PART 1 – GENERAL

1.01 SECTION INCLUDES

A. System overview
B. Protection
C. Control
D. Automation
E. Communication and integration
F. Metering, monitoring, and reporting
G. Voltage and current input/output
H. User interface
I. Security
J. Power supply
K. Self-monitoring
L. Test and maintenance accessories
M. Spare parts
N. Factory testing

1.02 RELATED SECTIONS

A. Refer to the following Sections for requirements:
   1. Section 01 33 00 Submittal Procedures
   2. Section 01 33 23 Shop Drawings, Product Data, and Samples
   3. Section 01 42 19 Reference Standards
   4. Section 01 43 00 Quality Assurance
   5. Section 01 45 00 Quality Control
   6. Section 01 45 24 Testing Program Requirements
7. Section 01 78 23 Operation and Maintenance Data
8. Section 01 78 39 Contract Record Documents
9. Section 26 05 53 Identification Requirements
10. Section 27 13 01 Communication Cables and Related Equipment
11. Section 34 21 17 AC Switchgear (SF-6 Gas Insulated Type)
12. Section 34 21 18 AC Switchgear (Sealed Vacuum Type)
13. Section 34 21 33 Traction Power Control, Monitoring and Display Panel
14. Section 34 21 35 Emergency and Transfer Trip System
15. Section 34 21 40 DC Control Power System
16. Section 34 21 50 Common Materials and Methods for Traction Power
17. Section 34 21 75 Traction Power Facility System Factory Functional Testing
18. Section 34 21 80 Traction Power System Field Acceptance and Testing Requirements

1.03 MEASUREMENT AND PAYMENT

Separate measurement or payment will not be made for work required under this Section. All costs in connection with the work specified herein will be considered to be included with related items of Work in the Bid Schedule of the Bid Form, or incidental to the Work.

1.04 REFERENCES

A. Electronics Industries Association (EIA):

1. EIA/TIA 232_F Interface Between Data Terminal Equipment and Data Circuits

B. Institute of Electrical and Electronics Engineers (IEEE):

1. IEEE 802.3 Standard for Ethernet
2. IEEE C37.90 Standard for Relays and Relay Systems Associated with Electric Power Apparatus
INTEGRATED PROTECTION RELAY EQUIPMENT – HIGH VOLTAGE AND TRACTION POWER SUBSTATIONS

4. IEEE C37.90.3 Standard Electrostatic Discharge Tests for Protective Relays

5. IEEE C37.118 Synchrophasor for Power Systems - Measurements


8. IEEE 1588 Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems


C. International Electrotechnical Commission (IEC):


3. IEC 61850 Power Utility Automation

4. IEC 62439-3 Industrial Communication Networks – High-availability Automation Networks - Part 3: Parallel Redundancy Protocol (PRP) and High-availability Seamless Redundancy (HSR)

1.05 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 TIA/EIA, IEEE, and IEC 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. Integrated Protection Relay (IPR) product data, providing name of manufacturer, model/brand/catalog number/activated optional features, and one copy each of the applicable standards for major components. 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. Shop drawings including:
   a. IPR block diagram showing specified functional interfaces with external equipment including the AC switchgear, control and annunciator panel (C02), and communications equipment cabinet (C04), and emergency and transfer trip Cabinet (ETTC).
   b. IPR elementary control diagrams depicting logical functions or equipment including interfaces with the C02 panel, communications, and ETTC.

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

4. Required IPR control and protective device settings and software configuration files for each relay installed.

5. Communications protocols demonstrating compatibility with Modbus TCP/IP or DNP3 communications protocols.

6. IPR installation requirements.

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

8. Production Test Certifications.

9. Field test procedures and data sheets.

1.06 SYSTEM OVERVIEW

A. IPR equipment provide control and protection functions for AC switchgear located at the following BART 34.5 kV power distribution system facilities:

1. High Voltage Substations (HVS): HVSs receive power at 230 kV, 115 kV, or 60 kV utility transmission voltages at the facility primary side. HVS equipment consists of motorized high voltage air switches, high and medium voltage circuit breakers, a transformer, protection, control, and metering equipment, and station ancillary equipment. HVS convey 34.5 kV voltages from the facility secondary side for use in BART 34.5 kV sub-transmission system circuits.
2. Traction Power Substations (TPSS): TPSS are located along the track alignment at intervals varying between one-half and four miles. Each TPSS is supplied by two independent 34.5 kV sub-transmission system circuits, and converts the incoming AC power to 1,000 V (nominal) DC to power trains via the positive (contact rail) and negative (track running rail) DC distribution systems. TPSS equipment consists of medium voltage circuit breakers, traction power IEEE Circuit 31 type rectifier transformer-rectifier units, DC switchgear, AC vacuum switches, DC no-load break switches, protection and control equipment, and station ancillary equipment.

