TMEiC
We drive industry

TMdrive®-MVG Product Guide

Medium Voltage Multilevel IGBT Drive
Up to 10,000 kVA at 11 kV

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

Global Products for Meeting Global Needs

The TMdrive-MVG is a general-purpose, medium-voltage, variable-frequency AC drive for industrial power ratings up to 10 MW, in the voltage range of 3/3.3 kV, 6/6.6 kV, and 10/11 kV. Featuring high-quality Japanese design and manufacture, the TMdrive-MVG works with existing or new induction or synchronous motors and meets users' basic system requirements as described below:

Design Feature	Customer Benefit
• Conservative design using 1700-volt IGBTs (Insulated Gate Bipolar Transistor)	• Highly reliable operation and expected 100,000 hour (12 years) drive MTBF, based on field of experience with the large global installed base of TMdrive-MV technology
• High energy efficiency approx. 97%	• Considerable energy savings, in particular on flow control applications
• Diode rectifier ensures power factor greater than 95% in the typical speed control range	• Capacitors are not required for power factor correction
• Multiple level drive output waveform to the motor (27 levels for the 6.6 kV inverter, line to line voltage, peak to peak)	• No derating of motor for voltage insulation or heating is required due to motor-friendly waveform
• Multi-pulse converter rectifier and phase shifted transformer: 3.3 kV Class: 18 pulse 10 kV Class: 54 pulse 6.6 kV Class: 36 pulse 11 kV Class: 30 pulse	• No harmonic filter required to provide lower harmonic distortion levels than IEEE-519-1992 guidelines
• Designed to keep running after utility supply-transient voltage dropouts – up to 300 msec.	• Uninterrupted service for critical loads
• Synchronous transfer to line option with no interruption to motor current (Additional equipment required)	• 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 • Simplified installation • Lower cost installation • Mitigation of harmonics on the primary side
• Direct drive voltage output level	• No output transformer required to match motor voltage, saving cost, mounting space, cabling, and energy • Allows easy retrofit of existing motors

Bringing Reliable Control to a Wide Variety of Industries

Cement

The TMdrive-MVG's compartmentalized design streamlines installation, commissioning, and maintenance of medium-voltage drives in the cement industry. With a Mean Time Between Failure (MTBF) exceeding 100,000 hours (12 years), the MVG is engineered to deliver rock-solid performance in virtually any application, making the TMdrive-MVG a best choice of many consultants, end users, and cement plant builders all over the world, including:

- Raw mill fans, bag house fans
- Preheater fans, coal mill fans
- Grinding mills
- Rotary kilns

Oil and Gas

In the Oil and Gas Industry, the MVG family of drives can be seamlessly integrated with the rest of your pump station control system with a choice of either 3/3.3, 6/6.6, 10, or 11 kV. They can be applied to existing motors and cabling, making them an excellent fit in modernization/retrofit applications, including:

- Oil pumps
- Gas compressors
- Fans

Mining

Accurate torque control is a key in controlling large conveyors. The MVG's flux vector algorithm provides the accuracy and response for this demanding application,. Mining applications include:

- Raw material conveyor
- Grinding mills
- Pumps

Utilities/Power Generation

Traditional mechanical methods of controlling flow are inefficient and require considerable maintenance. In the Power Generation Utilities Industry, the MVG provides more reliable, accurate, and energy-efficient control of flow while eliminating the maintenance associated with dampers, vanes, or valves on:

- Induced and forced draft fans
- Primary and secondary air fans
- Boiler feed water pumps
- Condensate extraction pumps

Metals

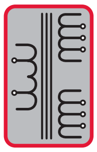
The metal-making part of the steel plant uses large air flows and requires high power levels supplied by the MVG to operate:

- Water gas fans
- BOF ID fans
- Dust collection fans
- Blast furnace blower fans
- Utility pumps

A Look Inside

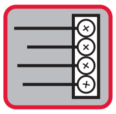
MV Drive Technology for medium voltage operation:

- 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 multi-pulse converter operation. This design exceeds the IEEE 519-1992 guidelines for input current distortion.



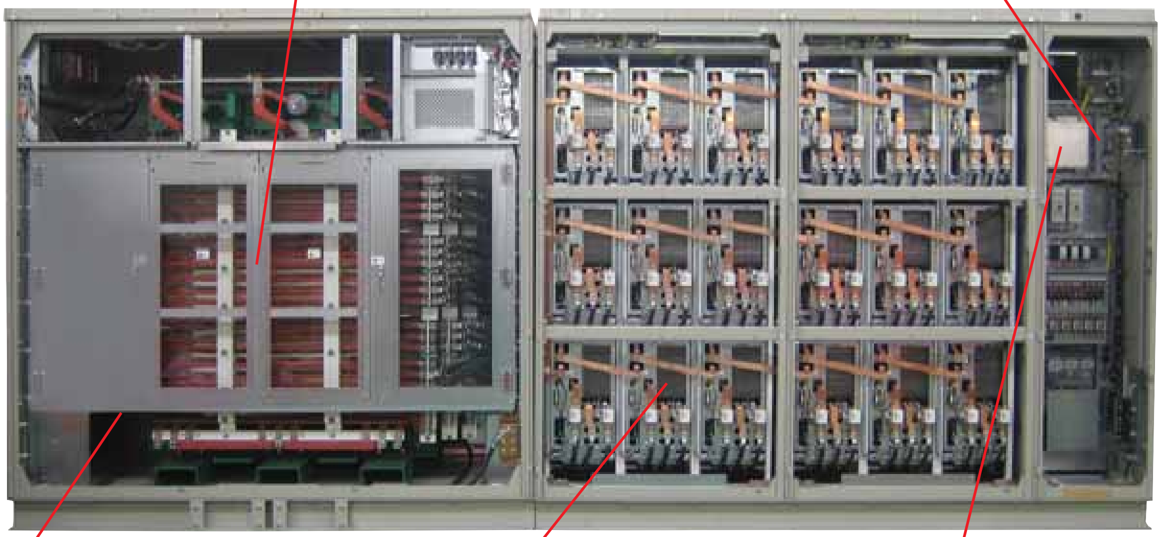
I/O Board

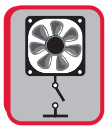
The I/O board supports encoder, 24 V dc I/O, 115 V ac inputs and analog I/O, standard. All I/O are terminated to a two-piece modular terminal block for ease of maintenance, located in right hand cabinet.

