

# 2400

## Modular Performance AC Drive



**Overview** The 2400 is an all-digital pulse-width-modulated (PWM) inverter that provides superior control of three-phase AC motors. Its revolutionary technology and modular design make it the optimum solution where superior performance, flexibility, and ease of operation are important.

### Motor-Independent Design

A unique design incorporating a proprietary digital current regulator and a state-of-the-art controller allows the 2400 to operate any AC induction, AC synchronous, or brushless DC motor without the current-loop setup required by conventional drives. Digital space vector control can be selected for reduced motor noise and low current ripple.

### Application Flexibility

The 2400 is extremely flexible and can accommodate a wide range of servo applications. It can be configured to control torque, velocity, or position in applications requiring either constant-, variable-, or extended-torque. Extensive controller options enable the analog and digital I/O, feedback, and serial communication capabilities of the drive to be tailored to the requirements of the application.

### Auto Tuning

Once routine electrical connections have been made, simple-to-use auto-tuning features adjust virtually all motor and inertial parameters to the given motor and connected load. Simply enter a few values from the motor nameplate, and the advanced setup routines do the rest. The drive is completely tuned within minutes.

### Modular Design

The modular bus design of the 2000 family provides space, cost, and energy savings in many applications. A 2400 drive system incorporates a separate 2490 converter unit that rectifies incoming AC power to provide a common DC bus. The converter is comprised of a full-wave diode or SCR bridge, a link choke, a bus-charging circuit, a dynamic braking circuit, and a capacitor bank. The 2400 consists of a six-IGBT, four-quadrant PWM amplifier that operates from the DC bus of the converter unit. High-power inverters are comprised of three separate poles.

### Energy Savings

Multiple inverter units can be operated from a single converter unit. This allows applications that naturally share regenerative energy, such as an uncoiler and recoiler, to reuse the energy, rather than dissipate it as heat through resistors. A much smaller converter is therefore needed than would be required using two integrated drives. Alternately, an inverter can be used in place of the converter to regenerate power to the line. In cyclic applications, an optional capacitor bank can be used to store regenerated energy and to return stored energy to the load.

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## **Overview Power Quality**

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The 2490 converter unit incorporates a link choke that provides near-unity overall power factor and low harmonic line currents at all motor speeds. High-power units also offer a six-phase (twelve-pulse) configuration for further minimizing line harmonics in critical applications. When a regenerative inverter is used in place of the converter, a unity power factor is achieved and virtually all harmonic currents are eliminated.

### **Application-Specific Software**

Application software determines the specific features and operation of the 2400. A wide variety of general-purpose and application-engineered software options enables each drive to be tailored to specific customer requirements. Software is available for such applications as test stands, elevators, press feeders, winders, rotary cutoffs, spindles, flying cutoffs, and wire drawing, to name a few. Further customization is possible with many programs using UEdit™, a Windows-based programming tool that allows users to extend an application using ladder diagrams and function blocks.

### **Optically Isolated Digital I/O**

All digital inputs and outputs are optically isolated. Depending upon the controller, as many as 32 individually isolated digital I/O are locally provided, each of which can be programmed by the application to be an input or output. The voltage of each can be selected from a wide range of AC and DC values.

### **Transducer/Transducerless Design**

The 2400 can operate with or without a feedback transducer. An incremental encoder is typically used for feedback, although absolute encoders, resolvers, and serial sincos encoders are also supported. Transducerless operation is offered for less demanding velocity-loop applications.

## **Features & Benefits**

### **General**

- All-digital control for zero drift and repeatable motor operation
- 24-bit DSP computational power for fast, dynamic response
- High-switching-frequency IGBT devices for quiet operation
- Digital current regulator for high-speed operation and fast response
- Digital space vector control for reduced motor noise and low current ripple
- Flux vector control for full torque from zero to rated speed
- Servo loop operation for precise velocity, position, or torque control
- Field weakening at constant horsepower up to four times base speed

