



Product Catalog

# Remote-Mounted Medium Voltage Air-Cooled Adaptive Frequency™ Drive with Tracer AdaptiView™ Control



March 2020

AFDJ-PRC001B-EN

TRANE  
TECHNOLOGIES



## Introduction

Improve efficiency and maximize profitability with a single solution for all your motor control applications from 200 hp to 5,900 hp (150 kW to 4,400 kW). The PowerFlex 7000 medium voltage (MV) drive enables soft-starting and variable-speed control of chillers with high power demands, to reduce energy costs, maintenance and motor wear. The advanced power semiconductor technology reduces component count to the lowest of any MV drive available, translating to increased savings and reliability, less downtime and fewer spare parts. These drives use intelligent motor control strategies to further your investment, using communication software and programmability to monitor and control your chiller. Our entire product line delivers virtually perfect current and voltage waveforms to allow the use of standard or existing motors and motor cables. All PowerFlex 7000 MV drives adhere to the applicable standards from NEC, IEC, NEMA, UL, and CSA. Maximum uptime, ease-of-use and lowest total cost of ownership is what the PowerFlex 7000 delivers.

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# Direct-to-Drive

## Technology

**Direct-to-Drive™ Technology.** Reduce the cost, size and weight of your MV drive system with the PowerFlex 7000 with Direct-to-Drive technology. This is the first and only technology that allows you to directly connect a MV drive to utility power without the requirement of an isolation transformer. Isolation transformers with multiple secondary windings are required for traditional AC drives to address line-side harmonic concerns and common mode voltage. However, typical isolation transformers are large, heavy, costly, complex and inefficient. Direct-to-Drive technology combines an active front end (AFE) rectifier to dramatically lower line-side harmonics and a patented DC link inductor to address common mode voltage at its source. By addressing harmonics and common mode voltage, the isolation transformer becomes redundant. This reduces system complexity to maximize uptime and increases system efficiency to lower operational costs. Exceptional output voltage and current waveforms, true of our entire product line, make this ideal for retrofit applications and allow the use of standard motors for new applications.

**Air-Cooled, PowerFlex 7000.** Enhance motor control and increase energy efficiency on motor applications from 200 hp to 5,900 hp (150 kW to 4,400 kW) with the PowerFlex 7000 air-cooled MV AC variable frequency drives.

**Medium Voltage Motor Controllers.** Customize total system control for your specific application with the wide range of MV starters. Drive output/bypass starters, drive input starters, full-voltage starters, reduced voltage starters and solid-state reduced-voltage starters, two-speed starters, and synchronous starters. All controllers provide monitoring and diagnostic options for faster, more accurate troubleshooting, maintenance planning, asset management and reduced downtime.

### Reduce Capital, Installation and Operating Costs

#### *Direct-to-Drive technology can:*

- Reduce capital costs: No isolation transformer purchase required.
- Reduce installation costs: No need for an isolation transformer protection relay, a dv/dt filter, sine filter, motor terminator or special line-side or motor-side power cables.
- Reduce shipping costs: A smaller, lighter drive system is easier to handle and less costly to ship.
- Reduce operating costs: Higher system efficiency and inherent regenerative capability that can return power to the utility.
- Reduce maintenance costs: Low parts count and many components are common between the rectifier and inverter.
- Only front access is required for maintenance and service.

### Reduce Size and Weight of Drive System

Reduced drive system size and weight are a strategic advantage for industries world-wide, where the use of transformers and control room space is challenging and expensive, such as in existing mechanical equipment rooms. PowerFlex 7000 with Direct-to-Drive technology systems are:

- Typically smaller and lighter than drive technologies using isolation transformers.
- Perfect for retrofit, process improvement or energy-savings projects with existing motors, switches and control rooms.

**Intelligent Motor Control.** All PowerFlex 7000 drives provide Intelligent Motor Control capabilities such as:

#### *Communications Software*

- Integrated Tracer AdaptiView chiller control to drive control interface optimized for system reliability and efficiency.

