TMEiC
We drive industry

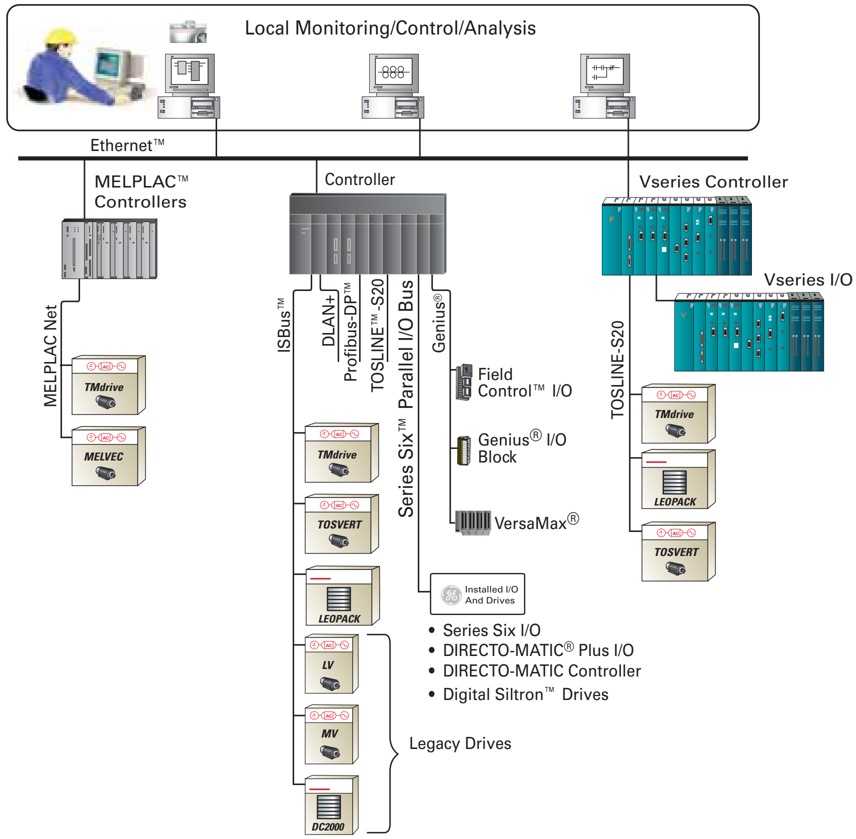
TMdrive®-10 Product Application Guide

Low Voltage IGBT System Drive

metals | cranes | mining | testing | oil & gas | cement | utilities | paper

The family of TMdrive® ac system drives is targeting specific customer requirements for:

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



TMdrive-10

Features	Benefits
• Heat Pipe Cooling Technology The cabinet-based IGBT power bridges use heat pipe cooling technology.	• Reduces Footprint and Lowers Audible Noise This technology reduces the footprint of the drive, saving valuable floor space. It also lowers the required cooling-air speed, significantly reducing the associated audible noise.
• Microsoft® Windows®-Based Configuration The toolbox is used to configure, install, and maintain the TMdrive–10 drives.	• Common Tool Across All System Drives This common tool for all of our system drive products is a source of productivity for the life of the system. • Flexible Tool Connectivity Native Ethernet drive interface allows flexible toolbox communications point-to-point, over a control LAN or even via your factory LAN.
• LAN Options: • ISBus • TOSLINE-S20 • Profibus-DP • DeviceNet™ • Modbus RTU/Ethernet • EGD	• Multiple Controller Platforms Supported For virtually all controller platforms, these LAN options provide seamless integration with the rest of your factory. Either ISBus or Ethernet can be used to provide configuration/diagnostic support with the Windows-based tool. • Connectivity to Legacy Equipment Existing equipment can be seamlessly integrated into new systems.

Bringing Reliable Control To System Applications

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

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

In the automation of container cranes, tight integration between the system drives and the controller is a requirement. The high-performance networks provide:

- Run-time control at 1-8 ms
- Remote connectivity for toolbox configuration and monitoring

A Look Inside

Two-Level Phase Leg Assembly

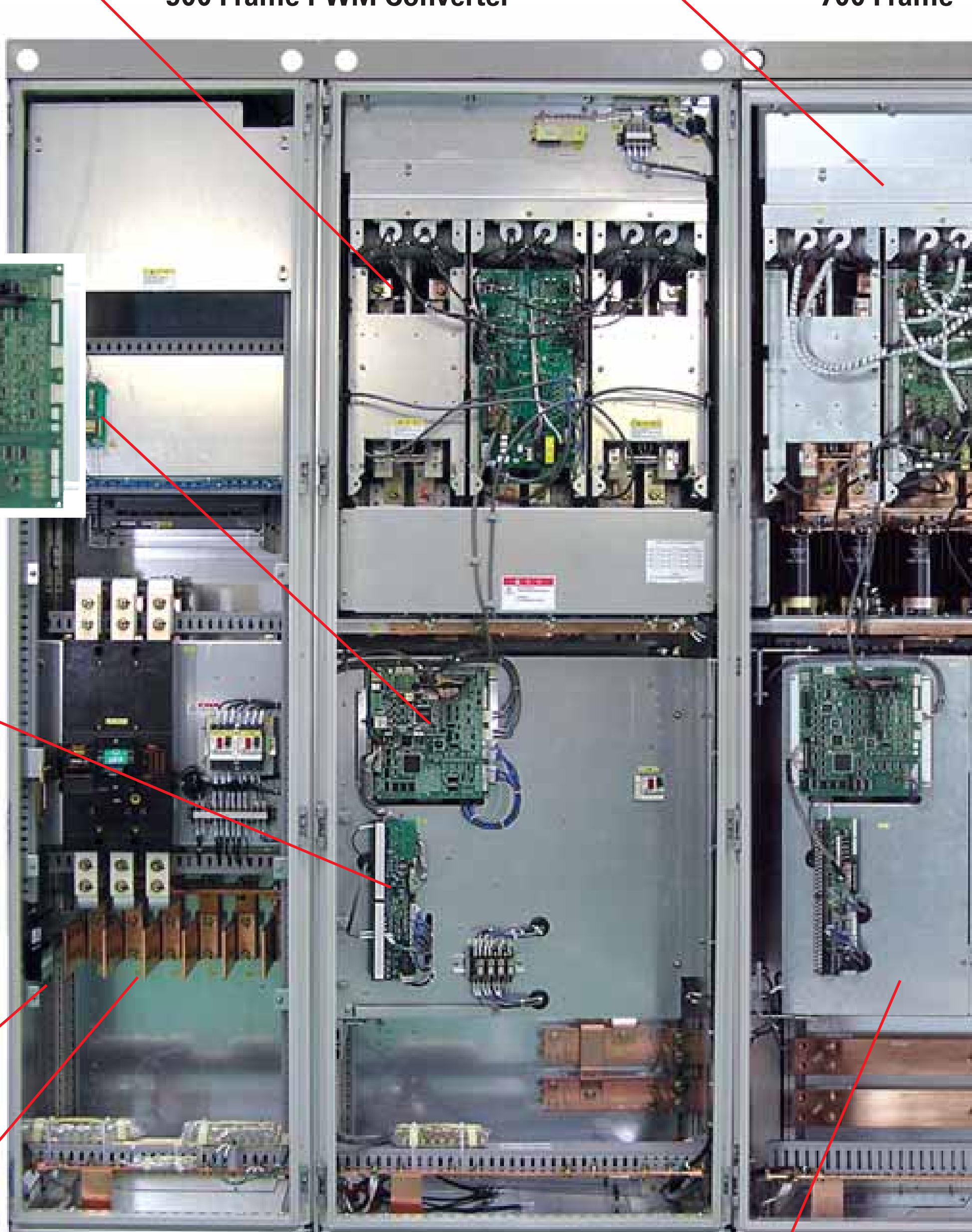
The cabinet style inverters have modular two-level phase leg assemblies.
Each phase leg includes:

