel (600 mm)



Cubicle Panel (800 mm)



Draw-out Panel (Option A)



Draw-out Panel (Option B)

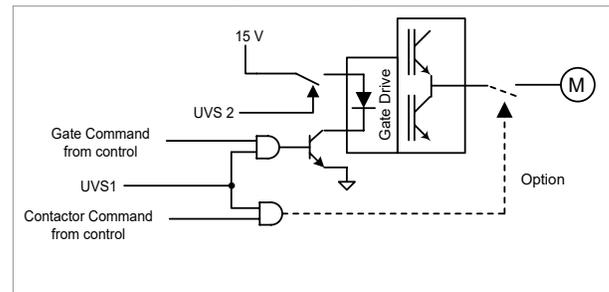
LAN Interface Options

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 B

Digital Inputs	<ul style="list-style-type: none"> Adds Quantity 6 configurable Relay or solid state
Digital Outputs	<ul style="list-style-type: none"> Adds Quantity 6 user defined Relay (1A) or solid state (70mA)
Analog Inputs	<ul style="list-style-type: none"> Adds two isolated channels
Analog Outputs	<ul style="list-style-type: none"> Adds two isolated channels

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



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



RJ-45 Ethernet port is used for local tool connection

Interlock button disables the drive

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.

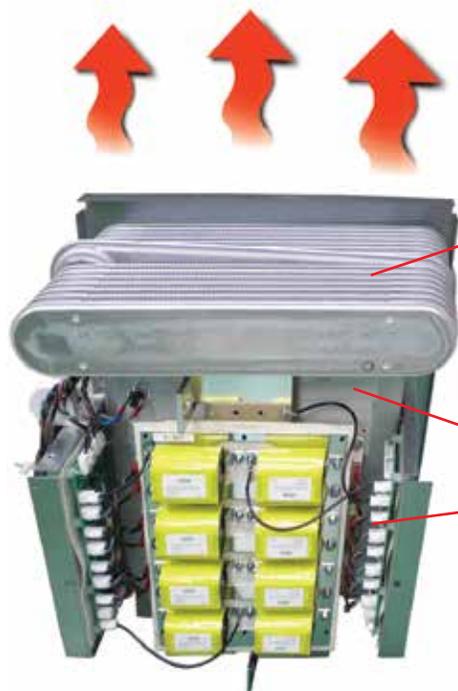
Heat Pipe Technology Used In TMdrive-10e2

This dramatic advance in power bridge cooling design provides:

- Significant reduction in the footprint of the power bridge
- Lower audible noise

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-channelled 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.



Thermal Cycle

Condensing unit with several fins for the flow of refrigerant

Vapor To Condensate

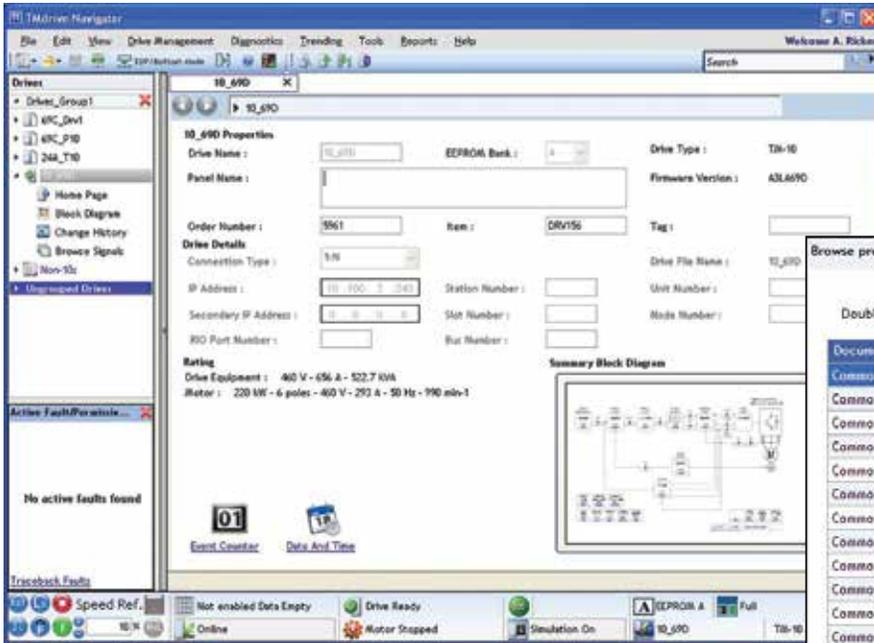
The refrigerant cools while moving through the condensing unit. Cooling air is pulled vertically through the power bridge and then the condensing unit by both convection and fans mounted in the top of the cabinet. The multi-channelled chill plate contains a CFC free refrigerant which is practically non-toxic to humans and ozone friendly.

IGBT power switches.

