SECTION 34 21 11

MULTI-FUNCTION PROTECTION RELAY EQUIPMENT

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Multi-function protection relay (MPR) equipment for DC feeder circuit breakers

B. MPR Main Processor

C. DC feeder circuit breaker automatic reclosing function

D. Short circuit protection functions

E. Contact rail potential indication function

F. Other internal logic functions

G. EtherNet interface functions

H. MPR discrete I/O

I. Data recording and retrieval functions

J. Security functions

K. Self-monitoring functions

L. MPR operator interface panel

M. MPR high-voltage measurement transducer

N. MPR power supply

O. Test and maintenance accessories

P. Factory testing

1.02 MEASUREMENT AND PAYMENT

Not Used

1.03 REFERENCES

A. Electronics Industries Association (EIA)

1. EIA 232-F — Interface Between Data Terminal Equipment and Data Circuit –Terminating Equipment Employing Serial Binary Data Interchange.

2. EIA 455-11-177A — Standards for Test Measurements and Inspection of Fiber Optic Cables, Connectors, and/or Other Fiber Optic Devices.

B. Institute of Electrical and Electronics Engineers (IEEE)

1. IEEE 37.90 — Standard for Relays and Relay Systems Associated with Electric Power Apparatus

2. IEEE 37.90.1 — IEEE Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus

3. IEEE 37.90.3 — Standard Electrostatic Discharge Tests For Protective Relays

4. IEEE 802.3 — Carrier Sense Multiple Access With Collision Detection.

C. National Electrical Manufacturers Association (NEMA)

1. NEMA WC70 / ICEA S-95-658 — Standard for Non-Shielded Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy

D. National Fire Protection Association (NFPA)

1. NFPA 70 — National Electric Code

2. NFPA 262 — Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air Handling Spaces.

E. Underwriters Laboratories (UL)

1. UL 1581 — Standard for Safety Electrical Wires, Cables, and Flexible Chords.

1.04 SUBMITTALS

A. Refer to Section 01 33 00 - Submittal Procedures, and Section 01 33 23 - Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.

B. Submit the following to demonstrate compliance with applicable standards:

1. Where equipment or materials are specified to conform to the standards of organizations such as ANSI, IEEE, NEMA, and UL, submit evidence of such conformance. The label of the specified agency will be acceptable evidence.

2. As an alternative to the label or listing, submit a written certificate from an approved nationally recognized testing organization, adequately equipped and competent to perform such activities, stating that the items have been tested and that the units conform to the specified standards.

C. Submit as a minimum, the following:

1. MPR product data, providing name of manufacturer, model/brand/catalog number, and one copy each of the applicable standards for each major component. Submittal shall be made in one package with a listing of the components arranged and identified in numerical sequence by article numbers within this Specification section.

2. Design drawings including:

a) MPR block diagram showing specified functional interfaces with external equipment including the dc switchgear, control and annunciator panel (CO2), and communications equipment.

b) MPR elementary control diagrams depicting logical functions or equipment including all interfaces with the CO2 panel and communications equipment.

c) Automatic reclosing system software logic diagram.

3. Required fusing, wiring, and other control circuit requirements.

4. Recommended MPR automatic reclosing and overcurrent protection settings.

5. Communications protocols demonstrating compatibility with protocols specified herein and the BART Communications Protocol (BCP).

6. MPR installation requirements for design coordination with the DC switchgear equipment layout.

7. Factory design and production test procedures and data sheets.

8. Recommended field test procedures and data sheets.

D. Submittals shall be made in both electronic format using the latest version of AutoCAD, and hard copy format.

PART 2 – PRODUCTS

2.01 GENERAL REQUIREMENTS

A. The MPR equipment shall provide data sensing/measurement on the 1000Vdc bus; DC feeder circuit breaker controls, indications, and protection; input/output (I/O) control functions; data logging; event recording; operator's interface; local & remote communication capabilities; and, other functions as indicated for dc feeder circuit breakers in traction power substations (TPSS's) and gap breaker stations (GBS's).

B. The MPR shall function properly in the BART system having the following characteristics:

1. Peak fault current – 100,000 amperes, maximum (DC feeder fault current in a 10 MW traction power substation).

2. Peak system operating current: For mainline DC feeder circuit breakers, load current peaks of up to 12,000 amperes for up to 20 second duration.

3. Rail Impedances:

a) Low Resistance Contact Rail: 0.00225 ohms/1000 feet

b) Standard Contact Rail: 0.00387 ohm/1000 feet

c) Running Rail (one track; two rails): 0.00485 ohms/1000 feet

C. The MPR shall be designed so that parts requiring adjustments and maintenance are easily accessible. The MPR shall be designed for 40 years service life.