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

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 dramatically reducing the audible noise.

900 Frame PWM Converter **700 Frame**

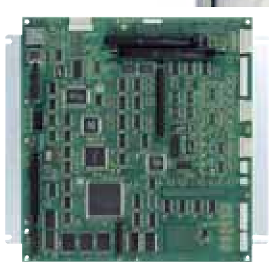


Control Functions

Each inverter and regenerative converter shares a common set of control boards. The primary control board performs several functions:

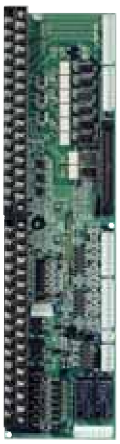
- Speed and torque regulation
- Sequencing
- I/O mapping
- Diagnostic data gathering

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



I/O Board

All TMdrive–10 products share a common I/O board. The I/O board supports an encoder, 24 V dc I/O, 115 V ac inputs, and analog I/O, standard. In addition, a resolver interface option can be provided. All I/O are terminated to a two-piece modular terminal block for ease of maintenance.



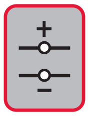
Control **Main**

Incoming Power (Main and Control)

The converter in each lineup is fed 3-phase ac power. 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.

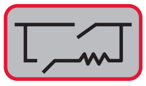


DC Bus
The converter in each lineup generates dc power for each of the inverters. The inverters then create variable frequency ac power to control the induction motors. This dc power for the lineup is conveyed on a solid copper bus near the bottom of the cabinets. Tin-plated bus may be used as an option.

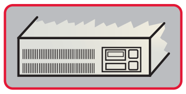
Inverter **300 Frame Inverter** **Draw-Out Style Inverters**

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
- **Common control hardware** that lowers the cost of spare parts inventory



Inverter DC Bus Disconnect
Cabinet style inverters can be equipped with an optional dc bus disconnect to allow lockout of individual inverters. The draw-out style inverters are tied to the dc bus using a set of staggered stab connectors that provide proper charging.



Draw-Out Style Inverters
For applications up to 130 kVA (140 hp), a draw-out style converter and inverters are available in a very compact package. Draw-out inverters are mounted on heavy-duty slides with staggered dc bus 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.

A Low Voltage Power Bridge Topology To Fit Your Application

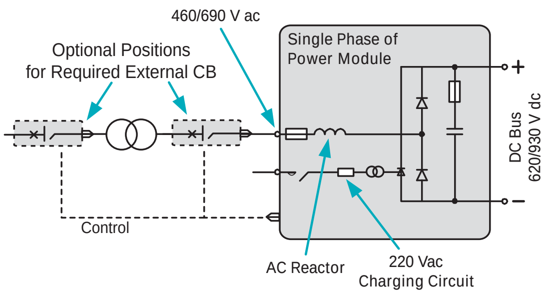
TMdrive–10 Converter Technologies

Frame | **Power Switch Technology**

TMdrive-D10™

150
600
1200
1800
2400
3000
3600

Non-Regenerative Diode-Based Power Bridge

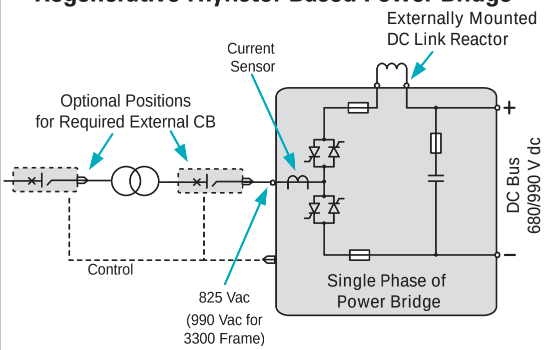


- **150 frame includes Internal Circuit Breaker**

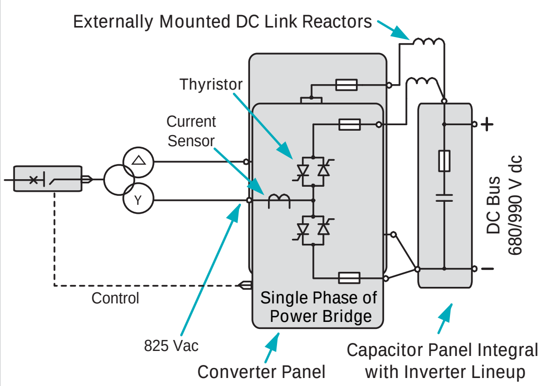
TMdrive-T10™

800
1600
3300

Regenerative Thyristor-Based Power Bridge



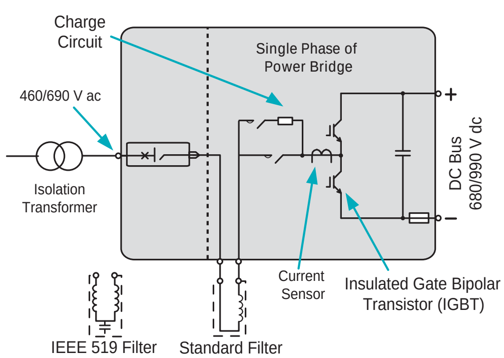
3200



TMdrive-P10™

125
300
700
900
1400
1800

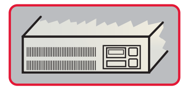
Regenerative with Power Factor Correction IGBT-Based Power Bridge