- Operator interface software monitors a variety of drive parameters and trends real-time information to help predict and prevent downtime.

**Innovative Design.** Historically, MV motor AC drives (2.4 kV to 6.9 kV), use power topologies that generate common-mode voltage, which can cause premature failure of the motor winding insulation. Multi-pulse isolation transformers are typically used to address this common-mode voltage stress and also to mitigate harmonics.

The innovative PowerFlex 7000 with Direct-to-Drive technology connects the power supply directly to the MV drive without an isolation transformer. Leading edge technology combines three innovations to achieve transformerless Direct-to-Drive technology: the Symmetrical Gate Commutated Thyristor (SGCT) in both the inverter and rectifier allows operation of high switching frequency to minimize switching losses; the AFE rectifier used at the input stage; and the common mode choke to block common mode voltage.

#### ***The Symmetrical Gate Commutated Thyristor***

- The SGCT is an integration of the power semiconductor and its gate drive to achieve superior pulse-width modulation switching patterns that significantly reduce line current harmonics and minimize snubber requirements and switching losses.
- Total Harmonic Distortion (THD) of the input current is within IEEE 519-1992 and most global harmonic guidelines in virtually every system.
- Current and voltage waveforms are near sinusoidal, minimizing voltage stress on the motor winding, even if connected through long cables.

#### ***The Active Front End Rectifier***

- To reduce harmonics, the AFE uses active switching and Selective Harmonic Elimination (SHE) and provides near-unity power factor.

#### ***Common Mode Voltage Protection***

- The integrated common mode choke provides a very high impedance to the common mode current and mitigates motor neutral-to-ground voltage. This eliminates the need for an isolation transformer, reducing size and cost.



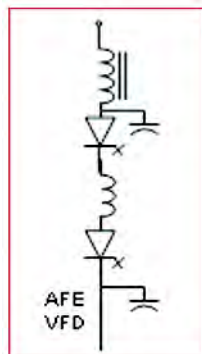
# Air-Cooled

## Compact Packaging

**PowerFlex 7000 Air-Cooled Drives.** Increase energy efficiency on motor applications from 200 hp to 5,900 hp (150 kW to 4,400 kW) and supply voltages from 2,200 V to 13,800 V. Enhance motor control and increase system reliability with the low component count, design simplicity and 6,500 V SGCT power semiconductor switches that help reduce downtime and spare parts stock. Maintenance is simple and quick with the patented PowerCage inverter and rectifier modules that allow SGCT replacement in under ten minutes.



**Direct-to-Drive™ Technology.** Direct-to-Drive technology directly connects to the utility power without an isolation transformer. On new or existing motors, Direct-to-Drive technology eliminates unnecessary motor filtering and common mode voltage and saves control room space with a drive system that is smaller and lighter than a drive that requires a transformer. Installation costs are minimized by eliminating the need for a transformer protection relay, a dv/dt filter, sine filter or motor terminator and special cables.





# Operator Interface

## Easy-to-Use Drive Interface Technology

Available in a variety of languages, everything about the PowerFlex 7000 operator interface terminal is user friendly starting with the greeting on the opening screen. The terminal is designed for easy startup, monitoring and troubleshooting. The setup wizard helps the user set the required parameter menus by asking questions or prompting selections for desired operation. Warnings and comments appear complete with help text to keep the user on the right track. The setup wizard, combined with the autotuning feature, allows the drive to be tuned to the motor and to load quickly and accurately, resulting in fast startups, smooth operation and less down time.

**Large Text and Graphic Display Area.** The operator interface terminal features a 16-line, 40-character, LCD display that makes text and graphics easy to read. Bar chart meters are configurable for common process variables including speed, voltage and load. The membrane keypad includes function keys, cursor selection keys, and number keys for menu navigation, item selection and data entry. The standard push button on the exterior door is an emergency stop.