D. MPR equipment shall be microprocessor based and shall include operational modules located in the following DC switchgear compartments:

1. A main processor board, located in the associated dc feeder breaker control cubicle.

2. A high-voltage signal measurement isolation transducer, located in the associated 1000 V DC feeder bus compartment.

3. Operator interface panel, mounted on the door of the associated DC feeder breaker control cubicle.

E. MPR equipment shall include all hardware, software, and ancillary circuits inter-connecting the various MPR equipment modules so as to implement the functional requirements specified herein.

F. Reliability Requirements

1. Mean Time Between Failure (MTBF) shall be at least 100,000 hours for core MPR components including main processor, high voltage measurement transducer, and operator interface unit, including cables interconnecting these components. MTBF

calculation shall include all failures that prevent these MPR components from operating normally as a complete system.

2. Contractor shall certify, using historical field service data or by calculation, a 95% certainty that equipment meets above reliability standard.

G. Environmental Immunity Requirements: The MPR shall be designed to operate properly and without malfunctions under the following environmental and service conditions:

1. Ambient Temperature: From –20 °C to +50 °C in accordance with IEEE 37.90-5.1.1.

2. Humidity: Up to 55% humidity outside the switchgear enclosure at temperatures up to 40°C, with excursions up to 95% humidity for a maximum of 96 hours, without internal condensation.

3. Dust: Extremely dusty environment; and enclosure shall at a minimum meet the requirements of a NEMA 12 type installation.

4. Electromagnetic Interference (EMI): The MPR shall function continuously and without error when subjected to all electromagnetic interference and static discharges present in the vicinity of 1000V DC and 34.5 kV AC power circuits.

5. Noise Rejection – Shall meet requirements of IEEE C37.90.1, Surge Withstand Capability (SWC) Tests, and IEEE C37.90.3, Electrostatic Discharge Tests.

6. Electrostatic Discharge (ESD) Immunity: The MPR shall meet the ESD immunity requirements of IEEE 37.90.3.

H. The MPR shall be capable of processing EtherNet and discrete input/outputs concurrently.

2.02 MPR MAIN PROCESSOR

A. The main processor board shall include following hardware as a minimum for implementing all the functions specified herein

1. Processor: 32-bit RISC processor.

2. Memory: Three memory modules shall be provided as listed below. Both flash EPROM and NVRM shall be non-volatile and shall be used to save and retain the equipment software, system parameters and settings, alarm log and data traces. The memories shall be designed and configured to retain all the software, settings, parameters, alarm logs, and recorded traces and other pertinent information without any power requirements. Memory capacity shall, as a minimum, be as follows:

a. 16 MB of RAM working memory

b. 16 MB of flash EPROM memory

c. 16 KB of non-volatile memory (NVRAM) to store system parameters and alarm log.

3. Watchdog circuit for processor supervision.

4. System clock with power backup for 30 days.

5. Communication Ports: The following communication ports shall be provided:

a. A dedicated fiber optic communication controller shall provide a high-speed serial interface to the isolation amplifier. The controller shall also monitor the integrity of the amplifier and the link.

b. A minimum 10/100 Mbps primary EtherNet port to communicate with the PLC in the CO2 panel. The port shall be equipped with 10BaseFX send/receive ports with ST connectors for multimode fiber.

c. A minimum 10/100 Mbps secondary EtherNet/IP communications port to communicate with remote terminals over the BARTNet Ethernet system. The port shall be equipped with 10BaseFX send/receive ports with ST connectors for multimode fiber.

2.03 DC FFEDER CIRCUIT BREAKER AUTOMATIC RECLOSING FUNCTION

A. MPR shall provide load measuring and automatic reclosing circuits for DC feeder circuit breakers. Reclosing logic shall permit bi-directional automatic re-closing; and load measuring when one side of the feeder circuit breaker circuit is energized and with the other side either energized or de-energized. The MPR shall prohibit reclosing if the DC buses on both sides of the DC feeder breaker are de-energized.

B. Provide sufficient noise immunity to achieve the required voltage measurement sensitivity during peak period system operation.

C. Automatic Reclosing System Parameters – The MPR shall at a minimum provide the following adjustable automatic reclosing system parameters. These parameters shall be adjustable as described below, and shall use the given acronyms:

1. Bus Voltage High Threshold, **Vhi**: 500 to 1000VDC

2. Bus Voltage Low Threshold, **Vlo**: 0 to 500VDC

3. Minimum Load Resistance to Allow Reclosing, **Rlim**: 0.1 to 0.4 Ω, adjustable in steps of not greater than 0.1 Ω.

4. Load Measurement Pulse Duration, **Pls**: 0.5 to 9.9 seconds, adjustable in steps of not greater than 0.5 seconds.

5. Delay between successive load measuring pulses, **Del**: 1 to 99 seconds, adjustable in steps of not greater than 1 second.

6. Load Measurement Delay (Lead, Neutral, Follow), **LNF**: -1=lead, 0=neutral, +1=follow. The Load Measurement Delay shall be used to avoid possible confusion between two or more MPR's attempting to reclose dc feeder breakers connected to the same contact rail section, so that a test voltage placed on the contact rail section during one MPR's load measuring cycle will not cause a misleading voltage reading during the voltage checking part of a second MPR's reclosing cycle.