Main Power Input

Four voltage levels are available:

- **3-3.3 kV**, 3-phase, 50/60 Hz
- **6-6.6 kV**, 3-phase, 50/60 Hz
- **10 kV**, 3-phase, 50/60 Hz
- **11 kV**, 3-phase, 50/60 Hz

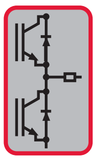




Air Cooling

Forced air cooling system with:

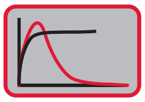
- Intake through cabinet doors
- Upward flow through inverter cells and transformer
- Exhaust at top of cabinet



Cell Inverters

Example: six banks of three, series connected inverter cells, each containing:

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



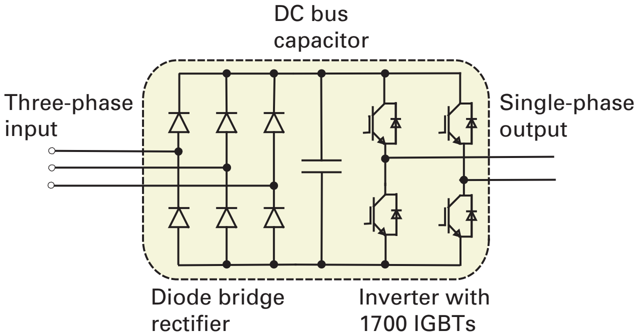
Control Functions

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

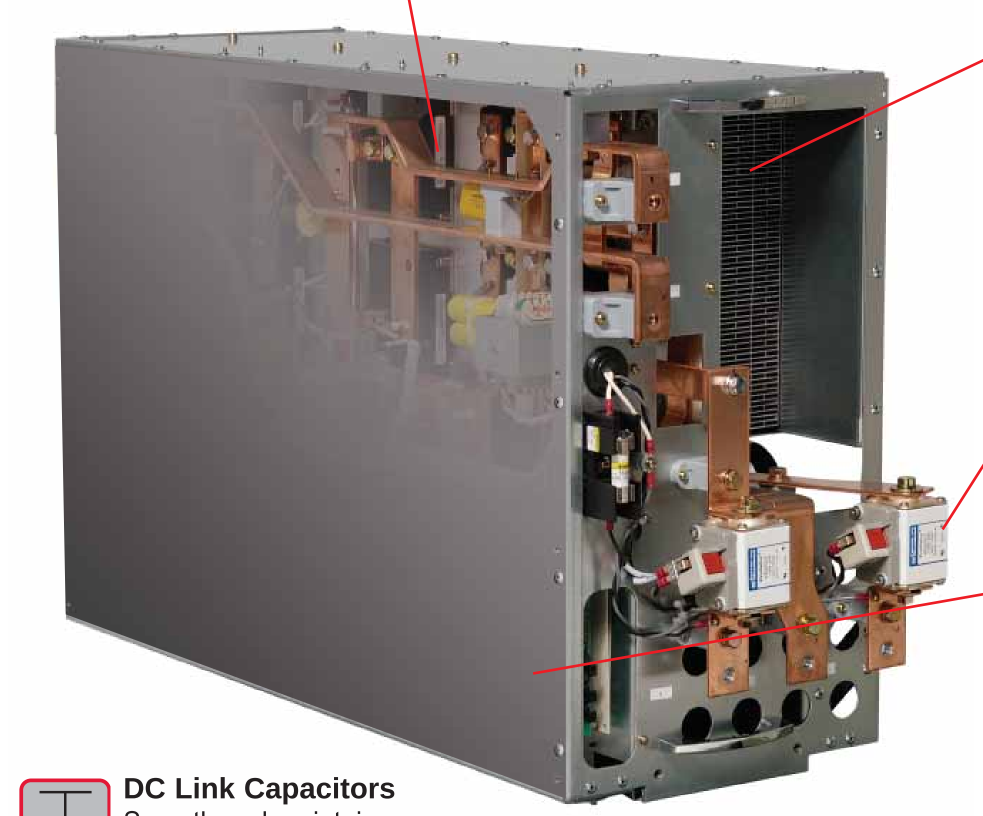
Slide-Out Inverter Modules

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. The mean time to repair the drive (MTTR) is 30 minutes or less.



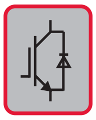
Inverter Cell Module

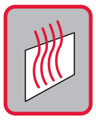
Inverter Cell Module Removed from Rack



Switching Devices

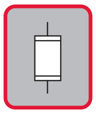
Switching devices are Insulated Gate Bipolar Transistors (IGBT)





