

PPL ELECTRIC UTILITIES CORPORATION

RELAY AND CONTROL REQUIREMENTS FOR PARALLEL OPERATION OF GENERATION

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Revision history:

- 11. Revised layout, coordinated with Customer point of contact requirements, and clarified parallel generation protection requirements.
- 12. Added clarification on test switches, the PPL EU control switch, locks for the PPL control switch, ownership of IPR relaying, and drawing sizes, as well as minor spelling and grammatical errors. Added clarification in large inverter based facilities.

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FOREWORD

The information contained in this document was prepared by PPL Electric Utilities. This information represents minimum design requirements relative to safe and reliable operation for the PPL Electric Utilities system and personnel. However, this shall not relieve the customer from sole and complete responsibility for all aspects of design, installation, and operation of his facilities. Neither PPL Electric Utilities nor any person acting on behalf of PPL Electric Utilities; (a) makes any warranty with respect to the use of information disclosed in this document or that such use may not infringe on privately owned rights; or (b) assumes any liabilities with respect to the use of, or for damages resulting from the use of, any information disclosed in this document.

To ensure that all proposed installations are handled uniformly and to minimize the possibility of misinterpreting PPL EU requirements, this document outlines the protection requirements for parallel operation of generation. These requirements will also ensure the safety of the general public and PPL EU personnel, and minimize possible damage to PPL EU equipment and that of PPL EU customers. The amount of protection applied to a particular generator will vary with the specific location on our system. It must be clearly understood that the protection identified in this document is for PPL EU electrical system protection, not protection of the generator or generating equipment.

For NEW installations, this document is to be used in conjunction with the document “POINT OF CONTACT REQUIREMENTS FOR HIGH VOLTAGE CUSTOMER-OWNED FACILITIES”, which covers new installation requirements.

SCOPE

This document is intended for generation installations on the PPL EU distribution (12 kV) and subtransmission (69 kV and 138 kV) lines. The intended installations will be connected to PPL EU LINES, and are subject to being isolated with PPL EU customers if the source substation line termination is opened for any reason.

The installation of the generation equipment shall not cause any reduction in the quality of service to PPL EU customers.

Generation connected to networked facilities above 100kV (on the PPL EU system, 115 kV and above), will be under the RFC (Reliability First Corporation) and NERC (North American Electric Reliability Council) reliability requirements and standards. The control and protection of these facilities must be reviewed based upon the RFC and NERC requirements and this document. The generator's control and protection must adhere to the most restrictive of these requirements. This refers to facilities defined by RFC as the "Bulk Electric System".

Due to multiple Authorities Having Jurisdiction (AHJ) the process and requirements will vary for IPP facilities having various MVA capacity levels and connected at different voltage levels.

Pennsylvania Public Utility Commission (PUC) has enacted rules for installations below 2 MVA that are NOT covered by the PJM or FERC processes. In general these will be small installations connected at distribution voltage levels 12 kV and below. The current PA PUC rules can be found on the Pennsylvania state web site.

Typically, installations between 2 MVA and 20 MVA will fall under the PJM Interconnection process, specifically in PJM Manual 14A, Section 3 "Small Resource Interconnection Process." These facilities will generally be connected to 69 kV facilities. The practical limit for connection of generation to the PPL EU distribution system (operating at 12.47 kV), is 1.5 MVA for typical feeders. Generation in excess of 1.5 MVA will be considered on a case by case basis, but generally will not exceed 5 MVA. Facilities above the 5 MVA will typically require a 69 kV connection and additional protection equipment.

Installations connected to 69 kV and *non-networked* 115 to 138 kV lines are also governed by this document.

Installations at 12 kV will be covered by a combination of the REMSI (Rules for Electric Meter Service Installation) document, PA PUC, and PJM rules as noted above. The web site is: www.pplelectric.com. The current drop down has a selection for Electric Tariff, which will have all of the current documents listed.

SECTION 1 OVERVIEW

INTERCONNECTING GENERATION WITH THE UTILITY SYSTEM

This document is intended to serve as a reference for PPL EU engineers and Generation sponsors when planning protection for the parallel operation of a generation facility on the PPL EU system. *NOTE: the term generation will be used throughout this document to designate ANY form of generation. This would include traditional PURPA installations, as well as newer Merchant Power Installations (MPI), Independent Power Producer (IPP), (DG) Distributed Generation, and (DR) Distributed Resources.* Minimum requirements (IEEE 929, IEEE 1547, and UL 1741) for generation intertie are identified to provide for safe and effective operation of the PPL EU system. Some installations may be required to install additional protection, after a review of the proposed generation installation. **No specific protection is provided for the generator by the IPR relays.**

This document is intended to cover ALL generation connected to the PPL EU system. However, there are multiple AHJ; the intent is to treat all generation facilities in a similar manner.

Inverter based installations, 10 kva or less, using CERTIFIED equipment (either under FERC, PJM, or PA PUC regulations) will be classified as INVERTER for protection requirements.

Inverter based installations, above 10 kva and less than 2,000 kva; using CERTIFIED equipment (either under FERC, PJM, or PA PUC regulations) will be classified as FAST TRACK for protection requirements.

Installations above 2,000 kva to 20,000 kva are classified as FERC section 3 Study Process. This is very similar to the PJM study process, and to the PA PUC Level 3 review process. All of the installations in this size range will fall under the TYPE 3 to 7 classifications for protection requirements.

Installations from 1 kva to 2,000 kva that do NOT use CERTIFIED equipment will be classified as TYPE 1 or 2 for protection requirements.

Where feasible, generation equipment built and certified to IEEE standards (IEEE 929-2000 and IEEE 1547-2003, and IEEE 1547.1 or later versions) and UL 1741 will be permitted to be installed with little or no additional protection requirements. However, multiple installations on a single line or substation, or the installation of a large unit, may have sufficient impact that additional protection will be required.

The PJM Small Generation Interconnection Procedures cover the installation of up to 10 MVA *AGGREGATE* to the local Utility. Since there may be existing generation in the area, the sponsor of the generation project is cautioned to not assume that the proposed project will fall under these procedures.

Generation will *not* be permitted to connect to a PPL EU "Low Tension" network system, without prior detailed review. Installation of generation equipment on a low-tension network can have a very negative impact on the operation of the network. Under no circumstances will the PPL EU network protector be used to isolate the generation from the PPL EU system. The installation of generation on PPL EU network system must not result in operation of the network protectors for reverse flow conditions. See IEEE 1547 section 4.1.4.2.

Multiple PPL EU Sources

Under no circumstances shall two or more PPL EU lines of differing voltages (12 kV and 69 kV for example) be paralleled through generation facilities. Where one or more sources is intended to back-up the primary supply to a generation facility, the electrical circuit to the primary supply must be interrupted before the circuit to the back-up is closed. (Key switch interlocks or break-before-make transfer switches are suitable devices for this type of transfer.)

Multiple sources at the same voltage will be handled on a case by case basis.

1.1 INITIATING A REQUEST TO INSTALL OR CHANGE OPERATION OF GENERATION EQUIPMENT

All projects to add or modify a connection to PPL's system should start with a call to the PPL Industrial and Commercial Services Group at 1-888-220-9991 to contact an ICS service representative, who will be happy to respond to your inquiry. Alternatively, you may initiate a contact to ICS via the PPL website at: www.pplelectric.com, the Industrial and Commercial Services page.. The link below should work.

<http://www.pplelectric.com/Business+Partners/Tools+and+Reference+Center/High+Voltage+Customer+Owned+Facilities/>

1.2 POINT OF CONTACT (POC) and INTERTIE PROTECTIVE RELAYING (IPR)

Point of Common Coupling (PCC), as defined in IEEE1547

Point of Interconnection (POI), as defined by PJM

This document defines specific practices required for the interconnection of generation to the utility system at 12 kV through radial 138 kV. The point of interconnection for a customer facility will be defined by the term Point of Contact (POC), which defines the physical point where the customer's facilities connect to the PPL EU system. This is also the location where the Intertie protective relay (IPR) protection is usually applied.

The POC and IPR protective relay functions MUST be in separate protective relays and must be for PPL EU use only. Under no circumstances will IPR or POC relays be used for customer functions or logic. Where practical separate CTs should also be used for these functions, see Current and Voltage transformers below.

Refer to: "POINT OF CONTACT REQUIREMENTS FOR HIGH VOLTAGE CUSTOMER-OWNED FACILITIES", for specific POC protection requirements...

- Customers requiring service on networked 138 kV or at 230 kV or higher voltages must consult PPL for the proper POC protection. Services at these high voltages will require customized designs matched to the existing protection schemes already on the lines. These protection schemes may require PJM approval and special permits which are not covered in this document.

1.3 IPR SYSTEM DESIGN REQUIREMENTS

SCOPE

The scope of this document is limited to the Intertie Protective Relaying (IPR) and Controls only and does not cover the POC protection or any other relaying applied for the protection of the generator or any other equipment associated with the generation facility.

The IPR cabinet will contain all relays and controls specified by PPL EU for a particular installation, with the possible exception of the Out of Step, and Synch Check which may be applied on a per generator basis for multiple generator installations.

PPL EU prefers a dedicated cabinet suitable for a PPL EU lock, however, if this is not practical, passwords can be enabled on the protection equipment to limit access. The IPR protection equipment is installed to protect the PPL EU system from adverse effects of the generation. For this reason, control of this equipment is to remain with PPL EU.

This can be in the form of a locked cabinet (PPL EU lock), suitable passwords on the protective equipment, or a combination of both forms of control.

IEEE 1547 compliant equipment will generally have most of the required protection functions built into the generation equipment. IEEE 1547 states that the 'requirements shall be met at the point of common coupling', reference section 1.2. In general the point of common coupling will be at the point where the PPL EU facilities connect to the customer equipment. This may be a substantial distance away from or other equipment between the actual generation equipment and the PPL EU system.

In the case where there is substantial distance or other equipment between the generation equipment and PPL EU, it may be necessary to have the sensing CTs and PTs located at the point of common coupling (PCC). Also in this case, the generation operator may desire to have the IPR relaying operate a breaker other than the generation breaker. When the CTs, PTs, or controlled breaker are remote from the IEEE 1547 compliant equipment, then the protection and drawings requirements below need to be met.

GENERAL

The PRIMARY FUNCTION of the Intertie Protective Relaying (IPR) is to ISOLATE the GENERATOR from the PPL EU system for faults on the PPL EU system or whenever continued operation would be detrimental to PPL EU or PPL EU customers.

The SECONDARY FUNCTION of the IPR is to BLOCK CLOSING of all circuit breakers that can be used to parallel the generation whenever the PPL EU source is unavailable or abnormal.

Unless specified, all relays will use phase-to-neutral potential (67 volt taps) and phase-current (from WYE connected CTs). Proper phasing and polarities must be followed as indicated in manufacturers' instruction books. **ALL IPR relays and SCADA transducers are to be connected according to PPL EU phase designations.**

All relays must incorporate an isolation device, to isolate ALL inputs and ALL outputs of the IPR relaying for testing.

Contact PPL Electric Utilities for a list of currently approved IPR relays.

DRAWING ACCEPTANCE

All IPR drawings are subject to review by PPL EU. The elementary drawings (potential, current, and control) and the physical layout drawing must be ACCEPTED by PPL EU. The IPP is expected and required to submit ALL drawings required to completely review the Intertie Protection Relaying design from the PT and CT inputs, the DC supplies, to the trip and close coils of the controlled equipment as well as any and all interlock devices. This includes any manufacturers or subcontractor drawings. NOTE: all drawings submitted electronically, must be scalable to the original size for plotting. See "Drawing Requirements for Generation Intertie Protective Relay Cabinets" for further information. **ALL drawings submitted to PPL EU for the generation facility, above 10 kva must be signed by a licensed Professional Engineer in good standing.**

All drawings are reviewed subject to this NOTICE: This information was prepared from a review of customer drawings by PPL Electric Utilities. Drawing review applies only to the general arrangement of the facilities and the primary and the control equipment associated with the Intertie Protection Equipment. Neither PPL EU nor any person acting on behalf of PPL EU (a) assumes any responsibility for the correctness of design, drawings, installation or operation: or (b) assumes any liabilities with respect to the use of, or for damages of any kind resulting from the use of, any comments disclosed in the review document.

It is suggested that, panel construction should not begin until PPL EU approval has been obtained on the above drawings.

CURRENT AND VOLTAGE TRANSFORMERS

PPL will approve the voltage transformer (VT or PT) and current transformer (CT) ratios. In general, we require WYE connected VTs (or PTs) and WYE connected CTs. These VTs and CTs must be relaying class accuracy (see "Protection Requirements for Parallel Operation of Generation," Section 6, for minimum requirements) and be able to support the connected burden during normal load and fault conditions. Typically 200 VA PTs (or VTs) and class 400 CTs will be acceptable for facilities using discrete relays. IEEE 1547 compliant equipment using remote mounted CTs and PTs will be required to supply equipment compatible with the IEEE 1547 manufacturer's specifications. Equipment with lower ratings must be approved by PPL.

PPL will supply fault current data at the point of connection to facilitate the proper sizing of protective equipment.

NOTE: CTs and VTs (relay windings) for IPR relaying may be shared with POC relaying; however these are NOT to be shared with any customer or generation relaying, or revenue metering.

TRIPPING RELAYS

The current microprocessor based protective relays typically provide multiple trip and block close contacts. It is expected these contacts will be connected to directly trip and block close of the required breaker.

When a normally de-energized auxiliary relay or lockout is used to trip and block closing of the generator or other breaker, the IPP should install suitable equipment to monitor continuity of this relay coil, without effecting operation.

CONTROL SWITCHES

PPL CONTROL SWITCH (PCS) is located in the IPR Cabinet, see appendix for additional switch details.

The generator must provide a control switch (designated PCS), located in the IPR cabinet for PPL EU use. This switch will provide the capability to locally disconnect the generation from the PPL EU system when circumstances require manual disconnection.

A standard PPL EU control switch (General Electric Company Type SB-1, Model 16SB1B2X2) or equivalent with flag, sliding contacts; etc. must be used for the PPL EU control switch. See Attachment LA-94000, Sheet 10, for switch details. Alternative suppliers for this equipment will be considered as long as the functional requirements are met.

The PPL EU control switch shall be a three-position switch with spring return from close to normal and from trip to normal. (The "close" position shall be to the right of "Normal" and the "Trip" position shall be to the left of "Normal." This will maintain compatibility with standard PPL EU controls.)

The PPL EU switch shall be able to trip but not close the point-of-contact or generator circuit breaker. The PPL EU control switch will provide an interlock to block closing of the generator circuit breaker by generation control switch unless the PPL EU control switch is in the normal-after-close position. There must be provision for a PPL EU padlock to be installed to prevent unauthorized access to this switch. The exception to this requirement is for facilities under PJM agreements and subject to PJM rules and regulations.

BREAKER STATUS

PPL EU must be able to determine the actual status of the generator breaker contact position (open or closed) before any switching is attempted on the safety switch or point of contact air switch. Indicating lamps (driven by circuit breaker auxiliary switches) and a means of sensing actual current flow (CTs and an ammeter) or a physical indication (breaker semaphore) must be available to PPL EU switchman.

INDICATING LAMPS

Two indicating lights should be located within 6" of the PPL EU control switch: A red lamp (labeled CLOSED) to indicate when the generator or point-of-contact circuit breaker is closed, and a green lamp (labeled OPEN) to indicate when the generator or point-of-contact circuit breaker is open.

CONTROL SYSTEMS

The IPP has the option to use either an AC or DC control system, as described below. When a battery system is used for the DC supply the DC monitoring relay must be completed and functional. Capacitor trip devices shall not be used.

AC SYSTEM

Typically AC control schemes will be used on very small generation projects. The AC control system supply must use 60 Hz power derived from the PPL EU line. The system must be designed to be fail-safe and the failure of any single component must result in a trip of the generator breaker.

NOTE: In AC powered schemes the generator breaker will probably be a contactor. In such cases a latching contactor is not acceptable. The AC system should use continuously energized auxiliary relays with contacts arranged to trip the generator circuit breaker whenever the relays drop out, by interrupting the undervoltage trip coil. If a

molded case circuit breaker (or equal) is used, it must be equipped with an undervoltage trip option.

All installations must isolate (trip) the generator in such a manner that return of the generation (i.e. closure of the generator or POC breaker) can only occur by:

- a manual operation under the direct control of the PPL EU System Operator/Power System Dispatcher or
- A time-delayed automatic synchrocheck or voltage check supervised operation after the PPL EU source has returned to normal.

Under no circumstances is the generator contactor (breaker) to close immediately upon restoration of the PPL EU source. Automatic operation of these facilities must be discussed with PPL EU.

A white lamp and nameplate should be provided to monitor the AC source.

DC SYSTEM

This system will use a battery to supply tripping energy to the generator circuit breaker. This DC source must be continuously monitored by the (27/DC) undervoltage relay which will trip the generator circuit breaker if the DC source voltage falls below 10% of nominal. In general, the DC system should use normally de-energized relays.

All such installations must isolate (trip) the generator in such a manner that uncontrolled automatic reclosing of the isolation breaker can not occur for:

- a manual tripping operation or
- An automatic (protective relay initiated) operation. In such situations, a time-delayed automatic synchrocheck or voltage check supervised operation is required to close the generator or point-of-contact breaker (contactor) after the PPL EU source has returned to normal.

Under no circumstances is the generator contactor (breaker) to close immediately upon restoration of the PPL EU source. An automatic reclosing operation of these facilities must be discussed with PPL EU prior to implementation.

Under no circumstances is the generator contactor (breaker) to close immediately upon restoration of the PPL EU source. Automatic operation of these facilities must be discussed with PPL EU.

An amber or yellow lamp with a nameplate should be provided to monitor the DC source.

RECLOSING

The need for automatic reclosing modifications is directed towards protection of the PPL EU system and the equipment of PPL EU customers. Unsupervised reclosing with parallel generation could cause damage to customer's equipment. It is the generator's responsibility to evaluate the potential effect of PPL EU reclosing practices on the generation system and to provide suitable protection.

PPL EU normally provides automatic, multiple shot reclosing with *no intentional time delay on the first* reclose on all 12 kV line circuit breakers. Additionally, automatic sectionalizing for faults is provided on the distribution system with electronic and hydraulic reclosers that reclose in approximately 2 seconds following a trip operation. To protect both PPL EU and customer's equipment from possible damage due to out-of-phase reclosing, the substation 12 kV line circuit breaker and the line reclosers may have to be modified with voltage check relays.

Lines operated at 69 kV and above also utilize 3-shot automatic reclosing with the first reclose delayed approximately 1 second. Reclosing logic for these lines may need to be modified to include synchronism check relaying and audio tone signaling facilities to minimize the possibility of closing out of phase into an isolated generator.

TARGETS

Individual protective relays should be equipped with targets that indicate operation. These targets are to be arranged in the control circuit to operate only when the associated relays trip the generator or point-of-contact circuit breaker. Microprocessor based relays will have internal targets (typically LED indicators) to indicate the type of fault, and tripping.

INDICATING METERS

Where required, the IPP shall install an ammeter to indicate the flow of current in the POC air switch.

For three-phase installations, an ammeter switch (General Electric Company, Westinghouse, or Electro Switch) must be installed, to allow ALL phase currents to be read.

NOTE: If SCADA is to be installed, the above ammeters should be replaced with suitable IEDs (Intelligent Electronic Device). This meter will be directly connected to the PPL EU SCADA to supply the required analog data, equipment position, and can supply local indication of current.

CURRENT AND POTENTIAL CIRCUIT GROUNDING

Neutral and ground are not to be confused. All current and potential neutrals are to be isolated from all other circuits. Each neutral is to be grounded at one point only. The preferred grounding location will be at the Intertie protective relay cabinet, on the cable side of the isolating links. Other locations can be considered if the safety of PPL EU personnel is not compromised.