3. Switching Stations (SWS): SWSs receive power at 34.5 kV from HVS facilities for distribution to the BART 34.5 kV sub-transmission system. The sub-transmission system consists of two independent parallel feeder circuits that distribute power to traction power substations along the track alignment. SWS equipment consists of medium voltage switchgear, protection, control, and metering equipment; and station ancillary equipment.

4. Sectionalizing Stations (SS): Each 34.5 kV sub-transmission system power zone is normally supplied by a dedicated SWS. SSs located at the power zone boundaries enable power to be supplied from an adjacent power zone SWS in the event that the normal power supply unavailable. The SS 34.5 kV circuit breakers are normally open, but may be closed if needed to bring power from an adjacent zone’s SWS. SS and SWS circuit breakers are interlocked to prevent parallel feeding from independent utility supply sources. SS equipment consists of medium voltage switchgear, protection and control equipment, and station ancillary equipment.

1.07 WARRANTY

A. The IPR shall include a ten-year warranty for material and workmanship defects. The warranty shall cover accidental customer-induced damage.

B. The manufacturer shall support a 72-hour turnaround on warranty repairs.

1.08 SERVICE

A. Provide no-cost technical support during the warranty period.

PART 2 – PRODUCTS

2.01 GENERAL

A. The IPR microprocessor-based relay shall provide a combination of functions including protection, monitoring, control, and automation, as described herein.
B. Environmental Immunity Requirements: The IPR shall be designed to operate without malfunctions under the following environmental and service conditions:

1. Environmental Requirements: The IPR shall be suitable for continuous operation over a temperature range of minus 40 degrees to 85 degrees Celsius, and shall meet the following requirements:
   a. Cold: IEC 60068-2-1, Severity Level: 16 hours at minus 40 degrees Celsius
   b. Damp Heat: IEC 60068-2-30, Severity Level: 25 degrees Celsius to 55 degrees Celsius, 6 cycles, Relative Humidity: 95 percent
   c. Dry Heat: IEC 60068-2-2, Severity Level: 16 hours at 85 degrees Celsius

2. Vibration:
   a. IEC 60255-21-1, Severity Level: Class 1 – Endurance
   b. IEC 60255-21-2, Severity Level: Class 1 – Shock Withstand, Bump, and Class 2 – Shock Response
   c. IEC 60255-21-3, Severity Level: Class 2 – Seismic Tests

3. Surge Withstand Immunity: IEEE C37.90.1, Severity Level: 2.5 kV oscillatory; 4.0 kV fast transient waveform.

4. Electrostatic Discharge Immunity: IEEE 37.90.3, Severity Level: 2, 4, 8 kV contact; 2, 4, 8, 15 kV air.

2.02 PROTECTION

A. IPR for HVS and TPSS shall meet the following:

1. The relay shall include protection functions as indicated on the Contract Drawings. Relays requiring functionalities described below shall provide characteristics hereunder.

2. Relays requiring differential protection shall include differential protection using at least five three-phase current inputs capable of monitoring four zones. Differential functions shall include:
   b. Negative Sequence Differential Protection (87N): Include negative-sequence differential protection for turn-to-turn fault detection within the transformer. The negative-sequence differential element shall detect turn-to-turn faults as low as two percent of the total winding.
c. Unrestrained Differential Protection (87U): The relay shall include unrestrained differential protection to provide rapid tripping for internal faults.

d. Relay shall be programmable to accommodate phase shifts and current transformations.

3. Combined Currents: The relay shall incorporate elements to provide overcurrent protection based on summation of currents from a minimum of four protection zones, implemented using combinations of three-phase CT inputs.

4. Overcurrent Protection: Relays requiring overcurrent protection shall include phase, negative, and zero-sequence overcurrent for both instantaneous and time-overcurrent elements. Torque control capability shall be provided for the inverse-time elements. Adaptive time-overcurrent elements shall be provided that allow operate quantity selection and programmable time-delay and pickup settings.