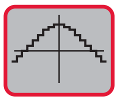
Cooling Heat Sink

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



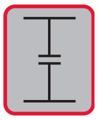
Input Fuse

Fused three-phase inputs to converter



Control Board

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

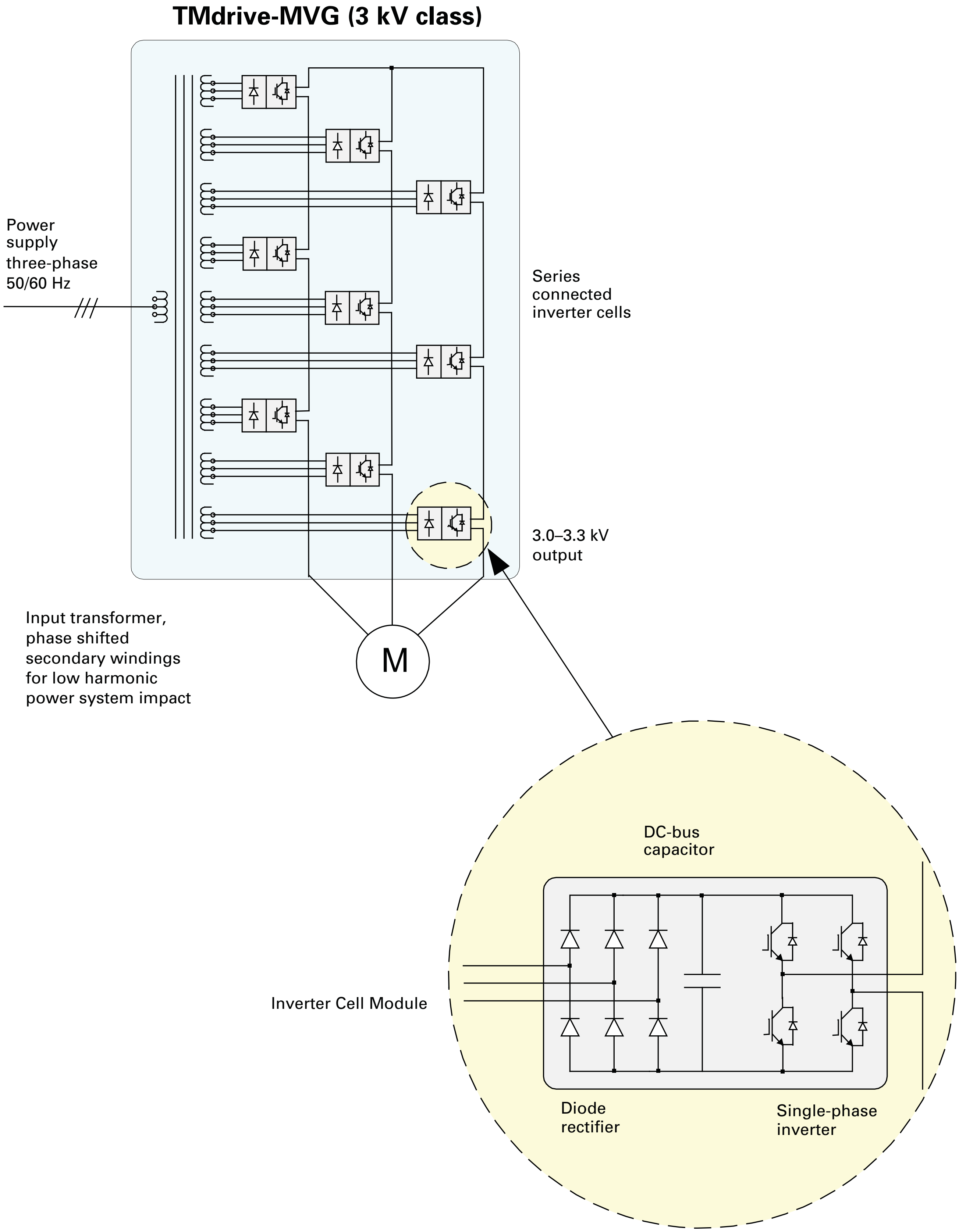


DC Link Capacitors

Smooth and maintain DC voltage supply to the inverter (on opposite side of module).

TMdrive-MVG Architecture

The TMdrive-MVG main circuit consists of an input transformer and single-phase PWM inverter cells. For 3 kV, three inverter cells are series connected to create an output with 7 output voltage levels.



TMdrive-MVG Specifications

3.0/3.3 kV TMdrive-MVG

Frame	Rated Output Current Amps *1	3.0 kV Output kVA	3.3 kV Output kVA	Approx. Motor Power HP @3.3 kV *2	Approx. Motor Power kW @3.3 kV *2	Panel Width mm (inch)	Panel Height with channel base mm (inch)	Panel Depth mm (inch)	Approx. Weight kg (lbs)
I	35	180	200	200	160	2100 (83)	2670 (106)	900 (36)	2700 (5940)
	53	270	300	300	225				
	70	360	400	400	300				
II	105	540	600	650	480	2200 (87)	2670 (106)	900 (36)	3400 (7480)
	140	720	800	875	650				
III	167	860	950	1000	780	2800 (111)	2850 (113)	1000 (40)	4300 (9460)
	193	1000	1100	1200	900				
	228	1180	1300	1400	1000	3100 (122)	2850 (113)	1100 (44)	5700 (12540)
	263	1360	1500	1600	1225				
IV	315	1630	1800	1900	1400	4000 (158)	2895 (114)	1100 (44)	6800 (14960)
	350	1810	2000	2100	1600	4100 (162)			7400 (16280)
	385	2000	2200	2400	1750				
	CF 665	3450	3800	4100	3100	11800 (465)	2895 (114)	1100 (44)	Later
	CF 727	3770	4150	4500	3400				Later
V	420	2180	2400	2600	1900	4600 (182)	2895 (114)	1300 (52)	9400 (20680)
	525	2720	3000	3200	2400				
	CF 788	4090	4500	5000	3700	12800 (504)	2895 (114)	1300 (52)	Later
	CF 998	5180	5700	6200	4600				Later

Notes:
For cabinet clearances, overload ratings, and power calculations, see page 11
*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 (0.94) and power factor (0.87)
CF These are two banks; consult factory for dimensions and weights
Redundant cooling fans increase height

