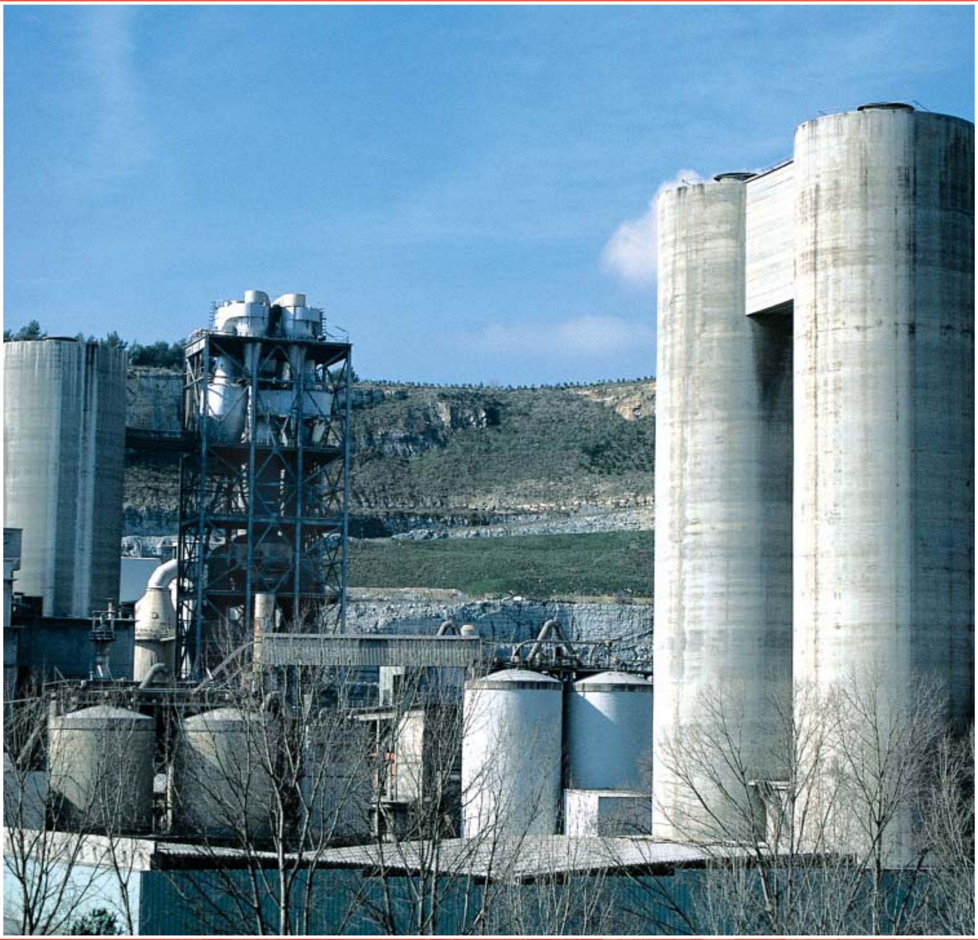
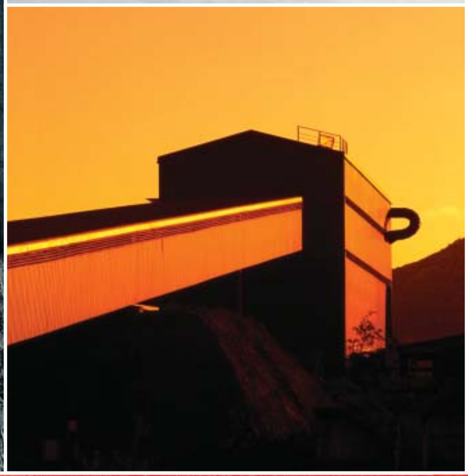
TMEIC
We drive industry





Drive Solutions for the Global Cement Industry

metals | cranes | mining | testing | oil & gas | solar inverters | utilities | cement

About TMEIC

A Global network

TMEIC is built on the combined and proud heritage of Toshiba and Mitsubishi-Electric in the industrial automation, control and drive systems business. TMEIC's global business employs more than 2,200 employees, with sales exceeding U.S. $2.4 billion, and specializes in Metals, Oil & Gas, Material Handling, Utilities, Cement, Mining, Paper and other industrial markets.

TMEIC Corporation, headquartered in Roanoke, Virginia, designs, develops and engineers advanced automation and variable frequency drive systems.

The factory for the World's factories

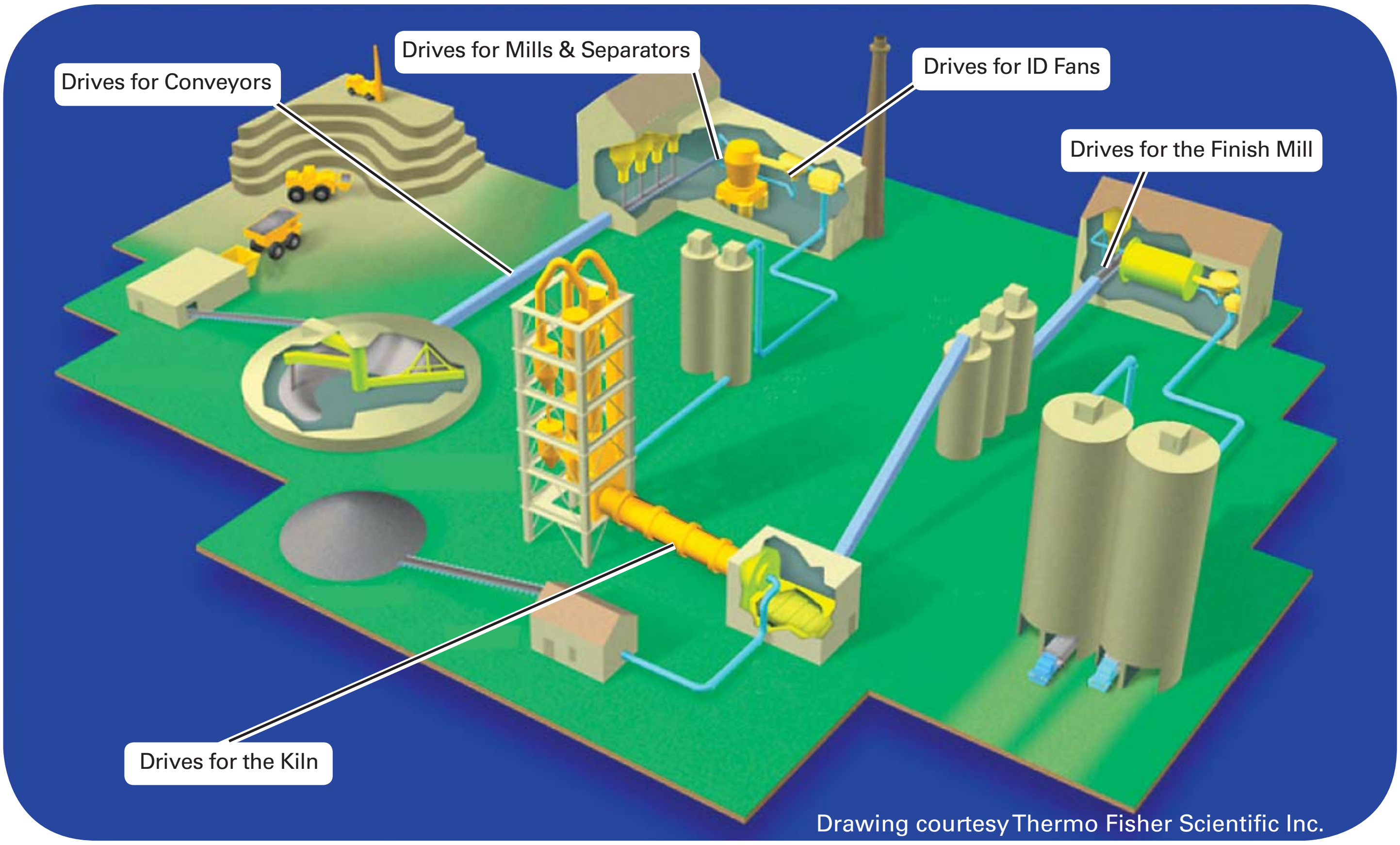
TMEIC delivers high quality advanced systems and products to factories worldwide, while serving as a global solutions partner to contribute to the growth of our customers.

Customer Service

At TMEIC, our focus is on the customer, working to provide superior products and excellent service, delivering customer success every project, every time.

Variable Frequency Drives in the Cement Industry

Every step of the way, from the quarry to the finished cement product, variable frequency drives (VFDs) are used to smoothly start large motors and continuously adjust the speed as required by the process. Induction and synchronous motors driving excavators, crushers, conveyors, mills, kilns, and fans use VFDs to provide high power, speed control, and low-loss flow control with significant associated energy savings



Drawing courtesy Thermo Fisher Scientific Inc.

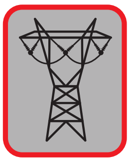
Controlling fan flow by adjusting speed avoids wasting energy in adjustable dampers and louvers. When large flows are involved and the motor energy consumption is significant, varying the speed is the answer. With large machines, the electrical power savings can amount to hundreds of thousands of dollars per year. In addition, the motors are protected against starting inrush currents, thus avoiding thermal stress and extending motor life.

Why Use Electrical Variable Frequency Drives?

Here are some of the reasons to use electrical medium voltage drives:

Increased Reliability **Pages 5, 5, 9**

Variable speed motor-drive systems are more reliable than traditional mechanical approaches such as using louvers, valves, gears, or turbines to control speed and flow. Because electric drives have no moving parts, they provide very high reliability.