5. Directional Element: The relay shall include voltage polarized directional elements for phase and ground currents.

6. Earth Fault Protection: The relay shall provide three separate earth fault protection elements for the detection of ground faults in wye-connected windings.

7. External Faults: Upon detection by the relay of a fault external to the differential zones, the relay shall enter into a high-security mode to change the sensitivity of the relay (slope of differential) to avoid nuisance tripping.

8. Breaker Failure Protection: The relay shall include internal breaker failure protection with retrip functions for each of the terminals, and be selectable to accept external breaker failure protection. (call alarm “A0X trip circuit problem”)

9. Current Unbalance: The relay shall provide current unbalance elements for detecting phase current unbalance as compared to the average phase current.

10. Voltage Elements: The relay shall include three-phase over- and undervoltage elements as well as negative- and zero-sequence overvoltage elements.

B. IPR for SWS and SS shall meet the following:

1. The relay shall include protection functions as indicated on the Contract Drawings. Relays shall provide functionalities described below:

a. Phase, neutral, residual, and negative-sequence overcurrent elements (50P/50N/50G/50Q)

b. Phase, neutral, residual, and negative-sequence time-overcurrent elements (51P/51N/51G/51Q)

c. Over and undervoltage (59, 59G, 59Q, 27)

d. Power factor (55)

e. Synchronism check (25)
f. Residual overcurrent (50G/51G)
g. Breaker contactor failure
h. Line Voltage Check; The relay shall be programmable to allow closing when just one of line and load sides are energized, and shall block closing when both line and load sides of the circuit are either energized or de-energized.

2.03 CONTROL AND INDICATION

A. The relay shall accept commands to operate (CLOSE/OPEN) the associated circuit breaker:
   1. Over an Ethernet connection to the relay.
   2. Through optically isolated inputs.
   3. From CLOSE/OPEN pushbuttons on the relay control panel.

B. The relay shall issue commands to operate (CLOSE/OPEN) the associated circuit breaker via dry contacts.

C. The relay shall provide CLOSED/OPEN indication status for the associated circuit breaker:
   1. Over an Ethernet connection to the relay.
   2. Through the facility backup control system via dry contacts.

D. The relay shall issue alarms, trouble indications, protective indications, and control functions and indications for the associated circuit breaker over an Ethernet connection to the RTAC PLC via the C04 panel. Convey relay trouble indications via hardwire connection to an IOM for transmittal to the C02 RTAC PLC via fiber optic media. Trouble indications shall alarm upon relay trouble or loss of power, and shall automatically trip the associated circuit breaker.

E. Provide under- and overvoltage elements for creating protection and control routines.

F. Transformer Inrush and Overexcitation Detection:

1. IPR of HVS and TPSS: The relay shall incorporate 2nd, 4th, and 5th harmonic blocking. In addition, 2nd and 4th harmonic restraint shall be provided. These restraint and blocking elements may be used independently, or in combination to prevent restrained differential element operation during inrush or overexcitation conditions. An independent fifth-harmonic element shall be included to warn of transformer overexcitation conditions. Wave-shape-based inrush detection addresses inrush conditions that contain low 2nd and 4th harmonic content.

2. IPR of SWS and SS: Not applicable.
G. The relay shall provide positive, negative, and zero-sequence voltage elements that can be logically configured for either under- or overvoltage applications.

H. Circuit breaker automatic transfer functions shall be provided through C02 RTAC PLC programming. Interlocking logic implemented through IPR relay programming is not acceptable.

2.04 AUTOMATION

A. The relay shall include 32 local control switches, 32 remote control switches, 32 latching switches, and programmable display messages in conjunction with a local display panel in the relay for use as internal relay program variables. The relay shall be capable of displaying custom messages.

B. The relay shall include programmable logic functions for user-configurable protection, monitoring, and control schemes. Logic shall have the ability to use relay elements, math functions, comparison functions, and Boolean logic functions.

C. The relay shall not need external auxiliary relays. Configuration and logic shall be realized in the relay software.

2.05 COMMUNICATION AND INTEGRATION

A. The relay shall provide capacity to support two physically independent Ethernet ports as follows:

1. Primary port: 100 Mbps primary physical port equipped with 100BaseFX send/receive ports with LC connectors for multimode fiber, to communicate with the C04 Panel Ethernet switch.

