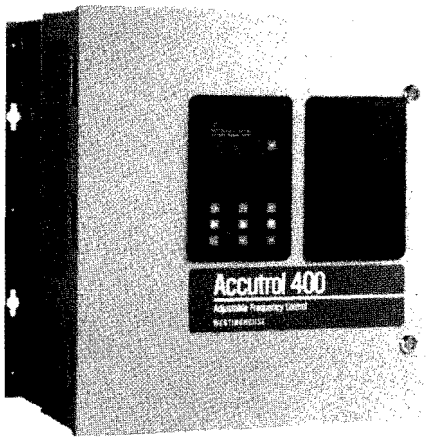
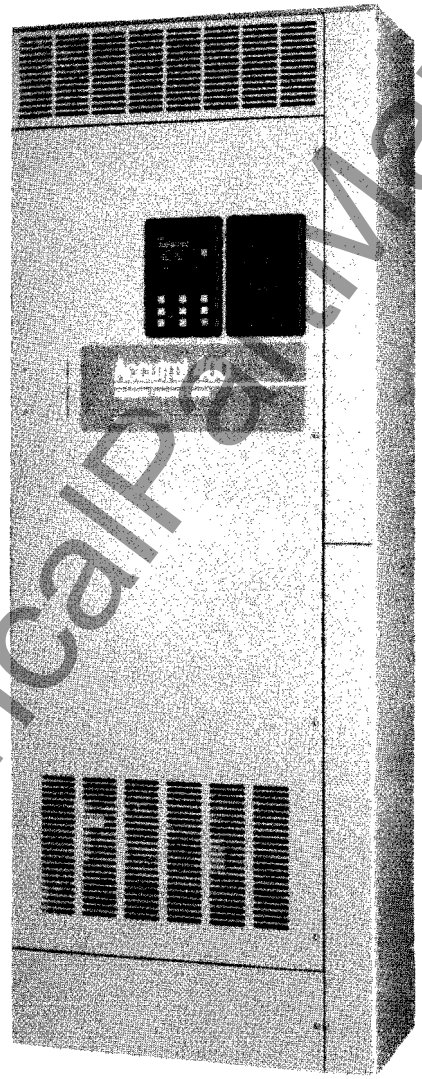
Accutrol 400 Adjustable Frequency Motor Control



27 Amp (20 Hp) Accutrol 400



180 Amp (100 Hp) Accutrol 400

General Information

The Westinghouse Accutrol 400 solid state, adjustable frequency motor controller is designed to provide continuous speed adjustment of three phase Ac motors from 3 to 250 Hp. Designed to operate from a three-phase, 380 or 480 volt, 50/60 Hz supply, it is available either as an open panel device or in a NEMA 1 or a NEMA 12 enclosure. It can be used with standard three phase squirrel cage induction motors when properly sized.

The rectifier converts incoming Ac supply voltage to a fixed potential Dc bus level. The Dc voltage is in turn inverted by a three phase, pulse-width-modulated inverter section to an adjustable frequency output, whose voltage is also adjusted proportionately to the frequency to provide constant volts per Hertz excitation to the motor terminals up to 60 Hz. Above 60 Hz, the voltage remains constant. In this way energy efficient speed control is obtained in the range from 4 to 120 Hertz.

Application

Available in both variable and constant torque ratings, the Accutrol 400 is well suited to most variable torque flow applications where speed control, with the resulting energy savings, is desired, because of the elimination of throttling devices such as valves and dampers.

Other industrial applications for adjustable speed such as conveyors, machine tools and material handling equipment are good applications for the constant torque rated Accutrol 400.

