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*ABB Inc.*

*Effective January 1, 2022*

*ACH580-PNPT05U-EN REV B*

*Long Form Sample Specification for
Ultra Low Harmonic*

*Variable Frequency Drives*

*For HVAC Applications*

To remove formatting restrictions use password: ABBHVAC - not recommended

Example styles in this document per CSI Master/Section/Page specifications. Sub paragraphs levels 5 and 6 are added to compensate for all 9 multi-list level styles in Microsoft Word

1. Part
	1. Part | Article
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Master Specification Note: This guide specification is written according to the Construction Specifications Institute (CSI) Format. The section must be carefully reviewed and edited by the Architect or Engineer to meet the requirements of the project. Coordinate this section with drive schedule, other specification sections and the drawings.

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HEATING, VENTILATING & AIR CONDITIONING [23 ## ##]

VARIABLE FREQUENCY DRIVES

1. GENERAL
	1. DESCRIPTION
		1. This specification is to cover a complete Variable Frequency Drive (VFD) consisting of a pulse width modulated (PWM) inverter designed for use with induction (asynchronous) motors, permanent magnet motors, Synchronous reluctance motor (SynRM) and permanent magnet-assisted synchronous reluctance motor (PMa-SynRM/EC Titanium).
		2. The drive manufacturer shall supply the drive and all necessary options as specified. All drives installed on this project shall be from the same manufacturer and have a common user interface (control panel). The manufacturer shall have been engaged in the production of drives for a minimum of 30 years, and active front end drives for a minimum of 20 years. Drives that are manufactured by a third party and “brand labeled” shall not be acceptable. Drive manufacturers who do not build their own power boards and assemblies, or do not have full control of the power board manufacturing and quality control, shall be considered as a “brand labeled” drive.
		3. This specification is intended to supplement a drive schedule. The drive schedule identifies the optimized BOM for the project and includes quantity, size, voltage, enclosure rating, options, and harmonic mitigation requirements of the drives. IEEE 519-2014 is an electrical system standard for harmonic mitigation and not intended to be applied to an individual piece of equipment. The EOR (Engineer of Record) has determined all drives provided on this project shall be active front end drives, thus confirming that the drives will not take the electrical system out of IEEE 519-2014 compliance.
	2. QUALITY ASSURANCE
		1. Referenced Standards and Guidelines:
			1. Institute of Electrical and Electronic Engineers (IEEE)
				1. IEEE 519-2014, IEEE Recommended Practice and Requirements for Harmonic Control in Electric Power Systems
			2. Underwriters Laboratories (as appropriate)
				1. UL 508A
				2. UL 61800-5-1
			3. National Electric Code (NEC)
				1. NEC 430.120, Adjustable-Speed Drive Systems
			4. CSA Group
				1. CSA C22.2 No. 274
			5. International Building Code (IBC)
				1. IBC 2018 Seismic – referencing ASCE 7-16 and ICC AC-156
		2. Qualifications:
			1. Drives shall be UL labeled as a complete assembly. The base VFD shall be UL listed for 100 kA SCCR when installed in accordance with the manufacturer’s guidelines.
			2. CE Mark – The base drive shall conform to the European Union Electromagnetic Compatibility directive, a requirement for CE marking. The base drive shall meet product standard EN 61800-3 for the First Environment restricted distribution (Category C2). Base drives that only meet the Second Environment (Category C3, C4) shall be supplied with filters to bring the base drive into compliance with the First Environment levels.
			3. The base drive shall be seismically certified and labeled as such in accordance with the 2018 International Building Code (IBC):
				1. Seismic importance factor of 1.5, and minimum 2.5 SDS rating is required.
				2. Ratings shall be based upon actual shake test data as defined by ICC AC-156, via all three axis of motion.
				3. Seismic certification of equipment and components shall be provided by HCAI (formerly OSHPD) preapproval.
			4. The base drive shall be SEMI-F47 certified. The drive must tolerate voltage sags to 50% for up to 0.2 seconds, sags to 70% for up to 0.5 seconds, and sags to 80% for up to one second.
			5. Acceptable Manufacturers
				1. ABB ACH Series.
				2. Alternate manufacturer’s requests shall be submitted in writing to the Engineer for approval at least 20 working days prior to bid. Approval does not relieve the supplier of specification requirements.
	3. SUBMITTALS
		1. Submittals shall include the following information:
			1. Outline dimensions, conduit entry locations and weights.
			2. Electrical diagrams must be drive package specific and generic drawings are not allowed. Hand marked or manually modified diagrams are not acceptable
			3. HCAI (formerly OSHPD) preapproval, seismic certification, and installation requirements where applicable.
			4. Complete technical product description with complete list of options provided. Any portions of this specification not met must be clearly indicated or the supplier and contractor shall be liable to provide all additional components required to meet this specification.
