GE
Critical Power

Guide Specification

Standby/Utility Parallel Power Generator Systems

Part 1 General

1.1 Scope

Provide a complete standby [utility parallel] digital power control and distribution system to automatically start and parallel ___ engine generator sets, rated ____ kW ___ Vac, at 0.8 pF for a three phase, 4[3] wire, 60 [50] Hz application.

The Switchgear lineup shall be a complete free-standing assembly, containing the necessary number of the control and distribution sections, including selected optional accessories.

1.2 Reference Standards

A. The Generator Paralleling Control Switchgear and all related components shall be designed, manufactured and tested in accordance with the latest edition of the following applicable standards:

1. American National Standards Institute, Inc. (ANSI)
   C37.20.1 Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear
   C37.51 Testing of Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear Assemblies
2. National Fire Protection Association (NFPA)
   NFPA - 70 National Electrical Code
   NFPA - 99 Essential Electrical Systems for Health Care Facilities
   NFPA - 110 Standard for Emergency and Standby Power Systems
3. Underwriters Laboratories, Inc. (UL)
   UL 1558 Switchgear Assemblies
   UL 891 Switchboards
   UL 508A Control Panels
4. National Electrical Manufacturers Association (NEMA)
   NEMA SG-5 Power Switchgear Assemblies
5. International Standards Organization (ISO)
   ISO 9001:2000

1.3 Quality Assurance

A. **Manufacturer's Qualifications:**

1. The equipment shall be the product of a manufacturer who has produced this type of equipment for at least 25 years. The manufacturer must be certified under ISO 9001.

B. **Site Conditions:**

1. Altitude: up to 5000 feet above mean sea level
2. Relative Humidity: 100 % maximum, continuous, non-condensing
3. Ambient temperature range: -20 to 105 degree F

1.4 Submittals

A. Upon receipt of purchase order, manufacturer shall provide six (6) submittals for approval within thirty (30) working days after receipt of an order, that shall include the following:

1. Project Summary
2. Project Architecture
    a. Distribution SwitchgearEnclosure information
        1. UL standard
        2. Bus configuration
        3. Cable/lug information
    b. Low Voltage Controls
        1. Digital Commander control components
    c. Master System Control
    d. Generator Control
    e. Utility Control
3. Sequence of Operations
    a. Description of hardwire interlocks
    b. Automatic method of operation
    c. Test w/ Load and Test w/out load
    d. Manual Operation
    e. Generator optimization
    f. Load controls

4. HMI touchscreen menus
    a. Screen Header and Sidebar Information
    b. Icon legend
    c. Sample of each operator screen including
        1. System mimic
        2. System controls
        3. Load controls
        4. Generator Optimization
        5. Metering
        6. Maintenance
5. Detailed Bill of Materials
6. Drawings
    a. Mechanical Drawings:
        1. Dimensional plans and elevations, with front and side views, and other pertinent elevation views
        2. Conduit entrance locations and dimensions within all assemblies for both bottom and top entrance
        3. Door details.
        4. Circuit Breaker ratings.
        5. Weight of equipment (lbs.)
        6. Assembly ratings including:
            i. Bus Bracing (kA)
            ii. Short circuit rating (kAIC)
            iii. System Voltage (V)
            iv. Continuous current rating (A)
    b. Electrical Drawings:
        1. Typical AC Three-Line Schematic diagrams with all components cross referenced
        2. Typical DC Schematic diagrams with all components cross referenced
        3. Typical equipment interconnecting drawings showing terminal points and external device function
7. Major component product data sheets

Part 2 Products

2.1 General Requirements

A. Approved Vendors

1. General Electric (also known as GE, Zenith, GE Critical Power or GE Zenith Controls)

2.2 Construction

A. The enclosures shall be freestanding, floor supported, with front and rear access. Removable lifting eyes shall be supplied for lifting purposes. Adequate number of anchor bolt-holes spaced to place the base in direct contact with the concrete pad when bolted. All doors shall be pan type and be provided with sufficient hinges to support the door and components for minimum deflection and wobbling when opening or closing. Front doors shall be supplied with a lockable handle. All door locks shall be keyed alike to operate from a single key, with one key supplied for each lock. All panel covers are secured with captive screws as necessary.

B. An assembly shall be submitted to a degreasing and cleaning process. The finish shall be ANSI-61, light gray, electrostatically charged polyester powder paint process, minimum 1.5 mils in density. Finish shall be suitable for indoor and outdoor environments.

2.3 Bus

A. Bus shall be silver plated copper and shall have a maximum current density of 1000 A per square inch.

B. Main bus shall be rated for [XXXXXA] and have a minimum bracing level and short circuit capacity not less than 100,000 A

C. A full size copper neutral bus and a 25% ground bus shall be provided and shall extend the full length of the Switchgear.

2.4 Wiring/Terminations

A. Control wiring 600 V, per UL 1015 or SIS. Use solder-less compression screw type connectors for terminating all wires. Current transformer circuit terminations shall be ring tongue compression type. Other circuits shall be ring tongue compression type where feasible, otherwise they shall be spade type applied with the proper tooling.

B. Current transformer circuits are connected through shorting terminal blocks.

2.5 Power Circuit Breakers

A. The generator [utility-tie] and distribution circuit breakers shall be low voltage draw-out, either 3 or 4 pole with interrupting current ratings no less than 100 kAIC (symmetrical) and shall be UL 1066 (ANSI C37) rated.

B. The draw-out feature shall provide for connected, test and disconnected positions. In the connected position, the main line and load terminals and all auxiliary control contacts and circuitry shall be connected and the breaker shall be fully operable. In the test position, the breaker auxiliary control contacts and circuitry only shall be connected to permit automatic operation of the complete control system without actually connecting the generator to the main bus. Main and auxiliary control contacts and circuitry shall be completely disconnected in the disconnect position.

C. The breaker draw-out mechanism shall be mechanically interlocked with the breaker to permit draw-out operation only when the breaker main contacts are open.

D. The generator circuit breakers shall be electrically operated with shunt trip, furnished with electronic trip units with Adjustable Long Delay, Short Delay and Instantaneous over current trips and Ground Fault Alarm only functions, and rated as described on the drawings.

E. The distribution circuit breakers shall be electrically operated with shunt trip [or manually operated] , and furnished with electronic trip units with Adjustable Long Delay, Short Delay and Instantaneous over current [and Ground Fault] trip or alarm functions and rated as described on the drawings. Circuit breaker electronic trip unit shall include instantaneous overcurrent functions “on/off” feature.

