# GENERAL

## SECTION INCLUDES

### Medium Voltage Motor Controllers

## RELATED SECTIONS

## REFERENCES

### The medium voltage motor controllers and protection devices in this specification are designed and manufactured according to latest revision of the following standards (unless otherwise noted).

### ANSI C19.3, Industrial Control Apparatus

### MIL SPEC TT-C-490, Rev. D, Cleaning Methods for Ferrous Surfaces and Pretreatment for Organic Coatings

### NEMA ICS 1, Industrial Control and Systems: General Requirements

### NEMA ICS 1-109

### NEMA ICS 2, Industrial Control and Systems: Controllers, Contactors and Overload Relays, Rated Not More Than 2000 Volts AC or 750 Volts DC

### NEMA ICS 324

### NEMA ICS 6, Industrial Control and Systems: Enclosures UL 347 7th edition, Medium-Voltage AC Contactors, Controllers, and Control Centers

### UL 508, Standard for Safety for Industrial Control Equipment

## DEFINITIONS

## SYSTEM DESCRIPTION

### The MCC shall be rated at [2300] [2400] [3300] [3600] [4000] [4160] [4200] [4800] volts, three phase, [3] wire, [60] [50] Hertz power system having a short circuit availability of 50 kiloamperes RMS symmetrical.

### Controllers shall be for medium voltage solid state motor starter specified in this document. This specification describes the performance, functional specifications and fabrication details for a digital reduced voltage, stepless, solid state medium voltage motor starter that shall provide a selectable voltage ramp, current limit or current ramp (all standard) method of soft starting 3-phase AC induction motors.

### Each motor starter(s) shall be complete self-contained Class E-2 Combination Starters and house the fused disconnect switch, in-line isolation contactor, solid-state controller, motor overload protection and bypass contactor..

## SUBMITTALS

### Manufacturer shall provide [quantity] copies of following documents to owner for review and evaluation in accordance with general requirements of Division [1] [01] and Division [16] [26]:

#### Product Data on specified product;

#### Shop Drawings on specified product;

## PROJECT RECORD DOCUMENTS

### Contractor to maintain an up-to-date set of Contract documents. Note any and all revisions and deviations that are made during the course of the project.

## OPERATION AND MAINTENANCE DATA

### Manufacturer shall provide [quantity] copies of installation, operation and maintenance procedures to purchaser in accordance with general requirements of Division [1] [01] and Division [16] [26].

## QUALITY ASSURANCE (QUALIFICATIONS)

### Manufacturer shall have specialized in the manufacture and assembly of medium voltage motor controllers for [50] years.

### Medium voltage motor controllers shall be listed and/or classified by Underwriters Laboratories in accordance with standards listed in Article 1.03 of this specification.

### Equipment shall be qualified for use in seismic areas as follows:

#### High seismic loading as defined in IEEE Std 693-2018, with 2.5 amplification factor.

#### IBC-2018 & CBC-2019, Ss = 2.76g, Sds = 1.84g, Ip = 1.5, for z/h equal to 1 and Ss = 4.41g, Sds = 2.94g, Ip = 1.5, for z/h equal to 0 in accordance with ICC-ES-AC156.

#### Seismic compliance shall be qualified only through shake table testing. Compliance by calculation is not acceptable.

## DELIVERY, STORAGE, AND HANDLING

### The installer shall store, protect, and handle products in accordance with recommended practices listed in manufacturer's Installation and Maintenance Manuals.

### Deliver each shipping split mounted on shipping skids and wrapped for protection.

### Installer shall inspect and report concealed damage to carrier within specified time.

### Installer shall store motor controller in a clean, dry space. Maintain factory protection or cover with heavy canvas or plastic to keep out dirt, water, construction debris, and traffic. (Heat enclosures to prevent condensation.)

### Installer shall handle motor controller in accordance with NEMA [ \_\_\_ ] and manufacturer's written instructions to avoid damaging equipment, installed devices, and finish. Lift only by installed lifting eyes.

## PROJECT CONDITIONS (SITE ENVIRONMENTAL CONDITIONS)

### The Contractor shall follow (standards) service conditions before, during and after motor controller installation.

### Medium voltage motor controllers shall operate up to 3300 feet (1000 meters) without de-rating.

### Medium voltage motor controllers shall be located in well-ventilated areas, free from excess humidity, dust and dirt and away from hazardous materials. Ambient temperature of area will be between zero and plus 40 degrees C. Indoor locations shall be protected to prevent moisture from entering enclosure.

## WARRANTY

### Manufacturer warrants equipment to be free from defects in materials and workmanship for 1 year from date of installation or 18 months from date of purchase, whichever occurs first.