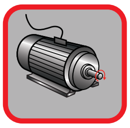


Dramatic Energy Savings **Pages 4, 5, 10**

On an induced draft fan with a variable speed motor-drive system, the flow control louver or valve is not required, avoiding large flow energy losses. In fact, the variable speed motor-drive system is more efficient than all other flow control methods including turbines and hydraulic transmissions. For more information on this topic, refer to Application 1, and the brochure *Selecting Variable frequency drives for Flow Control* in the library at www.tmeic.com.

Significantly Less Maintenance **Pages 8, 19**

The cement plant demands high system availability. Because electric variable speed drive systems have no moving parts, they require virtually no maintenance. This is in sharp contrast to speed and flow control devices such as louvers, guide vanes, valves, gears, and turbines that do require extensive periodic maintenance and associated downtime.



Soft Starting One or Multiple Motors, and Improved Power Factor **Pages 8, 9**

When electric drives soft start large motors, starting inrush current with associated mechanical and thermal wiring stress is eliminated. This removes limitations on motor frequency of starts, reduces insulation damage, and provides extended motor life. With synchronization logic, one drive can start multiple motors. Finally, large variable frequency drives improve overall system power factor.

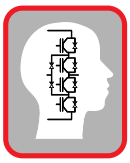
Why TMEIC Drives Make Sense

Choose TMEIC, a Global Supplier **Page 18**

TMEIC sells and services drive systems worldwide, supported by engineering and service offices and spare parts depots in North & South America, Europe, Asia, Japan and Australia.

We've got you covered! A Complete Family of Drives **Page 19**

Our family of low and medium voltage (LV and MV) drives covers all your needs from 450 hp up to 12,000 hp (335 kW to 8,950 kW) and beyond, with a wide output voltage range up to 11 kV, and a line of DC drives, to meet your requirements.



Engineering Expertise **Page 11**

TMEIC drive and motor application engineers bring an average of 25 years of practical industry experience to your application. After analyzing your system requirements, they can recommend the most cost effective solution and design the complete drive system for you.

Configuration Software **Pages 19, 20**

The TMDrive Navigator world-class configuration software is used on all TMEIC drives. Live block diagrams and tune-up wizards streamline commissioning and maintenance activities.

Drive Applications for Fans, Mills and Kilns

Variable frequency drives are used to control the speed of fans, mills, conveyors and kilns in the cement industry. VFDs are also used to smoothly start large mill motors, synchronize, and connect them across the line. The following seven pages describe four typical applications and present the reasons why electrical drives were chosen. These applications are:

1. Induced draft fans
2. Cement kiln rotation
3. Crushers and roller mill drives
4. Slip Power Recovery drives

Application 1. Induced Draft Fan for Cement Kiln

The ID fan induces kiln air flow, which must be continuously varied to match the process requirements. Because cement making is a thermal and a chemical process, both air volume and mass flow must be controlled. The process control system continuously monitors process conditions such as inlet air temperature, kiln feed, cement composition, and required fuel-air ratio. The process control system then directs the blower and flow control system to provide the optimum air flow.

Traditional flow control methods use constant speed motors with mechanical flow reducing devices such as:

- Inlet louvers (dampers) in the ducting
- Outlet louvers (dampers) in the ducting
- Flow guide vanes in the fan casing
- Variable slip clutches in the fan drive shaft

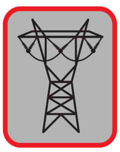
These mechanical solutions have significant disadvantages:

- High energy consumption at reduced flow rates
- Mechanical wear and required maintenance
- Process interruptions due to mechanical problems
- Limitations on motor starting duty

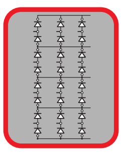
The electrical solution replaces the mechanical equipment with a Dura-Bilt5i MV VFD. This brings a number of advantages.

Advantages of the Drive System

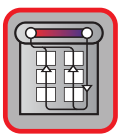
Very High Reliability – The Dura-Bilt5i MV uses 3,300 Volt Insulated Gate Bipolar Transistors (IGBT) allowing a simpler, more reliable inverter design. Since mechanical flow devices are not used, process interruptions caused by mechanical failures are minimized.



Energy Savings – Elimination of the air flow losses through the dampers is usually the most compelling reason for applying a Dura-Bilt5i MV drive. The ID fan power can be several thousand hp and using a drive to vary air flow can result in energy savings of over $100,000 per year, as described on the next page.



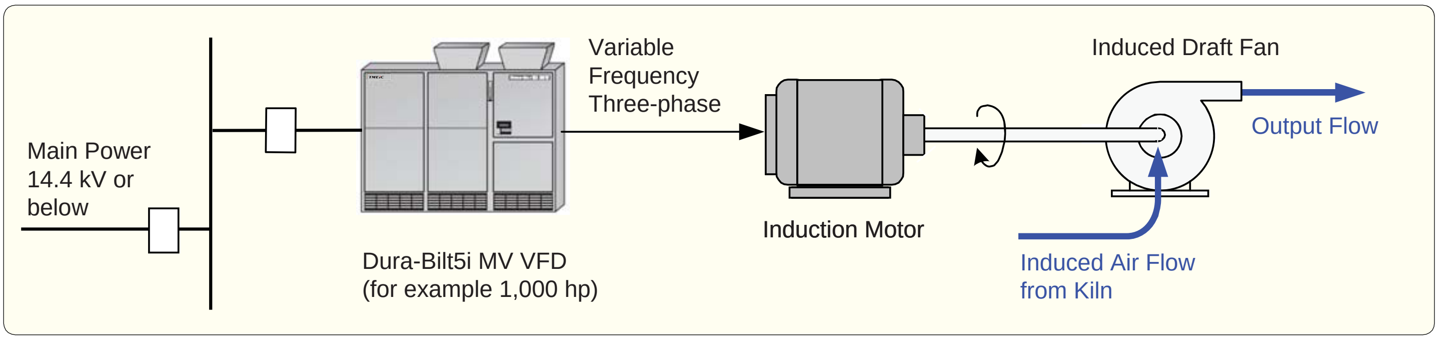
Power System Friendly – The converter is a 24-pulse diode rectifier with a design exceeding the requirements of the IEEE 519-1992 standard for Total Harmonic Distortion (THD). This means that other equipment connected to the power system is not adversely affected by harmonic frequency disturbances.



Heat Pipe Cooling – The IGBTs in the three inverter legs are cooled with heat pipe technology, which maintains uniform working temperature, prolongs the semiconductor life, reduces fan noise, and saves valuable floor space in the plant.

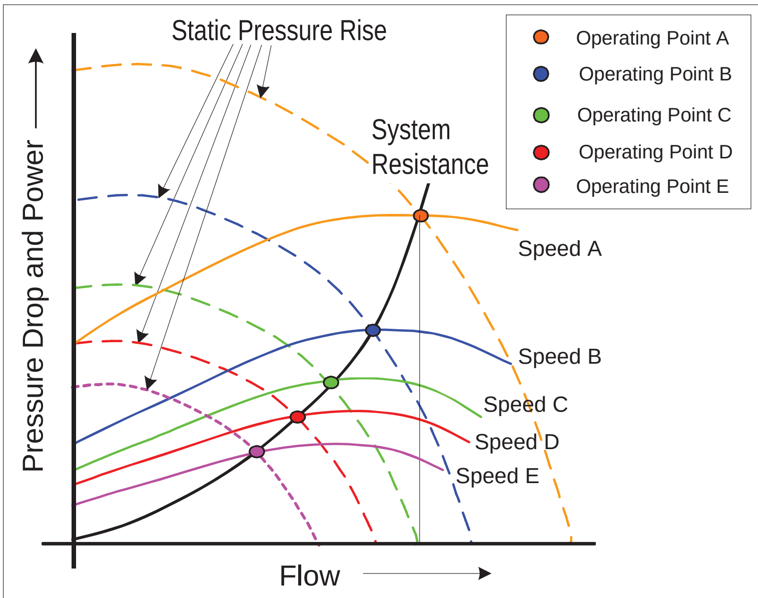
Energy Savings using a TMEIC Variable Frequency Drive Fan System

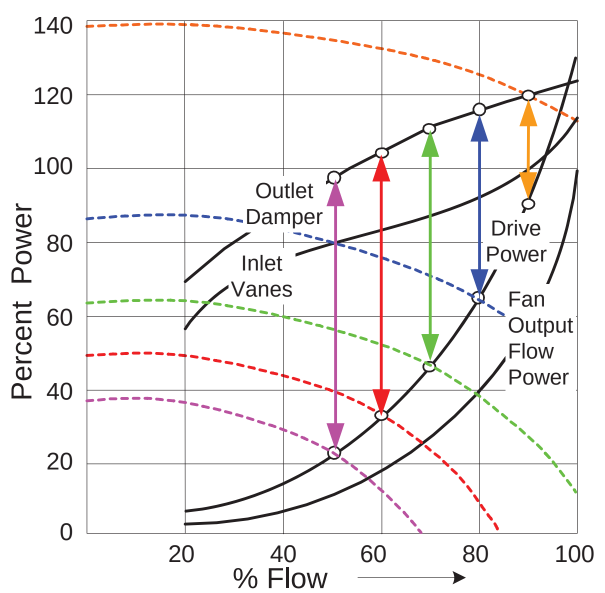
Variable flow can be provided by varying fan RPM to precisely match process operating conditions. The variable frequency drive provides variable fan speed which varies the air flow according to the system resistance.



The first chart shows how different fan speeds are used to select the proper operating points A through E on the system resistance curve. Depending upon the size of the cement kiln, the required ID fan output power can vary from a few hundred hp to several thousand hp. The second chart shows a system using mechanical dampers to achieve flow control. Pairs of flow and pressure operating points correspond to points A through E.

Power level percentages shown are total input power including all motor, transformer, fan, and system losses as percentages of required fan output power. The energy deltas (vertical lines) allow calculation of energy savings and drive cost justification. A table of expected annual operating times and power level differences is shown below. Energy cost factors for the site are applied and the annual savings calculated.





