



# PC10

## *Mini Vector AC Drive*



## *Specification Guide*



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## **PC10 Specification**

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## **Guide-Form Specification**

### **1.0 General**

#### **1.1 Purpose**

This specification shall establish the minimum requirements for adjustable frequency drive equipment. Drives that do not meet these requirements shall not be acceptable. The adjustable frequency drive equipment shall be the PC10 as furnished by Safronics, Inc..

#### **1.2 Driven Equipment**

The Drive shall be capable of operating a NEMA design B squirrel cage induction motor with a full load current equal to or less than the continuous output range of the Drive. At base speed (60 hertz) and below, the Drive shall operate in constant volts per hertz mode. Above base speed (60 hertz), the Drive may selectively operate in either a constant volt per hertz mode or a constant voltage extended frequency mode.

#### **1.3 Drive Construction**

The adjustable frequency Drive shall be a sinusoidal PWM type Drive with sensor-less Dynamic Torque Vector Control capability. The Drive shall be provided in a IP20 or NEMA 1 enclosure at all ratings. The Drive shall be of modular construction for ease of access to control and power wiring, and maintenance. It shall consist of the following general components:

- 1.3.1 Full wave diode rectifier to convert supply AC to a fixed DC voltage.
- 1.3.2 DC link capacitors
- 1.3.3 Insulated Gate Bipolar Transistor (IGBT) power section, with soft-switching technology.
- 1.3.4 The Drive shall be microprocessor based with an LED display to monitor operating conditions. The Drive display section shall allow for local operation and setting of Drive function codes and display fault indication and reasons associated with the fault. The LED display shall offer five (5) different display.
- 1.3.5 Separate control and power terminal boards, with option plug shall be provided by the drive to allow for remote operation.
- 1.3.6 The Drive shall have an RS485 port as a standard and options for communicating with recognized industry standard device level networks such as DeviceNet, Interbus-S, Profibus, Modbus Plus.

## 2.0 **Operating Conditions**

- 2.1 The Drive's operating ambient temperature range shall be -10°C to 50°C. Storage temperatures shall be between -25°C to 65°C.
- 2.2 The relative humidity range shall be 5-95% non-condensing.
- 2.3 The Drive shall be suitable for operation at altitudes up to 3300 feet without de-rating.
- 2.4 The Drive shall meet IEC 61200-2 for vibration levels.
- 2.5 The Drive shall be capable of side-by-side insulation with zero clearance at 30 HP and below.

## 3.0 **Standards**

- 3.1 The Drive shall be cUL and UL listed and not require external fuses. The Drive shall also be CE labeled and comply with standards EN 61800-3 for EMC compliance and EN 61800-2 for low voltage compliance.
- 3.2 The Drive shall be designed in accordance with applicable portions of NEMA standards.
- 3.3 The Drive shall be compatible with the installation requirements of interpretive codes such as National Electric Code (NEC) and Occupational Safety & Health Act (OSHA).
- 3.4 The Drive with optional filters shall be capable of operating in compliance with IEEE 519-1992.

## 4.0 **Input Power**

- 4.1 The Drive design shall be such that it will be available for use either with 200-230 or 380-480 VAC, 3-phase power input.
- 4.2 The Drive shall be able to withstand voltage variations of -15% to +10% and imbalance no greater than 2% without tripping or affecting Drive performance.
- 4.3 System frequency shall be 50 or 60 Hertz with a maximum frequency variation of  $\pm 5\%$ .
- 4.4 The displacement power factor of the Drive shall be 0.95 lagging or higher with the use of a DC reactor. (Note: Displacement power factor is not the same as the actual power factor.)
- 4.5 Drive efficiency at rated load shall be 96% or higher depending on Drive's operating carrier frequency and rating.
- 4.6 Line notching, transients, and harmonics on the incoming line shall not affect Drive performance.
- 4.7 The Drive shall have provisions to add a DC Link Inductor, if required by the installation, but not for the Drive's operation (less than 10 Hp).

## 5.0 **Output Power**

- 5.1 The Drive shall be capable of horsepower ratings through 10 HP (constant torque) and output frequencies up to 400 Hertz. It shall also have an energy saver feature with the capability of selecting a V/Hz automatic control function that will modify the V/Hz curve based on light load characteristics that will minimize power consumption.
- 5.2 Drive output voltage shall vary with frequency to maintain a constant volts/hertz ratio up to base speed (60 hertz) output. Constant or linear voltage output shall be supplied at frequencies greater than base speed (60 hertz).
- 5.3 Rated output voltage shall be programmable for motor ratings from 180 to 240 volts, or from 320 to 480 volts.
- 5.4 The Drive shall be capable of a minimum of 100% rated current in continuous operation, in accordance with the requirements of NEC Table 430-150.
- 5.5 The Drive one minute overload current rating shall be 150% of rated current, 200% (1/8 to 10 HP) for 0.5 seconds.