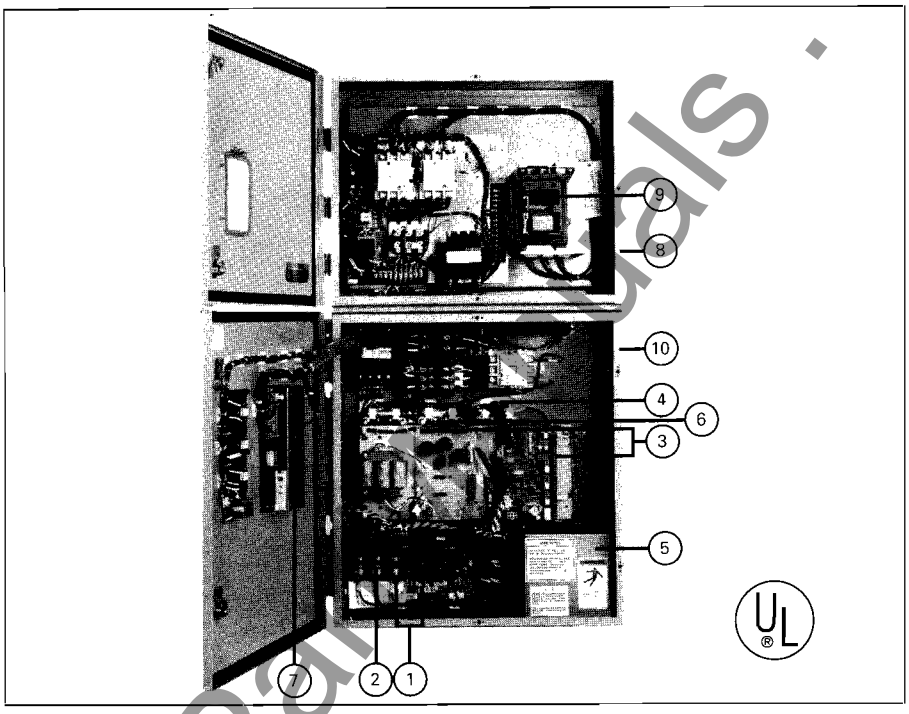
In adverse environmental conditions, the NEMA 12 enclosed Accutrol 400 allows the use of Ac motors with their inherent advantages as compared to expensive, hard to maintain Dc machines. Typical of these applications are food packing plants, dairies, chemical plants, sand and gravel plants, paper mills and cement plants.

Accutrol 400 Adjustable Frequency Ac Motor Control

Design Features
Accutrol 400, 96 Amp and Smaller

The Westinghouse Accutrol 400 comes in two basic configurations. From 8 to 96 Amps, the Accutrol 400 is a space efficient, wall mounted design. The Westinghouse Accutrol 400, 124 Amp and above is a free-standing, floor mounted design. Both have been designed for complete front accessibility with easily removable assemblies to allow fast, efficient maintainability when required.

Solid state micro-processor logic is the key to high versatility and excellent performance. The Accutrol 400 design utilizes a full wave diode bridge Ac to Dc section that converts 3 phase, 460 volt AC power into a fixed voltage DC source. The DC power is then transformed into an adjustable frequency and voltage AC waveform in the inverter section to power any AC squirrel cage induction motor. The DC to AC inverter section utilizes pulse width modulation switching techniques via highly efficient Darlington Transistor modules which eliminate the need for commutating components often required in competitive designs. The pulse width modulation (PWM) waveform provides constant volts per Hertz excitation to the motor. These inputs are then buffered by optical couplers to provide additional isolation between the control and logic circuitry.



Items 1 to 10 described below are indicated in Figure 1.

1. Three-pole power terminals provide for input and output line wiring.

2. Current limiting fuses provide short circuit protection for the power converter semiconductors as well as greater interrupting short circuit capability.

3. External control connections are provided by highly accessible terminal blocks.

4. The fixed voltage Ac input line power is converted into a fixed Dc voltage by a diode power module.

5. The output of the converter is smoothed by the Dc capacitor bank.

6. The fixed voltage Dc link is inverted to the desired output frequency by the inverter section. This section utilizes highly efficient Darlington Transistor power blocks for the power conversion process, with high peak voltage ratings for maximum protection from switching transients.

7. The Accutrol 400 features a microprocessor control system. The use of microprocessor control increases versatility and accuracy and allows simpler, more effective diagnostics and troubleshooting.

8. The optional expansion unit, for ampere ratings below 96 A, can be used to mount the circuit breaker (9), line reactor and output or bypass contactors. When the breaker is included, interlocking is provided so that the doors cannot be opened unless the breaker is in the off position.

9. Circuit breaker option with padlockable door interlocked handle mechanism.

10. NEMA 1 and NEMA 12 enclosure for wall mounting includes stand-off mounting brackets to assure airflow to rearmounted isolated heat sinks.