			5. Building Information Modeling (BIM) objects shall be available online.
2. PRODUCTS
	1. VARIABLE FREQUENCY DRIVES
		1. The drive package as specified herein and defined on the drive schedule shall be enclosed in a UL Type enclosure (enclosures with only NEMA ratings are not acceptable), completely assembled and tested by the manufacturer to ISO9001 standards.
		2. The drive shall provide full rated output from a line of +10% to -15% of nominal voltage. The drive shall continue to operate without faulting from a line of +30% to -35% of nominal voltage.
			1. Drives shall be capable of continuous full load operation under the following environmental operating conditions:
				1. Ambient temperature -15 to 40° C (5 to 104° F).
				2. Altitude 0 to 1000 m (0 to 3,300 ft) above sea level.
				3. Humidity 5 to 95%, non-condensing.
		3. All drives shall utilize the same Advanced Control Panel (keypad) user interface.
			1. Plain English text
				1. The display shall be in complete English words for programming and fault diagnostics (alpha-numeric codes are not acceptable).
				2. Safety interlock and run permissive status shall be displayed using predetermined application specific nomenclature, such as: Damper end switch, smoke alarm, vibration trip, and overpressure.
				3. Safety interlock, run permissive, and external fault status shall have the option of additional customized project specific terms, such as: AHU-1 End Switch, Office Smoke Alarm, CT-2 Vibration.
			2. The control panel shall include at minimum the followings controls:
				1. Four navigation keys (Up, Down, Left, Right) and two soft keys to simplify operation and programming.
				2. Hand-Off-Auto selections and manual speed control without having to navigate to a parameter.
				3. Fault Reset and Help keys. The Help key shall include assistance for programming and troubleshooting.
			3. Multiple Home View screens shall be capable of displaying up to 21 points of information. Customizable modules shall include bar charts, graphs, meters, and data lists. Displays shall provide real time graphical trending of output power, frequency, and current within selectable intervals of 15/30/60 minutes and 24 hours.
			4. The control panel shall display the following items on a single screen; output frequency, output current, reference signal, drive name, time, and operating mode (Hand vs Auto, Run vs Stop). Bi-color (red/green) status LED shall be included. Drive (equipment) name shall be customizable.
			5. There shall be a built-in time clock in the control panel. The clock shall have a battery backup with 10 years minimum life span. Daylight savings time shall be selectable.
			6. I/O Summary display with a single screen shall indicate and provide:
				1. The status/values of all analog inputs, analog outputs, digital inputs, and relay outputs. Drives that require access to internal or live components to measure these values, are not acceptable.
				2. The programmed function of all analog inputs, analog outputs, digital inputs, and relay outputs.
				3. The ability to force individual digital I/O high or low and individual analog I/O to desired value, for increased personal protection during drive commissioning and troubleshooting. Drives that require access to internal or live components to perform these functions, are not acceptable.
			7. The drive shall automatically backup parameters to the control panel. In addition to the automatic backup, the drive shall allow two additional unique backup parameter sets to be stored. Backup files shall include a time and date stamp. In the event of a drive failure, the control panel of the original drive can be installed on the replacement drive, and parameters from that control panel can be downloaded into the replacement drive.
			8. The control panel shall display local technical support contact information as part of drive fault status.
			9. The control panel shall be removable, capable of remote mounting.
			10. The control panel shall have the ability to store screen shots, which are downloadable via USB.
			11. The drive shall generate a QR code, which contains drive identification data, information on the latest events, and values of status and counter parameters.
			12. The LCD screen shall be backlit with the ability to adjust the screen brightness and contrast, with inverted contrast mode. A user-selectable timer shall dim the display and save power when not in use.
			13. The control panel shall include assistants specifically designed to facilitate start-up. Assistants shall include: First Start Assistant, Basic Operation, Basic Control, and PID Assistant.
			14. Primary settings for HVAC shall provide quick set-up without the use of alpha-numerical parameters, for commissioning the drive and customer interfaces to reduce programming time.
			15. The drive shall be able to operate with the control panel removed.
			16. The drive shall be able to support a Bluetooth Advanced Control Panel. The Bluetooth control panel shall be FCC and QDL (Qualified Design Listing) certified.
				1. A free app (iOS and Android) shall replicate the control panel on a mobile device or tablet. The control panel’s programming and control functionality shall function on the device. Customizing text, such as AHU-1 End Switch, shall be supported by the device’s keyboard.