TMdrive-MVG Specifications

6.0/6.6 kV TMdrive-MVG

Frame	Rated Output Current Amps *3	6.0 kV Output kVA	6.6 kV Output kVA	Approx. Motor Power HP @6.6 kV *4	Approx. Motor Power kW @6.6 kV *4	Panel Width mm (inch)	Panel Height with channel base mm (inch)	Panel Depth mm (inch)	Approx. Weight kg (lbs)
I	35	360	400	400	300	3200 (126)	2670 (106)	900 (36)	3800 (8360)
	53	540	600	650	475				
	70	720	800	875	650				
II	105	1090	1200	1300	950	4000 (158)	2700 (107)	900 (36)	5400 (11880)
	140	1450	1600	1750	1300			1000 (40)	7000 (15400)
III	167	1720	1900	2000	1500	5000 (197)	2750 (109)	1000 (40)	7800 (17160)
	193	2000	2200	2400	1800				
	228	2360	2600	2800	2000	5100 (201)		1100 (44)	9100 (20020)
	263	2720	3000	3200	2400				
IV	315	3270	3600	3900	2900	6100 (241)	2895 (114)	1200 (48)	12000 (26400)
	350	3630	4000	4300	3200				
	385	4000	4400	4800	3500				
	CF 595	6180	6800	7500	5500	15800 (622)			Later
	CF 665	6900	7600	8300	6000				Later
	CF 731	7590	8350	9000	6800				Later
V	420	4360	4800	5000	3900	6300 (248)	2895 (114)	1400 (56)	15200 (33440)
	473	4900	5400	6000	4400				
	525	5450	6000	6500	4900				
	CF 797	8270	9100	10000	7400	16200 (638)			Later
	CF 898	9320	10260	11000	8350	16600 (654)			Later
	CF 998	10360	11400	12000	9300	16800 (662)			Later

Notes:

*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 (0.94) and power factor (0.87)

CF These are two banks; consult factory for dimensions and weights

Redundant cooling fans increase height

10/11 kV TMdrive-MVG

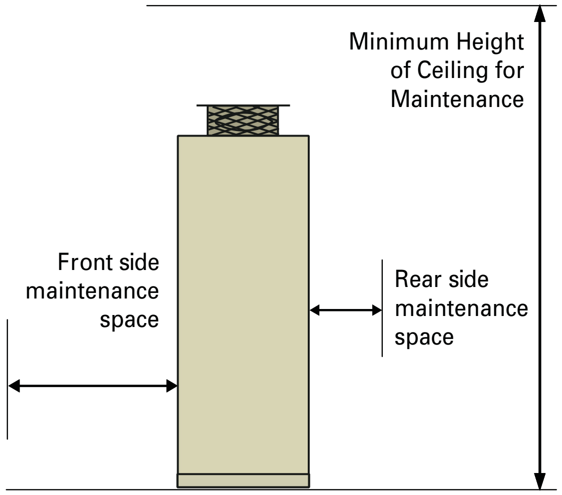
Frame	Rated Output Current Amps *5	10 kV Output kVA	11 kV Output kVA	Approx. Motor Power HP @11 kV *6	Approx. Motor Power kW @11 kV *6	Panel Width mm (inch)	Panel Height with channel base mm (inch)	Panel Depth mm (inch)	Approx. Weight kg (lbs)
I	35	600	660	700	500	5600 (221)	3250 (128)	1400 (56)	8750 (19260)
	53	900	990	1100	800				
	70	1200	1320	1400	1000				
II	87	1500	1650	1800	1350	6800 (268)	3250 (128)	1400 (56)	10850 (23880)
	105	1800	2000	2200	1600				
	122	2100	2300	2500	1800				
	140	2400	2640	2900	2100				
III	162	2800	3080	3500	2500	7500 (296)	3250 (128)	1500 (60)	15500 (34110)
	191	3300	3630	4000	3000				
	226	3900	4290	4500	3500	7700 (304)			18500 (40700)
	263	4500	5000	5500	4000				
IV	315	5400	6000	6500	4900	12800 (504)	3250 (128)	1500 (60)	29350 (64580)
	347	6000	6600	7200	5400				
	386	6680	7350	7800	5800				
V	420	7200	8000	8700	6500	12800 (504)	3250 (128)	1500 (60)	29850 (65680)
	473	8100	9000	9800	7300				
	525	9000	10000	10900	8000				

Notes:
*5 1.25 PU overload, 60 sec rating; use Frame Amp rating for most acceptable match with motor
*6 Approximate capacity for 11 kV-based 6-pole induction motors with typical efficiency (0.94) and power factor (0.87)
Redundant cooling fans increase height

TMdrive-MVG Specifications

Cabinet Minimum Maintenance Space

Drive	Frame	Capacity	Front Side Space	Rear Side Space	Ceiling Height
3/3.3 kV class	I	400 kVA	1600 mm (63 in)	20 mm (0.8 in)	3050
	II	800 kVA	1600 mm (63 in)	20 mm (0.8 in)	
	III	1500 kVA	1700 mm (67 in)	20 mm (0.8 in)	3100
	IV	2200 kVA	1700 mm (67 in)	20 mm (0.8 in)	
	V	3000 kVA	1900 mm (75 in)	20 mm (0.8 in)	
6/6.6 kV class	I	800 kVA	1600 mm (63 in)	20 mm (0.8 in)	3050
	II	1600 kVA	1600 mm (63 in)	20 mm (0.8 in)	
	III	3000 kVA	1700 mm (67 in)	20 mm (0.8 in)	3100
	IV	4400 kVA	1700 mm (67 in)	20 mm (0.8 in)	
	V	6000 kVA	1900 mm (75 in)	20 mm (0.8 in)	
10/11 kV class	I	1320 kVA	1800 mm (71 in)	600 mm (24 in)	3500
	II	2640 kVA	1800 mm (71 in)	600 mm (24 in)	
	III	5000 kVA	1900 mm (75 in)	600 mm (24 in)	3550
	IV	7350 kVA	2000 mm (79 in)	600 mm (24 in)	
	V	10000 kVA	2000 mm (79 in)	600 mm (24 in)	