Accutrol 400 Adjustable Frequency Ac Motor Control

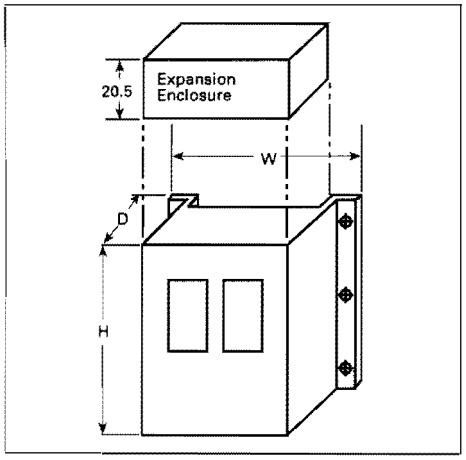


Figure 3: Accutrol 400, 8-96 Amp (3-75 Hp) NEMA 1 or NEMA 12 Wall Mounting

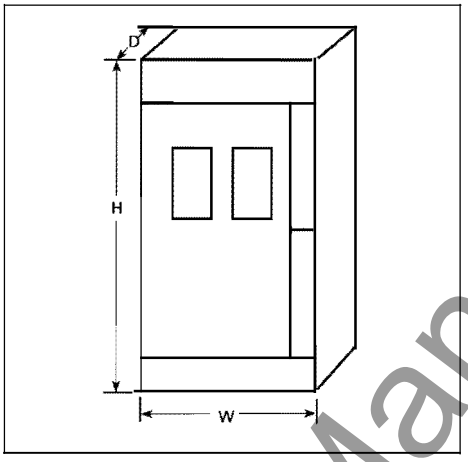


Figure 4: Accutrol 400, 124-300 Amp (100-250 Hp) NEMA 1 Free Standing

Dimensions (Inches), Weights (Lbs.)

Amp (Hp) Rating①				Dimensions			Weight
NEMA 12 Enclosure		NEMA 1 Enclosure					
110%②	150%②	110%②	150%②	Height	Width	Depth	
8-21 (5-15)	8-21 (3-10)	21-27 (15-20)	21-27 (10-15)	26.31	26.37	15.66	101
27-34 (20-25)	27-34 (15-20)	34-52 (25-40)	34-52 (20-30)	32.31	26.37	15.66	159
40-77 (30-60)	40-77 (25-50)	65-96 (50-75)	65-96 (40-60)	46.31	26.37	16.91	290
—	—	124-180 (100-150)	124-180 (75-100)	90.00	32.00	20.35	800
—	—	240-300 (200-250)	240-300 (125-150)	Contact Factory			

Accutrol 400 Ratings

Model No.			Hp Rating①		Amps	
Open Panel	NEMA 12 Enclosure	NEMA 1 Enclosure	110%② Capability	150%② Capability	Continuous Output	One Min. Output
A4008-4PR	A4008-4DR		5	3	8	9
A4011-4PR	A4011-4DR		7.5	5	11	12
A4014-4PR	A4014-4DR		10	7.5	14	21
A4021-4PR	A4021-4DR	A4021-4VR	15	10	21	24
A4027-4PR	A4027-4DR	A4027-4VR	20	15	27	32
A4034-4PR	A4034-4DR	A4034-4VR	25	20	34	41
A4040-4PR	A4040-4DR	A4040-4VR	30	25	40	51
A4052-4PR	A4052-4DR	A4052-4VR	40	30	52	60
A4065-4PR	A4065-4DR	A4065-4VR	50	40	65	78
A4077-4PR	A4077-4DR	A4077-4VR	60	50	77	98
		A4096-4VR	75	60	96	116
		A4124-4VR	100	75	124	144
		A4156-4VR	125	75	156	172
		A4180-4VR	150	100	180	198
		A4240-4VR	200	125	240	264
		A4300-4VR	250	150	300	330

① Hp rating based on typical NEMA B design 4 or 6 pole induction motors.
② 1 minute capability; 150% for constant torque applications; 110% typical for variable torque applications.
● Pending as of print date.

Standard Conditions for Application and Service

Humidity: 0 to 95% noncondensing
Altitude: to 3,300 feet (1,000 meters)
Ambient Temperature: 0 to 40°C enclosed unit, 0-to 50°C open panel
Ac Incoming Line (Nominal): 480 volts, three-phase, 50/60 Hz
Ac Line Voltage Variation: +5-10%
Output Ac Volts . . . 0-460 V
Output Frequency Range, Hz . . . 4-120
Ac Line Frequency Variation: ±2 Hertz
Service Factor: 1.0
Momentary Overload, 1 min . . . 150/110%
Insensitive to Input Phase Rotation
UL Listed●

Accutrol 400 Standard Protective Features

200,000 AIC rated Incoming Line Fuses
Phase Loss Protection
Overload Protection
Overfrequency Protection
Electronic Instantaneous Overcurrent Protection
Dc Bus Overvoltage Protection
Dc Bus Undervoltage Protection
Output Terminal Short Circuit Protection
Ground Protection
Overtemperature Protection
Control Circuit Fuses
Status and Fault Indicator via Keypad
Trip Contact

Accutrol 400 Standard Software Adjustments

Minimum Speed: 4 to 60 Hz
Maximum Speed: 40 to 120 Hz
Four Preset Speeds: 4 to 120 Hz
Four Acceleration Times: 2-300 Seconds
Four Deceleration Times: 2-300 Seconds
Voltage Boost: 0-100% at 4 Hz
Dwell Time (0-18 sec)
Process Follower Min/Max Adjustments
Critical Frequency Avoidance (3 Adjustable 10 Hz Bands)
Carrier Frequency (700-1300 Hz) for reduction of motor noise
Acceleration/Deceleration (Linear or S Curve)
V/Hz Pattern (Linear or Reduced)
Current Limit (70%-120%)
Auto Restart
Ability to Catch a Spinning Motor