VISIBLE BREAK SAFETY SWITCH (or visible breaker disconnect switch)

DEFINITION

A switch, which when in the open position can allow the physical contacts to be viewed and provides positive interruption of the circuit by physical separation of the contacts.

ACCEPTABLE DEVICES

Devices in compliance with IEEE 1547, devices designated for use as 'visible break disconnect', fused disconnect switches, circuit breakers that can be physically removed from switchgear and locked on the removed position.

NONACCEPTABLE DEVICES

- Load-break switches with arc chutes that obscure a direct view of the contacts with the switch in the open position.
- Molded case circuit breakers.
- Any device with hidden or non-observable contacts

This device is required on all generation installations ***except the single phase certified inverter based installation of 10 kva or less.***

A "racked out" breaker can be considered a visible break for large installations using switchgear. The breaker must be capable of being locked in the "racked out" position, however.

If the facility requires load-break capability, then a second device must be installed in series with the visible break safety switch, to provide the load breaking capability.

This visible break safety switch is a safety item and must be reviewed by PPL EU Engineering for: correct application, correct position, and correct type, prior to the start of construction.

Please contact PPL EU for the latest specification, possible switch locations, and types of switches available.

1.4 IPR CABINET

PPL EU requires control of the intertie protective relaying. This can be provided by a dedicated locked cabinet, with a PPL EU lock, or by the use of passwords on the relays or both. NO other protection or customer/generation protection or control logic is to be implemented in the intertie protective relaying. PPL EU will specify relaying requirements and any special metering for the generation installation.

IEEE 1547 compliant equipment will typically be housed or otherwise included in the generation facility. For this reason, the specifications below will not apply to these facilities. If however, additional protection, control, or monitoring equipment is required, then these requirements should be followed as closely as possible for the proposed installation. This additional equipment could be DTT (Direct Transfer Trip), local control switches for PPL EU use, or PPL EU SCADA, for example. Special purpose schemes may be included depending on the impact of the facility.

1.4.1 GENERAL

- Only "Intertie Protective Relays and Controls" as detailed by PPL EU may be installed in the IPR cabinet, unless passwords have been implemented to limit access to the IPR relay(s). The IPR relays will NOT contain any IPP or generation logic, interlocks, alarms, or controls.
- The IPP will furnish all equipment required for the IPR cabinet, except for special metering equipment, and the SCADA protocol converter, if required.
- All component (relay, resistor, fuse, etc.) ratings and ranges must be approved by PPL EU.
- The IPP is requested to identify PPL EU as the end user to all suppliers of protective relays and switches. In general PPL EU will maintain the equipment, and we request access to possible firmware updates or manufacturers service bulletins.
- The maximum voltages allowed in the cabinet are 140 VDC and 240 VAC nominal. Any voltages above this level must be barricaded and labeled.
- All relays must be current production utility grade relays, and must be approved by PPL EU. PPL EU will supply a list of currently approved vendors if requested.
- PPL will inspect the cabinet prior to assuming operational control; any deficiencies must be corrected by the generator before acceptance
- The IPP is responsible for mounting the cabinet in an easily accessible location. The IPP is to provide an access procedure for PPL EU access to any PPL EU owned, maintained, or controlled equipment (IPR, DTT or SCADA). This is not applicable to inverter based systems.
- The IPP shall supply copies of the drawings listed below for review by PPL. Contact PPL EU for the specific quantity required. AutoCAD is the preferred electronic format; however, PDF is also acceptable. The drawings will be assigned a PPL EU drawing number, and entered into the PPL EU drawing system, and re-issued as the 'drawings of record' for the IPP installation.
- ALL drawings must be suitable to be scaled to "D" size (24 inches by 36 inches), except for reports, word or excel documents. Reduced size drawings are NOT acceptable.

1.4.2 DRAWINGS

Potential/current elementary - showing the IPR equipment.

Control elementary - showing the circuit breaker controls. (See DLB2)

Wiring diagram or wire list - for the Intertie protective relay cabinet. (See DLB1 and DLB3)

PPL will approve elementary drawings typically within 30 days, of receipt. Wiring diagrams or lists will not be approved. Panel construction should not begin until PPL EU has approved the elementaries.

The generator is responsible for the accuracy of all drawings.

The generator shall supply copies of all "As Built" drawings and instruction books for relay switches, auxiliary relays, VT, CT and any other devices as requested by PPL, prior to final acceptance of facility. Contact PPL EU for the number of copies required.

1.4.3 EQUIPMENT HOUSING

For outdoor installations, there must be a minimum three (3) feet of clearance between the IPR cabinet and any fence or other structure that might interfere with the opening of the doors or access to the cabinet. The IPR can be installed in a switchgear type line up of cabinets provided that sufficient clearances exist for access to the IPR cabinet, per NEC and NESC standards.

For indoor installations all walkways around the IPR cabinet must be a minimum of three (3) feet wide. Any other structures or cabinets must not obstruct doors.

With the trend to using microprocessor based relays, and to include ALL of the required IPR protection in a single device, failure of this device must be considered. PPL EU strongly suggests that two (2) relays be provided, such that the failure of one will allow continued operation of the IPP facility until the failure can be repaired. Failure of a single relay installation requires the immediate disconnection of the generation from the PPL EU system. *PPL EU will assume and retain ownership of the relaying installed to protect the PPL EU system*, referred to in this document as the IPR protection. NOTE: in some cases, the IPP may own and arrange for testing based on legal agreements for the specific project. However, PPL EU will still maintain control of the IPR equipment.

A. General Construction

The cabinet minimum size must allow easy access to all components and if equipped, must not restrict motion of internal swing panel.

1. IPR cabinets, which will be subjected to an outdoor environment, shall conform to specifications for a NEMA Type 3R - Ventilated Enclosure. Indoor cabinets shall conform to specifications for a NEMA Type 4 Enclosure. Specifications for these enclosures are contained in NEMA Standard ICS 6-1978.

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2. Single door cabinets will need the following:
 - a) A latch handle on the door with provisions for PPL's padlock (3/8" hole).
 - b) A latch or equivalent to keep the door in the open position and hold it there.
 - c) A hinged panel, opening in the same direction as the door.
 - d) A handle to facilitate opening and closing of the hinged panel.
 - e) A latch or equivalent to keep the panel in the open position or the fully closed position, and hold it there.
 - f) All components and wiring must be accessible from the front door.
 3. For double door cabinets all components and wiring must be accessible from the front (and/or rear) doors. If all components are not accessible from the doors, then the cabinet shall have a continuously hinged panel opening in the same direction as the front access door.
 4. IPR relays may be mounted on the doors of cabinets not exposed to weather. However, the PPL EU control switch is not to be mounted on the doors. This switch must be mounted on the panel behind lockable doors, or under PJM generation agreements for the operation of this type of equipment.
 5. The IPR controls and lamps may be mounted on the door provided that components subjected to an outdoor environment are of weatherproof construction.
 6. Space shall be provided near the terminal blocks to allow connection of conduits.
 7. Hinges exposed to the weather shall be stainless steel or equivalent non-rusting material.
 8. One duplex 120 VAC, 15 amp, receptacle must be located in the cabinet or within 10 feet of the cabinet and must be accessible for PPL EU use. This circuit cannot be supplied by the PT's or VT's used for relaying.
 9. Cabinet is to be labeled "Generation name control cabinet" in black letters with a yellow background and a minimum height of 1".
 - B. Heaters
 1. Heaters are required in all outdoor cabinets to control condensation, and shall be operated at 120 VAC, and rated at 125 VAC.

-
2. Heaters shall not be located near a device when the performance of that device is dependent on ambient temperature.
 3. A protective screen or shield shall enclose all heaters.
 4. Humidistats and thermostats may be installed subject to PPL EU review to control heat during summer months and maintain an adequate temperature differential if there is sufficient heat provided by other components.

C. Grounding

1. Cabinet and duplex receptacle must be solidly grounded.

1.4.4 **WIRING** - Guidelines

A. General

1. Cabinet wiring shall meet current NEC and industry standards, and suitable for operation at 90°C.
2. Cabinet wiring should be free from abrasions and tool marks, and all bends of wires shall have a minimum of 1/4" radius.
3. All wires should be anchored to the cabinet or bundled when running between devices. Wiring should be installed so that it can be visually traced and checked.
4. Wiring should be installed so as to avoid damage to the cable and its insulation. Movement of the hinged panel shall not damage the cable or its insulation or cause stress to the termination points on the panel or on the door.
5. Wiring and device location should not prevent the removal of any equipment, block access to equipment for inspection and maintenance.
6. All equipment should be mounted and wired in such a manner that no energized terminals or connections are exposed with cabinet swing panels and doors closed.
7. All protective relays or IEDs (Intelligent Electronic Devices) not equipped with internal isolation devices must be connected through an external test device (i.e., WHSE FT-1 or similar as determined and approved by PPL EU). ALL inputs and outputs for protective relays and IEDs are to be connected through suitable test switches. Further the switches are to be connected to allow the isolation of the device and the injection of current or voltage WITHOUT disturbing other devices that may be connected to the same CT or PTs.
8. All incoming and outgoing cables/conductors will terminate on sliding link terminal blocks located in the IPR cabinet.

B. Terminal Blocks

1. Terminal blocks shall be mounted such that the connections and links are accessible and not blocked by projecting equipment.
2. Terminal blocks shall be mounted a minimum of 6" from sidewalls and adjacent equipment and a minimum of 4" above the bottom of the housing.
3. Terminal blocks shall be mounted such that the sliding link:
 - a) Falls closed when loosened, if mounted in horizontal rows.
 - b) Moves toward the front of the cabinet when opened, if mounted in vertical rows on side panels.
 - c) Moves away from the panel centerline when opened, if mounted on the rear panel.
4. There shall be a minimum of 10% or 2, whichever is greater, spare terminals included in the cabinet for modifications.

C. Terminal Connections

Suitable connections or connector are to be used for the applications. PPL EU prefers Ring tongue lugs, which completely encircle the screw or the stud. The crimping tool should be suitable for the connectors used. Soldered terminals or connections should generally be avoided.

D. Identification

A suitable means of identifying the conductors or wiring should be employed to provide a method to trace the wiring.

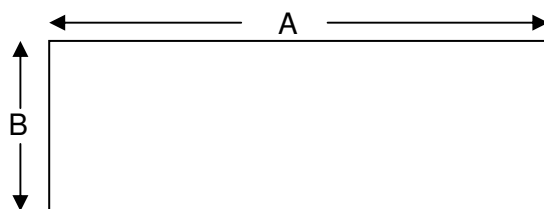
5. Nameplates

Suitable nameplates should be applied to the various pieces of equipment to avoid miscommunication or switching errors. The actual text on the nameplates should be shown on the drawings for PPL EU review.

The same wording on these nameplates should be referenced in any operational instructions.

Below is a typical list of nameplate schedules.

NAMEPLATE SCHEDULE



All dimensions in inches.

FIG	DIM A	DIM B	HEIGHT OF LETTERS	WHERE USED
1	2-1/2	1	7/32	All primary circuits on generating or substation switchboards (up to two lines)
2	2	3/4	1/8	Equipment on switchboards or in cabinets (up to 3 lines)
3				
4				
5	2-1/4	1-1/2	1/8	Equipment on switch boards or in cabinets (up to 3 lines)
6				
7	4	1	1/8	Equipment on switch boards or in cabinets (up to 4 lines)
8				
9	3-5/8	3/4	1/8	3 gang fuses and indicating lights (up to 3 lines)
10	2-3/4	1-1/4	1/8	Equipment on switch boards or in cabinets (up to 5 lines)
11	1-5/8	13/16	1/8	SCADA
12	4-1/2	1	7/32	Small cabinet doors (up to 2 lines)
13	8	2	1/2	Large cabinet doors (up to 2 lines)
14	3-1/2	1-1/4	7/32	Identification on front and back of switchboards (up to 3 lines)
15				
16				

1.5 METERING OF ELECTRIC SERVICE AND GENERATION

For billing metering of electric service at 12 kV or lower voltages, please refer to the PPL document titled, [REMSI \(Rules for Electric Metering and Service Installation\)](#). Link does not work.

Distributed Generation installation may require metering facilities not discussed in REMSI. To obtain these requirements, please contact [Industrial and Commercial Services](#) (Link does not work).

The subject of metering needs to be discussed carefully so that the correct sensing equipment is installed for the desired operation. There are many variations on the sale and purchase of the power associated with these types of facilities. A complete discussion of all of these options is outside the scope of this document. Contact PPL Electric Utilities for the various options.

Generators that intend to participate in the PJM market will need to make arrangements to get specific information to PJM in a timely manner. One method to do this is the installation of a PJM SCADA RTU. This PJM SCADA RTU uses the Internet to transmit the data to PJM. It also connects to revenue meters to get this information. This option needs to be discussed if PPL EU supplies the metering equipment.

1.6 DEFINITIONS

Overview

Please note that PPL uses the following defined terms for various utility and customer facilities' configurations.

CTs	Current Transformers
DG	Distributed Generation (aka – generator)
DR	Distributed Resource (aka – generator)
FID	Fault Interrupting Device (a circuit breaker or fuse)
KI	Kirk Key Interlock
ICS	Industrial and Commercial Services
IPP	Independent Power Producers (aka – generator)
IPR	INTERTIE PROTECTIVE RELAY
NUG	Non Utility Generator (aka – generator)
PLC	Programmable Logic Controller
POC	Point of Contact
PPL EU	PPL Electric Utilities
PTs	Potential Transformers
REMSI	Rules for Electric Meter and Service Installations
SCADA	Supervisory Control And Data Acquisition
TCM	Trip Circuit Monitor
RTU	Remote Terminal Unit (SCADA)

TABLE 1
RELAY DEFINITIONS AND FUNCTIONS FOR FIGURES

TYPE	FUNCTION	DESCRIPTION
21Z1	Zone 1 Distance	Provides a trip signal for a power system fault on the PPL EU supply line.
21Z0S	Out-of-Step	Provides a trip signal for loss of power system-generator synchronism.
25	Synchronism Check	Provides a 'permission to close signal' to the breaker used to parallel the generation to the PPL EU system.
27GEN	Generator Voltage Check	Used to block closing of generator breaker (or other) if voltage is present on generator side. Used primarily with induction generators.
27I	Instantaneous Undervoltage	Provides a trip signal within three cycles of an undervoltage condition; also provides a block closing signal until source is normal.
27N	Narrow Band High Accuracy Undervoltage	Set above 27I or 27T; provides an alarm to generator operator and a trip after a delay (via 62L) of several minutes. (99% reset)
27T	Time Delay Undervoltage	Set at 94% of nominal voltage with a time delay of .1 to 2 seconds to override local voltage dips.
27DC	Battery Monitor	Set to trip the generator breaker when the battery reaches $\cong 90\%$ of nominal DC voltage with a time delay sufficient to override momentary voltage transients.
32	Power Directional	Monitors power flow into PPL EU system.
51V	Torque-Controlled Time Overcurrent	Set to approximately 25% of the machine full load rating with the torque control being supplied by the 27 relay(s).
50/51	Time and Instantaneous Overcurrent	This is the POC protection and is connected to monitor phase current flow on the high side of the transformer.
50/51N	Time and Instantaneous Overcurrent Neutral	This relay is connected to monitor the neutral current flow in the high side of WYE connected transformers. It is usually set to 1 amp secondary current.
59N	Narrow Band High Accuracy Overvoltage	Set below 59I/59T; provides an alarm to generator operator and a trip after a delay (via Overvoltage 62L) of several minutes.
59T	Time Delay Overvoltage	Set at 106% of nominal voltage with a time Overvoltage delay of .1 to 2 seconds
62	Auxiliary Timer (Short	Used with 27I and/or 59I to produce 27T and/or 59T function.

	Time)	
62L	Auxiliary Timer (Long Time)	Used with 27N and 59N to provide several minute delay to allow plant operator to correct voltage deviation.
810	Overfrequency	Typically set at 60.5 Hz.
81U	Underfrequency	Typically set at 59.5 Hz no time delay. May be set to 57.5 Hz with 5.0-second delay for large units to coordinate with load shedding relays.
DTT1	Direct Transfer Trip	Sends a signal from PPL EU Terminal A to trip generator and a second signal from generator breaker to Terminal A to allow reclosing.
DTT2	Direct Transfer Trip	Same as DTT1 except to Terminal B.

NOTE: For all installations, the preferred relays are microprocessor-based units which include multiple protective or control functions. These relays provide many of the above functions in one case as well as oscillographic and sequence of events capability. ALL microprocessor-based relays are to be supplied with suitable communication software to allow transfer of data and settings from a personal computer and are required to derive control power from a DC source. AC supply of microprocessor based relays from the grid is not acceptable.

Use of a single microprocessor based relay has the potential to lose ALL protection upon failure of the microprocessor based relay. Therefore, if only one (1) microprocessor based relay is installed, the relay failure (or health) contact must be connected to isolate the generation from the PPL EU system upon failure of the relay. Installation of a second or backup relay eliminates the need for this trip, and is strongly recommended.

PPL EU will consider allowing the POC relay to backup the IPR relay and the IPR relay to backup the POC relay IF BOTH relays are provided with the suitable protective functions. Please contact PPL EU directly to discuss.

1.7 POWER TRANSFORMER CONNECTIONS AND VECTOR DIAGRAMS

All three phase Generation must be isolated from PPL EU customers by a power transformer. For new three phase installations the **PREFERRED** isolation transformer is WYE-grounded high side (PPL EU). The low side will typically be delta, but the generation can specify WYE if necessary. The transformer high side winding is to be specified for full insulation to allow for impedance grounding. The need for impedance grounding depends on the impact of the generation to the PPL EU system. It will not be necessary in all cases. Existing facilities which install generation will typically have a Delta high side and WYE low side transformer. This will be accepted by PPL EU; however, additional high voltage protection may be required. Further, the generator sponsor should review the transformer connection and the impact on the connection of the generation equipment to the existing plant.

PPL System - 230 kV and Below

PPL employs a "C-B-A" phase sequence at voltage levels of 230 kV and below. Most references site an "A-B-C" or "1-2-3" sequence. For PPL, the equivalent would be "C-B-A" or "1-2-3."

PPL chose to connect the high side of delta-wye power transformers in the following manner in all divisions except the Lancaster Division.

A phase - H1 Bushing
B phase - H2 Bushing
C phase - H3 Bushing

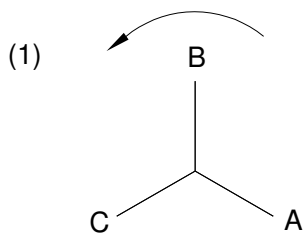
For the Lancaster Division:

C phase - H1 Bushing
B phase - H2 Bushing
A phase - H3 Bushing

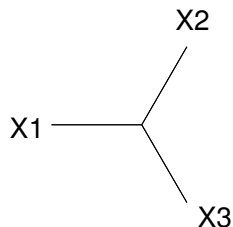
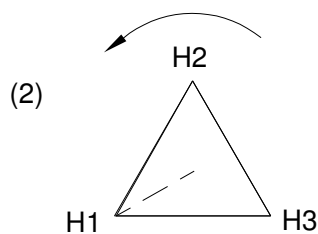
For all PPL divisions except Lancaster, the transformer connections noted above and the standard phase relationships and transformer terminal designations for three-phase power transformers as outlined in IEEE Standard C57.12.00-1993 result in a non-standard phase displacement of the low side voltage leading the high side voltage by 30 degrees.

For Lancaster Division, the transformer connections noted above and the standard phase relationships and transformer terminal designations for three-phase power transformers as outlined in IEEE Standard C57.12.00-1993 result in the low side voltage lagging the high side voltage by 30 degrees.