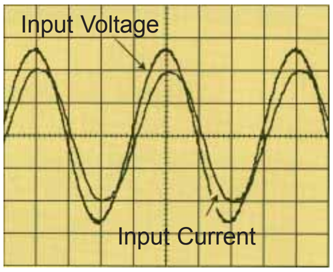
Notes

1. $kVA_{Inverter} = (Power_{Mtr\ Shaft}) / (Mtr\ PF \times Mtr\ Eff)$
   $I_{Phase} = (kVA_{Inverter}) \times (1000) / (1.732) \times (V_{Mtr\ Line\ to\ Line})$
   - Mtr PF – 0.87, Mtr Eff = 0.94, ambient temperature is 32˚F–104˚F (0˚C–40˚C).
   - Ratings based on a variable torque load (industrial fans and pumps).
   - Altitude above sea level is 0–3300 ft (0–1000 m).
   - Dimensions to top of cooling fans are for the nonredundant type fans.
2. An optional bypass circuit can be separately mounted.
3. Redundant cooling fans are available as an option; overall height increases.
4. No rear access is required except for 10/11 kV Class drives.
5. Incoming power cabling and motor cabling are bottom entry; top entry is an option.
6. Air is pulled in through the filters in the cabinet doors and vented out the top.
7. Available options include motor cooling fans and control, cabinet space heater, bypass power/control and dv/dt filter, HV input, sync motor control, smooth transfer to and from utility.
8. For conservative sizing of cooling equipment, heat rejection is 3 kW/100 hp of output power.
9. The panels are fixed to the channel bases and shipped.

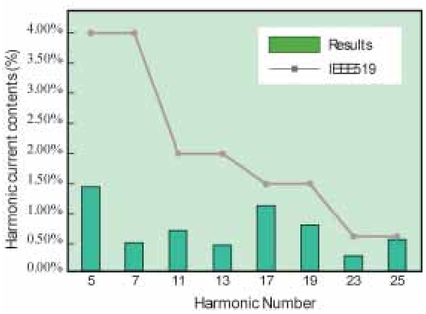
Features of the TMdrive-MVG

A Clean Wave Inverter

Using the multiple winding input transformer, the TMdrive-MVG has multi-pulse rectification and more than meets the requirements of IEEE-519 (1992). This reduces the harmonic current 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.



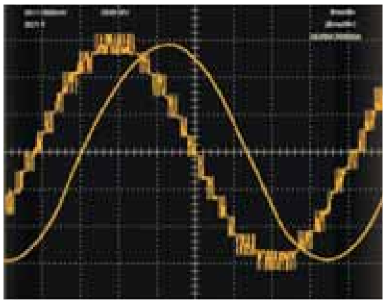
Typical Input Wave Forms



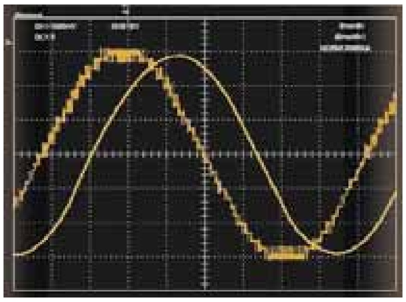
Typical Harmonic Contents
of Input Current for 18-pulse System

A Clean Output Wave

As a result of the multilevel 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.



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 approximately 97% (design value). This high efficiency is a result of:

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

Example: 6.6 kV drive at 6,000 kVA and 50 Hz			
Current	***100%***	***75%***	***50%***
Efficiency	***97.1%***	***97.2%***	***97.5%***
Except for the consumption of control power and auxiliary power.			

A High Input Power Factor

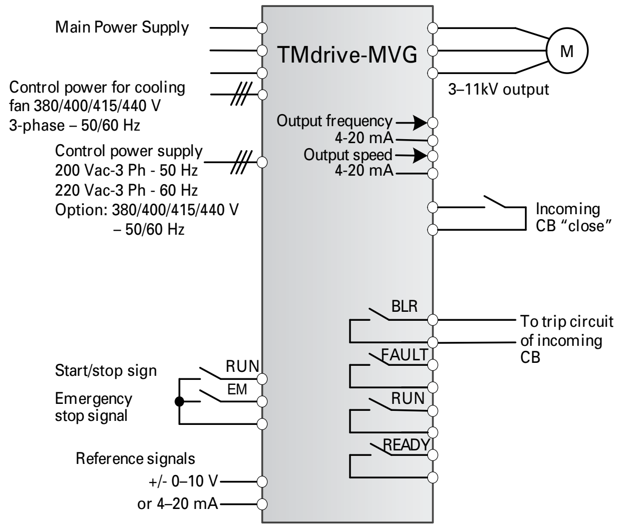
Each inverter cell has a diode bridge rectifier. As a result, the input power factor is above 95% over the entire normal operating speed range, even when driving a multiple-pole induction motor of low power factor. With this high power factor, no power factor correction capacitor is required.