Accutrol 400 Standard Customer Inputs Analog and Discrete

- Remote Mode Start Contact (Maintained)
- Forward Reverse Contact (Maintained)
- Preset Speed Contacts (Maintained)
- External Trip Contact (Maintained)
- 0-10 Volt Speed Control Signal (Differential Amplifier Isolated)
- 4-20mA Speed Control Signal (Differential Amplifier Isolated)

Accutrol 400 Standard Customer Outputs Analog and Discrete

- Inverter Enable (Form C Contact)
- Trip (Form C Contact)
- One Programmable Form C Contact
- Output Frequency (4-20mA)
  Choice of Output Current (4-20mA)
  Output Voltage (4-20mA)
  Output Power (4-20mA)

Accutrol 400 Adjustable Frequency Ac Motor Control

Accutrol 400 Digital Operator Keypad

Monitoring Display
Single line 8 character LED display visible from virtually all angles
- Output Frequency
- Frequency Set Point
- Motor RPM
- Output Current
- Output Voltage
- Elapsed Run Time

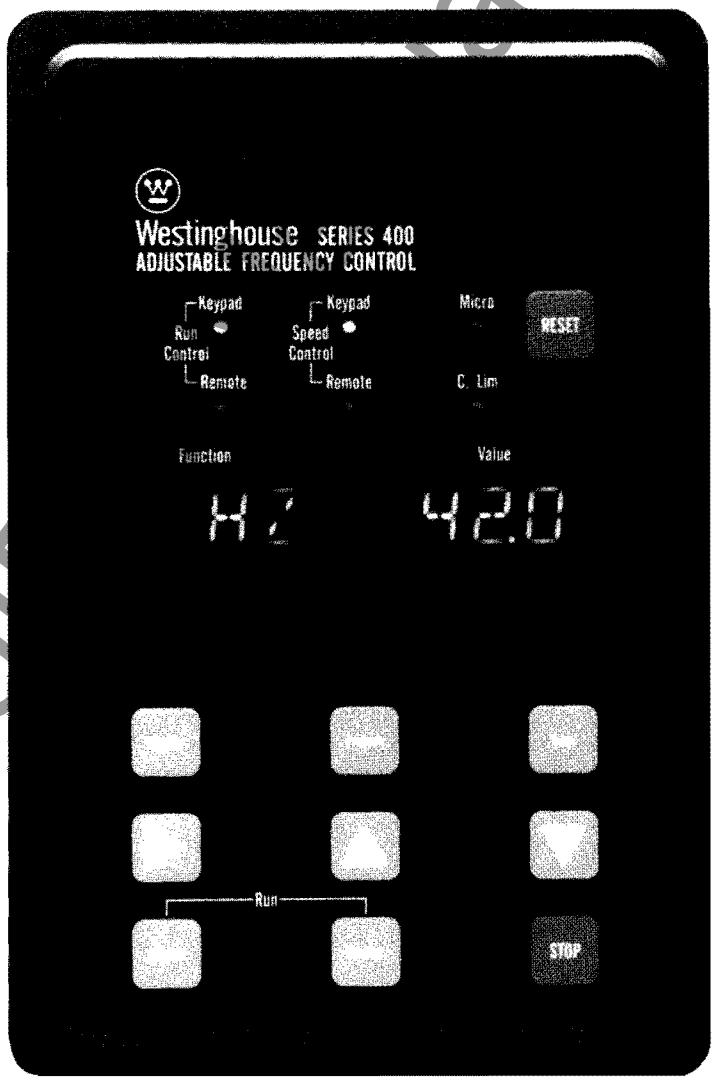
Trip Logging
Logs the condition of five most recent trips
- Dc link voltage
- Motor current
- Output frequency
- Cause of trip
- Elapsed run time at time of trip

Single LED Displays
- Keypad Mode (Start Control)
- Remote Mode (Start Control)
- Keypad Mode (Speed Control)
- Remote Mode (Speed Control)
- Current Limit
- Microprocessor Trip

Fault Indication
- Undervoltage
- Overvoltage
- Overcurrent
- Phase Loss (Line)
- Overtemperature
- Loss of Input Process Signal
- External Trip
- Ground Fault
- Permissive Trip
- Thermal Switch Open
- Overfrequency
- Overload

Stop Button

Forward & Reverse Start Buttons
- Electronic reversing



Programmable Parameters

Parameters that can be adjusted while drive is running
- Start Control (Keypad or Remote)
- Speed Control (Keypad or Remote)
- Minimum Speed (4-60 Hz)
- Maximum Speed (40-120 Hz)
- Acceleration Time (Keypad Mode)
- Deceleration Time (Keypad Mode)
- Carrier Frequency (700-1300 Hz) for reduction of motor noise
- V/Hz Ratio