[Optional - to provide paralleling with utility functions and overcurrent protection]

F. The utility-tie circuit breaker shall be electrically operated with shunt trip, furnished with electronic trip units with Adjustable Long Delay, Short Delay and Instantaneous over current and Ground Fault trip functions, and rated as described on the drawings. The utility–tie circuit breaker shall be equipped with a control switch with breaker position indicating lights, all mounted on a section door.

G. Required breaker design and accessories:

1. Draw-out structure (Cassette)
2. Shutter
3. Electrically operated (EO): 120Vac Charge, 24Vdc Shunt trip
4. Breaker Push-To-Close Button
5. Breaker Push-To-Open Button
6. Auxiliary contact (source breakers): 4a/4b (Source Breakers), minimum 2a/2b (Distribution breakers)
7. Truck-Operated Contact (TOC) for draw-out type breaker: 1a/1b [2a/2b]
8. Bell-Alarm Lockout (BAL)
9. Trip unit / Generator Breaker: Released-Energy-Let-Through (RELT) Technology with LSIGA (Ground Fault Alarm - Generator)
10. Trip unit / Main and Distribution Breakers: Released-Energy-Let-Through (RELT) Technology with LSIG (Ground Fault Trip)
11. Pushbutton cover (E/O and source breakers)
12. Mechanical Counter (Source Breakers)
13. Under Voltage Trip Coil (UVT) – CoGen Breaker
14. Padlock provision
15. Advanced Metering/Modbus (power) communication
16. Zone Selective Interlock (ZSI) [CM – Must include 1 – TIM-1 module for GE Breakers]

2.6 Control and Power Components

A. **Current Transformers** - Current transformers are furnished with VA burden ratings suitable to supply the metering, protective devices and electronic governor without affecting their accuracy.

B. **Potential Transformers** (if required) - Potential transformers are provided in turns ratio and V.A. burden rating to be compatible with the controls, metering and the electronic governor. Transformers shall have integrally mounted primary and secondary fuses.

2.7 Protective Relays

A. **Generator Relay – GE Multilin 489** - Generator management shall be provided using a relay with complete protection, metering, and monitoring functions. The relay may be applied on synchronous or induction generators of 25, 50, or 60 Hz.

1. Protection:
    a. Instantaneous overcurrent when offline (50)
    b. High-set overcurrent (50)
    c. Distance (21)
    d. Ground directional (67)
    e. Instantaneous and definite time overcurrent for ground (50/51GN)
    f. Stator thermal modeling and RTD (49)
    g. Negative sequence overcurrent (46)
    h. Bearing overtemperature (38)
    i. Phase differential (87G)
    j. Over and undervoltage (59/27)
    k. Reverse power for anti-motoring (32)
    l. Inadvertent generator energization (50/27)
    m. Overspeed (12)
    n. Voltage restrained phase overcurrent (51V)
    o. 100% stator ground protection (59GN/27TN)
    p. Bearing vibration (39)
    q. Voltage phase reversal (47)
    r. VT fuse failure detection (60FL)
    s. Breaker failure detection (50BF)
    t. Trip coil supervision
    u. Sequential tripping logic
2. Synchronous generator protection:
    a. Overexcitation (24)
    b. Loss of field (40 & 40Q)
    c. Over and under frequency (81)

3. Monitoring and metering:

    a. RMS current, negative sequence current, voltage, three phase power, temperature (via the 12 RTDs), and four analog inputs

    b. Four analog output channels which can be configured to any measured parameter

    c. An event record which shall maintain a record of the last 40 events

    The current and voltage inputs shall be sampled 12 times a cycle. The relay shall store these waveforms into a user definable buffer (up to 64 cycles long) in the event of a trip.

4. User Interfaces:

    a. A 40 character LCD display, control keys and full numeric keypad located on the front panel

    b. LED indicators located on the front panel which shall indicate the status of the protection relay, generator, and output relays

    c. An RS232 port located on the front panel with a baud rate of 9600 bps

    d. Two RS485 ports located on the rear of the unit with baud rates from 300 to 19,200 bps

    e. The communications ports shall allow simultaneous independent access using Modbus® RTU and DNP 3.0 protocol

    f. Windows® based PC software which enables setpoint programming, file storage, on-line help, and real time display of status and measured data

    The protective relay shall be provided with drawout construction to facilitate testing, maintenance, and interchange flexibility.

B. **Utility Relay - GE Multilin 850** - Protection, monitoring and metering shall be supplied in one integrated digital relay package for application to motors suitable for incorporation into an integrated station control system. The Digital Relay shall have a common Hardware & Firmware platform that shall support Feeder, Motor, Transformer & Generator applications. The relay shall be equipped with separate processors for protection and for communication related functions. The relay shall be equipped with the following protection monitoring, control, automation, and reporting functions. If supporting functions are not available within the relay suitable external devices shall be provided to meet the specification requirements.

1. Protection:

    a. The protection relay shall provide analog input systems that can reproduce up to 46 times rated current at secondary levels.

    b. The relay shall execute protection related algorithms at 8 times per power system cycle.

    c. The relay shall provide the following current based protection functions

        1. Current unbalance (46R)
        2. Phase reversal (47P)
        3. Phase/neutral/ground instantaneous overcurrent (50P/N/G)
        4. Sensitive ground instantaneous overcurrent (50SG)
        5. Phase/neutral/ground time overcurrent (51P/N/G)
        6. Sensitive ground time overcurrent (51SG)
        7. Negative sequence instantaneous overcurrent (50_2)
        8. Negative sequence Timed overcurrent (51_2)
        9. Phase/neutral directional overcurrent (67P/N)
        10. Ground directional overcurrent (67G)
        11. Sensitive ground directional overcurrent (67SG)

12. Negative sequence directional overcurrent (67_2)
13. Restricted Ground Fault (87REF)
14. Breaker Failure (50BF)
15. Cable Thermal Model (49)
16. Cold Load Pickup (CLP)

d. The phase over current can be selected to operate either on RMS or Fundamental value.

e. The relay shall provide the following voltage based function

1. Phase Over and Under Voltage (59P, 27P)
2. Auxiliary Over and Under Voltage (59x, 27x)
3. Neutral Over Voltage (59N)
4. Negative Sequence Over Voltage (59_2)
5. Directional Power (32)
6. Over/Under Frequency (81O/81U)
7. Rate of change of Frequency (81df/dt)
8. Voltage restrained phase time overcurrent (51V)
9. Under power (37P)
10. Synchrocheck (25)

f. The relay shall provide the following control functions

1. 4 Shot Auto Reclose (79)
2. VT Fuse failure (VTFF)

g. The relay shall have an ability to build trip and alarm matrices without using programmable logic.

h. The relay shall have configurable option to select any protection elements to be used as a trip, alarm or latched alarm function without using programmable logic.

i. The relay shall have 6 switchable setting groups for dynamic reconfiguration of the protection elements due to changed conditions such as system configuration changes, or seasonal requirements.

