PART 1 – GENERAL

1.01 SECTION INCLUDES

A. General requirements
B. Thyristor assembly
C. Analog signal sensor
D. Controller
E. Manual by-pass switch
F. Bus, bus connections and shunts
G. NGD enclosure
H. Test and maintenance accessories
I. 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 39 Contract Record Documents
8. Section 27 13 01 Communication Cables and Related Equipment
9. Section 34 21 21 Transformer-Rectifier Units – Oil Filled Transformer, Uncontrollable Rectifier
10. Section 34 21 22 Transformer-Rectifier Units – Dry-Type Transformer, Uncontrollable Rectifier
11. Section 34 21 25 DC Switchgear
12. Section 34 21 33 Traction Power control, Monitoring and Display Panel
13. Section 34 21 35 Emergency and Transfer Trip System
14. Section 34 21 40 DC Control Power System
15. Section 34 21 50 Common Materials and Methods for Traction Power
16. Section 34 21 75 Traction Power Facility System Factory Functional Testing
17. Section 34 21 80 Traction Power System Field Acceptance and Testing Requirements

1.03 MEASUREMENT AND PAYMENT

A. Measurement: Negative grounding devices will be measured for payment per individual unit that is fabricated, factory tested, delivered to Jobsite, installed and field functioning tested in accordance with the Contract Documents.

B. Payment: Negative grounding devices will be paid for at the Contract unit price per each individual switchgear cubicle as indicated in the Bid Schedule of the Bid Form.

1.04 REFERENCE STANDARDS

A. American Iron and Steel Institute (AISI)

B. Telecommunications Industry Association (TIA):

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

2. TIA 455 General Requirements for Standard Test Procedures Optical Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and other Fiber Optic Components

3. TIA 455-13 Visual and Mechanical inspection for Fiber Optic Components, Devices, and Assemblies

4. TIA-568.3-D Optical Fiber Cabling and Components Standard

5. TIA-526-14-C Optical Power Loss Measurement of Installed Multimode Fiber Optic Cable Plant

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

1. IEEE C37.30 IEEE Standard Requirements for AC High-Voltage Air Switches Rated Above 1000V


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

D. National Electrical Manufacturers Association (NEMA):
   1. NEMA 250 Enclosures for Electrical Equipment (1000V Maximum)
   2. NEMA KS1 Heavy Duty Enclosed and Dead-Front Switches (600 Volts Maximum)

E. National Fire Protection Association (NFPA):
   1. NFPA 70 National Electric Code

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 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 standard.

C. Submit the following:

1. Negative Grounding Device (NGD) 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. Block diagrams showing functional interfaces between the NGD and the substation rectifier, DC switchgear, SCADA, and communications equipment.
   b. Elementary control diagrams depicting logical functions or equipment including interfaces with SCADA and communications equipment.

3. Design calculations that verify suitable ratings for:
   a. NGD circuit components, cables, and fuses.
   b. Forces generated with 60 KA peak system short circuit current between the 1200V DC system positive and the negative DC cables entering the NGD compartment.

4. Design calculations showing that NGD shunt mounting and buswork can withstand forces generated by peak system short circuits with no mechanical distortion or degradation of connections.

5. Recommended NGD settings.

6. Communications interface protocols that demonstrate compatibility with TPSS/GBS Ethernet network, and with Operations Control Center (OCC) SCADA network.

7. Equipment installation drawings showing equipment layout in NGD enclosure. Show spatial configuration, mounting details, and provision for maintenance access.

8. Enclosure finish coating procedures including:
   a. Surface preparation and coating application, including coating thickness.
   b. Manufacturer’s data sheets for materials proposed for use.