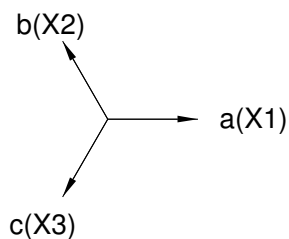
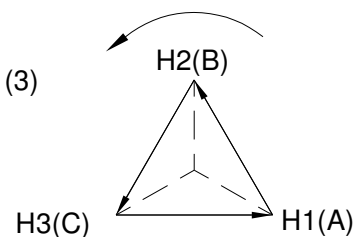
The diagrams on the following page illustrate the transformer connections and angular displacements noted in the discussion above.



PPL 230KV AND BELOW
C-B-A ROTATION



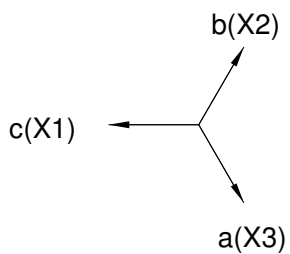
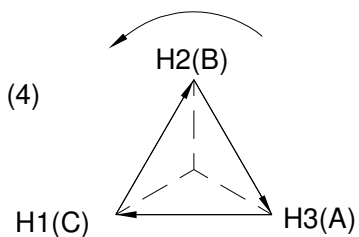
INDUSTRY STANDARD



LOW VOLTAGE LEADS
HIGH VOLTAGE BY 30°
(SYSTEM).

HIGH VOLTAGE

LOW VOLTAGE



LOW VOLTAGE LAGS
HIGH VOLTAGE BY 30°
(LANCASTER).

HIGH VOLTAGE

LOW VOLTAGE

1.8 BASIC INSULATION LEVELS AND CLEARANCES

The generator owners equipment BIL is expected to coordinate with established PPL EU designs. In addition, NESC clearances are to be maintained. Please refer to POINT OF CONTACT REQUIREMENTS FOR HIGH VOLTAGE CUSTOMER-OWNED FACILITIES for additional information.

1.9 VOLTAGE LEVELS AND VARIATION

Please refer to POINT OF CONTACT REQUIREMENTS FOR HIGH VOLTAGE CUSTOMER-OWNED FACILITIES for additional information.

1.10 INSTALLATIONS INVOLVING 15 KV CLASS SWITCHGEAR

Please refer to POINT OF CONTACT REQUIREMENTS FOR HIGH VOLTAGE CUSTOMER-OWNED FACILITIES for additional information.

1.11 POC or GENERATOR BREAKER(S)

This breaker is typically the main device used to isolate the generation from the PPL EU system. It must be able to withstand 2 per unit voltage (minimum) across the open contacts. It should be equipped with breaker failure protection to provide an alternate means of isolation should the breaker fail to trip. It may be necessary to coordinate the breaker failure relaying with PPL EU protective relaying. SF-6 breakers require special consideration since loss of SF-6 gas pressure will reduce the breaker's dielectric capability and the ability to interrupt current. Consequently, loss of SF-6 gas will initiate a local and a PPL EU SCADA alarm, and then trip the breaker before the gas pressure is too low to operate the breaker. The manufacturer's recommendation for the specific breaker will be carefully reviewed to determine if the suggested operation on loss of SF-6 gas will be acceptable on the PPL EU system.

1.12 TELEPHONE CIRCUITS

Telephone circuit requirements for GENERATION installations vary depending on the size of the generator and how it is connected to the PPL EU power system. Any or all of the following may be implemented for any generation installation:

All phone lines (DTT, SCADA) must be available approximately one month prior to synchronism date. (Generally only larger systems.)

- SCADA - Requires a dedicated 4-wire line (type FDDA).
- DTT - Requires a dedicated 4-wire line for each dual channel application (type PRDA).
- Voice grade - A voice grade phone line is required. In addition, PPL EU needs to be able to read the revenue meters daily. Therefore, a **shared voice grade** phone line is suitable for this function.

-
- Further, an extension phone should be located in the vicinity of the SCADA and DTT equipment.

PPL EU will provide specific information on the type and quantity of phone lines to be provided and the typical protection requirements for the phone lines for each project. The local telephone company may have additional requirements.

All copper phone circuits required by PPL EU (SCADA, DTT) must be equipped with **telephone company approved** high voltage isolating devices. See IEEE 487-2000 latest version, and the local telephone company specific requirements. NOTE: these specialized phone lines tend to be long lead items, and may not be available in all locations.

In addition telephone companies may have their own specific requirements. Some *typical* requirements are:

- IEEE 487 – “The dedicated cable should be routed in a well drained insulated conduit, e.g., polyvinylchloride (PVC), within the station ground grid area.”
- IEEE 789 – “In the case of the dedicated communications cable leaving the station, it is recommended that this cable be installed in a continuous PVC conduit within the station and for at least 3 m (10 ft) beyond the ground grid or the power station perimeter fence.”
- IEEE 789 – “It is important that metallic conduits should not be used or extended outside the station grid.”
- Specific telephone company requirements at power stations (customer handout) – “Schedule 80 PVC conduit (suitable for cable pulling) from the HVP [High Voltage Protection] location to a point 10 feet (3 m) beyond the substation fence or ground grid.”
- Some telephone companies also specify the use of lightning arrestors for these installations.

1.13 SCADA

A PPL EU SCADA remote will be required for installations equal to or above 2.5 Mw or connected at 69 kV or above, to allow PPL EU to remotely determine:

- Status of all circuit breakers and motor-operated switches between the point of contact and the generator(s).
 - Three-phase megawatt and megavar flows at the point of contact.
 - Three phase voltage at the point of contact.
 - Hourly integrated megawatt hours delivered to the PPL EU system.
 - Hourly integrated megawatt hours delivered to the generation facility.
 - Status of the direct transfer trip and protective relay equipment.
- Alarm condition of various pieces of equipment considered critical.

NOTE: Wind parks tend to have many small generators over a large area. These facilities will only be monitored at the point of contact and the main high voltage circuit breaker.

When a PPL EU SCADA is required, PPL EU will supply typical drawings for this equipment, as well as a listing of the various inputs and outputs. Analog data will be provided by digital meters connected to the SCADA by a suitable communication network.

A SCADA trip from PPL EU to the generator will be required. At the option of the IPP and, with PPL EU agreement, any of the following devices may be operated (tripped) by this SCADA trip signal:

1. The high side breaker
2. The low side breaker
3. The generator synchronizing breaker (if different from 1 or 2 above).

Also, PPL EU can provide a 'unit trip' signal that can be used to operate:

1. The unit Master Fuel Trip device
2. The Turbine Master lockout device
3. The Turbine Stop valves

The purpose of this unit trip signal is to provide a more controlled shutdown of the generation facility.

The intent of the SCADA trip signal is to isolate the generation from the PPL EU system, in the safest possible manner. At some locations, operation of the high side breakers may cause the generation to overspeed. The above optional trips are designed to allow for a more controlled shut down of the generation, by eliminating the fuel flow, or energy source to the turbine BEFORE the breaker between the generator and PPL EU is opened.

For these installations, the PPL EU SCADA will be used to provide the trip signal. The PPL EU SCADA equipment in general CAN NOT trip circuit breakers directly and will need a suitable interface relay. The generator will provide a suitable interface relay from the PPL EU SCADA to their equipment.

Installations below 10 MVA and connected to the PPL EU 12 kV distribution system MAY be permitted to use the PJM Internet based SCADA for their installation. This option REQUIRES a fixed IP address and an "always on" internet connection. A 'dial-up' internet connection will not be suitable due to the random assignment of IP addresses. The use of the PJM SCADA in place of the PPL EU SCADA is subject to PPL EU review and approval.

With respect to the PPL EU Distribution System, multiple Generator connections on the same distribution line will be permitted up to an aggregate of 2000 kva per line, without the installation of SCADA. Lines with generation in excess of 2000 kva will require the installation of SCADA at one or more of the generation installations. PJM offers an Internet based SCADA option that maybe suitable for units connected at 12 kV and below, where PPL EU determines that control (tripping only) is NOT required. If PPL EU determines that we must have tripping control at the generator facility, then a PPL EU SCADA must be installed.

SECTION 2 IPP RESPONSIBILITIES

The list of IPP Responsibilities covered in the following pages provides the IPP with a list of activities that must be completed before the generation equipment can be operated in parallel with the utility system. ***These are NOT in project sequence.***

Obtaining the information listed from the IPP in a timely manner will aid PPL greatly in our efforts to coordinate the installation of IPR and POC protection equipment at the point of Interconnection. Items below that refer to “POINT OF CONTACT REQUIREMENTS FOR HIGH VOLTAGE CUSTOMER-OWNED FACILITIES”, which covers new installation requirements, will have **POC** designation.

2.1 IPP RESPONSIBILITIES

<u>Description</u>	<u>Reference</u>
<input type="checkbox"/> Complete Application for Parallel Generation (for small projects), or the PJM forms for large projects.	PPL Application for Parallel Generation or the PJM Generation manuals
<input type="checkbox"/> Submit preliminary site drawings, including plan and elevation views, showing desired location and orientation of substation for PPL to provide design tensions for customer dead-end structure(69 kV and above)	
<input type="checkbox"/> Provide Letter of Intent prior to the start of PPL Engineering (small project), or PJM procedures for large project	PJM Generation manuals
<input type="checkbox"/> Return signed Electric Service Contract (may be required)	
<input type="checkbox"/> Submit customer proposed one-line diagram as described in the reference, include POC protection for installations with high side circuit breakers.	Point of Contact Protection & Control Requirements (Section 8) and *REMSI sketch as required, IPR requirements, section 6.
<input type="checkbox"/> Submit preliminary control drawings and specifications for PPL approval prior to ordering equipment	Point of Contact Protection & Control Requirements, (Section 5), and IPR protections requirements
<input type="checkbox"/> Submit final control drawings incorporating required PPL changes for point-of-contact protection prior to ordering equipment	Point of Contact Protection & Control Requirements (Section 6)
<input type="checkbox"/> For Underground Services: Submit switchgear drawings for approval - must comply with reference	PPL Drawing 6-09-199 & REMSI Rules 8 & 18
1. Termination cubicle	6-09-199, Sheet 4
2. Metering cubicle	6-09-199 Sheet 5 & REMSI Sketch #37

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- For Overhead Services: Switch & Meter poles **must** comply with reference Specifications A-6-09-194, A-6-09-197 & REMSI Sketches #30-#34 & REMSI Rules 7, 8, & 18
 - Submit CT/PT/meter location and drawings for Approval REMSI Rules 3, 7, 8, 13, 18
 - Complete transformer data sheet and submit transformer drawings for review **prior** to ordering (kva, connection, taps, impedance, primary/secondary voltages) Transformer Data Sheet and Physical & Electrical Design Requirements (**POC** Section 4)
 - If applicable, inform PPL when point-of-contact and IPR relays are available for testing/setting NOTE: PPL EU removes these relays for bench testing
 - Supply slide bar lock on substation gate and disconnecting device
 - Submit switch, interlock schematic & details Physical & Electrical Design Requirements (**POC** Section 4)
 - Return signed Electric Service Contract prior to the start of PPL construction (small projects); large projects are through the PJM process.
 - Provide payment of costs to PPL for 12 kV or lower service (small projects)
 - Execute Right-of-Way agreement for transmission line easement
 - Submit final substation site location and orientation, horizontal and vertical survey control points, and phase orientation of transformer Physical & Electrical Design Requirements (**POC** Section 4)
 - Submit final control drawings incorporating required PPL changes for point-of-contact protection **prior** to connection to PPL system Point of Contact Protection & Control Requirements (**POC** Section 5)
 - Provide power transformer certified test reports for compensated metering (%) exciting current, % impedance, core loss, full load copper loss) Physical & Electrical Design Requirements (**POC** Section 4)
 - Provide Bill of Material (major electrical equipment only) Physical & Electrical Design Requirements (**POC** Section 4)
 - Inform PPL when point-of-contact relays are available for testing/setting
 - Call PPL when ready for PPL billing metering (separate from POC equipment) CT/PT delivery
 - Install PPL billing metering CTs and PTs per PPL specifications *REMSI & Supervisor - Large Power Metering

-
- Provide substation ground grid resistance test report per IEEE Standard 81. Physical & Electrical Design Requirements (POC Section 4)
 - Provide insulation test results for all 69/138 kV equipment up to and including point-of-contact protection device
 - Complete inspection requirements - independent electrical final one-line diagram. This includes all PPL EU required station and equipment inspections. REMSI Rule 19
 - Provide as-built drawings for PPL file
 - Provide proof all POC and IPR protection is functional and tested prior to the energization of the facility.

*REMSI (Rules for Electric Metering & Service Installation)

SECTION 3 PPL TRANSMISSION LINE REQUIREMENTS FOR 69 KV OR 138 KV SUPPLY

Please refer to POINT OF CONTACT REQUIREMENTS FOR HIGH VOLTAGE CUSTOMER-OWNED FACILITIES for additional information on Dead-end structure requirements and PHASING, etc.

SECTION 4 SUBSTATION PHYSICAL ELECTRICAL AND EQUIPMENT REQUIREMENTS

4.1 SUBSTATION ORIENTATION AND PPL TRANSMISSION LINE

The location and orientation of the customer-owned substation must be coordinated with the PPL Transmission Line requirements of Section 3.

4.2 SUBSTATION LINE DEAD-END STRUCTURE

The customer shall provide a suitable free-standing or guyed structure to terminate PPL's line(s). The structure can be steel, aluminum or wood and shall be designed to accommodate the tension and clearance requirements of the distribution or transmission line(s) as noted in Section 3 (above).

Parameters for terminating the transmission line must be obtained from Transmission Engineering before the customer commits to a design for the dead-end structure.

4.3 GROUNDING REQUIREMENTS

Please refer to POINT OF CONTACT REQUIREMENTS FOR HIGH VOLTAGE CUSTOMER-OWNED FACILITIES for additional information. At a minimum these will meet IEEE 80 for step and touch safety requirements.

4.4 GROUND GRID TESTING

The customer shall have the substation grounding system tested for "resistance to remote earth" prior to making connections to the PPL lines and energizing the facility. The customer is responsible for arranging the test(s) and costs associated with such work. The tests shall be made in accordance with the "Fall of Potential" method as outlined in IEEE Standard 81, "Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System," latest revision.

All tests shall be conducted before any PPL shield wires, counterpoises and/or system neutrals are connected to the facility. If any external neutrals are connected before conducting ground testing, the results will yield false, lower value readings. Neutral(s) of any temporary construction power services must be properly isolated from the substation grounding system before tests are made. The test circuit configuration shall be so arranged that no "sneak circuits" exist through the measurements.

The reference "current probe" (C2) must be driven at a point beyond the "extent" of the ground system under test to obtain meaningful results.

All ground resistance test results must be submitted to PPL for approval and must include:

- 4.1 Geometry of the test circuit showing relative positions/directions and distances between test and reference electrodes. An accurate sketch or field-marked location plan drawing is acceptable.
- 4.2 Actual resistance measurements at several reference points including the "theoretical 62% point." Measurements shall be submitted as tabled values and graphically to illustrate the "plateau" and inflection points in the resistance curve.

PPL requires the effective resistance to remote earth of the customer's substation ground grid to be **five (5) ohms** or less.

4.5 POINT OF CONTACT SWITCHING DIAGRAMS AND NOTES

Please refer to POINT OF CONTACT REQUIREMENTS FOR HIGH VOLTAGE CUSTOMER-OWNED FACILITIES for additional information.

4.6 EQUIPMENT AND MATERIAL

4.6.1 Power Transformers

The customer's power transformers must have WYE grounded-connected primary windings. This requirement is for customers with parallel generation; if the customer has NO Generation, see the document titled "POINT OF CONTACT REQUIREMENTS FOR HIGH VOLTAGE CUSTOMER-OWNED FACILITIES". Existing load customers that are connecting generation may be required to install additional protection equipment due to the high side delta connection of the transformer.

Connection arrangement of the secondary windings is customer's option, but must be reviewed with PPL EU to ensure PPL EU System protection and coordination are adequate.

The voltage taps should accommodate the voltage criteria discussed in Section 1, Paragraph 6.0, document titled "POINT OF CONTACT REQUIREMENTS FOR HIGH VOLTAGE CUSTOMER-OWNED FACILITIES". The PPL representative may be contacted to provide transformer tap recommendations prior to purchase and a desired tap setting at the specific location given the customer's load characteristics.

For services at 12 kV, please see the REMSI document, found at website: [REMSI \(Rules for Electric Metering and Service Installation\)](#). Link does not work.

4.6.2 Point-of-Contact Circuit Interrupting Devices (CID) - Switches and Interrupter Accessories

Please refer to POINT OF CONTACT REQUIREMENTS FOR HIGH VOLTAGE CUSTOMER-OWNED FACILITIES for additional information. In all situations, the equipment must be capable of interrupting expected current flows.

4.6.3 Point-of-Contact Fault Interrupting Devices (FID)

Please refer to POINT OF CONTACT REQUIREMENTS FOR HIGH VOLTAGE CUSTOMER-OWNED FACILITIES for additional information. In all situations, the equipment must be capable of interrupting the maximum expected fault duties expected at the facility which may be different from the actual present data.

4.6.4 Insulator and Surge Arrester

Please refer to POINT OF CONTACT REQUIREMENTS FOR HIGH VOLTAGE CUSTOMER-OWNED FACILITIES for additional information. In all situations, such equipment must comply with PPL EU Insulator coordination and Surge Arrester protection requirements.

SECTION 5 PROTECTION AND CONTROL REQUIREMENTS

Also refer to the “**POINT OF CONTACT REQUIREMENTS FOR HIGH VOLTAGE CUSTOMER-OWNED FACILITIES**” for additional details.

5.1 Background

The functional characteristics designed into intertie protection schemes for generators being connected to the existing 12 kV distribution system are:

- Fast operation by undervoltage to disconnect the facility for a supply line fault or isolation prior to the first instantaneous reclosure. This is required to prevent the generation from possibly sustaining the fault and thus causing the line test to be unsuccessful or to minimize the chance of an out-of-phase reclosure.
- Fast operation on overvoltage if overexcitation and/or ferro-resonance cause a rapid, severe voltage rise.
- For smaller units, a simple, reliable, fail-safe system is considered important. The main emphasis is to assure disconnection on loss of source line. It is desired that tripping be initiated as directly as possible from the measured supply voltage with minimum reliance on interspersed devices. An AC powered, non-latching contactor is a suitable device.

For those installations connected to a 12 kV line serving other facilities, 'window' relays are specified which trip the generator if voltage or frequency are outside a specified bandwidth. While it is desired to maintain precise limits of 114 and 126 volts and 59.5 to 60.5 Hz, some compromise may be necessary when selecting the actual voltage relay set points. Normal operating voltages can closely approach these desired limits. The tolerances and reset ratios of typical relays must also be considered. A larger voltage bandwidth may be considered acceptable since:

- Smaller units cannot influence voltage appreciably while operating interconnected, because the PPL EU system is large compared to that of the generator. In cases where the unit can influence the local voltage, limits will be placed on the operation of the unit.
- The possibility of stable island operation with the generation supplying isolated load served by the 12 kV line is small.

Regardless of the type of relays used, the main emphasis designed into the intertie package is prompt tripping for supply line problems. Relay Coordination is considered secondary to this objective.

NOTE: Under no circumstance are the IPR relays to trip through a PLC or other programmable device. The IPR must trip directly to avoid any additional time delay for an interposing programmable device. Auxiliary relays can be used only IF ABSOLUTELY necessary. The trip signal may be MONITORED by a PLC or other programmable device to facilitate control functions at the IPP facility.

Relays - Basic 12 kV Package

- 27 - Undervoltage - relay to be set at approximately 95% of nominal voltage (114 secondary volts on a 120 volt base). If VTs are located on the low side of the power transformer, settings may approach the generation operating voltage and may interfere with normal operation of the generator.
- 59 - Overvoltage - relay to be set at approximately 106% of nominal voltage - (127 secondary volts on a 120 volt base).