Ref Point	Required Flow %	% Power Using Outlet Damper Control	% Power Using Adjustable Speed Drive	Delta % Power Saved	% Time on Annual Basis	% Saved on Annual Basis
A	90	120	91	29	15	4.35
B	80	117	66	51	25	12.75
C	70	111	46	65	25	16.25
D	60	103	34	69	20	13.8
E	50	96	23	73	15	10.95
				Total Annual % Energy Consumption Savings		**58.1**

Savings. Based on the annualized percent savings in the table, an ID fan system with 1,000 hp output, operating for 8,000 of 8,760 hours per year, at an energy cost of $0.035 per kWh, saves:

1000 x 0.746 x 58.1% x $.035 x 8000 = $121,359

If installed added costs of drive equipment are $150,000, the payback period will be only 15 months. A good return on investment!

Application 2. Cement Kiln Speed and Torque Control

In cement plants, variable frequency drives provide controlled torque and speed to the kiln. In addition to enhanced process control, the VFD increases the life of the mechanical equipment and reduces mechanical maintenance and operating costs. The drives also provide accurate torque and speed feedback signals, which are used by the distributed control system to improve kiln process control.

The cement kiln drive system has a number of performance requirements including the following:

- 200 to 250% starting torque for 60 seconds
- Timed acceleration rate, typically 60 seconds from 0 to top speed
- Motor current limit protection during starting
- Continuous monitoring of motor loading conditions, with an alarm output for any overload
- Up to 100% continuous operating torque available from 25% to 100% speed

To meet these requirements TMEIC provides both ac and dc drive technology. With the rapid advance of power semiconductors and ac drive controls in recent years, ac drives are now preferred over dc drives for many kiln applications. Modern drives provide advanced diagnostic features to simplify troubleshooting and greatly reduce downtime.

Four TMEIC drive types are usually selected for kiln applications:

- TMdrive-10e2 for low voltage systems up to 690 V ac
- Dura-Bilt5i MV for medium voltage systems up to 4,160 V ac output
- TMdrive-MVG for medium voltage systems up to 6,600 V ac
- TMdrive-DC for operating dc motors up to 1,200 V dc

Advantages of the VFD Kiln Drive System

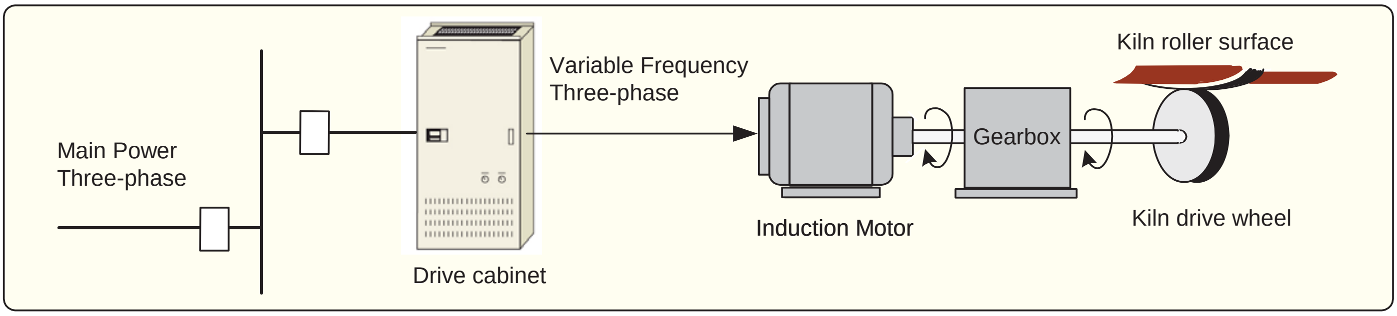
High Reliability – Advanced design, including use of medium voltage Insulated Gate Bipolar Transistors (IGBTs) and efficient cooling systems, creates a drive with high reliability and low maintenance.

Heat Pipe Cooling Technology – The TMdrive-10 and Dura-Bilt IGBT power bridges use heat pipe cooling to move heat to the top of the cabinet close to the fans, thereby saving valuable floor space, and reducing the cooling air speed and associated fan noise.

Toolbox Configuration – The Microsoft Windows-based Toolbox software is used to configure, install, and provide diagnostics. The Toolbox is used by all the TMEIC system drives and is a source of productivity for the life of the system. Either Ethernet or ISBus is used for connectivity.

Lan Communications – The selection of LAN options includes ISBus, Profibus-DP, DeviceNet™, and Modbus (Ethernet or RTU). These options support virtually all controller platforms and legacy equipment allowing seamless integration into new systems.

Kiln Variable Frequency Drive System



Important Kiln Drive Control Requirements are provided by the VFD

1. Controlled Acceleration

The controlled and timed acceleration provided by a variable frequency drive is very beneficial for the kiln, compared to starting the kiln motor directly from the AC line. Rapid, across-the-line starting of the kiln motor could result in unwanted torsional oscillations and stresses in parts of the driven machinery.

For example, a typical kiln could easily be accelerated to top speed in 2 to 3 seconds if the motor were permitted to do so. But the kiln's long cylindrical tube, large reduction gear, and its associated mechanisms would be subjected to excessive stresses and perhaps damage. A precisely controlled, timed kiln acceleration provided by the VFD, helps extend the mechanical equipment life, and maintain consistent product output.

2. Controlled Starting Torque

The starting torques typically required for a normal kiln are 125 to 175% of motor rated torque assuming the following:

- There are no clinker rings
- There are no mud rings
- The idler rolls are properly aligned
- There is normal lubrication for all of the kiln's supporting idler rolls and gears
- The charge in the kiln is at the minimum elevation (the "6 o'clock" position.)

The effects of clinker rings, mud rings on wet process kilns, and misaligned or poorly lubricated idler rolls (especially when cold) are to increase the starting torques needed from 175 to 225%. This has led to the practice of specifying 200% or greater starting torque for 60 seconds. Starting torques are often specified to be as high as 250% of motor rated torque for 60 seconds. This gives more margin to assure kiln breakaway from rest under all anticipated conditions.

3. Feedback to the Process Control System

A variable frequency drive provides a very useful torque or kW feedback signal to help improve kiln process control. The kiln torque provides the earliest warning of conditions such as a flush coming through the kiln, a clinker ring beginning to break up, or a mechanical problem such as an idler roll bearing developing major friction.

Automatic kiln control systems often use a filtered torque signal and its rate of change as part of the logic for controlling the kiln and its operating speed. Therefore, a good noise-free torque signal is critical, and is available from the TMEIC drive products.

The VFD also provides a kiln speed analog output signal which, together with torque, is sent to the process control system.

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Application 3. Starting Multiple Mill Motors

Customer installations at two adjacent cement plants use variable frequency drives for a number of applications. At these plants, eight motors ranging from 250 to 2,400 hp are driven by TMEIC medium voltage drives, and there are six large mill motors, each one requiring a medium voltage motor of 4,000 hp size.

Synchronous Motor for Mill

The cement company had several requirements when selecting their six large mill motors, and associated drives and controls, including:

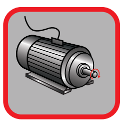
- Ability to soft start any of the motors from any drive and reduce the impact on the power system.
- Ability to synchronize the motors with the utility supply and run some or all of the motors on the utility supply at constant speed.
- Ability to run one motor at variable speed to allow grinding process optimization
- Use synchronous motors, because synchronous motors can supply leading VARs to the power supply system to help correct poor plant power factor.

After reviewing their alternatives, the company decided to install a TMEIC VFD in each plant to individually soft start the three mill motors. In addition, since the two plants are adjacent, it was decided to install a tie contactor allowing any VFD to start any mill motor in either plant, providing backup in case of any problems.