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%***

Examples of measured power factor

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	(4) ± 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, 10 kHz, 5 or 15 V dc diff. input, A Quad B, with marker
LAN Interface Options	Profibus-DP, ISBus, DeviceNet™, TOSLINE™-S20, or Modbus RTU
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 Drive Navigator 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 multi-drop, 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 11 kV, 3-phase, +10%/–10%
- Tolerates power dips up to 25% without tripping, complete power loss ride through of 300 msec
- 125% Overload (OL) for 60 seconds; other OL ratings available
- Frequency: 50 Hz or 60 Hz, ±5%
- Power factor (PF): 0.95 lag
- True PF: greater than 0.95 lag over 40–100% speed range
- Exceeds the IEEE 519-1992 standard for harmonics, without filters
- Bottom cable entry

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

Transformer
- Dry type transformer
- Air cooled type
- Multi LV windings

Inverter
- Multilevel inverter cells:
  - three in series for 3.3 kV inverter
  - six in series for 6.6 kV inverter
  - nine in series for 10 kV inverter
  - ten in series for 11 kV inverter
- 0–72 Hz
- Up to 120 Hz, option for 3/3.3 and 6/6.6 kV
- For 10/11 kV, maximum frequency 72 Hz
- Multilevel output for motor-friendly waveform

Applicable Standards
- IEC61800-4, JIS, JEC, JEM

Control
- Nonvolatile 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 dropouts of 300 ms
- Synchronous transfer to line option
- Synchronous motor control (option)

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

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

Mechanical Specifications

Operating Environment and Needs
- Temperature: 0˚ to +40˚C
- Humidity: 85% maximum, noncondensing
- Altitude: Up to 1000 m (3300 ft) above sea level:
- Fan: 380/400/440 Vac, 3 phase, 50 Hz or 60 Hz

Cooling
- Air-cooled with fans on top

Sound
- Approx. 76-83 dB(A), at 3.1 ft (1 m) from enclosure

Enclosure
- IP30 except for fan openings (IEC 60529), NEMAI gasketted equivalent
- Color: Munsell 5Y7/1 (Option: ANSI 61 gray, RAL7032 etc.)

Drive/Motor Monitoring

Operator Keypad

High Function Display

- LCD backlight gives great visibility & 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 to operate the equipment from the keypad

RJ-45 Ethernet port is used for the local Drive Navigator (toolbox) connection

Instrumentation Interface

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

Interlock button disables the drive

Display Group	Icon	Status Indication
Heartbeat		Communication OK
		Communication error
Control State	L	Local mode
	R	Remote mode
	T	Test mode
Fault State	Blank	Drive OK
		Alarm state
	Blinking	Trip fault
Drive Indication	F	Forward rotation
	R	Reverse rotation
Motion		Drive not ready
		Drive not running
		Drive running forward
		Drive running reverse

Multi-language Keypad – Optional Operator Interface (below)

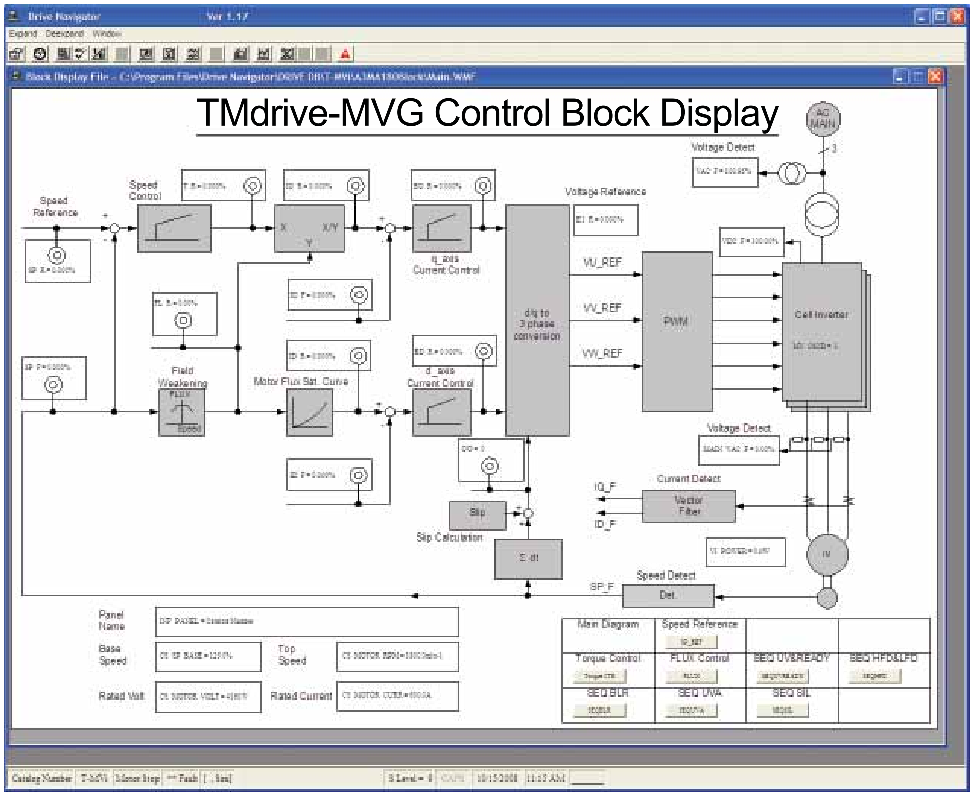
The optional multi-language keypad is a touch-panel display with the same functionality as the standard keypad. Chinese version is shown here. The main features are:

- 5.7 inch (145 mm) LCD color display
- Choice of languages, touch selection:

  -English
  -Japanese
  -Chinese
  -Russian
  -Spanish
  -French
  -Portuguese
  -Italian
  -Korean

- The Ethernet communication with the drive, analog check pins, interlock button, and status LEDs are mounted separately

Monitoring & Analysis



Real-Time Drive Block Diagram

Drive Configuration

All the TMdrive family of drives are configured and commissioned with the Windows-based Drive Navigator. Wizards intelligently guide the user through the required steps. Included are live block diagrams, highly integrated help, and high-performance diagnostics. Several sets of drives can be maintained using Ethernet communication. The control block display opposite shows the main drive control functions together with real-time values of the important variables. Available Navigator functions include:

Parameter (Set Point) Control

- Loading and saving a parameter file
- Changing a parameter
- Comparing parameter files