Parameters that can be adjusted only when the drive is stopped
- Acceleration (Linear or S Curve)
- Deceleration (Linear or S Curve)
- Remote Start (Contact or Signal)
- Dwell Time (0-18 seconds)
- Voltage Boost (0-100% of nominal voltage at 4 Hz)
- V/Hz Pattern (Linear or Reduced)
- Preset Speed 1 (4-120 Hz)
- Preset Speed 2 (4-120 Hz)
- Preset speed 3 (4-120 Hz)
- Current Limit (70%-120%)
- Auto Restart (none, or multiple attempt restart for all faults or for source faults only)
- Loss of process signal (stop or go to preset speed)
- Four acceleration times (2-300 seconds)
- Four deceleration times (2-300 seconds)
- Critical Frequency Avoidance (4-120 Hz)
- 3 Bands with variable width less than or equal to 10 Hertz band

Accutrol 400 Adjustable Frequency Ac Motor Control

Factory Modifications
A number of factory modifications are available for the Accutrol 400 product to meet nearly every specific application need in the industry. After selecting the basic controller from page 3 to match the voltage, current and horsepower requirements of the application, add factory modifications shown below as required.

List of Available Modifications

Catalog Number Suffix	Description
	Instruction Manuals Specify Instruction Manual 9075A92G01 The basic controller price includes one instruction manual shipped with the controller. Additional manuals can be ordered as required with this modification
	Special Drawings, Approval or Reproducible Specify by description When drawing approval of the external connection and/or outline drawings are required by the purchaser, material procurement and manufacture will be held until final drawing approval is received at the factory.
Z	**Expansion Enclosure** Available for Accutrols 8 through 96 Amps. Required for the addition of an input breaker, output contactor, bypass switch or input line reactors. The expansion enclosure extends the height of the standard enclosure and still maintains the NEMA 12 capability of units 60 Hp and smaller.
C	**Input Disconnect Switch**① Accutrol 400 is provided as standard without an AC line disconnect. In some applications, this must be provided to meet applicable electrical codes. This option includes a Westinghouse Series C thermal-magnetic circuit breaker or HMCP with padlockable door interlocking mechanism.
D	**AC Output Contactor**① Provides a means for positive disconnection of the controller output from the motor terminal where required by local codes, customer or specification. The contactor coil is interlocked with the internal Accutrol permissive logic. For 96 Amps and below this option **requires the use of the expansion enclosure.** This is included in the I2 and X2 options.
I2	**Contactor Bypass with Input Disconnect and Overcurrent Relay**① The contactor bypass option provides a means of bypassing the Accutrol 400 while still providing power to the motor terminals. This option includes an input disconnect, a controller output contactor, bypass contactor, motor overcurrent relay, fused control power transformer, indicating lights and a restart time delay relay. Contactors are electrically interlocked. All components are mounted and wired in the Expansion Enclosure.
X2	**Automatic Electric Bypass with Input Disconnect and Overcurrent Relay**① Same as I2 except X2 will automatically transfer to the bypass supply when the Accutrol 400 is out of service due to a fault induced shutdown. The trip circuit activates Automatic Bypass.
I3	**Contactor Bypass with Overcurrent Relay, Input Disconnect and AFC Only Disable Switch**① Same as **I2** with the addition of an AFC only disable switch to completely isolate the AFC when in the bypass mode. Available through 96 Amp (75 Hp).
X3	**Automatic Electric Bypass with Overcurrent Relay, Input Disconnect and AFC only Disable Switch**① Same as I3 except X3 will automatically transfer to the bypass supply when the Accutrol 400 is out of service due to a fault induced shutdown. The trip circuit activates Automatic Bypass. Available through 96 Amp (75 Hp).
I4	**Contactor Bypass with Overcurrent Relay, Input Circuit Breaker and Solid State Reduced Voltage Bypass Starter**① Same as **I2** except with Solid State Reduced Voltage Starter in place of electro-mechanical bypass starter.
I5	**External Mechanical Bypass** This option provides a means of mechanical bypass. It consists of an externally mounted, manually operated, no load transfer switch (frequently used with an existing starter).
L	**Line Reactors** AC line reactors are standard on units rated 34-180 amps. An Ac line reactor is recommended for the 8 through 34 Amp unit if: a) More than one solid state motor drive (i.e., Dc drive, inverter, wound motor drive, variable volatge Ac drive) is operated from the same transformer supply, or b) The supply source transformer kVA rating is more than three times the Accutrol continuous kVA rating, for 11 through 34 Amps, and six times for 96 through 180 Amps, or c) Ac line voltage unbalance is greater than 2% unbalance defined as . . . $100 \times \frac{\text{highest line voltage} - \text{lowest line voltage}}{\text{nominal voltage}}$

● Requires Expansion Enclosure Z for units 96 Amps and less.