2. Programmable Logic

a. Relays shall support 1024 lines of user defined logic to build control schemes supporting logic gates, timers, nonvolatile latches.

b. The programmable logic in the relay shall be executed at 8 times per power system cycle

c. The relay configuration tool shall have embedded graphical user interface to build programmable logic.

3. Communications/Integration

a. The relay shall support the following communication protocols; Modbus RTU, Modbus TCP/IP, IEC 61850 GOOSE, IEC 61850 Ed 2, DNP 3.0, IEC 60870-5-104, IEC 60870-5-103

b. The relay shall have the ability to configure both protection and IEC61850 related settings within a single setting file. The 61850 settings shall be configurable by any third party system configuration tools.

c. The relay shall support up to four IEC61850 concurrent client connections.

d. The relay shall support file transfer protocol TFTP and file transfer through 61850.

e. The relay shall support multiple time synchronization sources such as IRIG-B, IEEE 1588 and SNTP with the ability to configure priority for the time sources and dynamically switch based on availability of each sources

f. Relays shall provide two fiber optic Ethernet ports with two modes of operation – fail over mode or independent mode.

g. Relays shall support networks for IEC62439/PRP (Parallel Redundancy Protocol)

h. Relay shall have an option for Wi-Fi (IEEE 802.11 b/g/n) connectivity to configure settings and retrieve operational records.

i. A front panel USB port that shall provide connectivity to configure settings and retrieve operational records.

j. The relay shall provide a User Definable Memory Map.

4. Front-Panel Visualization

   a. User interface shall provide a large color LCD front panel display, and navigation keys

   b. The front panel shall be capable of displaying measured values, calculated values, I/O status, device status, target messages, events, motor learner data and configured relay settings

   c. The front panel shall have user-programmable LEDs and pushbuttons.

5. Metering & Digital Fault Recording

   a. Relay shall record its exposure to temperature, humidity and surge and a report shall be retrievable via the communication ports on the min, max average of those recorded values

   b. The relay shall provide Breaker Health Monitoring features including Breaker close and breaker open times, Trip/Close circuit monitoring, Spring charging time, Per-phase arcing current, Trip counters

   c. The relay shall provide information on the power factor of the protected device(55)

   d. The relay shall provide up to 64 digital channels and up to 40 analog channels of oscillography at a sampling rate of 128 samples per cycle.

   e. The relay shall provide Event Records - with a record of the last 1024 events, time tagged with a resolution of 1ms.

   f. The relay shall store all its recorded data in nonvolatile memory.

   g. The relay shall provide a separate data logger function which shall record a maximum of 16 Analog channels with a settable sampling rate of 1 cycle, 1 second, 30 seconds, 1 minute, 15 minutes, 30 minutes or 1 hour.

   h. The current metering accuracy shall be at +/- 0.25% of the reading for up to 2 times rated secondary current and +/- 1% for above them.

   i. The voltage metering accuracy shall be at +/- 0.5% of the reading from 15 to 208V.

   j. The power metering accuracy shall be at +/- 1% of the reading.

   k. The frequency metering accuracy shall be typically at 1 mill Hertz accuracy level.

6. Hardware

   a. The relay shall have conformal coated electronic board assemblies for harsh environment deployment.

   b. Microprocessor based protective relays shall employ IPC (Institute for Interconnecting and Packaging Electronic Circuits) Class 3 printed circuit boards (PCB). Specifically, IPC Class 610-3

   c. The relay shall have a draw-out construction to facilitate testing, maintenance and interchange flexibility

   d. The relays shall not use electrolytic capacitors as any component or sub-components.

e. The relay shall provide field upgradable power supply module.

f. The relay shall have a scan rate of 128 samples per power system cycle for digital inputs and provide less than 1 msec time stamp resolution for state changes.

g. The relay shall provide an Operating temperature range of –40° to + 70°C

h. The Relay shall support at a minimum 10 Digital Outputs & 14 Digital Inputs.

i. The Digital Inputs should capable of accepting wet or dry input signals.In case external wetting voltage is used, the Voltage Threshold shall be software selectable for 24V, 48V, 125V & 250V DC sources.

j. The relay contacts should be rated for a minimum of 10A continuous

7. Security

a. The relay shall provide RBAC (Role based access control) with three roles such as Observer for accessing operational data, Operator for start-stop of the motor, Administrator for configuring the relay.

b. The relay shall provide option for password complexity

c. The relay shall provide option for local device level authentication and for remote server authentication using RADIUS.

d. The relay shall provide support for SYSLOG to publish security related events

e. The relay shall support secure file transfer protocol SFTP

f. Security Setting Reports must include the following events with time stamp and Mac address:

1. Failed Authentication
2. User lock out
3. Setting changes
4. Login in
5. Authentication lockout
6. RADIUS server unreachable
7. Clear Event/Transient/Fault records

8. Service and Support

a. Warranty: The device shall include a ten-year for all material and workmanship defects.

C. **Feeder Relay – GE Multilin 350** - The feeder protection relay shall provide primary protection of medium voltage distribution feeders.