2. Secondary port: 100 Mbps secondary physical port equipped with 100BaseFX send/receive ports with LC connectors for multimode fiber, to communicate with remote terminals over the BARTNet Ethernet system via the C04 Panel Ethernet switch.

3. The secondary Ethernet port may be implemented using a serial port and fiber optic transceiver.

B. Synchrophasors. The relay shall provide high-accuracy, synchrophasor data that is compliant with the IEEE C37.118 synchrophasor data standard. The IEEE C37.118 synchrophasor data shall be supported on serial and Ethernet ports of the relay. The relay shall provide the capability to produce up to five phasor measurement unit (PMU) data configurations, and provide three selectable filter responses to measured PMU input signals. The relay shall provide the ability to alias the names of the phasors, analog quantities, and digital quantities.

C. Expandable Remote I/O: The relay shall send and receive real time data (RTD) or analog and binary data directly from remote I/O modules compatible with the relay. Any EIA 232 port may be configured for direct communication with the compatible remote I/O modules.
D. Terminal Communication: The relay shall allow communication from any ASCII terminal without proprietary software.

E. IRIG-B Time Input: The relay shall include an interface port for a demodulated IRIG-B time-synchronization input signal.

F. IEEE 1588 Precision Time Protocol: The relay shall support Precision Time Protocol version 2 (PTPv2), providing for high-accuracy timing over an Ethernet network.

G. IEC 61850 Ethernet Communications: The relay shall be capable of providing communications compliant to IEEE 1815 DNP3 and IEC 61850 protocol standards.

H. Simple Network Time Protocol (SNTP): The relay shall be capable of synchronizing the internal timekeeping to a network time source.

I. Web Server: The relay shall allow inspection of settings, metering reports, self-test reports, and configuration via an integrated web server.

J. Digital Relay-to-Relay Communications: The relay shall send and receive logic elements and analog and virtual terminal elements in each of two communications ports for dedicated relay-to-relay communications.

K. Provide following serial communications features:
   1. Two independent EIA-232 serial ports
   2. Full access to event history, relay status, and meter information from the communications
   3. Settings and group switching password control
   4. Synchrophasor data via C37.118 data format
   5. Standard ASCII, Compressed ASCII, Fast Operate, Fast Meter, Fast SER and Enhanced MIRRORED BITS protocols (SEL)

2.06 METERING, MONITORING, AND REPORTING

A. The relay shall provide access to information for use in metering and data recording, including fundamental primary and secondary current and voltage magnitudes and angles; RMS voltage and current; differential metering showing the operating and restraint currents for each three-phase differential element; and the reference current.

B. The relay shall monitor and retain the following instantaneous values:
   1. Fundamental power system frequency voltages.
   2. Fundamental voltages compensated to account for delta/wye-transformer and PT configurations.
3. Positive, negative, and zero-sequence currents and voltages.

4. RMS voltages and currents shall include fundamental plus total harmonic distortion (THD) including measurable harmonics to the 16th harmonic.

5. Currents measured at the fundamental frequency of the power system, with transformer phase-compensation applied.

6. Power Factor: A, B, C, 3P single and three-phase power factor, leading or lagging.

C. The relay shall provide the following metering capabilities:

1. Power and energy metering quantities shall be calculated using fundamental voltage and current measurements; \( S = \text{MVA}, P = \text{MW}, Q = \text{MVAR} \).

2. For IPR of HVS and TPSS, differential metering shall include:
   a. Operate current magnitude and restraint current magnitude (both in per unit).
   b. Harmonic quantities representing the effective harmonic content of the operate current used for harmonic blocking and harmonic restraint.

3. Demand/peak metering shall include thermal or rolling interval demand.

4. Metering reports shall include fundamental phase and real and reactive power, per phase voltage magnitude, angle, and frequency.

D. Synchrophasor Data Recording: Provide 120-second synchrophasor data recording stored in nonvolatile memory using IEEE C37.118 binary data format.

E. Event Reporting:

1. IPR for HVS and TPSS: The relay shall automatically record disturbance events as long as three seconds at 8 kHz sampling rate and 24 seconds at 1 kHz sampling rate. Events shall be stored in nonvolatile memory. The relay shall provide event reports at 8 kHz in COMTRADE data format, eight samples per cycle, and four samples per cycle.