7. Lead, Neutral, Follow Time Delay, **LNFDel**: 0 to 10 seconds, adjustable in steps not greater than 1 second.

8. Delay before starting first load measurement cycle, **Cdel**: 2 to 9 seconds.

9. Successful Close Timer (Time breaker shall remain closed to consider reclosing successful), **SucTm**: 0.5 to 3 seconds, adjustable in steps of not greater than 0.5 seconds.

10. Load Measurement Attempts (Number of times load measuring is attempted during one load measuring cycle), **LMTry**: 1 to 4

11. Close Attempts (Number of times the circuit breaker is allowed to close and trip again during the Successful Close Time interval before system initiates a 'soft' lockout. Sending the DC feeder breaker a trip command shall clear a soft lockout.), **CloseTry**: 1 to 4
12. Total time for the closing process before entering the soft lockout state, **LockOutTime**: 1 to 99 min.
13. Lockout Counter (Number of lockout resets given during the **HardLockDel** time that is necessary to force the MPR into the Hard Lockout state. Note that in these specifications the term "lockout" indicates a soft lockout that can be reset by issuing the MPR a trip command.), **SoftLocksNum**: 1 to 5
14. Hard Lockout Timer (Time during which a set number lockout resets, counted by the Lockout Counter, initiates hard lockout. Only pushing the RESET button on the Operator Interface can clear a Hard Lockout. Pushing the RESET button converts a hard lockout to a soft lockout, which can be cleared as explained above in Item 13), **HardLocksDel**: 1 to 99 minutes, adjustable in steps not greater than one minute.

D. Automatic Reclosing System Functional Logic – MPR Automatic Reclosing System logic shall operate in accordance with the Automatic Reclosing Routine Logic Diagram shown in Figure 1 in the Attachment to these Specifications, and the following text description:

1. Upon receipt of an 'Open' command (commanded 'Trip'), increment the Lockout Counter. If the Hard Lockout Timer = 0, then start the Hard Lockout Timer. If Lockout Counter = **SoftLocksNum**, and Lockout Timer ≥ **HardLocksDel**, then go to the Hard Lockout state and indicate Hard Lockout.

2. Upon receipt of a 'Close' command, if the MPR is neither in Hard nor Soft Lockout, and has previously been reset by an 'Open' command to enable closing, then initiate the automatic reclosing cycle.

3. On initiation of the auto-reclose cycle, measure voltages on both buses of the DC feeder breaker in accordance with the following logic:

   a) If voltages on both DC feeder breaker buses are > **Vhi**, then the DC circuit breaker shall be closed. If circuit breaker remains closed for longer than **SucTM** then the appropriate counters and timers shall be reset.

   b) If either **Vlo** < Bus Voltage < **Vhi** on line or load side DC feeder breaker bus, or **Vlo** < Bus Voltage for both buses, then monitoring of bus voltages during **LockOutTime** shall continue. Such voltage levels shall be unacceptable, and DC feeder breaker closing shall be prohibited when either of these conditions exists. If during **LockOutTime** the voltage states change to those of either Case (3a) or (3c), then action as indicated by the appropriate case shall be taken. If unacceptable voltage levels remain after **LockOutTime** has expired then lockout shall be indicated, operation shall proceed to Lockout state, and the appropriate counters and timers shall reset.

   c) If voltage on one side of the DC feeder breaker > **Vhi**, and voltage on the other bus is < **Vlo**, then load measuring shall commence, and 'Load Measuring/Reclosing' shall be indicated.

4. Prior to commencement of Load Measuring, the Load Measuring Attempt Counter shall be set = 1. Then the load measuring circuit contactor (Device 173) shall be closed, and the voltage across the load-measuring circuit resistor (across the open DC feeder breaker) shall be measured. If the measured load resistance between the contact rail and negative return rail is ≥ 0.2 ohms then the DC feeder breaker shall be allowed to close. If the circuit breaker remains closed for longer than **SucTM**, then the appropriate counters and timers shall be reset. If the measured load resistance is less than 0.2 ohms, then the Load Measuring Attempt Counter shall be incremented and another reclosing cycle shall be initiated.

5. If the Load Measuring Attempt Counter reaches **LmTry**, then operation shall proceed to the Lockout state, Lockout shall be indicated, and the appropriate counters and timers shall be reset.

6. If there is a number > **CloseTry** of successful reclosures and subsequent trips during the **SucTm** time setting, then Lockout shall be indicated and operation shall proceed to the Lockout state. The appropriate counters and timers shall be reset.

7. To clear a regular (Soft) Lockout, an 'Open' command shall be issued to the DC feeder breaker MPR. The MPR shall then accept and act on a subsequent 'close' command. To clear a Hard Lockout, the reset button on the MPR Operator Interface shall be pressed, and an 'Open' command shall be issued.