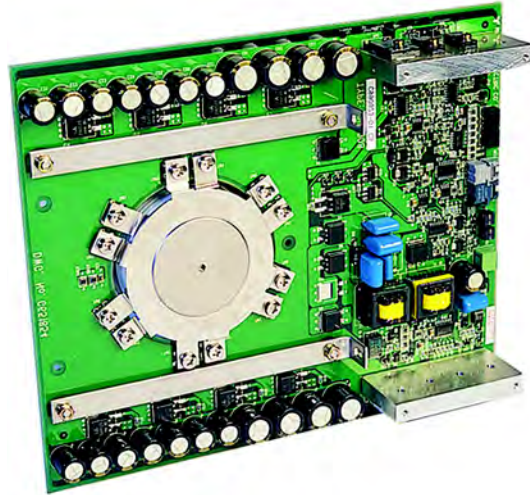
**Drive Identity Module Pre-loads Order Data.** A drive identity module, unique to every PowerFlex 7000 drive, captures order data from our automated business systems. The order data provides information to the drive firmware about specific drive hardware and application details. This results in less setup time at the end site, saving you time and money.



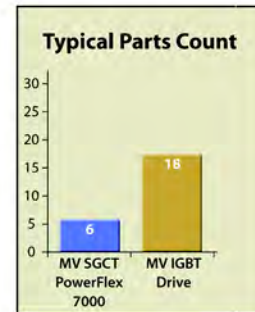
# Symmetrical Gate Commutated Thyristors

## Power Semiconductor

The PowerFlex 7000 uses 6.5 kV rated SGCTs and has the fewest number of inverter switching devices of any MV drive topology. The power structure is fuseless, inherently regenerative, and utilizes a current limiting DC link inductor. The result is a simple, rugged product with very low component count, and optimum reliability.



The unique characteristics of the SGCT and the PowerFlex 7000 drive topology make it possible to cost-effectively apply this versatile component into both the pulsed width modulation (PWM) inverter and PWM AFE rectifier.



**Low Parts Count.** The PowerFlex 7000 requires only six inverter SGCTs (at 2,300 V) while other drives using Insulated Gate Bipolar Transistors (IGBTs) or Integrated Gate Commutated Thyristors (IGCTs) require from 18 to 36 power semiconductor switches. The superior characteristics of the SGCTs combined with the fewest number of components makes the PowerFlex 7000 drive inherently more reliable.

**SGCT—The Ideal Power Semiconductor Switch for MV Drives.** The SGCT with integrated gate drive, high switching frequency, and double-sided cooling is an ideal power semiconductor switch for MV drive applications. Its compact and efficient inverter design results from a Pulse Width Modulation (PWM) switching pattern for the SGCTs and is optimized for the lowest possible conduction and switching losses. The SGCT has a non-rupture, non-arc failure mode, meaning the fault is contained within the device. This ensures minimum mean-time-to-repair (MTTR). Other MV drives using IGBTs can have rupture/arc failure modes that can lead to significant MTTR to rebuild the drive.

### Power semiconductor comparison

	PowerFlex 7000 MV SGCT	MV IGBT
Conduction Losses	Low	High
Switch Losses	Low	Medium
Switching Frequency	Medium	High
PIV Rating (Volts)	6,500	3,300
Gate Drive	Integral	Synchronized with IGBT
Failure Rate	Low	High
Failure Mode	No-rupture, no-arc	Rupture, no-arc
Cooling	Double sided	Single sided
Thermal Stress	Low	High
Parts Count	Low	Medium-high
Mean Time Between Failures (MTBF)	20 years <sup>(a)</sup>	10 years

(a) Based on 8,760 hr/year—MTBF 180,000 hr.





# PowerCage

## Air-Cooled Designs

**Innovative PowerCage™.** Reduce mean-time-to-repair (MTTR) time with fast and simple power semiconductor device changeout. The patented PowerCage converter modules in every PowerFlex 7000 drive house the SGCT power semiconductors in a compact, modular package that has fewer components and faster semiconductor device changeout than any other MV drive.