### **Ease of Installation, Setup, and Maintenance**

- Complete, self-contained package requires few option boards
- Identical control boards across full power range reduces spare parts
- Snap-in signal connections for ease of wiring
- Automated setup feature requires no chart recorders or meters
- Software calibration and adjustment eliminates tuning components
- Software input and output scaling eliminates potentiometers
- Automated hardware configuration check

### **Ease of Use**

- Full keypad for easy entry of application-specific setup adjustments
- Two line by 24-character/line descriptive, plain-English display
- Process variable display in bar graph and engineering units
- Comprehensive plain-language, self-diagnostic message display
- Real-time motion information and historical fault log
- RS-232/422/485 for communication with process controllers
- Optional software for managing the drive from a personal or handheld computer

### **Reliable Operation**

- Tolerant of AC line fluctuations
- Extensive electronic protection circuits reduce failures
- Optically isolated signals for high noise immunity
- S-curve acceleration reduces shock and extends equipment life
- Fiber-optics for noise-free serial communication
- Designed to meet or exceed accepted international standards

## Specifications **Electrical**

### Input Supply

Line voltage:	200 to 240, 380 to 480, or 500 to 600 V AC, three-phase Phase sequence insensitive
Voltage tolerance:	-10% of minimum, +10% of maximum
Frequency:	47 to 63 Hz
Power factor:	Displacement: 1.00 at all loads and speeds Overall: 0.94 at rated load

### Output Rating

Voltage:	Zero to input voltage, three-phase
Frequency:	Zero to 120 Hz without transducer Zero to 480 Hz with transducer
Switching frequency:	Programmable from 2.0 to 12.0 kHz

### Service Conditions

Efficiency:	97% nominal at rated switching frequency												
Overload current:	<table><thead><tr><th><i>Torque</i></th><th><i>Overload (1 min)</i></th><th><i>Maximum</i></th></tr></thead><tbody><tr><td>Constant</td><td>150% to 200% of rated</td><td>200% of rated</td></tr><tr><td>Variable</td><td>120% to 150% of rated</td><td>140% to 160% of rated</td></tr><tr><td>Extended</td><td>110% to 120% of rated</td><td>120% to 140% of rated</td></tr></tbody></table>	<i>Torque</i>	<i>Overload (1 min)</i>	<i>Maximum</i>	Constant	150% to 200% of rated	200% of rated	Variable	120% to 150% of rated	140% to 160% of rated	Extended	110% to 120% of rated	120% to 140% of rated
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### Conversion

Converter unit (2490):	Six-pulse standard; six- or 12-pulse (150 hp CT or more)
Inverter unit (2400):	Six-IGBT, four-quadrant, PWM
Regeneration:	Dynamic braking transistor with resistors, capacitor bank energy storage, or regenerative inverter

## Environmental

Operating temperature:	Control section: 32° to 131° F (0° to 55° C) Heat sink: 32° to 131° F (0° to 55° C) through 100 hp CT, 32° to 104° F (0° to 40° C) 125 hp CT or more
Storage temperature:	-40° to 158° F (-40° to 70° C)
Relative humidity:	95% maximum, noncondensing
Altitude:	To 3,300 ft. (1,000 m) without derating

## Performance

### Position Control

Bandwidth:	50 Hz
Settle time:	10 ms

### Velocity Control

Bandwidth:	100 Hz with transducer 10 Hz without transducer
Range:	Zero to base speed at full torque Base speed to 480 Hz at constant power with transducer Base speed to 120 Hz at constant power without transducer
Regulation:	±0.001% of base speed, down to zero, with transducer ±0.5% of base speed, 2 Hz and above, without transducer

### Torque Control

Bandwidth:	300 Hz with DCR control 100 Hz with DSV control
Regulation:	±3.0% of maximum with transducer ±10% of maximum without transducer

## Control Modules

### Common Features:

- Three ±10 V DC or 0 to 20 mA 12-bit analog inputs
- Two ±10 V DC 12-bit analog outputs
- Two programmable contact outputs
- Fiber-optic high-speed synchronous/asynchronous serial port with clock synchronization up to 1 Mbaud
- Fiber-optic synchronous serial port with clock synchronization at 2 Mbaud
- One optional communication interface provision