8. Note that the Lockout Counter shall keep a running count of 'Open' commands (or commanded 'Trip' commands) during a moving time window of length **HardLockDel**. If a period of more than **HardLockDel** passes with not more than one 'Open' command received, then the **HardLockDel** counting period shall automatically reset to zero.

E. Auto-reclosing Logic Negative Rail Potential Rise Compensation: When evaluating contact rail voltage, the MPR shall measure the voltage between the DC positive contact rail and the DC negative return rail. This measured voltage shall be greater than the **Vhi,** Contact Rail Energized Detection Threshold, in order to allow reclosing of the DC feeder breaker.

2.04 SHORT CIRCUIT PROTECTION FUNCTIONS

A. MPR shall implement short circuit protection for DC feeder circuit breakers. Provide, as a minimum, the following protective functions. Breaker tripping for Instantaneous, Reverse, Low Level Fault, and Timed Overcurrent functions shall be initiated when the feeder current > Trip Threshold, and Time > Trip Delay.

B. Instantaneous Overcurrent Trip (bi-directional, sensing current in both directions)

1. Trip Threshold, $\mathbf{I_{inst}}$: 0.3 to 9 PU

2. Trip Delay, **InstDel**: 0 to 250 millisec.

C. Timed Overcurrent Trip (bi-directional): Provide time overcurrent trip function with inverse time characteristic that can be graphed with the set current, $\mathbf{I_{tmd}}$, as the y-axis, and the time delay, TmdDel, as the x-axis. Tripping shall be initiated when the load current exceeds the set current during the period of time t such that (**t / TmdDel**) and ($\mathbf{I_{load}}$ / $\mathbf{I_{tmd}}$) correspond to a point on the curve.

1. Trip Threshold, $\mathbf{I_{tmd}}$: 0.2 to 2.5 PU

2. Time Delay, **TmdDel**: 0.1 to 150 sec

D. Low Level Fault Trip (bi-directional)

1. Trip Threshold, $\mathbf{I_{LLF}}$: 0.05 to 5 PU

2. Trip Delay, **LLFDel**: 0.5 to 99 min

E. Reverse Overcurrent Trip

1. Trip Threshold, $\mathbf{I_{rev}}$: 0.1 to 9 PU

2. Trip Delay, **InstDel**: 0 to 250 millisec

F. Rate of Rise (ROR) Trip

1. Current trip limit, **di/dt**: 1 to 50 PU/sec

2. Current rise limit, **ΔI**: 0.1 to 2 PU

3. Delay time, **Delay**: 40 to 400 millisec

4. Rate of rise trip shall be initiated if all of the following conditions are met:

a. Current di/dt exceeds the trip limit, **di/dt**

b. di/dt stays above the trip limit during the delay time, **Delay**

c. During the delay time current exceeds the current rise limit, **ΔI**

2.05 CONTACT RAIL POTENTIAL INDICATION FUNCTION

A. Provide Contact Rail Potential Indication function with the following user-adjustable parameters:

1. Pick-up voltage threshold, **Thr**: 0 to 1000V

2. Hysteresis, **Hst**: 0 to 300V (When the contact rail indication pickup voltage has indicated an undervoltage condition, then (**Thr** + **Hst**) shall be the value at which the relay 'drops out' and the undervoltage indication becomes inactive).

3. Contact Rail Potential Undervoltage Pickup Delay: 0 to 3 sec.

B. The Contact Rail Potential function shall be fail-safe such that in the event of MPR equipment function failure, contact rail energized shall be indicated.

2.06 OTHER INTERNAL LOGIC FUNCTIONS

A. Close Command with Circuit Breaker in Test Position: With a circuit breaker in TEST position, its associated MPR shall issue a Close command to the circuit breaker upon receipt of a Close command input from the corresponding breaker test control switch mounted on the breaker cubicle door. Under this condition the circuit breaker shall close without load measuring.

B. Load Measure Command – The MPR shall issue a Load Measure command, using a discrete dry contact relay output specified in Article 2.08.C, when directed to do so by the automatic reclosing logic, provided the following conditions are satisfied:

1. Circuit breaker is open

2. Door switch interlock indicates that circuit breaker cubicle door is closed

3. Circuit breaker is in the CONNECTED position

C. Directional Current, Forward and Reverse

1. The MPR shall receive output current from the shunt in the Forward direction (main bus to feeder bus) and the Reverse direction (feeder bus to main bus)

2. The MPR directional current functions shall detect current levels of 25% of the rated shunt current, at a minimum

D. Transfer Trip Initiate Commands, Forward and Reverse

1. The MPR shall issue a Transfer Trip Initiate command when the Transfer Trip Initiate logic is true, and the following conditions are satisfied:

   a) Circuit breaker direct acting series trip input is activated

   b) OR the MPR has detected an overcurrent condition.

   c) AND MPR current direction logic detects either forward or reverse shunt current flow.