## 6.0 **Drive Features**

- 6.1 The Drive shall have four digital LED readouts providing display of: Output Current, Output Voltage, Output frequency, Frequency reference, Line speed (calibration adjustable from 0 to 200% of frequency, with 0.01% resolution).
- 6.2 The Drive shall be capable of remote mounting with simple connection to the keypad or via an RS485 serial port.
- 6.3 Unless the application requires it, the Drive shall operate as an open-loop control system requiring no feedback devices.
- 6.4 The Drive shall accept and follow a selectable external frequency reference of either analog 0-5 VDC,  $0\pm 10$  VDC, 4 - 20mA with signal inversion.
- 6.5 The Drive shall maintain the output frequency to within 0.2% of reference when the reference is analog, and to within .01% of reference when the reference is digital (Speed level inputs from keypad, contact closure or digital interface).
- 6.6 The Drive shall maintain set frequency regardless of load fluctuations.
- 6.7 The Drive shall be capable of at least 2 different acceleration rates and 2 different deceleration rates. Each acceleration and deceleration rate shall be independently adjustable from 0.01 to 3600 seconds.
- 6.8 The Drive will have a starting torque of 200% at 0.5 Hz for 1/8 HP to 10 HP when the Dynamic Torque Vector Control function is activated.

- 6.9 The Drive will have the capability of determining motor characteristics to optimize its operation through the use of pre-programmed motor data information or self-tuning operation where the Drive can determine the motor characteristics initially.
- 6.10 The Drive shall allow the user to select whether the shaft does or does not move during auto-tune.
- 6.11 The Drive Auto-tune will include an online mode that automatically and dynamically compensates the drive's regulator for changes in motor temperature.
- 6.12 The Drive shall offer three selectable acceleration/deceleration patterns: linear, S-curve, and non-linear for variable torque loads.
- 6.13 The drive shall have selectable torque (voltage) boost settings that will enable smooth acceleration of high inertia or high static friction type loads during starting. One level will allow for automatic calibration that will compensate for the ac motor's primary resistance (IR compensation); one level is to be set for variable torque loads; one level is to be for proportional torque loads where torque is directly related to set speed, or for constant torque loads. A second Torque Boost function setting is to be available for a 2<sup>nd</sup> motor with different characteristics and/or set of operating requirements.
- 6.14 The Drive shall have a selectable Automatic Torque Boost function that will adjust motor torque based on the operating load conditions.
- 6.15 All Drive Operating Function Codes shall be stored in non-volatile memory (EEPROM). Potentiometer adjustments are not required nor allowed. The Drive will have a default set of Function Code settings.
- 6.16 The Drive shall have adjustable switching frequency settings ranging from 0.75 kHz to 15 kHz to limit and adjust the level of audible motor noise.  
Range: Up to 10 HP                      0.75-15 kHz
- 6.17 The Drive shall be able to operate with its output disconnected for troubleshooting and startup.
- 6.18 The Drive shall have a reference filter that eliminates the effects of noise that may be present in the analog signals.
- 6.19 The Drive shall have a selectable function to prevent reverse operation of the drive.
- 6.20 The Drive shall be able to reset itself up to ten (10) times (adjustable with adjustable intervals of 2-20 seconds) after over-current, over-voltage, overheating, and overload faults.
- 6.21 The Drive shall be able to operate after a voltage dip below 175 VAC on 230 VAC input power and 310 VAC on 460 VAC input power for 15 milliseconds at 85% full load current without any disturbances in output power delivered to the load. If power exceeds this level, six (6) different modes or active and inactive restart modes will be available. The decrease in motor speed will be adjustable in the event of a momentary power outage.

- 6.22 The Drive shall have a programmable start frequency, adjustable from 0.1 to 60 hertz, with a 1 hertz resolution (refer to 7.9), with a holding time adjustable from 0.1 to 10 seconds.
- 6.23 The Drive shall have the ability to operate in a sensor-less, dynamically controlled torque vector mode for applications that require improved motor speed control and operating characteristics.
- 6.24 The Drive shall have IGBT soft switching and a low noise control power supply system to reduce the noise from the drive.