- **Filters can be connected directly to transformer secondary if desired**

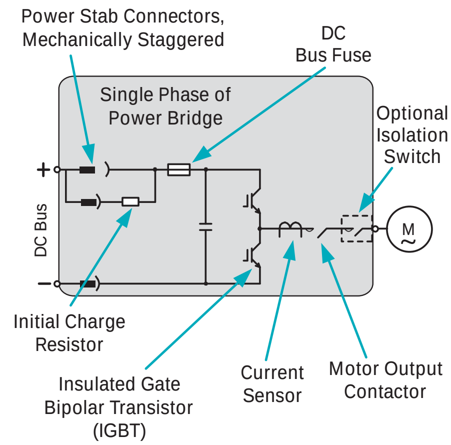
TMdrive–10 Inverter Topologies

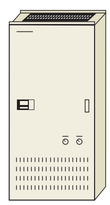
Inverter Frame | **Topology**



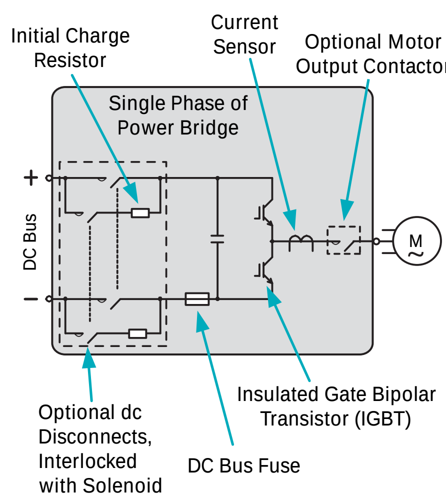
Draw-Out Construction

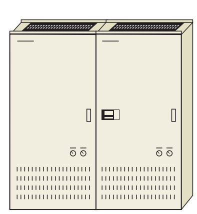
4
8
15
25
45
75
125



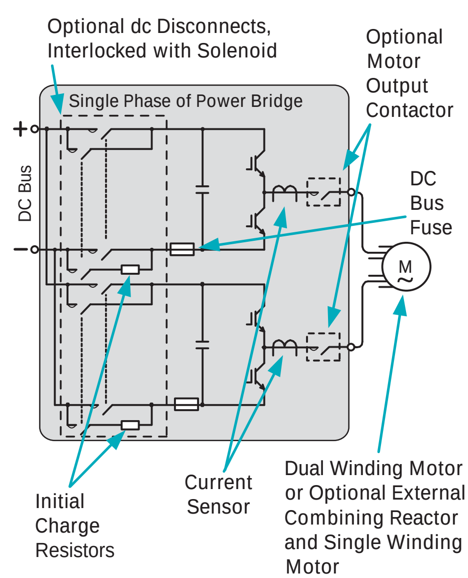


200
300
400
500
700
900



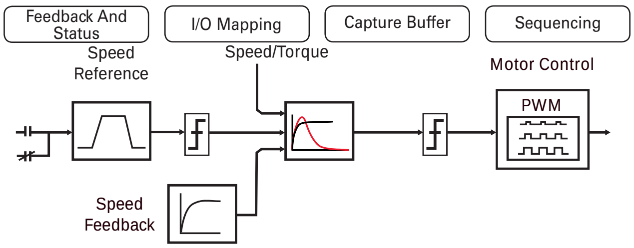


1000
1400
1800



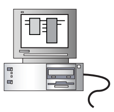
A Common Control To Reduce Cost Of Ownership

Control Functions



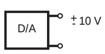
Instrumentation Interface

Configuration



- RJ-45 Ethernet interface
- 10 Mbps maximum
- Drive Navigator option of TOSLINE-S20 to Ethernet connection using V-Series controller as gateway
- Toolbox option of ISBus to Ethernet using Innovation Series controller as gateway

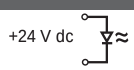
Meter Outputs



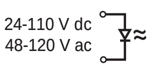
- Motor current A and B, ±10 V
- Quantity 5 configurable, ±10 V, 8-bit resolution

I/O Interface

Digital Inputs

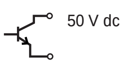


- Opto-coupled 20 mA
- Quantity 6 configurable mapping



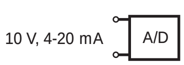
- Opto-coupled 10 mA
- Quantity 1 configurable mapping
- Quantity 1 dedicated mapping

Digital Outputs



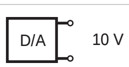
- Open collector 70 mA
- Quantity 6 user defined

Analog Inputs



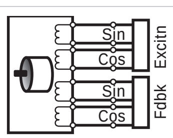
- Quantity 2 ±10 V or 4-20 mA
  - Differential 8 kΩ input impedance
  - 12-bit resolution
- Optional Quantity 2 ±10 V
  - 12 bit resolution *(Optional for Inverters only)*

Analog Outputs



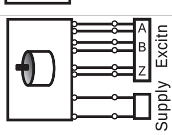
- Quantity 3 ±10 V, 10 mA max
- User defined
- 8-bit resolution

(Optional) Speed Feedback Resolver Input



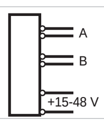
- Excitation frequency of 1 or 4 kHz
- Source for resolvers is Tamagawa: www.tamagawa-seiki.co.jp

Speed Feedback Encoder Input



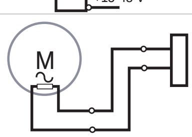
- A quad B with marker
- Maximum frequency of 100 kHz
- Differential 5 or 15 V dc
- 5 or 15 V dc at 200 mA supply

Speed Tach Follower Output



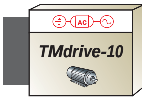
- Maximum frequency of 10 kHz
- External 15-24 V dc at 100 mA max

Motor Temperature Feedback



- High-resolution torque motor temperature feedback
- 1 kΩ positive temperature coefficient RTD or other sensor using optional signal conditioning module

LAN Interface Options



ISBus

- Supports both run-time control (10 words in and 10 words out) and Toolbox configuration/monitoring using the Innovation Series controller as a gateway between the ISBus and Ethernet
- RS-485 or optional fiber-optic bus in a synchronous ring configuration
- 5 Mbps master/follower (drive is the follower) protocol using copper or fiber; bus scan time based on the number of nodes:

Quantity of Nodes	Bus Scan Time
2-4	1 ms
17-32	8 ms

TOSLINE-S20

- Supports run-time control (6 words in and 10 words out) from an Innovation Series controller or V Series controller
- Drives can directly exchange data between themselves (4 words)
- Fiber-optic bus in a star configuration
- 2 Mbps peer-to-peer protocol; bus scan time based on the number of nodes:

Quantity of Nodes	Bus Scan Time
2-3	1 ms
9-64	25 ms

Modbus

- Supports run-time control (fixed 10 words in/out) from a Modbus-RTU controller
- RS-485 copper bus
- 1.2 kbps to 57.6 kbps master/follower protocol; update rates up to 20 ms/node possible at the highest baud rate
- Number of notes: 127 max per LAN

Profibus-DP™

- Supports run-time control (6 words in and 10 out) from a Profibus-DP master controller
- Copper bus in a daisy-chain configuration
- 9.6 kbps to 12 Mbps master/follower protocol; bus scan time based on the number of nodes

DeviceNet™

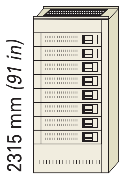
- Supports run-time control (4 words in and 10 words out) from a DeviceNet master controller
- Copper bus in a daisy-chain configuration
- 125 kbps to 500 kbps master/follower protocol; bus scan time based on the number of nodes

Ethernet Global Data (EGD)

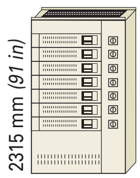
- Supports run-time control (10 Words in/out)
- RJ-45 Ethernet interface
- Update rates up to 20 ms using standard 10 Mbps hardware or rates up to 2 ms with optional 100 Mbps card
- Drives can exchange data directly
- Supports peer to peer operation (No master needed)
- No limit to maximum number of nodes

Note: 1 word = 16 bits

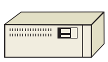
Inverter Specifications
For Models With DC Disconnects



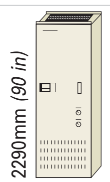
Control Power (CP) = 160 VA for each single high inverter and 200 VA for double high inverters plus 440 VA for the cabinet.



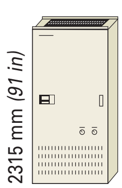
Single High Inverters



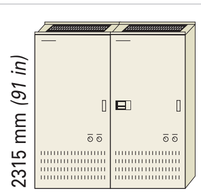
Double High Inverters



CP = 350 VA



CP = 650 VA



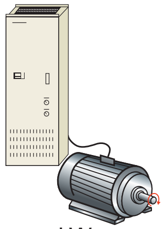
CP = 1.3 kVA

			440/460 V ac				575/690 V ac		
Frame	Weight kg *(lbs)*	Full Load Losses kW	440 V Inverter kVA/ Motor kW *(hp)*	460 V Inverter kVA/ Motor kW *(hp)*	Motor Current A ac	Allowable Overload %	575 V Inverter kVA/ Motor kW *(hp)*	690 V Inverter kVA/ Motor kW *(hp)*	Motor Current A ac
4	31 *(68)*	0.2	3.8/3.1 *(4.1)*	4/3.2 *(4.3)*	5 4.5 4 3.2 2.7	100-150 175 200 250 300	3.2/2.7 *(3.4)*	4/3.3 *(4.3)*	3.2 2.7 2.5 2.0 1.7
8	31 *(68)*	0.3	7.5/6.1 *(8.2)*	8/6.4 *(8.6)*	10 9 8 6.5 5.5	100-150 175 200 250 300	6.5/5.5 *(7)*	8/6.5 *(8.5)*	6.5 5.5 5.0 4.0 3.5
15	31 *(68)*	0.4	15/12 *(16)*	16/13 *(17)*	20 18 16 13 11	100-150 175 200 250 300	13/11 *(14)*	16/13 *(17)*	13 11 10 8 7
25	33 *(73)*	0.5	26/21 *(28)*	27/22 *(29)*	34 30 27 23 19	100-150 175 200 250 300	23/18 *(24)*	27/22 *(29)*	23 19 17 14 11
45	34 *(75)*	0.7	45/36 *(48)*	47/38 *(51)*	59 52 47 39 34	100-150 175 200 250 300	39/32 *(42)*	47/38 *(51)*	39 34 29 24 20
75	36 *(79)*	1.2	75/61 *(82)*	78/63 *(84)*	98 87 78 65 56	100-150 175 200 250 300	58/47 *(63)*	70/57 *(75)*	59 50 44 35 29
125	57 *(125)*	2.0	125/101 *(135)*	131/106 *(142)*	164 146 131 109 94	100-150 175 200 250 300	110/89 *(119)*	131/106 *(142)*	110 94 82 66 55
200	255 *(561)*	3.2	201/162 *(217)*	210/170 *(227)*	264 235 211 176 151	100-150 175 200 250 300	175/142 *(189)*	210/170 *(227)*	176 151 132 106 88
300	260 *(572)*	4.4	277/224 *(300)*	289/233 *(313)*	363 323 290 242 202	100-150 175 200 250 300	241/194 *(261)*	289/233 *(313)*	242 207 182 145 121
400	425 *(935)*	6.3	402/325 *(436)*	421/340 *(456)*	528 469 411 329 274	100-150 175 200 250 300	351/283 *(380)*	421/340 *(456)*	352 302 264 211 176
500	430 *(946)*	6.5	500/404 *(542)*	523/422 *(566)*	656 656 586 469 390	100-150 175 200 250 300	484/391 *(523)*	581/469 *(628)*	486 417 365 292 243
700	445 *(979)*	8.9	700/565 *(757)*	732/591 *(792)*	919 861 753 602 502	100-150 175 200 250 300	583/471 *(631)*	700/565 *(757)*	586 502 440 352 293
900	450 *(990)*	11	700/565 *(757)*	732/591 *(792)*	919 919 848 678 565	100-150 175 200 250 300	583/471 *(631)*	700/565 *(757)*	586 586 540 432 360
1000	860 *(1892)*	13	1000/808 *(1083)*	1045/844 *(1131)*	1312 1312 1171 937 781	100-150 175 200 250 300	968/782 *(1049)*	1162/939 *(1259)*	972 833 729 583 486
1400	890 *(1958)*	17.8	1401/1131 *(1516)*	1464/1182 *(1585)*	1838 1721 1506 1205 1004	100-150 175 200 250 300	1167/943 *(1264)*	1401/1132 *(1517)*	1172 1005 879 703 586
1800	900 *(1980)*	22	1401/1131 *(1516)*	1464/1182 *(1585)*	1838 1838 1695 1356 1130	100-150 175 200 250 300	1167/943 *(1264)*	1401/1132 *(1517)*	1172 1172 1080 864 720

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 175% for 10 sec, but has a rms duty cycle of 150 kW *(201 hp)*.