1. Protection functions:

a. Phase Undervoltage (27P)

b. Auxiliary Undervoltage (27x)

c. Thermal Model (49)

d. Breaker Failure (50BF)

e. Phase Instantaneous Overcurrent (50P)

f. Neutral Instantaneous Overcurrent (50N)

g. Ground Instantaneous Overcurrent (50G)

h. Negative Sequence Instantaneous Overcurrent (50_2)

i. Phase Time Overcurrent (51P)

j. Neutral Time Overcurrent (51N)

k. Ground Time Overcurrent (51G)

l. Phase Overvoltage (59P)

m. Auxiliary Overvoltage (59x)

n. Neutral Overvoltage (59N)

o. Negative Sequence Overvoltage (59_2)

p. Neutral Direction Overcurrent (67N)

q. Ground or Sensitive Ground Direction Overcurrent (67G/67SG)

r. Four Shot Autorelcose (79)

s. Underfrequency (81U)

t. Overfrequency (81O)

u. Cold Load Pickup (CLP)

v. Synchronism-check (25)

2. The relay shall have a draw-out construction to facilitate testing, maintenance and interchange flexibility. The relay shall have a set-screw on the draw-out handle. The relay shall operate with three phase, four wire connected current transformers. The relay shall be equipped with Cold Load Pickup which allows automatic or manual blocking or raising of trip settings for a period after the breaker has been closed. This feature adapts the pick up of overcurrent elements to override the higher overload currents resulting from re-energization of feeders after a long period of time.

   The relay shall be equipped with an Autoreclose function that can be initiated externally or from an overcurrent protection. Up to four reclose operations shall be available, each with a programmable dead time. For each reclose shot, the relay can be programmed to block any overcurrent element.

   The relay shall be equipped with an ambient temperature monitor that continuously monitors the temperature that the relay is exposed to. The ambient temperature monitor shall alarm when the device is exposed to extreme temperatures and undesirable conditions such as air-conditioning unit or station heater failures.

   The feeder protection relay shall have seven (7) output relays.

   a. 2 Form-A with coil monitor

   b. 5 Form-C

   The feeder protection relays shall have ten (10) digital inputs. The digital inputs shall be fully user programmable and have four voltage thresholds.

3. Monitoring and metering functions:

   a. Current: Phasors, RMS Values of per Phase, Neutral Current, Negative Sequence Current

   b. Voltage: Phase-to-Phase and Phase-to-Ground, Neutral Voltage, Negative Sequence Voltage, Zero Sequence Voltage, Auxiliary Voltage

   c. Power: Active, Reactive, Apparent & Power Factor

   d. Frequency

   e. An event recorder with a record of the last 256 events, time tagged with a resolution of 1ms.

   f. The waveform capture (oscillography) feature is similar to a transient/fault recorder. The oscillography shall capture 32 samples per cycle and the digital states.

4. Security / Change History Report

   The relay must comply with NERC CIP security reporting requirements and provide traceability. The relay must maintain a history of the last changes made to the configuration, including modifications to settings and firmware upgrades. A summary history of the last ten sessions and a list the last 100 specific setting changes made must be recorded and stored in non-volatile memory. The report must be available to be saved and printed in PDF format.

   Security Setting Reports must include the following information:

   a. Dates and times of setting changes

   b. MAC address of user making setting changes

   c. Listing of modified changes

   d. How setting changes were made

   e. Keypad, Front USB port, Ethernet & Rear Serial Port

5. User interfaces shall include:

   a. A 4 x 20 character LCD display, and navigation keys

   b. Indicator LEDs on the front panel which shall provide a quick visual indication of status

   c. A front panel USB serial port that shall provide easy computer access.
   The communications protocol shall be Modbus RTU

   d. One rear RS485 port. The communications protocol shall be Modbus RTU

   e. An optional RJ45 & MTRJ Fiber Optic Ethernet port shall be provided to allow 10BaseT Ethernet connectivity to Local or Wide Area Networks. The communications protocol shall support Modbus TCP

   f. The relay shall support the following communication protocols:

      1. Modbus RTU
      2. Modbus TCP/IP
      3. IEC 61850 GOOSE
      4. IEC 61850
      5. DNP 3.0
      6. IEC 60870-5-104
      7. IEC 60870-5-103
      8. PRP & HSR (IEC 62439-3)
      9. OPC-UA

   g. The Protection Relay shall have an IRIG-B input to allow time synchronization using a GPS clock over a wide area network.

   h. The IRIG-B input shall support both AM and DC time synchronization with an auto detect feature that removes the requirement of manual selection.

   i. The Protection Relay shall have support for IEEE 1588 Precision Time Protocol (PTP) to synchronize the time between different nodes on an Ethernet network and it is used when very precise time synchronization is required.

   j. The relay shall be capable of being set by Windows-based, Easy to use, Setup graphical terminal interface

k. To make the data acquisition more efficient, the feeder relay shall provide a User Definable Memory Map, which shall allow a remote computer to read up to 125 nonconsecutive data registers by using one Modbus packet. The User Definable Memory Map shall be programmed to join any memory map address to one in the block of consecutive User Map locations, so that they can be accessed by means of these consecutive locations. The User Definable area shall have two sections:

1. A Register Index area containing 125 Actual Values registers
2. A Register area containing the data located at the addresses in the Register Index

The relay must be capable of being programmed through a windows based software program that is capable of the following:

a. The software program will operate in the following fashion

1. Request system data from user through display screens.
2. Generate settings file
3. Review settings with user with the option to disable any configured settings that are not required
4. Provide PDF report outlining the settings that have been generated
5. Report and Settings file to be saved in user-selectable location

b. The setup software shall also allow the user to program the relay via a 'Quick Setup' feature.

1. This Quick Setup function shall be a single page screen.

6. Automation

a. The Protection Relay shall have programmable automation functions to allow the user to build simple logic.

1. The logic must include 16 (sixteen) logic elements
2. The logic elements can be programmable using the state of any contact, virtual or remote input or an output operand from protection or control elements.
3. The logic provides for assigning up to three triggering inputs in an 'AND/OR' gate for the logic element operation and up to three blocking inputs in an 'AND/OR' gate for defining a block signal.
4. Pickup and dropout timers shall be available for delaying the logic element operation and reset respectively.

To help extend product life, and to protect the feeder relay from hostile and harsh environments including moisture, temperature variations, salt spray, organic attack (fungus), and aggressive chemicals and vapors, the product manufacturer shall provide optional harsh environment conformal coating.

2.8 Engine-Control/Protection

A. Configurable Start And Stop Logic For Diesel And Gas Engines With Fully Programmable Settings

B. Can Sae J1939 Network Communication/Control To Engine Ecu

C. Engine Overspeed And Underspeed (Ansi 12 & 14)

D. Engine Speed/Frequency Mismatch Detection

E. Cool Down Timer

F. Customizable Protection Based Upon J1939 Or Analog Inputs

Part 3 Control System

3.1 Engine Generator Control shall be equipped with the following functions:

A. Should the generators supplied for the project not be able to synchronize with other generators, the Engine Generator Control shall have its own dedicated I/O and controls performing functions such as start/stop, synchronizing, load sharing, VAR/PF sharing, without depending upon Master Controller.