Return Of Condensate

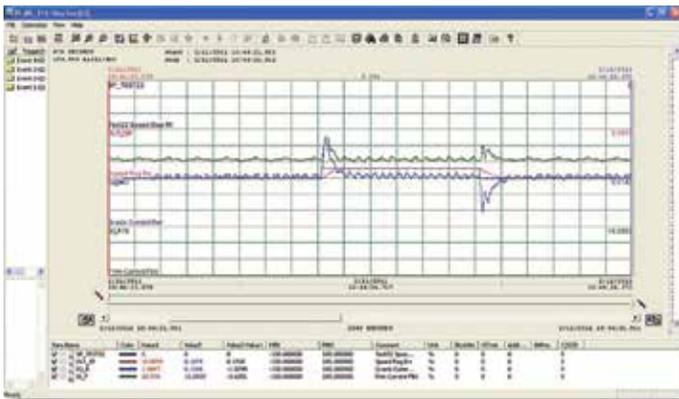
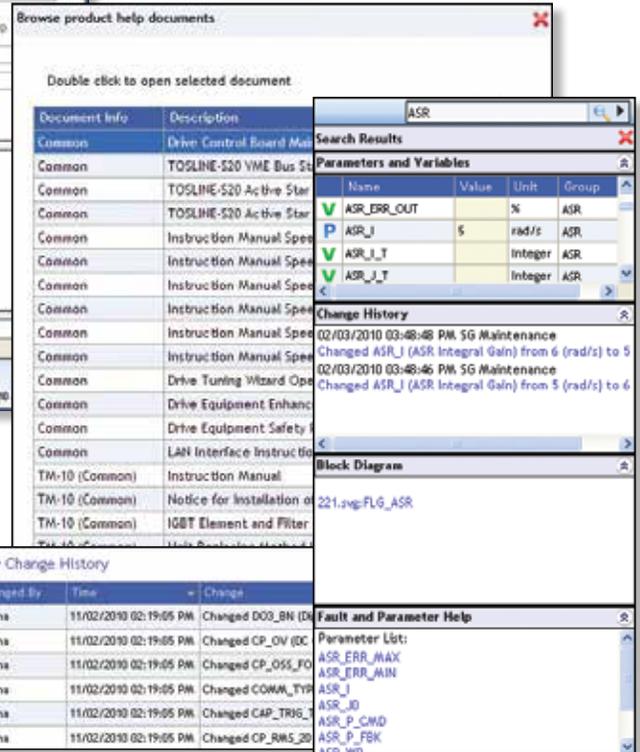
The condensate (refrigerant in liquid form) returns to the bottom of the multi-channelled chill plate for the beginning of another thermal cycle.

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.

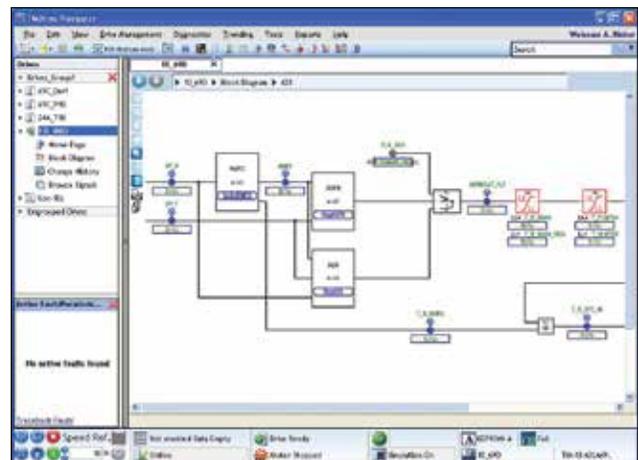
Wizards support tuning of drive functions.

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

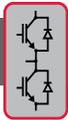
Product documentation is integrated right into the tool. Users can even capture their own notes to benefit future troubleshooting.

Compatible with:

- Windows XP, Vista, 7
- Windows Server 2003, 2008

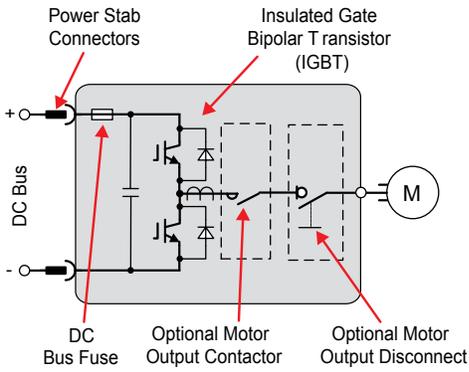


A Low Voltage Power Bridge Topology To Fit Your Application

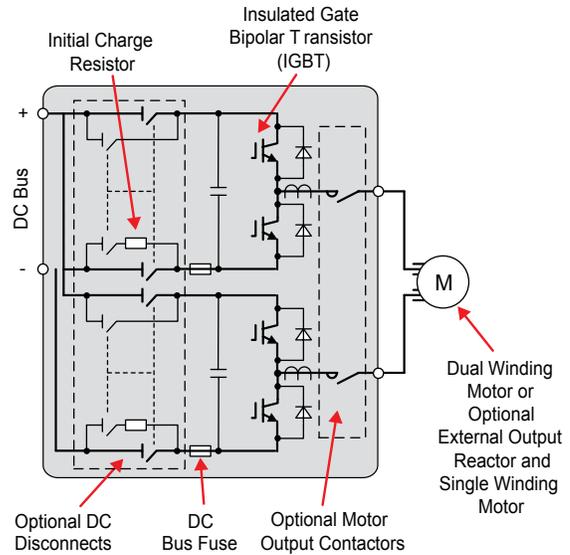


TMdrive-10e2 Inverter Topologies

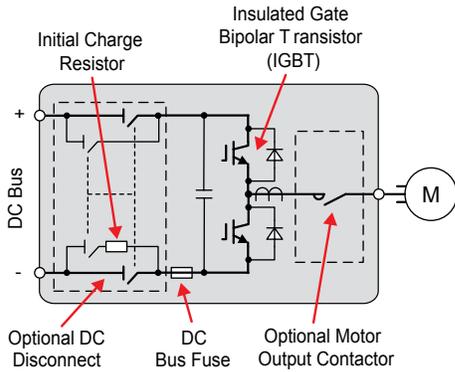
Frames 15-250



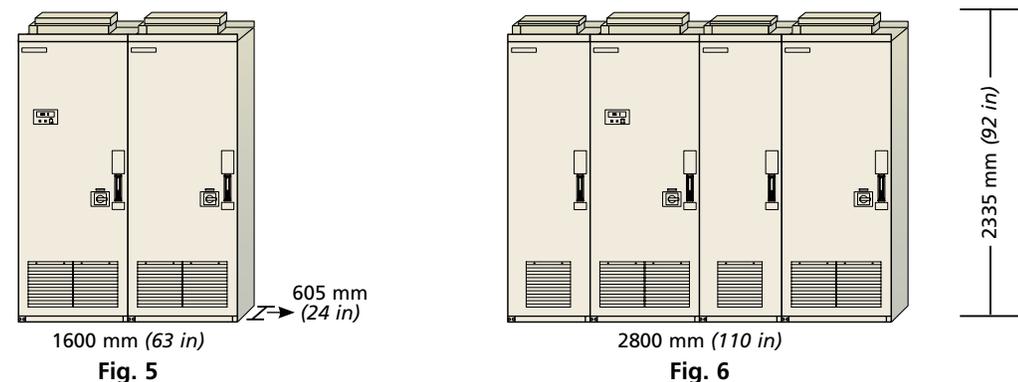
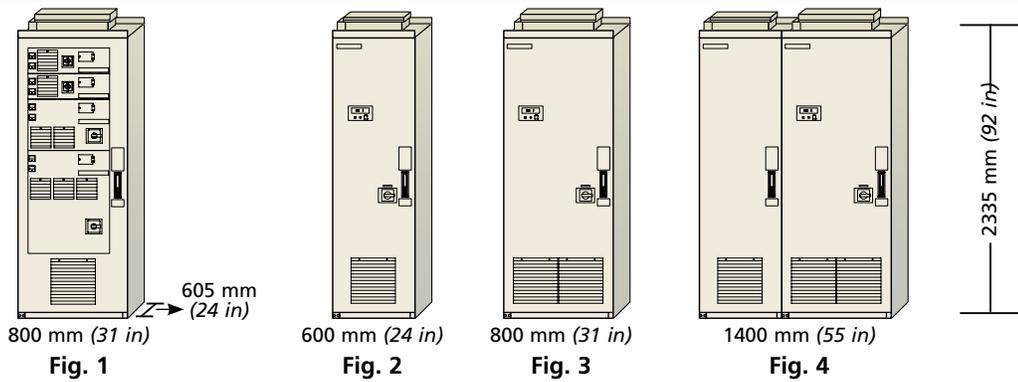
**460 V Frames 1200-1800
690 V Frames 1500-2400**



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



TMdrive-10e2 Inverter Enclosures



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%

Inverter Notes

- 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.
- 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.
- 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.
- 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.
- Inverters support bottom cable entry. Top cable entry is supported with one 600 mm (24 in) auxiliary cabinet between every two inverter cabinets.
- Each of the inverters requires 3-phase control power.
- For high-performance torque regulation, a temperature sensor is mounted in the motor.
- 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.
- Air is pulled in through the front and out through the top for all cabinets. $\text{Response} = \frac{3T_{\text{acc}}}{\text{ms}}$ (radians/s)
- The dc bus for the lineup has a maximum current capacity of 2350 amps.
- For frames 2-250, add 500 VA of control power for inverter enclosure.