## EXTRA MATERIALS

### Provide [parts] [spares] as indicated in drawings.

### Provide [2] of each size and rating of fuses.

## FIELD MEASUREMENTS

### The Installer shall make all necessary field measurements to verify that equipment shall fit in allocated space in full compliance with minimum required clearances specified in National Electrical Code.

# PRODUCTS

## MANUFACTURER

### ABB Company products have been used as the basis for design. Other manufacturers' products of equivalent quality, dimensions and operating features may be acceptable, at the Engineer's discretion, if they comply with all requirements specified or indicated in these Contract documents.

## SYSTEMS

### Furnish [quantity] ABB Type Limitamp® motor controllers (or approved equal) as indicated in drawings.

## EQUIPMENT

### Refer to Drawings for: actual layout and location of equipment and components; current ratings of devices, bus bars, and components; voltage ratings of devices, components and assemblies; and other required details.

### Controllers shall be NEMA Class E2 high-voltage with ratings as indicated in drawings.

### Enclosures shall be NEMA Type [1, general purpose] [1A, gasketed] [2, Driptight] [3R, Weather-resistant] [12, Dusttight].

### Enclosures shall be 90 inches high, 22 to 48 inches wide, and 30 inches deep for bus ratings to 2000A, at 3000A depth shall be 42”.

### For personnel safety, enclosure(s) shall have: low-voltage control compartment with separate door; high voltage compartment with separate interlocked door; ac bus compartment with protective barriers; and cable entrance compartment.

### Arrange load terminations for cable connections as indicated.

### Incoming cables shall enter enclosure at [top] [bottom][as indicated on the drawings or data sheets]. Cables shall be separated from high and low voltage compartments by barriers unless in a dedicated incoming section.

### Motor cables shall enter enclosure at [top] [bottom][as indicated on the drawings or data sheets]. Cables shall be separated from high and low voltage compartments by barriers.

### Enclosure

#### Enclosure shall be [NEMA 1 general purpose][NEMA 1A gasketed] [NEMA 2, Driptight] [NEMA 3R Weather-resistant non-walkin] [NEMA 3R Weather-resistant enclosed aisle walkin] [NEMA 12, Dusttight]

#### [Provide pad lockable features for doors][provide door stops]

#### [Provide compartment space heaters][ control voltage to space heaters shall be [115AC][230AC]][Space heaters shall be controlled by [thermostat][humidistat][ Heater circuit shall be monitored by ammeter][space heaters shall be provided with covers]

### Bus bars shall be full sized and rated as indicated in drawings. Bus shall be arranged for future extension.

#### Bus shall be [bare copper][tin plated copper][silver plated copper]

#### Bus shall be [non-insulated][insulated with boots on splice plates]

#### Ground bus shall be [bare copper][tin plated copper][silver plated copper][is not required]

## RATINGS

### Input: [2300VAC],[2400VAC], [3300VAC], [4160VAC], +10% to –15%, 3 phase, 50/60Hz (selectable) ± 6Hz. Unit(s) will operate with any incoming phase sequence.

### Output: Reduced voltage 3 phase AC derived from phase-angle fired inverse-parallel thyristors, ramped to full voltage.

### Current SCR Rating(s): [200] [400][800]

### Output Capacity: Heavy Duty, rated as follows: Overload Capacity = 500% of unit rating for 60 seconds; 600% for 30 seconds; minimum 115% of nominal motor FLA continuous. Light duty rated starters are not acceptable.

### Contactor voltage ratings shall be 5000V minimum.

### Vacuum contactors shall be rated for maximum starting current of the unit design. The Bypass Contactor shall be rated to be capable of emergency across-the-line start.

### Interrupt rating shall be in coordination with the primary fuses as per UL 347.

### Rated Short Circuit Amps: Starter and contactors shall be rated for 50kA RMS symmetrical. The entire assembly as a NEMA Class E2 controller shall have fault withstand ratings as per UL 347 of 200MVA symmetrical at up to 2300V and 350MVA symmetrical at up to 4160V.

### Overall BIL Rating: Entire starter assembly shall have a BIL (Basic Impulse Level) rating of 60kV.

### Insulation Rating: Standard insulation design shall be for 5kV. Insulation shall be tested for dielectric voltage withstand of 2.25XL-L Voltage + ZKV for 60 seconds.

### Control Power: 115VAC, 60Hz, derived from an integral transformer sized to be adequate to operate all associated devices in each starter.

## CONTROLLER

### General

#### For overload protection, furnish electronic overload relay with phase unbalance and selectable OL class (10, 20, 30)] with hand-reset, shall be included.[Furnish solid state multi-function overload relay as specified hereinafter]

#### Control power at 115 or 230 volts shall be provided from a control power transformer in each controller. Transformer shall be protected by current-limiting fuses.