The PowerFlex 7000 air-cooled design PowerCage:

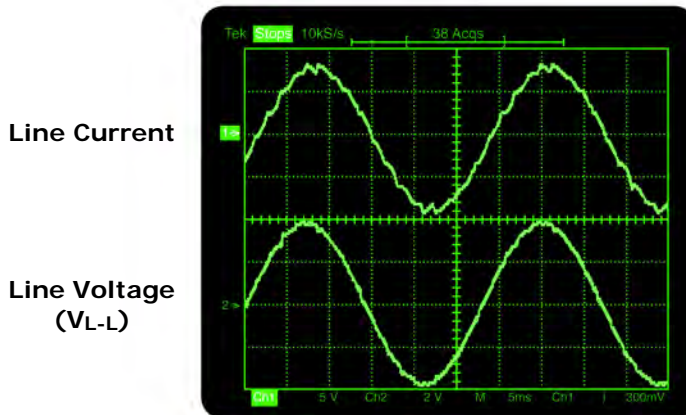
- Uses an advanced heatsink design that works with a high air flow pattern to ensure highly effective heat transfer and reduction of thermal stress.
- Allows power device changeout in less than ten minutes.



# Power Quality

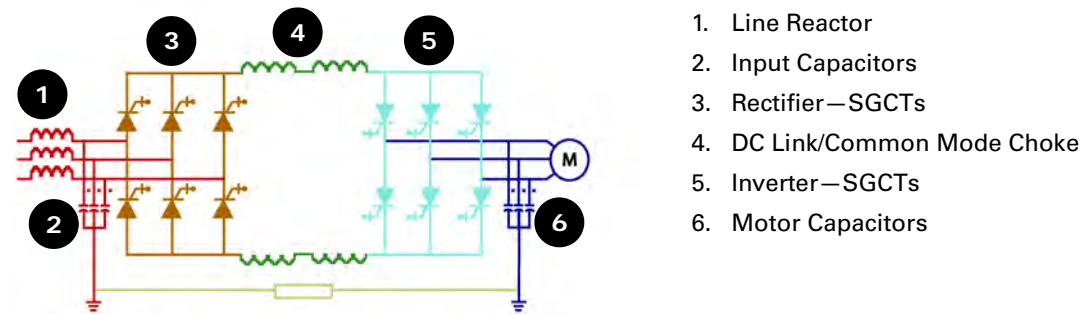
## Lower Line Harmonics

Most MV drives on the market today reduce line-side harmonics by increasing the rectifier pulse number through parallel rectifier bridges and phase-shifting transformers. These drives have a higher component count, higher complexity and higher number of connections.



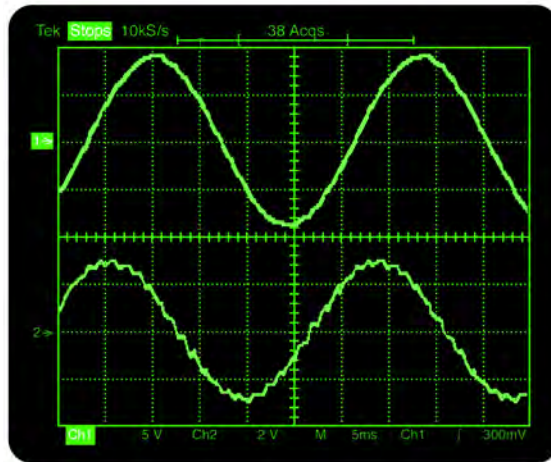
The Direct-to-Drive feature mitigates line current harmonics to levels compliant to IEE 519-1992, EN61000-2-4, and G5/4.

**Active Front End Rectifier.** At the drive input, the AFE rectifier meets IEEE 519-1992 and most global harmonic guidelines, provides near unity power factor, and optimizes drive performance.



**Compatible with Standard Motors.** Motor-friendly waveforms have been the trademark of MV drives since their introduction in 1990. All PowerFlex 7000 MV drive configurations have near sinusoidal output current and voltage waveforms at all speeds and loads, are compatible with standard induction or synchronous motors without derating and do not require an inverter duty motor.