Accutrol 400 Adjustable Frequency Ac Motor Control

Catalog Number Suffix	Description
	Failure to provide a line reactor will cause larger than rated line currents to be drawn from the Ac line for any of the above situations. An isolation transformer may be used instead of a line reactor. **Line reactors are included as standard in ratings 34 through 180 Amps.** For units up to 34 Amp the reactors may be separately mounted by the customer in his enclosure, or be factory mounted in the expansion enclosure.
M	**3-15 PSIG Pneumatic Process Signal Follower** In some applications it may be desirable for the Accutrol 400 to follow a 3-15 PSIG pneumatic control signal. This modification includes a printed circuit board with a pneumatic transducer which converts 3-15 PSIG to a voltage signal to interface with the standard Accutrol 400. This signal can be either direct or reverse acting. This is especially advantageous in retrofit applications where the 3-15 PSIG signal was used for damper position control.
M1	**Electronic Potentiometer Floating Point Process Signal Follower** Low cost, reliable floating point control can be achieved by the addition of this electronic potentiometer printed circuit board. This option allows the Accutrol 400 to follow an increase or decrease contact closure to maintain a setpoint variable. The electronic floating point follower enables the Accutrol 400 to follow discrete contact closures which tells the Accutrol 400 to accelerate or decelerate motor speed.
M3	**4-20 mA Output Signal Proportional to Current (Load)②**
M11	**4-20 mA Output Signal Proportional to Voltage②**
M12	**4-20 mA Output Signal Proportional to Power②**
M14	**Isolated Process Follower** Provides a means of totally isolating the drive from grounded process control signals. This option must be supplied when several drives are being controlled via one input signal or when the process signal input is greater than 35 VDC in reference to ground.
M15	**120 VAC 3 Wire Control Interface** This option provides the customer a means of using 3 wire 120 VAC control instead of dry contact closures. This will allow the customer to control the drive from distances up to about 600 feet.
N	**Special Nameplates** A laminate plastic (N1) or stainless steel (N2) nameplate which may be engraved with the user's identifying number or name for the Accutrol 400 is available for mounting on enclosure door.

② Only one of options M3, M11, M12 may be chosen. If not specified, M3 will be provided.

Catalog Number Suffix	Description
	Specify the engraving desired, maximum of two lines of eighteen characters each.
P1	**H-O-A Selector Switch** Full functionality of an H-O-A switch is standard in the digital keypad. This traditional device may be added to the drive in the 8 piece device panel next to the digital keypad.
P2	**Speed Potentiometer** Full functionality of a speed potentiometer is standard in the digital keypad. This traditional device may be added to the drive in the 8 piece device panel next to the digital keypad.
Y	**Auxiliary Run Relay** Whenever the Accutrol is in an operating condition, the Auxiliary Run Relay will be energized, providing an external indication. Two Form C relay pairs are provided. The contacts are rated 120 VAc, 2.0 amp non-inductive.
Y1	**Auxiliary Trip Relay** Provides three Form C contact pairs rated 120 VAc, 3 amps, non-inductive. This option provides additional trip contacts by wiring the coil of the auxiliary relay into the drive's trip contact.
Y3	**Auxiliary Relay** Provides three Form C contact pairs rated 120 VAc, 3 amps, non-inductive. Interconnecting wiring is not included.
Y4	**Motor Overcurrent Relay** Provides motor overcurrent sensing of a given level of load current. Does not provide motor overload protection except at base speed on self cooled motors or for all speeds on TENV motors, because of the variable cooling effect of shaft mounted fans operating at other than base speed. Dependent upon heater selection, protection can be extended to approximately fifty percent speed for many motors. The recommended protection for all motor types and all speed ranges is an internal thermal sensor. Upon trip, the relay output contact opens. This can be used for an external indication of overcurrent or to trip off the Accutrol 400 controller. The relay provided is Westinghouse Type BA. Price does not include heaters which should be chosen for the current trip level desired.