#### Controls shall provide [instantaneous undervoltage protection] when momentary contact push-button is used [undervoltage release] when maintained contact switch is used]. [Push-button] [Switch] shall be [mounted on door] [remotely located].

#### Each control shall be protected against single-phasing due to blown fuses and shall have blown fuse indication. Blown fuse indicator shall be mounted on controller door.

#### Motor starter types shall be: Reduced Voltage Solid State (RVSS.[As indicated on drawings and data sheets].

#### Provide load break fusible switches type IC 1074 as indicated on the drawings or data sheets. Switches shall be [one high][two high][fused][non-fused] construction.

#### Control terminal blocks shall be [stationary][pull apart]. Provide spare terminal points.

#### Control wire size shall be minimum of [#14][#12].

#### Control wires shall be terminated with [stripped bare wire][non insulated ring terminals][insulated ring terminals][non insulated spade terminals][insulated spade terminals].

#### Control cable wire markers [are required][not required].

#### Indicating lights where required shall be [full voltage][LED][[LED push to test].

#### Push buttons where required shall be [non illuminated][illuminated].

#### Indicating lights where required shall be [full voltage][LED][[LED push to test].

#### Indicating lights where required shall be [full voltage][LED][[LED push to test].

### Reduced Voltage Non-Reversing, Medium Voltage Solid State Starter (MVSS) motor controllers shall have the following features:

#### Controller(s) shall be fused type with current-limiting power fuses that provide an interrupting rating as indicated in drawings.

##### Fuses shall be ANSI class “R” for motor starting duty, sized according to motor locked rotor current and coordinated with the overload relay. Fuse and overload coordination shall be designed to allow the controller and contactor to clear low and medium level faults without blowing and without exceeding the contactor withstand capabilities. Fuses shall be used to interrupt high level faults exceeding those ratings

b. [Fuse holders shall include blown fuse indicators, wired to the isolation contactor circuit to disconnect all three phases if any one of the fuses clears.]

#### Controllers shall use three pole vacuum contactor(s) rated as indicated in drawings.

#### Main Contactor(s) shall be [{stationary}{draw-out}]. Bypass contactors are stationary type. The contactor coil shall be removable without removing contactor from its mounts. Vacuum interrupter wear checks shall not require removal of the contactor. The contactor fuses shall be capable of being removed without any disassembly of the contactor. No special tools shall be required to remove the fuses. The contactor shall be capable of one million load operations and two million mechanical operations.

#### The contactor shall be isolated by a non-load-break quick-make quick-break isolation switch operated by an externally mounted handle. Disconnect switch design voltage shall be 7200V. The isolation switch shall open the control power transformer secondary before opening the main circuit. Mechanical interlocks shall be provided to prevent:

##### Inadvertent operation of isolation switch under load;

##### Opening high voltage compartment door when isolation switch is ON;

##### Closing isolation switch with high voltage compartment door open;

##### Operating contactor with isolation switch in intermediate position

#### A viewing window in the Main Incoming Power Compartment shall allow visual inspection of the disconnect blade status prior to opening the door.

***NOTE TO SPECIFIER: 800A RVSS AVAILABLE AS NON-UL LABELED***

#### Controllers rated 400 amperes up to 5kv shall be rated 60 KV Basic Impulse Level (BIL). Control power transformer and autotransformer shall be rated 25 KV BIL standard.

#### In addition to the MVSS starter requirements, reduced voltage reversing controllers shall be provided with:

##### 2 - three pole vacuum contactors for reversing.

##### 1 - forward-reverse-stop push button.

#### In addition to the MVSS starter requirements, brush-type synchronous motor starters shall be provided with:

##### 1 – solid state variable field contactor (VFC) or static field contactor (SFC)

##### 1 - Multilin 869 with integral SPM [or approved equal] digital electronic synchronizing device for field application, load-angle field removal and squirrel-cage protection with built-in digital power factor and line amps and field amps readout

##### 1 - field starting and discharge resistor.

#### In addition to the MVSS starter requirements, brushless-type synchronous motor starters shall be provided with:

##### 1 - brushless exciter field supply (7 amps maximum)

##### 1 - variable autotransformer for exciter field supply

##### 1 - Multilin 869 with integral SPM [or approved equal] digital electronic synchronizing device for field application, load-angle field removal and squirrel-cage protection with built-in digital power factor and line amps and field amps readout.