2. Transfer Trip Initiate command shall be issued through discrete dry contact relay outputs, one for Transfer Trip Initiate Forward, and another for Transfer Trip Initiate Reverse as described in Section 2.08.C. MPR shall be provided with a means to allow the District to choose between forward or reverse current flow.

2.07 ETHERNET INTERFACE FUNCTIONS

A. The MPR shall accept and communicate the following input/output functions through the primary Ethernet port connecting to the control and annunciator panel (C02) PLC, specified in Section 34 21 33, Control, Monitoring and Display Panel:

1. Inputs

   a. Breaker OPEN command (non-reclosing)

   b. Breaker CLOSE command

2. Outputs

   a. Breaker OPEN indication

   b. Breaker CLOSE indication

   c. Trip-reclose indication

   d. Contact rail undervoltage (latching, defined so that system defaults to ‘RAIL ENERGIZED’ state upon MPR indication failure)

   e. MPR soft lockout indication

   f. MPR hard lockout indication

   h. Transfer trip forward (current flow from main bus to dc feeder bus)

   i. Transfer trip reverse (current flow from dc feeder bus to main bus)

g. MPR trouble / loss of control power output (latching, normally closed (NC), to indicate trouble/loss of control power)

h. Analog data output: instantaneous dc main and feeder bus voltages, and dc feeder bus current.

B. A secondary EtherNet port shall allow access to MPR system diagnostic data only. This EtherNet port shall be non-routable with the primary EtherNet port, and shall provide no ability to control the MPR or alter any MPR parameter setting.

1. The following diagnostic functions only shall be available through the secondary EtherNet port:

a. View analog data: instantaneous dc main and dc feeder bus voltages, and dc feeder shunt current.

b. View and download alarm log

c. View and download Softscope data traces

d. View MPR parameter settings

2. The secondary IP-addressable EtherNet port shall be remotely accessible by host computers over the BARTNet system using TCP/IP protocol.

3. The secondary EtherNet port shall be locally configurable to allow uploading of software upgrades and modifying MPR parameters from a test set computer.

2.08 MPR DISCRETE I/O

A. General – The MPR shall be equipped with discrete inputs and outputs and a circuit breaker tripping output as described below. The I/O board shall be powered from the MPR main module. All inputs and outputs shall be optically isolated and filtered and shall have LEDs for status annunciation.

B. Discrete Inputs – Each input shall be powered from the MPR controller, and shall accept input voltage levels from between 32 and 125V AC or DC. Programmable discrete inputs shall be as follows:

1. Breaker CLOSE command

2. Breaker TEST CLOSE command

3. Breaker OPEN (non-reclosing trip) command

4. Breaker TRIP-RECLOSE command: The Trip-Reclose command input shall cause circuit breaker to trip immediately. Following tripping of circuit breaker due to Trip-Reclose signal, the MPR shall take no action until cessation of the Trip-Reclose input

signal. Upon cessation of the Trip-Reclose command the circuit breaker shall attempt reclosing.

5. Breaker Auxiliary indication (Open/Closed)

6. Breaker direct acting series trip indication

7. Breaker Position indication (Test/Connected)

8. Breaker cubicle door indication (Open/Closed)

9. System control power ON

10. Two general-purpose programmable inputs

C. Discrete Outputs – Relay output contacts shall be rated at 5 amps at a maximum contact voltage of 150 VDC. The outputs shall be programmable to provide maintained or non-maintained operation, with the non-maintained signal duration programmable from 0.5 to 3.0 seconds. Programmable outputs shall be as follows:

1. Close breaker command

2. Load Measure

3. Circuit breaker Open indication

4. Circuit breaker Closed indication

5. Transfer Trip Forward (current flow from main dc bus to dc feeder bus)

6. Transfer Trip Reverse (current flow from dc feeder bus to dc main bus)

7. Two general-purpose programmable outputs

D. The MPR shall have an optically isolated triggering circuit, rated 40A for 0.5 sec, one amp continuous, 300 V DC maximum voltage. This output will be used for the breaker trip command. The triggering pulse shall be programmable between 0.5 and 3 seconds.

E. Each MPR input and output, including the tripping output, shall have an associated LED on the I/O board that indicates:

1. Input received

2. Output relay picked up

3. Tripping output active

2.09 DATA RECORDING AND RETRIEVAL FUNCTIONS

A. Alarm Memory – The MPR shall, at a minimum, retain records of last 200 trips and/or alarms with date/time stamps. Alarms shall include all trip events, failures to reclose, and system malfunctions. The following alarm indications shall, as a minimum, be provided:

1. Rate of Rise
2. Instantaneous Overcurrent
3. Reverse Overcurrent
4. Timed Over current
5. Low Level Fault
6. Breaker Open trip
7. Breaker Trip-Reclose
8. Uncommanded Breaker Trip
9. Breaker Closure Timeout
10. Soft Lockout Initiated
11. Hard Lockout Initiated
12. Closure Fail (volt level)
13. Closure Fail (de-energized)
14. Closure Fail (success timeout)
15. Contact Rail Undervoltage
16. Incomplete Sequence
17. Isolation Amplifier initialization problem
18. Isolation Amplifier data problem
19. Warning Current

B. Voltage and Current Records

1. Oscilloscope – Built in softscope type oscilloscope shall allow taking of voltage and current snapshots, before and after a triggering event. Softscope shall have the capability of setting up to ten simultaneously active triggering events. Each of the events shall be selectable from among the alarm events to include positive and negative overcurrent, positive and negative overvoltage, and other abnormal system conditions to be specified.