Benefits of the Variable Frequency Drive and Synchronous Motors

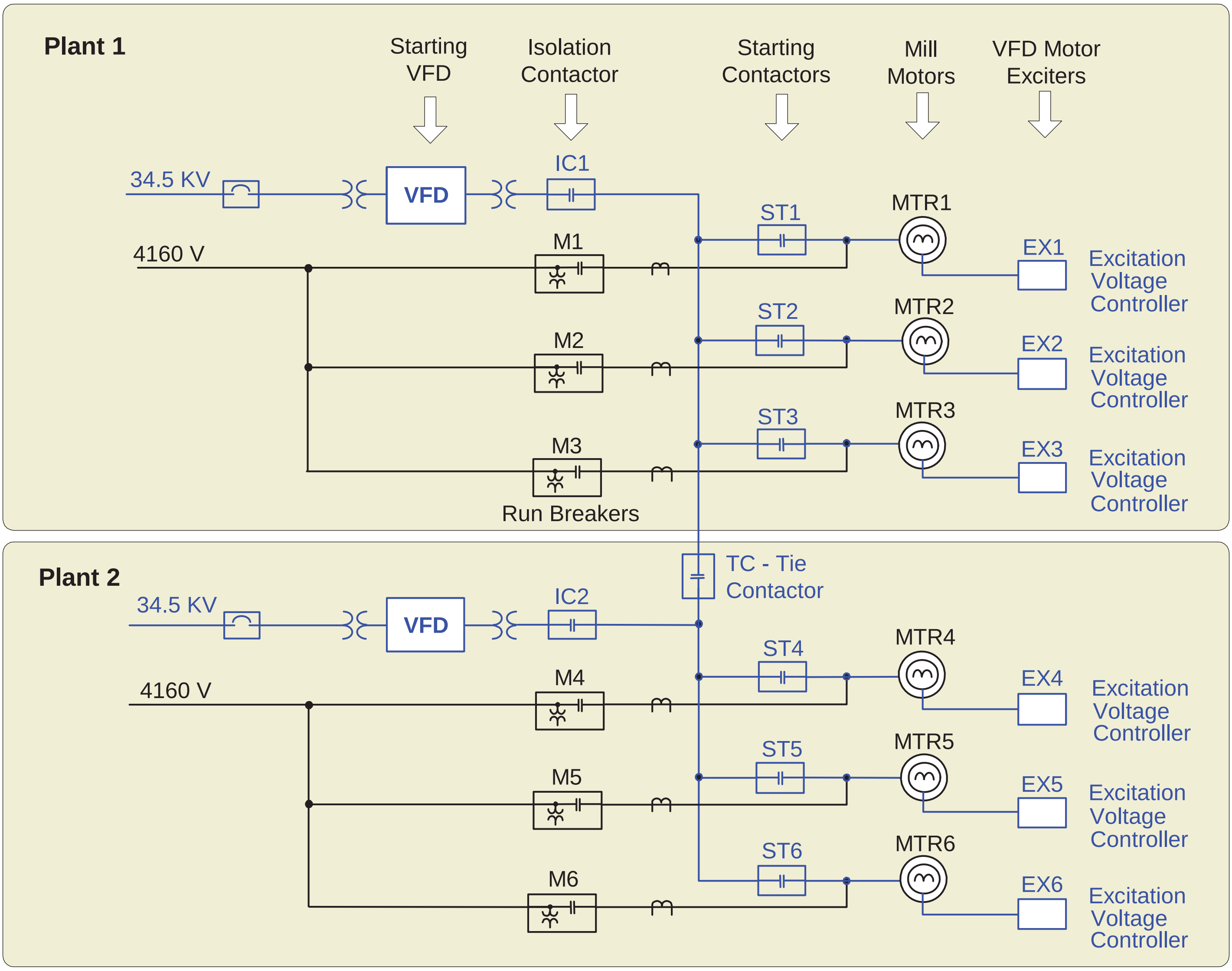
Cost Savings – The customer's analysis indicated excellent savings by using synchronous motors because they correct the power factor for the whole plant, and they have a high efficiency. In this location the utility charges users a penalty for low power factor operation.

High Reliability – The VFD has a proven history of high reliability. Sharing the two VFDs between the six motors using power switches yields an availability of better than 99.999%.



Smooth Motor Starting – The VFD controls the rotor field (through the exciter) and the stator current to provide a smooth starting profile without exceeding rated volts and amps, thereby protecting the motor against overheating. Controlling the motor current is also important where power system grids are weak or the plant is at the end of a long transmission line. In addition to starting, the VFD provides smooth motor synchronizing with the supply.

Multiplexing Two Drives to Start and Control Six Large Motors



Redundant Drive Starting System Ensures Availability

All six mills are driven by synchronous motors of identical ratings. One VFD can start any of the three motors in any desired sequence as shown by the blue lines in the figure. Once the synchronous motor is started, the VFD synchronizes the motor with the supply to operate directly across the line.

As soon as the first mill motor is started and bypassed to the line, the VFD is available to start the second mill. The same process is repeated to make the VFD available for starting the third mill.

All three mills can operate directly across the line, or one can remain connected to the VFD for variable speed operation if required. This system saves on the customer's capital cost.

The VFD is responsible for the actual phase and voltage matching for the final transfer of the motor to utility operation. This transition is coordinated to within a few milliseconds to prevent damaging torques or loss of motor synchronization.

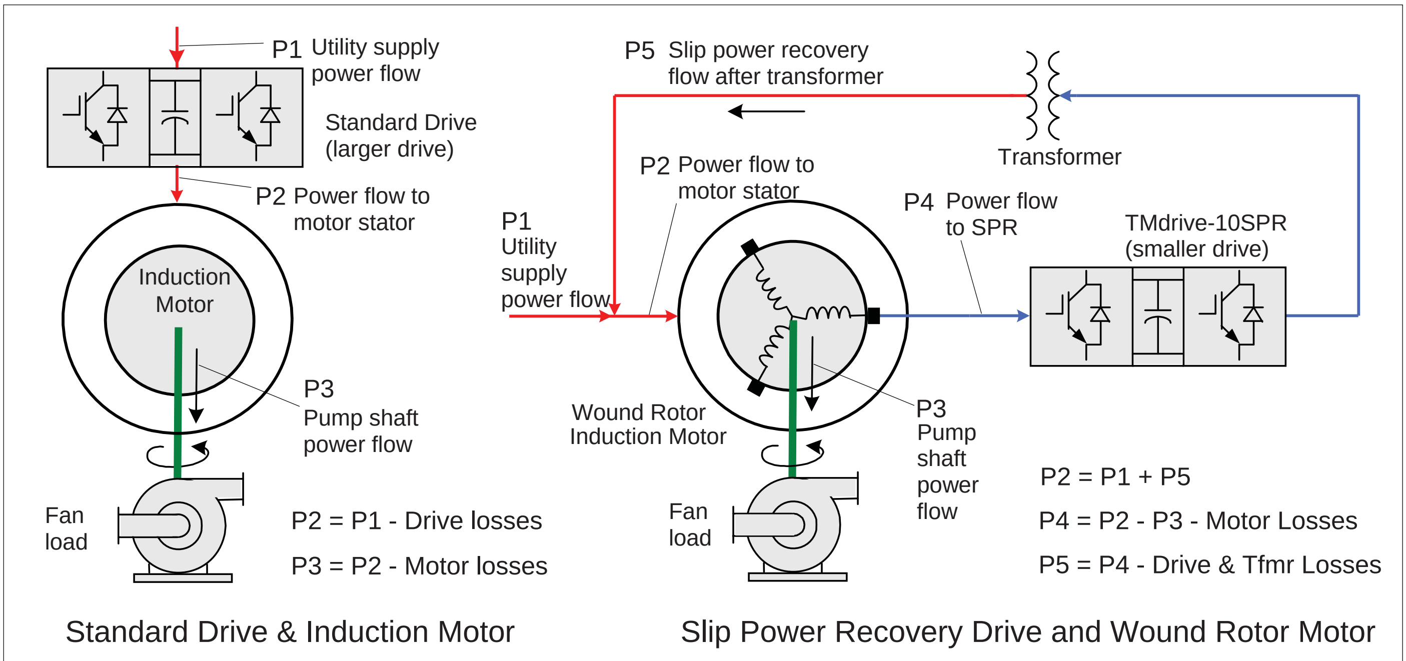
Application 4. Energy Savings using Slip Power Recovery Drive System

Wound rotor induction motors have been popular in some industries, particularly cement, for decades. Until about 1985, a wound rotor induction motor (WRIM) was the only large ac motor that allowed controlled starting characteristics and adjustable speed capability.

A WRIM is a machine with a 3-phase wound stator that is usually connected directly to the power system. The rotor also has a 3-phase winding, usually connected in a wye (or star) circuit. The three terminals of the rotor winding are connected to separate slip rings, which are normally connected to a liquid rheostat or resistor bank. Changing rotor resistance changes the motor speed. In the past the power in the resistor was lost as heat. The slip power recovery drive, TMdrive-10SPR, discussed on page 26, is used to vary the motor speed by varying the power taken off the rotor and returned to the utility supply.

The example below compares the case of an induction motor driven by a large standard drive, with the case of a WRIM controlled by a small SPR drive, and calculates the energy savings. In the larger standard drive system, all the motor power passes through the drive. With the SPR drive, only a fraction of the motor power passes through the drive.

For a rated fan load of 5,000 hp, running at 90% speed, the power saving using the SPR drive is 88 kW. With an electrical cost of 5¢/kWh, the annual savings amount to $38,540. At lower speeds the savings are even higher.



Operating Conditions	Power Flow	Standard Drive & Induction Motor	Slip Power Recovery Drive and Wound Rotor Motor
Fan Load at Full Speed, shaft kW	—	3730 kW (5,000 hp)	3730 kW (5,000 hp)
Fan Load at 90% Speed, shaft kW	P3	2720 kW	2720 kW
Utility supply power flow	P1	2980 kW	2892 kW
Power flow to motor stator	P2	2863 kW	3180 kW
Power flow to Slip power recovery drive	P4	0	300 kW
Slip power recovery after transformer	P5	0	288 kW
Difference in utility power flows P1(IM)-P1(SPR)	—	—	88 kW
SPR system savings with 5¢/kWH electrical power	—	—	$38,540 per year

Global Customer Support Network

Comprehensive technical service is provided by our Customer Support Organization, staffed by TMEIC service engineers with offices and spare parts depots across the globe.

In North and South America
Customers are supported by the TMEIC Corporation service personnel, design engineers and Spare Parts Depot in Virginia, and the TMEIC Factory in Japan.

In Europe
TMEIC service engineers service all drive systems in Europe, supported by the European TMEIC Spare Parts Depot.

In Asia and the Pacific Rim
TMEIC services drive systems throughout China, India and the Pacific Rim, supported by multiple Field Engineers, Spare Parts Depots, and the TMEIC factory in Japan.

Remote Drive Diagnostics
TMEIC supports drive customers through the ***Remote Connectivity Module (RCM)***, a remote diagnostic service link with the TMEIC design and service engineers in Roanoke, Virginia. The RCM enables seamless integration between your drives and our engineers.

Remote System Diagnostics
TMEIC's remote system diagnostics tool, included in level 1 software, offers a quick path to problem resolution. System faults are automatically identified, and provide an integrated view of product, process and system information. TMEIC design and service engineers in Roanoke, Virginia, can analyze the data and provide steps for resolution.

Remote Diagnostic Service reduces Mean Time To Repair (MTTR)
Remote diagnostic service offers protection for your investment, by reducing downtime, lowering repair costs and providing peace of mind. Remote diagnostics requires an internet connection between your plant and TMEIC for retrieval of fault logs and files to diagnose drive or system issues.

