TMEIC
We drive industry

TMdrive®-MV Product Application Guide

Low Voltage 7-Level IGBT System Drive

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

Unique design of the TMdrive-MV provides significant customer benefits:

- Motor friendly power at 3.3 or 6.6 kV
- High energy efficiency
- Proven reliability
- High power factor

Design Feature	Customer Benefit
• Conservative design using 1700 Volt IGBTs (Insulated Gate Bipolar Transistor)	• Highly reliable operation and proven 12-year drive MTBF – no service interruptions
• High energy efficiency over 97%	• Considerable energy savings, in particular on flow control applications
• Diode rectifier ensures power factor greater than 95% in the speed control range	• Capacitors are not required for power factor correction
• Multiple level drive output waveform to the motor (seven levels for the 6.6 kV inverter)	• No derating of motor for voltage insulation or heating is required due to motor friendly waveform
• 18-pulse converter rectifier and phase shifted transformer	• No harmonic filter required to provide lower harmonic distortion levels than IEEE-519-1992 guidelines
• Designed to keep running after utility supply-transient voltage drop outs – up to 300 msec.	• Uninterrupted service for critical loads
• Synchronous transfer to line option with no interruption to motor current	• Allows control of multiple motors with one drive • No motor current or torque transients when the motor transitions to the AC line
• Input isolation transformer included in the drive package	• Better protection of motor • Less total space required and simplified installation • Lower cost installation
• Front access roll-out inverter modules with air cooling fan on top of the panel	• Simple and fast maintenance and repair using easily removed inverter cell

Bringing Reliable Control To A Wide Variety of Industries

Cement Plant

The TMdrive-MV's compartmentalized design streamlines installation, commissioning, and maintenance of medium voltage fans, mills, separators and kilns. With a Mean Time Between Failure (MTBF) exceeding 12 years, the MV is engineered to deliver rock solid performance in virtually any application.

Pump Station

The MV family of drives can be seamlessly integrated with the rest of your pump or compressor station control system with a choice of either 3.3 or 6.6 kV. They can be applied to existing motors and cabling, making them an excellent fit in modernization/retrofit applications.

Mining Conveyor

Accurate torque control is a key in controlling large conveyors. The MV's flux vector algorithm provides the accuracy and response for this demanding application.

Induced Draft (ID) Fan

Traditional mechanical methods of controlling airflow are inefficient and require considerable maintenance. The MV provides more accurate and energy-efficient control of airflow while eliminating the maintenance associated with dampers or vanes.

A Look Inside

MV Drive Technology for 3.3 or 6.6 kV operation:

- Series connected inverter cell architecture uses 1700 V IGBT inverters for best reliability and high energy efficiency
- Diode bridge rectifiers yield high power factor operation
- Multi-winding transformer produces low input power distortion
- Modular drawable power cell design minimizes the time required for any maintenance activities

Input Transformer
The special input transformer has phase-shifted secondary windings to produce 18-pulse converter operation. This design exceeds the IEEE 519-1992 guidelines for input voltage and current distortion.

Cell-Inverters
Three banks of three, series connected inverter cells, each containing:

- Diode bridge rectifier
- IGBT PWM inverter
- DC bus capacitor
- Drawable module for ease of maintenance.

Main Power Input
Two voltage levels are available:

- 3-3.3 kV, 3-phase, 50/60 Hz using 9 inverter cells as shown here
- 6-6.6 kV, 3-phase, 50/60 Hz using architecture with 18 inverter cells (described later)

Air Cooling
Forced air cooling system with:

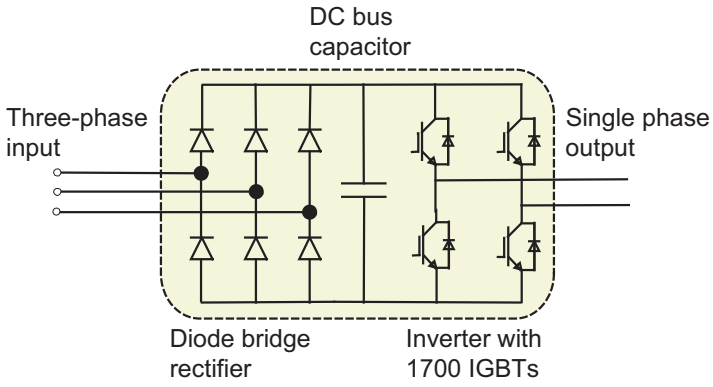
- Intake through cabinet doors
- Upwards flow through inverter cells and transformer
- Exhaust at top of cabinet

I/O Board
The I/O board supports encoder or resolver, 24 V dc I/O, 115 V ac inputs and analog I/O, standard. All I/O are terminated to a two-piece modular terminal block for ease of maintenance.