2. IPR for SWS and SS: Provide, at a minimum, 15 cycle-length (up to 77 reports) or 64-cycle length (up to 19 reports) with 4 or 16 samples/cycle resolution.

F. Sequential Events Recorder (SER):

1. IPR for HVS and TPSS: Provide a SER report that stores the latest 1000 entries of at least 250 monitored points.

2. IPR for SWS and SS: Provide a SER report that stores the latest 1000 entries.
G. Transformer Thermal Monitor:

1. IPR for HVS and TPSS: Provide a transformer thermal monitor based on IEEE C57.91. The model shall include capability for entering known transformer thermal constants as well as default constants. Three loss-of-insulation-life alarms shall be provided, including loss-of-life per day, total loss-of-life, and insulation aging factor. Up to 12 temperature inputs shall be accommodated by the relay from either RTD or from IEC 61850 Goose Messaging Remote Analog Quantities.

2. IPR for SWS and SS: None.

H. Through-Fault Event Monitor:

1. IPR for HVS and TPSS: Provide the capability of reporting fault current level, duration, and date/time for overcurrent events through the differential protection zone. Through-fault monitoring shall provide accumulated through-fault levels, number of through-faults and the total consumed through-fault capacity of the transformer, based on IEEE C57.109.

2. IPR for SWS and SS: None.

I. Fault Identification Logic:

1. IPR for HVS and TPSS: The relay shall determine, on a per-terminal basis, which phase(s) was involved in a fault for which the transformer tripped. Faulted phase identification is based on current inputs from wye-connected CTs.

2. IPR for SWS and SS: None.

2.07 VOLTAGE AND CURRENT INPUTS/OUTPUTS

A. Provide sufficient optoisolated level-sensitive analog inputs necessary to support relay functions, including each current transformer winding, earth fault current, and potential transformer input.

B. Current transformer inputs, 5A secondary:

1. IPR for HVS and TPSS: The relay shall accept CTs from different classes and a ratio mismatch of 35:1 as indicated. Measuring quantities shall be on a phase-segregated basis and not from summation CTs.

2. IPR for SWS and SS: Four 5A AC current inputs, minimum.

C. Potential transformer inputs, 300V maximum:

1. The relay shall accept potential transformer inputs as indicated.

D. Provide high current, high speed outputs necessary to support relay functions.
E. Provide dedicated inputs and outputs for each relay function. Provide 30 percent spare of inputs and outputs as a minimum.

F. Provide independently operated breaker open/close switches or pushbuttons with following characteristics:

1. Indicating lamps.

2. Device close switch with a programmable time delay of 1 to 20 seconds minimum between switch actuation and initiating circuit breaker closing.

3. Sealable guards to prevent unauthorized operation and protection from inadvertent operation.

4. Switch contacts shall include solid-state protection to eliminate arcing damage and prolong contact life.

5. Switches and breaker status lamps shall be functional regardless of the relay status.

G. Provide digital and analog outputs necessary to drive C02 panel meters, as indicated in the Contract Drawings. Include two spare inputs and two spare outputs.

2.08 USER INTERFACE

A. Front panel: provide as a minimum:

1. LCD screen with active area 3.2 inches by 3.2 inches, minimum.

2. 24 tri-color LED target indicators

3. 12 control pushbuttons with indicating LEDs for local control functions

4. Target and pushbutton indication custom configurable with easily changed slide-in labels.

B. Provide LCD control through navigation pushbuttons, automatic messages the relay generates, and user programmable display points.

C. LCD display: A rotating display shall scroll through any active, nonblank display points. If none are active, the relay shall scroll through displays of the differential operating and restraint quantities and the primary current and voltage values. Each display shall remain for five seconds before the display continues scrolling. Any message generated by the relay because of an alarm condition shall take precedence over the rotating display.
2.09  **SECURITY**

A. Provide following security levels:

1. Level one shall allow viewing of relay information, parameters, and settings. Level one does not require password security for viewing only.

2. Level two, requiring password protected security, shall allow the use to change parameters and settings, as well as download SER and other stored relay data.

B. Relay security authorizations shall be accessed through the relay front panel user interface or remotely through the secondary Ethernet port.