				2. Bluetooth connectivity shall allow uploading, downloading, and emailing of parameter sets.
				3. Bluetooth connectivity shall include two pairing modes: Always discoverable with a fixed passcode, and manual discovery with a unique generated passcode every pairing.
				4. Bluetooth connectivity shall be capable of being switched off.
		4. All drives shall have the following hardware features/characteristics as standard:
			1. Two (2) programmable analog inputs shall accept current or voltage signals. Current or Voltage selection configured via control panel. Drives that require access to internal components to perform these functions, are not acceptable.
			2. Two (2) programmable analog outputs. At least one of the analog outputs shall be adjustable for current or voltage signal, configured via control panel. Drives that require access to internal components to perform these functions, are not acceptable.
			3. Six (6) programmable digital inputs. All digital inputs shall be programmable to support both active high and active low logic, and shall include adjustable on/off time delays. The digital input shall be capable of accepting both 24 VDC and 24 VAC.
			4. Three (3) programmable Form-C relay outputs. The relay outputs shall include programmable on/off time delays. The relays shall be rated for a continuous current rating of 2 Amps. Maximum switching voltage of 250 VAC / 30 VDC. Open collector and Form-A relays are not acceptable. Drives that have less than (3) Form-C relay outputs shall provide an option card to provide additional relay outputs.
			5. Drive terminal blocks shall be color coded for easy identification of function.
			6. The drive shall include an isolated USB port for interface between the drive and a laptop. A non-isolated USB port is not acceptable.
			7. An auxiliary power supply rated at 24 VDC, 250 mA shall be included.
			8. Harmonic mitigation hardware shall be provided to limit the current distortion to 3% total harmonic current distortion, when measured at the lugs of the drive. The harmonic mitigation hardware shall be internal to the drive package and include the following characteristics:
				1. An active front end (AFE) design, such as ultra-low harmonic (ULH) drives, IGBT based design, with an input LCL filter shall be used for mitigation of low and high frequency line current harmonics. Passive filter, 12-pulse, and 18-pulse solutions alone are not acceptable.
				2. The drive shall provide full motor nameplate voltage while operating the motor at nameplate RPM. The output IGBTs must be modulating and in control of the motor during this 100% speed/load operating condition. The specified 3% current distortion and 1.0 displacement power factor shall be achievable during this operating condition.
				3. The hardware structure of the front end shall be capable of boosting the DC bus voltage by 10% during low line conditions without the need to derate the drive. Active front end solutions without a boost feature are not acceptable.
				4. Displacement power factor shall be 1.0 throughout the speed range. The displacement power factor shall also be programmable to provide a specific leading or lagging power factor value, based on the system needs.
				5. The combined harmonic content of all the drives on the project must be small enough to not interfere with an emergency generator’s voltage regulator. Drives capable of regeneration shall not be allowed on applications with a generator.
				6. A reactive power reference parameter in the drive software shall be available to adjust the power factor by changing the kVAR leading or lagging for optimal electrical system performance.
				7. Active braking shall have the ability to regeneratively brake a motor to a stop, including catching a motor freewheeling in the reverse direction and regeneratively braking the motor to a stop before accelerating the motor in the correct direction.
				8. The AFE drive shall have an override function to allow for function during override mode when requested by the building automation or control system
			9. The drive shall have cooling fans that are designed for field replacement. The primary cooling fan shall operate only when required and be variable speed for increased longevity and lower noise levels. Drives whose primary cooling fans are not variable speed, shall include a spare cooling fan.
			10. The overload rating of the drive shall be 110% of its normal duty current rating for 1 minute every 10 minutes, 130% overload for 2 seconds every minute. The minimum current rating shall meet or exceed the values in the NEC/UL table 430.250 for 4-pole motors.
			11. The input current rating of the drive shall not be greater than the output current rating. Per NFPA 70 430.122, drives with higher input current ratings may require the upstream wiring, protection devices, and source transformers to be upsized.
			12. Circuit boards shall be coated per IEC 60721-3-3; Chemical gasses Class 3C2 and Solid particles Class 3S2.
			13. The drive shall have the ability to protect itself from incorrect power and motor cable connection (ie. input power cable is connected to drive motor connection) and a fault code shall annunciate the problem and provide corrective recommendation.
			14. Earth (ground) fault detection shall function in both modulating (running) and non-modulating modes.