## SOLID STATE CONTROL

### Load Protective Functions

#### Motor and Load Protection shall be integral to the starter assembly. Motor protection shall be based upon modeling of the thermal characteristics of the motor as programmed by the user and measured by the starter. All current referenced protection features shall be calculated from the motor nameplate FLA, and automatically adjusted for the Service Factor, NEMA Design, Insulation Class, Line Voltage and Line Frequency as entered by the user. All time-based protection features shall be based on a Real Time Clock, remaining active through any power loss. Starter shall provide the following functions:

##### Thermal Overload shall be provided by the on-board microprocessor control. Basic protection shall be inverse time-current trip curves as defined by NEMA trip curve Classes. The trip curve classes shall be programmable from between Class 5 and Class 30 and the starter shall be UL listed to provide each individual class. As the most important protection feature of a starter, the overload protection shall be based on a Dynamic Thermal Register retained in memory and provide the following features:

###### Retentive Thermal Memory shall be used to ensure that the Dynamic Thermal Register does not loose track of motor temperature after the power is lost or shut down. Upon reapplication of power, the microprocessor shall be automatically updated as to the motor temperature and adjusted for real time cooling while the power is off.

###### Dynamic Reset Capacity shall retain a snapshot of the thermal capacity necessary to restart the motor. The starter shall determine these requirements by recording and averaging the previous 3 successful start-ups. After an overload trip has occurred the protection shall prevent resetting until enough cooling time has passed and sufficient motor thermal capacity is available.

###### True Thermal Modeling shall be a feature of the overload and reset calculations. Once established at setup, the Dynamic Thermal Register shall be biased according to the following input information when available: Cold Stall Time, Hot Stall Time, Stopped Cool Down Time, Running Cool Down Time, and all of the real time information from the RTD Option if ordered.

###### Separate Trip Curves shall be provided for Start and Run, allowing a higher level curve to avoid nuisance tripping during acceleration, but dropping to another level for accurate motor protection while at full speed. To maximize flexibility, each trip curve shall be programmable as follows:

Basic, using the NEMA Class ranges described above.

Locked Rotor programmable between 400 – 800% of FLA, and a trip time from 1 – 30 seconds.

Measured Start Capacity (I\*I\*T curve area) taken from the previous successful start (only applicable to the Start Curve).

###### Overload Alarm shall be provided to warn users of an impending overload trip. The Alarm level shall be programmable between 40 – 95% of the Dynamic Thermal Register value. It shall provide an adjustable delay of 1 – 20 seconds.

###### Manual or Automatic Reset shall be selectable in programming to provide for automatic reset in unattended remote applications.

##### Phase Monitoring shall be standard and based on motor current. In order to protect against disconnected motor leads, this feature will function even if the line voltage remains normal. All features shall be as follows and capable of being disabled if not needed:

###### Phase Loss shall shut down the starter if current through any leg drops to 20% of unit FLA or less. This protection shall be implemented via hardware and shall be non-adjustable. It shall provide an adjustable trip delay of 1 – 20 seconds.

###### Phase Imbalance Protection shall be provided with programmable sensitivity to provide both Alarm and Trip points. The sensitivity shall be adjustable for phase-to-phase imbalances of between 5% and 30%. Each point shall provide an adjustable delay of 1 – 20 seconds.

###### Phase Rotation protection shall be self-learning and field programmable. If phase rotation varies from the initial set pattern, the starter shall trip immediately. If phase rotation is correct, the starter can be re-taught to recognize the new rotation.

##### Short Circuit Detection with dual mode protection for starting and running operation shall be standard. This circuit MUST be provided to protect the starter from load failures. This protection shall be implemented via hardware and shall be non-adjustable.

###### In the starting mode the starter shall employ a ¼ second pre-check routine to determine if the load circuit has a fault condition and disable the ramping prior to reaching the Initial Voltage setting. This is to avoid additional equipment damage after a fault that may have occurred while the starter was off.

###### In the running mode, this feature will shut down the starter if current through any leg exceeds 10 times unit FLA for 12.5 milliseconds.

##### Over Current Protection shall be provided separate from the above to be used as a Shear Pin trip. It shall be adjustable at lower levels for protecting mechanical components from undue shock when rapid unexpected load changes occur.

###### Adjustment level shall be from 100% to 300% of the programmed motor FLA.

###### A time delay of up to 20 seconds shall avoid nuisance tripping from short duration transients.

##### Under Current Protection shall alarm the starter on an adjustable condition. This Load Loss sensor shall be programmable from 10% to 90% of the programmed motor FLA, and, with a time delay of up to 20 seconds shall avoid nuisance tripping from short duration transients.

##### Ground Fault protection shall be provided to protect the motor from damage using the Residual Current method. An Alarm and 2 trip levels, each adjustable from 5 – 90% shall be available with separate trip times as follows:

###### ALARM level preset at 5% with a 0.5 – 20 second delay.

###### LOSET Trip level preset at 7% with a 1 – 20 second delay.

###### HISET Trip level preset at 10% with an 8 – 250 millisecond delay.

##### Line Frequency Window shall be programmable from a 1 – 6Hz variance from the nominal line frequency as entered by the user. It shall provide an adjustable trip delay of 1 – 20 seconds.