Control Functions
A single set of control boards feeds all inverter cells. The primary control board performs several functions:

- Speed and torque regulation
- Sequencing
- I/O mapping
- Diagnostic data gathering
- Provision for optional LAN interface

Slide-Out Inverter Modules
Each inverter cell contains a three-phase diode converter and a single phase IGBT inverter, connected by a DC bus. One cell module is shown opposite, drawn out of the rack on a slide for service. All the modules are the same, refer to the diagram below.



Inverter Cell Module

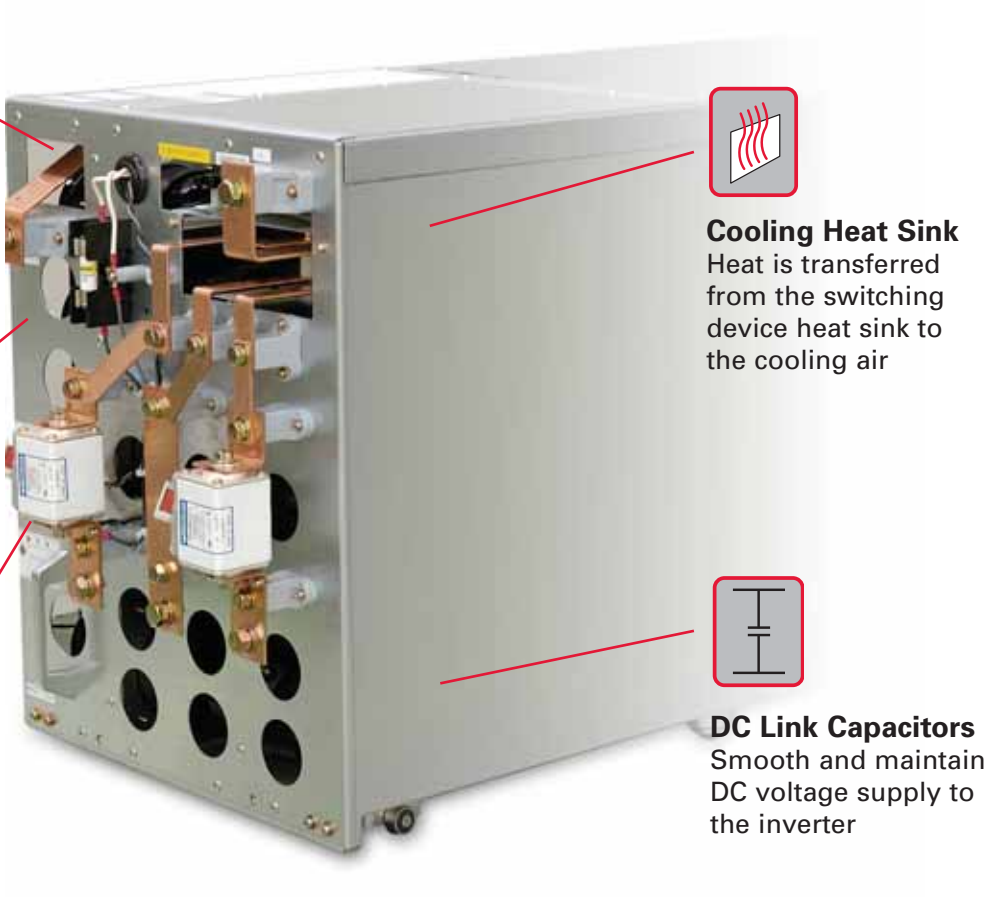
Inverter Cell Module Removed from Rack

Switching Devices
Switching devices are Insulated Gate Bipolar Transistors (IGBT)

Control Board

- Board passes Pulse Width Modulated control signal to the gate drivers
- Gate driver circuit boards connect directly to IGBTs