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

11. Factory design and production test reports.

12. Recommended field test procedures and data sheets.


14. Maintenance data including recommended maintenance materials and spare parts list.

D. Submittals shall be made in electronic format using the latest version of AutoCAD, and hard copy format.
PART 2 – PRODUCTS

2.01 GENERAL REQUIREMENTS

A. The NGD thyristor assembly shall be used for connection between the rectifier 1200V DC negative bus and the substation ground mat, and shall remain in a non-conducting state during normal system operation, keeping the DC negative return system and ground electrically isolated. When vehicle operations or short circuit current cause voltage potential between the DC negative system and ground to exceed a pre-determined time-voltage threshold profile, the appropriate forward or reverse thyristor shall be triggered. Once triggered, the thyristors shall stay in conduction until the resulting current flow remains below a pre-determined time-voltage threshold, indicating absence of unsafe voltage potential between the 1200V DC negative system and ground.

B. The NGD shall use microprocessor-based logic and shall consist of the following functional elements housed within an enclosure:

1. SCR (thyristor) assembly
2. Firing circuit
3. Analog signal sensing equipment
4. Microprocessor controller
5. LED and relay drivers
6. Output relays
7. Front panel including LCD display and operator controls
8. Manual by-pass switch
9. Substation communications interface

C. The NGD manual bypass switch shall be used to connect the DC negative system to TPSS ground when the NGD is removed from service for maintenance.

D. The NGD equipment and accessories shall be mounted in a dedicated outdoor-type enclosure. Equipment including thyristor, control panel, relay power supply, bus work, and connecting cables shall be factory-assembled and tested and shall be contained within the NGD enclosure.

E. Provide voltage isolation of controller electronic equipment, relays, and other control equipment from the DC negative return circuits.

F. Environmental requirements:

1. Temperature: Equipment shall function properly in the temperature range of minus 20 degrees Celsius ≤ t ≤ 55 degrees Celsius, per IEEE 37.90-5.1.1
2. Humidity: Equipment shall function properly with an average relative humidity of up to 55 percent and ambient temperature of up to 40 degrees Celsius outside the enclosure, with excursions of up to 95 percent for a maximum of up to 96 hours, without causing internal condensation in accordance with IEEE 37.90-5.1.2.

3. Dust: Outdoor type NGD enclosures shall at a minimum meet the requirements of a NEMA 3R type installation. Solid state and electro-mechanical equipment, relays, microprocessors, and ancillary equipment shall function continuously in this class of environment.

4. System Electrical Transients: The design shall provide protection against damage to the NGD, false triggering, and erratic operation due to transients appearing on the DC system negative with respect to ground. Include transient filtering devices, allowing equipment to meet the requirements of IEEE C37.90.1 and IEEE C37.90.3.

2.02 THYRISTOR ASSEMBLY

A. The thyristor assembly shall consist of semiconductor controlled rectifier (SCR) devices able to transmit current in both directions. Each of two functional SCRs may consist of groups of more than one in parallel, but the design shall minimize the number of parallel devices while still meeting required ratings. Series configurations shall not be used.

B. Definitions:

1. SCR positive current direction – ground to substation DC negative bus

2. SCR negative current direction – substation DC negative bus to ground

C. Current Balance:

1. For both forward and reverse functional SCR groups, all SCRs in the group shall be matched such that the current conducted by each individual SCR is within plus or minus 10 percent of the current conducted by each of the other SCRs within that group.

2. Submit test reports and certification by the manufacturer of the SCR assemblies that each assembly meets this current balance criterion over the SCR current operating range specified.

3. The thyristor controls shall ensure current balance through parallel SCR groups using close coupling reactors or other means so that firing in both forward and reverse direction causes simultaneous activation and firing of all thyristors in the group to avoid overloading of individual components.

D. SCRs shall be appropriately rated in order for the NGD to withstand the operating conditions including voltage levels and frequencies as listed below, and achieve the specified reliability figures. SCR assembly shall meet the following minimum ratings:

1. Minimum voltage rating: 3,000 V DC
2. Current ratings for SCR assemblies:
   a. 60 kA for 8 cycles (0.13s)
   b. 20 kA for 15 cycles (0.25s)
   c. 5 kA continuous operation

E. Only standard devices and standard mounting hardware for SCR devices are acceptable.

F. Cooling: SCRs shall be mounted on heatsinks and cooled using natural convection. Heatsinks and thyristor mounting arrangement shall be provided to limit maximum junction temperature to no greater than 25 degrees C less than the rated maximum junction temperatures when operating under any of the current levels specified in Paragraph D above. The NGD unit shall not require the use of fans for cooling.