2 Select motor based on process requirements and computer 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.

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

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

$$= 297 \text{ amps}$$

4 Select inverter based on continuous current and overload requirements.

Scan the 175% entries in the inverter tables for a frame where the continuous current rating exceeds 297 amps. The **300 frame** meets this criterion (**323 amps**) and is appropriate for this application.

Current A ac	Allowable Overload %
363	100-150
323	175
290	200
242	250
202	300

Specifications For Models Without DC Disconnects

Frame	Weight kg *(lbs)*	Full Load Losses kW	440 V Inverter kVA/ Motor kW *(hp)*	460 V Inverter kVA/ Motor kW *(hp)*	Motor Current A ac	Allowable Overload %	575 V Inverter kVA/ Motor kW *(hp)*	690 V Inverter kVA/ Motor kW *(hp)*	Motor Current A ac
200	250 *(550)*	3.2	201/162 *(218)*	210/170 *(227)*	264 235 211 176 151	100-150 175 200 250 300	175/141 *(189)*	210/170 *(227)*	176 151 132 106 88
300	250 *(550)*	4.4	277/224 *(300)*	289/233 *(313)*	363 323 290 242 202	100-150 175 200 250 300	241/195 *(261)*	289/233 *(313)*	242 207 182 145 121
400	395 *(869)*	6.3	402/325 *(435)*	421/340 *(456)*	528 469 411 329 274	100-150 175 200 250 300	351/283 *(379)*	421/340 *(456)*	352 302 264 211 176
500	400 *(880)*	7.5	574/464 *(622)*	600/485 *(649)*	753 669 586 469 390	100-150 175 200 250 300	484/391 *(524)*	581/469 *(629)*	486 417 365 292 243
700	405 *(891)*	9.3	732/591 *(792)*	765/618 *(828)*	960 861 753 602 502	100-150 175 200 250 300	584/472 *(633)*	700/565 *(758)*	586 502 440 352 293
900	410 *(902)*	13.5	861/695 *(932)*	900/727 *(974)*	1130 969 848 678 565	100-150 175 200 250 300	717/579 *(776)*	860/694 *(931)*	720 617 540 432 360
1000	800 *(1760)*	14.9	1148/927 *(1243)*	1200/969 *(1299)*	1506 1339 1171 937 781	100-150 175 200 250 300	968/782 *(1048)*	1162/938 *(1258)*	972 883 729 583 486
1400	810 *(1782)*	18.6	1463/1181 *(1583)*	1530/1235 *(1656)*	1920 1721 1506 1205 1004	100-150 175 200 250 300	1167/942 *(1263)*	1401/1131 *(1516)*	1172 1005 879 703 586
1800	820 *(1804)*	27	1722/1391 *(1865)*	1801/1454 *(1949)*	2260 1937 1695 1356 1130	100-150 175 200 250 300	1434/1158 *(1552)*	1721/1390 *(1863)*	1440 1234 1080 864 720

Inverter Specifications

Inverter Power Output

Output Voltage	0-460 V, 0-690 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 200-1800 frames 2 kHz for 4-125 frames Up to 6 kHz available with derating
Inverter Type Modulation	Two-level voltage converter Pulse Width Modulation (PWM)
Power Semiconductor Technology	Insulated Gate Bipolar Transistor (IGBT)

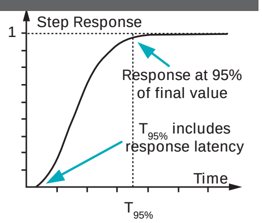
Motor Control

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. Reserve an additional 115 mm (5 in) in height for equipment requiring a debris hood (UL).
2. A minimum of 500 mm (20 in) should be allocated above cabinet for fan maintenance. No back access is required. Reserve 800 mm (32 in) front clearance for maintenance.
3. Motor power ratings based assume 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 the previous page.
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 the top for all cabinets.
10. The dc bus for the lineup has a maximum current capacity of 2000 amps.
11. High temperature current derating: all frames -2.5% per ˚C above 40˚C.
12. Inverter doors are electrically interlocked with controls to inhibit gating when the doors are open.
13. Low temperature current derating: frames 200 to 1800 -1.75% per ˚C except frame 400 which is -2.5% per ˚C below 0 ˚C. All other frames no derating.
14. The ratings shown in green in the inverter table for motor currents and the associated overload percent indicate the maximum peak current that inverter frame can produce.



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

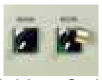
Environmental (Inverters and Converters)

Operating Temperature	0 to 40°C (32 to 104°F) at rated load -20 to 50°C (-4 to 122°F) with derating
Storage Temperature	-25 to 55°C (-13 to 131°F)
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 575 V inverters above 3000 m (9840 ft) for 690 V inverters above 2000 m (6560 ft)
Vibration	10-50 Hz, <4.9 m/s^2 (0.5 G)

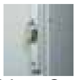
Mechanical (Inverters and Converters)

Enclosure	NEMA 1 (IP20) IP32 or IP31 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
Acoustic Noise	≤ 68 dB
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	Canada United States; European Union


Draw-Out Style Inverter Lockout (dc bus power)

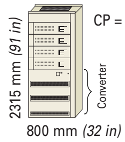
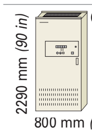
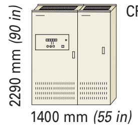
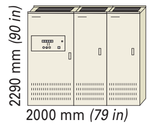
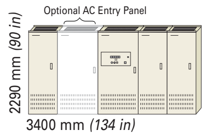
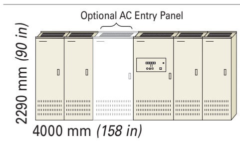
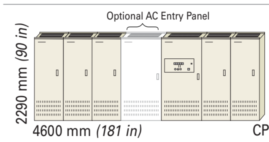
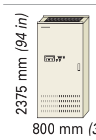
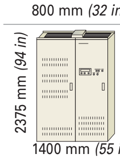
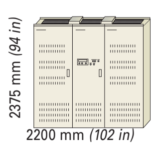
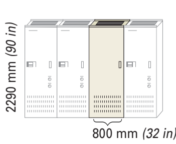
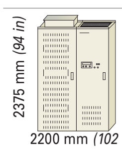
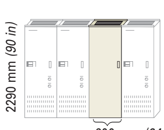