Input Fuse
Fused three phase inputs to converter

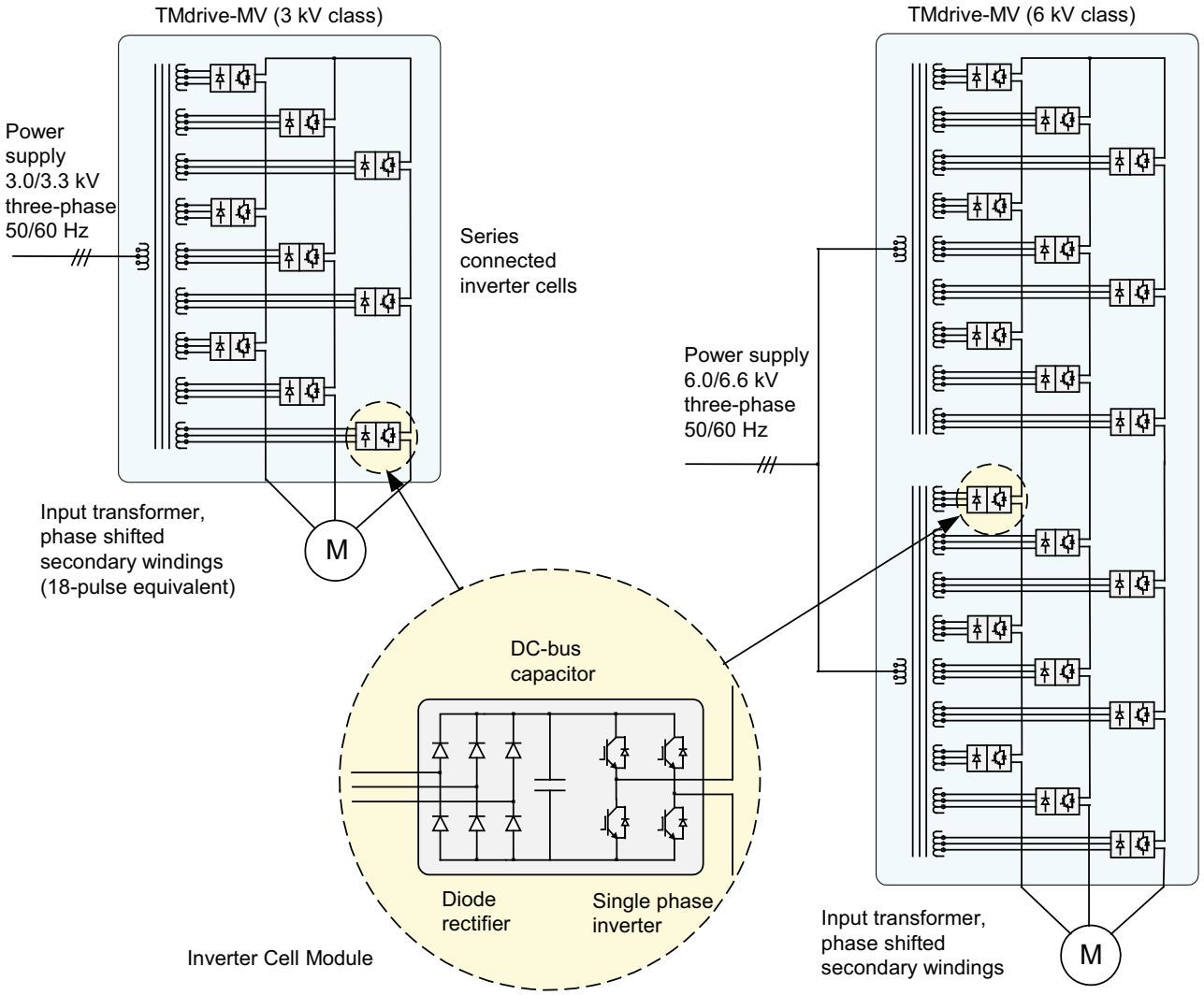


Cooling Heat Sink
Heat is transferred from the switching device heat sink to the cooling air