2.03 ANALOG SIGNAL SENSOR

A. Required voltage and current indications shall be obtained using an analog signal sensor with a millivolt shunt. The analog signal sensor shall communicate with the NGD controller by a fiber optic cable to electrically isolate the analog signal sensor from the controller. Provide a signal sensor with a minimum 13-bit analog-to-digital converter and local microcontroller to transmit digital data to the NGD controller. The controller shall monitor the signal sensor integrity over the fiber link.

B. Provide analog signal sensor with the following minimum characteristics:
   1. Isolation:
      a. Continuous: 1,200 VDC
      b. Peak: 4 kV DC
      2. Accuracy: plus or minus two percent full scale
      3. Range: 0 to 5kA

C. Hall effect devices to sense current values shall not be used.

2.04 CONTROLLER

A. A solid state NGD controller shall manage required NGD functions including microprocessor based logic, thyristor firing circuit, analog signal sensor, LED driver, digital I/O, output relays, operator interface, communication controller, and modem.

B. Control circuitry shall include the following characteristics:
   1. Mount circuitry on plug-in printed circuit boards
   2. Electrically isolate control circuitries from SCRs.
3. Provide test points on the printed circuit boards for ease of use during testing.

4. Indicate typical scope patterns in the schematic drawings at various troubleshooting points.

C. Control logic shall enable SCR firing circuit upon:
   1. Detection of DC negative return system or ground overvoltage
   2. Command from the microprocessor originating from key pad

D. Display shall be TFT/LCD active matrix, with the following minimum characteristics:
   1. Active area: 30 square inches
   2. Diagonal size: 8.0 inches
   3. Resolution: VGA, 640 by 480 pixels
   4. Response time: 80 ms
   5. Brightness: 380 nits
   6. Contrast Ratio: 250

E. In the main operating mode, the display shall show, at a minimum, the measured values for voltage, current, accumulated amp-hours, counters for SCRs firing in each direction, incoming 120V AC voltage, and station battery 125V DC voltage. On the display submenus, user shall be able to access all system parameter settings, event log, system clock time/date, security level, and test parameters.

F. Touch Pad: Touch pad shall allow operator to easily navigate display menus, access and change numeric system parameters, access stored voltage and current data, and adjust display contrast. Include 10 numeric keys, four arrow keys, minus (–) sign key, and the following specific function keys:
   1. Enter
   2. Menu
   3. Alarm reset
   4. System reset
   5. Manual fire – positive and negative SCR
   6. Manual bypass switch release
   7. Help – Allow access to context sensitive help
G. LEDs: Controller shall be provided with LEDs to indicate the following:

1. Bypass switch unlocked
2. SCR firing
3. 125 VDC control voltage OK
4. 120 VAC control voltage OK
5. System OK

H. Security Levels: The NGD shall provide the following password-protected security levels, as a minimum:

1. Observer: No password required, allows user to view NGD parameter settings and stored data, but does not allow modify system parameter settings.
2. Operator: In addition to observer level permissions, allows user to:
   a. Modify time and date
   b. Download alarm log and stored data traces
   c. Modify parameters

I. Menus: User interface shall provide intuitive pull down menus that easily facilitate navigating the screens and selecting system parameters.

J. Microprocessor Logic:

1. Logic and control functions shall be microprocessor based with digital outputs. Provide programming capability in electrically programmable read only memory (EPROM) or other similar solid-state non-volatile memory devices allowing reprogramming of the memory. System parameters shall be able to be entered on the keypad and read/verified on the alphanumeric display. Software programming required shall be provided for a fully functional unit.

2. The control circuits shall provide for manual and automatic operation of the NGD. Remote control operation is not required. Automatic operation will be the normal mode of control. In automatic operation the NGD voltage sensing circuits shall control triggering of the thyristors, indicators, and relay circuits.