Cabinet Style Inverter Lockout (dc bus power)


Optional Single DC disconnect Inverter Lockout


Cabinet Style Inverter Lockout (control power)

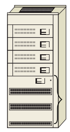
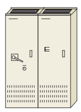
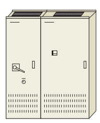
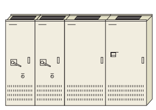

Draw-Out Style Inverter Lockout (control power)

Converter Specifications

Type	Frame	Weight kg (lbs)	Losses kW	440/460 V ac: Power kW at 440 V (hp)	440/460 V ac: Power kW at 460 V (hp)	440/460 V ac: Current A dc (A ac)	Overload – Time	575/690 V ac: Power kW at 575 V (hp)	575/690 V ac: Power kW at 690 V (hp)	575/690 V ac: Current A dc (A ac)
Non-Regenerative Diode (TMdrive-D10)	 CP = 150 VA + 500VA for cabinet 150	412 *(906)*	0.8	150 *(200)*	155 *(208)*	250 *(204)*	150% – 60s			
Non-Regenerative Diode (TMdrive-D10)	 CP = 400 VA 600	480 *(1056)*	3	574 *(769)*	600 *(804)*	966 *(788)*	150% – 60s	500 *(670)*	600 *(804)*	644 *(526)*
Non-Regenerative Diode (TMdrive-D10)	 CP = 550 VA 1200	830 *(1826)*	6	1148 *(1539)*	1200 *(1609)*	1932 *(1577)*	150% – 60s	1000 *(1340)*	1200 *(1609)*	1288 *(1052)*
Non-Regenerative Diode (TMdrive-D10)	 CP = 700 VA 1800	1180 *(2596)*	9	1722 *(2308)*	1800 *(2413)*	2898 *(2366)*	150% – 60s	1500 *(2011)*	1800 *(2413)*	1932 *(1577)*
Non-Regenerative Diode (TMdrive-D10)	 2400 CP = 1 kVA	1530 *(3366)*	12	2296 *(3078)*	2400 *(3217)*	3864 *(3154)*	150% – 60s	2000 *(2681)*	2400 *(3217)*	2576 *(2104)*
Non-Regenerative Diode (TMdrive-D10)	 3000 CP = 1.2 kVA	1880 *(4136)*	15				150% – 60s	2500 *(3351)*	3000 *(4021)*	3220 *(2629)*
Non-Regenerative Diode (TMdrive-D10)	 3600 CP = 1.3 kVA	2230 *(4906)*	18				150% – 60s	3000 *(4021)*	3600 *(4826)*	3864 *(3154)*
Regenerative Thyristor (TMdrive-T10)	 CP = 500 VA 800	550 *(1210)*	5	758 *(1016)*	792 *(1062)*	1200 920 760 650 810	150% – 60s 200% – 60s 250% – 60s 300% – 60s 300% – 10s	990 *(1327)*	1188 *(1592)*	1200 930 760 650 820
Regenerative Thyristor (TMdrive-T10)	 CP = 500 VA 1600	900 *(1980)*	10	1515 *(2031)*	1584 *(2123)*	2400 1940 1620 1380 1790	150% – 60s 200% – 60s 250% – 60s 300% – 60s 300% – 10s	1980 *(2654)*	2376 *(3185)*	2400 2040 1700 1460 2060
Regenerative Thyristor (TMdrive-T10)	 CP = 1000 VA 3200  Capaciter panel integral with inverter lineup	1800 *(3960)*	20	3030 *(4062)*	3168 *(4246)*	4800 3880 3240 2760 3580	150% – 60s 200% – 60s 250% – 60s 300% – 60s 300% – 10s	3960 *(5308)*	4752 *(6370)*	4800 3800 3240 2760 3580
Regenerative Thyristor (TMdrive-T10)	 CP = 1200 VA 3300  DC Incoming panel integral with inverter lineup	2000 *(4400)*	22				150% – 60s 200% – 60s 250% – 60s 300% – 60s 300% – 10s	2750 *(3678)*	3301 *(4424)*	3334 2727 2300 1980 2448

Converter Specifications

Regenerative IGBT (TMdrive-P10)

Frame	Weight kg *(lbs)*	Losses kW	440/460 V ac: Power kW at 440 V *(hp)*	440/460 V ac: Power kW at 460 V *(hp)*	Current A ac	Overload –Time	575/690 V ac: Power kW at 575 V *(hp)*	575/690 V ac: Power kW at 690 V *(hp)*	Current A ac
125  2315 mm *(91 in)*; 800 mm *(32 in)*; CP = 250 VA + 500 VA for cabinet; Converter	422 *(928)*	2	100 *(134)*	105 *(140)*	137	150% – 60s	87 *(116)*	104 *(139)*	91
					137	175% – 60s			91
					120	200% – 60s			80
					96	250% – 60s			64
					80	300% – 60s			53
300  2290 mm *(90 in)*; 1200 mm *(48 in)*; CP = 500 VA	475 *(1045)*	3.7	225 *(302)*	236 *(317)*	308	150% – 60s	196 *(263)*	235 *(316)*	205
					308	175% – 60s			205
					290	200% – 60s			180
					242	250% – 60s			144
					207	300% – 60s			120
700  2315 mm *(91 in)*; 1400 mm *(56 in)*	680 *(1496)*	8.5	510 *(684)*	533 *(714)*	697	150% – 60s	445 *(598)*	534 *(717)*	465
					697	175% – 60s			465
					697	200% – 60s			407
					558	250% – 60s			325
					465	300% – 60s			271
900 CP = 1 kVA	795 *(1749)*	11	678 *(910)*	709 *(952)*	926	150% – 60s	590 *(792)*	709 *(952)*	617
					926	175% – 60s			617
					895	200% – 60s			540
					716	250% – 60s			432
					597	300% – 60s			360
1400  2315 mm *(91 in)*; 2800 mm *(111 in)*	1330 *(2926)*	17	1020 *(1370)*	1067 *(1433)*	1394	150% – 60s	890 *(1195)*	1067 *(1433)*	929
					1394	175% – 60s			929
					1394	200% – 60s			813
					1115	250% – 60s			651
					929	300% – 60s			542
1800 CP = 1.8 kVA	1560 *(3432)*	22	1356 *(1821)*	1417 *(1903)*	1852	150% – 60s	1180 *(1584)*	1416 *(1901)*	1235
					1852	175% – 60s			1235
					1790	200% – 60s			1080
					1432	250% – 60s			864
					1194	300% – 60s			720