3.2 Master Control

A. The Master Control shall have a color touch screen Human Machine Interface (HMI) that allows the operator to view status and allows adjusting system variables. The Master Controls shall integrate a programmable controller, a Touch Screen Interface, Networking and I/O into a single compact unit utilizing single programming software for all graphics and logic.

B. The master controls shall have single or redundant hot standby processors

C. The touchscreen panel shall provide the following features and characteristics:

1. The HMI shall have a 19" color touchscreen display with at a minimum has available resolution of 1350 x 750, TFT-LCD, at a minimum supporting 100,000 different colors. System shall be a true PC with a common commercially available operating system, and the reliability of an industrial Programmable Logic Controller. Windows PC based systems are preferred. The controller shall be programmed via ladder logic. The faceplate shall utilize capacitive touchscreen technology in order to be more resistant to damage and discoloration.
2. The Control Panel shall be supportive of portable memory in the form of USB ports supporting common industry external memory drives. The Control Panel should allow operator access to a memory card slot without requiring the cabinet door to be opened.
3. The unit shall be powered with a 24Vdc control voltage using engine starting batteries. Necessary equipment shall be installed to prevent "brownout" situations during the engine crank cycle.
4. The unit shall operate at the temperatures range from 0 to 140 degree F
5. The unit shall be UL labeled and CE approved, including any ancillary AC power monitoring devices.

D. The HMI shall include, but not be limited to, the following screens:

1. **Menu Navigation Sub-Screen** - to provide one touch access all available system screens
2. **System Mimic Screen** – to display system paralleling configuration. Shall depict system configuration in a single line format and system status and can be reached in one touch from any screen in the system. Mimic screen will display the following information:
    a. Circuit Breaker Position
    b. Real time power values of generator set(s) Voltage, Amps, kilowatts, and Frequency, as well as visual display of generator status
    c. Real time power values of utility Voltage, Amps, kilowatts, and Frequency
    d. Real time Voltage, Amps, kilowatts, and Frequency of any common bus
    e. Animated and color coded electrical single line of the complete system
    f. Generator status
3. **System Setup Control Screen** – to allow user access to system settings and non-emergency operation wand tests such as:
    a. Engine cool down timer
    b. Fail to sync timer
    c. Minimum engine run timer
    d. All engine run timer
    e. Engine Selection for test functions
    f. Test with no load function
    g. Test with load function
    h. Test with load back function
    i. Light test
    j. Horn silence
4. **Generator Summary Screen** – allows operator to see detailed information and 3 phase metering of any generator. Data includes, but is not limited to, the following:
    a. 3 phase voltage and current readings
    b. Power readings such as kW, kVAR, kVA, and power factor
    c. Number of main breaker operations
    d. Generator bus voltage and frequency metering
    e. Generator priority rating
    f. Engine Data such as oil pressure, RPM, water temp, battery voltage, etc.
    g. Energy reading (kWH)
5. **Utility Summary Screen** – allows operator to see detailed information and 3 phase metering of incoming utility. Data includes, but is not limited to, the following:
    a. 3 phase voltage and current readings
    b. Power readings such as kW, kVAR, kVA, and power factor
    c. Number of main breaker operations
    d. Energy reading (kWH)

6. **Feeder Breaker Summary Screen:** graphical analog (270 electrical degree) meteringrepresentation with digital display. Shall display the following minimum metering data for selected generator set or selected main bus.
    a. 3 phase voltage and current readings
    b. Power readings such as kW, kVAR, kVA, and power factor
7. **Generator Control Screen** – allows operator to operate the generator manually and include:
    a. Engine Control Switch [ECS]
    b. Generator Breaker Control Switch
    c. Emergency Stop Push Button
    d. Alarm/Shutdown Reset push button
8. **ATS Summary Screen** – allows operator to see detailed information and 3 phase metering of any ATS. Data includes, but is not limited to, the following:
    a. 3 phase voltage and current readings
    b. Power readings such as kW, kVAR, kVA, and power factor
    c. Number of main contactor operations
    d. ATS switch position and source availability
    e. Test with load function
9. **Login and Security Screen** – allows operator to login, log off or exit the screens:
    a. Adjustable Timer to log off automatically if there is no activity.
    b. Logon push button
    c. Log OFF push button
    d. Exist push button
10. **Event Logs** – to display system status and warning information including:
    a. Current active alarms
    b. List of historical alarms and shutdowns with minimum of 100 events available for display
11. **Generator Annunciation Screen:**
    a. Generator shutdowns listed in Red with a minimum of 32 possible shutdowns
    b. Generator alarms listed in Yellow with a minimum of 32 possible alarms
    c. Generator status listed in Green with a minimum of 16 possible status
12. **Real Time Trending:** real time trending of voltage, current, power, and frequency is available for the following:
    a. Each available generator
    b. Utility
    c. Tie Breakers
    d. Main bus

13. **Maintenance Screens:** Password protected maintenance screens are available for the following information
    a. Breaker Maintenance which tracks or alarms the following information:
        1. Number of operations
        2. User configurable operation interval for maintenance
        3. Days since last maintenance
        4. warning for breaker past maintenance window
    b. Engine Maintenance which tracks or alarms the following information
        1. Engine run hours
        2. User configurable operation interval (hours) for maintenance
        3. Days since last maintenance
        4. warning for engine past maintenance window
14. **Communications Status Screen:** to display status of communication of each device in communication with the PLC. Each device will be displayed with either a Green or Red indication for communication status.
15. **Generator Optimization Screen:** Capable of managing generation system optimization either automatically or manually with the following adjustable parameters.
    a. Minimum reserve capacity
    b. Maximum reserve capacity
    c. Upper load limit
    d. Lower load limit
    e. Auto lead value switch [Auto/Man]
    f. Optimization main switch [Active/Bypass]
    g. Generator priority selector switch
16. **Load Control and Prioritization:** to provide flexibility to configure and control loads in various modes automatically or manually with adjustable following parameters
    a. Critical load shed value
    b. Maximum critical load shed value
    c. Critical load shed time
    d. Maximum critical load shed timer
    e. KW load shed reset switch [Auto/Man]
    f. Load configuration screen
    g. Load block enable switch [ON/OFF]

3.3 Special Features

A. Monitoring shall be based on true RMS three phase, phase to neutral on all generators sensing methods. Monitoring based on averaging or calculating a potential phase from the other two phases is not acceptable.