K. Memory: Provide the following:

1. Program memory: Use non-volatile flash memory or equivalent to store system program, and to allow upgrading of the software remotely and without physical removal of the chip.
2. Nonvolatile memory: Provide nonvolatile memory (NVRAM) to store system parameters, alarm log, and voltage and current snapshots captured during SCR triggering. Write operation of NVRAM shall be disabled if the voltage drops below a minimum level. Critical parameters and snapshot data shall be retained in the event of a complete power loss.

L. Firing Circuit: Firing circuit shall provide firing pulses to the hardware to instantly trigger the appropriate positive or negative SCR assembly. Firing pulses shall be synchronized as required to ensure simultaneous firing and conduction of current in each SCR of the forward and reverse SCR groups.

M. Communications Ports:

1. A dedicated fiber optic communications port shall provide a high-speed serial interface between the controller and the analog signal sensor. The controller shall monitor the integrity of the amplifier and the link.

2. A minimum 10/100 Mbps primary physical Ethernet port to communicate with the control and annunciator panel (C02) PLC, as specified in Section 34 21 33, Control, Monitoring, and Display Panel. The port shall be equipped with 100BaseFX send/receive port with ST connectors for multimode fiber.

3. A minimum 10/100 Mbps secondary physical Ethernet port to communicate with remote host computers as an IP address over the BARTNet Ethernet system using the TCP/IP protocol. The secondary Ethernet port shall be non-routable with the primary Ethernet port. The port shall be equipped with a 100BaseFX send/receive port with ST connectors for multimode fiber.

The secondary Ethernet port shall be locally configurable to permit uploading software upgrades and modifying NGD parameters and downloading stored event logs and data traces. The secondary Ethernet port shall allow viewing and download of NGD settings parameters and system diagnostic data, including:

a. Analog data: instantaneous DC negative and ground bus voltages, and NGD shunt current.

b. Alarm log

c. Softscope data traces

d. NGD parameter settings

4. Serial port meeting EIA/TIA 232-F.

N. NGD Ethernet Output Functions

The NGD shall recognize and communicate the following outputs through the primary Ethernet port connecting to the C02 panel:

1. High current in positive SCR

2. High current in negative SCR
3. Timed current in positive SCR

4. Timed current in negative SCR

5. High current trip control

6. System trouble – indication of any of the following system trouble conditions:
   a. 125VDC station battery undervoltage
   b. 120VAC undervoltage
   c. NGD complete loss of control power – 125VDC primary or 120VAC backup
   d. Self-test logic failure
   e. Thyristor failure due to excessive on-state voltage or apparent failure to fire following a gate signal

7. Manual bypass switch status (open/closed)

8. Analog data: instantaneous DC negative and ground bus voltages, and NGD shunt current

O. Digital Inputs: Provide six (6) digital inputs, each having positive and negative logic capability, suitable for interface via relay contact closures rated 5A, 125 V DC.

P. Output Relays: Provide at least six (6) output relays to interface the NGD controller with the traction substation 125 VDC control circuits, each having one Form C contact, rated 125 V DC, 5A, 24W/60VA minimum switching capacity. Output functions shall be programmable, and shall automatically reset when the alarm condition ceases.

Q. Power supplies: Provide following system energy sources:

1. The NGD shall be powered by dual energy sources to power controls, SCR firing circuits, and bypass switch enable solenoid:
   a. Primary power: 125 V DC from the station battery power. This shall be connected to the system input power terminals through an isolating DC/DC converter in the NGD enclosure.
   b. Secondary power: 120V AC shall be connected to the system input power terminals through an isolation transformer and a full wave rectifier in the NGD enclosure.
   c. NGD shall operate satisfactorily at plus or minus 10 percent of specified AC and DC input sources.
   d. Provide appropriate fusing for the dual energy sources.

2. A backup power supply shall power the system clock and critical microprocessor logic in the event of concurrent 120VAC and 125 VDC power failure. The backup power supply shall enable function of clock and retention of system data and parameters for 30 Days, minimum.
3. Provide the microprocessor logic power supply circuit with thermal, current limit, and overvoltage protection.