##### Coast Down Lockout shall be provided to prevent restarting of the motor during backspin or other dangerous mechanical conditions after shutting off. The coast down lockout time shall be programmable between 0 and 60 minutes following a Stop command.

##### Starts-per-Hour Lockout shall be provided to prevent damage to the motor from rapid cycling of start commands for any reason. The maximum starts-per-hour shall be programmable between 1 and 10 starts.

###### Time Between Starts Lockout shall also be programmable to work with the above. A minimum time of between 0 and 60 minutes between start attempts shall prevent restarting too rapidly for the motor and load conditions as determined by the user.

### Start/Stop Control

#### Acceleration Control shall be fully adjustable in programming to match any application. As a minimum, starter shall come complete with the following settings:

##### Ramp Type: To ensure maximum flexibility in matching the load conditions in the field, the starter shall provide all of the following methods of closed loop acceleration ramp control: Voltage Ramp, Voltage Ramp with Current Limit, Current Limit Only (Current Step), Current Ramp (Torque Ramp) or 2 Custom Ramp profiles and 1 Pump Curve that can be programmed by the user.

##### Starting Torque: Initial torque output shall be programmable as either Current or Voltage output, and adjustable between 0-100% of maximum Locked Rotor Torque (600% current) available from the motor.

##### Maximum Current Limit: To ensure reliability of starting under any circumstance that the motor can function in, Current Limit shall be adjustable between 200 and 600% of the unit rating. This will allow locked rotor current to be delivered to the motor if necessary. Lighter duty starters with lower current limit settings will not be acceptable.

##### Ramp Time: The time between Initial Torque and Full Output shall be adjustable between 1 and 120 seconds.

##### Dual Ramps: To accommodate changing load conditions, the starter shall provide 2 separately adjustable ramp profiles, selectable via a dry contact closure. Each ramp will provide all of the above features.

##### Custom Ramp Curves shall be available that can be configured by the user to match any load or starting condition. Each of the 3 available custom curves can be profiled by entering 8 torque and time points. The starter shall create a smooth acceleration curve from these plotted axis points.

##### Kick Start: To provide for starting difficult loads, the starter shall include a Kick Start feature that will apply a high output for a short time on initial start command. The Kick-Start voltage level shall be adjustable from 10 – 100% voltage, for 0.1-2 seconds max.

##### Jog: For checking rotation at start-up or other testing procedures, the starter shall provide a programmable Jog feature, adjustable from 5 – 75% of line voltage.

#### Deceleration Control (Ramp Down) shall be completely independent of any Accel Ramp settings and provide a fully adjustable Decel profile in order to avoid possible motor damage. Pre-programmed decel “algorithm” systems that do not allow contouring to match load conditions are not acceptable.

##### Step Down Voltage: adjustable from 100 to 0% of line voltage, allowing the motor torque to drop off immediately to a level that affects output without waiting for a linear ramp.

##### Deceleration Ramp Time: adjustable from 0 – 60 seconds to allow gentle controlled deceleration in excess of the natural coast-to-stop time of the load.

##### Stop Voltage Level: adjustable from 100 – 0% of line voltage to automatically turn off the starter when the output torque has reached a desired level or custom S-curve. Programming shall not allow the Stop level to be set higher than the Step Down Level. External timers shall not be needed to turn off the starter.

##### Selectable Operation During Overload shall be available to allow the user to decide if the motor shall turn off or continue to Decel when an overload condition is detected.

### Starter Protection

#### Shorted SCR Detection shall be standard. This function must automatically prevent a “start” sequence when at least one SCR is shorted. A means of having qualified service personnel defeat the lockout of this circuit MUST be provided to allow for “Must Run” situations.

#### Starter Overtemp Trip shall be built-in and protect the SCRs from excessive heat build-up in the enclosure or heat sinks. Thermal sensors on the heat sinks shall be pre-wired to one of the programmable inputs that has been factory preset as the Over Temp input.

#### Thermal: Heat sink temperature switches designed to trip at 85° C.

### Input/Outputs

#### Digital Inputs: All input and control devices shall be rated for 120VAC control or shall require dry contact closures without the need for external power supplies or interposing relays.

##### On-Off Control shall be 120VAC to avoid potential problems with voltage drop in long control wire runs. The starter shall provide for 2-wire or 3-wire control schemes. Seal-In relay contact for the 3-wire control scheme shall be internal, dedicated to that use and not counted as an output contact. Terminals shall be provided for use in interlocking with programmable output relays or external devices.