			15. Coordinated AC transient surge protection system consisting of 4 MOVs (phase-to-phase and phase-to-ground), a capacitor clamp, and internal chokes. The MOVs shall comply with UL 1449 4th Edition. Drives that do not include coordinated AC transient surge protection shall include an external TVSS/SPD (Transient Voltage Surge Suppressor/Surge Protection Device).
			16. The drive shall include a robust DC bus to provide short term power-loss ride through. The DC bus Joule to drive kVA ratio shall be 4.5 J/kVA or higher. An inertia-based ride through function should help maintain the DC bus voltage during power loss events. Drives with control power ride through only, are not acceptable.
		5. All drives shall have the following software features as standard:
			1. A Fault Logger that stores the last 16 faults in non-volatile memory.
				1. The most recent 5 faults save at least 9 data points, including but not limited to: Time/date, frequency, DC bus voltage, motor current, DI status, temperature, and status words.
				2. The date and time of each fault and fault reset attempt shall be stored in the Fault Logger.
			2. An Event Logger that stores the last 16 warnings or events that occurred, in non-volatile memory.
				1. Events shall include, but not limited to: Warning messages, checksum mismatch, run permissive open, start interlock open, automatic reset of a fault, power applied, auto start command, auto stop command, modulating started, and modulating stopped.
				2. The date and time of each event’s start and completion points shall be stored in the Event Logger.
				3. The drive shall also provide the user the ability to configure what events to log for application specific requirements.
			3. Programmable start method. Start method shall be selectable based on the application and function even if the motor was freewheeling in the reverse direction: Flying-start, Normal-start, and Brake-on-start.
			4. Programmable loss-of-load (broken belt / coupling) indication. Indication shall be selectable as a control panel warning, relay output, or over network communications. This function to include a programmable time delay to eliminate false loss-of-load indications.
			5. The following three-phase AC motor technologies shall be compatible:
				1. Asynchronous induction motors
				2. Permanent magnet synchronous (non-salient pole) motor
				3. Synchronous reluctance motor (SynRM)
				4. Permanent magnet assisted synchronous reluctance motor (PMaSynRM)
			6. Motor heating function to prevent condensation build up in the motor. Motor heating adjustment, via parameter, shall be in “Watts.” Heating functions based only on “percent current” are not acceptable.
			7. Motor disconnect detection function enables the drive to detect when an output disconnect is opened, disable the drive output, and provide an indication message. Drives without this functionality shall have a disconnect switch auxiliary contact wired through dedicated conduit back to the drive enable control circuit.
			8. Motor phase order shall be changeable through software interface.
			9. Advanced power metering abilities shall be available in the embedded field bus in the drive. Drives without these data points, must include a separate power meter with each drive.
				1. Input Current (A)
				2. Input Voltage (V)
				3. Input Power (kW), also broken down by active, reactive, and apparent power components.
				4. Total power broken down by kWh, MWh, and GWh units of measurement. Power meters that only display kWh and roll over or “max out” once the maximum kWh value is reached, are not acceptable. There shall be resettable and non-resettable total power meters within the drive.
				5. Time based kWh metering for: current hour, previous hour, current day, and previous day.
				6. Energy saving calculation shall be included that shows the energy and dollars saved by the drive.
			10. The drive shall include a motor flux optimization circuit that will automatically reduce applied motor voltage to the motor to optimize energy consumption and reduce audible motor noise.
			11. DC bus voltage ripple function shall provide a DC voltage reference for troubleshooting AC line issues or bus capacitor health.
			12. Run permissive circuit - There shall be a run permissive circuit for damper or valve control. The drive shall provide a relay output to the damper actuator, monitor end-switch status, and start running the motor based on application requirements. Damper control shall include the following configurable features fully functional in both Hand and Auto modes:
				1. A timeout function that identifies and annunciates a specific warning message when a damper has not opened or closed within the allotted time.
				2. Ability to interface with both damper open and damper closed end-switches on a single damper actuator.
				3. Sequence control that runs the fan initially at a fixed speed before commanding a discharge air damper to open. Required for all applications feeding a common plenum/space to prevent the fan from freewheeling backwards while damper strokes open.
				4. Multiple damper sequence control to support units with discharge air and outside air dampers. The drive shall command and verify the outside air damper is open before ramping the fan to a fixed speed, and then commanding the outside air damper open.