Accutrol 400 Adjustable Frequency Ac Motor Control

Catalog Number Suffix	Description
V1	**Enclosure Floor Stands** Allows Accutrols that are normally wall mounted to be floor standing. Although installation against a wall is still recommended for stability, this option allows the units to be free standing if suitably anchored. A back plate is included to cover rear sinks for proper air flow. Basic Accutrols that are 26" and 32" height utilize 24" floor stands and 46" units are mounted on 12" stands.
V2	**Space Heaters** In situations where the Accutrol may be utilized in environments where condensation is possible due to high humidity and rapid temperature reduction, the use of a space heater is recommended. This modification provides a thermostat controlled fused space heater to minimize the condensation potential upon shutdown of the Accutrol. A single phase 115 VAC source, with appropriate NEC and other applicable code specified protection, is required for space heater power.
V3	**Force Ventilated/Filtered Enclosure** Through 77 Amps the Accutrol 400 can be provided as NEMA 12. Units 96 Amps and above are NEMA 1. For 96 Amps and above, this option provides door gasketing, inlet and outlet filters, and an enclosure fan for forced air flow. Positive ventilation is provided to restrict the ingress of airborne particulate due to air leakage. The enclosure fan is energized when AC power is applied to the controller.
W1	**Dynamic Braking** This option provides additional braking power for regenerative loads. If an attempt is made to decelerate the motor faster than the internal losses can absorb the regenerative energy, a Dc overvoltage condition will occur. The dynamic braking modification causes a resistor bank to be switched onto the Dc link as required to absorb the regenerative energy. This allows the fastest controlled deceleration and/or motor stop. The dynamic braking electronics are mounted separately. The resistor bank is located external to the controller and is to be separately mounted.
T5	**Input Power Isolation Transformer** Accutrols are capable of operation on a properly rated Ac line without use of an isolation transformer. In some circumstances, the use of an isolation transformer or Ac line reactor is recommended. Isolation transformers are **optional**, available in a NEMA 1 enclosure for separate mounting. 5% FCBN and FCAN taps are included. The transformer impedance should be 2.5% to 6%.

NEMA 12 Model	Max. Short Circuit Amps	NEMA 1 Model	Max. Short Circuit Amps
A4008	12.5kA	..	..
A4011	12.5kA	..	..
A4014	12.5kA	..	..
A4021	12.5kA	A4021	12.5kA
A4027	12.5kA	A4027	12.5kA
A4034	12.5kA	A4034	12.5kA
A4040	12.5kA	A4040	12.5kA
A4052	12.5kA	A4052	12.5kA
A4065	12.5kA	A4065	12.5kA
A4077	12.5kA	A4077	12.5kA
..	..	A4096	14kA
..	..	A4124	75kA①
..	..	A4156	112kA①
..	..	A180	112kA●

① Should not exceed interrupting capacity of input circuit breaker, either factory mounted or supplied separately.

Isolation transformers are REQUIRED:
- When the ac line voltage does not match the input voltage requirement of the controller.
- If the added reliability of operating with one accidental ground on the system is required.
- If required by local codes or the customer specifications.

Line reactors or isolation transformers are REQUIRED:
- If the ac line voltage unbalance is greater than 2%.

$$\text{Line Voltage Unbalanced} = \frac{\text{highest voltage} - \text{lowest voltage}}{\text{nominal voltage}} \times 100$$

- If the system short circuit capacity (current) available at the input terminals of the controller is larger than the allowed levels listed above. This will cause higher than rated line currents to be drawn from the input line and can cause fuse blowing or equipment failure.

Line reactors **or** isolation transformers are RECOMMENDED:
- To reduce or alleviate possibilities of electrical interference.
- If more than one solid state motor drive (ac, dc, wound rotor, etc.) is operated from the same power supply.
- For maximum controller protection from high voltage transients and short circuit currents in the ac line.

Input isolation transformers have a 460V, 60 Hz primary and a 460V secondary. Specify catalog number **M1004XXXA** where XXX is the current rating. For 575V primary, specify **M1004XXXB** and for 208V primary, specify **M1004XXXC**.

Adjustable Frequency Controllers
(480 Volt 5 HP to 250 HP VT)
(480 Volt 3 HP to 200 HP CT)

1.0 Scope

1.1 This section describes the Adjustable Frequency Controllers (AFC's) to be used in conjunction with the Driven equipment as described in this section and as detailed on the applicable drawings.

1.2 The controllers with all options shall be UL listed as a complete assembly and shall be built in compliance with the latest standards of ANSI, IEEE, NEMA and the National Electrical Code.

2.0 Construction

2.1 The AFC shall be of the Pulse Width Modulated design converting the fixed utility voltage and frequency to a variable voltage and frequency output via a two step operation. AFC's utilizing a third power section are not acceptable. Efficiency shall exceed 96% at 100% speed and load. Line side displacement power factor shall exceed (0.95) regardless of speed and load. The AFC shall be rated for 110% current for one minute for variable torque loads and 150% current for one minute for constant torque loads.

2.2 The AFC shall be housed in a NEMA 1 metal enclosure.

2.3 Standard operating conditions shall be:
a) Incoming three phase 480 volt ac power, plus 5% or minus 10%, 50 or 60 hz.
b) Humidity 0 to 95% (noncondensing and noncorrosive).
c) Altitude 0 to 3,300 feet above sea level.
d) Ambient temperature 0 to 40 degrees C.