B. Shall have Soft-load transition during Load Demand Mode (standby operation) when load sharing between engine generators, on all diesel and natural gas generator sets. When a unit is in the Load Demand Mode and is being added, it will soft-load on to the bus. If a unit is taken off-line normally under load demand operation, the units should gradually unload before the generator breaker is signaled to open.

C. Shall have Bus Load Optimization

3.4 Communications Requirements

A. The Digital Commander Switchgear shall be interconnected to allow the control or monitoring of any unit by a single connection to a Local Area Network via either Modbus TCP (Ethernet) or Modbus RTU (serial). All information including transfer switches, engine points and parameters, and other third party devices can be communicated with effectively.

B. The Switchgear shall have the capability of communicating directly with different engine generator set manufacturers

C. Serial RTU/Modbus master/slave RS232/485

D. Utilizes Modbus protocol

E. Ethernet supporting, EGD, SRTP, Modbus/TCP

3.5 Security

A. **Security Code Required For Access** – Digital Commander has built-in security to protect against configuration changes and alarm purges by unauthorized personnel

1. System must have three (3) different levels of operator access to the HMI menus
2. System access must be password protected including both letter and number characters in the password
3. System must allow passwords up to 8 characters in length

B. **Levels of Access:**

1. Monitor with no control - Access to all Status Screens, view Alarm / Event Log Display, View only access.
2. Operator - Access to control system non-emergency modes of operation, alarm acknowledge and reset
3. Master - Allows access to edit settings and configurations of the system

3.6 Optional Control Features

A. The Digital Commander platform shall be fully flexible, in adding additional equipment such as future engine generators, external third party communication devices, AND additional I/O, with all this information easily sent to a Building Management System or owner host computer through one connection over Ethernet.

B. The Digital Commander control platform shall be supplied standard with controls for up to 64 ATS's

1. Available options include:
   a. Controls for 16 generators
   b. Controls for 64 loads (either ATS or feeder breakers)

C. The Control system shall have the option to add Master Controller Redundancy, with GE Intelligent Platforms RX3i PLC the only approved master controller.

D. The Control system shall have the option to add Master Touch Screen Redundancy.

E. The DPCS shall have capability to additional Remote Nodes for optional Remote Annunciation Panels and Mimic Graphic Panels accessing same information as primary Master Touch Screen Operator Interface Panel.

3.7 Remote Generator Alarm Annunciator Panels

A. The Switchgear controls shall have capability to add up to two optional Remote Annunciation Panels Touch Screen type [or LED type] that shall fully duplicate the Master Operator Interface Panel with virtual monitoring (no control) capability to provide the total system and individual generators remote status, alarm and display functions.

B. Visual and audible alarms shall be provided for each engine generator malfunction and adverse condition.

C. Visual status indications shall be provided for each automatic transfer switch in the system.

D. The Remote Annunciator Panel (RAP) shall comply with NFPA 99. It shall include an alarm horn and a single selector switch with “Alarm lamp/test”, “Alarm silence” and “Automatic” positions.

E. RAP shall be capable to locate up to 6500 feet (2000m) from the Paralleling Switchgear. RAP shall include proper communication (Ethernet switch with fiber optic) device interfacing with Digital Platform Control Cabinet – all fiber optic cables and installation are by others.

3.8 Remote POWER Monitoring

A. The Switchgear controls shall have capability to communicate with Building Management System [BMS] or Electrical Power Monitoring System [EPMS] via Ethernet, Modbus TCP or Serial Modbus RS-485 protocols.

3.9 Miscellaneous Components

A. **Control Fuses** - Control fuses shall be mounted in locations where they are readily accessible. Pullout type fuses shall be provided for all primary circuits and shall be of the current limiting type.

B. **Electromagnetic Control Relays** - All electromagnetic control relays shall be suitable and adequately rated f or their intended service in the control system.. Relays used for other than logic and dry contact switching shall have contact ratings suitable for make and carry of their duty current at the voltage of operation. All relays for control circuit duty shall be plug-in type with retaining clips and transparent plastic covers.

C. **Engine Controller** - The digital commander shall be provided with engine controller per each engine set. The controller shall be equipped with built-in synchronizer and load sharing module

D. **Door Mounted Control station with the following system controls:**

1. Audible Alarm Horn. Located in Master.

E. **DC Control Power Selector -- Best Battery System**
Control power for the system logic shall be derived from the engine starting batteries. The control logic shall be powered through a suitable means which shall permit continuity of power until the last battery is no longer available. The controls shall be powered from any battery or combination of batteries and prevent feedback to a failing battery. The transition of control logic power from any battery combination to any other battery combination shall be accomplished without disruption in the power flow.

3.10 Sequence of Operation

The Paralleling Switchgear Shall Have The Following Sequence Of Operation.

A. **Automatic Sequence of Operation**
Description applies to all engine generator sets.

A Programmable Logic Controller (henceforth referred to as PLC) is employed as the main logic unit for automatic operation of the paralleling system. All future references to interface and operator control switches are soft switches found on the touchscreen display.

When the Engine Control Switches (ECS) are in the "AUTO" position and the System Auto/Manual Switch (AUMS) on the Master Control is in "AUTO" position, the generating system is placed in Emergency Standby Mode.