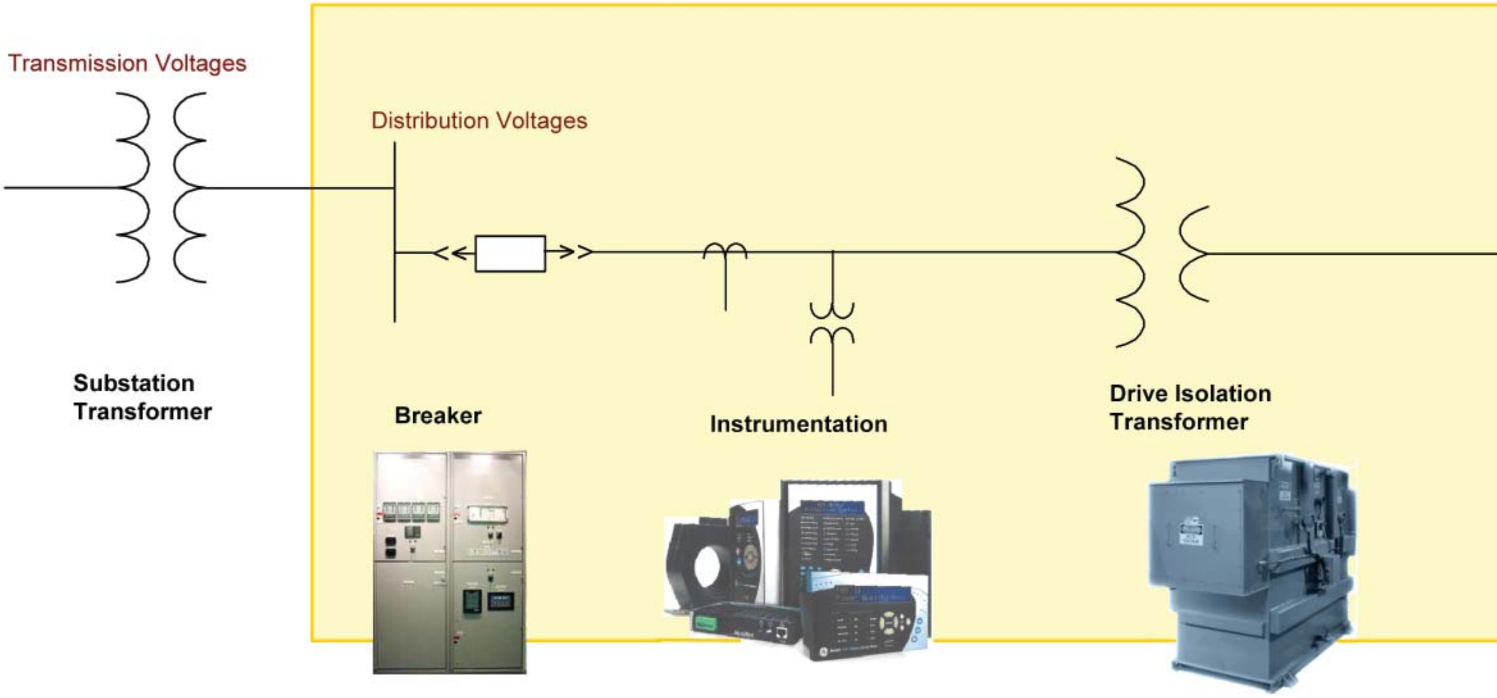
Features	Benefits
• Reduced downtime and Mean-Time-to-Repair	**Quick support saves thousands of $ in lost production** TMEIC engineers can quickly connect to the drive and diagnose many issues in a matter of minutes.
• Secured connection	**Customer-controlled access** All remote activity is conducted with permission of the customer. Drive start/stop is not permitted remotely.
• Fault Upload Utility	**Proprietary Fault Upload Software** Historical drive faults are identified; TMEIC design and service engineers can analyze the issue resulting in the fault and provide a solution.

We Engineer the Medium Voltage Power System

TMEIC application engineers design the power system from the medium voltage switchgear to the adjustable speed drive and motor. The critical engineering process for a successful installation is illustrated in the chart (top page 14) and detailed in this Project Engineering section. Icons indicate where the various teams of engineers in the factory and field service are involved in the project.

A typical MV power system is shown below. TMEIC Application Engineers size and select all the equipment for the optimal drive solution.

Medium Voltage Power System



MV switchgear is selected for the application considering:

- The type, such as vacuum or SF6
- The size for the current and voltage
- The CTs, PTs, and protective relays to operate the breaker
- The enclosure for outdoor or indoor
- The environment such as temperature and humidity

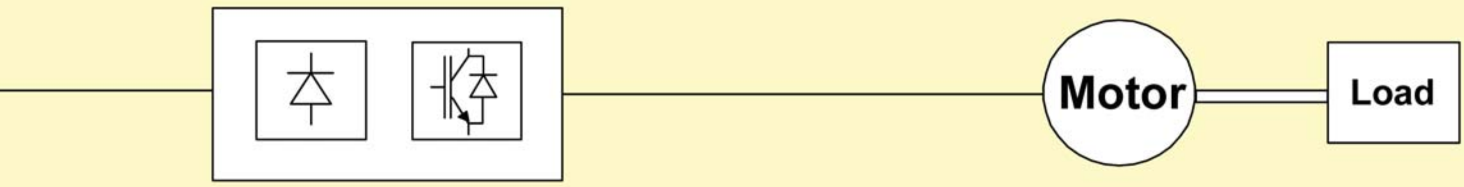
Instrumentation for equipment metering, monitoring, protection and control is selected, including:

- Amp transducer and ammeter
- Watt and Watt-hour transducers
- Phase CTs and phase overcurrent relay
- Ground sensor CT and relay
- Power quality monitor

Drive isolation, input and output, transformers are selected for the application considering:

- The type, such as dry or liquid filled
- Size for the kVA and voltage
- Cooling if required
- The enclosure for outdoor or indoor
- The environment such as temperature and humidity
- Special drive requirements

Drive Utilization Voltage



Adjustable Speed Drive

Control PLC

Motor

Selection of the best adjustable speed drive for the application based on:

- Continuous and overload torque and power requirements
- Type of load, including constant or variable torque or regenerative
- Drive and motor voltage
- Power system compatibility
- Overall efficiency of the ASD and motor combination
- Harmonic analysis

Selection of optional drive associated equipment such as:

- PLC for logic control, for example synchronizing multiple motors with the supply for soft start capability
- Air conditioned equipment house if required
- Switchgear if motor is to be synchronized with the line
- Reactor for use with an LCI

Selection of the motor and associated equipment including:

- Induction, synchronous, or wound rotor motor
- Motor size including the power, torque, voltage, current, and speed
- Selection of the exciter if a synchronous motor is used
- Required motor protection devices
- Optional tachometer-special applications
- Torsional analysis

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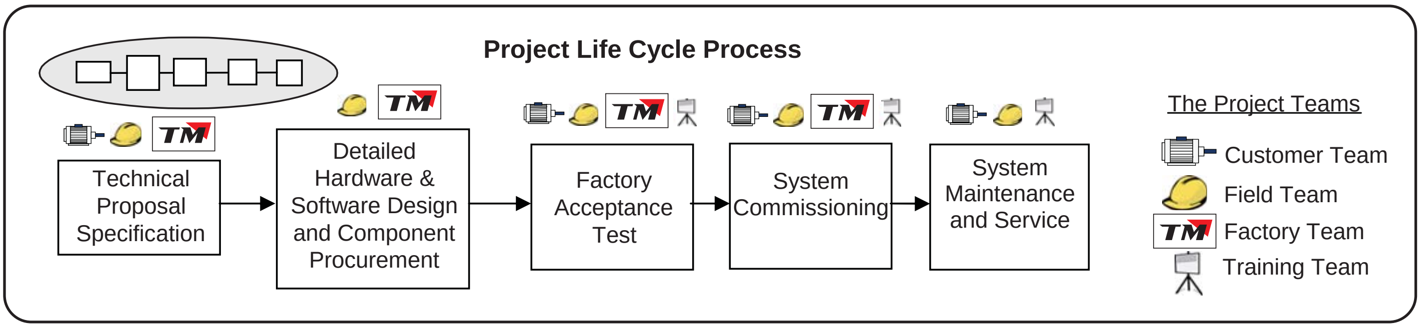
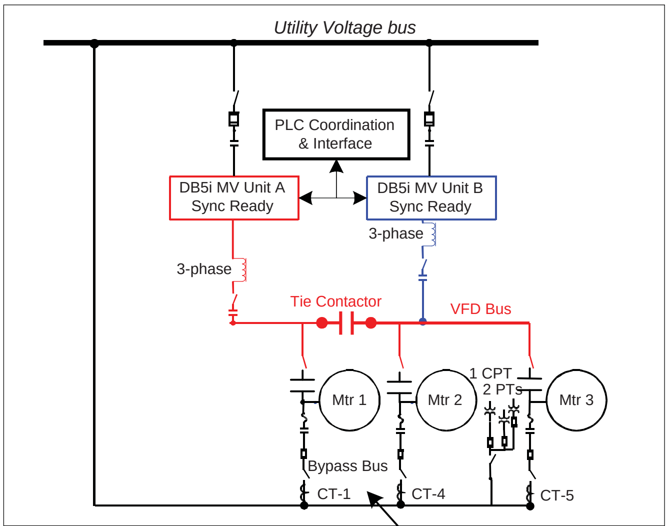