### Standard Control Module:

- Eight optional configurable I/O points
- One optional feedback interface provision
- One RS-422/485 asynchronous serial port up to 115.2 kbaud

### Expandable Control Module:

- Two programmable isolated inputs
- 16 or 32 optional configurable I/O points
- One incremental encoder interface
- Two optional feedback interface provisions
- Two RS-422/485 asynchronous serial ports up to 115.2 kbaud

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**Specifications**

*(continued)*

**Communication Modules**

**Serial Communications:**

- Two isolated RS-232/422/485 synchronous/asynchronous serial ports up to 1 Mbaud

**Fiber-Optic Communications:**

- One isolated fiber-optic synchronous/asynchronous serial port up to 1 Mbaud
- One RS-232/422/485 synchronous/asynchronous serial port up to 1 Mbaud

**Remote I/O Communications:**

- Dual Remote I/O interface

**Modbus Plus Communications:**

- Modbus Plus interface

**ControlNet Communications:**

- ControlNet interface

**Profibus Communications:**

- Profibus DP interface

**Ethernet Communications:**

- Ethernet interface

**Transducer Options**

A variety of motor-mounted transducers are available to provide feedback of motor position, velocity, and acceleration.

**Incremental Encoder:**

Two quadrature channels with marker pulse operating up to a maximum frequency of 300 kHz per channel  
Up to 14-bit resolution

**Single-Turn Resolver:**

24-bit resolution with RS-422/485 synchronous serial communication

**Multiturn Absolute Encoder:**

**Inputs and Outputs**

**Input Converters:**

2.5 to 28 V DC @ 30 mA, 90 to 140 V AC @ 11 mA, or 180 to 280 V AC @ 5 mA

**Output Converters:**

5 to 60 V DC @ 3 A, 12 to 140 V AC @ 3 A, or 24 to 280 V AC @ 3 A

**Relay Converters:**

250 V AC @ 8 A, normally open or normally closed

**Control Module Relay Contacts:**

Form A 250 V AC @ 5 A

**Optional Analog Interface Module:**

Two ±10 V DC inputs and two ±10 V DC outputs

**Protection**

- Ground fault
- Drive thermal overload
- Software circuit breaker
- DC bus overvoltage
- DC bus undervoltage
- DC bus fuse and blown fuse
- Instantaneous overcurrent
- Motor thermal overload
- Braking unit overcurrent
- Heat sink overtemperature
- Phase loss
- Power transistor fault
- Control undervoltage
- Excessive position error
- Uncommanded motion
- Motor overspeed
- Feedback transducer failure
- Memory malfunction
- Processor not running fault
- Serial communication error

**Power Range**

Input Voltage	Constant-Torque Applications	Variable-Torque Applications	Extended-Torque Applications
230 V AC	1 1/2-75 hp (1.1-55 kW)	2-100 hp (1.5-75 kW)	—
380 V AC	1 1/2-1000 hp (1.1-750 kW)	2-1100 hp (1.5-825 kW)	—
460 V AC	1 1/2-1000 hp (1.1-750 kW)	2-1100 hp (1.5-825 kW)	25-1200 hp (18-900 kW)
575 V AC	125-1100 hp (90-825 kW)	150-1200 hp (110-900 kW)	200-1300 hp (150-975 kW)

Consult factory for other powers. Other voltages require appropriate derating or adjustment of the switching frequency.

**UNICO—Worldwide**

**Corporate Headquarters**

UNICO, Inc.  
3725 Nicholson Road  
P. O. Box 0505  
Franksville, Wisconsin  
53126-0505  
USA

voice: 262.886.5678  
fax: 262.504.7396

www.unicous.com

**United States**

Novi, Michigan  
248.380.7610  
New Lenox, Illinois  
815.485.5775  
Sandy, Utah  
801.501.7586

**Canada**

Mississauga, Ontario  
905.602.4677

**South America**

El Tigre, Venezuela  
58.283.241.4024

**Europe**

Milton Keynes, England  
44.1908.260000  
Wilnsdorf, Germany  
49.2739.303.0

**Asia**

Osaka, Japan  
81.66.945.0077  
Beijing, China  
86.10.6218.6365



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