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)

Motor Control

With Speed Sensor (Resolver or Encoder)	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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%

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	1 Single (200 VA)	25 (55)	0.6	22.5 (30)			36						45				100
							28						35				150
							18						22				300
60	1 Single (200 VA)	28 (62)	1	48 (64)			76						95				100
							60						75				150
							34						43				300
100	1 Single (200 VA)	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	3 (650 VA)	470 (1036)	10.8	602 (806)	829	797	829/819	1040	1000	1040/1028					100		
							745						935				150
							382						479				300
900	3 (650 VA)	480 (1058)	13.8	740 (992)	1020	797	1020	1280	1000	1280					100		
					916	797	916	1150	1000	1150					150		
							492						617				300
900 [†]	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	5 (1.3 kVA)	940 (2072)	21.6	1203 (1612)	1657	1593	1657/1638	2080	2000	2080/2056					100		
							1490						1870				150
							763						958				300
1800	6 (1.54 kVA)	960 (2116)	27.6	1479 (1983)	2040	1593	2040	2560	2000	2560					100		
					1833	1593	1833	2300	2000	2300					150		
							983						1234				300
1800 [†]	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

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	
30	1 Single (200 VA)	25 (55)	0.6	25 (34)	31				26				100
					31				26				150
					22				18				300
60		28 (62)	0.9	46 (62)	69				58				100
					57				48				150
					31				26				300
100		28 (62)	1.5	69 (93)	102				85				100
					86				72				150
					48				40				300
150	1 Double (300 VA)	53 (117)	2.7	114 (152)	141				118				100
					141				118				150
					102				85				300
250	1 Quad (300 VA)	83 (183)	3.9	193 (259)	239				200				100
					239				200				150
					139				116				300
400	2 (350 VA)	280 (617)	5.4	313 (420)	442				370				100
					388				325				150
					213				178				300
600	3 (650 VA)	460 (1014)	9.6	511 (685)	789				660				100
					633				530				150
					339				284				300
750		470 (1036)	12	627 (841)	944				790				100
					777				650				150
					430				360				300
900		480 (1058)	13.2	723 (970)	1052				880				100
					896				750				150
					490				410				300
1200	974 (1306)	16.2	974 (1306)	1374	1195	1374	1150	1000	1150	100			
				1207	1195	1207	1010	1000	1010	150			
				639				535				300	
1200 ¹	4 (770 VA)	790 (1741)	16.2	974 (1306)	1374				1150				100
					1207				1010				150
					639				535				300
1500	5 (1.3 kVA)	940 (2072)	24	1254 (1681)	1888				1580				100
					1554				1300				150
					860				720				300
1800		960 (2116)	26.4	1447 (1940)	2103				1760				100
					1793				1500				150
					980				820				300
2400		960 (2116)	32.4	1949 (2613)	2749	2390	2749	2300	2000	2300	100		
					2414	2390	2414	2020	2000	2020	150		
					1279				1070				300
2400 ¹	6 (1.54 kVA)	1580 (3483)	32.4	1949 (2613)	2749				2300				100
					2414				2020				150
					1279				1070				300

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.
- 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.
- 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.

$$kW_{\text{shaft}} = 150 \text{ kW} \quad (201 \text{ hp})$$

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).

$$I_{\text{ac Inverter}} = \frac{kW_{\text{shaft}} \times 1000 \times SF_{\text{Mtr}}}{\text{Eff}_{\text{Mtr}} \times \text{PF}_{\text{Mtr}} \times 3 \times V_{\text{Motor rated voltage}}}$$

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

$$= 297 \text{ amps}$$

Frame	Motor Current A				Allowable Overload %
	No Options	Both Options	Only Contactor	Only Disconnect	
400			504		100
			455		150
	263				300

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.
- 2** Compute continuous ac current requirement of the converter based on its power requirements.
- 3** Scan the 150% for 60 sec entries in the regenerative converter tables for a frame where the continuous current rating exceeds 203 amps.

$$kW_{\text{dc}} = \frac{kW_{\text{shaft}}}{\text{Eff}_{\text{Mtr}} \times \text{Eff}_{\text{Inv}} \times \text{Eff}_{\text{Conv}}}$$

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

$$= 162 \text{ kW}$$

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

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

$$= 203 \text{ amps}$$

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

$$kW_{\text{dc}} = kW_{\text{shaft}} \times (\text{Eff}_{\text{Mtr}} \times \text{Eff}_{\text{Inverter}} \times \text{Eff}_{\text{Conv}})$$

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

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

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

$$= 652 \text{ V}$$

Assumptions:

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

$$I_{\text{dc Converter}} = \frac{kW_{\text{shaft}} \times 1000}{\text{Eff}_{\text{Mtr}} \times \text{Eff}_{\text{Inv}} \times V_{\text{dc Bus}}}$$