DC Link Capacitors
Smooth and maintain DC voltage supply to the inverter

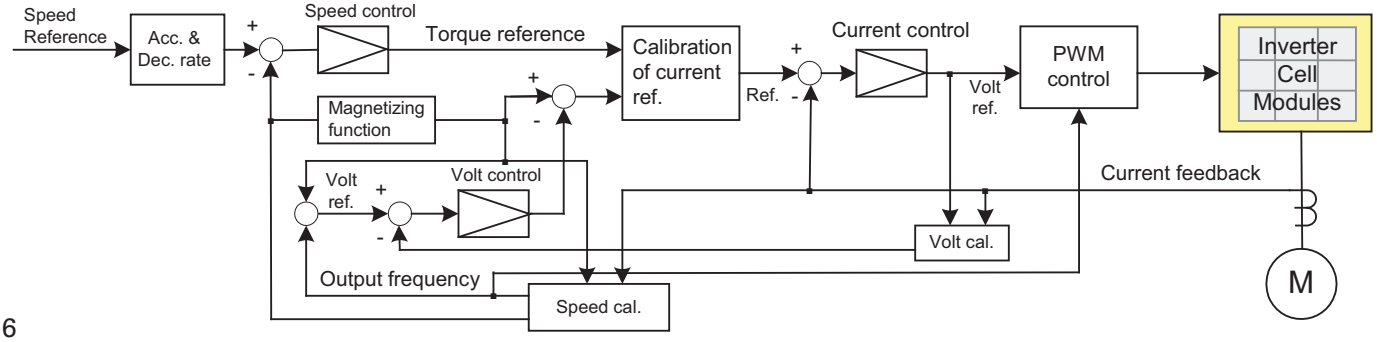
TMdrive-MV Architecture

The TMdrive-MV main circuit consists of an input transformer and single-phase PWM inverter cells.
For 6 kV, six inverter cells are series connected to create an output with seven output voltage levels.



Control Block Diagram

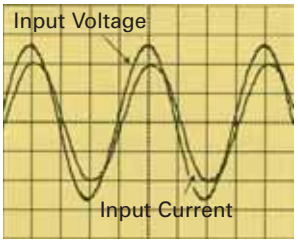
Vector control enables stable speed control without the use of a speed sensor. A sensor can be used for applications requiring high-precision speed control or higher starting torque. Simple open loop V/Hz control is also available.



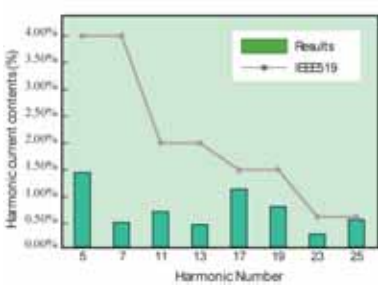
Features of the TMdrive-MV

A Clean Wave Inverter

Using the multiple winding input transformer, the TMdrive-MV has 18-pulse rectification and more than meets the requirements of IEEE-519 (1992). This reduces the harmonic voltage distortion on the power source and protects the other equipment in the plant. The harmonic current content measured in an actual load test is compared with IEEE-519 in the chart opposite.



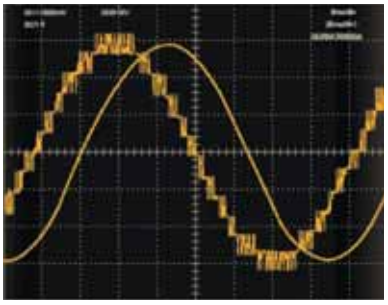
Input Wave Forms



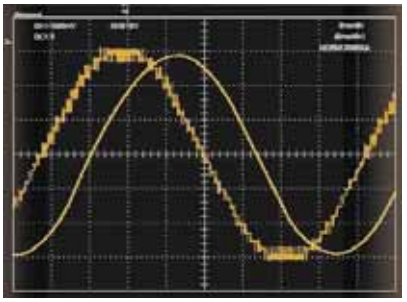
Harmonic contents of input current

A Clean Output Wave

As a result of the multi-level PWM control, the output waveform is close to a sine wave, and the heat loss caused by harmonics is negligible. In addition, harmonic currents in the motor are minimized so there is very little torque ripple on the output shaft and very little risk of torsional load resonance.



Current and Voltage Output waveforms for 3 kV Drive



Current and Voltage Output waveforms for 6 kV Drive

A Higher Efficiency than Conventional Drives

Actual factory load tests show the drive efficiency is 97.6%. This high efficiency is a result of:

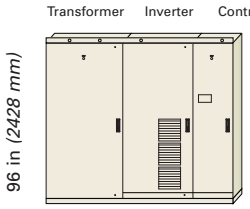
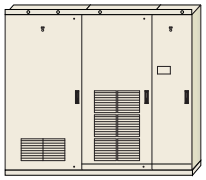
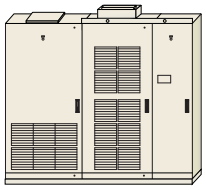
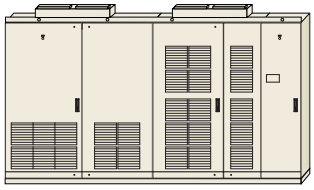
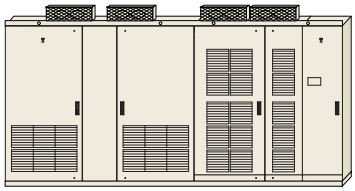
- A smaller number of switching semiconductors by using 1700 V IGBTs
- Lower switching frequencies using multi-level PWM control reduce the switching loss of each IGBT
- Direct connection of 6 kV motor without an output transformer