## 7.0 Drive Speed Control

- 7.1 Drive base shall be programmable from 25 to 400 hertz, and maximum frequency shall be programmable from 50 to 400 hertz, both with 1 hertz resolution.
- 7.2 The Drive shall have both low frequency limit and high frequency limit functions. Each will be programmable from 0-400Hz of maximum frequency, with 1Hz resolution.
- 7.3 The Drive shall have a frequency bias (starting frequency) function programmable from -400-400 Hz of maximum frequency, with 0.1 Hz resolution.
- 7.4 Drive frequency gain shall be programmable from 0-200%, with 0.1% resolution.
- 7.5 The Drive shall be capable of at least fifteen (15) independently programmable preset frequencies, adjustable from 0.00 to 400.00 hertz.
- 7.6 The Drive shall be capable of starting into a rotating load (forward or reverse) and shall smoothly accelerate or decelerate to the set point without experiencing component damage.
- 7.7 The Drive shall be capable of motor slowdown or stop by selectable regenerative (to the DC link) dynamic braking while following one of the two selectable deceleration ramps, and control the braking torque by setting it's value from 0, 20 to 200%, 999 (no limit) of Drive rating. It will also be capable of changing the rate of deceleration automatically by stopping the braking action long enough to avoid Drive over-voltage trip.
- 7.8 The Drive shall be capable of stopping by selectable DC injection braking. It shall be adjustable from 0 to 100% braking level and have a programmable starting frequency for DC braking (0.2-60 hertz) and programmable braking time (0.1 to 30.0 seconds).
- 7.9 The Drive shall have a start Frequency Setting that incorporates a Holding Time at the Frequency Setting, adjustable up to 10 seconds in duration.
- 7.10 The Drive shall provide at least three selectable skip frequencies with programmable band widths, adjustable 0 to 30 Hz , which will not allow operation at or near mechanical resonance speeds.
- 7.11 The Drive shall provide selectable slip compensation, which will sense output current and adjust output frequency, to improve motor speed fluctuations. This will allow approximately 1% or less (depending in the slip value selected) speed regulation without the use of a speed feedback device. This function is to be adjustable over a range of 0 to 15.00 Hz.

- 7.12** The Drive shall have Droop operation, balancing drooping characteristics to speed and load variations. This function shall be adjustable from –9.9 to 0.0 Hz.
- 7.13** The Drive shall be constructed to support external signals, whether variable reference or discrete inputs, from distances up to 66 feet when proper cable is used.
- 7.14** Required Drive performance criteria includes:
- |                          |  |
|--------------------------|--|
| Frequency Control Range: | 0.1 to 400 Hertz   |
| Frequency Stability:     | Digital reference: $\pm 0.01$ % of maximum frequency<br>Analog reference: $\pm 0.2$ % of maximum frequency   |
| Frequency Resolution:    | Digital reference: 0.01 Hz at max. frequency up to 99.99 Hz<br>0.1 Hz at max frequency 100 Hz and above<br>Analog reference: 1/3000 at max frequency |

## **8.0 Drive Control & Options**

- 8.1** The Drive shall accept inputs from external dry contacts for the following functions:
- 8.1.1 Run forward command
  - 8.1.2 Run reverse command
  - 8.1.3 Multi-step frequency selection
  - 8.1.4 Acceleration/Deceleration time selection
  - 8.1.5 Stop command
  - 8.1.6 Coast to stop command
  - 8.1.7 Alarm reset
  - 8.1.8 Trip command (external fault)
  - 8.1.9 Jogging operation
  - 8.1.10 Frequency setting 2 and Frequency setting 1
  - 8.1.11 Motor 2 and Motor 1 setting
  - 8.1.12 DC brake command
  - 8.1.13 Torque limiter 2 and Torque limiter 1
  - 8.1.14 Switching operation between line and inverter (50 and 60 Hz)
  - 8.1.15 Speed Increase command
  - 8.1.16 Speed Decrease command
  - 8.1.17 PID control cancel
  - 8.1.18 Inverse mode changeover
  - 8.1.19 Link enable
  - 8.1.20 Pick up start mode
  - 8.1.21 Forced stop command
  - 8.1.22 Forced stop command with Deceleration time
  - 8.1.23 Pre-excitation command
- 8.2** The Drive shall be capable of selectable external start/stop control, either 2-wire or 3-wire type.