Support Functions

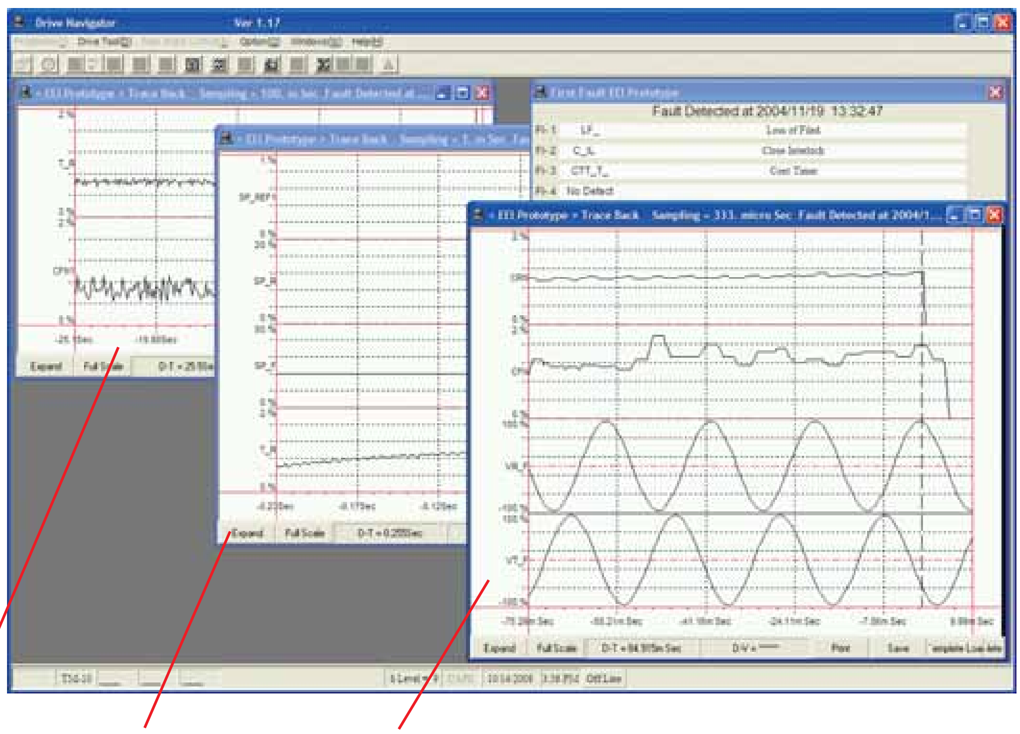
- Control block display
- Snapshot function
- Step response test
- Response wave display

Drive Troubleshooting

This screen displays a drive first fault and shows selected trend displays to assist in determining the cause. The fastest trend displays four variables sampled at a rate of 333 microseconds. The other two slower trends are sampled at 1 millisecond and 100 milliseconds.

Available Troubleshooting Functions:

- First fault display
- Operation preparation display
- Fault trace back
- Trouble records
- Fault history display
- Online manual



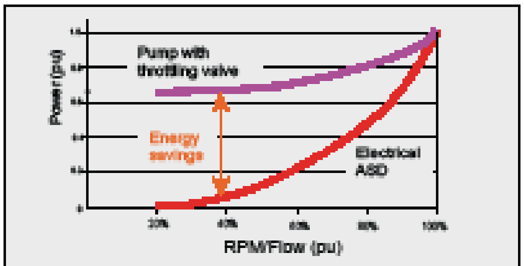
100 msec. sampling | 1 msec. sampling | 333 micro sec. sampling

Energy Savings Payback Calculations

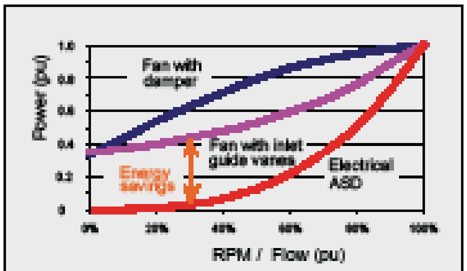
Replacing a mechanical speed control device with an adjustable speed drive usually produces large energy savings plus a reduction in maintenance costs. This appendix outlines how the energy savings can be calculated as follows:

1. Calculate the cost of energy used by the electric drive speed control system, outlined on this page.
2. Calculate the cost of energy used by the mechanical speed control system, outlined on the next page.

The difference is the energy cost savings. Typical power consumption curves for pumps and fans are shown below.

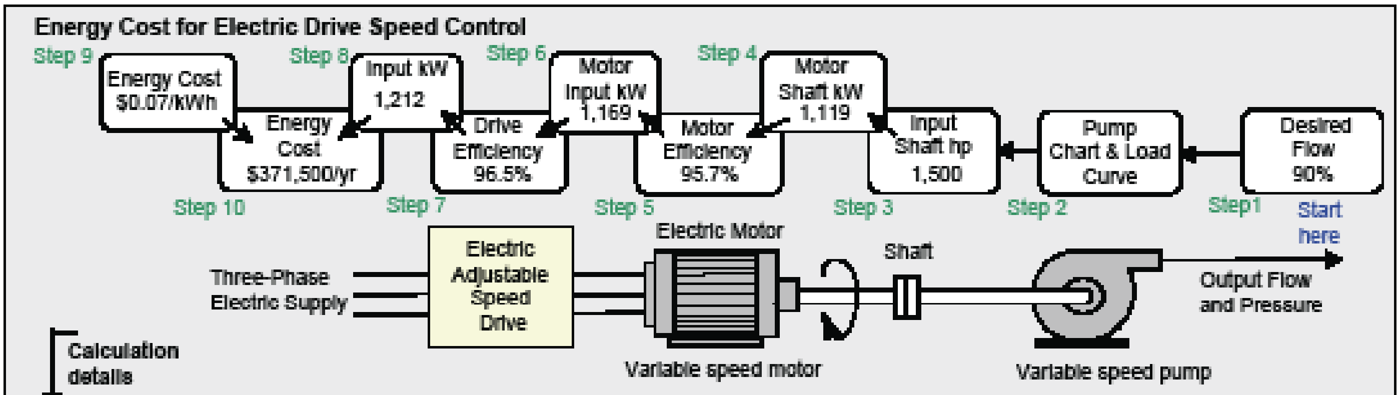


Example: Pump power savings using electric drive (ASD)