				5. Time based damper control for when an end-switch is not provided. For units with outside air and discharge air dampers, both dampers should have independent time based control capability.
			13. Start interlock circuit - Four separate start interlock (safety) inputs shall be provided. When any safety is opened, the motor shall be commanded to stop. The control panel will display the specific safety(s) that are open. The status of each safety shall be transmitted over the network communications. Wiring multiple safeties in series is not acceptable.
			14. External fault circuit – Three separate external fault inputs shall be provided. This circuit shall have the same features and functionality as the start interlock circuit, except it shall require a manual reset before the drive is allowed to operate the motor.
			15. The drive shall provide automatic protections to allow uninterrupted operations at a reduced speed or switching frequency.
				1. Switching frequency control circuit, that reduces the switching frequency based on actual drive temperature and allows higher switching frequency settings without derating the drive. It shall be possible to set a minimum and a target switching frequency.
				2. The drive shall include a temperature limit that when exceeded will reduce the drive output current.
				3. Input phase loss protection shall be provided, whereas the output current is automatically derated by 50% if an input phase loss is detected by the drive.
			16. Visual function block adaptive programming allowing custom control schemes, minimizing the need for external controllers. I.e. cooling tower staging logic. A free software tool shall be used to configure adaptive programming.
			17. The ability to automatically restart after an over-current, over-voltage, under-voltage, external fault, or loss of input signal protective trip. The number of restart attempts, trial time, and time between attempts shall be programmable. Each of these faults may have automatic restart individually disabled via a parameter selection.
			18. Three (3) programmable critical frequency lockout ranges to prevent the drive from operating the load continuously at an unstable speed/load.
			19. The drive shall have three methods to control constant frequency/speed references:
				1. Seven (7) programmable preset frequencies/speeds using (3) inputs.
				2. Six (6) different programable preset frequencies/speed tied to 6 independent control inputs and requires an additional start command.
				3. Six (6) different programable preset frequencies/speed tied to 6 independent control inputs and does not require any additional start command input.
			20. Two independently adjustable accel and decel ramp sets with 1 – 1800 seconds adjustable time ramps.
			21. PID functionality shall be included in the drive.
				1. Programmable “Sleep” and “Wake up” functions to allow the drive to be started and stopped based on the level of a process feedback signal.
				2. The drive shall include an independent PID loop for customer use, assigned to an Analog Output. This PID loop may be used for cooling tower bypass valve control, chilled water valve, etc.
			22. At least 4 parameter user sets that can be saved to the permanent memory and recalled using a digital input, timed function, or supervision function.
			23. Drive shall be compatible with an accessory that allows the control board to be powered from an external 24 VDC/VAC source, allowing the drive control to remain powered by a UPS during an extended power outage.
			24. A computer-based software tool shall be available to allow a laptop to program the drive. The drive shall be able to support programming without the need for line voltage. All necessary power shall be sourced via the laptop USB port.
			25. The drive shall include a fireman’s override mode. Upon receipt of a contact closure from the Fire Alarm Life Safety system, the drive shall operate in a dedicated Override mode distinct and separate from the drive’s Normal operation mode. The following features will be available in the drive override function:
				1. The Override mode shall be secured by passcode to prevent changes once programmed.
				2. The drive shall ignore external inputs and commands not defined as part of the override function.
				3. Override operation mode shall be selectable between: single frequency, multiple fixed frequencies, follow an analog input signal, PID control, or come to a forced stop.
				4. High priority safeties shall stop the drive and lower priority safeties shall be ignored in Override mode.
				5. Drive faults shall be defined in Critical and Low priority groups. Critical faults shall stop the drive. Low priority faults shall be reset. Reset trials and timing shall be programmable.
				6. The drive shall be configurable to receive from 1 to 3 discrete digital input signals and operate at up to three discrete speeds.
			26. The drive shall have multi-pump functionality and an intelligent floating leader/follower configuration, so no one drive takes down the system, for controlling up to 8 parallel pumps equipped with drives. The drive shall have a parameter synchronization feature to program the PID, multi-pump, and AI parameters in all parallel drives. The functionality to start and stop the pumps based on capacity, operating time or efficiency of the pump to ensure each pump is operated regularly .
				1. The multi-pump functionality shall control:

Flow Control

Pressure Control

Pump Alternation

* + - 1. The drive shall have pump protection functions for flow and pressure to avoid damages to the pump such as dry pump protection, min/max flow and pressure protection.
		1. Security Features
			1. The drive manufacture shall clearly define cybersecurity capabilities for their products.
			2. The drive shall include passcode protection against parameter changes.
				1. There shall be multiple levels of passcode protection including: End User, Service, Advanced, and Override.
				2. The drive shall support a customer generated unique passcode between 0 and 99,999,999.
				3. The drive shall log an event whenever the drive passcode has been entered.
				4. The drive shall provide a security selection that prevents any “back door” entry. This selection even prevents the drive manufacturer from being able to bypass the security of that drive.
				5. A security level shall be available that prevents the drive from being flashed with new firmware.
			3. A checksum feature shall be used to notify the owner of unauthorized parameter changes made to the drive. The checksum feature includes two unique values assigned to a specific programming configuration.
				1. One checksum value shall represent all user editable parameters in the drive except communication setup parameters.  A second checksum value shall represent all user editable parameters except communication setup, energy, and motor data parameters.
				2. Once the drive has been commissioned the two values can be independently saved in the drive.
				3. The drive shall be configurable to either:  Log an Event, provide a Warning, or Fault upon a parameter change when the current checksum value does not equal the saved checksum value.
			4. The “Hand” and “Off” control panel buttons shall have the option to do the following:
				1. Be individually disabled (via parameter) for drives mounted in public areas to prevent unauthorized changes.
				2. Require a second button press of “Hand” or “Off” within 5 seconds of the original selection to confirm the change and prevent accidental transition out of “Auto” mode. The capability to disable Bluetooth on control panels that include Bluetooth functionality shall be provided.
		2. Network Communications
			1. The drive shall have an EIA-485 port with removable terminal blocks. The onboard protocols shall be BACnet MS/TP, Modbus, and Johnson Controls N2. Optional communication cards for BACnet/IP, LonWorks, Profibus, Profinet, EtherNet/IP, Modbus TCP, and DeviceNet shall be available. The use of third-party gateways are not acceptable.
			2. The drive shall have independent end of line (EOL) termination and biasing switches for EIA-485 networks.
			3. The drive shall contain EIA-485 network self-diagnostics to assist in troubleshooting issues such as incorrect polarity, incorrect baud rate, noise on the wire or addressing errors.
			4. The drive shall have the ability to communicate via two protocols at the same time, one onboard protocol and one option card-based protocol. Once installed, the drive shall automatically recognize any optional communication cards without the need for additional programming.
			5. The drive shall not require a power cycle after communication parameters have been updated.
			6. The embedded BACnet connection shall be a MS/TP interface. The drive shall be BTL Listed to Revision 14 or later. Use of non-BTL Listed drives are not acceptable.
			7. The drive shall be classified as an Applications Specific Controller (B-ASC). The interface shall support all BIBBs defined by the BACnet standard profile for a B-ASC including, but not limited to:
				1. Data Sharing: Read Property Multiple-B, Write Property Multiple-B, COV-B
				2. Device Management: Time Synchronization-B
				3. Object Type Support: MSV, Loop
			8. The drive’s relay output status, digital input status, analog input/output values, Hand-Auto status, warning and fault information shall be capable of being monitored over the network. The drive’s start/stop command, speed reference command, relay outputs and analog outputs shall be capable of being controlled over the network. Remote drive fault reset shall be possible.