4. Operation of the NGD shall not cause either side of any power source to be grounded.

R. System Diagnostics:

1. Watchdog: A watchdog circuit shall supervise operation of the controller, such that if the controller fails to toggle watchdog input for more than one second, the watchdog circuit shall store an alarm indication in the alarm log and restart the system. It shall also store the last system state to assist in troubleshooting. Alarm log shall be retrievable at the operator interface or through the RS-232 or Ethernet ports.

2. Provide as a minimum the following series of self-test functions when control power is connected to the NGD:
   a. Test of non-volatile and volatile memory
   b. CPU test
   c. Power supply voltages normal
   d. System monitoring active
   e. Ethernet connections active

3. If any of the start-up tests have failed or if the watchdog timer is not satisfied, the NGD System Trouble alarm shall indicate.

4. Provide a means of resetting the microprocessor and performing the self-test functions to be used during maintenance operations.

5. NGD system trouble shall be indicated locally by an LED and an alarm contact activated for remote reporting of the system trouble. Provide settable option for firing or inhibit firing.

6. The program shall provide a function, that in the event of start-up test failure, system trouble, or SCR failure this function can be set to either:
   a. Fire the SCRs to ground the DC negative bus, or
   b. Inhibit SCR firing.

7. Provide capability to access internal system diagnostics both through the operator touch pad, through a PC via the RS-232 connection, and through the Ethernet connection.

S. Data Recording and Retrieval:

1. Alarm Memory: System shall store a minimum of the 200 most recent alarms with date and time stamp in non-volatile memory. Retain records of following alarms:
a. Latching alarms related to hardware failure and requiring manual reset, as follows:
   1) Firing fuse failed
   2) SCR failed to close
   3) SCR shorted
   4) Self-test malfunction
   5) Analog signal sensor failure

b. Non-latching alarms in pairs, one for the alarm and another for its clearance, as follows:
   1) Current positive (negative bus grounded)/SCR off
   2) Current negative (negative bus grounded)/SCR off
   3) Instantaneous positive current high/current normal
   4) Instantaneous negative current high/current normal
   5) Timed positive current high/current normal
   6) Timed negative current high/current normal
   7) 125 VDC voltage low/voltage normal
   8) 120 VAC voltage low/voltage normal
   9) Manual bypass switch closed / switch open

2. Voltage and Current Records

a. Provide built-in softscope type oscilloscope to allow taking of voltage and current snapshots, before and after a triggering event. Softscope shall have the capability of setting up to eight simultaneously active triggering events at a minimum. The events shall be selected from a menu including, at a minimum, positive and negative overcurrent, positive and negative overvoltage, and other abnormal system conditions.

b. Data shall be retained in non-volatile memory, retrievable following complete failure of NGD primary and backup power.

c. Data capture upon selectable triggering events shall be provided. Minimum fast and slow sampling rates shall be provided as follows:

   1) Fast: 65 microsecond/sample, from 220 milliseconds before the event until 40 milliseconds after the event.
   2) Slow: 65 millisecond/sample, from 220 seconds before the event until 40 milliseconds after the event.
   3) System shall provide full data retention for a minimum of eight events, with fast and slow sampling rates selected concurrently.
T. Programmable Parameters: Provide the following programmable general and system parameters with abbreviations noted:

1. General:
   a. Voltage thyristor firing level adjustable from 20V to 150VDC in steps less than or equal to 5V. At set trip level, the firing circuit shall fire the SCR.
   b. Voltage delay: the delay time between reaching the voltage firing level and firing of the SCR, adjustable from 1 to 255 milliseconds to avoid frequent firing due to short surges.
   c. Instantaneous high current, thyristor current level at which an output relay will issue a high current positive or negative indication, adjustable from 500 to 50,000 A in steps less than or equal to 100 A.
   d. Timed current: thyristor current level at which an output relay will issue a timed current positive or negative indication, adjustable from 1 to 1,000 A in steps less than or equal to 5 A.
   e. Current time delay: the delay time between reaching the timed current level and providing a timed current positive or negative indication, adjustable from 1 to 300 seconds in steps less than or equal to 10 seconds.