2. MPR shall retain oscillogram records of voltage and current traces for at least the last ten preset alarm events. These alarm events shall be retained in the non volatile memory and shall be retrievable even after complete power failure to the MPR.

3. Each oscillogram data record shall consist of two sets of data:

   a) One set shall store samples for the period of time from approximately 220 ms before a tripping action to 40 ms after the tripping action, with a 65 μs sampling interval.

   b) The second set shall store samples for the period of time from approximately 230 sec. before and 30 sec. after a tripping action, with a 65 ms sampling interval.

   c. Data trace triggering events shall be selected from among the alarm events specified above.

2.10 SECURITY FUNCTIONS

A. MPR shall provide the following password-protected security levels, as a minimum:

1. Observer: Lowest security level, no password required to access Observer level.

   a. Allows viewing of all relay parameter settings and stored data.

   b. Does not allow access to system security passwords.

2. Supervisor: In addition to all Observer level permissions, allows:

   a. Modifying time and date

   b. Allows downloading alarm log and stored data traces

3. Expert: In addition to all Supervisor permissions, allows:

   a. Modifying all parameters

   b. Modifying Supervisor and Expert security passwords

4. Master: Password for Master level shall not be able to be reset. The Master security level overrides all other levels.

B. A physical lock/key type security system is not acceptable.

2.11 SELF-MONITORING FUNCTION

A. MPR shall initiate a self-test on power-up, and shall continuously monitor internal operations using a watchdog circuit. If the controller fails to toggle the watchdog circuit for more than one second, the watchdog circuit shall initiate a trouble alarm. The MPR shall indicate system trouble locally by an LED located on the Operator Interface Unit. In addition, the MPR shall be provided with an output relay contact and an alarm signal available at the MPR's primary Ethernet port. Alarms shall be stored in the alarm log.

B. As a minimum, the MPR shall perform the following series of self-test functions when control power is connected to the MPR:

1. Test of non-volatile and volatile memories
2. CPU test
3. Power supply voltages normal
4. System monitoring active
5. Output relays functional
6. Primary and secondary EtherNet connection active

C. MPR shall allow access for internal system diagnostics through the operator keypad, and through the secondary Ethernet/IP network connection.

D. Main Processor shall monitor high voltage transducer and shall initiate MPR trouble alarm upon any malfunction.

2.12 MPR OPERATOR INTERFACE PANEL

A. Display – Provide TFT/LCD active matrix color display with the following characteristics:

1. Active area: 6.4 inches x 4.8 inches, minimum.
2. Diagonal size: 8.0 inches, minimum.
3. Resolution: VGA, 640 x 480 pixels, minimum.
4. Response time: 80 ms, minimum.
5. Brightness: 380 nits, minimum.
6. Contrast Ratio: 250, minimum.

B. Operator keypad – A numeric and/or arrow membrane keypad controlling the display panel shall allow user to view the alarm log and system diagnostics, and to change user-adjustable parameters.

C. System shall allow user to access system parameters, status, control, and indication through hierarchical graphical menus viewed on the Operator Interface Panel viewing screen and controlled through the operator keypad.

D. The top level default screen shall display:

1. Present instantaneous DC feeder breaker line voltage, load voltage, and shunt current.

2. System status indications, including “System Healthy”, “Lockout”, “Hard Lockout”, and “Overcurrent Trip”.

E. User shall be able to access system sub-menus from the top level screen, including:

1. General system functions including shunt and system configuration parameters.

2. Protection function parameters, including:

a. Instantaneous, Timed, Low Level, and Reverse overcurrent

b. Rate-of-Rise

c. Contact Rail Potential

3. Automatic Reclosing function parameters, including voltage, load measuring, timing, lockout, and hard lockout.

4. Command functions including Alarm Log, Time/Date, security level, and password definition.

5. Gain adjustments allowing user to adjust 1000V DC system measured voltage and current gain to within ± 1% of actual, independently measured values.

6. Help functions, including context-sensitive how-to operating instructions

F. Parameter display screens shall highlight parameter settings that are adjustable at user’s present security level.

2.13 MPR HIGH VOLGTAGE MEASUREMENT TRANSDUCER

A. MPR shall obtain voltage and current indications using a transducer mounted in the switchgear 1000V-dc circuit breaker compartment as near as possible to its associated shunt. The transducer and its ancillary hardware and cables shall be sufficiently rugged to withstand dust; dirt; and thermal, mechanical and electrical stresses associated with 1000V, high current DC circuits.