Efficiencies in *Italic*, expressed in % ** = Interpolated value*		**Percent Efficiency = 100 x output power/ (input power including losses)**				
		Percent of Top Speed vs % Efficiency				
		20	**40**	**60**	**80**	**100**
Percent of Full Load	**20**	***92.2%***	***96.1%***	****96.7%***	****97.4%***	***98.1%***
	40		***96.1%***	***97.2%***	****97.8%***	***98.4%***
	60			***96.8%***	***97.3%***	***98.1%***
	80				***97.1%***	***97.7%***
	100					***97.5%***

A High Input Power Factor

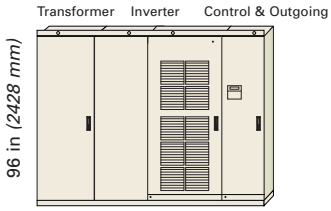
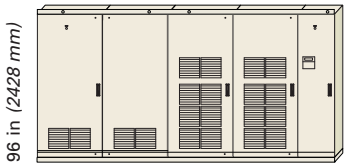
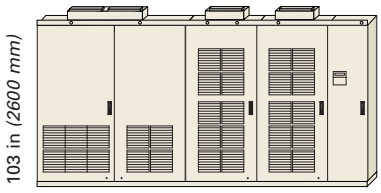
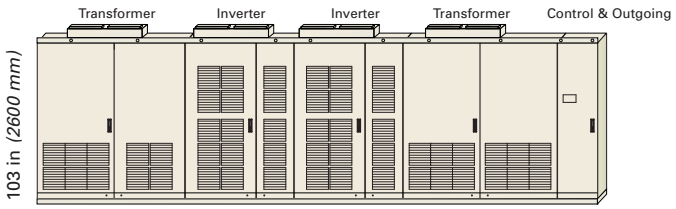
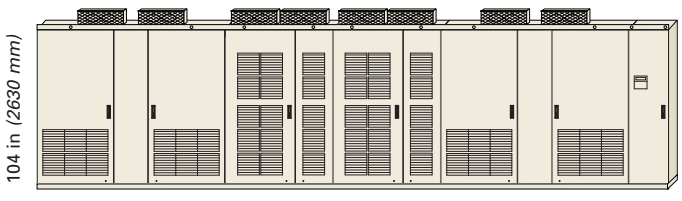
Each inverter cell has a diode bridge rectifier. As a result the input power factor is over 95% over the entire normal operating speed range, even when driving a multiple-pole induction motor of low power factor. With this high power factor, no power factor correction capacitor is required.

Power factor in *Italic*, expressed in % ** = Interpolated value*		**Percent of Top Speed vs % PF lagging**				
		20	**40**	**60**	**80**	**100**
Percent of Full Load	**20**	***94.7%***	***95.5%***	****95.6%***	****95.7%***	***95.8%***
	40		***96.6%***	***96.7%***	****96.4%***	***96.2%***
	60			***96.3%***	***96.4%***	***96.4%***
	80				***96.1%***	***96.8%***
	100					***97.1%***

	3.3 kV Output kVA	3.0 kV Output kVA	Rated Output Current Amps*1	Approx Motor Power HP (kW)*2	Cabinet Weight Pounds (kg)
 96 in *(2428 mm)* 111 in *(2810 mm)* Depth: 36 in *(910 mm)*	200	180	35	200 (153)	6600 (3000)
	300	270	53	300 (230)	
	400	360	70	400 (307)	
 96 in *(2428 mm)* 111 in *(2810 mm)* Depth: 36 in *(910 mm)*	500	450	88	500 (383)	7920 (3600)
	700	630	123	700 (543)	
 103 in *(2600 mm)* 111 in *(2810 mm)* Depth: 40 in *(1010 mm)*	900	810	158	900 (698)	9020 (4100)
	1000	900	175	1000 (775)	
 103 in *(2600 mm)* 166 in *(4220 mm)* Depth: 40 in *(1010 mm)*	1200	1090	210	1200 (930)	15400 (7000)
	1500	1360	263	1600 (1203)	
	1800	1630	315	1900 (1443)	
	2000	1810	350	2100 (1603)	
 104 in *(2630 mm)* 198 in *(5020 mm)* Depth: 60 in *(1510 mm)*	2400	2180	420	2600 (1924)	20680 (9400)
	3000	2720	525	3200 (2405)	

*1 1.25 PU overload, 60 sec rating, use frame Amp rating for most acceptable match with motor.