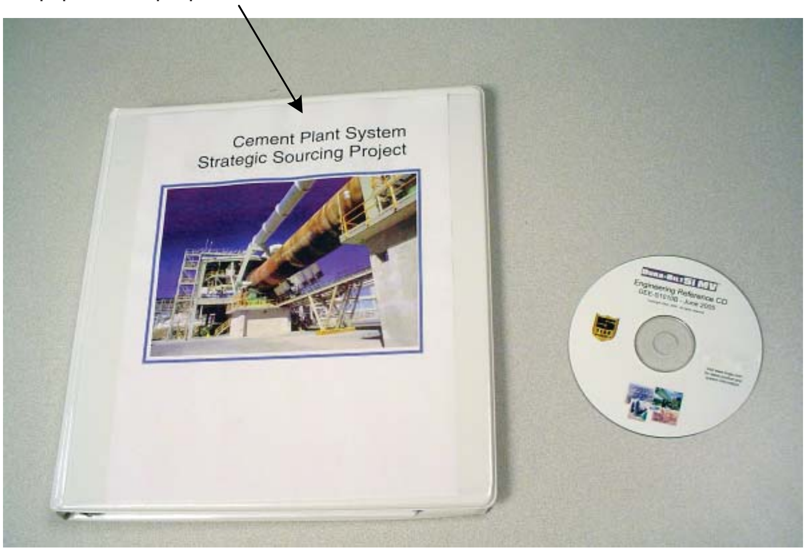
Technical Proposal Specification

TMEIC Assists in the Project Planning



System architecture illustration

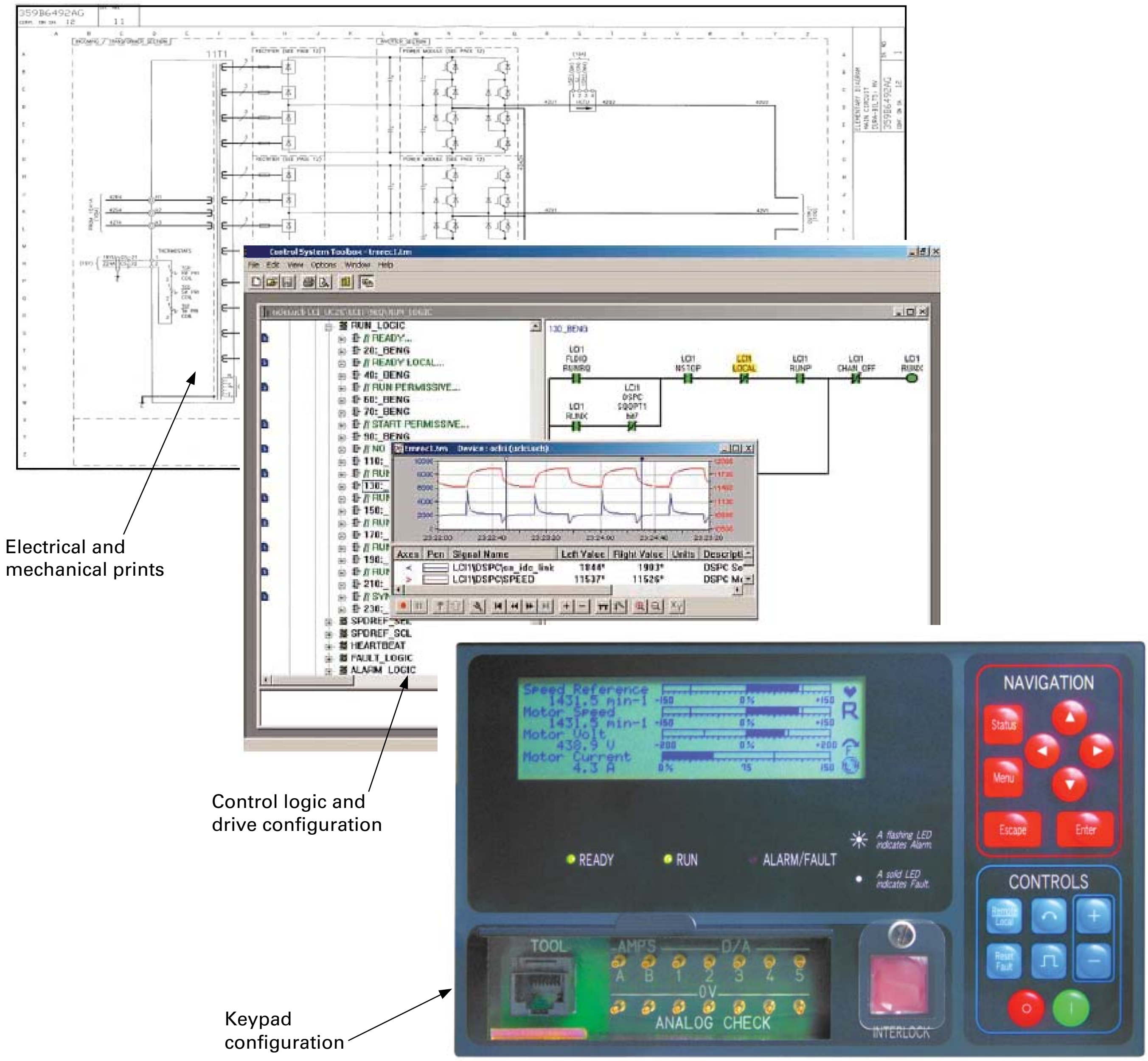
Detailed description of equipment in proposal



During all phases of your project planning, TMEIC assists by supplying information, training, guide-form specifications, and general advice. Experienced drive application engineers prepare a technical proposal that includes:

- Customized system architecture for your project.
- Detailed equipment specifications for the drives, exciters, transformers, switchgear, and housings.
- Thorough description of the PLC control functions, including logic for synchronizing and de-synchronizing the motors.
- Formal bid documentation.

Detailed Hardware/Software Design & Procurement



Based on the proposal specification, the project engineering team proceeds with four main tasks:

- **Control Software Design.** Control engineers configure the drives and PLC controller logic, if a PLC is required for the application. The illustration above shows a typical toolbox logic function diagram in Relay Ladder Diagram format. The toolbox is used for drive configuration, tuning, sequencing, and drive diagnostics.
- **Optional HMI Screen Design.** Interface screens for maintenance and drive control are configured using the touch panel engineering tools. These screens provide real-time drive data and operator interaction.
- **Hardware Design.** All equipment is specified per the project requirements, and a complete set of elementary diagrams, layout, and outline drawings is created.
- **Component Procurement.** We work with our parent companies to source the most cost effective system components for your application.

System Test

TMEIC understands the importance of a thorough system test. Our engineering team conducts a comprehensive factory test before shipment.

For example, the Dura-Bilt5i MV drive tests in the factory include:

- Full voltage check of power cells, insulation, and control circuits
- Acceleration and run test with unloaded MV motor
- Full current test into a reactor
- Validation of all I/O interfaces
- Validation of the drive test modes and any special logic, or optional PLC

Dura-Bilt 5i MV Drive Factory Test

Dura-Bilt 5i MV Control System Validation in the Factory

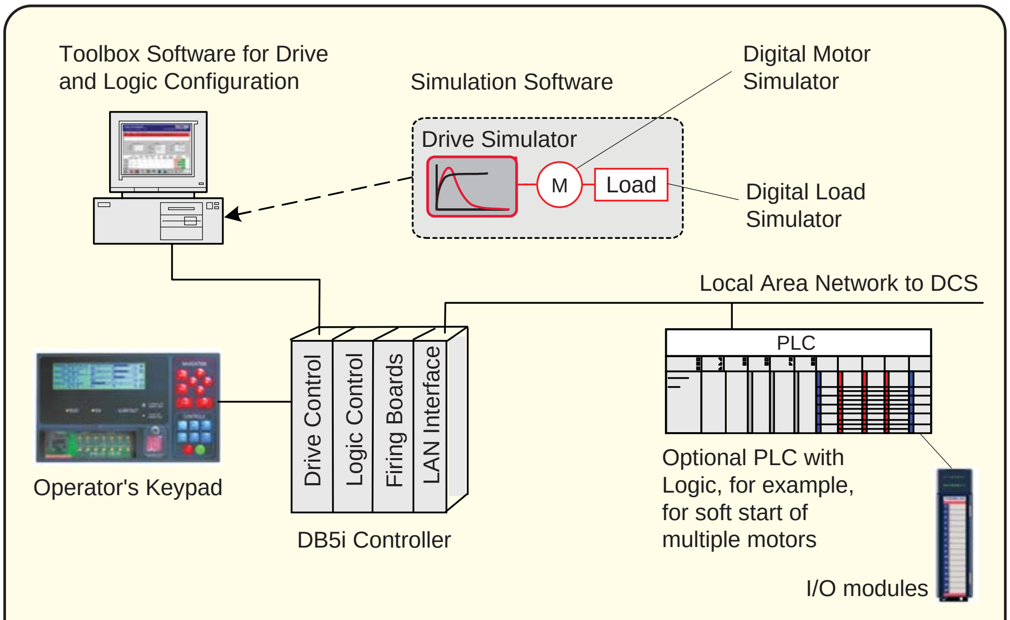


Diagram of Dura-Bilt Control System Test Setup

Factory validation of the drive control system is available as an option, either in Roanoke, Virginia, or in Houston, Texas.

Validation of the optional LAN interface, DCS link, and PLC sequencing and logic can be done as shown opposite. Drive, motor, and load simulators are available if required. Using the simulated equipment, the PLC can be run through its sequencing and the resulting outputs validated.

Note: Logic for synchronizing a single motor to the line can be included in the Dura-Bilt5i controller, so a PLC is not required for this.

System Commissioning

In the commissioning phase, the TMEIC team includes the field engineers you know and trust, alongside the engineer who designed and tested the system. This overlap of teams between engineering design and the site ensures a smooth and on-schedule startup.

The TMEIC service engineer, who is responsible for startup and commissioning, and for any future service required at the site, is part of the project team and participates in the factory system test to become familiar with the system. Commissioning is supported by TMEIC design and service engineers.