**No Additional Heating or Voltage Stress to Motor Insulation Compared to Fixed Speed Operation.** The PWM switching pattern in the PowerFlex 7000 reduces the harmonics going to the motor, especially at lower operating frequencies. The PWM pattern works in combination with a small integral capacitor to reduce the large order harmonics at higher frequencies. The result is no additional motor heating or voltage stress to motor insulation compared to fixed speed operation.



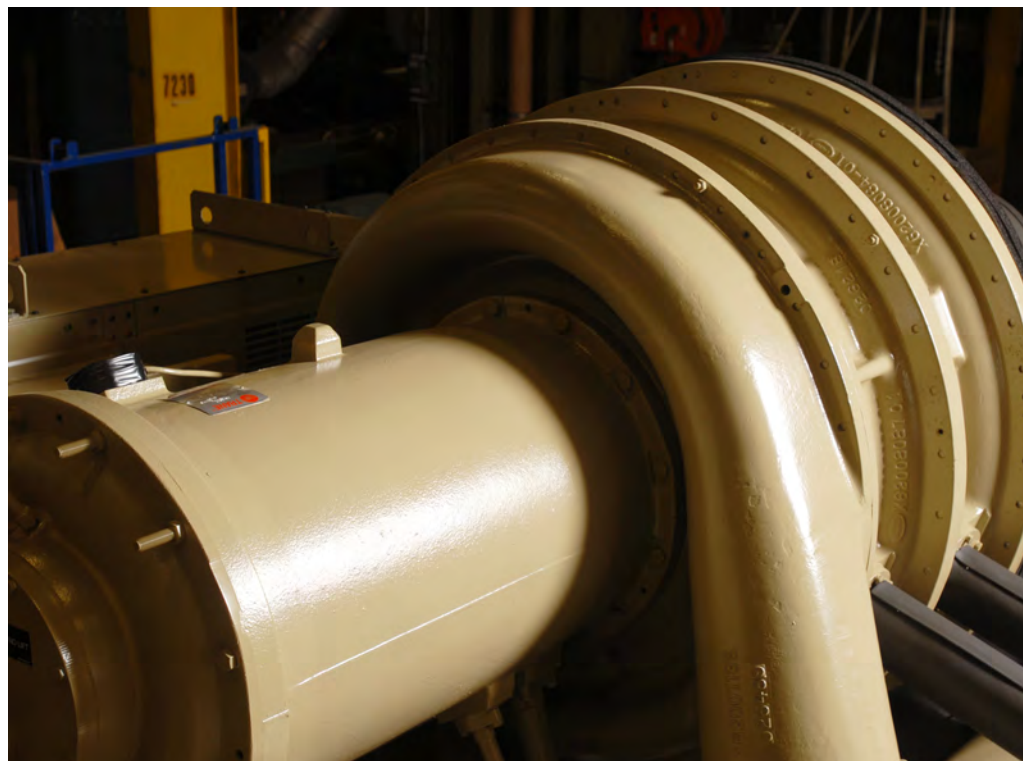
Motor Voltage  
(VL-L)

Motor Current

The Direct-to-Drive feature mitigates common mode voltage and does not produce dv/dt or reflected wave stress on motors.

**Virtually Unlimited Motor Cable Distance.** While some variable frequency drives have limitations in motor cable distance due to high switching frequencies or capacitive coupling, the cable distance with the PowerFlex 7000 is virtually unlimited. This technology is capable of controlling motors as far away as 15 kilometers (9.2 miles) from the drive.

**Quiet, Smooth Motor Operation.** For a quieter, safer work environment, the PowerFlex 7000 MV drive operates the motor with less audible noise than across-the-line, due to the quality of voltage and current waveforms, optimal voltage balancing and reduced speed.