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

$$= 245 \text{ amps}$$

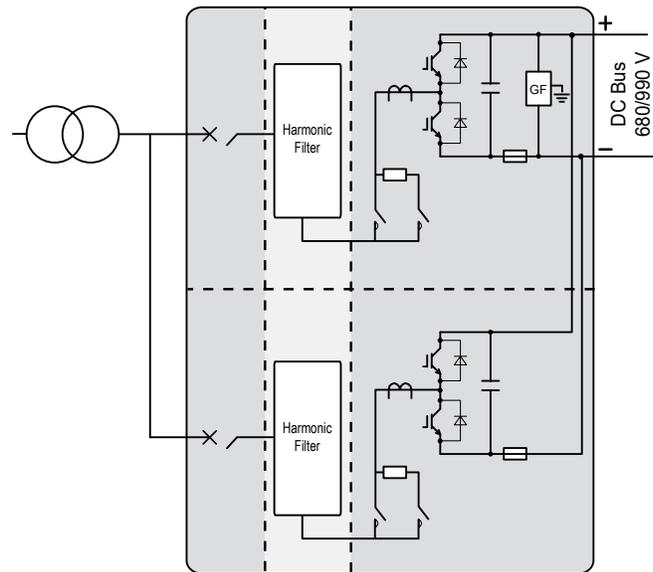
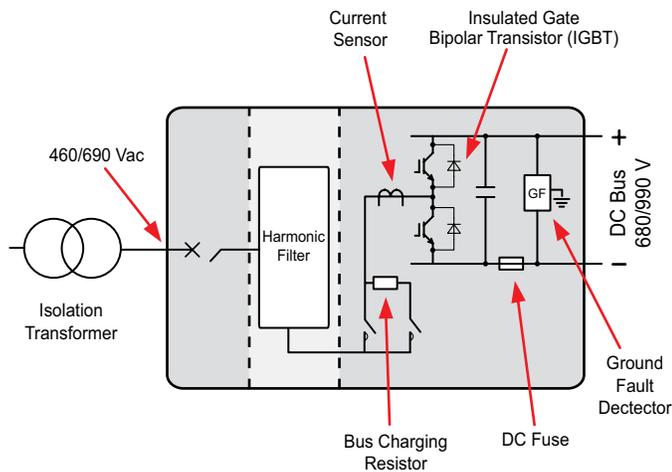
Flexible Converter Topologies To Fit Your Application

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

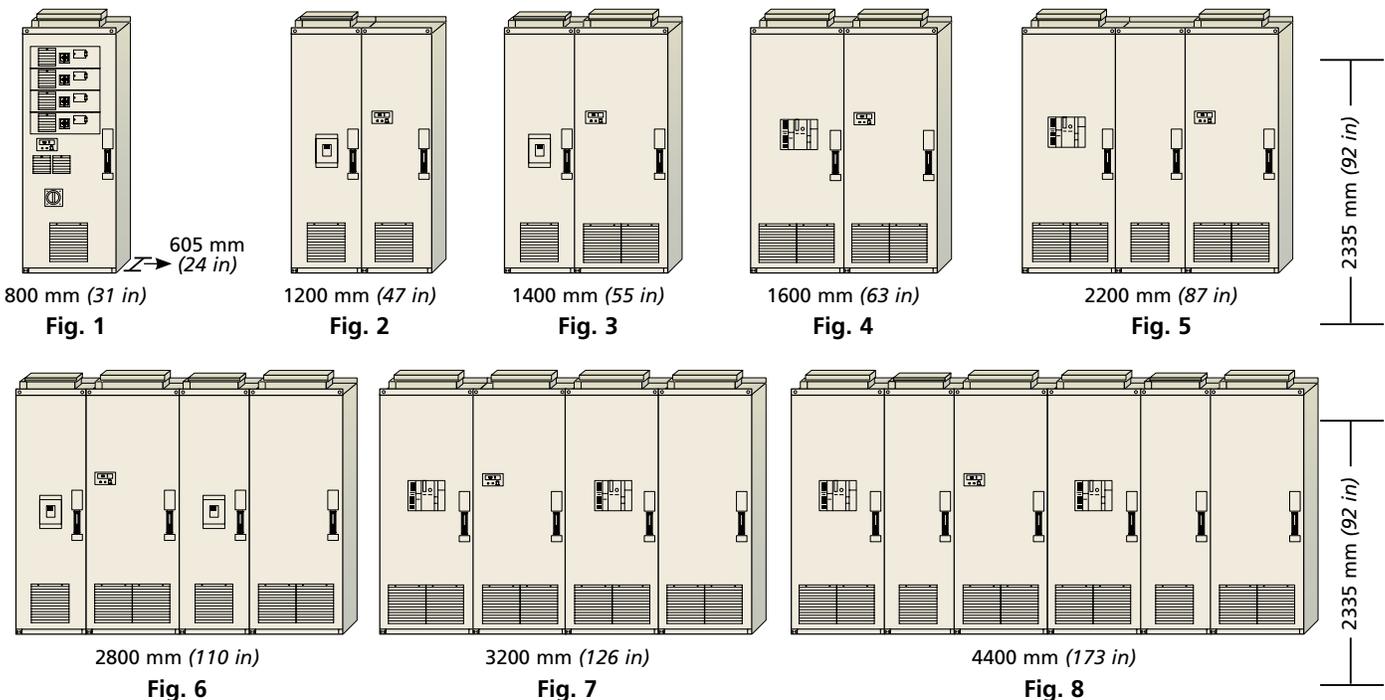
Frames 1500-2400



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



TMdrive-P10e2 Converter Enclosures



The figures shown include AC breakers.