Drive Training at the Factory or in Your Plant

Customer engineers, maintenance and operations personnel are trained on the drives and control system at the TMEIC Training Center in Virginia. This world-class facility features large classrooms and fully-equipped training labs.

Classroom and hands-on training consists of 50% class time and 50% hands-on lab time. Topics include:

- Overview of the drive system
- Function of the main assemblies
- Technical details of the components
- Drive and control system tools
- System diagnostics and service

As an alternative to the standard factory training in Virginia, TMEIC can offer a course tailored to your project and held at your location. In this case, a project engineer trains your operators, maintenance technicians and engineers in your facility.

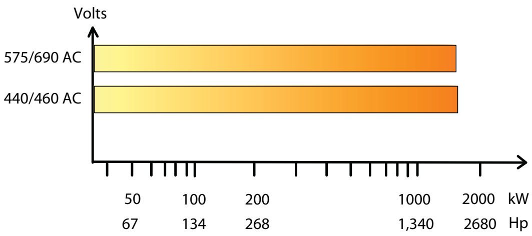
Complete and Detailed Drive System Documentation

Along with the hardware and software, TMEIC delivers complete system documentation:

- An electronic instruction book with all the prints on CD with a hyperlink index
- Recommended wiring and grounding procedures
- Renewal parts list
- Standard third-party vendor documentation

At the end of the project, the drawings are updated to reflect the final changes.

TMdrive®-10e2 Low Voltage System Drive



The family of low voltage AC system drives has an integral DC bus structure with a wide variety of inverters (DC to AC) and converters (AC to DC) to match virtually any application in the paper industry.

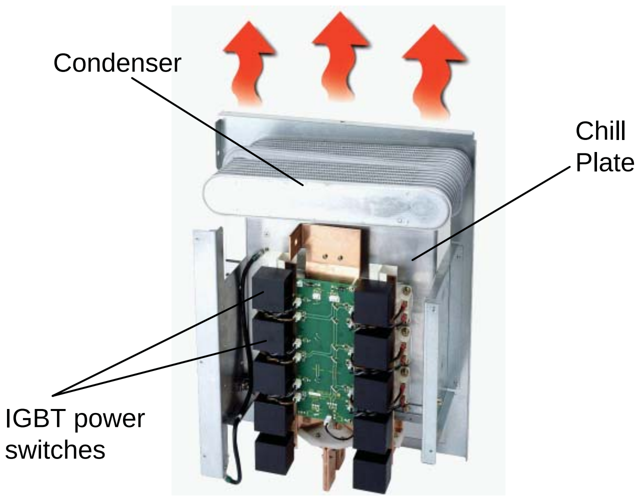
- 400, 460, 575, or 690 volt operation
- Motor power up to 1,949 kW
- Regenerative converter option

Draw-Out Style Inverters

For applications up to 193 kW (249 hp), draw-out style 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.



Heat Pipe Cooling Technology

The use of heat pipe technology provides a dramatic advance in power bridge cooling, including a significant reduction in the footprint of the power bridge, and fewer fans lower the audible noise.

The Thermal Cycle

1 Condensate to Vapor
IGBT's are mounted to the multi-channeled chill plate which cools them. Heat generated by the IGBTs vaporizes the refrigerant, moving it upwards through the chill plate to the finned condensing unit.

2 Vapor To Condensate
Cooling air is pulled up through the IGBTs and the condensing unit, and cools the refrigerant, which condenses back to liquid.

3 Return of Condensate
The condensed refrigerant returns to the bottom of the chill plate to start the thermal cycle over again.

TMdrive-10e2 Operator Interfaces

Cabinet Enclosure Displays

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

Standard Display

RJ-45 Ethernet port is used for local tool connection

Interlock button disables the drive

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

LED indication

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

Optional Enhanced Keypad

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

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

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

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

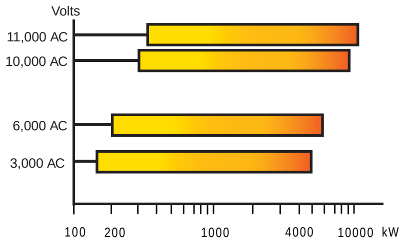
Draw-out Enclosure Displays

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

LED indication

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

TMdrive®-MVG



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.

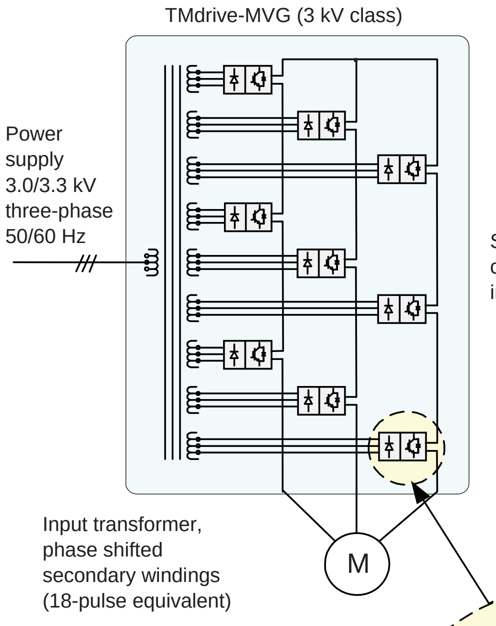
Featuring high-quality Japanese design and manufacture, the TMdrive-MVG works with existing or new induction motors and meets users' basic system requirements as described below.

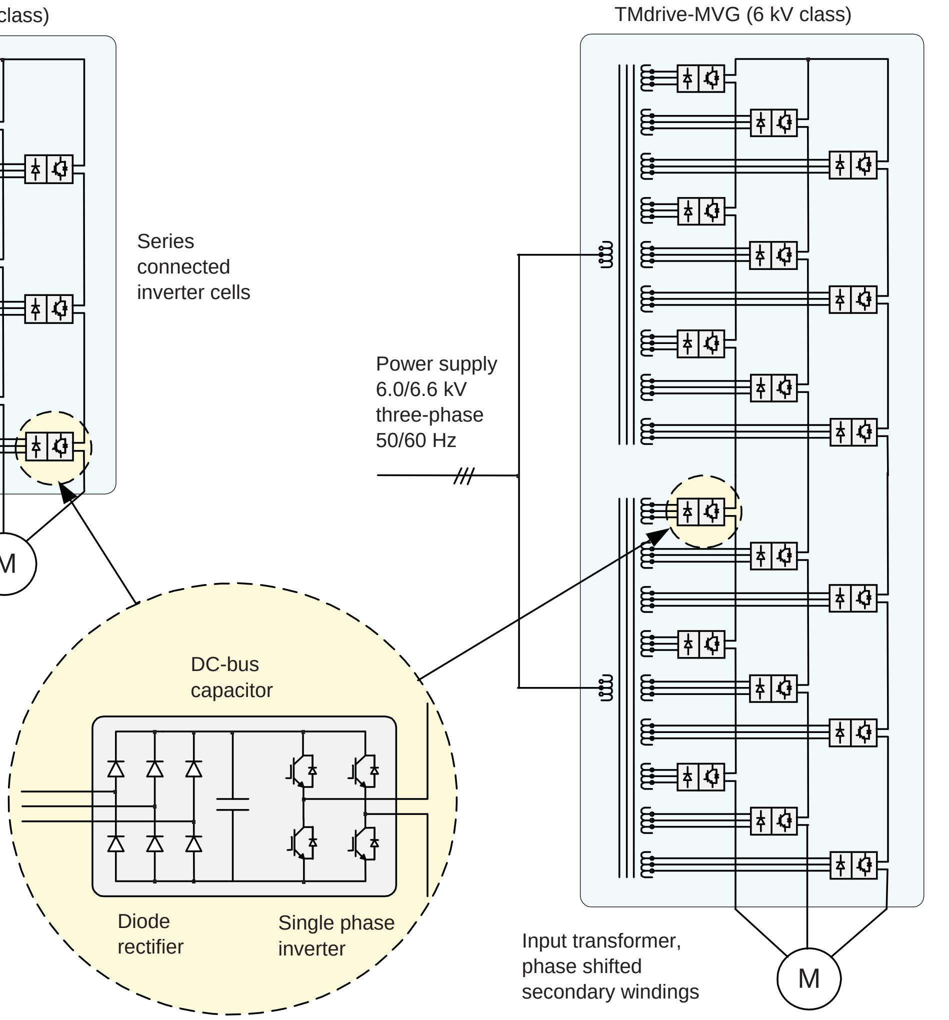
High reliability, low harmonic distortion, and high power factor operation are designed into the MVG drive.