##### User Inputs: 4 programmable digital inputs shall be provided. Each input shall accept dry contact closures from external user supplied devices, and can be named for display on the display when energized. 2 of these inputs shall be preset as Temperature and Dual Ramp Select, but can be changed by the user. Inputs can be programmed as N.O. or N.C., and programmed with a de-bounce timer of 0 – 60 seconds. Each input can be assigned to operate any of the Programmable Outputs.

##### Analog Input shall be provided for optional Tach Feedback Starting. This input shall accept 4-20ma with adjustable offset and gain.

#### Outputs shall be provided for the following functions in addition to the seal-in relay used in 3-wire control schemes as mentioned above.

#### Digital Outputs shall be eight (8) Form “C” contact relay outputs, rated for 240VAC, 5AMPS, 1200VA max., with each relay being programmable for any one of the following functions;

##### Indicator Relay programmable to change state on any of the following conditions: Run / Stop, Start / End of Decel, Timed Output, At Speed / Stop, At Speed / End of Decel, Dual Ramp Selected, Self Test Fail.

##### Fault Trip Relay programmable for each of the following fault conditions: Overload, Phase Imbalance / Loss / Reversal, Lock Out Inhibits, External Inputs, Short Circuit, Over Current / Shear Pin, Ground Fault HISET / LOSET, Over / Under Frequency, I2T Start Curve, Shorted SCR, Shunt Trip, Over Temp, Under Current / Load Loss.

##### Alarm Relay including the following conditions: Overload Warning, Overcurrent Warning, Ground Fault Warning, Under Current Warning, Imbalance Warning, Thermal Register Warning.

##### RTD Relay (when RTD Input option is ordered) including Stator or Non-Stator Trip and/or Warning, and RTD Failure.

#### Analog Outputs (2) shall be included for providing information to external controls and be programmable as RMS Current or Percentage of Motor FLA.

##### If the Tach Feedback Starting option is used, the Analog outputs can be programmed as RPM. Tachometer Feedback is not included as standard.

##### If the RTD input option is used, the Analog outputs can be programmed as Hottest RTD Temperature for Stator or Non-Stator RTDs.

#### [Tach Feedback Starting input card shall be provided to allow linear speed acceleration based on closed loop feedback from a tachometer.]

#### [Provide RTD Inputs, allowing biasing and adjustment of the Dynamic Thermal Register based on real-world temperature readings from up to 12 RTDs, with the following features:

##### Programmable RTD Type, shall accept 100 ohm platinum, 100 ohm nickel, 120 ohm nickel and/or 10 ohm copper RTDs

##### Configurable RTDs allowing for up to 6 RTDs to be used for the Stator. All RTDs can have names assigned in programming for clear indication on the display.

##### RTD Voting providing for the requirement of at least 2 RTDs to be exceeding the setpoints for Trip or Alarm. This feature shall be programmable as Enabled or Disabled.]

### Operator Interface Panel

#### Operator interface panel shall provide simple to use adjustment and status indication on a dead-front shroud of the starter.

#### Adjustments shall be made by keypad with tactile feedback keys for high noise environments. To prevent confusion, no binary coded dip switches shall be used for programming. Pass code protection shall be available to prevent unauthorized changes to the programming.

#### Alpha-Numeric Display shall be Backlit LCD with 2 lines by 20 characters.

#### Indicators using long life LED devices shall provide additional quick annunciation of Power, Run Alarm and Trip operation, as well as the status of the eight output relays.

#### Password Protection shall be provided, allowing 3 levels of access to program information, 2 of these levels requiring separate Passwords.

### Metering functions shall be provided through the Alpha-Numeric Display for indicating the following. This data can be exported via the Comm. Port to be plotted on a graph or spreadsheet for baseline measurement and maintenance analysis:

#### Output Current for each individual phase or avg. of all 3. Indicating range to be 0.0 – 9999.9 amps.

#### Ground Fault Current

#### Motor Load % of FLA

#### Line Frequency

####  Phase Order

#### Remaining Thermal Capacity to indicate heating effect and cooling rate of the motor. Range shall be 0 – 100% of the remaining capacity and count up towards 100% while cooling.

#### Thermal Capacity to Start indicating the required value that will be added to the thermal register as learned and averaged from the previous 3 successful starts.

#### Average Start Time learned from previous 3 successful starts

#### Average Start Current learned from previous 3 successful starts

#### I2T to Start measured from the previous start.

#### Last Start Time measured from Start Command to At-Speed.

#### RTD Metering (when RTD Option is ordered) for up to 12 Stator and Non Stator RTDs, displayed in degrees C and degrees F. Metering includes Hottest RTD, each RTD Temp, each RTD Max Temp Since Clear, Measured Run Cool Time in minutes, and Measured Stop Cool Time in minutes.