Converter Specifications

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 dimensions. 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

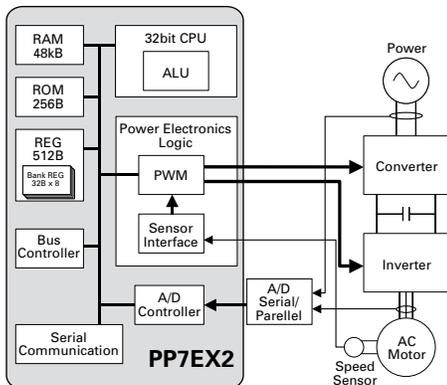
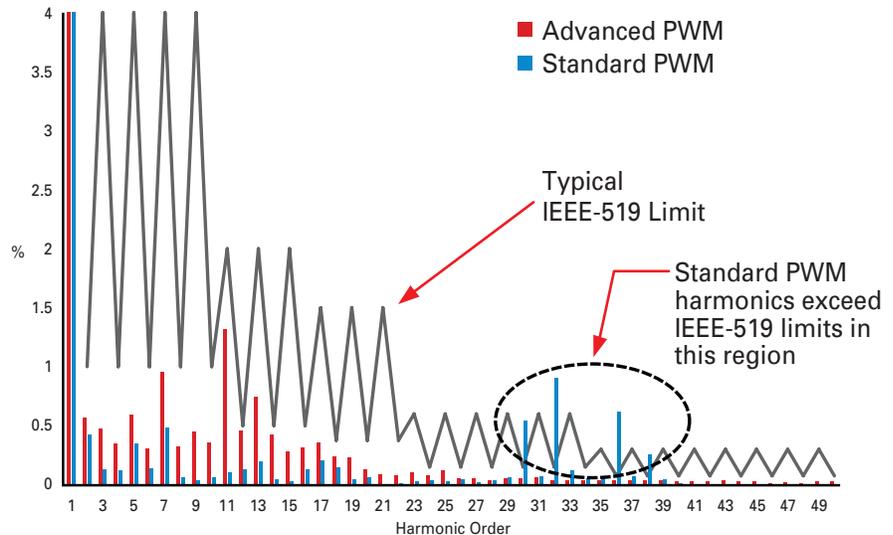


Fig. 1. Functional control block diagram.



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

TMdrive-P10e2 Converter Specifications

460 V Design

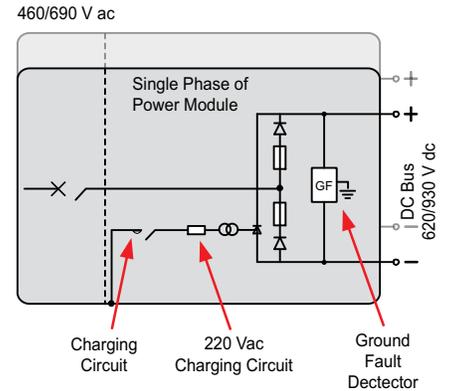
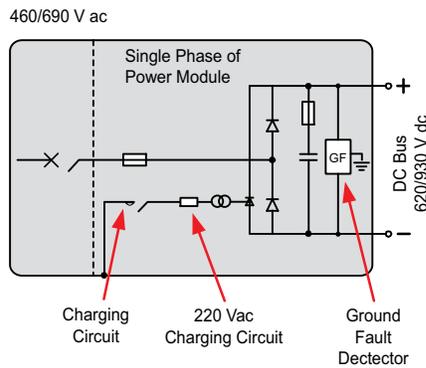
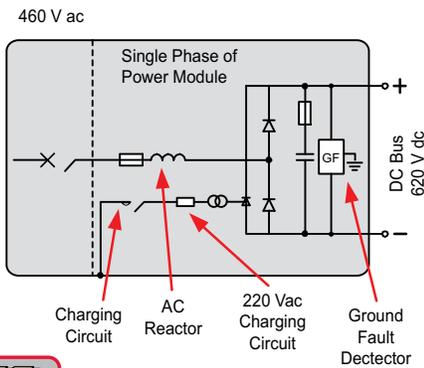
Frame	Voltage V	AC Current A	Allowable Overload %	Control Power kVA	Losses kW	Capacity kW	IEC Design				UL Design			
							Encl. Fig. #	MCCB Short Circuit kA	Weight kg (lbs)	Width mm (in)	Encl. Fig. #	MCCB Short Circuit kA	Weight kg (lbs)	Width mm (in)
150	460	170	150	0.2	2.3	130	1	50	540 (1190)	800 (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



