



TMdrive®-XL Series Family Product Application Guide

metals

cranes

mining

testing

oil & gas

paper

utilities

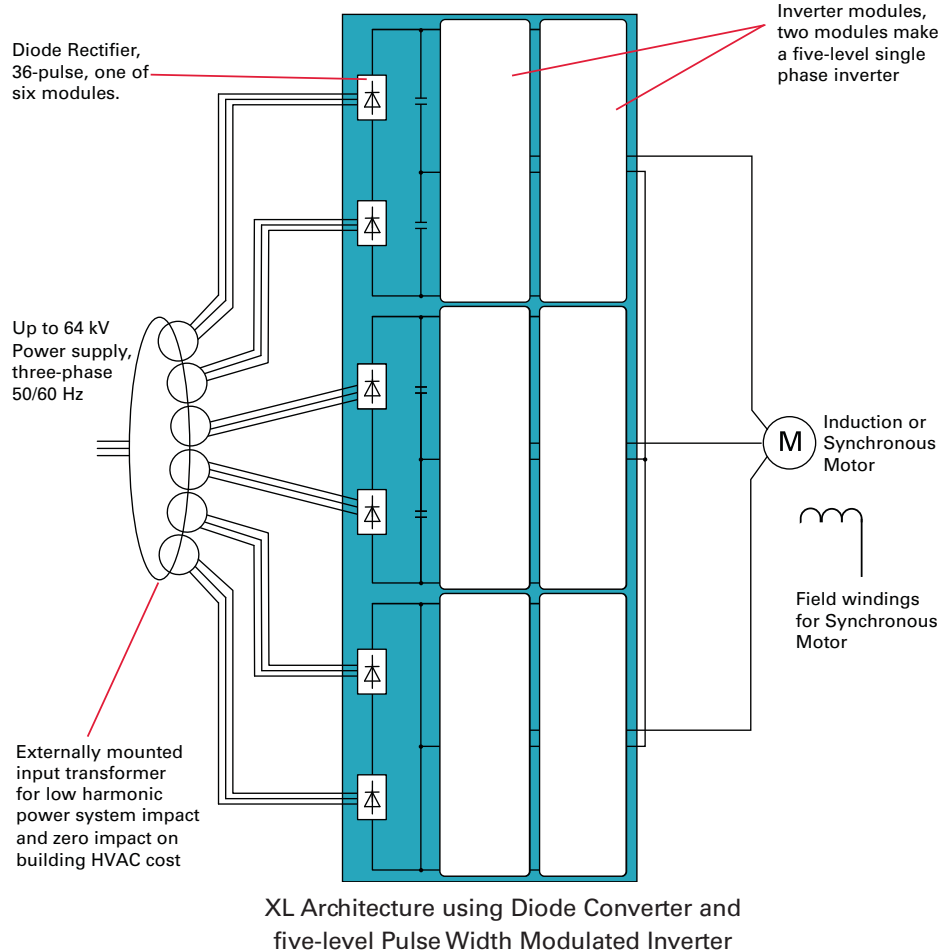
cement

TMdrive-XL Series



The TMdrive XL series family of variable frequency drives (VFD) provides the high power levels and speed required to drive large motors that power rotating machinery used in the Oil & Gas industry. Important VFD features common to the family include:

- Common architecture, pulse width modulation and control, water cooling, I/O modules, and TMdrive-Navigator programming software
- Multi-level VFD output for smooth waveform to the motor
- 24-36 pulse diode converter rectifier for low harmonic distortion
- High VFD reliability and availability with MTBFs in excess of 20 years and MTTR of less than 30 minutes.
- Output frequency range high enough for direct compressor drive with no gearbox, eliminating costly lube oil systems in addition to the gearbox, resulting in increased system efficiency.
- Up to 7.2 kV supply to the motor with no output transformer required
- Ability to operate drive banks in parallel for higher power levels up to 120 MVA



Three different inverter modules for this architecture, three per VFD:

8 MVA VFD Power Module
Single Phase
Inverter using IGBTs

IGBT

0.9 kA, 4.5 kV

20 MVA VFD Power Module
Single Phase
Inverter using IEGTs

IEGT

5.5 kA, 4.5 kV

15/30 MVA Power Module
Single Phase
Inverter using GCTs

GCT

6 kA, 6 kV

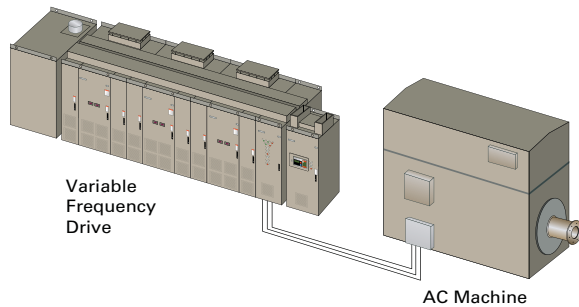
XL Drive Family Power Expansion

Higher Power Levels. The XL VFDs can be run in parallel to produce higher power levels than single banks. Two, three, or four banks can be combined to obtain the desired power. The example below shows how an XL VFD can be expanded to four banks for a power of 120 MVA (156,000 hp). The table shows the maximum power levels available from the VFD family.

The multi-bank VFDs provide drive and control redundancy for improved reliability.

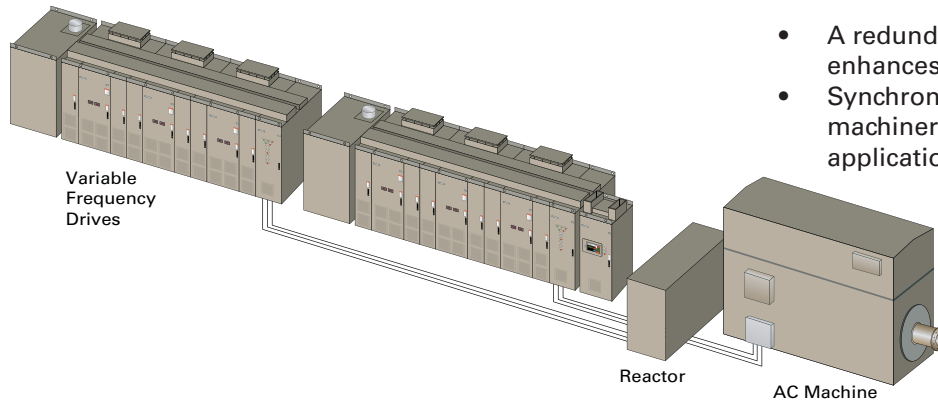
XL Drive Power Levels, Single Bank	Multiple Banks, Max
TMdrive-XL85 30 MVA (39,000 hp)	120 MVA (156,000 hp)
TMdrive-XL75 20 MVA (26,000 hp)	80 MVA (104,000 hp)
TMdrive-XL80 15 MVA (19,500 hp)	30 MVA (39,000 hp)
TMdrive-XL55 8 MVA (10,400 hp)	16 MVA (20,800 hp)

One-Bank TMdrive-XL – Power level up to 30 MVA



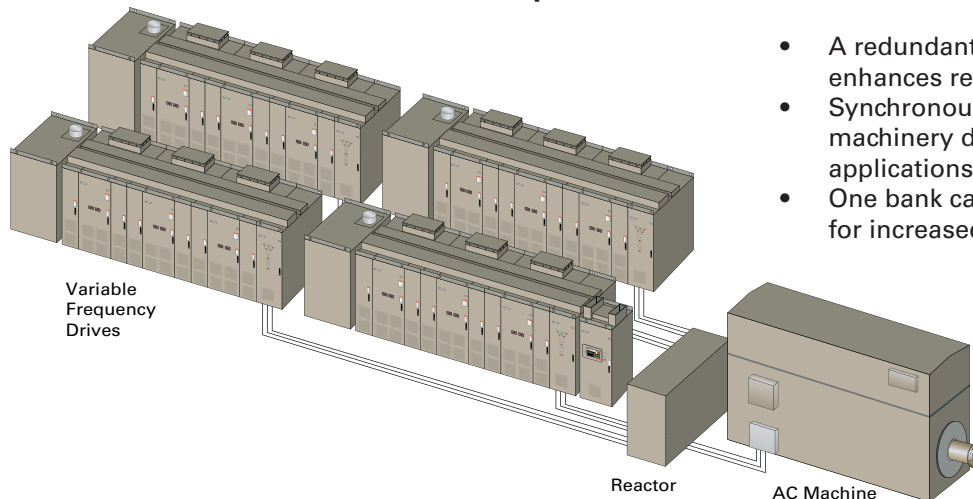
- Synchronous or Induction motor can control rotating machinery directly for low and high speed applications.