B. **Emergency Standby Mode of Operation- Loss & Return of Utility Power Source**
Transferring automatically from utilities to the generators:

1. If the normal power drops below 80 percent of the nominal voltage for an adjustable period of time, a start signal will be sent to the master control PLC. The P timer (delay to engine start after normal voltage failure) is designed to avoid engine starts on momentary normal source failure. The P timer is adjustable from 0 to 10 seconds time delay, the factory setting is 3 seconds.
2. Start signal will be sent to all generators. Upon receipt of the remote start signal, the auto start relay will be energized and all available generators will be given a signal to start.
3. When any of the generators reaches operating voltage and frequency, a closure signal will be sent to that respective generator's circuit breaker to connect to the emergency generator paralleling bus through the dead bus relay logic. The DBR closing circuit prevents the simultaneous closing of two or more generators to the dead bus irrespective of the small probability of this event.
4. Once the next generator (random selection) reaches operating voltage and frequency, its respective automatic synchronizer will electrically adjust the engine governor to the frequency and phase angle of the energized generator bus.
5. When the next generator has been synchronized to the generator bus for 0.5 seconds, a closure signal is sent to that generator's circuit breaker to connect to the generator bus.
6. If the generator plant became overloaded during operation due to load increase or some generators failed to start, and is in danger of imminent shutdown, the system will initiate load shedding in reverse order.
7. When normal power is restored and all loads have transferred to the normal source, the Remote Start Signal Received Light on the annunciator panel will extinguish. A signal will then be sent to each of the generator circuit breaker to trip. Engine-generators will continue to run at no load for an adjustable cooldown period before shutting down and will be ready for the next loss of normal power operation. After a stabilization time delay [adjustable from ACS 0-60m].
8. If inhibit signal is active for any ATS, the generator start signal from that ATS will stay active, and the generators will keep running to feed that ATS. As soon as this signal is inactive, the remote start signal will be removed and the system will implement step 7 above.

Failure Modes during the loss & return of Utility Sequence

Notes:

A. All failures are PLC interlocked and one single mode failure is covered. Multiple failures are not considered.

B. Failures must be fixed to return to normal operation.

1. If all generator failed and utility was available
    a. The system should alarm (light and sound)
    b. The generators' breakers will open
    c. All loads and/or ATS will transfer to utility power
2. If any generator breaker failed to open after utility returns
    a. The system should alarm (light and sound)
    b. The generator shall continue running, until problem is fixed on the generator breaker. Or it requires operator intervention to open the breaker to allow the generator to shutdown. Problem on the breaker need to be fixed before allowing the unit to operate.
3. If any generator breaker failed to close/synch.
    a. The system should alarm (light and sound)
    b. The system will put the other available generators online.
    c. The system will shed the load if greater than generators capacity.
    d. The problem needs to be fixed
4. If any generator breaker LOCKED-OUT.
    a. The system should alarm.
    b. The system will proceed with rest of sequence of operation with locked out Generator not available until the specific fault condition is cleared.
5. If any breaker in the switchgear is withdrawn.
    a. The system will not send a close signal to any withdrawn breaker.

Manual Operation

A. When the AUMS switch is placed in the "MANUAL" position, all automatic functions will be locked out, and the opening and closing of breakers, synchronizing and paralleling procedures will be manually performed. It will be the responsibility of the operator to operate the switchgear.

Manual Operation for Generators

B. Manual operation of the switchgear is performed via the HMI touchscreen panel, as mentioned previously, all references to switches are soft switches located in the HMI. The manual paralleling is normally verified at initial system start-up but can be done for testing or if the generator's automatic synchronizer is inoperable. The MANUAL procedures for a typical generator are described as follows:

1. Place the AUMS, in the MANUAL position.
2. Place the ECS in the Manual position; this will initiate a start signal.

3. Initially, the emergency bus is DE-ENERGIZED; turn Synchronizing Switch (SS) to the ON position.
    a. Observe the reading of generator's voltmeter and frequency meter. In addition, observe the incoming voltmeter and frequency meter, located in the generator summary screen on the ACS.
    b. Compare the generator's incoming voltmeter and frequency meter to those of the master's running voltmeter and frequency meter located in the swing panel. The voltages must be within 5% of each other, and the frequency within ½ Hz of each other. Note that there are no running voltage or frequency reading for the first unit.
    c. Place circuit breaker switch (52S) in the CLOSED position. The emergency main bus is now energized by the first engine-generator.
    d. For the next and subsequent units, the speed and voltage of the incoming generator will be automatically adjusted by the engine controller and when the unit is in synch with the bus the breaker will be commanded to close.
4. Apply the same procedures for the remaining engine-generators.
5. Interlocking is provided to ensure that the synchroscope is turned on before a generator circuit breaker can be closed to the emergency bus

System Test

Test No Load

A. A two (2) position (OFF-TEST NO LOAD ON) Test No Load Switch (TNLS) is provided in the ACS. The system can be exercised using the TNLS without affecting the load as follows:
    1. Go to System Control Screen
    2. Press the TEST NO LOAD button (TNLS), the TEST NO LOAD ON label will illuminate. Concurrently, the system is performing the following steps:
        a. System under test light located on the system annunciation screenl will illuminate
        b. Start signal will be issued to selected engine-generator sets.
        c. First generator reaching proper operating parameters will close to the de-energized emergency bus.
        d. Subsequent units will synchronize and connect to the energized emergency bus.
        e. The load will be feed by normal power during this operation
    3. To remove the test no load operation, press the TNLS button again. The label will change from TEST NO LOAD ON to OFF. Concurrently, the system is performing the following operations:
        a. Signal is sent to open each generator circuit breaker.
        b. The engine-generators will run through a cooldown cycle before shutting down.
    4. If the utility power source fails during system test operation, the test will be aborted and the system will operate according to the automatic sequence of operation.

Load Test Sequence

A. A two (2) position (OFF-TEST WITH LOAD ON) Test With Load Switch (TWLS) is provided in the ACS. The system can be exercised using the TWLS as follows:

1. Go to System Control Screen
2. Select the TEST WITH LOAD button, the TEST WITH LOAD ON label will illuminate. Concurrently, the system is performing the following steps:
    a. System under Test light located on the system annunciator screenl will illuminate.
    b. Start signal will be issued to all engine-generator sets.
    c. First generator reaching proper operating parameters will close to the de-energized emergency bus.
    d. Test with Load Relays (TWLR) located on the back panel of master control section will energize.
    e. Subsequent units will synchronize and connect to the energized emergency bus.

B. To remove the test with load operation, press the TWLS button again. The label will change from TEST WITH LOAD ON to OFF. Concurrently, the system is performing the following operations:

1. Signal is sent to open each generator circuit breaker.
2. TWLR is de-energized (indicating light on relay should turn off).
3. The engine-generators will run through a cooldown cycle before shutting down.

C. If the utility power source fails during system test operation, the test will be interrupted and the system will operate according to the automatic sequence of operation.