#### Starter Status including Ready, Starting, Running, Last Trip Cause

#### Remaining time for O/L Trip, Thermal Inhibit, Coast Down Lock Out, Time Between Starts and Starts per Hour.

#### Event Recorder (last 60 events) with Phase and GF currents record at each event.

#### Last Trip including Cause, Phase and GF currents, Unbalance %, Hz, Hottest Stator and Non Stator RTD recorded.

#### Statistics including Elapsed Run Time, Total Trips, Trips on Short Circuit, Start O/L, Run O/L, Frequency, Overcurrent, Stator RTD, Non-Stator RTD, G/F LOSET and HISET, Acceleration Time, Start Under Curve, Start Over Curve, I\*I\*T Start, Fail Shunt Trip, Phase Loss, Tach Accel, and 4 External Inputs

#### Learned Start Curve. When enabled, the starter will record a start curve with 100 data points of current and time between Start and At-Speed.

### Serial Communications shall be built-in as a standard feature without the need for separate modules.

#### Communications protocol shall be RS-232 to a windows based program for data entry, and/or Modbus RTU protocol via RS485 signals.

#### Units shall be capable of being connected to an intelligent communication device in a network of up to 247 devices with unique addresses.

### SCR Modules

#### PIV Ratings: SCRs will be connected as inverse parallel pairs in series circuits to attain the following Peak Inverse Voltage ratings as a minimum for each phase:

##### System Voltage: 1500 / 2300V, 1 Pair, PIV Rating 6500V

##### System Voltage: 3300 / 4160V, 2Series Pairs, PIV Rating 13000V

#### RC snubber network circuits shall be provided on each phase assembly. To avoid possible component damage, MOV protective devices shall be used only on the gate firing circuitry.

#### Efficiency shall be 99.7% through SCRs, 99.97% in bypass mode.

#### Firing circuits shall use individual phase transformer coupling method for maximum isolation and rapid rise of firing pulse to ensure reliable gate firing even when powered with on-site generators.

#### The gate firing circuitry shall be protected from electrical noise and transients to ensure reliable starting and firing of the SCRs under all power conditions, regardless of the available fault current or motor lead length.

##### They shall be amplified and isolated from the control voltages by means of rugged encapsulated ring transformers that provide separate power sources for each set of SCR gate drives. The design shall allow for a “back-porch” DC carry-over of the firing pulse to prevent the SCRs from falsely turning off due to ringing of the output current or line notching caused by other connected equipment. The gate drive shall be maintained for 240 electrical degrees from the zero cross point to avoid motor switching transients.

##### For additional reliability and to protect against EMI/RFI interface generated by the internal components, connections to the Digital Control Unit shall be fiber optic.

##### When at all possible, the starter shall not require line reactors in the Medium Voltage power section. Those that do shall include them within the same enclosure as the starter and shall be UL listed in this configuration.

### Electronics

#### Non-Volatile Memory will be used throughout the control and protection systems. To prevent the possibility of loosing protection values, stored programs or statistical data, battery back-up memory systems will not be allowed.

##### The starter shall store all factory defaults in a preset replaceable EPROM memory chip.

##### User Programming and statistical data shall be stored in EEPROM memory for ready alteration. Loss of power shall not affect memory status.

##### For fast updates and operation, running programs shall use DRAM memory. The starter shall store the DRAM memory contents to the EEPROM upon power failure, and restore it upon return to normal.

#### Data Sampling

##### Critical operating data such as instantaneous current for Short Circuit, Ground Fault and Immediate Overload calculations shall be sampled every 2 milliseconds to prevent lagging operation.

##### Non-Critical data shall be obtained from a true RMS calculation circuit, and sampled in a 350 millisecond moving window of individual phase currents.

#### Real Time Clock with automatic leap-year updating shall be provided. This clock alone shall use a battery back-up with a Lithium-Ion battery rated for at least 10 years of continuous operation without power applied. The clock shall be capable of being reset in the field after changing the battery, without affecting any other stored information.

### Quality Requirements

#### All incoming material shall be inspected and/or tested for conformance to quality assurance.

#### Power semiconductors shall be fully tested for proper electrical characteristics (dv/dt, di/dt, etc.).

#### All subassemblies shall be inspected and/or tested for conformance to vendors engineering and quality assurance specifications.

#### Printed circuit boards shall be burned in for a minimum of 48 hours at 60°C.

#### The complete unit shall be functionally tested under load before shipment to assure proper operation per specification. Complete test reports shall be available upon request.

### Start Up and Adjustments

#### Start Up Procedures. All starters will come factory pre-set for general applications with defaults per Operation Manual so that only minor adjustments are necessary in the field to match specific conditions. Start-up procedures shall be intuitive and simple enough so as not to require factory assistance or training. Basic start-up shall include entering of motor data and Overload selection Additional features will only be activated when necessary.