NOTE: The suffix I indicates a relay that operates instantaneously, and the suffix T indicates a relay that incorporates an intentional time delay on tripping.

- 62 - Time Delay Relay - may be required to provide a time delay for undervoltage tripping in order to provide coordination with motor starting and system faults.
- 81 - Over or Underfrequency - The overfrequency relay will be set at 60.5 Hz and the underfrequency relay at 59.5 Hz. Some installations will not require both relays; therefore, 81 OF will designate overfrequency and 81 UF will designate underfrequency. When both relays are required 81 UF/OF will be designated.

The relays above provide a "window" of allowable operation for the GENERATION and are needed to ensure that PPL EU customers who could be isolated with the generating unit are not subjected to service with abnormal frequency or voltage.

- 25 - Synchronism Check - will compare the voltages on both sides of the generator breaker and any other breaker to be used to synchronize the generator to verify that voltage, phase angle, and slip frequency are within acceptable limits. Where synchronism check is required, breakers between the point of contact and generator which are not supervised by synchronism checking relays must be equipped with interlocks or other PPL EU approved means to prevent these breakers from paralleling the generator with the PPL EU system.
- 27DC -When a battery is provided for the generator breaker controls, a 27-DC relay (DC undervoltage trip) must be included. The DC undervoltage trip may incorporate a time delay sufficient to override momentary voltage transients, but the relay must trip a breaker to isolate the generator *before* the battery voltage has fallen to a level where the protection or breaker operation would be impacted.
- 32 - A single phase power relay which is connected to monitor power flow into the PPL EU system. This relay is used to limit the maximum amount of power supplied to the PPL EU system by the generation to the contractual level.

For three-phase installations, devices 27, 51V and 59 can be three single-phase relays or a single three-phase relay, or a single microprocessor based relay

providing these functions. The preferred relays are microprocessor based multifunction units.

For units below 10 kva the undervoltage relay (27) may not be required if the generator contactor or breaker is wired such that loss of PPL EU supply will open and block closing of this device.

12 kV Interconnected Synchronous Generators - General

Synchronous generators will require additional relaying when compared to similar size induction generators, since synchronous generators can operate in an isolated mode and supply continuous fault current.

All units will require a synchronism check relay (25) to monitor correct closing of any breaker used to synchronize the generator to the PPL EU power system. This relay blocks out-of-phase closing and any attempt to energize a de-energized PPL EU source. A power directional relay (32) may also be required to limit power delivery to PPL EU to the contractual maximum.

Units above 25 kva may require a torque controlled time overcurrent relay (51V). This relay will limit damage due to fault current supplied by the synchronous generator.

Synchronous Generators - Single Phase (200 kva limit)

Units below 10 kva will require an undervoltage relay (27) and a synchronism check relay (25). A power directional relay (32) may also be required. See Type 1 in index.

Units between 10 kva and 25 kva will require undervoltage (27), underfrequency (81UF), synchronism check (25), and possibly overfrequency (81OF), overvoltage (59), and power directional (32) relays. See Type 1 in index.

Units between 25 kva and 200 kva will normally require the full compliment of relays including: undervoltage (27), overvoltage (59), over/ underfrequency (81 OF/UF), power directional (32), torque controlled time overcurrent (51V), and synchronism check (25) relays. See Type 1 in index.

Synchronous Generators - Three Phase

Units less than 10 kva will require an undervoltage relay (27) and a synchronism check relay (25), and possibly a power directional relay (32). See Type 2 in index.

NOTE: For units below 10 kva the undervoltage relay (27) may not be required if the generator contactor or breaker is wired such that loss of PPL EU supply will open and block closing of this device.

Units between 10 kva and 25 kva will require undervoltage (27), synchronism check (25), underfrequency (81UF), and possibly, overvoltage (59), overfrequency (81OF), and power directional (32) relays. See Type 2 in index.

Units between 25 kva and 200 kva will normally require the full complement of relays including: undervoltage (27), overvoltage (59), under/ overfrequency (81UF/OF), power directional (32), synchronism check (25) and possibly torque controlled time overcurrent (51V) relays. See Types 2 and 3 in index.

12 kV Interconnected Induction Generators - General

Induction Generators - Single Phase (200 kva limit)

Single-phase generators will be permitted to connect to the PPL EU system up to a maximum of 200 kva per phase per circuit.

Units less than 25 kva will require an undervoltage relay (27) to disconnect the unit when the supply line is de-energized. A power directional relay (32) may also be required to limit power delivery to PPL EU to the contractual maximum. NOTE: In some cases, the (27) undervoltage function will be satisfied by the use of a non-latching AC powered contactor, if the dropout voltage is 75% of rated voltage or higher.

Units above 25 kva, but less than 200 kva, will require an undervoltage relay (27), and a power directional relay (32); underfrequency (81 UF) relays may be required to enhance tripping on loss of the supply system, where operation of the undervoltage relay may be delayed.

If system load can be delivered while the generator is self-excited, overfrequency (81OF), underfrequency (81UF) and instantaneous overvoltage (59I), relays will be required.

Induction Generators - Three Phase

Units less than 25 kva will require only an undervoltage relay (27), voltage check relay (27 GEN) and may require a power directional relay (32). See note for single phase less than 25 kva.

Units between 25 kva and 200 kva will require an underfrequency relay (81UF) in addition to above.

If system load can be delivered while self-excited, overfrequency (81OF), and instantaneous overvoltage (59I), relays will be required in addition to the above.

If a capacitor is used to serve as the excitation source for an induction generator the capacitor must not be capable of remaining on the system with the generator off line.

Inverters / Direct Current Generators

The designs of the inverters, especially the large inverters (above 10kW) is changing rapidly. Below is a list of items that may need to be addressed depending on the specific application.

- Static inverters convert DC power to AC by means of electronic switching. Switching can be controlled by the AC voltage of the supply system (line-commutated) or by internal electronic circuitry (forced-commutated). Line-

commutated inverters are generally not capable of operating independently of the AC supply system and, as such, cannot supply fault current or isolated loads. Forced-commutated inverters are capable of supplying fault current and load independent of the AC supply system. All inverters will be expected to conform to ANSI/IEEE Standard 929-2000 [Recommended Practice for Utility Interface of Photovoltaic (PV) Systems] latest version and UL Publication 1741-1999 [“Power Conditioning Units for Use in Residential Photovoltaic Power System”], latest version.

- Equipment like Solar arrays (photovoltaic), certain wind turbines, and microturbines, for example, generate their power at DC or high frequency AC and use inverters to convert this power to 60 Hz AC at a suitable voltage level. Units below 10 Kw covered by IEEE 929, and UL-1741 can be connected to the PPL EU system without any other additional protection. Units up to 2 Mw or locations using multiple inverters will be subject to PPL EU review, and may require additional external protection (IPR) equipment.

The IEEE 1547 standard is primarily intended to be applied at the Area Electric Power System (EPS) or the utility DISTRIBUTION system, see IEEE 1547, section 1.3 limitations. Further ALL of the requirements of this standard are to be met at the PCC (point of Common Coupling), which on the PPL EU system is typically the 12.47 kV or 69 kV connection to the IPP equipment, see IEEE 1547, section 1.2 Purpose, second paragraph.

With the above background information, the following items need to be discussed:

1. Facilities connected to the PPL EU 69 kV system will be required to have DTT (Direct Transfer Trip) installed to the PPL EU substation supplying the 69 kV line. This is to limit interference with existing PPL EU under frequency schemes.
2. Facilities connected to 12 kV lines MAY need DTT depending on the impact of the IPP on the line and the source substation. The concern is for islanding, and reclosing on other customers rotating equipment.
3. These facilities will be required to have POC (Point of Contact) protection and IPR (Intertie Protection Relay) protection. Care must be exercised when choosing fuses for the high side protection as under some circumstances, the IPP fuses may operate before PPL EU relaying for faults on the PPL EU system. PPL EU strongly recommends the use of a three phase fault isolation device (circuit breaker or recloser).
4. The IEEE 1547.1 tests as well as the UL 1741 tests only test the operation of the inverter to THE TERMINALS OF THE INVERTER. However, the application of LARGE PV requires the use of one or more transformers to get from the low voltage inverter output (120 to 600 vac) to the utility 12 kV or 69 kV. The inverters can NOT correctly control or maintain the required settings at the PCC as they do not have a direct connection (sensors, CTs, or PTs) to the PCC. See IEEE 1547, section 1.2, second paragraphs, which states “The requirements shall be met at the point of common coupling (PCC), although the devices used to meet

these requirements can be located elsewhere.” Per IEEE 1547.1 Testing Requirements, section 5.2 “If the EUT senses voltage at a different point than the PCC with the area EPS or at the point of DR connection as specified in IEEE Std 1547, it shall be tested under load in conjunction with any external isolation transformer supplied or required by the EUT manufacturer.” The IPP or the inverter vendor needs to provide additional information on this item.

5. The IPP or the inverter vendor is requested to supply a copy of the UL1741 test report as well as any documentation of the effects of multiple units operating in parallel on the IEEE settings and operating times.
6. At larger facilities, high voltage CTs and PTs (or CCVTs) will be required for the POC, IPR relaying as well as the PPL EU SCADA and revenue metering. In most cases the PTs (or CCVTs) can be supplied with dual windings to support both the protection equipment as well as the revenue metering requirements. Separate CTs will be needed for protection and metering. Backup protection has not been specified as PPL EU is of the opinion that the built in IEEE functions will be able to provide this capability, subject to the design of the overall system.
7. The IPP or the inverter vendor will need to comment on the capability of the proposed equipment to REGULATE the power factor of the overall facility as measured at the PCC per PPL EU requirements. The equipment will need to be able to adjust the var flow with respect to the real power level. Also, since these facilities are typically LINE connected, they will typically be required to ABSORB vars to maintain the correct line voltage at the PCC. While IEEE 1547 section 4.1.1 states “The DR shall not actively regulate at the PCC. The DR shall not cause the area EPS service voltage at other local EPS’s to go outside the requirements of ANSI C84.1-1995, range A.”, the second sentence will typically be the requirement for LINE connected facilities.
8. The IPP must provide a one line with sufficient detail to show all transformer connections, and the location and connection of all of the above equipment.
9. The IPP or the inverter vendor must supply full electrical specifications for the inverters, including but not limited to the fault current levels and duration.
10. PPL EU employs automatic reclosing on its distribution level electrical systems. The initial reclosure is typically instantaneous at the 12 kV voltage level and typically delayed 1.5 seconds at higher voltage levels. Both of these are much faster than the IEEE 1547 anti-island settings of 2 seconds. The IPP or the inverter vendor must provide data or other information on the potential out of phase reclosing that could potentially exist with other customer’s rotating equipment connected to this area EPS.

The above items are specific technical issues identified for inverter based equipment. Other issues that may be necessary for an inverter based IPP

installation include: SCADA, DTT, metering equipment, telephone lines, and other protection or communication equipment.

The inverter installation must be designed such that an interruption to the PPL EU supply line will result in the removal of the inverter infeed to the supply system. Since this feature is normally included in the inverter interface, additional inertia protective relaying will not be required for certified system 10 kva or less. This equipment is required to conform to IEEE Standard 1547 [IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems] latest version and UL Publication 1741 ["Power Conditioning Units for Use in Residential Photovoltaic Power System"], latest version. In order to verify conformance with this requirement, PPL EU must be provided with sufficient information on the interface package. Harmonics and distortion of the voltage or current, generated by the generator-inverter combination, must not exceed PPL EU harmonic distortion requirements. Under no circumstances will these installations be allowed to inject DC current above the IEEE 1547 limits in to the PPL EU system.

Synchronous and Induction Generators

Synchronous generators can be excited externally or by a self-contained excitation system. In either case, such units will generally be capable of supplying sustained fault current for faults on the PPL EU supply system. Such units are also capable of operating independently of the PPL EU system and supplying isolated load. Protection will be required to limit these effects.

Induction generators are basically induction motors that are mechanically driven above synchronous speed to produce electric power. Such units do not have a separate excitation system and, as such, require that their output terminals be energized with AC voltage and supplied with reactive power to develop the necessary magnetic flux. Induction generators are therefore not capable of supplying sustained fault current for failures on the PPL EU supply system. Such units are generally not capable of supplying isolated load when separated from the supply system; however, it is possible for an induction generator to become self-excited if a sufficient amount of capacitance exists at its output terminals. Under conditions of self-excitation an induction generator may be capable of supplying isolated load providing the load is within the units' output capability. In most cases when self-excitation occurs, it will be accompanied by a sudden increase in terminal voltage, and change in frequency.

A note of caution: It is possible for both synchronous and induction generators to become self-excited due to capacitance on the line and to operate in a ferro-resonant mode with possibly damaging overvoltages.

Hybrid generators are basically induction generators that have additional components (capacitors, windings, or other equipment) installed to limit the amount of reactive required for operation. Each type of unit must be specifically reviewed to see if it can operate isolated (self-excited), or if it will be subject to self excitation from capacitors on the PPL EU system.

Due to the rapidly changing products for providing various protection requirements, the generator and PPL EU will discuss current offerings, and come to an agreement on one or more suitable devices. Prepackaged IEEE 1547 certified generators will be accepted as meeting the requirement for various voltage, frequency, and other included protective functions.

Generation equipment certified to IEEE 1547 will provide sufficient protection for most installations. Occasionally the generation will have such a large impact that the PPL EU equipment can not be coordinated with the generation facility, or the generation facility can support an island. Under these circumstances, additional protection beyond that specified in IEEE 1547 in the form of DTT or voltage block closing, or both may be required. SCADA will be applied to large units, or combinations of separate units that exceed 2000 kva per line.

- Large units, while interconnected, can have an appreciable impact on system voltage levels. Also, with more sophisticated controls it is more probable that larger units may continue operating if isolated with a portion of our system. There is a need for a precise reactive power or voltage schedule and for a control system which prevents excessive deviation from the developed voltage schedule.
- Obtaining selectivity, to prevent false trips, for system faults not on the source line takes on greater importance. Unnecessary tripping of these larger units can have a negative impact on the PPL EU system. High speed reclosing typically will not be used on these supply lines. Where dead time must be limited, DTT equipment can be used to control the reclosing of the PPL EU supply terminal.
- Larger units can impact a significant portion of the power system, and therefore, a high assurance of tripping the generator for trip outs of the line to which it is connected is required.

12 kV line Oil Circuit Recloser (OCR) Modifications

To determine if an automatic reclosing device on the PPL EU 12 kV system must be modified, it is necessary to compare the *minimum load* beyond the closest recloser whose operation can isolate the paralleled generation, with the maximum amount of generation. When the generation is capable of supplying isolated load and the ratio of load to generation is less than 3 to 1, the recloser must be modified with voltage check relays or other suitable means to prevent island operation. Only electronic reclosers can be modified; therefore, if the device is a hydraulic recloser, it must also be upgraded to an electronic recloser. This load to generation ratio check must be made for each recloser between the parallel generator and the substation until the ratio equals or exceeds 3 to 1.

Load survey information indicates that the average maximum to minimum load ratio is approximately 3 to 1 for urban areas, 4 to 1 for suburban areas and 5 to 1 for rural areas. Minimum loads should be approximated by using these ratios, if available, more accurate field data should be used for individual installations.

For units 10 kva per phase or less it will not be necessary to modify automatic reclosing at the substation CB or line OCR.

Temporary Installations:

Temporary installations are those installations where the generation is rented or installed for specific period of time, and is not permanently connected to the PPL EU system. This generation is also subject to being removed and replaced with different equipment. This generation is usually installed in a campus type setting, removed from the high voltage connection to PPL EU system. These installations also are usually limited to less than 200 hours of operation per year.

The following items should be considered for these applications:

1. The IPR relaying should be installed in such a manner that it will NOT need to be removed or re-installed with the generation.
2. Consideration should be given to limiting or eliminating the connections between the generator controls (tripping, closing, and auxiliary switches), and the use of a single breaker to isolate multiple generators.
3. If at all possible, IEEE 1547 requirements should be met by the relaying, independent of the generation installed.
4. For installations above 2.0 Mw, PPL EU will generally need to know WHEN this generation is operating, via SCADA. Generally a dial-up type of SCADA, or a PJM Internet bases system, will be specified due to the very limited amount of operation.
5. The entire design of the facility should take in to consideration the probability of changing out the generation equipment on a yearly basis WITHOUT the need to make changes to the PPL EU required IPR cabinet.

Installations Interconnected with the 69 kV System and above

Generation installations larger than 2000 kva and below 10 MVA generally require connection to the 69 kV system or to a dedicated 12.47 kV line. Units above 10 MVA must be connected to the 69 kV or higher system. Following are intertie protection concerns and requirements for such installations. Modern microprocessor relays provide several of the functions listed below in one relay package, and are the preferred equipment for these functions. NOTE: all microprocessor-based relays are to be ordered with suitable communication software to allow setting and transferring of data from a laptop Personal Computer.

1. Under/Overvoltage Relaying

69 kV voltage levels will typically vary within a 2-3 kV band over the load cycle. Specific values will typically range from about 62 kV to 68 kV over the system. Resultant low-side voltages at 69-12.47 kV substations will follow a similar pattern and taps are selected so secondary phase to neutral voltages remain with a range of 122 to 126 volts.

Standard practice is to apply voltage relays as part of the intertie protection package at the generator facility. The main intent of these relays is to prevent the generator from supplying excessively high or low voltage to PPL EU customers in the event the generator should become isolated with a portion of the system. Typically solid-state voltage relays used in this function are designed with a reset ratio of around 97% and overall accuracy to about 2%.

These characteristics limit the setting to within about 5% of the normal bandwidth level that may exist at the generator location.

Larger units may be capable of significantly affecting system voltage levels while operating interconnected. Voltage changes of as little as 1½% may affect PPL EU customers by elevating existing levels above the desired secondary distribution voltage level (126 volts x 1.02 = 128.5 volts). While voltage settings 5% above and below the normal pattern are considered satisfactory to prevent damage due to excessively high or low voltage during an isolated operation, such settings are not considered adequate for normal operation. Action needs to be taken prior to secondary voltage being driven to outside the range of 110 to 130 volts during normal operating conditions.

For those installations that can change system voltages by more than 2½%, it is recommended that high accuracy voltage relays with a reset ratio of 99% or higher be utilized. It should be possible to set such relays to about 2.5% of the normal voltage pattern limits. Operation of these relays would initiate an alarm to the generation plant operator and PPL EU System Operator/Power System Dispatcher and may be used to trip if corrective action is not taken within a specified time.

Standard voltage 'window' relays would also be utilized to provide for fast tripping on excessively high or low voltage.

2 Under/Overfrequency Relaying

Underfrequency intertie relay settings must coordinate with PJM and PPL EU system load shedding underfrequency protection. During a system condition when load exceeds generation, system frequency will drop as a function of the amount of mismatch between load and generation and the inertia of on-line generators. To prevent system collapse, load is shed in steps at three frequency values - typically, 59.3, 58.9, and 58.5 Hz. If sufficient load is shed, the system should recover and, after some possible frequency oscillations, settle back to stable 60 Hz operation. During this recovery process, it would be undesirable to trip any significant amount of generation. However, if sufficient load cannot be shed, the system frequency will continue to drop until it becomes necessary to trip all generation to avoid causing permanent damage to the generating equipment. PPL EU, as a member of the PJM, Inc., has agreed generators connected to its system will trip at a frequency of 57.5 Hz after a delay of 5 seconds. Therefore, at larger generation installations, the underfrequency relays must be set at 57.5 Hz/5.0 seconds. Overfrequency relays will be set to trip at 61 Hz.