2.4 AFC's shall include the following system interfaces:
a) Speed reference interface with a differential amplifier input 0-10 volts dc or 4-20 ma dc signal.
b) Run relay with an isolated set of form C contacts.
c) Programmable contacts (form C-selectable)
d) Trip contacts (form C)
e) AFC will accept an external trip contact and indicate this on the display.
f) Dedicated terminal blocks for interface with maintained remote start contact contacts.
g) Output signal proportional to output frequency (0-10 Vdc or 4-20mAdc)
h) Output signal proportional to output current (0-10Vdc or 4-20mAdc)

2.5 The AFC shall include the following protective features:
a) Input fuses rated for 200,000 Amps AC
b) Electronic instantaneous overcurrent protection
c) Dc bus undervoltage protection
d) DC bus overvoltage protection
e) Ability to withstand output line-to-line short circuits without component failure
f) Status indication via an eight character LED display of the following protective functions: DC Bus undervoltage, Overcurrent, DC Bus Overvoltage, Controller Overtemperature, Overload, Overload Warning, Overfrequency & Phase Loss. A single light to indicate an AFC trip is not acceptable.
g) Overload capability shall be 110% of the inverter rating for one minute.
h) Line reactors for units 25 hp and larger.
i) Selectable auto restart.
j) AFC will catch a motor spinning in the forward or reverse direction upon starting.
k) Upon loss of the input signal (4-20mA) the drive will stop, or go to preset speed.

2.6 Standard adjustments shall include:
a) Minimum frequency (4-60 hz)
b) Maximum frequency (40-120 hz)
c) Four preset speeds (4-120 hz) initiated by contact closures.
d) Four acceleration times (2-300 seconds)
e) Four deceleration times (2-300 seconds)
f) Minimum speed dwell time (0-18 seconds)
g) Voltage boost (0-40 volts) for starting torque control
h) V/Hz linear or reduced for motor noise reduction.
i) Carrier frequency 700-1300 Hz for motor noise reduction.
j) Current limit (70-120%)
k) Critical Frequency avoidance (3 bands with 10 Hz adjustable widths)

2.7 Door Mounted Operator Controls and status indication from the 8 character LED display shall include:
a) Run/stop selection and LED indication (keypad or remote)
b) Speed control selection and LED indication
c) Forward/Reverse selection
d) Manual speed adjustment
e) Frequency meter
f) Motor RPM
g) Ammeter
h) Output Voltage
i) Elapsed time meter

2.8 The keypad shall have an eight character LED display. The reverse button and the programming functions may be locked out if desired.

2.9 Testing
a) All printed circuit boards shall be burned in elevated temperature for at least 24 hours.
b) The completed controller will be tested for 12 hours at full load.

3.0 Service

3.1 The AFC manufacturer shall provide to the owner a startup service package for all AFC's provided. Service shall include inspection, final adjustment, operational checks, and a final report for record purposes. The service package shall include a one year parts warranty from date of startup (not to exceed 18 months from date of shipment) and 90 days of labor from date of startup and be performed by local factory trained service engineers. The service center must be permanently located within 200 miles of the job site.

4.0 Acceptable Manufacturers

4.1 Adjustable Frequency Controllers are specified on the basis of Westinghouse Series 400 product line for function and quality. Products which are in compliance with the specification and manufactured by others with ten years of experience manufacturing AFC's will be considered only if pre-approved by the engineer ten days prior to bid date.

5.0 Optional Features

**(Note to spec writer) The following is a partial list of options which are available for the Series 400 product line. Please select the appropriate options for your application.

5.1 Input disconnect breaker required in some electrical codes.

5.2 Output contactor to provide electrical output isolation when the AFC is not running.

5.3 Motor overcurrent relay (heaters provided and installed by the electrical contractor).

5.4 Contactor bypass which includes an output contactor electrically and mechanically interlocked with a bypass contactor, run relay including control logic, status lights and a motor overcurrent relay. (Heaters provided and installed by the electrical contractor.) The complete bypass system and Inverter-Off-Bypass selector switch shall be packaged in the AFC's enclosure.

5.5 Automatic contactor bypass which will transfer the motor to full speed across the line operation in the event of an AFC trip. This option includes an output contactor electrically and mechanically interlocked with a bypass contactor, run relay including control logic, status lights and a motor overcurrent relay. (Heaters provided and installed by the electrical contractor.) The complete bypass system and Inverter-Off-Bypass selector switch shall be packaged in the AFC's enclosure.

5.6 External mechanical bypass featuring a separately mounted no load break switch which will be used in conjunction with an existing starter.

5.7 3-15 psig follower for applications with pneumatic control systems.

5.8 Electronic potentiometer to allow AFC to follow discrete increase speed and decrease speed contact closures from a photohelic or similar device.

5.9 NEMA 12 enclosure for 3-60hp Variable Torque 3-50hp constant torque.

5.10 120 V control input interface.

5.11 Isolation transformer or Line reactor.

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