Two-Bank TMdrive-XL – Power level up to 60 MVA



- A redundant control cabinet significantly enhances reliability.
- Synchronous motor can control rotating machinery directly for low and high speed applications; paralleling reactor feeds the motor

Four-Bank TMdrive-XL – Power level up to 120 MVA



- A redundant control cabinet significantly enhances reliability.
- Synchronous motor can control rotating machinery directly for low and high speed applications ; paralleling reactor feeds the motor
- One bank can be redundant to other three banks for increased reliability.

TMdrive-XL Series

TMdrive-XL55 – 8 MVA Frame



- Power Rating:** 8 MVA, expandable to 16 MVA
- Output Voltage:** 6.6 kV
- Output Frequency:** Rated 50-60 Hz, 50 to 250 Hertz option
- Dimensions:** Width 6.5 m
Height: 2.5 m
- Motor type:** Synchronous or Induction



Insulated Gate Bipolar Transistor (IGBT). Rated 4,500 Volts, 900 Amps.

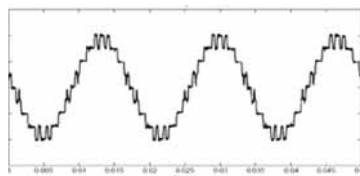


Power Input/Output

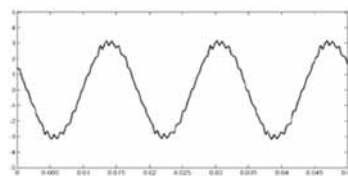
Input Voltage	Any utility voltage using separate transformer input 50/60 Hz $\pm 2\%$
Output Voltage	6,600 Vac
Output Current	700 A rms
Output Frequency	50-60 Hz, for over 75 Hz, consult TMEIC
Output Chopping	600 Hz (max)
Efficiency	98.6%
Cable Entry	Bottom or top

Clean Motor Output Wave

As a result of the five-level PWM control, the output current waveform is close to a sine wave. Harmonic currents in the motor windings are minimized so the heat loss is negligible and there is very little shaft torque ripple. Illustrated waveform is from the similar TMdrive XL85 test.



Line-to-Line Voltage at 100% Speed



U-phase Current at 100% Speed

Protective Functions Include:

- Inverter overcurrent
- Inverter overvoltage
- Low system voltage
- Motor ground fault
- Motor overload
- Cooling fan abnormal
- Over-temperature
- CPU error
- Water cooling alarm
- Exciter fault
- DC voltage drop
- Motor inverse rotation
- Stall detection
- Ground detection



Power Circuits

Converter

- AC-fed 36-pulse diode rectifier using externally mounted phase shifted transformer; no harmonic filter required to meet IEEE 519 guidelines
- DC bus voltage: 3 x 5,000 Vdc
- Power factor greater than 95% in speed control range

Inverter

- Five-level inverter for motor friendly wave form
- Uses 8 IGBT devices for each of three phases
- 6 kV output to motor – no output transformer required
- Inverter power modules water cooled
- Conservative design for expected 20 year MTBF



Motor Control

Frequency Control

- Volt/Hertz Control – standard
- Sensorless vector control - optional

Output Voltage Modulation

The output switching modulation strategy is dynamically adjusted based on three speed zones to minimize motor torque pulsation.