The TMdrive-MVG is available in 3 voltage classes:
3 – 3.3 kV Voltage Class: 3,000 – 3,300 V ac
6 – 6.6 kV Voltage Class: 6,000 – 6,600 V ac
11 kV Voltage Class: 10,000 – 11,000 V ac

Features	Benefits
Conservative design using 1700-volt IGBTs (Insulated Gate Bipolar Transistor)	Highly reliable operation and expected 12-year drive MTBF, based on field experience with the large global installed base of TMdrive-MVG technology
High energy efficiency over 97% (design value)	Considerable energy savings, in particular on flow control applications
Diode rectifier ensures power factor greater than 95% in the typical speed control range	Capacitors not required for power factor correction
Multiple level drive output waveform to the motor (13 levels for the 6.6 kV inverter) Direct drive voltage level	No derating of motor for voltage insulation or heating is required due to motor-friendly waveform No output transformer required
Multi-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 dropouts – up to 300 msec.	Uninterrupted service for critical loads
Input isolation transformer included in drive package	Better protection of motor Simplified installation Lower cost installation

Modular Architecture Creates Performance Advantages





Inverter Cell Module

Inverter Cell Module removed from rack

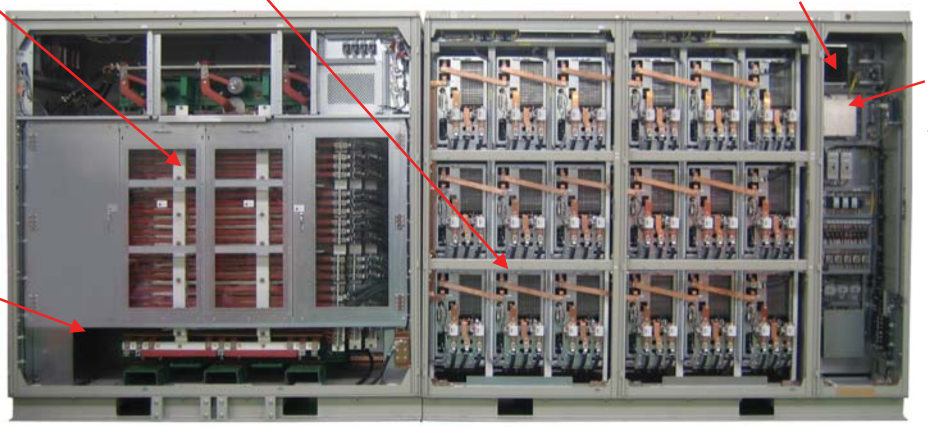
Inside the TMdrive-MVG Cabinet – an example of the 6 kV class drive with inverter cell detail.

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

Air Cooling
Forced air cooling system with:
- Intake through cabinet doors
- Upwards flow through inverter cells and transformer
- Exhaust at top of cabinet
- Optional redundant cooling fan system is available.

Cell inverters
Example: six banks of three, series connected inverter cells:
- Diode bridge rectifier
- IGBT PWM inverter
- DC link capacitor

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.



Control Functions
A single set of control boards feeds all inverter cells. The primary control board performs several functions:
- Speed & torque regulation
- Sequencing
- I/O mapping
- Diagnostic data gathering
- Provision for optional LAN interface

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TMdrive®-10 SPR – Slip Power Recovery for Wound Rotor Motors

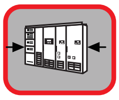
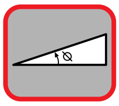
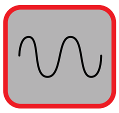
The Slip Power Recovery (SPR) version of the TMdrive-10 provides speed control of a wound rotor motor and efficient recovery of slip power from the rotor. This is discussed in Application 4 on page 10. Features of the SPR include:

- Significant energy savings and low cost of ownership
- Highest efficiency adjustable speed drive
- Pulse width modulated converter
- High power factor operation
- High reliability

MV Motor: for wound rotor motors, from 1,000 hp to 10,000 hp

Speed Range: depends on rotor voltage; super synchronous speed operation is available

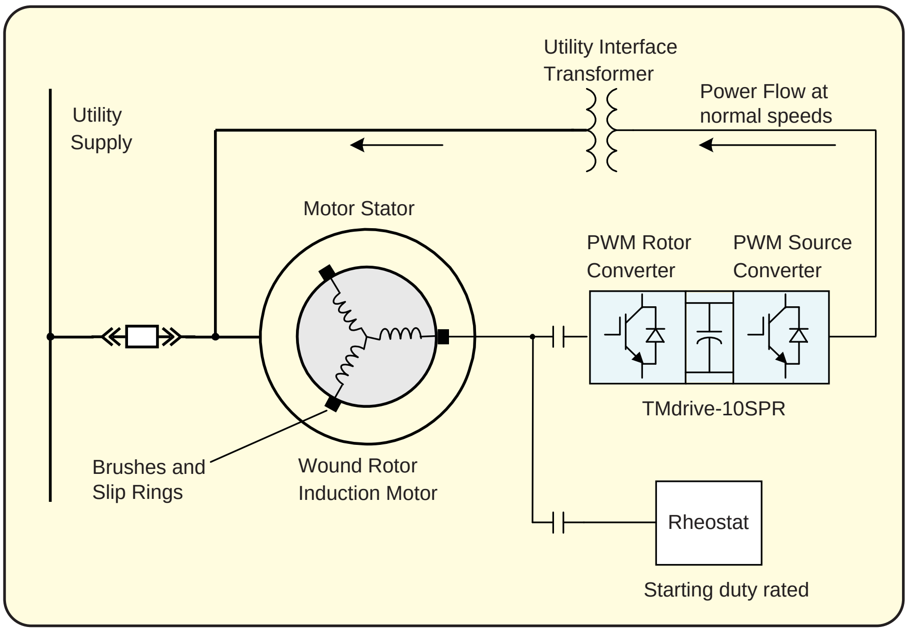
I/O, LAN Interface, & Cabinet Size: same as TMdrive-10

	Features	Benefits
	**Based on TMdrive-10 Drives** Standard TMEIC low voltage drive hardware is applied for use as a wound rotor motor drive	**Reliable Hardware & Available Spare Parts** No modifications to production hardware are required
	**High Power Factor, Low Harmonic Interface** The source converter feeds power back into the utility at unity power factor	**Reduced Motor Current & Harmonics** The higher pf results in reduced reactive power demands - no utility supply filtering required
	**Low Harmonic Currents in Rotor Circuit** The PWM converter provides sinusoidal current to the rotor	**Negligible Rotor Heating & Smooth Torque** Sinusoidal current results in low rotor heating and low torque pulsations

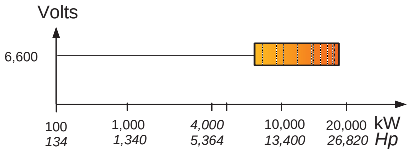
SPR Operation

The TMdrive-10SPR takes power out of the rotor to reduce the motor speed. At reduced speeds, power flows out of the rotor through the SPR to the transformer and back into the supply, instead of being dissipated in the rheostat.

The SPR is the highest efficiency VFD because only a fraction of the motor power goes through the drive. During startup the rheostat is connected to the rotor and the SPR is disconnected. Once up to minimum speed, the SPR drive is connected and the rheostat disconnected. The motor speed is then controlled by the SPR.



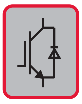
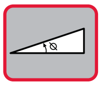
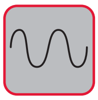
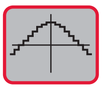
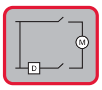
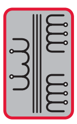
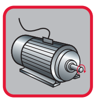
TMdrive®-XL55 6.6 kV Drive



The TMdrive-XL55 is a medium voltage, ac fed drive designed for high-efficiency and power-friendly operation in a broad range of industrial applications.

High reliability, low harmonic distortion, and high power factor operation are designed into the drive.

The TMdrive-XL55 is available for 6.0 – 6.6 kV voltage class output.

	Features	Benefits
	Conservative design using 4500 V IGBTs	Highly reliable operation, expected 10-year drive MTBF
	High energy efficiency approximately 98.6%	Considerable energy savings
	Diode rectifier ensures power factor greater than 95% in the speed control range.	Capacitors not required for power factor correction
	36-pulse converter rectifier by using separated phase shifted transformer.	No harmonic filter is required to provide lower harmonic distortion levels than the IEEE-519 guidelines.
	Multiple level drive output waveform to the motor (five levels for the 6.6 kV inverter)	Suitable for standard motors due to motor friendly wave form.
	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
	Remote input isolation transformer	Less power loss in drive room Less total space required Simplifies design and installation
	6.6 kV direct drive voltage output level	No output transformer required, saving cost, mounting space, and energy

TMEIC

A Family of Drives up to 11kV

TMdrive-10e2
TMdrive-10SPR

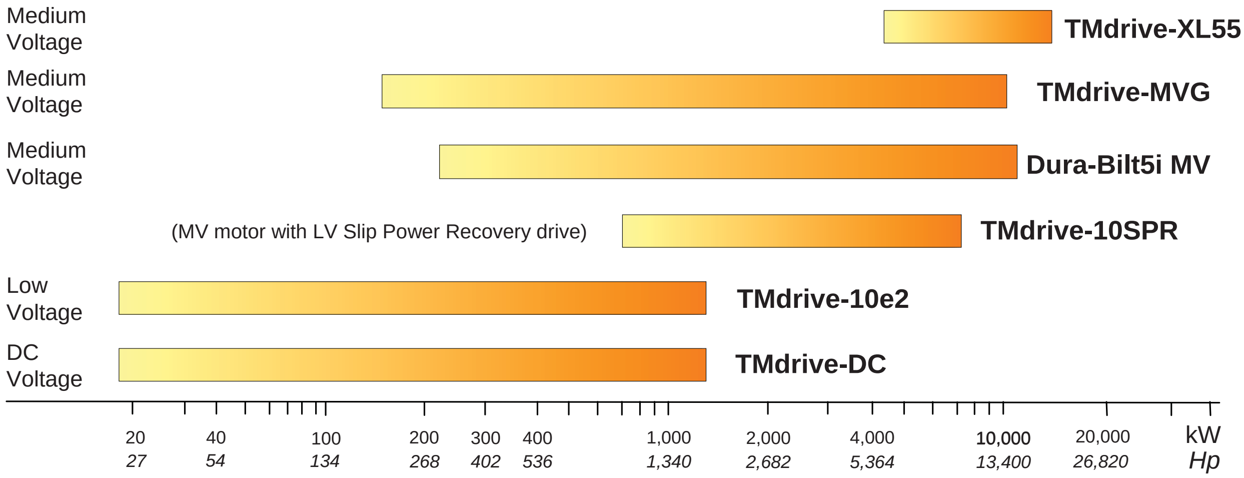
Dura-Bilt5i MV

TMdrive-DC

TMdrive-MVG

TMdrive-XL55

Power Rating of AC and DC Drive Family



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