3. Zone 1 Distance Relaying

Zone 1 distance relays are required to be included in the intertie protection package to minimize clearing time for supply line faults while maintaining coordination for system faults not on the supply line. These distance relays will be microprocessor based, and include fault recording capability.

4. Out-of-Step Relaying

Out-of-Step relays are required in the inertia protection package to isolate the generator from the power system during unstable conditions. For installations with multiple generators connected to a single transformer, the Out of Step relaying may be required on each generator.

5. Power Directional Relay

A power directional relay may be required to limit power delivery into the PPL EU power system to the contractual maximum.

6. Synchronism Check

A synchronism check relay is required on all breakers that the generator desires to use to synchronize the generation to the system. The intent of this relay is to prevent synchronizing at an excessive angle difference by providing an angle 'window' within which breaker closing is permitted. The synchronism check relay should be capable of being set for an angular difference of about 10-20 degrees and have a relatively fast operating time (less than 10 cycles).

7. Voltage Check

A voltage check relay should be used to supervise closing of all breakers, which the generator does not desire to use for synchronizing, connected between the generator and the system. Closing of these breakers shall be blocked if voltage exists on the generator terminals. An auxiliary type AC voltage relay can be used for this function or "b" fingers from synch check supervised breakers can be wired as interlocks to prevent synchronizing by unsupervised breakers.

8. Direct Transfer Trip

The primary method of tripping large generators on loss of the PPL EU supply line is by telephone line based dual-channel Direct Transfer Trip or equivalent fiber optic based, or radio based system. The tripping signal is initiated by the PPL EU line breaker position logic and by operation of the PPL EU line protective relays. Automatic reclosing of the line breaker is blocked until a return signal is received from the generator location indicating the unit is disconnected from the PPL EU system. Synchro-check relays are also applied on the PPL EU line breaker(s) as a back up to the permissive signal for closing.

Direct Transfer Trip is used for all generators requiring connection to the 69 kV and above system or 12.47 kV lines where an island may form.

9. Battery Monitor

A battery monitor relay is required to monitor continuity of DC power to the IPR cabinet and the ability of the station battery to perform its function. A relay specifically designed for this purpose should be used to trip the POC breaker. A time delay sufficient to override momentary voltage transients may be included. The trip circuit of the POC breaker must be fused independently of the monitored IPR circuit.

Generator Relay Settings

PPL EU will request specific setting information on any generation relays, which will act to trip the generator. The purpose of this request is to review the generation settings to ensure proper coordination of the generation relays with PPL EU operating practices. It is, however, the responsibility of the generator owner to apply generator protective relay settings that will provide adequate generator protection to meet IEEE guidelines and other regulatory body requirements.

PPL Control Switch

All installations must include a PPL EU control switch (PCS) located inside the intertie protective relay cabinet. The PCS must be wired to trip the point-of-contact breaker (or other breaker agreed to by PPL) and to block closing in the "Normal After Trip" position. The PCS shall be wired to permit closing only when placed in the "Normal After Close" position, but it shall not close the breaker directly.

Based on the above, the following changes/additions to the intertie protection package developed for smaller units are considered necessary for larger units:

- In addition to the normal 'window' relays (27T, 59T, 810, 81U), a set of narrow band high accuracy voltage relays (27N, 59N) may be applied. These relays will alarm to the plant and will be connected to trip after a time delay.
- Direct Transfer Trip (DTT) is utilized to disconnect the generator whenever the PPL EU source line breaker trips.
- Instantaneous tripping on undervoltage should not be applied.
- Time and instantaneous phase and ground overcurrent and directional distance Zone 1 phase relays will be included as part of the intertie package.
- Out-of-step relaying should be included as part of the generator protection package. For installations with multiple generators connected to one or more main transformers, the Out of Step protection will normally be applied at the generator, on a per generator basis.
- Output power will be continuously monitored, via a dedicated SCADA remote located at the generation facility.
- Underfrequency relays are typically set to 57.5 Hz with five-second delay to coordinate with the PJM and PPL EU under frequency load shedding program.
- A means of tripping a back-up circuit breaker for failure of the generation primary circuit breaker must be included in the intertie package.
- Large generators or generators that could impact the PPL EU system if improperly synchronized shall have a synchrocheck relay installed on the synchronizing

breaker. For installations with multiple generators connected to one or more main transformers, the synchrocheck protection will normally be applied at the generator.

5.2 **General - CTs, VTs, Metering, Etc.**

The preferred location for the source of relay potentials and currents is the high side of the generation power transformer. For all single phase and three-phase installations up to 100 kva with a fused point-of-contact where use of high-side VTs and CTs is uneconomical or impractical, these devices may be located on the low-side of the generation power transformer. This configuration must be reviewed and approved by PPL EU and, in general, will only be permitted if service to other PPL EU customers will not be impacted.

All installations must include:

- An ammeter (for single-phase installations), or an ammeter and a switch to monitor all three phases (for three-phase installations).
- Where a PPL EU SCADA is to be installed a digital multi-function meter is required. This meter will be used to collect the analog data for the SCADA, and to provide local readings. Contact PPL EU for current equipment requirements.
- A visible SEMAPHORE on each of the breakers between the generator and the PPL EU system to determine the actual status of the breaker (open or close).

To prevent a possible undesirable (out of phase) connection of the generation to the PPL EU system, synchronous generators will require a synchronism check relay (25). Induction generators require a voltage check relay (27). These devices must be located in the IPR cabinet and connected to prevent closing of the generator circuit breaker, or other breaker as agreed to by PPL EU, for:

- An out-of-phase condition.
- A de-energized line condition (PPL EU supply breaker open).
- A de-energized synchronous generator condition.
- An energized induction generator condition.

When a synchronism or voltage check relay is required, the generator must install a relay accuracy class voltage transformer on the generator side of the generator breaker, or other breaker as agreed to by PPL EU, to supply potential to this relay.

When the generator utilizes a battery to supply tripping energy, a DC undervoltage relay (27-DC) is required. This relay must be connected to trip the generation main breaker for low DC voltage, *before* the DC voltage has fallen to a level where operation of the breaker or the associated protective relaying is rendered nonfunctional.

SECTION 6 CLASSIFICATION OF INSTALLATIONS

The following general classifications show the major operating characteristics and protection requirements for typical installations. Each classification gives a general review of the types of parallel connections approved for service on the PPL EU system. A summary of these classifications is shown below.

CONNECTION DEVICE	BREAKER				
	VOLTAGE LEVEL / FACILITY SIZE	12 kV	69 kV	12 kV	69 kV
SINGLE PHASE LESS THAN 200 kva 10 kva inverter Certified equipment	TYPE 1 Figure 1 INVERTER	*	*	*	*
THREE PHASE LESS THAN 200 kva	TYPE 2 Figure 2	*	TYPE 2 Figure 3	*	
THREE PHASE 200 kva TO 2000 kva Up to 2000 kva certified equipment	TYPE 2 Figure 2 FAST TRACK	*	TYPE 2 Figure 3 FAST TRACK	*	
THREE PHASE INDUCTION GENERATOR 2000 kva TO 20 MVA	*	*	*	TYPE 3 Figure 4	
THREE PHASE SYNCHRONOUS GENERATOR GREATER THAN 2000 kva	*	*	*	TYPE 4 Figure 5	
MOMENTARY PARALLEL OPERATION - NO POWER TO PPL	TYPE 5 Figure 6	*	TYPE 5 Figure 6	TYPES 3 & 4 Figures 4,5	
No Power to the Utility – campus type installation	TYPE 6		TYPE 6		
LARGE UNITS AT 69kV AND ABOVE CONNECTED TO A SWITCHING STATION	*	*	*	TYPE 7	

*Not practical or common type of installation, must be reviewed on an individual basis.

*Contact PPL EU for any other type of installation to determine the type of connection and the protection requirements.

FASTRACK refer primarily to INVERTER based projects that have passed the PA PUC screening process. These installations use IEEE certified equipment.

TYPE 1

A Type 1 installation, shown in Figure 1, covers single-phase synchronous or induction generators up to 200 kva on a distribution circuit. These installations are characterized as:

- Having a fuse (D) specified by PPL EU as the intertie protective device, which also provides the visible break for safety.
- Having a safety switch (G) lockable in the open position, to block the generator from operation.

Relay Requirements

Induction Generator

25 kva or less	Undervoltage relay (27) and a voltage check (27 GEN) relay are required. (Note 1.) A power directional relay (32) may also be required.
Greater Than 25 kva (200 kva max)	Undervoltage relay (27), voltage check (27 GEN) and power directional relay (32) are required. Where the operation of U.V. relay (27) may be delayed an underfrequency relay (81U) will be required for coordination. If system load can be delivered while self-excited, instantaneous overvoltage (59I) and under/overfrequency (81 UF/OF) relays are also required.

Synchronous Generator

10 kva or less	Undervoltage relay (27) and synchronism check relay (25) are required. (Note 1.) A power directional relay (32) may also be required.
Greater Than 25 kva (200 kva max)	Undervoltage (27), overvoltage (59), under/ overfrequency (81 UF/OF), and a synchronism check (25) relay. (When the ratio of minimum load to maximum generation is high, the overvoltage and overfrequency relays may not be required.) A power directional relay (32) may also be required. Note 1: In some cases, the (27) undervoltage function will be satisfied by the use of a non-latching AC powered contactor. PPL EU will determine if this is an option.

The relays above are to be located in the IPR cabinet. The preferred location for the current and voltage transformers is on the high side of the power transformer. However, connection to the low side of the power transformer can be accepted.

Notes on Figure #1:

- VTs must have a minimum VA rating of 150 VA. If connected burden equals or exceeds the 150 VA rating, and then the VT shall be sized for 150% of the connected burden.
- CTs must have a minimum class size of C100 or T100 when used for relaying, or the engineer must provide suitable calculation and CT saturation data to prove the CTs will function correctly for all fault conditions.
- See rules for electric meter and service installation rules 7 and 8 for details on fused disconnect/disconnect.
- AC powered shunt trips are not acceptable for tripping the generator.
- An AC undervoltage trip should be included on the generator circuit breaker if normal tripping is by a DC shunt trip.
- IEEE 1547 certified equipment will provide all of the required protection. It is assumed this equipment will also provide suitable switches or pushbuttons to shut down the generation.

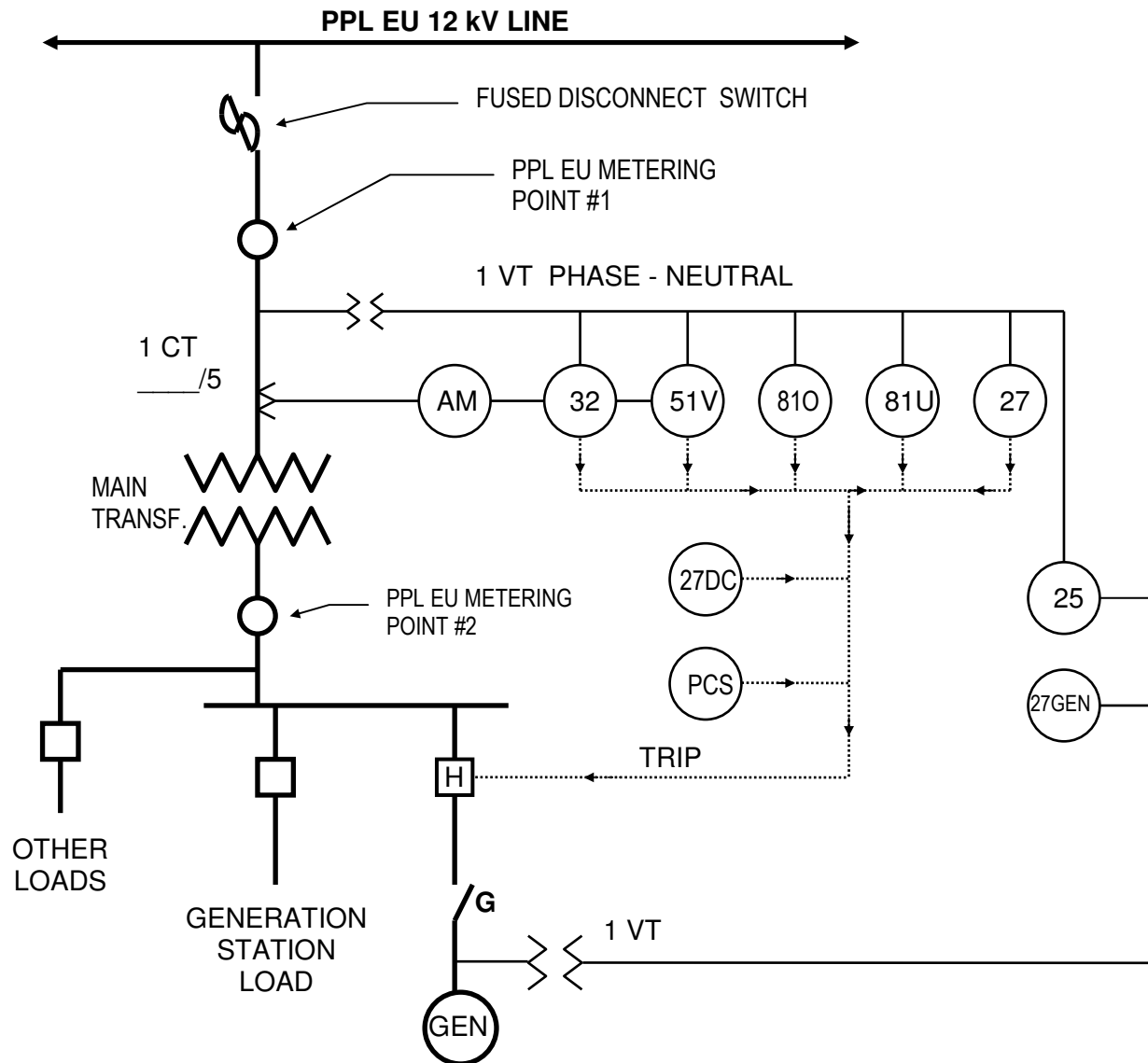


Figure 1

INTERTIE PROTECTIVE RELAYING:

- AM AMMETER (0-5 AMP)
- AS AMMETER SWITCH
- 25 SYNCHRONISM CHECK RELAY
- 27 GEN GENERATOR VOLTAGE CHECK
- 27I INSTANTANEOUS UNDERVOLTAGE
- 27DC BATTERY/DC SYSTEM UNDERVOLTAGE
- 32 POWER DIRECTIONAL RELAY
- 51V TORQUE CONTROLLED TIME OVERCURRENT
- 810 OVERFREQUENCY RELAY
- 81U UNDERFREQUENCY
- PCS PPL EU CONTROL SWITCH

KEY LIST:

- D FUSED DISCONNECT SWITCH
- G GENERATOR SAFETY SWITCH
- H GENERATOR BREAKER

NOTES:

1. The Safety Switch (G) must be lockable in the open position, and must be located between the generator and the PPL meter, and provide a visible break for safety.
2. Contact PPL for specific metering requirements.
3. When this drawing is supplied for a specific project, an X will be placed in the box (□) for equipment required at this specific site.

TYPE 2

A Type 2 installation, shown in Figures 2 and 3, covers three-phase synchronous and induction generators, up to 2000 kva, connected to a distribution circuit. These installations are characterized as:

- Being connected through a three-phase transformer.
- Having fuses (D - Figure 2) or a circuit breaker (E - Figure 3) as the intertie protective device.
- Having a safety switch (G), lockable in the open position, to block the generator from operation.

Relay Requirements

Induction Generator

25 kva or Less	Undervoltage relay (27), voltage check relay (27 GEN) relays are required. (Note 2.) A power directional relay may also be required.
25 kva - 200 kva	Undervoltage relay (27), voltage check (27 GEN), and a power directional relay (32), and where the operation of the U.V. relay (27) may be delayed an underfrequency relay (81UF) will be required. If system load can be delivered while self-excited, instantaneous overvoltage (59I) and under/overfrequency (8I UF/OF) are also required.
Greater Than 200 kva (2000 kva max)	Undervoltage (27), voltage check (27 GEN), power directional (32), and underfrequency (81 UF) relays are required. If system load can be delivered while self-excited, an instantaneous overvoltage relay (59I) and overfrequency relay (81 OF) are required.

Synchronous Generator

10 kva or Less	Synchronism check (25), undervoltage (27) relays are required. In some cases, the (27) undervoltage function will be satisfied by the use of a non-latching AC powered contactor. PPL EU will determine if this is an option.
10 kva - 25 kva	Synchronism check (25), undervoltage (27) overvoltage (59), underfrequency (81 UF) and overfrequency (81 OF). If the minimum load to maximum generation ratio is high, undervoltage (27), underfrequency (81 UF) and synchronism check (25) relays may be considered sufficient.
25 kva - 2000 kva	Synchronism check (25), undervoltage (27), power directional (32), overvoltage (59) and under/overfrequency (81 UF/OF) relays are required. A voltage restraint time overcurrent (51V) may be required. If the minimum load to maximum generation ratio is high, undervoltage (27), underfrequency (81 UF) and synchronism check (25) relays may be considered sufficient.

The relays above are to be located in the IPR cabinet. The protective relays will trip breakers E or F. Circuit breaker F is optional and may be desired by customers to carry their own load for failures on the PPL EU system.

The undervoltage relay (27) will also block closing of the tripped breaker if the source line is dead and relay (25) is not provided. This is to prevent the generator from energizing a de-energized PPL EU line.

When fuses are used as the intertie protective devices, they will be specified by PPL EU and can also be utilized to provide a visible break for safety.

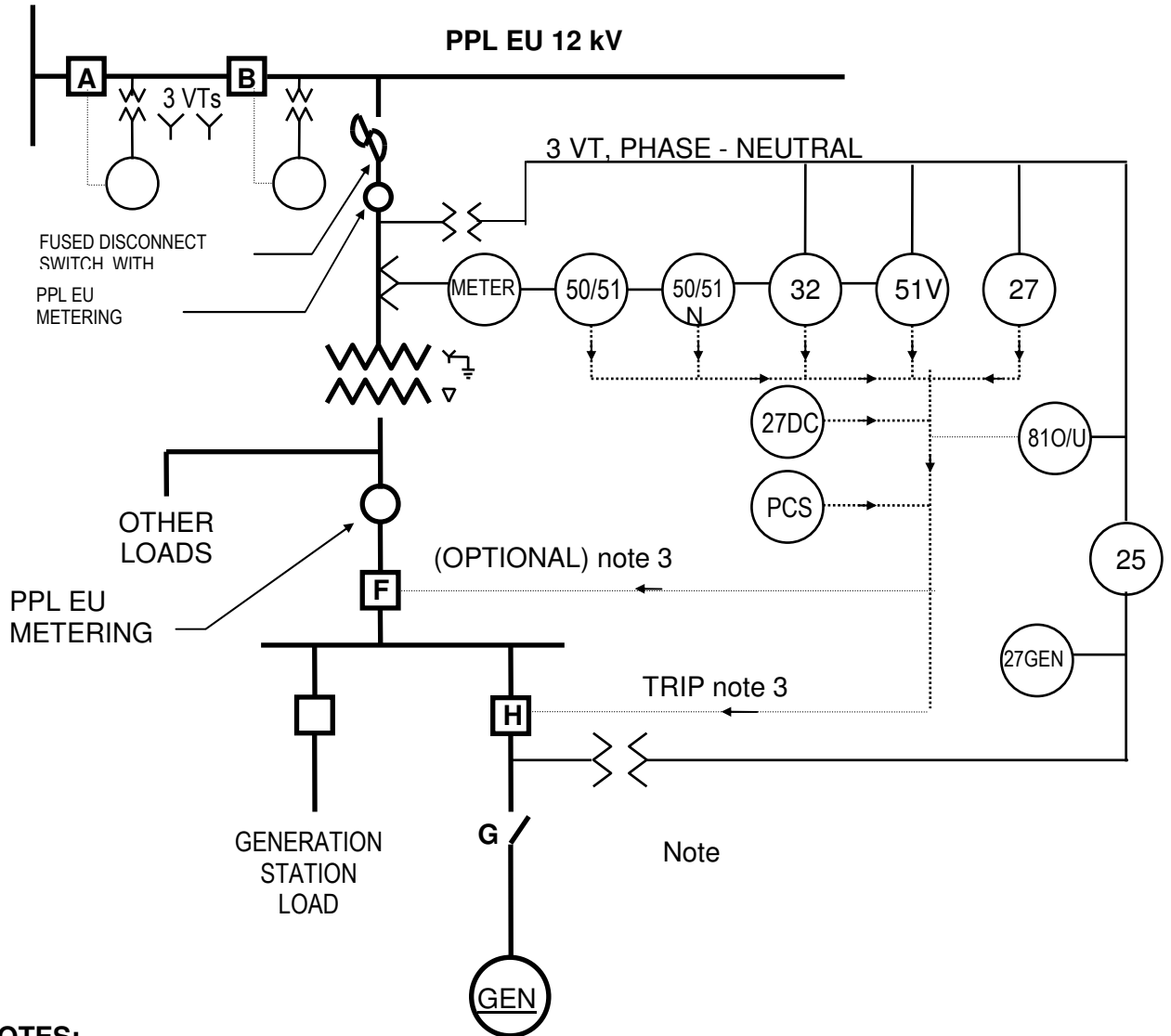
When a circuit breaker is utilized as the intertie protective device, its disconnects can be utilized to provide the visible break for safety.