Drive Inputs

- LAN Interface Options: Profibus-DP, DeviceNet, Modbus RTU, TOSLINE
- Input/Output: 6 Analog I/O, 8 Digital I/O

TMdrive-XL75 – 20 MVA Frame



Injection Enhanced Insulated Gate (IEGT). Rated 4,500 Volts, 2,100 Amps

Power Rating: 20 MVA, expandable to 80 MVA
Output Voltage: 6 kV
Output Frequency: Rated 50-60 Hz, 50 to 250 Hertz

Dimensions: Width 9.4 m
 Height: 2.7 m
Motor type: Synchronous or Induction

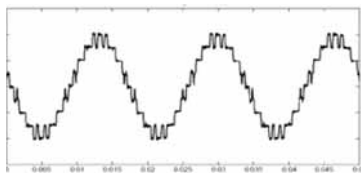


Power Input/Output

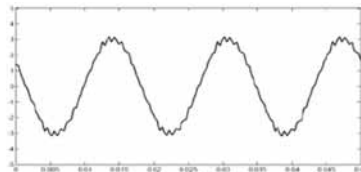
Input Voltage	Any utility voltage using separate transformer input 50/60 Hz $\pm 2\%$
Output Voltage	5,820 Vac
Output Current	1925 A rms
Output Frequency	50-60 Hz
Output Chopping	600 Hz (max)
Efficiency	98%
Cable Entry	Top or bottom

Clean Motor Output Wave

As a result of the five-level PWM control, the output current waveform is close to a sine wave. Harmonic currents in the motor windings are minimized so the heat loss is negligible and there is very little torque ripple on the output shaft.



Line-to-Line Voltage at 100% Speed



U-phase Current at 100% Speed

Protective Functions Include:

- Inverter overcurrent
- Inverter overvoltage
- Low system voltage
- Motor ground fault
- Motor overload
- Cooling fan abnormal
- Over-temperature
- CPU error
- Water cooling alarm
- Exciter fault
- DC voltage drop
- Motor inverse rotation
- Stall detection
- Ground detection



Power Circuits

Converter

- AC-fed 36-pulse diode rectifier using externally mounted phase shifted transformer; no harmonic filter required to meet IEEE 519 guidelines
- DC bus voltage: 3 x 4,540 Vdc
- Power factor greater than 95% in speed control range

Inverter

- Five-level inverter for motor friendly wave form
- Uses 8 IEGT devices for each of three phases
- 6 kV output to motor – no output transformer required
- Inverter power modules water cooled
- Conservative design for expected 20 year MTBF



Motor Control

Frequency Control

- Volt/Hertz Control – standard
- Sensorless vector control – optional
- Power factor control for synchronous motors

Output Voltage Modulation

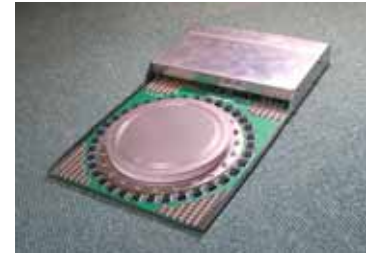
The output switching modulation strategy is dynamically adjusted based on three speed zones to minimize motor torque pulsation.

Drive Inputs

- LAN Interface Options: Profibus-DP, DeviceNet, Modbus RTU, ISBus, TOSLINE
- Input/Output: 6 Analog I/O, 8 Digital I/O

TMdrive-XL Series

TMdrive-XL85 – 30 MVA Frame



Gate Commutated Thyristor (GCT) with driver board. Rated 6,000 Volts, 6,000 Amps - the world's largest switching device

Power Rating: 30 MVA, expandable to 120 MVA
Output Voltage: 7.2 kV
Output Frequency: Rated 50-60 Hz, 50 to 200 Hertz

Dimensions: Width 8.1 m
 Height: 2.6 m
Motor type: Synchronous or Induction

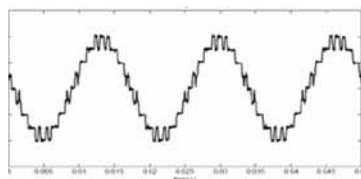


Power Input/Output

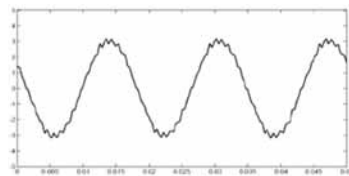
Input Voltage	Any utility voltage using separate transformer input 50/60 Hz $\pm 10\%$
Output Voltage	7,200 Vac
Output Current	2400 A rms
Output Frequency	50-60 Hz
Output Chopping	600 Hz (max)
Efficiency	98%
Cable Entry	Top or bottom

Clean Motor Output Wave

As a result of the five-level PWM control, the output current waveform is close to a sine wave. Harmonic currents in the motor windings are minimized so the heat loss is negligible and there is very little torque ripple on the output shaft.