2. System parameters shall be factory set and shall require minimum security level of operator for modification:
   a. Switch Operate Current Threshold: used to determine an SCR shorted failure or to allow the manual bypass switch to be opened, adjustable from 1 to 30 A.
   b. Switch Operate Voltage Threshold: used to determine if the SCR is ON or to allow the manual bypass switch to be closed, adjustable from 1 to 30 V.
   c. Current Adjustment Maximum: the maximum value of offset adjustment in Amperes, adjustable from 1 to 100 A.
   d. Battery Threshold: low station battery voltage below which the “125 VDC OK” light goes out and an entry is made in the alarm log, adjustable from 1 to 150 VDC.
   e. Incoming Power Threshold: low backup power voltage below which the “120 VAC OK” light goes out and an entry is made in the alarm log, adjustable from 1 to 1500VAC.
   f. EPROM Check Sum: used to verify EPROM integrity during the power up test.

U. System Clock: Provide system clock with power backup for 30 days. The system clock shall be capable of being automatically updated by the BARTNet system clock using Network Time Protocol either directly from the BARTNet system or via the substation SCADA Ethernet Switch. The system clock shall allow for setting local time zone and daylight saving time settings. The system shall support synchronization of data records’ timestamps with the corresponding timestamps of other substation devices.
V. Mounting: Controller shall be mounted in an enclosure within the NGD to protect sensitive electronics from moisture and possible splattering of water at the outdoor NGD locations. Mounting enclosure shall be set back a minimum of six (6) inches from the outer NGD doors on a hinged mounting bracket allowing easy access to the electronics at the back of the controller unit.

2.05 MANUAL BYPASS SWITCH

A. Fixed-mounted, no-load, single pole, single throw, bolted pressure type manual bypass switch shall be provided with the NGD assembly, that shall bypass the NGD during maintenance. Switch position indicator shall be visible through a viewing window.

B. Voltage rating: 3,000V DC, minimum.

C. Current rating: Equal to positive SCR assembly rating.

D. Insulation: Insulate live metal parts for 3,000V DC, minimum.

E. Provide required interlock hardware to prevent operating switch under load. Interlock shall be as follows:

1. It shall not be possible to open the bypass switch unless current magnitude through the switch is less than the switch operate current threshold set value.

2. It shall not be possible to close the bypass switch unless voltage across the switch is less than the switch operate voltage threshold set value.

F. Bypass switch and its interlock circuitry shall be failsafe. Switch operation shall require pressing the ‘Switch Operate’ key on the operator touch pad.

G. Provide normally open and normally closed auxiliary contacts for indication of bypass switch status.

2.06 BUS, BUS CONNECTIONS, AND SHUNT

A. A two-inch minimum clearance between bus work and the NGD enclosure or other metal parts shall be maintained.

B. DC bus shall be fabricated of rigid, high quality copper, rated 5,000 amperes and capable of carrying the indicated overloads without exceeding the allowable temperature rise as specified in ANSI, IEEE, and NEMA standards. Bus and bus connections shall be of adequate strength to withstand thermal and mechanical stresses associated with the maximum short-circuit currents equal to the current rating of the forward thyristor assembly.

C. Bus Connections: Silver plate bolted copper bus connections including bus taps, and shall allow each joint to have conductivity at least equal to that of the bus bar. Provide Belleville washers and hardware for the bolted assemblies. Provide connections of the type that will not deteriorate with cyclic loading or lose pressure.
D. Design bus work so that cable entry into the NGD unit is made as simple as possible, minimizing negative DC system and ground cable routing in the NGD enclosure and allowing easy access for cable terminations and inspection. Provide provisions for four 750 kcmil ground cables and four 750 kcmil cable connections to DC negative system. Use standard NEMA 2-hole standard cable lugs.