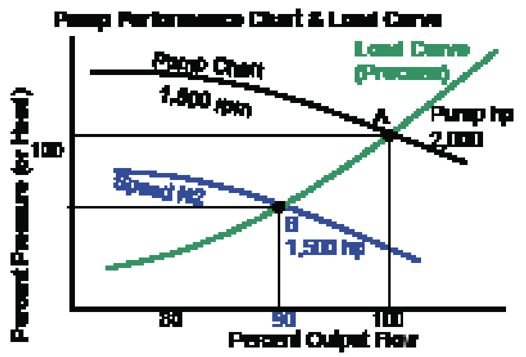
Example: Fan power savings using electric drive (ASD)

Below is an example of the energy cost calculation for a pump driven by a motor and electric drive. The calculation for the mechanical system is similar and is described on the next page. Since energy consumption varies with speed and flow, you need the load profile table which shows the number of hours running at the various flows. Refer to the example below.



<table>
<tr><td>Step 1

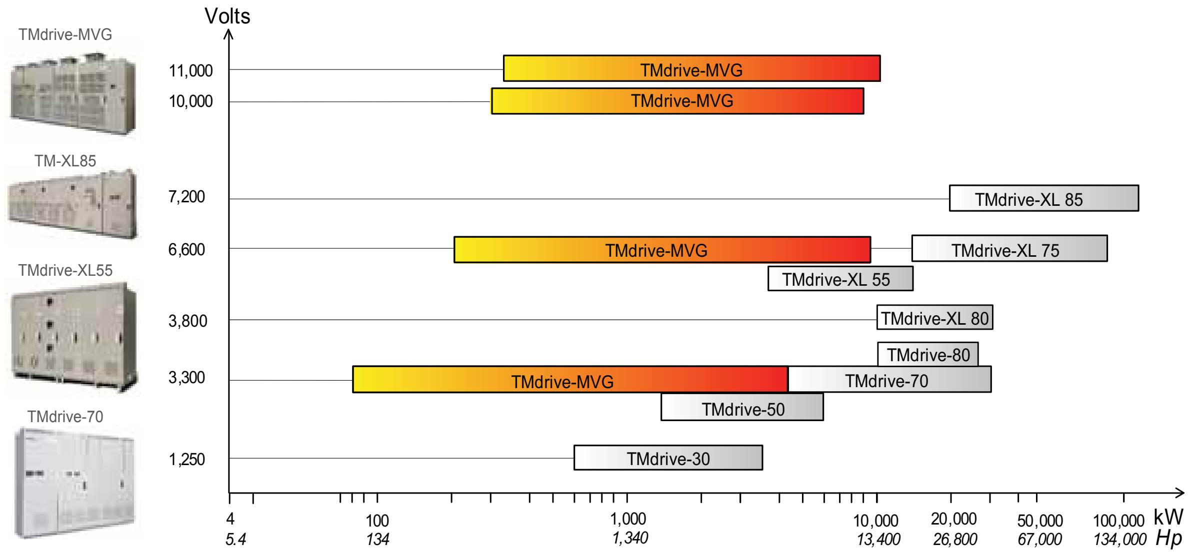
Step 2

Step 3</td><td>Select the desired pump output flow, for example 90%, and number of hours/day at this flow, for example 12.
Obtain the variable speed pump performance chart and the load pressure-flow curve, which is the flow resistance of the process being fed.
Find the pump input power.</td><td></td><td>Overlay the load pressure-flow curve on the pump chart and find the pump input shaft horsepower at the 90% flow (point B). You need the load profile. See example below.

Pump input power at N2 rpm = 1,500 hp at point B, 90% flow.

Daily Load Profile (example)<table><tr><td>Operation Hours/day</td><td>5</td><td>12</td><td>5</td><td>1</td><td>1</td></tr><tr><td>Percent Flow</td><td>100%</td><td>90%</td><td>80%</td><td>70%</td><td>60%</td></tr></table></td></tr>
<tr><td>Step 4</td><td>Convert the input shaft horsepower to shaft kW</td><td>Conversion: Horsepower x 0.746 = kW</td><td>Input shaft kW = 1,500 hp x 0.746 = 1,119 kW</td></tr>
<tr><td>Step 5
Step 6</td><td>Obtain the electric motor efficiency</td><td>Example: Induction motor efficiency 95.7% from manufacturer's data sheets (find at each RPM)</td><td>Motor input power = 1,119 kW/0.957 Efficiency = 1,169 kW</td></tr>
<tr><td>Step 7
Step 8</td><td>Obtain the adjustable speed drive efficiency</td><td>Example: Drive efficiency 96.5% from manufacturer's data sheets (find at each RPM)</td><td>Drive input power = 1,169 kW/0.965 Efficiency = 1,212 kW</td></tr>
<tr><td>Step 9
Step 10</td><td>Obtain the electric power cost</td><td>Example: Energy cost = $0.07/kWh. Calculate cost for the hours at this flow from load profile; in this example it is 12 hours/day.</td><td>Energy cost = 1,212 kW x 0.07$/kWh x 12 hrs/day x 365 days per year = <u>$371,500 per year</u>. (Repeat calculation for other flows in load profile and total).</td></tr>
</table>

TMEIC Drives Offer Complete Coverage



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