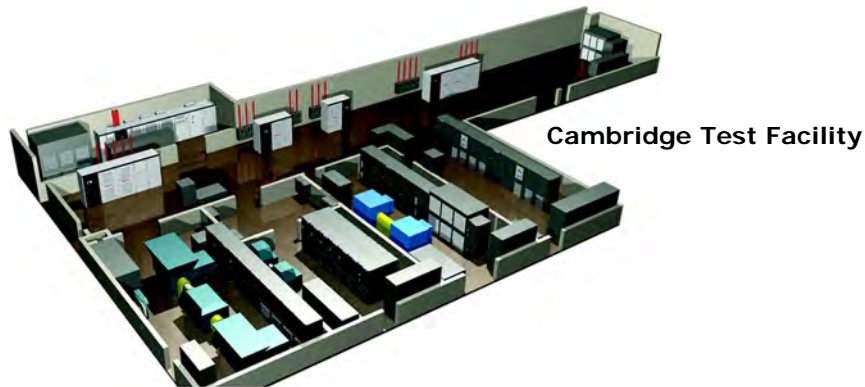


# Take a Test Drive

## Performance Testing MV Drives

**In-house Testing Saves You Time and Money.** In-house testing ensures that your MV drive meets your expectations before delivery. On-site testing can be impractical due to typically short startup time and unforeseen issues that can cause unnecessary and costly downtime. The drive system functions flawlessly upon startup, thus maximizing your initial production. Our in-house test facility tests your drive at the full field capacity, and ensures the entire system functions and produces the power needed. This reduces startup time (and therefore reduces overall project lead-time) and provides for efficiency-testing for energy savings, customer witness testing, overload and system testing, and diagnostics for field issues.

**Cambridge Test Facility.** The multi-million dollar Rockwell Automation MV drive test facility in Cambridge, Ontario, Canada enables full load testing of MV drives up to 7000 hp. The facility also has a motor base to mount a customer motor for combined testing with the PowerFlex 7000 drive and has the infrastructure to test large transformers with the drive system. The dynamometer (the motor and drive arrangement used for load testing) consists of two 2,500 hp (1,865 kW) induction motors (3,810/6,600 volts) and one 5,500 hp (4,103 kW) induction motor at 2,400/4,160 volts. The dynamometer is capable of simulating two different load types: constant torque found in conveyor and reciprocating compressor applications, and variable torque found in pump, fan and centrifugal compressor applications. Several dry-type transformers power the test area and produce voltage from 1,000 V to 13.8 kV in 6-pulse and 18-pulse configurations. A second 8,600 kVA transformer powers the high-horsepower test bay.



### Features

- 10,325 ft<sup>2</sup> (959 m<sup>2</sup>) MV test facility.
- Ten test bays.
- Three regenerative drives plus two customer demonstration drives.
- 9-MV motors totaling 16,650 hp (12.4 MW).
- Seven transformers totaling 23,860 kVA.

### Capabilities

- Tests 6-pulse, 18-pulse or AFE rectifier.
- Can simulate two load profiles.
- 100-hp to 7,000-hp (76-kW to 5,222-kW) drives at voltages from 1,000 V to 6,900 V.

### Benefits

- Reduced startup time.
- Efficiency testing for energy savings.
- Customer witness testing and training.
- Overload, system and performance testing.