*2 Approximate capacity for 3.3 kV-based 6-pole induction motors, with typical efficiency and power factor.

	6.6 kV Output kVA	6.0 kV Output kVA	Rated Output Current Amps*3	Approx Motor Power HP (kW)*4	Cabinet Weight Pounds (kg)
	400	360	35	400 (307)	9240 (4200)
	600	540	53	600 (460)	
	800	720	70	800 (613)	
	1000	900	88	1100 (784)	13200 (6000)
	1400	1270	123	1500 (1098)	
	1800	1630	158	1900 (1411)	15400 (7000)
	2000	1810	175	2100 (1568)	
	2400	2180	210	2500 (1882)	29480 (13400)
	3000	2720	263	3300 (2433)	
	3600	3270	315	3900 (2919)	
	4000	3630	350	4300 (3244)	
	4200	3810	368	4600 (3406)	48400 (22000)
	4800	4630	420	5200 (3892)	
	5400	4900	473	5900 (4379)	
	6000	5450	525	6500 (4866)	

*3 1.25 PU overload, 60 sec rating, use frame Amp rating for most acceptable match with motor.

*4 Approximate capacity for 6.6 kV-based 6-pole induction motors, with typical efficiency and power factor.

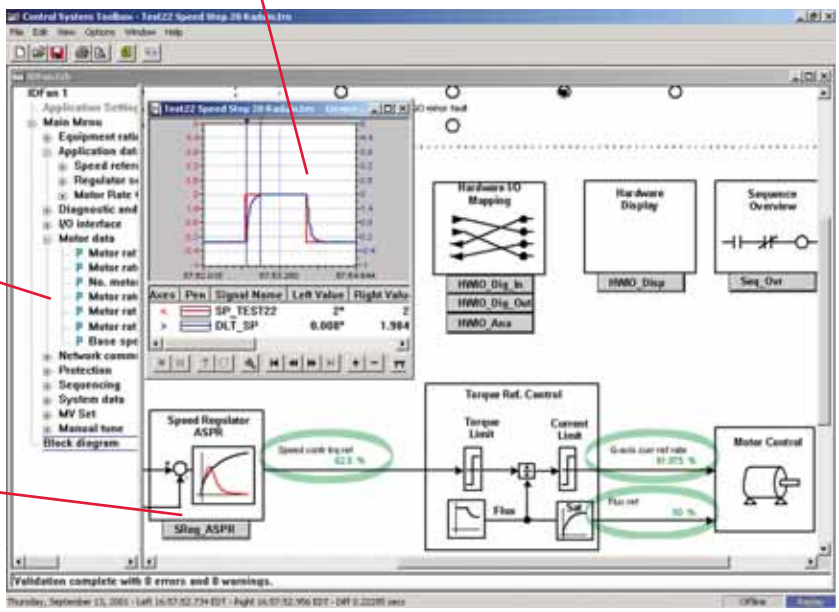
Drive/Motor Monitoring & Analysis

The keypad, coupled with the Windows®-based Control System Toolbox, brings productivity to your commissioning and maintenance activities.

Integrated Trend Window
The toolbox application has an integrated trend window that allows the user to:
- Define a trend with drag-and-drop variables from function block diagrams or select the variables from a list.
- Conduct online real time trending with the drive or upload the capture buffers in the drive for trending.
- Define a link with integrated historian database for historical trending.
- Quickly define a display with the auto scaling toolbar button.
- Analyze a specific time frame with the zoom in/out toolbar buttons.
- Create different views using variable hiding.
- Analyze specific times with cross hairs.
- Perform frequency-based analysis of the trend using the Fast Fourier Transform (FFT) function.

Outline View
Functionally organized parameters and variables allow quick access to any given function.

Animated Block Diagrams
Provide an animated graphical display of drive sequencing and regulation functions. Animated variables are shown in green, and the buttons are used to navigate to associated functions.