- 8.3** The frequency reference shall be from, selectively, an external speed potentiometer, external analog signals (0-5 VDC, 0±10 VDC, 4 to 20mA with signal inversion), from the built in keypad, or from bus communication.
- 8.4** The Drive shall provide an adjustable (to a maximum of 0-200% / 10.3 VDC) analog output or a frequency pulse output. The analog output shall be selectively proportional to either output frequency (before or after slip compensation), output current, output voltage, output torque, load factor, input power, PID feedback value, DC link voltage. The frequency pulse output shall be suitable for both an analog meter indication as well as digital frequency indication.
- 8.5** The Drive shall provide selectable outputs indicating the following:
- 8.5.1 Four (4) Programmable digital open collector outputs and a dry contact output for:
- 8.5.1.1 Inverter running
  - 8.5.1.2 Frequency equivalence signal
  - 8.5.1.3 Frequency level detection
  - 8.5.1.4 Torque polarity
  - 8.5.1.5 Torque limiting
  - 8.5.1.6 Auto-restarting
  - 8.5.1.7 Overload early warning
  - 8.5.1.8 Inverter stopping
  - 8.5.1.9 Ready input
  - 8.5.1.10 Motor 2 / Motor 1
  - 8.5.1.11 Auto resetting
  - 8.5.1.12 Second frequency level detection
  - 8.5.1.13 Second overload early warning
- 8.5.2 Transistor output (Y1 to Y2) are either sink or source operation.
- 8.6** The Drive shall be compatible with DeviceNet, Interbus-S, Profibus, and Modbus Plus by an option card and allow for communication interface either directly or via third party interface boards.

## **9.0 Drive Protective and Diagnostic Features**

- 9.1** When a fault occurs, the Drive shall have a controlled shut down sequence. The reason for the fault condition shall be enunciated on the LED display. The Drive shall monitor, sense, and display the following fault conditions:
- 9.1.1 Over-current during acceleration
  - 9.1.2 Over-current during deceleration
  - 9.1.3 Over-current during constant speed operation
  - 9.1.4 Ground fault
  - 9.1.5 Input phase loss
  - 9.1.6 Over-voltage during acceleration
  - 9.1.7 Over-voltage during deceleration
  - 9.1.8 Over-voltage during constant speed operation
  - 9.1.9 Under-voltage

- 9.1.10 Overheating of heatsink
  - 9.1.11 External thermal relay
  - 9.1.12 Over-temperature of internal air
  - 9.1.13 Overheating at Dynamic Braking circuit
  - 9.1.14 Motor 1 overload
  - 9.1.15 Motor 2 overload
  - 9.1.16 Inverter unit overload
  - 9.1.17 Memory Error
  - 9.1.18 Keypad panel communication error
  - 9.1.19 CPU error
  - 9.1.20 Option error (quantity 2)
  - 9.1.21 Operational procedure error
  - 9.1.22 Output wiring error / Impedance imbalance
- 9.2** The Drive shall have a selectable Torque Limiting function for both motoring and braking that will sense an overload condition and will reduce frequency and current temporarily until the load reaches acceptable levels. If the overload condition is not settled in the proper amount of time, the Drive will trip on overload. The Torque Limiting shall be programmable from 20-200% of Drive rated motor torque (10 HP and below), with 1% resolution.
- 9.3** The Drive shall have a selectable electronic inverse time thermal overload function as required by NEC and UL Standard 991 for an AC Induction Motor (Refer to applicable codes for specific installation requirements). The overload shall be programmable from 20 - 135% of Drive rated current.
- 9.4** The Drive shall have an over-voltage protection function that operates if supply voltage rises above rated value or by motor's regeneration.
- 9.5** The Drive shall treat short circuits in either the output load or the output module as an over-current.
- 9.6** If the Drive heat sink temperature exceeds approximately 100°C, the Drive will shut down on over temperature fault.
- 9.7** The Drive shall provide output ground fault protection.
- 9.8** The Drive shall provide LED indication of DC bus voltage, which, when lit, will signify to maintenance people the presence of potentially dangerous voltage.

## **10.0 Quality Assurance**

- 10.1** All Drives shall be 100% factory tested to ensure proper performance upon delivery.
- 10.2** The Drive vendor shall provide a warranty for material and workmanship, for a period of 12 months after start up or 18 months after shipment, whichever occurs first.

**11.0 Start-Up Service and Training**

Drive operational and maintenance training and/or startup service shall be offered by the Drive vendor separately. The Drive vendor shall have factory trained personnel at field locations convenient to the installation site, available for trouble shooting and/or startup assistance.

**12.0 Documentation**

An instruction manual, complete with wiring diagrams, schematics, operating, and maintenance instructions, shall be provided with the Drive at the time of shipment.

**13.0 Spare Parts**

Spare parts shall be available locally through local stocking distributors.