B. Transducer shall have following minimum characteristics:

1. Isolation:

a) Continuous: 4 kV

b) Peak: 8 kV test

2. Accuracy: ± 2% Full Scale

3. Current Range: 0 – 40 KA

4. Mounting: Of adequate strength to withstand all thermal and mechanical stresses associated with the maximum short-circuit currents equal to the interrupting rating of the circuit breakers indicated above.

5. Transducer shall derive all voltage and current measurements from electrical connections with line and load sides of DC circuit breaker, and with a DC shunt.

C. Connection between Transducer and Main Processor

1. The fiber optic connection between the transducer and main processor shall transmit a current and voltage sampling pulse signal, and a link integrity pulse signal, between microcontroller and transducer once every 0.5 seconds, at a minimum.

2. Serial data connection shall be flexible duplex fiber optic cable, of small bend radius, certified to meet EIA-455-11-177A.

D. The transducer ancillary equipment shall include any bleeder resistors between DC positive and negative buses, and voltage transducer necessary to provide adequate filtering of any random switchgear operating transient voltages to assure correct MPR indication and control.

2.14 MPR POWER SUPPLY

A. MPR shall be designed for operation with either 125Vdc or 120Vac power supply from the station power sources. Normal power shall be from 125Vdc, and in case of normal power failure, the MPR shall automatically switch over to 120Vac back up supply without losing any of its functionality. The MPR shall operate over a range of ±10% of rated voltage.

2.15 TEST AND MAINTENANCE ACCESSORIES

A. Furnish three complete sets of special tools and test equipment, each set comprising all hardware and software necessary for field testing, diagnostics, maintenance and repair of the MPR, including the isolation transducer. At a minimum, each set of test apparatus shall comprise the following:

1. Laptop computer shall be the latest applicable model at time of bid, and shall furnish the following minimum capabilities:

a. 2.5 GHz processor speed

b. 1024 MB SDRAM memory

c. 40 GB hard drive

d. 48 x Max RW CD-ROM

e. One Ethernet, one RS-232 serial, and two USB ports

f. 13.3-inch LCD flat panel display

g. Latest Windows operating system

2. Software required for MPR testing, set-up, and diagnostics

3. Test apparatus to verify MPR discrete input and output operation. Apparatus shall connect to the discrete input and output I/O ports and shall activate the indicating LED's to verify correct I/O operation.

4. Any other hardware and software, including all cables, laptop carrying case, and batteries, and computer software to provide complete and functional test equipment.

2.16 FACTORY TESTING

A. General: Testing of the MPR and isolation transducer shall be in accordance with the requirements of Section 01 45 24, Testing Program Requirements.

B. Design Tests: The following design tests shall, as a minimum, be performed on one MPR including Isolation Transducer and Operator Interface Panel. Where appropriate, the MPR, Isolation Transducer, and Operator Interface Panel shall be tested as a unit. The testing shall be performed by a company or agency certified by the International Electric Testing Association (NETA):

1. Dielectric Strength: Tests per IEEE 37.90; and for the isolation transducer input, also at voltages as required by these Specifications.

2. Surge Withstand Capability (SWC): Tests involving oscillatory and fast transient surges per IEEE 37.90.1.

3. Electrostatic Discharge (ESD) Immunity: Test per IEEE 37.90.3

4. Performance Verification Tests: Detailed procedures for the tests listed below shall be prepared and submitted for approval by the Engineer. Tests shall ascertain the proper functioning, accuracy and response time of the MPR including isolation transducer. At a minimum, tests shall include the following:

a. Input voltage measurements (accuracy and range verification).

b. Input current measurements (accuracy and range verification).

c. Verification of the proper operation of all protective functions.

d. Verification of the proper operation of the load-measuring and auto-reclosing logic, including observance of user-defined parameters.

e. Verification of the proper functioning of the self-diagnostic features, including trouble alarms, events storage and current and voltage data traces.

f. Verification of the proper operation of all user interfaces, including parameter updates through the operator interface panel and interrogation/diagnostics via the EtherNet ports.

g. Verification of the correct operation of the MPR and isolation transducer when the power supply voltage is varied within the specified operating range and confirmation of the proper functioning of the dual power supply with automatic changeover between the normal and backup power sources.

h. Verification of the proper functioning of all MPR inputs and outputs.

i. Verification of proper communications between the MPR primary EtherNet communications port and the CO2 panel PLC as described in Section 34 21 33, Control, Monitoring, and Display Panel. Tests shall verify all required controls, indications, and data access functions.

j. Verification of proper communications between the MPR secondary EtherNet/IP communications port and a host PC terminal. Tests shall verify all required controls, indications, and data viewing and download functions.

k. Verification that stored alarm and data trace information is retained in memory and can be readily accessed following a complete MPR primary and back-up power failure.