C. A physical key type security system using a USB key or other means is not acceptable.

2.10  **POWER SUPPLY**

A. Power supply: 125/250 VDC

B. Absolute range: 83 to 300 VDC

2.11  **SELF MONITORING**

A. The IPR relay shall initiate a self-test on power-up, and shall continuously monitor internal operations using a ‘watchdog’ function. The watchdog function shall assert a trouble alarm indicated locally at the front panel user interface if the control routine fails to toggle the watchdog function for more than one second. The IPR shall be provided with an output relay contact and an alarm signal available at the IPR’s primary Ethernet port. Alarms shall be stored in the SER.

B. Relay internal diagnostics shall be accessed through the operator keypad and the secondary Ethernet/IP network maintenance port connection.

2.12  **TEST AND MAINTENANCE ACCESSORIES**

A. Furnish three complete sets of special tools and test equipment, each set comprising hardware and software necessary for field testing, diagnostics, maintenance and repair of the IPR relay. At a minimum, each set of test apparatus shall include:

1. Laptop computer: Latest applicable model at time of bid, with the following minimum capabilities:
   
   a. Quad-core processor
   b. 2.5 GHz processor speed
   c. 8 GB DDR3L 1600 MHz RAM memory
   d. 1 TB solid state hard drive
   e. DVD +/- RW drive
f. One Ethernet, one RS-232 serial, and two USB ports

g. 17-inch LCD flat panel display

h. Minimum 8-hour battery charge during warranty period

i. Latest operating system compatible with IPR software

j. The laptop computer wi-fi shall be capable of being disabled.

2. Laptop carrying case, batteries, and computer software to provide complete and functional test equipment.

3. Software required for relay set-up, testing, and diagnostics. Required software licenses shall be included. Software shall be provided on laptops and on separate storage media.

4. Cable connecting hardware needed to connect laptops with the IPR, using a USB connector at the computer end of the connection.

2.13 SPARE PARTS

A. For each ten IPR relays furnished, provide one spare IPR relay.

2.14 FACTORY TESTING

A. General: Testing of the IPR, and operator interface shall be in accordance with the requirements of Section 01 45 24, Testing Program Requirements.

B. Design Tests: Provide certification from an independent testing agency certified by the International Electric Testing Association (NETA) that the IPR relay meets test requirements specified herein. Tests shall include, but are not limited to the following:

1. Dielectric Strength: Tests per IEEE 37.90.


3. Performance Verification Tests

a. Tests shall ascertain the proper functioning, accuracy and response time of the IPR relay. At a minimum, tests shall verify the following:

1) Input voltage and current measurements (accuracy and range verification).

2) Isolation and voltage and current ratings of relay inputs and outputs.

3) Specified electrical withstands.

4) Operation of protective functions.

5) Functioning of the self-diagnostic features, including trouble alarms, events storage, and current and voltage data traces.
6) Operation of user interfaces, including parameter updates through the operator interface panel and interrogation/diagnostics via the Ethernet ports.

7) Function of IPR relay inputs and outputs.

8) Communications over the IPR primary Ethernet communications port using communications protocols described in Section 34 21 33, Control, Monitoring, and Display Panel. Test to show that required controls, indications, and data access function correctly.

9) Communications between the IPR secondary maintenance access Ethernet communications port and a host PC terminal to verify required indications, settings adjustments, and data viewing and download function.

10) Verify that stored event recordings remain available following a relay power failure.

11) Operation of user interface, RS-232, and Ethernet user interfaces.

4. Design test certifications may be considered in lieu of design tests for acceptance by the Engineer for design tests performed on equipment identical to that proposed.

C. Production Tests: Production tests certifications shall show proper performance of each IPR relay provided. Certifications shall confirm correct:

1. Calibration for relay current and voltage measurement functions, and correct function of the relay software.

2. Operation of user interface, RS-232, and Ethernet user interfaces.

3. Voltage and current ratings of relay inputs and outputs.

4. Isolation of relay inputs.

D. Coordinate and perform factory testing per requirements of Specifications Section 34 22 75, Traction Power System Facility Functional Factory Testing.

PART 3 – EXECUTION

3.01 FIELD TESTING

A. Coordinate and perform field testing per requirements of Specifications Section 34 22 80, Traction Power System Field Acceptance Testing.

END OF SECTION 34 21 12