For installations of 100 kva or less, the CTs and VTs may be located on the low side of the power transformer, although connection to the high side is preferred. The VTs must be located on the high side of the power transformer for all installations greater than 100 kva.

Notes on Figures 2 and 3:

- Relay 27A provides three-phase voltage check relay supervising reclosing of substation CB.
- Relay 27B provides three-phase voltage check relay supervising reclosing of Electronic OCR "B."
- VTs must have a minimum VA rating of 150 VA. If connected burden equals or exceeds the 150 VA rating, then the VT shall be sized for 150% of the connected burden.
- CTs must have a minimum class size of C100 or T100 when used for relaying, or the Generator's design engineer must provide suitable calculation and CT saturation data to prove the CTs will function correctly for all fault conditions.
- See rules for electric meter and service installation rules 7 and 8 for details on fused disconnect/disconnect.
- AC powered shunt trips are not acceptable for tripping the generator.
- An AC powered undervoltage trip should be included on the generator circuit breaker if normal tripping is by a DC shunt trip.
- The protection is shown with the preferred WYE grounded high side transformation. The use of a DELTA high side will require addition high side protection equipment.

TYPE 2
INTERTIE REQUIREMENTS
A TYPICAL GENERATION FACILITY

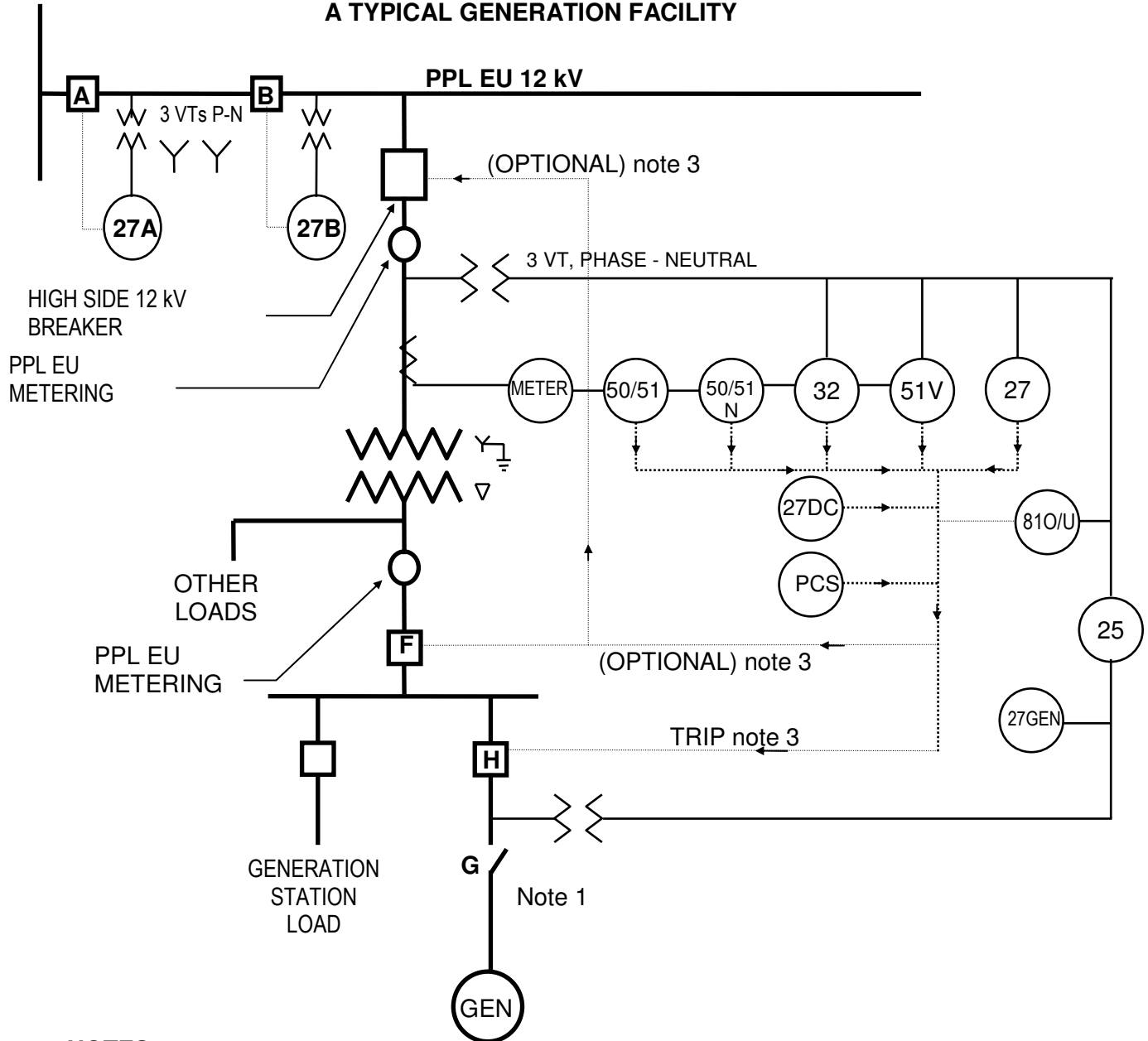


NOTES:

1. The safety switch (G) must be lockable in the open position, and must be located between the generator and the metering point #2, and provide a visible break.
2. Contact PPL EU for specific metering requirements.
3. The relaying must trip one of the breakers "F" or "H", with the other breaker acting as backup in case the first did not trip. The

Figure 2

TYPE 2
INERTIE REQUIREMENTS
A TYPICAL GENERATION FACILITY



NOTES:

1. The safety switch (G) must be lockable in the open position, and must be located between the generator and the metering point #2, and provide a visible break.
2. Contact PPL EU for specific metering requirements.
3. The relaying must trip one of the breakers "F" or "H" or the 12 kV breaker with one of the other breaker acting as backup in case the first did not trip. The choice of which breaker to trip will usually be determined by the operation of the plant, and PPL EU reclosing practice.

Figure 3

TYPE-2
(TYPICAL)

INTERTIE PROTECTIVE RELAYING:

- AM AMMETER (0-5A)
- AS AMMETER SWITCH
- 25 SYNCHRONISM CHECK RELAY
- 27GEN GENERATOR VOLTAGE CHECK RELAY
- 27I INSTANTANEOUS UNDERVOLTAGE (1 PER PHASE)
- 27T UNDERVOLTAGE WITH TIME DELAY
- 27DC BATTERY/DC SYSTEM UNDERVOLTAGE
- 32 POWER DIRECTIONAL RELAY (TRIP FOR POWER FLOW INTO THE PPL SYSTEM GREATER THAN THE CONTRACTUAL MAXIMUM)

- 51V TORQUE CONTROLLED TOC
- 59I INSTANTANEOUS OVERVOLTAGE
- 59T OVERVOLTAGE WITH TIME DELAY
- 81O OVERFREQUENCY
- 81U UNDERFREQUENCY
- PCS PPL CONTROL SWITCH

- = Not required item
- = Required item (these items will be filled in for each specific project)

NOTE: For all installations the preferred relays are microprocessor-based units with multiple functions. These relays provide many of the above functions in one case as well as oscillographic and sequence of events capability. All microprocessor-based relays are to be ordered with suitable communication software to allow setting and transferring of data from a Personal Computer.

KEY LIST: Figure 3

- A – SUBSTATION CIRCUIT BREAKER (SUB 1)
- B – ELECTRONIC OIL CIRCUIT RECLOSER
- D – FUSED DISCONNECT SWITCH OR DISCONNECT SWITCH
- E – HIGH SIDE BREAKER (POINT OF CONTACT)
- F – LOW SIDE BREAKER (OPTIONAL)
- G – GENERATOR SAFETY SWITCH
- H – GENERATOR BREAKER

TYPE 3

A Type 3 installation, shown in Figure 4, covers three-phase **induction** generators with ratings between 2.5 MVA and 20 MVA and connected to a radial or network 69 kV circuit. These installations are characterized as:

- Being connected through a three-phase transformer (WYE high side, delta low side).
- Having a high-side circuit breaker (E-Figure 4).
- Having a safety switch (G), lockable in the open position, to block the generator from operation.

Relay Requirements

Induction Generator

Undervoltage (27), voltage check (27 GEN), phase and neutral time and instantaneous overcurrent (50/51, 50/51N), and under/overfrequency (81 UF/OF) relays are required. If system load can be delivered while self-excited, an instantaneous overvoltage relay (59I) is also required. A power directional relay (32) may also be required to limit power delivered into the PPL EU system to the contractual maximum.

The relays above are to be located in the IPR cabinet. The protective relays will trip breakers E or F. Circuit breaker F is optional but may be desired by the sponsor to carry its own load for failures on the PPL EU system.

The under voltage relay (27) will also block closing of the tripped breaker if the source line is dead and relay (25) is not provided. This is to prevent the generator from energizing a de-energized PPL EU line.

Type 3 installations normally require bi-directional direct transfer trip. The transfer trip will ensure fast tripping of the generator upon receipt of a trip signal from all remote sources. Once the generator has been isolated, a signal will permit reclosing of PPL EU substation breakers. Also, SCADA is required at these installations to allow PPL EU to remotely monitor electrical conditions at the generation site and to provide a means for PPL EU to remotely disconnect the generation from the power system in the event of a system emergency.

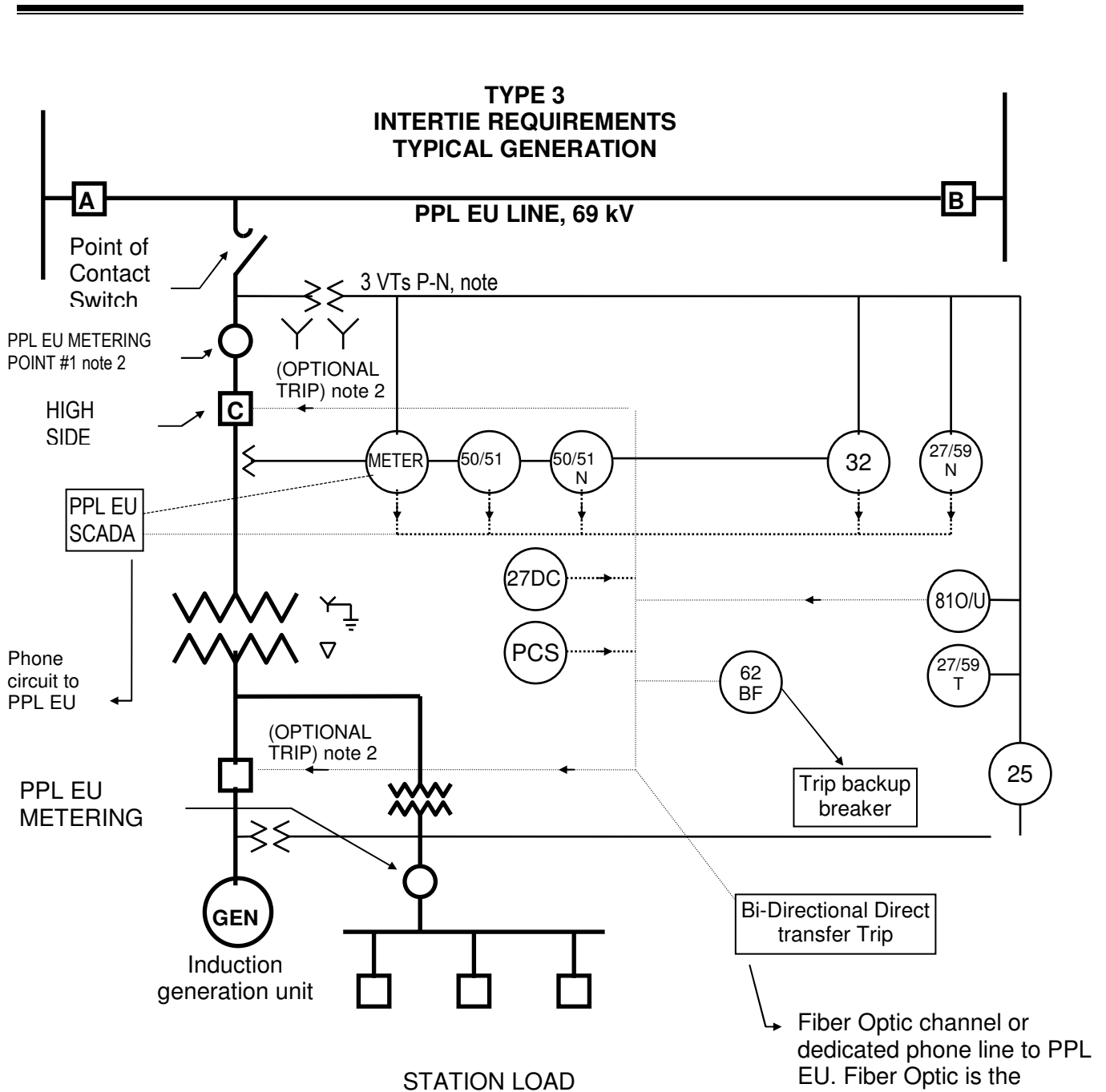
Notes on Figure 4:

- A three-phase voltage check relay supervises reclosing of substation CB "A." (This will delay reclosing until the generation is isolated. Reclosing will be approximately 1.5"-15"-15" after line is de-energized.)
- On all installations greater than 2000 kva, bi-directional direct transfer trip will be required to ensure fast tripping of the generator upon receipt of trip signal from all remote sources. Once the generator has been isolated, a signal will permit reclosing of the PPL EU substation breakers.

-
- VTs must be located on the transformer high side and have a minimum VA rating of 150 VA. If connected burden equals or exceeds the 150 VA rating, then the VT shall be sized for 150% of the connected burden.
 - CTs must have a minimum class size of C400 or T400 when used for relaying, or the Generators design engineer must provide suitable calculation and CT saturation data to prove the CTs will function correctly for all fault conditions.
 - See rules for electric meter and service installation rules 7 and 8 for details on fused disconnect/disconnect.
 - AC powered shunt trips are not acceptable to trip the generator.
 - The main transformer must have a fully insulated WYE winding (high side) suitable for impedance grounding.
 - Breakers "F" or "H" are to provide breaker failure protection for breaker "E."
 - A SCADA trip from PPL EU to the generator facility will be required. At the generator option, any of the following devices may be operated (tripped) by this SCADA trip signal:
 1. The high side breaker
 2. The low side breaker
 3. The generator synchronizing breaker (if different from 1 or 2 above).
 4. The unit Master Fuel Trip device
 5. The Turbine Master lockout device
 6. The Turbine Stop valves

UNIT TRIP SIGNAL

The intent of the SCADA UNIT TRIP SIGNAL is to isolate the generation from the PPL EU system, in the safest possible manner. At some locations, operation of the high side breakers may cause the generation to overspeed. The above optional trips are designed to allow for a more controlled shut down of the generation, by eliminating the fuel flow, or energy source to the turbine BEFORE the breaker between the generator and PPL EU is opened. For these installations, the PPL EU SCADA UNIT TRIP SIGNAL will be used to provide the trip signal. The generator will provide a suitable interface from the PPL EU SCADA to their equipment.



NOTES:

1. These CCVTs will have three secondary windings; one will be metering accuracy for use with the PPL metering equipment.
2. The IPR relaying must trip one of these breakers (C or D), depending on the operation of the facility, and the operation of the auxiliary supply to the station loads.
3. This diagram does NOT include the LINE relaying that may be required beyond the Zone 1 (21Z1) relay shown. Depending on the specific application, radial line versus tapped line, voltage level, and various other concerns, additional LINE relays may be required.

Figure 4

TYPE 3 INERTIE REQUIREMENTS

NOTE: ALL SETTINGS ARE APPROXIMATE AND MAY BE REVISED. INERTIE RELAY TYPES AND RANGES MUST BE REVIEWED AND APPROVED BY PPL

INERTIE PROTECTIVE RELAYING

- AM AMMETER (0-5A)
 - AMS AMMETER SWITCH
 - 25 SYNCHRONISM CHECK RELAY (20° @ 0-0.1 SEC.)
(SUPERVISES ALL SYNCHRONIZING WITH PPL)
 - 27GEN GENERATOR VOLTAGE CHECK RELAY
 - 27N HIGH SET UNDERVOLTAGE RELAY (92% DO)
(ITE 27N OR EQUIVALENT)
 - 27T UNDERVOLTAGE WITH TIME DELAY (83% DO)
 - 27DC BATTERY/DC SYSTEM UNDERVOLTAGE
 - 32 POWER DIRECTIONAL RELAY (TRIP FOR POWER FLOW INTO THE PPL EU
SYSTEM GREATER THAN THE CONTRACTUAL MAXIMUM)
 - 59N LOW SET OVERVOLTAGE RELAY (106% PU) (ITE 59N OR EQUIVALENT)
 - 59T OVERVOLTAGE WITH TIME DELAY (110% PU)
 - 62L LONG TIME DELAY (2-5 MIN.)
 - 81O OVERFREQUENCY (61.0 HZ @ 0-10 CYCLES)
 - 81U UNDERFREQUENCY (57.5 @ 5 SEC.)
 - PCS PPL CONTROL SWITCH
 - 50/51 OVERCURRENT PHASE RELAYS (MODERATELY INVERSE 4-12A)
 - 50/51N OVERCURRENT GROUND RELAYS (VERY INVERSE 0.5-2.0A)
 - 62BF BREAKER FAILURE TIMER 10-30 CYCLE PU (0-1 SEC)
- = Not required item
 = Required item (these items will be filled in for each specific project)

NOTE: For all installations the preferred relays are microprocessor-based units with multiple functions. These relays provide many of the above functions in one case as well as oscillographic and sequence of events capability. All microprocessor-based relays are to be ordered with suitable communication software to allow setting and transferring of data from a Personal Computer.