C. Production Tests: Detailed procedures for the tests listed below shall be prepared and submitted for approval by the Engineer. Tests shall be performed on all complete MPR units, including Isolation Transducer and Operator Interface Panel. At a minimum, these tests shall include:

1. Confirmation of the correct calibration for current and voltage measurements of the isolation transducer, and proper functioning of the MPR software.

2. Confirmation of the correct values for all default settings.

3. Confirmation of the proper operation of Operator Interface, RS-232, and EtherNet user interfaces.

4. Confirmation of the proper operation of the load–measuring and auto reclosing logic, and all protective functions, by the use of simulated fault conditions

5. Confirmation of the proper functioning of all inputs and outputs of the MPR.

PART 3 – EXECUTION

Not Used

ATTACHMENT

FIGURE 1 - MPR RECLOSING LOGIC DIAGRAM

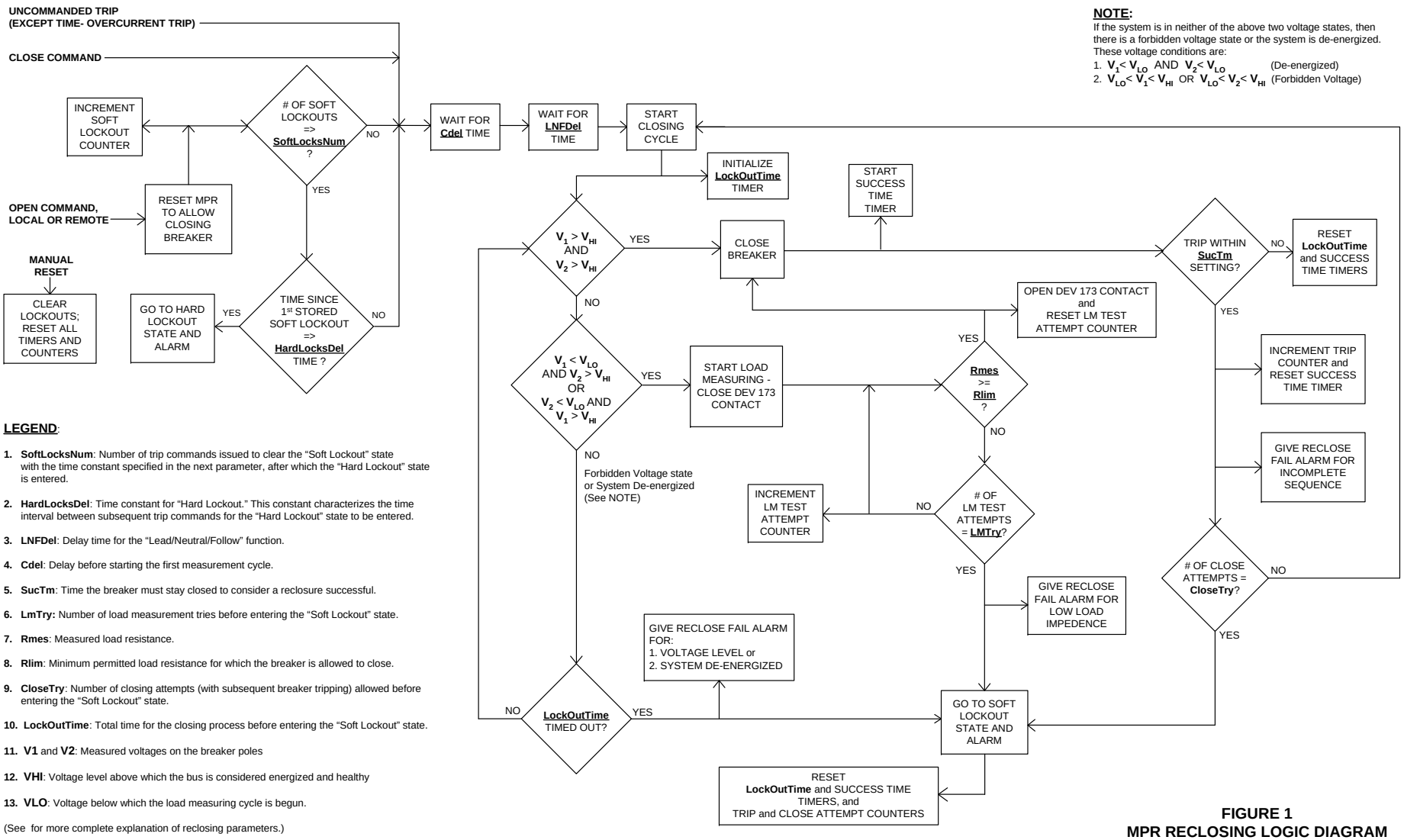

FIGURE 1
MPR RECLOSING LOGIC DIAGRAM

END OF SECTION 34 21 11