# Medium-Voltage Drive Specifications

## General Design Specifications

Description	Air-Cooled
Power Rating	150–3,000 kW (200–5,500 hp)
Motor Type	Induction or Synchronous
Input Voltage Rating	2400 V, 3300 V, 4160 V, 6600 V, 10,000 V, 11,000 V, 13,200 V, 13,800 V
Input Voltage Tolerance	±10% of Nominal Line Voltage
Voltage Sag	-30% <sup>(a)</sup>
Control Power Loss Ride-Through	5 cycles (Standard); >5 cycles (optional UPS) <sup>(a)</sup>
Input Protection	Surge Arrester
Input Frequency	50/60 Hz, ±5%
Input Short-Circuit Current Withstand	5-cycle
Short-Circuit Fault Rating	2,400–6,600 V (25 kA RMS SYM)
Basic Impulse Level (based on Altitude of 1000 m [3300 ft.])	50 kV
Power Bus Design	Copper—Tin plated
Ground Bus	Copper—Tin plated 6 x 51 mm (1/4 x 2 inches)
Customer Control Wireway	Separate and Isolated
Input Power Circuit Protection	Vacuum Contactor with Fused Isolating Switch or Circuit Breaker
Input Impedance Device	AC Line Reactor
Output Voltage	0–2,300 V, 0–3,300 V, 0–4,160 V, 0–6,000 V, 0–6,300 V, 0–6,600 V
Control Power	220/240 V or 110/120 V, 1-phase, 50/60 Hz (20 Amp)

(a) Chiller controller may set more restrictive limit.

## Design

Description	Air-Cooled
Inverter Design	Pulse Width Modulation
Inverter Switch	Symmetrical Gate Commutated Thyristor
Inverter Switch Failure Mode	Non-rupture, Non-arc
Inverter Switch Failure Rate (FIT)	100 per 1 Billion Hours Operation
Inverter/Rectifier Switch Cooling	Double-Sided, Low Thermal Stress
Inverter Switching Frequency	420–540 Hz
No. of Inverter SGCTs (per phase)	Two at 2,400 V, four at 3,300/4,160 V, six at 6,600 V
SGCT Peak Inverse Voltage (PIV) Rating	6,500 V per device
Rectifier Designs	Active Front End Rectifier
Typical Line Harmonic Content	<5% Current THD
Typical Power Factor	>0.95 (10:1 speed range)
Rectifier Switch	SGCT
Rectifier Switch Failure Mode	Non-rupture, Non-arc
Rectifier Switch Failure Rate (FIT)	100 (SGCT) per 1 Billion Hours Operation
No. of Rectifier Devices (per phase)	Two at 2,400 V, four at 3,300/4,160 V, six at 6,600 V
Fiber Optic Interface	Rectifier—Inverter—Cabinet (Warning/Trip)
Design Standards	CSA, UL, IEC, NEMA, ANSI, IEEE



## Medium-Voltage Drive Specifications

### Performance

Description	Air-Cooled
Output Waveform to Motor	Sinusoidal Current/Voltage
Medium Voltage Isolation	Fiber Optic
Modulation Techniques	SHE (Selective Harmonic Elimination); PWM (Pulse Width Modulation)
Control Method	Digital Sensorless Direct Vector, Full Vector Control <i>with</i> Tach Feedback (Optional)
Tuning Method	Auto Tuning via Setup Wizard
Speed Regulator Bandwidth	0.1–15 Radians/Second
Torque Response Bandwidth	20–100 Radians/Second
Service Duty Rating (Overload Rating)	Normal Duty (variable torque): 110% Overload for 1 minute every 10 minutes Heavy Duty (constant torque): 150% Overload for 1 minute every 10 minutes
Speed Regulation	0.1% <i>without</i> Tachometer Feedback, 0.01–0.02% <i>with</i> Tachometer Feedback
Acceleration/Deceleration Range	Independent Accel/Decel—1200 sec.
Acceleration/Deceleration Ramp Rates	4 x Independent Accel/Decel
S Ramp Rate	2 x Independent Accel/Decel—1200 sec.
Critical Speed Avoidance	3 x Independent <i>with</i> Adjustable Bandwidth
Stall Protection	Delay / Speed
Load Loss Detection	Adjustable level, delay, speed set points
Control Mode	Speed or Torque
Current Limit	Adjustable in Motoring and Regenerating
Output Frequency Range	0.2 Hz to 85 Hz <sup>(a)</sup>
Typical VFD Efficiency	>97.5%
Input Power Factor	AFE Rectifier: 0.98 min., 30–100% load
Harmonic Guidelines	IEEE 519-1992 Compliant
VFD Noise Level	<80 db(A) per IEEE 1566
Regenerative Braking Capability	Inherent—No additional Hardware or Software required
Flying Start Capability	Yes—Able to Start into and Control a Spinning Load in Forward or Reverse Direction <sup>(a)</sup>

(a) Chiller controller may set more restrictive limit.