Preliminary TMdrive-D10e2 Diode Converter Ratings

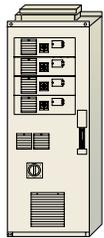


Fig. 1

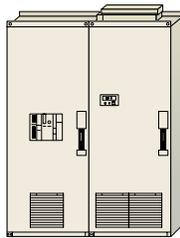


Fig. 2

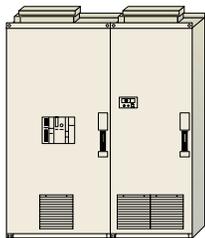


Fig. 3

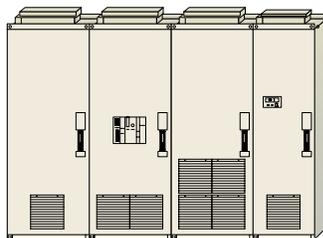


Fig. 4

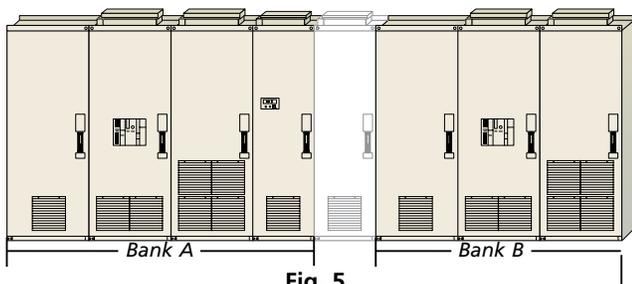


Fig. 5

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

- 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.
- Converters larger than frame 150 require external reactance of 3% minimum. Normally, a dedicated transformer is sufficient to satisfy this requirement.
- Dual bank converters require separate transformer windings for each half bridge.
- The currents ratings shown allow 150% overloads for 60 seconds.
- The 460Vac 150 frame converters have an option for an IGBT braking module rated for 400A. Resistors with the ratings appropriate for the application must be supplied and externally mounted to use this function.
- Enclosures shown on this page include option of circuit breaker, but without built-in ACL (except Frame 150).
- 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.
- 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.

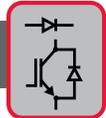
In situations where the regenerative power requirement is significantly different from motoring power requirement, hybrid converters offer a cost effective solution by using a diode converter for motoring and PWM converter for regeneration.

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

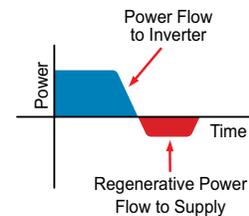
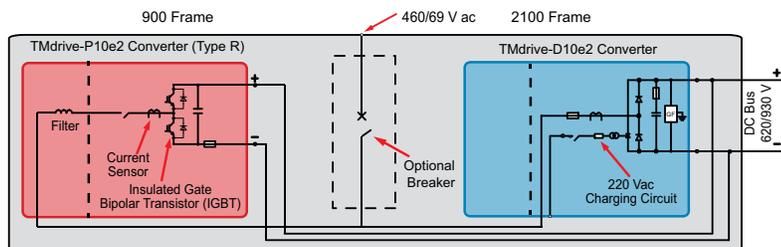
1 Select diode converter using the **Non-Regenerative converter** example on **page 14** using the required motoring power.