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Master Specification Note: Variable Frequency Drive options are included in the following paragraphs. All required options must be defined on the drive schedule.

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* + 1. Disconnect – A circuit breaker or disconnect switch shall be provided when indicated on the drive schedule. The disconnect shall be door interlocked and padlockable. Drive input fusing shall be included on all packaged units that include a disconnecting means. All disconnect configurations shall be UL Listed by the drive manufacturer as a complete assembly and carry a UL508A label. Disconnect packages manufactured by anyone other than the drive manufacturer, are not acceptable.
		2. Bypass – Bypass drive packages shall be provided when indicated on the drive schedule. All drive/bypass configurations shall be UL Listed by the drive manufacturer as a complete assembly and carry a UL508A label. Bypasses manufactured by anyone other than the drive manufacturer, are not acceptable.
			1. The drive and bypass package shall be a complete factory wired and tested bypass system consisting of a padlockable disconnect device, drive output contactor, bypass contactor, and drive input fuses.
			2. The drive and bypass package shall have a UL listed short circuit current rating of 100 kA, for 240 VAC and 480 VAC systems, and this rating shall be indicated on the rating label.
			3. The bypass control shall be powered by a three-phase switch mode power supply with a voltage tolerance of +30%, -35%. Single-phase power supplies and control power transformers (CPT) are not acceptable.
			4. The drive and bypass package shall be seismic certified and labeled to the IBC. Seismic importance factor of 1.5 rating is required and shall be based upon actual shake table test data as defined by ICC AC-156. Seismic certification of equipment and components shall be provided by HCAI (formerly OSHPD) preapproval.
			5. All bypass packages shall utilize a dedicated LCD bypass control panel (keypad) user interface. The bypass control panel must be a separate display from the drive control panel. Bypass packages that use a single shared drive/bypass control panel are not acceptable, due to that control panel acting as a single point of failure.
				1. The bypass shall include a two-line, 20-character LCD display. The display shall allow the user to access parameters and view:

Bypass input voltage, current (Amps) and power (kW)

Bypass faults, warnings, and fault logs

Bypass operating time and energy consumption (resettable)

* + - * 1. The bypass control panel shall include the following controls:

Four navigation keys (Up, Down, Enter, Escape)

Bypass Hand-Off-Auto, Drive mode / Bypass mode selectors, Bypass fault reset

* + - * 1. The following indicating lights (LED PTT type) or control panel display indications shall be provided.