E. Shunt: Provide DC shunt integral with bus work to interface with analog signal sensor equipment, with following characteristics:

1. Rating: 5KA
2. Accuracy: plus or minus 0.25 percent of rated value, maximum deviation
3. Temperature coefficient: plus or minus 0.000015 maximum, per change of degree Celsius
4. Support: Shunt support shall be designed to withstand short circuit forces.

2.07 NGD ENCLOSURE

A. NGD enclosures shall be self-supporting units, rated NEMA 3R, with the following characteristics:

1. The enclosure structure shall be of rigid, self-supporting and self-contained electrically welded sheet steel that is sufficiently rigid to support equipment under normal and short-circuit conditions. Structural support shall ensure enclosure orthogonality to enable smooth door operation. Panels shall be fabricated of not less than No.11 sheet steel framework.

2. Access doors shall be fabricated of not less than No. 14 gauge sheet steel.

3. Provide two-point latching handles on doors.

4. Base shall be provided with mounting channels not less than three inches not more than five inches high with a three-sixteenths inch minimum web.

B. Unit shall contain louvered expanded metal or mesh-covered openings to provide adequate ventilation and air-cooling for the components. Ventilation louvers shall have splashguards.

C. Provide dimpled or slanted roof allowing drainage of rainwater and condensation to unit rear or sides.

D. Doors and view windows shall have gaskets to ensure that door and window seals are moisture tight.

E. Provide detachable rain hood, as indicated, above the enclosure access doors for use in outdoor locations. Rain hood shall be affixed to top of enclosure in such a way that no holes or openings into the enclosure interior for screws or bolts are required. Rain hood shall extend a minimum of one foot beyond the front face of the enclosure.
F. SCR assembly, power supply, and other sensitive electronic equipment shall be positioned in the enclosure so that equipment is protected from splattering water when NGD front enclosure door is opened.

G. Provide switch-operated 120V AC light fixture providing 600 lumens minimum, placed to directly illuminate the NGD control panel within the enclosure.

H. Provide duplex, 20A, GFCI receptacle within the enclosure.

I. Provide space heater sufficient to maintain interior of NGD unit free of condensation and moisture at all times.

J. Provide convenient access to internal components for normal maintenance and inspection. NGD control panel shall have a 6 inch to 12 inch setback from enclosure door. Provide stainless steel, abrasion-resistant hasp for padlock on enclosure doors.

K. Enclosure Finish:

1. Enclosure finish surface shall be cleaned, primed, treated with a galvannealed coating, and finished with a powder coat.

2. The galvannealing coating process shall be a two-step coating process with the following characteristics:
   a. Lower coating shall be 10 percent iron-zinc alloy deposited by the hot-dip process
   b. Lower coating weight: 60 g/m², minimum.
   c. Upper coating shall be 80 percent iron-zinc alloy electroplated deposited by the hot-dip process
   d. Upper coating weight: 3 g/m², minimum
   e. Corrosion resistant capabilities: Maximum 1/8-inch creep corrosion when vertically scribed and exposed to five percent salt fog per ASTM B117 for 1500 hours.

3. The powder coating process shall be a two-step process with the following characteristics:
   a. Thickness; 5 mils, minimum
   b. Color:
      1) Powder coat: Medium beige, Sherwin Williams (#PLT6-IS4) or equal.
      2) Wet paint color: Medium beige, Sherwin Williams #F63RXN28022-4337 POLANE S or equal for touch-up.
      3) Aerosol can: Medium beige, Sherwin Williams #J22XXN28029-4337 or equal for touch up.
   c. Weather, graffiti, and ultra-violet (UV) resistant.
d. Following enclosure assembly, areas that have been affected by cutting or welding, shall be spot-galvanized with a primer that forms a dry film no less than 90 percent pure zinc. Touch-up paint shall be applied to match the powder coat finish.

4. Coatings, field or factory applied in California, shall comply with the latest regulations of the California Air Resources Board (CARB) and the Bay Area Air Quality Management District regarding regulations governing permissible content of volatile organic compounds.