Control System Toolbox

High Function Display
- LED 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

RJ-45 Ethernet port is used for the local toolbox connection, with additional rear RJ-45 connection for permanent installation

Keypad

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

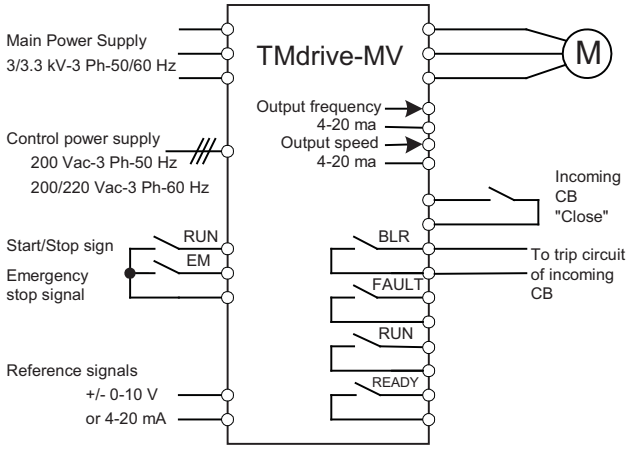
Switch to local mode and operate the equipment right from the keypad

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

Common Control Boards to Reduce Cost of Ownership

Standard Connections



Control I/O

Control Area	Specifications
Analog Inputs	(2) ±10 V or 4-20 mA, configurable, differential
Analog Outputs	(3) ±10 V, 8-bit, configurable, 10 mA max
Digital Inputs	(2) 24-110 V dc or 48-120 V ac; (6) 24 V dc, configurable
Digital Outputs	(6) 24 V dc open collector 50 mA
Speed Feedback Encoder Input	High-resolution tach, 125 kHz, 5 or 15 V dc diff. input, A Quad B, with marker
LAN Interface Options	Profibus-DP, ISBus®, DeviceNet™, or TOSLINE® -S30
Motor Temperature Sensor	High-resolution torque motor temperature feedback: 1 k Ohm platinum resistor or 100 Ohm platinum RTD (uses analog input with signal conditioner)

Display and Diagnostics

	Specifications
PC Configuration	Control System Toolbox for configuration, local and remote monitoring, animated block diagrams, dynamic live and capture buffer based trending, fault diagnostics, commissioning wizard, and regulator tune-up wizards. Ethernet 10 Mbps point to point or multidrop, each drive has its own IP address.
Keypad and Display	Backlit LCD, animated displays • Parameter editing • Four configurable bar graphs • Drive control
Instrumentation Interface	Two analog outputs dedicated to motor current feedback, plus five analog outputs that can be mapped to variables for external data logging and analysis.

Additional Specifications

Power System Input and Harmonic Data
- Voltage: up to 6.6 kV, 3-phase, +10%/-10%
- Tolerates power dips up to 25% without tripping, complete control power loss ride through of 300 msec
- 125% Overload (OL) for 60 seconds; other OL ratings available
- Frequency: 50 or 60 Hz, ±5%
- Displacement power factor (PF): 0.95 lag
- True PF: greater than 0.95 lag from 40%-100% speed range
- Exceeds the IEEE 519-1992 standard for harmonics, without filters
- Top or bottom cable entry

Converter Type
- AC fed 18-pulse diode using phase shifted transformer

Transformer
- Dry type transformer
- Class H insulation
- Nine LV windings

Inverter
- Multi-level inverter cells: three in series for 3.3 kV inverter; six in series for 6.6 kV inverter
- 1700 Volt IGBTs
- Roll-out phase modules for fast maintenance and repair

Applicable Standards
- IECI 46, JIS, JEC, JEM, CE
- 0-66 Hz, up to 120 Hz
- Seven-level output for motor-friendly waveform
- Top or bottom cable entry

Operating Environment and Needs
- Temperature: 0º to +40ºC
- Humidity: 85% maximum, non condensing
- Altitude: Up to 1000 m (3300 ft) above sea level
- Fan Power (by user): 220 V ac, 3-phase, 60 Hz, or 200 V ac, 3-phase, 50 Hz