KEY LIST: Figure 4

- A - PPL EU SUBSTATION BREAKER
- B - DISCONNECT SWITCH
- E - POINT OF CONTACT BREAKER WITH OUT-OF-PHASE SWITCHING RATING PER
ANSI/IEEE C37.09
- F - MAIN LOW SIDE BREAKER
- G - GENERATOR SAFETY SWITCH
PPL REQUIRES A VISIBLE BREAK BETWEEN THE GENERATOR AND PPL EU
METERING
- H - GENERATOR BREAKER
- DTT - DIRECT TRANSFER TRIP TRANSMITTER AND RECEIVER
- SCADA - PPL EU DATA ACQUISITION UNIT

TYPE 4

A Type 4 installation, shown in Figure 5, covers three-phase **synchronous** generators greater than 2.5 MVA and connected to the 69 kV transmission system. These installations are characterized as:

- Being connected through a three-phase transformer (WYE high side, delta low side).
- Having a circuit breaker (E - Figure 5) as the intertie protective device.
- Having a draw-out type circuit breaker or a safety switch (G), lockable in the open position, to block the generator from operation.

Relay Requirements

Synchronous Generator

Synchronism check (25), undervoltage (27), Zone 1 distance (21Z1), out-of-step (21Z0S), phase and neutral time and instantaneous overcurrent (50/51, 50/51N), overvoltage (59) and under/overfrequency (81 UF/OF) relays are required. Voltage controlled time overcurrent relays (51V) and a power directional relay (32) may also be required. All relays to be located in the IPR cabinet.

The protective relays will trip breakers E or F. Circuit breaker F is optional, but may be desired by the sponsor to carry its own load for failures on the PPL EU system.

The undervoltage relay (27) will also block closing of the tripped breaker if the source line is dead and relay (25) is not provided. This is to prevent the generator from energizing a de-energized PPL EU line.

All installations will require direct telephone voice communications to the Power System Dispatcher's office, a SCADA remote, and bi-directional direct transfer trip. The transfer trip will ensure fast isolation of the generator upon receipt of a trip signal from all remote sources. Once the generator has been isolated, a signal will permit reclosing of PPL EU substation breakers. The SCADA remote is required to allow PPL EU to remotely monitor electrical conditions at the generation site and to provide a means for PPL EU to remotely disconnect the generation in case of a system emergency.

The VTs and CTs are normally located on the transformer high side. When an intertie circuit breaker is provided, the intertie protective relaying can use the same CTs as the "point-of-contact" relays.

Notes on Figure 5:

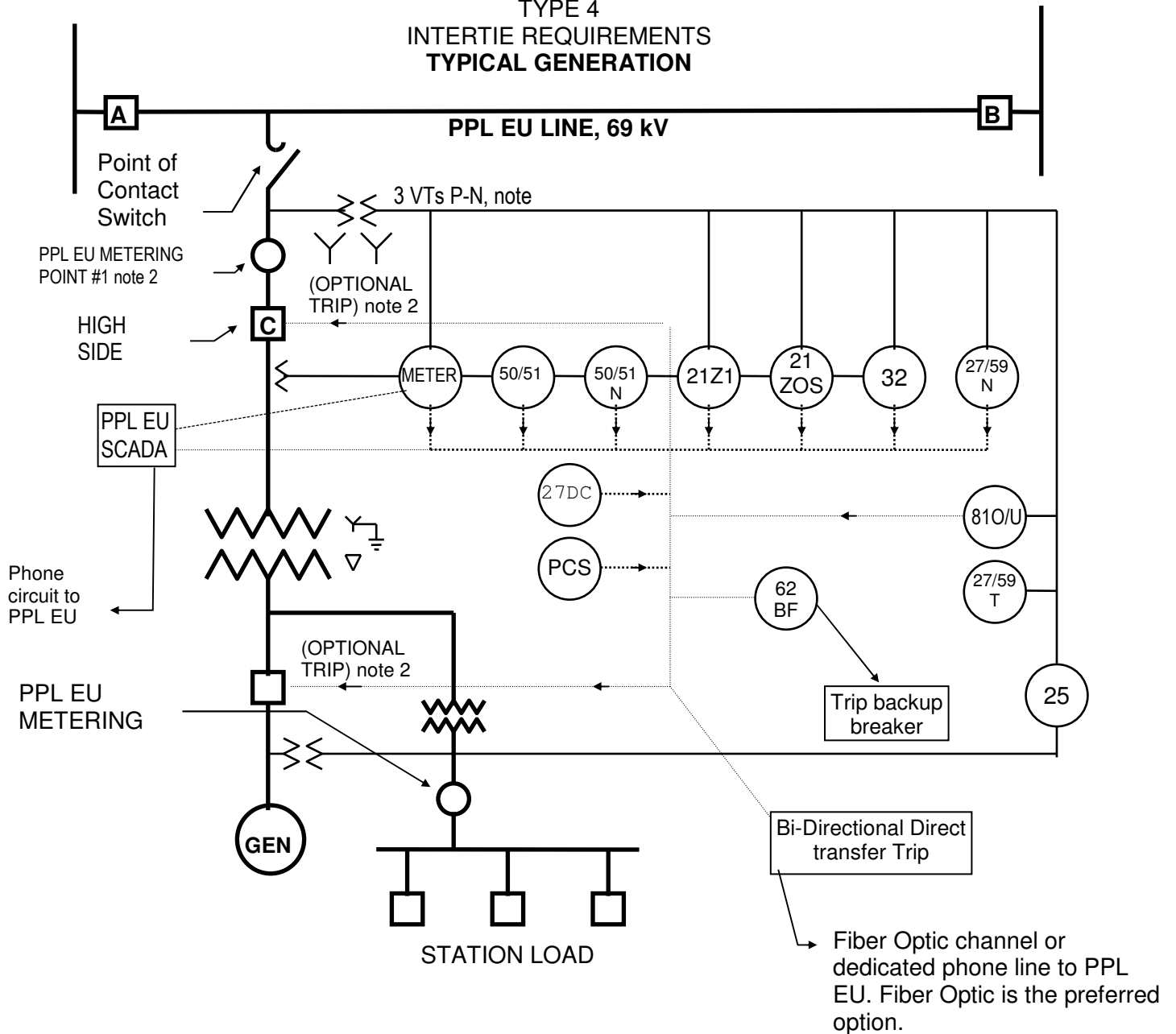
- A three-phase voltage check relay supervises reclosing of substation CB "A." (This will delay reclosing until the generation is isolated. Reclosing will be approximately 1.5"-15"-15" after line is de-energized.)
- VTs must have a minimum VA rating of 200 VA. If connected burden equals or exceeds the 200 VA rating, then the VT shall be sized for 150% of the connected burden.

-
- CTs must have a minimum class size of C400 or T400 when used for relaying, or the engineer must provide suitable calculation and CT saturation data to prove the CTs will function correctly for all fault conditions.
 - AC powered shunt trips are not acceptable for tripping the generator.
 - The main transformer must have a fully insulated WYE winding (high side) suitable for impedance grounding.
 - Breakers "F" or "H" are to provide breaker failure protection for breaker "E."
 - A SCADA trip from PPL EU to the generation facility will be required. At the generator's option, any of the following devices may be operated (tripped) by this SCADA trip signal:
 1. The high side breaker
 2. The low side breaker
 3. The generator synchronizing breaker (if different from 1 or 2 above).
 4. The unit Master Fuel Trip device
 5. The Turbine Master lockout device
 6. The Turbine Stop valves

} UNIT TRIP SIGNAL

The intent of the SCADA UNIT TRIP SIGNAL is to isolate the generation from the PPL EU system, in the safest possible manner. At some locations, operation of the high side breakers may cause the generation to overspeed. The above optional trips are designed to allow for a more controlled shut down of the generation, by eliminating the fuel flow, or energy source to the turbine BEFORE the breaker between the generator and PPL EU is opened. For these installations, the PPL EU SCADA UNIT TRIP SIGNAL will be used to provide the trip signal. The generator will provide a suitable interface from the PPL EU SCADA to their equipment.

**TYPE 4
INTERTIE REQUIREMENTS
TYPICAL GENERATION**



NOTES:

5. These CCVTs will have three secondary windings; one will be metering accuracy for use with the PPL metering equipment.
6. The IPR relaying must trip one of these breakers (C or D), depending on the operation of the facility, and the operation of

Figure 5

TYPE 4 INERTIE REQUIREMENTS

NOTE: ALL SETTINGS ARE APPROXIMATE AND MAY BE REVISED. INERTIE RELAY TYPES AND RANGES MUST BE REVIEWED AND APPROVED BY PPL EU

INERTIE PROTECTIVE RELAYING

<input type="checkbox"/>	AM	AMMETER (0-5A)
<input type="checkbox"/>	AMS	AMMETER SWITCH
<input type="checkbox"/>	25	SYNCHRONISM CHECK RELAY (20° @ 0-0.1 SEC.)(SUPERVISES ALL SYNCHRONIZING WITH PPL)
<input type="checkbox"/>	27GEN	GENERATOR VOLTAGE CHECK RELAY
<input type="checkbox"/>	27N	HIGH SET UNDERVOLTAGE RELAY (92% DO) (ITE 27N OR EQUIVALENT)
<input type="checkbox"/>	27T	UNDERVOLTAGE WITH TIME DELAY (83% DO)
<input type="checkbox"/>	27DC	BATTERY/DC SYSTEM UNDERVOLTAGE
<input type="checkbox"/>	32	POWER DIRECTIONAL RELAY (TRIPS FOR POWER FLOW INTO THE PPL EU SYSTEM GREATER THAN CONTRACTUAL MAXIMUM)
<input type="checkbox"/>	59N	LOW SET OVERVOLTAGE RELAY (106% PU) (ITE 59N OR EQUIVALENT)
<input type="checkbox"/>	59T	OVERVOLTAGE WITH TIME DELAY (110% PU)
<input type="checkbox"/>	62L	LONG TIME DELAY (2-5 MIN.)
<input type="checkbox"/>	81O	OVERFREQUENCY (61.0 HZ @ 0-10 CYCLES)
<input type="checkbox"/>	81U	UNDERFREQUENCY (57.5 @ 5 SEC.)
<input type="checkbox"/>	PCS	PPL CONTROL SWITCH
<input type="checkbox"/>	210S	OUT-OF-STEP TRIP (GSY51A & CEX57E) LOOKS INTO THE GENERATOR
<input type="checkbox"/>	21Z1	ZONE 1 RELAY (KD-10), LOOKS INTO THE PPL EU LINE
<input type="checkbox"/>	50/51	OVERCURRENT PHASE RELAYS (MODERATELY INVERSE 4-12A)
<input type="checkbox"/>	50/51N	OVERCURRENT GROUND RELAYS (VERY INVERSE 0.5-2.0A)
<input type="checkbox"/>	62BF	BREAKER FAILURE TIMER 10-30 CYCLE PU (0-1 SEC)

= Not required item

= Required item (these items will be filled in for each specific project)
NOTE: For all installations the preferred relays are microprocessor-based units with multiple functions. These relays provide many of the above functions in one case as well as oscillographic and sequence of events capability. All microprocessor-based relays are to be ordered with suitable communication software to allow setting and transferring of data from a Personal Computer.

KEY LIST: Figure 5

A - PPL EU SUBSTATION CIRCUIT BREAKER

B - DISCONNECT SWITCH

E - POINT OF CONTACT BREAKER WITH OUT-OF-PHASE SWITCHING RATING PER ANSI/IEEE C37.09

F - MAIN LOW SIDE BREAKER

G - GENERATOR SAFETY SWITCH PPL EU REQUIRES A VISIBLE BREAK BETWEEN THE GENERATOR AND PPL EU METERING

H - GENERATOR BREAKER

DTT - DIRECT TRANSFER TRIP TRANSMITTER AND RECEIVER

SCADA - PPL EU DATA ACQUISITION UNIT

TYPE 5

In a Type 5 installation, the generation is allowed to parallel with the PPL EU system **for a limited period of time (not greater than 5 minutes)**, but not send any power to PPL EU. The generation facility's load is always larger than the generation, and there will not be any excess power to send to PPL EU.

NOTE: This type is different from a make-before-break transfer switch. A make-before-break transfer switch is expected to parallel for less than 100 milliseconds, and generally does not have a failure mode that will maintain the parallel operation position of the switch. For applications involving transfer switches, contact PPL EU for approval of the proposed transfer switch.

The following requirements must be met (at a minimum):

1. The generator will be required to supply an IPR cabinet with (at a minimum):
 - 1 – synchrocheck relay (supervises closing of CB used to parallel customer facilities with PPL EU system when the generator is operating). The need for synchrocheck supervision will be evaluated on a case-by-case basis and will depend on size of the generator and potential impact of an out-of-phase parallel on the PPL EU system.
 - 1 - undervoltage relay for each phase, or a single three phase relay
 - 1 - sensitive reverse power relay (Connected to measure power **into** the PPL EU system at the utility/customer intertie location.)
 - 1 - Timer activated when the generation is paralleled, and connected to trip a breaker to separate the generation from the PPL EU system. Maximum time will be 5 minutes. Timer logic must be hardwired (not controlled with an electronic such as a programmable logic controller).
 - 1 - PPL EU control switch and lights
 - 1 - Ammeter and switch

NOTE: Depending on the exact location, size, and type of generation, additional relays may be required. Intertie relays that initiate tripping of the generator need only be in service *when the generator is paralleled with the PPL EU system*.

2. Due to the minimal relaying, PPL EU will require a "Fail-Safe" AC powered undervoltage trip control scheme or a DC powered control shunt trip scheme with a backup AC undervoltage trip.
3. The generator will not be allowed to send any power into the PPL EU system.
4. The generator must supply a visible-break disconnect (safety switch) between the generator and the PPL EU service. Application of this switch should be reviewed with PPL EU.
5. The generator must supply a complete set of drawings and system information as other generation installations.
6. PPL EU will assume operational control of the relay(s), etc., in the IPR cabinet.
7. PPL EU will review and approve the amount of time the generation will be allowed to operate in parallel with the PPL EU system.

TYPE 6

Campus type installations where one or more generators are installed at various locations within a facility.

The TYPE 6 installation may be similar to any of the previous connections, BUT there *is never any power flow back to PPL EU*. These installations will contain one or more reverse power relays that will be connected and set to detect ANY power flow into the PPL EU system. When reverse flow is detected, a suitable device will be operated to immediately remove the generation from the PPL EU system.

These installations tend to be part of campus style installations, and therefore do not lend themselves to a standard design. The generator is required to submit detailed ones lines to discuss which devices will operate, and the locations of the various sensing components (CTs, PTs, and the relaying). PPL EU will review the proposed design and comment as necessary.

The device to be used to isolate the generation is up to the generator depending on the operation of their facility.

Also, depending on the possible impact of the generation on the PPL EU system, additional functions as previously listed for TYPES 1 to 4 may be required in addition to the reverse power relay.

TYPE 7

Large Units connected at 69 kV and above to a transmission or sub-transmission switching station where there is a very remote likelihood of isolating generation on load.

Definition:

Type 7 installations will be large installations connected to the 69 kV through 500 kV PPL EU system. In general these facilities will be above 100 Mw in size, but may be smaller. These installations may consist of one or more smaller generators.

In general 230kv and above lines on the Bulk Power System are connected in parallel (or network) operation and do not have customer load connected directly to the line.

Such installations will have the following characteristics:

- Tripping of the generators will not be required for faults on a substantial portion of the PPL EU system.
- Due to the normal system configuration, for an outage of a single facility, the generation is not to isolate with PPL EU load.

Requirements:

In cases where generation facilities are connected to the 230kv and above system, they will be expected to install a full compliment of primary and backup relaying as required for reliability by NERC, RFC and PPL EU. Relaying will be specified on a case by case basis.

Installation with multiple generators will need to apply Out Of Step relaying on a per generator basis, directly on each generator. In general it will not be practical to apply this protection in the IPR cabinet.

Installation with multiple generators will need to apply Synchrocheck relaying on a per generator basis, directly on each generator. In general it will not be practical to apply this protection in the IPR cabinet.

Generally, the Interconnection Protective Relaying cabinet will not need to contain special protection schemes to prevent accidental generation isolation on customer load, since such load is not directly connected to 230kv and above facilities. However, special protection schemes may be required on a case-by-case basis to comply with RFC and NERC reliability criteria.

A SCADA trip from PPL EU to the generation facility will be required. At the generator's option, any of the following devices may be operated (tripped) by this SCADA trip signal:

1. The high side breaker
 2. The low side breaker
 3. The generator synchronizing breaker (if different from 1 or 2 above).
 4. The unit Master Fuel Trip device
 5. The Turbine Master lockout device
 6. The Turbine Stop valves
- } UNIT TRIP SIGNAL

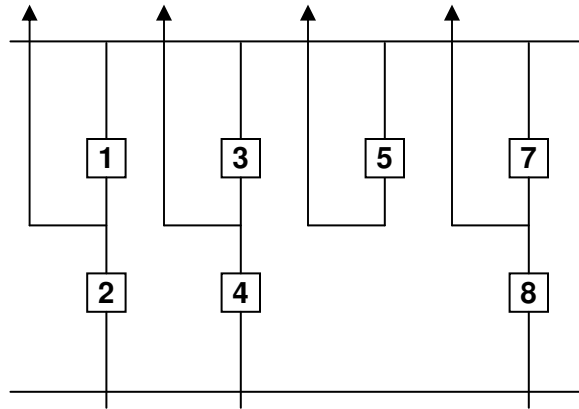
The intent of the SCADA UNIT TRIP SIGNAL is to isolate the generation from the PPL EU system, in the safest possible manner. At some locations, operation of the high side breakers may cause the

generation to overspeed. The above optional trips are designed to allow for a more controlled shut down of the generation, by eliminating the fuel flow, or energy source to the turbine BEFORE the breaker between the generator and PPL EU is opened. For these installations, the PPL EU SCADA UNIT TRIP SIGNAL will be used to provide the trip signal. The generator will provide a suitable interface from the PPL EU SCADA to their equipment.

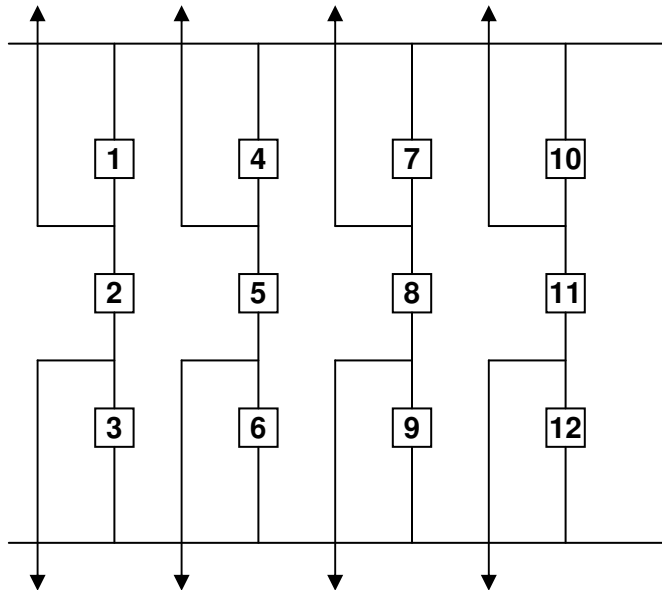
Below are typical switchyard connections:

These facilities are generally either double breaker design, or breaker and a half design. Examples of each are shown below for clarity.

Double Breaker design:



Breaker and half design:



Contact PPL EU for additional information on these types of installations.

SECTION 7 RELAY TEST PROCEDURES

The Relay Test Department at PPL provides technical field support for all customer "point-of-contact" (POC) installations involving systems with protection relays. They should be included in the early review of customer POC systems, along with other key PPL groups, to help the IPP to develop an optimum design.

As the POC work progresses to the physical construction stage, Relay Test participates in the initial "on-site" job meeting and develops a work plan to support all issues of concern to Test which are required to connect the customer to the PPL system.

These include POC related:

- 1) Relay acceptance tests and calibration of settings (issued by PPL Protection and technical Support).
- 2) Current Transformer tests.
- 3) Current Transformer saturation tests
- 4) Current circuit verification.
- 5) Potential circuit verification.
- 6) Control circuit tests.
- 7) In-service verification tests.
- 8) Plus any other issues related to the POC systems.