Drive mode selected, Bypass mode selected

Drive running, Bypass running

Drive fault, Bypass fault

* + - * 1. Safety interlock and run permissive status shall be displayed using predetermined application specific nomenclature, such as: Damper end switch, smoke alarm, vibration trip, and overpressure.
			1. All bypasses shall have the following hardware features/characteristics as standard:
				1. Six (6) digital inputs and five (5) Form-C relay outputs. The digital inputs shall be capable of accepting both 24 VDC and 24 VAC. The bypass control board shall include an auxiliary power supply rated 24 VDC, 250 mA.
				2. Drive isolation fuses shall be provided. Bypass designs which have no such fuses, or that only incorporate fuses common to both the drive and the bypass are not acceptable. Third contactor “isolation contactors” and service switches are not an acceptable alternative to drive isolation fuses.
				3. The bypass shall be able to detect a single-phase input power condition while running in bypass, disengage the motor, and provide a single-phase input power indication.
				4. The bypass shall be designed for stand-alone operation and be completely functional in both Hand and Automatic modes, even if the drive and/or drive’s control board has failed. Network communications shall remain functional. Bypass systems that do not maintain full functionality in the event of a drive failure, are not acceptable.
			2. All bypasses shall have the following software features as standard:
				1. Programmable loss-of-load (broken belt / coupling) indication shall be functional in drive and bypass mode.
				2. The bypass shall also support run permissive and start interlock control functionality, including start delay, as previously specified in the drive section.
				3. The bypass control shall monitor the status of the drive and bypass contactors and indicate when there is a welded contactor contact or open contactor coil.
				4. The bypass shall include a selection for either manual or automatic transfer to bypass. The automatic transfer mode shall allow the user to select the specific drive fault types that result in an automatic transfer to bypass. The automatic transfer mode shall not allow a transfer to bypass on motor related faults. Automatic transfer schemes that do not differentiate between fault types, are not acceptable.
				5. The bypass shall include the ability to select the operating mode of the system (Drive/Bypass) from either the bypass control panel or digital input.
				6. The bypass shall include the ability to know the phase sequence and provide a phase sequence fault to indicate if the bypass and drive would run the motor in the opposite direction, this feature shall be enabled by default
				7. The bypass shall include a supervisory control mode that monitors the value of the drive’s analog input (feedback). This feedback value is used to control the bypass contactor on/off state. The supervisory mode shall allow the user to maintain hysteresis control over applications such as cooling towers and booster pumps.
				8. Selectable Class 10, 20, or 30 electronic motor overload protection shall be included in both drive and bypass mode.
				9. The drive and bypass shall be designed to operate as an integrated system when in Override mode. Whether operating in drive or bypass mode, the low priority safeties will be ignored, and high priority safeties will be followed. External start/stop commands will be ignored. There shall be four selectable Override modes:

Bypass only, with two smoke control modes:

Fixed pre-configuration of digital inputs

Configurable high/low priority safeties and faults, to allow configuration to meet needs of local Authority Having Jurisdiction.

Drive only

Drive then transfer to bypass, in the event of a drive fault

Force to Stop

* + - 1. Network communications – the bypass shall include BACnet MS/TP, Modbus, and Johnson Controls N2 as standard. The bypass BACnet implementation shall be BTL Listed to Revision 14 or later. Optional communication cards for BACnet/IP, LonWorks, Profibus, Profinet, Ethernet/IP, Modbus TCP, and DeviceNet shall be available.
				1. The bypass relay output status, digital input status, warning and fault information can be monitored over the network. Status information shall be monitored, including; operating mode (drive vs bypass), current drawn in bypass mode, broken belt, and phase-to-phase voltage. The bypass start/stop command, force to bypass command, and relay outputs shall be capable of being controlled over the network.
1. EXECUTION
	1. INSTALLATION
		1. The responsible party shall install the drive in accordance with the recommendations of the drive manufacturer as outlined in the drive installation manual.
		2. Power wiring shall be completed by the responsible party. All wiring shall be installed in accordance with the recommendations of the drive manufacturer as outlined in the installation manual.
		3. Installation shall be in accordance with national, state and local building and electrical codes as may be in force in the installation area.
	2. START-UP
		1. Start-up shall be provided for each drive by an authorized local service provider.
	3. PRODUCT SUPPORT
		1. Factory trained application engineering and service personnel that are thoroughly familiar with the drive products offered shall be locally available at both the specifying and installation locations. A toll free 24/365 technical support line connected to factory support personnel located in the US and Canada shall be available.
		2. Training shall include installation, programming and operation of the drive, bypass and network communications. Owner training shall be provided locally upon request.
	4. WARRANTY
		1. The drive Product Warranty shall be 30 months from the date of shipment from the factory. The warranty shall include: Parts, on-site labor, and travel time and travel costs, or replacement of the complete drive as determined by the drive manufacturer’s technical support.

End of Section