Regenerative Converter (TMdrive-P10) 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 page 9):

1 Compute kW requirements into the inverter. It is assumed that the converter is dedicated to the inverter specified in the application example on page 9. It is also assumed that the converter is controlled to unity power factor.

$$kW_{dc} = \frac{kW_{Shaft}}{Eff_{Mtr}}$$

$$= \frac{150\ kW}{0.954}$$

$$= 158\ kW$$

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

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

$$= \frac{158\ kW \times 1000}{\sqrt{3} \times 460\ V \times 0.985 \times 0.98}$$

$$= 205\ amps$$

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

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

3 Scan the 175% for 60 sec entries in the regenerative converter tables for a frame where the continuous current rating exceeds 205 amps. The 300 frame meets this criterion (308 amps), thus is the appropriate regenerative converter for this application.

Current A ac	Overload – Time
308	150% – 60s
308	175% – 60s
290	200% – 60s
242	250% – 60s
207	300% – 60s

Non-Regenerative Converter (TMdrive-D10) 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 page 9).

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 on page 9.

$$V_{dc\ Bus} = 1.35 \times V_{Converter\ line\text{-}to\text{-}line}$$
$$= 1.35 \times 460 \times 1.05$$
$$= 652\ V$$

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.

$$I_{dc\ Converter} = \frac{kW_{Shaft} \times 1000}{Eff_{Mtr} \times Eff_{Inv} \times V_{dc\ Bus}}$$
$$= \frac{150\ kW \times 1000}{0.954 \times 0.98 \times 652}$$
$$= 246\ amps$$

3 Scan the specifications in the non-regenerative converter tables on page 11 for a frame where the continuous current rating exceeds 246 amps. The 150 frame meets this criterion (250 amps), thus is the appropriate non-regenerative converter for this application.

Current A dc (A ac)	Overload – Time
250 (204)	150% – 60s

Miscellaneous

Main Circuit Input Voltage Variation	± 10%
Input Frequency	50/60 Hz ±20%
TMdrive-P10 Input Chopping	2 kHz

Control Power	180-220 V ac, 50 Hz 3-phase 180-242 V ac, 60 Hz 3-phase
Displacement Power Factor (at all loads)	TMdrive-D10 - 0.98 TMdrive-T10 - 0.71 to 0.98 depending on application TMdrive-P10 - Unity power factor

Converter Notes

1. TMdrive-D10 and TMdrive-P10 cabinets are 605 mm (24 in) in depth, TMdrive-T10 cabinets are 650 mm (26 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 shown includes lifting means and fans. Reserve an additional 115 mm (5 in) in height for equipment requiring a debris hood (UL).
2. Allocate 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. The specified current ratings are continuous to which the referenced overload can be applied. Refer to the application example on the previous page. TMdrive-P10 ratings assume standard 2 kHz switching.
4. Each of the converters supports bottom or side cable entry standard. Top cable entry can be supported with adjacent ac entry or auxiliary panel.
5. All converters require 3-phase control power and the kVA requirements shown on pages 11 & 12 are the continuous requirements. TMdrive-D10 converters have an additional transient bus charging requirement of 40 amps peak.
6. TMdrive-D10 and TMdrive-T10 converters require an external circuit breaker that is not included. TMdrive-D10 converters larger than 600 frame require an additional 800 mm (32 in) ac entry panel when United States NEC compliance is required.
7. All TMdrive-T10 converters require an external dc link reactor.
8. TMdrive-P10 converters require an ac line reactor which may be mounted remotely or integrated in the lineup. Integrated reactors panels have the following width: 300 Frame – 600mm, 700 thru 1400 Frame – 1000mm, 1800 Frame – 2000mm.
9. Air is pulled in through the front and out the top for all cabinets.
10. DC through bus is limited to 2000 amps. Position converters within lineups so that this limit is not exceeded.
11. TMdrive-T10 power ratings shown on page 11 are the maximum obtainable and require converter ac voltages to be a minimum of 10% higher than maximum inverter ac motor voltages.
12. TMdrive-P10 and TMdrive-T10 require ac-phase rotation to match system elementaries.
13. There are no restrictions on total dc bus length or the minimum capacitance connected to any of these converters. For TMdrive-P10 converters please consult the factory when the combined rating of all connected inverters exceeds 4 times the converter rating (2 times for 300 frame).
14. Converter efficiency can be estimated in percent by dividing full load losses by rated power and then multiplying by 100.
15. Maximum shipping split from the factory is 2.4 m, 1400 and 1800 frame TMdrive-P10 are split for shipment.
16. The standard ac line reactor supplied with a TMdrive-P10 has 16.8% impendence. For systems operating at power factors other than unity it is advantageous to reduce this impedance. The minimum system impedance for the TMdrive-P10 is 15%
17. Alternate ac entry panel available for TMdrive-P10 1400 and 1800 frame converters which includes a single breaker and reduces total lineup length by 400 mm (16 in).
18. TMdrive-T10 converters operating with 50 Hz input require current derating of 10% from data shown on page 11.
19. Maximum ac input voltage for TMdrive-T10 converters is 825 V ac. Special dc bus voltage control is required to allow regeneration when converter input voltage matches inverter rated output voltage.
20. The 150 frame TMdrive-D10 converter includes an integrated dynamic braking module. Other frames can be supplied with external dynamic braking modules in 600 mm (24 in) cabinets. Dynamic braking resistors must be separately supplied and mounted.
21. All converters require isolation transformers rated for the application. 3200 frame TMdrive-T10 requires dual secondaries in 12-pulse configuration.
22. High temperature current derating: -2.5% per ˚C above 40˚C for all converter frames and types.
23. Low temperature current derating: -1.75% per ˚C for TMdrive-P10 and -2.25% per ˚C for TMdrive-D10 converters below 0˚C. No derating for TMdrive-T10 converters.

Operator Interfaces

Standard Display (Inverters and Regenerative Converters)

Optional analog meters can be supplied in addition to either the standard or enhanced display. For cabinet style equipment, four meters are provided. For draw-out style, two meters are provided for each inverter.