#### Adjustments. To facilitate ease of initial setup, all necessary adjustments shall be capable of being made without the need for pass codes. Pass code use shall be optional at users discretion. All settings and adjustments shall not require a battery back-up for retention.

## [ELECTRONIC MULTIFUNCTION POWER METER]

NOTE TO SPECIFIER: ADD APPROPRIATE METER SPECIFICATIONS HERE IF ELECTRONIC POWER METER IS DESIRED. A DIGITAL MOTOR PROTECTION RELAY CAN ALSO PROVIDE ADEQUATE POWER METERING CAPABILITY.

[PQM II Meter](file:///C%3A%5CUsers%5CUSKEWOO22%5CAppData%5CLocal%5CMicrosoft%5CWindows%5CINetCache%5CUSKEWOO22%5CAppData%5CLocal%5CMicrosoft%5CWindows%5CUsers%5CUSRISCH13%5CAppData%5CRoaming%5CLocal%20Settings%5CTemporary%20Internet%20Files%5CContent.Outlook%5Cpqm_ii_specs.doc)

## DIGITAL MOTOR PROTECTION RELAYS

### A multi-function, 3-phase microprocessor-based ABB Relion relay or approved equal shall be used. ABB Relion [REM615] [REM620] series relays or approved equal shall be used for motor protection.

## INSTRUMENTS

### Provide instrumentation as indicated on drawings or listed below.

#### [Elapsed-Time Meter]

#### [Provide [current] [voltage] [watt] [var] [power factor] transducers. Transducer output shall be [0 –1mA] [4 – 20mA]]

#### [ABB FT-1 Test Blocks (or equal)]

#### [Operation Counter]

## ACCESSORIES

### UL listed current limiting power fuses

### [Hand-Off-Auto selector switch for automatic starting from pilot devices]

### [T&B solderless connectors (or equal)]

### [Furnish nameplates for each starter device as indicated in drawings. Use [black letters on white background] [white letters on black background].]Nameplates shall be [adhesive mounted][screw attached]

## TESTING

### Equipment shall be factory tested in accordance with NEMA ICS 1-109 and ANSI C19.3 summarized in following list:

#### Production Inspections;

#### Mechanical Operation;

#### Function Operation:

##### Devices:

##### Sequence and Timing Circuits:

##### Polarity of Phase-Sensitive Circuits:

#### Grounding.

#### High Potential Insulation:

#### Control Wiring;

#### Power Cable Insulation and Isolation.

## FINISH

### The motor controller steel parts shall be cleaned and sprayed in controlled cleaning solutions by a 7-stage spray washer. The operation shall produce an iron phosphate coating of 40-50 milligrams per square foot to meet MIL Specification TT-C-490. The primed metal parts shall be electrostatically coated with powder paint consisting of 670-011 ANSI-61 Acrylic Paint (Light Gray). The paint finish shall withstand a minimum of 1000 hours salt spray test.

# EXECUTION

## EXAMINATION

### Examine installation area to assure there is enough clearance to install motor control centers.

### Check concrete pads for uniformity and level surface.

### Verify that medium voltage motor controllers are ready to install.

### Verify field measurements are as [shown on Drawings] [instructed by manufacturer].

### Verify that required utilities are available, in proper location and ready for use.

### Beginning of installation means installer accepts conditions.

## INSTALLATION

### Install per manufacturers instructions. Install required safety labels.

### Contractor shall furnish and completely install all motor control centers as shown on drawings and described in these specifications and in NEC.

## FIELD QUALITY CONTROL

### Inspect installed medium voltage motor controllers for anchoring, alignment, grounding and physical damage.

### Megger and record phase to phase and phase to ground insulation resistance of each bus section. Megger for [1] minute for each measurement at minimum voltage of [1000] VDC. Measured insulation resistance shall be at least [1] megohms. Refer to manufacturers instructions for proper testing procedures.

### Check tightness of all accessible mechanical and electrical connections [with calibrated torque wrench]. Minimum acceptable values are specified in manufacturers instructions.

### Test each key interlock system for proper functioning.

### Operate test push button to check ground fault system(s).

### List other controls as required.

## ADJUSTING

### Adjust all [switches] [, ] [access doors] [, ] [operating handles] for free [mechanical] [ and / or ] [electrical] operation as described in manufacturer's instructions.

### Adjust relay trip and time delay settings to values [specified] [determined] by Architect Engineer.

### Return "odd" Kirk keys to Engineer before energizing equipment.

## CLEANING

### Clean interiors of motor controller sections to remove construction debris, dirt, and shipping materials.

### Repaint scratched or marred exterior surfaces to match original finish.

### END OF SECTION