Load Bank Test Sequence

A. A two (2) position (OFF-Load Bank TEST) Test with Load Bank Switch (TLBS) is provided in the ACS. The system can be exercised using the TLBS without affecting the load as follows:

1. Go to System Control Screen
2. Press the TEST LOAD Bank button (TLBS), the TEST with LOAD Bank ON label will illuminate. Concurrently, the system is performing the following steps:
    a. System under test light located on the system annunciation screen will illuminate
    b. Start signal will be issued to selected engine-generator sets.
    c. First generator reaching proper operating parameters will close to the de-energized emergency bus.
    d. Subsequent units will synchronize and connect to the energized emergency bus.
    e. The load bank breaker will close
    f. The load will be feed by normal power during this operation
3. To remove the test with load bank operation, press the TLBS button again. The label will change from TEST With load Bank ON to OFF. Concurrently, the system is performing the following operations:
    a. Signal is sent to open the load bank breaker
    b. Signal is sent to open each generator circuit breaker.
    c. The engine-generators will run through a cooldown cycle before shutting down.
4. If the utility power source fails during system test operation, the test will be aborted and the system will operate according to the automatic sequence of operation.

PART 4 - EXECUTION

4.1 Factory Testing And Quality Assurance Inspection

A. The equipment shall be factory tested to simulate a complete and integrated system. The circuit breakers supplied shall be installed in their actual positions and electrically and mechanically tested. A narrative of the system operation shall be provided and shall be utilized when testing the equipment. A certified factory test report shall be furnished to verify system testing.

1. The switchgear shall be subjected to the factory testing and quality control inspections to insure reliable operation. These tests and inspections shall include, but not necessarily be limited to, the following:
2. Perform a megger test on the entire main current carrying path with a 1000 volt megger. The minimum acceptable megger. Reading shall be 100 megohms on the switchgear, with all fuses, switches, circuit breakers, and contactors in the open position.
3. Circuit continuity and wiring
4. Mechanical equipment adjustment and operation of all moveable equipment and devices.
5. Equipment arrangements, types, and ratings for conformance with approved drawings.
6. Bus bar phase arrangement and bracing.
7. Integrity of all electrical connections.
8. Conformity with the nameplate and circuit identification indicated on the drawings and the approved manufacturer's drawings.
9. Demonstration of switchgear functions.

B. All switchboard equipment shall be given complete operational tests to ascertain that all design functions are satisfactorily performed. Testing shall include:

1. Actuation of all alarm indication devices.
2. All control circuits, automatic operations and interlocks shall be tested under simulated operating conditions.
3. All of the above shall be tested according to design specifications for correct operation.

4.2 Installation - The installing contractor shall perform all receiving, unloading, storage and installation of the equipment per all local applicable codes.

A. Installation Instructions:

1. One copy shall be furnished of the installation, operation and maintenance instructions for all equipment and devices provided under this Contract for use during the installation and commissioning into service of the emergency power system.

B. After installation by others, the engine-generator set and switchgear manufacturers shall provide the services of competent service technicians and project managers to work with the customer on appropriate schedule and to coordinate the commissioning of the equipment. They shall assist in placing the equipment into operation and provide instruction, as required, to the person or persons who are delegated to operate the equipment. This service shall include a minimum as follows:

   1. Pre-installation coordination meeting to coordinate the installation and interconnection of the switchgear with the engine-generator equipment.
   2. Initial checkout of the installation of the equipment to allow energizing of the switchgear.
   3. Post-installation start-up and testing prior to system turnover and for the initial instruction period for operating personnel. This shall include all service required to checkout the emergency power system and demonstrate its complete operation, for final acceptance by the Owner.

C. The switchgear manufacturer shall maintain a proficient factory service organization that is available for service and on call 24 hours a day, 7 days a week.

D. It shall be the responsibility of the installing contractor to verify that the following items have been completed and are ready to perform as specified before the arrival of the start-up technician.

   1. Inspect for obvious shipping damage.
   2. The switchgear is installed, anchored down and grounded.
   3. Shipping splits have been reinstalled with the splits bolted together, interconnect wiring installed and bus splice plates installed.
   4. Terminate all power cables.
   5. Install customer control wiring to external equipment including engines, batteries, ATS, associated motor controls, etc.
   6. The engine-generator set is installed and ready to run. (Batteries charged and fuel in tank, etc.).
   7. Associated motor controls, plumbing, building utilities are complete and operational.

E. The start-up technician shall perform the following items:

   1. Verify contractor connections, control power availability, visually inspect any relay settings.
   2. With the engine generator supplier's technical representative controlling the engine, verify that the switchgear and control equipment are fully operational and perform per the sequence of operation specified. Equipment or services shall be provided by the engine generator set supplier.
   3. With the engine generator supplier's technical representative controlling the engine, demonstrate all functions of the control system, both automatic and manual, to the satisfaction of the customer's designated representative.
   4. Provide plant operators with instruction on the plant operating procedures and major component operation after acceptance by the approving engineer.

4.3 Warranty And Service

A. Switchgear manufacturer warrants the equipment to be free from defects in material and workmanship for eighteen months from date of shipment.

B. Switchgear manufacturer shall have an established network of factory trained service technicians within the continental US capable of servicing the specified equipment and able to be reached 24/7.

C. After-warranty service contracts shall be available to the owner by the manufacturer to provide periodic maintenance and/or repair of the specified equipment.

4.4 Operation And Maintenance Materials

A. Operation Instructions and Maintenance Manuals:

1. After completion of work and start-up of the equipment at the project site, deliver to the Owner's Representative an operation instructions and maintenance manual and drawings presenting full details for care and maintenance of each item of equipment provided under this Contract.

2. Each manual shall contain the operating and maintenance information and key parts lists for all equipment provided under this Contract. When necessary, provide supplemental drawings to show system operation and servicing and maintenance points. For all electrical components, provide wiring and connection diagrams. Manuals shall include instructions required to accomplish specified operation and functions.

3. Switchgear drawings and wiring diagrams shall be included and up to date at the completion of start-up and system acceptance by the Owner. Drawings and wiring diagrams shall include any field modifications or changes to reflect actual as installed conditions.

4. In general the manual shall include, but not necessarily be limited to, the following:

    a. Switchgear Elevation drawings & One Line diagrams

    b. AC & DC Schematic and Physical Component Layout Drawings

    c. Remote Interface drawing

    d. Bill of Material

    e. Circuit Breaker Operation Manuals

    f. Description of System Operation

    g. Intuitive help menus on the HMI, Lists of all failure modes, and trouble shooting guidelines.

    h. Recommended Spare Parts List - showing all consumables anticipated to be required during routine maintenance and testing.

    i. BMS or EPMS communication interface list

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