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

Three 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

RJ-45 Ethernet port is used for local toolbox connection

Interlock button disables the drive

Keypad Option (Inverters and Regenerative Converters)

High Function Display

- LCD backlight gives great visibility and long life
- Bar graphs, icons, menus, and digital values combine to provide concise status information, often eliminating the need for traditional analog meters

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

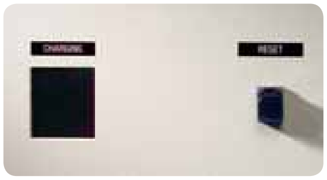
Switch to local mode and operate the equipment right from the keypad

RJ-45 Ethernet port is used for the local toolbox connection

Instrumentation Interface
- Two analog outputs are dedicated to motor current feedback
- Five analog outputs can be mapped to variables for external data logging and analysis

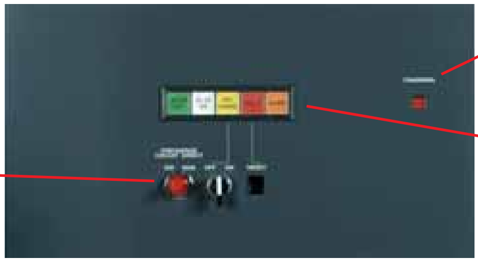
Interlock button disables the drive

Non-Regenerative Converters (TMdrive-D10)



TMdrive-**D10 150 Frame**

Controls
- Precharge circuit
- "On/Off" switch
- "Reset/Fault" switch



Bus Charged Indicator

Indicating Lamps
- Green — ac breaker open
- White — ac breaker closed
- Yellow — precharging
- Red — fault
- Orange — alarm

Control Functions

The TMdrive-10 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 (64 channels) • 14 kb buffer

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

Speed/Torque Regulator Functions

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

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

Automatic field weakening and saturation compensation

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

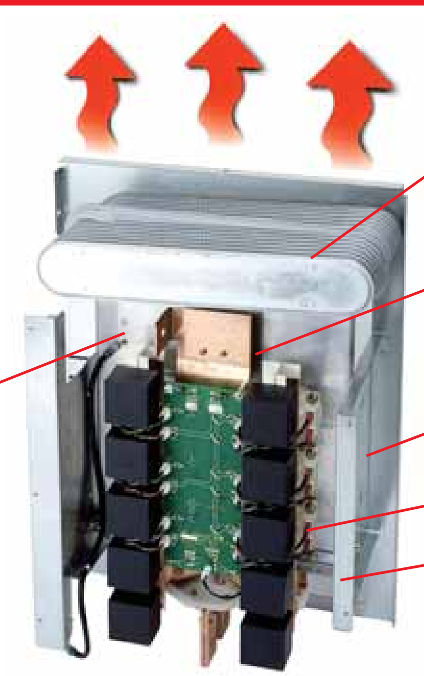
Load torque calculator accurately computes torque delivered to the load

Reference model following control for elimination of mechanical resonance problems

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

Heat Pipe Technology Used In TMdrive-10

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



1 2 3 Thermal Cycle

Condensing unit with several fins for the flow of refrigerant

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.

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.

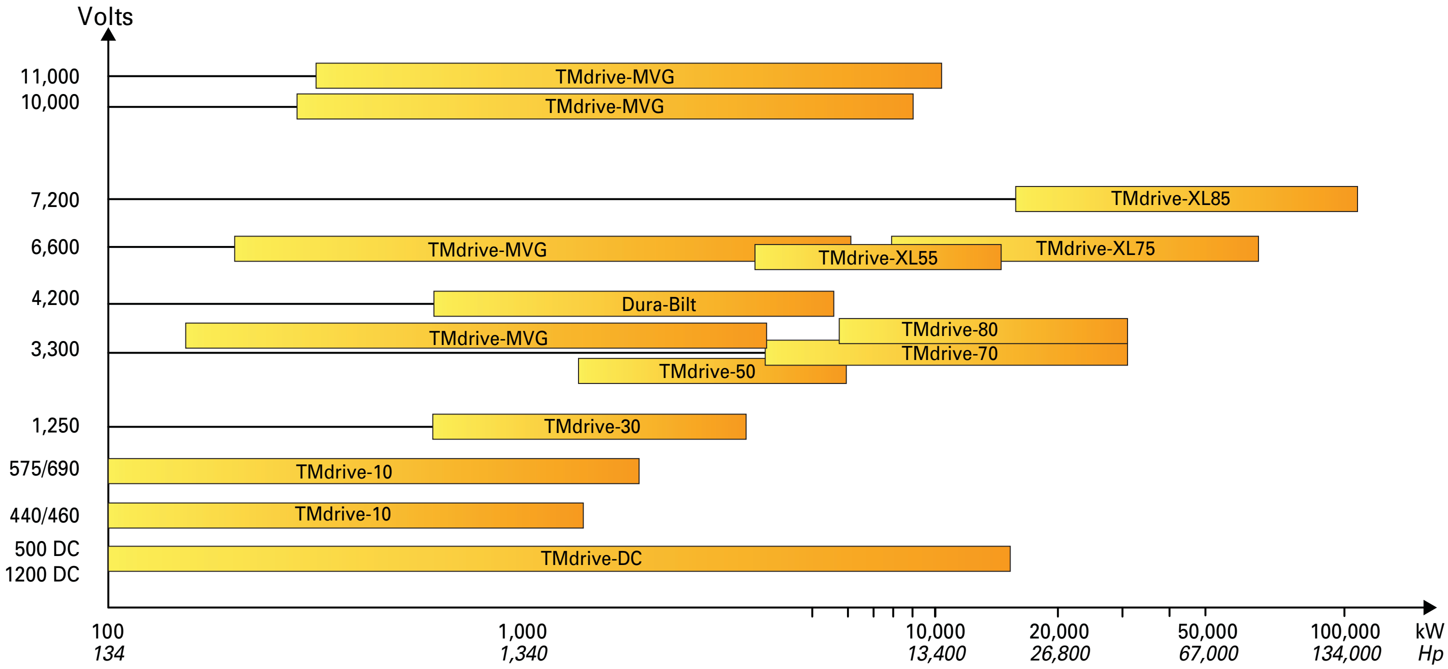
The multi-channeled chill plate contains a CFC free refrigerant which is practically non-toxic to humans and ozone friendly.

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.

TMEIC AC Drives Offer Complete Coverage



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