Cooling
- Air-cooled with fans on top

Sound
- Less than 75 dBA, at 3.1 ft (1m) from enclosure

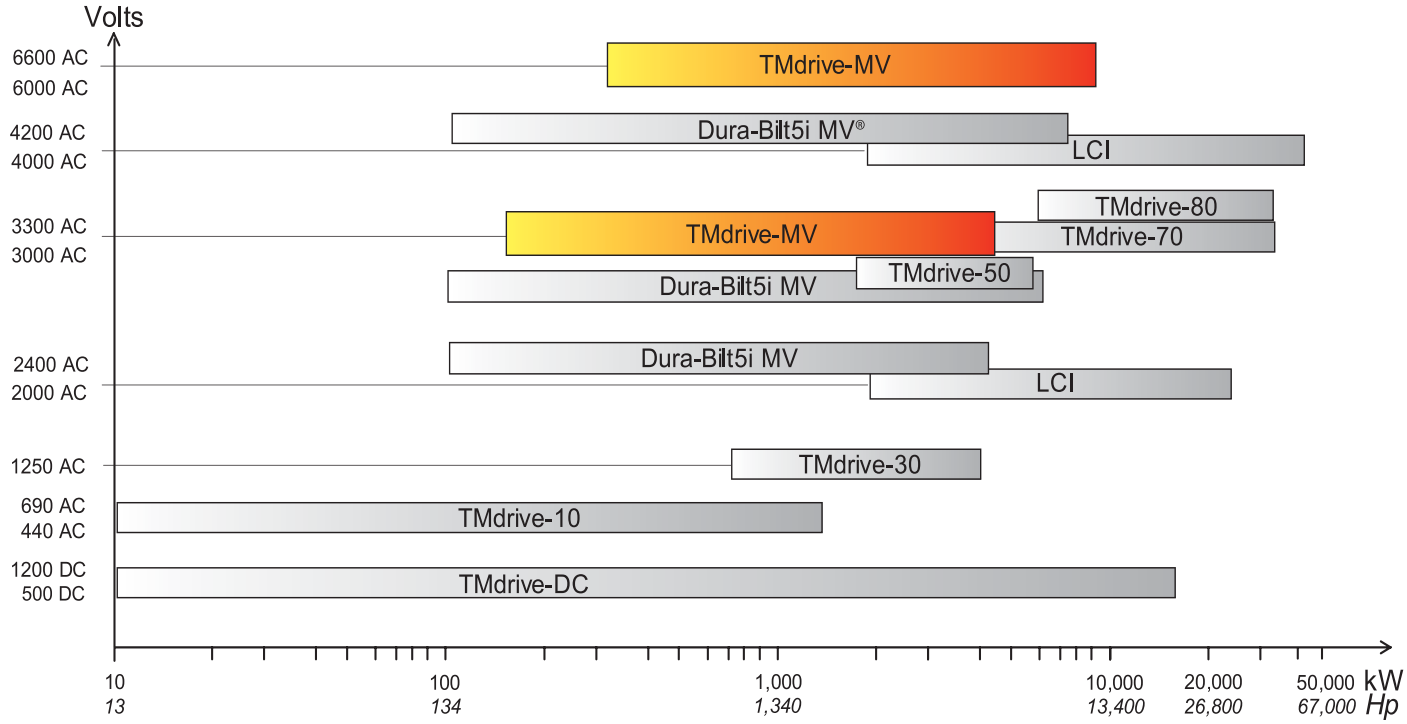
Control
- Non-volatile memory for parameters and fault data
- Vector control with or without speed feedback, or Volts/Hz
- Designed to keep running after utility supply transient voltage drop outs of 300 msec
- Synchronous transfer to line option

Vector Control Accuracy and Response
- Speed regulator: 20 rad/sec
- Speed regulation with speed sensor; ± 0.5%
- Torque response: 500 rad/s
- Torque accuracy: ± 3% with temp sensor, ± 10% without

Protective Functions
- Inverter overcurrent, overvoltage
- Low or loss of system voltage
- Motor ground fault
- Motor overload
- Cooling fan abnormal
- Over-temperature
- CPU error

Enclosure
- IP20 (IEC-529), NEMA1 gasketted equivalent
- Color: Munsell 5Y7/1 - ANSI 61 gray

TMEIC Drives Offer Complete Coverage



TMEIC Corporation
Roanoke, VA, United States
Tel.: +1-540-283-2000
Email: info@tmeic.com
Web: www.tmeic.com

Toshiba Mitsubishi-Electric Industrial Systems Corporation
Tokyo, Japan
Tel.: +81-3-5444-3828
Web: www.tmeic.co.jp

TMEIC Europe Limited
Uxbridge, Middlesex, United Kingdom
Tel.: +44 870 950 7220
Email: info@tmeic.eu
Web: www.tmeic.com

TMEIC Industrial Systems India Private Limited
Hyderabad, 500081, Andhra Pradesh, India
Tel.: +91-40-44434-0000
Email: inquiry_india@tmeic.com
Web: www.tmeic.in

TOSHIBA MITSUBISHI-ELECTRIC INDUSTRIAL SYSTEMS (Beijing) CORPORATION
Beijing, PRC
Tel.: +86 10 5873-2277
Email: sales@tmeic-cn.com