Line-to-Line Voltage at 100% Speed



U-phase Current at 100% Speed

Protective Functions Include:

- Inverter overcurrent
- Inverter overvoltage
- Low system voltage
- Motor ground fault
- Motor overload
- Cooling fan abnormal
- Over-temperature
- CPU error
- Water cooling alarm
- Exciter fault
- DC voltage drop
- Motor inverse rotation
- Stall detection
- Ground detection



Power Circuits

Converter

- AC-fed 36-pulse diode rectifier using externally mounted phase shifted transformer; no harmonic filter required to meet IEEE 519 guidelines
- DC bus voltage: 3 x 5,450 Vdc
- Power factor greater than 95% in speed control range

Inverter

- Five-level inverter for motor friendly wave form
- Uses 8 GCT devices for each of three phases
- 7.2 kV output to motor – no output transformer required
- Inverter power modules water cooled
- Conservative design for expected 20 year MTBF



Motor Control

Frequency Control

- Volt/Hertz Control – standard
- Sensorless vector control – optional
- Power factor control for synchronous motors

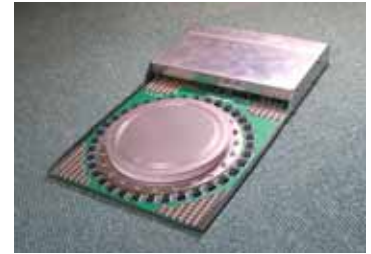
Output Voltage Modulation

The output switching modulation strategy is dynamically adjusted based on three speed zones to minimize motor torque pulsation.

Drive Inputs

- LAN Interface Options: Profibus-DP, DeviceNet, Modbus RTU, TOSLINE
- Input/Output: 6 Analog I/O, 8 Digital I/O

TMdrive-XL80 – 15 MVA Frame



Gate Commutated Thyristor (GCT) with driver board. Rated 6,000 Volts, 6,000 Amps - the world's largest switching device.

Power Rating: 15 MVA, expandable to 30 MVA
Output Voltage: 3.8 kV
Output Frequency: Rated 50-60 Hz, 50 to 200 Hertz option with derate above 100 Hz
Dimensions: Width 4.8 m; Height: 2.7 m
Motor type: Synchronous or Induction



Power Input/Output

Input Voltage	Any utility voltage using separate transformer input 50/60 Hz ±10%
Output Voltage	3,800 Vac
Output Current	2400 A rms
Output Frequency	50-60 Hz
Output Chopping	600 Hz (max)
Drive Efficiency	98%
Cable Entry	Top or bottom access

A Clean Output Wave

As a result of the three-level PWM control, the output current waveform is close to a sine wave. Harmonic currents in the motor are minimized so the heat loss is negligible and there is very little torque ripple on the output shaft.

Protective Functions Include

- Inverter overcurrent
- Inverter overvoltage
- Low system voltage
- Motor ground fault
- Motor overload
- Cooling fan abnormal
- Over-temperature
- CPU error
- Water cooling alarm
- Exciter fault
- DC voltage drop
- Motor inverse rotation
- Stall detection
- Ground detection



Power Circuits

Converter

- AC-fed 12- or 24-pulse diode rectifier using externally mounted phase shifted transformer; no harmonic filter required to meet IEEE 519 guidelines
- DC bus voltage: 3 x 5,700 Vdc
- Power factor greater than 95% in speed control range

Inverter

- Three-level inverter for motor friendly wave form
- Uses 4 GCT devices for each of three phases
- 3.8 kV output to motor – no output transformer required
- Inverter power modules water cooled
- Conservative design for expected 20 year MTBF



Motor Control

Frequency Control

- Volt/Hertz Control
- Vector control
- Power factor control for synchronous motors

Output Voltage Modulation

The output switching modulation strategy is dynamically adjusted based on three speed zones to minimize motor torque pulsation.

Drive Inputs

- LAN Interface Options: Profibus-DP, DeviceNet, Modbus RTU, TOSLINE S-20
- Input/Output: 6 Analog I/O, 8 Digital I/O

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across North America**

**Over 300 Service
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