### Language

Description	Air-Cooled
Operator Interface	40-character, 16-line formatted text; 0.1 Hz Display Speed Resolution
Languages	English, Spanish, Portuguese, Chinese (Mandarin), French, Italian, German, Russian, and Polish

### I/O and Communication

The remote frequency drive is controlled by the Tracer AdaptiView unit controller on the chiller. The communication interface was designed and developed to optimize the reliability and efficiency of the chiller drive system. Frequency drive data is available from the chiller control system. Additional frequency drive direct control inputs and outputs may be available; however, they are not standard. Contact your local Trane representative for more information.

## Medium-Voltage Drive Specifications

### Dimensions and Weights

**Note:** The following information is for general reference only. Consult with your Trane sales representative for detailed product information.

**Table 1. "A" Frame normal duty ratings—dimensions and weights**

Drive Configuration	Normal Duty Ratings					Dimensions and Weights	
	Nominal Line Voltage	VFD Continuous Current	Nominal Power (kW)	Nominal Power (HP)	Structure Code	Dimensions in. (mm) <sup>(a)</sup> W x H x D	Approx. Weight <sup>(b)</sup> lb (kg)
Direct-to-Drive <sup>(c)</sup>	2,400 (60 Hz)	46–140	150–450	200–600	71.9	94.49 X 104 X 39.4 (2,400 X 2,643 X 1,000)	6,500 (2,955)
	3,300 (50 Hz)	46–140	187–600	250–800	71.9	94.49 X 104 X 39.4 (2,400 X 2,643 X 1,000)	6,500 (2,955)
	4,160 (50/60 Hz)	46–140	261–750	350–1,000	71.9	94.49 X 104 X 39.4 (2,400 X 2,643 X 1,000)	6,500 (2,955)
	6,600 (50/60 Hz)	40–93	400–895	500–1,200	71.10	110.24 X 104 X 39.4 (2,800 X 2,643 X 1,000)	7,500 (3,410)

(a) Heights shown include the standard fan shroud (removable for shipping). If a redundant fan (removable for shipping) is specified, the height is 114.96 in. (2,920 mm). Actual VFD structure height is 89.56 in. (2,275 mm).

(b) Approx. Weight is maximum for the indicated size range.

(c) Structure code and data shown for Direct-to-Drive includes optional integral input starter. Dimensions and approximate weights are the same without integral input starter.

**Table 2. "B" Frame normal duty ratings—dimensions and weights**

Drive Configuration	Normal Duty Ratings					Dimensions and Weights	
	Nominal Line Voltage	VFD Continuous Current	Nominal Power (kW)	Nominal Power (HP)	Structure Code	Dimensions in. (mm) <sup>(a)</sup> W x H x D	Approx. Weight <sup>(b)</sup> lb (kg)
Direct-to-Drive	2,400 (60 Hz)	185–375	600–1,300	800–1,750	70.40	174 X 39X 104 (4,420 X 2,643 X 1,000)	11,800 (5,352)
	3,300 (50 Hz)	160–250	750–1,120	1,000–1,500	70.44	182 X 39 X 104 (4,623 X 2,643 X 1,000)	14,150 (6,418)
	4,160 (60 Hz)	160–250	933–1,500	1,250–2,000	70.44	182 X 39 X 104 (4,623 X 2,643 X 1,000)	14,150 (6,418)
	6,600 (50/60 Hz)	105–120	933–1,120	1,250–1,500	70.46	205 X 39 X 104 (5,207 X 2,643 X 1,000)	18,100 (8,210)

(a) Heights shown include the standard fan shroud (removable for shipping). If a redundant fan (removable for shipping) is specified, the height is 118.11 in. (3,000 mm). Width includes the input starter section.

(b) Approx. Weight includes the input starter section.

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