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

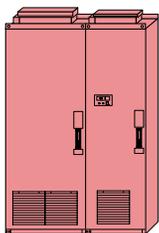


Hybrid Converter Lineup Example

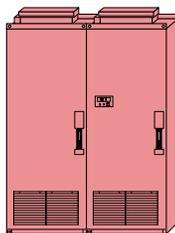
TMdrive-P10e2 (Type R) Enclosures

+ TMdrive-D10e2 Converter Enclosures

= Hybrid Converter Enclosure



1400 mm (55 in)
Frame 400



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

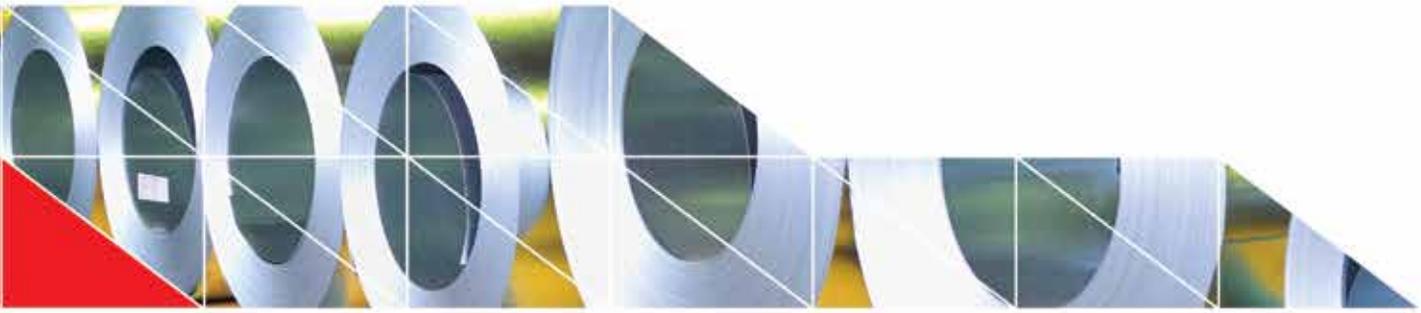


Frame 400
TMdrive-P10e2 Type R
Converter

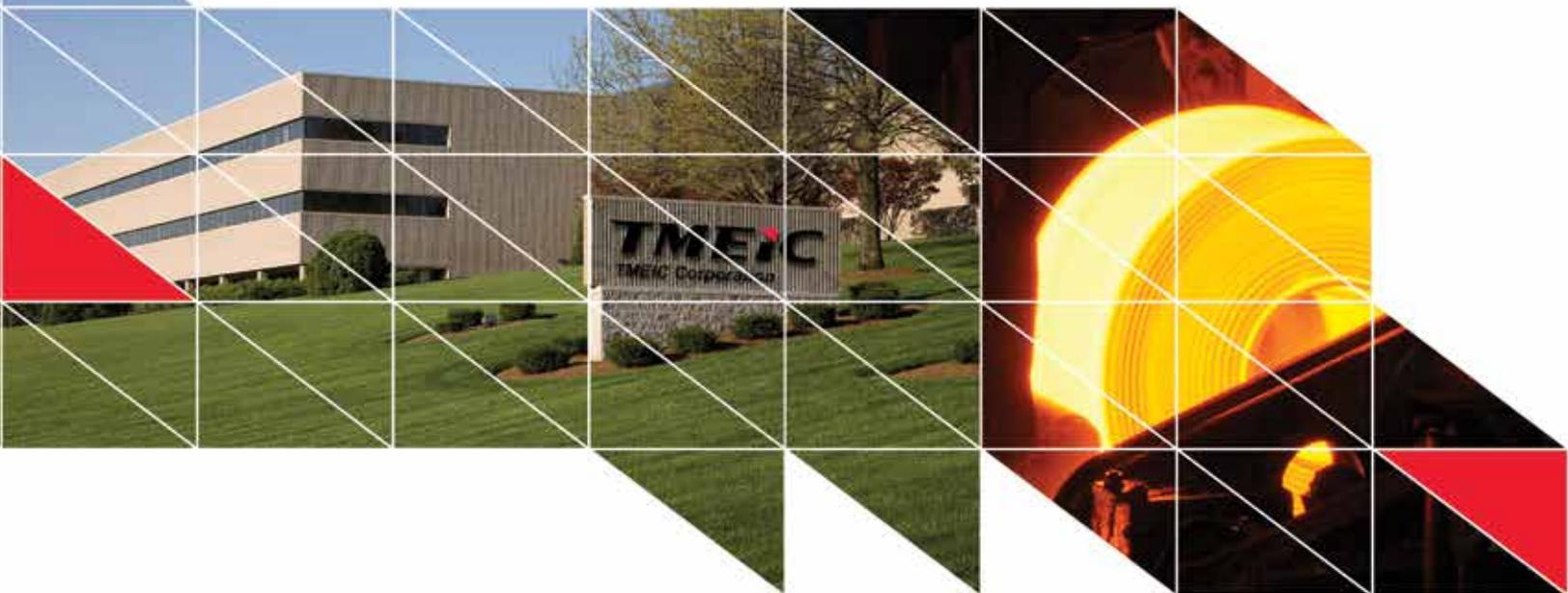
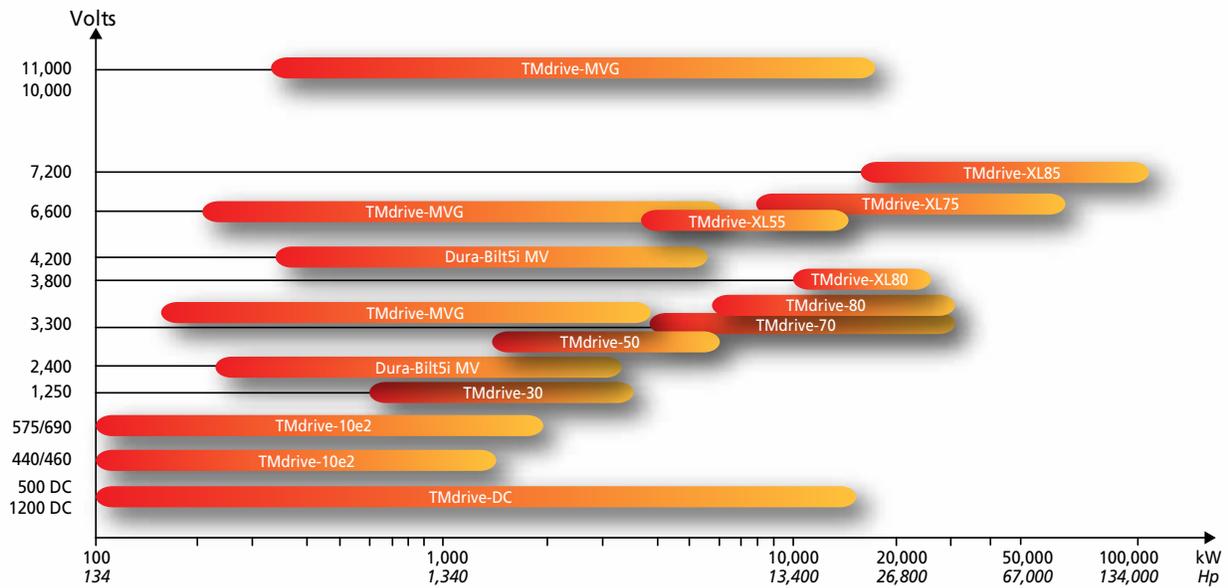
Frame 600
TMdrive-D10e2
Converter

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

(see page 18)



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