L. Provide minimum of 20 Days’ notice prior to fabrication of house exterior panels for the Engineer’s inspection and independent assessment of finish characteristics to determine specification compliance. Finish characteristics shall be confirmed by the Engineer’s independent inspection prior to commencement of house construction.

M. Provide enclosure with AISI Grade 316 stainless steel accessories, including door handles, hinge pins, padlock hasp, and rain hood attachment hardware.

N. Nameplates: Enclosure nameplates shall be as follows:

1. Fabricated of three-ply laminated phenolic plates with bevel edges, engraved through the black face to expose the white core. Lettering shall be condensed gothic, applied using a rounded or square cutter. V-shaped grooves will not be acceptable.

2. Nameplates showing enclosure designation shall have lettering not less than two inches high. Provide two nameplates for enclosure front and back, with designations as specified by the District.

3. Nameplates identifying relays, switches, controls, fuses, and other auxiliary devices shall have lettering not less than 1/16 inch high, and shall include ANSI device designations, as appropriate. Nameplates for fuses shall include fuse rating and circuit indication.

2.08 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 NGD, including the isolation transducer. At a minimum, each set of test apparatus shall comprise the following:

1. Laptop computers shall be the latest applicable model at time of bid, and shall include 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 MPR software

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

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

4. Cable connecting hardware needed to connect with the NGD using USB connector at the computer end of the connection.

5. Test apparatus to verify NGD discrete input and output operation. Apparatus shall connect to the discrete input and output I/O ports and shall activate the indicating LEDs to verify correct I/O operation.

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

2.09 FACTORY TESTING

A. General:

1. Testing of the NGD shall be performed in accordance with the requirements of Section 01 45 24, Testing Program Requirements.

2. Tests shall be performed by a company or agency certified by the National Electric Testing Association (NETA).

3. The District reserves the right to waive any tests.

B. Design Tests: The following design tests shall be performed on one NGD unit:

1. High bandwidth current measurement apparatus capable of accurately recording currents expected during the tests shall be used. Test results shall be in printed or graphical format.

2. Thyristor Assembly: Tests shall be performed to verify the following:

   a. Voltage rating: Continuous and transient voltage ratings.
   
   b. Transient surge current ratings for positive and negative thyristor assemblies.
   
   c. Continuous current ratings for positive and negative thyristor assemblies.
   
   d. Current balance: To within plus or minus 10 percent of parallel thyristors in positive and negative thyristor assemblies.
e. Simultaneous conduction: The test shall show that thyristor legs in the positive and negative current directions successfully conduct at the same time when the thyristor assembly is activated.

3. Analog Signal Sensor: Perform tests in accordance with IEEE 37.90 and 37.90.1 to verify the following:
   a. Voltage rating: Continuous and transient ratings.
   b. Transient surge current ratings.
   c. Continuous current rating.
   d. Sensing unit fiber optic outputs shall be verified for all tests.

4. Sensing and Control Logic: Perform tests in accordance with IEEE 37.90 and 37.90.1 to verify the following operating functions:
   a. Logic functions over the full range of selectable voltage and current parameter values.
   b. Control function response of anticipated system conditions and NGD equipment failures.
   c. Power supply functions and input voltage range characteristics.
   d. Function of front panel controls.

5. Input/Output Functions: Verify proper operation of digital inputs, relay outputs, alarms, and RS-232 and Ethernet system communication functions.

6. Manual Bypass Switch: Verify the following:
   a. On/off operation
   b. Thyristor interlock function: demonstrate blocking of switch operation during high current and voltage conditions as described in Section 2.05E above.
   c. Dielectric voltage withstand capability in accordance with NEMA SK 1.

7. Complete NGD Assembly: Verify isolation between:
   a. Live metal parts and enclosure.
   b. Live metal parts and control wiring
   c. Control wiring and enclosure

C. Production Tests: Each production unit shall be tested in accordance with the design tests specified above with the exception of intermediate and surge current rating tests specified in Articles 2.09B.2.b and 2.09B.3.b.
PART 3 – EXECUTION

3.01 FIELD TESTING

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

END OF SECTION 34 21 30