PPL Relay Test personnel will complete items 1 and 7. Items 2 through 6 can be done by the customer's contractor and witnessed by Relay Test employees, or completed by Relay Test with customer participation as appropriate.

PPL Relay Test personnel will require a written commissioning procedure proposed by the IPP's contractor. This procedure should cover a step-by-step listing of the tests required to ensure that the IPP's POC schemes operate properly. This commissioning procedure should be supplied to PPL at least two weeks prior to the scheduled in-service testing process. The generator is to provide a detailed procedure for PPL EU review of the initial phase-out and synchronization. This must be approved prior to actual synchronization. (Generally only larger systems.)

Customer billing for work done by PPL outside of the "core working hours" is described in Division Practice Instructions (DPI) #204. The customer should be made aware of this policy.

PPL EU will observe verification of the correct operation of synchronizing circuit, for synchronous units. The intent is to do this for all installation above 1000 kva.

The generator operator is to verify the phase rotation of the generator. Please note that in MOST cases the PPL EU system rotation is C-B-A. The generator is expected to verify with PPL EU the specific rotation at their facility.

SECTION 8 DRAWING REQUIREMENTS

ALL drawings must be suitable to be scaled to “D” size (24 inches by 36 inches), except for reports, word or excel documents. Reduced size drawings are NOT acceptable.

8.1 DRAWINGS AND INFORMATION FOR REVIEW

Equipment that is IEEE 1547 compliant will have greatly reduced drawing requirements. It is expected that most if not all of the required protection will be built in to the generation equipment... Under these circumstances, PPL EU will request copies of the manufacturer’s drawings, and any drawings showing external inputs to the protective equipment, for example CTs or PTs. If the Generation operator has decided to operate a different breaker than that supplied with the generation equipment, the drawing showing the controls and interlocks to this breaker will also be requested.

PPL's Substation Engineering section will require the following drawings/information for review and acceptance:

NOTE: A final set of “as built” drawings are required to be submitted to PPL EU within 90 days of initial synchronization of the generation.

- One Line Diagram *
- Three Line Diagram
- Transmission Line Dead-end Structure (proposed/final)
- Plan and Elevation Views (electrical arrangements only)
- Grounding Plan and Details
- Ground Test Report (when customer substation is complete but before PPL supplies are connected) *
- Bill of Material (major electrical equipment only, including switch, protective device, transformer, surge arresters, relays, etc.) *
- Switch Interlock Schematic and Details
- Three Line Potential Elementary
- Three Line Current Elementary *
- Control Elementaries, each 12 kV, 69 kV or 138 kV FID *
- Power Transformer Certified Test Report(s)
- Front view showing POC Relay and Control Equipment *
- A detailed written description of Point of Contact (POC) relay and Intertie Protective Relay (IPR), and control functions and description of operation. The generator is to provide a description of operation of the facility including:
 - Point of contact breaker or low side circuit breaker
 - Generator circuit breaker
 - Controls associated with the above circuit breakers
 - Any other equipment that connects to the above breakers
 - System interlocks
 - Direct transfer Trip equipment, if required
 - General description of the operation of the facility, including operational modes [parallel, isolated, peak shaving, etc.]
 - Any other unique facilities or operational modes
 - High side breaker isolation procedure, if a SF-6 high side breaker is used*
 - Commissioning procedure *

-
- POC relay instruction book *
 - POC CT saturation study *
 - Auto transfer switch make and model (if customer-owned backup generation is installed)

* Denotes drawings which must be supplied for every type of customer facility. Other drawings must be supplied as applicable.

8.2 CONTENTS OF DRAWINGS

The customer's POC drawings shall contain the following information:

8.2.1 One Line Relay Diagrams

This drawing shows the customer's substation functional arrangement. All the equipment shall be shown using single-line diagram and standard symbol notations (per latest ANSI/IEEE Standard 315; titled Graphic Symbols for Electrical and Electronic Diagrams). This drawing shall include:

- Equipment names and/or numerical designations for main Fault Interrupting Devices (FIDs), air switches, power transformers, and associated POC relays and control devices shall be shown to match with PPL line designation. (Note: The required information will be provided by PPL after the customer submits a preliminary one line diagram.)
- Power Transformers - Nominal kva, nominal primary/secondary and tertiary voltages and vector diagram.
- Instrument Transformers - Voltage and Current that supply the POC relaying.
- Lightning Arresters/Spill Gaps/Surge Capacitors - Ratings.
- Air Switches - Indicate status normally open with a (N.O), normally closed with a (N.C.) and type of operation manual or motor.
- Safety Switch - Continuous ampere and interrupting ratings.
- FIDs - Interrupting rating, continuous rating, operating times.
- Transformer Fuses - Size, type, location.
- Grounding.
- Generator(s) - Include type, connection, kva, voltage, current, phasing, rotation, PF, etc.
- Point of Connection to PPL EU (12 kV) and phase identification. NOTE: if the generation phase sequence is different then the PPL EU phase sequence, both must be shown on this diagram.

8.2.2 Current Elementary Diagrams

- Terminal designations of all devices - Relay coils and contacts, switches, transducers, etc.
- Relay Functional Designation - Per ANSI/IEEE standard C-37.2-1991. The same functional designation shall be used on all the drawings showing the relay.
- Complete relay type such as "SEL 321", etc., and the relay range.
- Range and settings of timing relays.
- Switch developments and escutcheons shall be shown on the drawing where the majority of contacts are used. Where contacts of a switch are used on a separate drawing, that drawing should be referenced adjacent to the contacts in the switch development. Any contacts not used should be referenced as spare.
- All switch contacts are to be shown in the open position with each labeled to indicate the positions in which the contacts will be closed.
- Switch contacts shall be referenced to the switch development if development is shown on a separate drawing.
- Isolating points (States sliding links, test switches, etc.).
- Grounding of CT cables.
- All other circuit elements and components with device designation, rating, and setting where applicable.
- Current Transformers - Polarity marks, rating, tap, ratio, and connection.
- Auxiliary CT ratios, connections and polarity, winding current rating, and arrows to indicate assumed current flow.
- Phase designations and rotation of both PPL and customer.
- Cable connection number or wire designation.

8.2.3 Potential Elementary Diagrams

- Terminal designations of all devices – relay coils and contacts, switches, transducers. etc.
- Relay functional designation – per ANSI/IEEE standard C-37.2-1991. The same functional designation shall be used on all the drawings showing the relay.

-
- Complete relay type such as "SEL 321", etc., and the relay range.
 - Relay contacts shall be referenced to the drawing when the coil is shown, provided the coil is shown on a separate drawing.
 - Relay contacts should be shown with each referenced to the drawing where they are used. Contacts not used should be referenced as spare.
 - Range and settings of timing relays.
 - Switch developments and escutcheons shall be shown on the drawing where the majority of contacts are used. Where contacts of a switch are used on a separate drawing, that drawing should be referenced adjacent to the contacts in the switch development. Any contacts not used should be referenced as spare.
 - All switch contacts are to be shown in the open position with each labeled to indicate the positions in which the contacts will be closed.
 - Switch contacts shall be referenced to the switch development if development is shown on a separate drawing.
 - Isolating points (States links, test switches, etc.).
 - Grounding of cables.
 - All other circuit elements and components with device designation, rating, and setting where applicable.
 - Coil voltage for all auxiliary relays.
 - Potential transformer – nameplate ratio, polarity marks, rating, primary and secondary connections.
 - Phase designations and rotation of both the utility and customer.
 - Current ratings and designation of all fuses.

8.2.4 Control Elementary Diagrams

Control elementaries are to be functionally complete schematics. They should be as simple and uncluttered as possible, and shall contain the following information:

- Terminal designations of all devices – relay coils and contacts, switches, transducers, etc.
- Relay functional designation – per ANSI/IEEE standard C-37.2-1991. The same functional designation shall be used on all the drawings showing the relay.

-
- Complete relay type such as "SEL 321", etc., and the relay range.
 - Range and settings of timing relays.
 - Switch developments and escutcheons shall be shown on the drawing where the majority of contacts are used. Where contacts of a switch are used on a separate drawing, that drawing should be referenced adjacent to the contacts in the switch development. Any contacts not used should be referenced as spare.
 - All switch contacts are to be shown in the open position with each labeled to indicate the positions in which the contacts will be closed.
 - Switch contacts shall be referenced to the switch development if development is shown on a separate drawing.
 - Isolating points (States links, test switches, etc.)
 - All other circuit elements and components with device designation, rating, and setting where applicable.
 - Cable connection number or wire designation.
 - Device auxiliary switches (FIDs, contactors) should be referenced to the drawings where they are used.
 - Any interlocks; electromechanical, key, etc.
 - Coil target ratings; on dual ratings underline the appropriate tap setting.
 - Complete internals for electromechanical protective relays. Solid-state relays may be shown as a "black box," with power supply and output connections, but manufacturer's instruction book number shall be referenced and terminal designations shown.
 - DC fuses protecting the point of contact relaying and FID's control circuit shall be monitored for blown fuse or open circuit with a yellow indicating light.
 - The trip coils of lockout relays should be monitored.
 - The coils and contacts of all timers and lockout relays shall be wired through States links or equivalent terminal blocks to provide isolation for testing.

8.2.5 Front View Diagrams

This drawing will show the physical arrangement of all the control and protective equipment for the POC relaying and shall contain the following information:

- Nameplates shall be provided for all switches, lights and hand reset lockout relays for the purpose of identification.

-
- The POC relaying shall be mounted and grouped in such a way as to be clearly differentiated from the other customer's relaying. The POC relaying may be located on a separate area within a relay panel housing other customer's relays.
 - The POC relaying shall be mounted on the switchboards in such an order that equipment associated with the various phases will be in A-B-C (PPL phase names) order from top to bottom or from left to right when facing front of panel on which they are mounted.

8.3 DRAWING APPROVAL PROCEDURES

- The customer must submit preliminary POC relaying drawings for PPL review and acceptance. These drawings must be submitted before the customer's equipment is ordered to ensure that it meets PPL requirements.
- The customer must submit final POC relaying drawings for PPL review and acceptance before the customer's facilities will be allowed to be connected to the PPL system and placed in-service. PPL will not be held responsible for possible late connection of customer's facilities if drawings are not received in time for review.
- The type of drawings submitted must be according to the list described under "Type of Drawings Required."
- All drawings submitted to PPL for acceptance must contain complete information as outlined under "Contents of Drawings."
- The drawings submitted by the customer to PPL for review apply only to POC switching devices and POC relaying.
- PPL will review the IPP's drawings and provide comments within 30 working days from the day a complete set of drawings and information are received by Substation Engineering.
- Specific Grading Plan, Foundation Plan, Foundation Details, Conduit Plan, Structural Steel Assembly, and Structural Steel Fabrication Detail drawings do not require PPL review.
- The responsibility of detail and correct design lies with the customer. Neither PPL nor any person acting on behalf of PPL:
- Assumes any responsibility for correctness of design, drawings, installation, or operations.
- Assumes any liability with respect to the use of, or from damages resulting from the use of, any comments disclosed in this document or in any other PPL correspondence with the customer.

8.4 FINAL AS-BUILT DRAWINGS

The customer must provide two (2) copies of the As-Built drawings listed in Section 5, Subsection 1. Also include copies of any and all inspection certificates with the copies.

The 'Final As Built' drawings can be provided in:

- **Hard copy**
- **Auto CAD format**
- **PDF format**

If providing hard copy, the text must be legible. For example, a 'D' size Drawing (22x34 inches) cannot be submitted as a 'C' or 'B' size final drawing.

NOTE: final as built drawings are required to be completed within 60 days of the initial synchronization of the generation.

SECTION 9 LIST OF APPLICABLE ANSI/IEEE STANDARDS

This document will be applied in conjunction with other industry standards pertaining to generation and PPL EU intertie installations:

- ANSI C2-1997, National Electrical Safety Code.
- ANSI/IEEE C37.010-1979 (R1988), Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis.
- ANSI/IEEE C37.2-1991, Standard Electrical Power System Device Function Numbers.
- ANSI/IEEE C37.5-1979, Guide for Calculation of Fault Current for Application of AC High-Voltage Circuit Breakers Rated on a Total Current Basis.
- ANSI/IEEE C37.90-1978 (R1994), Relays and Relay Systems Associated with Electric Power Apparatus.
- IEEE standard C62.41.2, or latest version, IEEE recommended Practice on Characterization of Surges in Low Voltage (1000 V or less) AC Power Circuits.
- IEEE standard C62.45-2002 or latest version, IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits.
- IEEE Standard C37.90.1-2002 or latest version, IEEE Standard Surge Voltage Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus
- IEEE Standard C37.90.2-1995, or latest version, IEEE Standard Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers.
- ANSI/IEEE C37.91-1985 (R1990), Guide for Protective Relay Applications to Power Transformers.
- ANSI/IEEE C37.93-1987 (R1992), Guide for Power System Protective Relay Applications of Audio Tones over Telephone Channels.
- ANSI/IEEE C37.99-1980 (R1994), Guide for Protection of Shunt Capacitor Banks.
- ANSI/IEEE C37.101-1993, Guide for Generator Ground Protection.

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- ANSI/IEEE C57.13-1993, Standard Requirements for Instrument Transformers.
 - ANSI C84.1-1995, or latest version, Electric Power Systems and Equipment – Voltage Ratings
 - ANSI/IEEE Std 141-1993, Recommended Practice for Electric Power Distribution for Industrial Plants (IEEE Red Book).
 - ANSI/IEEE Std 241-1990, Recommended Practice for Electric Power Systems in Commercial Buildings (IEEE Gray Book).
 - ANSI/IEEE Std 242-1986 (R1991), Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (IEEE Buff Book).
 - ANSI/IEEE Std 315-1975 (R1989), Graphic Symbols for Electrical and Electronics Diagrams.
 - ANSI/IEEE Std 446-1995, Recommended Practice for Emergency and Standby Power for Industrial and Commercial Applications (IEEE Orange Book).
 - ANSI/IEEE Std 493-1990, Recommended Practice for the Design of Reliable Industrial and Commercial Power Systems (IEEE Gold Book).
 - ANSI/IEEE Std 519-1992 IEEE Recommended Practices and Requirements for Harmonic Control in Electric Power Systems.
 - ANSI/NFPA 70-1996, National Electrical Code.
 - IEEE Std 80-1986 (R1991), Guide for Safety in AC Substation Grounding.
 - ANSI/IEEE 37.102-1995, Guide for AC Generator Protection.
 - IEEE Std C37.110-1996, IEEE Guide for the Application of Current Transformers Used for Protective Relaying Purposes.
 - IEEE Standard 929-2000 [Recommended Practice for Utility Interface of Photovoltaic (PV) Systems] latest version and UL Publication 1741 [“Power Conditioning Units for Use in Residential Photovoltaic Power System”], latest version.
 - ANSI/IEEE C57.105-1978 (R1992), IEEE Guide for Application of Transformer Connections in Three-Phase Distribution Systems
 - IEEE Standard 1547-2003, Standard for Interconnecting Distributed Resources with Electric Power Systems, latest version.
 - IEEE Standard 1547.1-2005, Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems, latest version.
 - Generation installations certified to be compliant with IEEE 1547.1 will generally be accepted as designed. In these cases, an IPR (Intertie Protective Relay) cabinet will not be required, as the required protective functions will be included in the generation package. IEEE 1547 is limited to Distributed Resource [generation] installations of 10 MVA or less for a single installation and 10 MVA or less for multiple generator installations on a single line or substation. For the PPL EU system, most of these installations will be at 12 kV. PPL EU will accept IEEE 1547.1 certified generators for parallel operation on our system up to 2.0 MW, with no additional system modifications. However installations above this limit will be reviewed to determine if additional protection, beyond that provided by IEEE 1547 is required. In general IEEE 1547 will not be accepted or applied to generators connecting at the 69 kV and higher voltage levels.

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- The PJM Small Generation (0 to 2.0 Mw) interconnection requirements will be used in place of the PPL EU for facilities in this range *AND UNDER THE JURISDICTION OF PJM*. Units in this range, but not under PJM jurisdiction will be classified as Inverter, and units failing the screens will be classified as TYPE 1, 2, 3 or 4 as appropriate.
 - CERTIFIED equipment will be tested and certified by a NRTL (Nationally Recognized Testing Laboratory) to IEEE 1547.1-2005 (or the latest version)
 - NEMA MG-1-1998, or latest version, Motors and Generators, Revision 2 (or later).
 - NEC 2005
 - NFPA 70 Nation Electrical Code

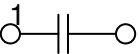
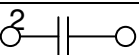

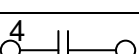
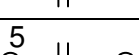
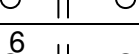
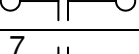
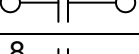
IEEE standard 519-1992, IEEE recommended Practice and Requirements for Harmonic Control in Electrical Power Systems.

APPENDIX:

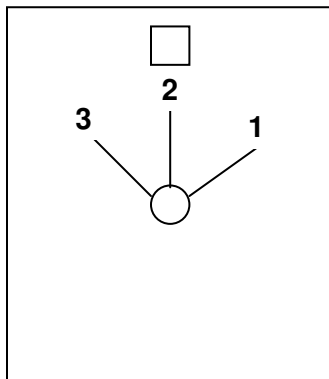
1. DETAILS FOR PPL EU CONTROL SWITCH (PCS)

Below is a TYPICAL control switch development showing the required functions. This information is taken from a General Electric type SB-1 switch, but alternative suppliers with the same functionality will be considered.

The switch is to have a PISTOL grip handle, with a target (or flag) indicator, and to be spring return from the close to the normal position and from the trip to the close position. The target (or flag) will indicate RED for the Normal After Close position, and GREEN for the Normal After Open position. The positions will be Trip, Normal, Close, from left to right when viewed from the front of the switch. The trip and close position should be approximately 45 degrees off of vertical, and the normal position will be the vertical position.

Contact	#	Trip (1)	NAT (2)	NAC (2)	Close (3)
 1C	1	X			
 2C	2				X
 3C	3	X			X
 4C	4	X			
 5C	5		X	X	
 6C	6				
 7C	7	X	X		
 8C	8	X	X		

FRONT VIEW:



ESCUTCHEON ENGRAVING:

1	TRIP
2	
3	CLOSE
NOTE: The Normal After Trip (NAT) and Normal After Close (NAC) position are not engraved.	

ITEMS TO BE DISCUSSED DURING THE PROJECT.

1.

This is a list of items that *generally* need to be addressed during a typical project. It is NOT all inclusive and is provided as a guide only.

1.1. ELECTRICAL INSPECTION

As required by local ordinances, authority having jurisdiction or other PPL EU requirements to meet the NERC FAC-001 Standard.

1.2. PLANT OPERATION

The generator should meet with PPL EU to discuss effect of plant operation on which breaker is tripped, and how the generator will maintain critical services during extended line outages.

1.3. ALTERNATE SUPPLY OR TWO LINE SUPPLY

Check to see if the generator requires an alternate supply of power to aid in powering the plant, or to allow operation during outages of the normal source.

1.4. POC BREAKER CONTROLS

Determine how the POC (Point Of Contact) breaker is to be controlled, tripped by IPR, PCS, DTT, SCADA, etc.

1.5. CONTROL SCHEME AC OR DC

Check to see what type of control scheme is to be implemented. An AC scheme requires the use of an UVT (Under Voltage Trip) and series connection of all the relays and other trip contacts, while a DC scheme requires the parallel connections of all the trip contacts, and a suitable DC source.

1.6. AUXILIARY LOADS

Get the minimum and maximum auxiliary loads, and the amounts of load the PPL EU system will be expected to pick up immediately after a unit trip.

1.7. FLICKER/HARMONIC PRODUCING LOADS

Get data from the generator for all loads connected to the PPL EU system capable of producing flicker or expected to have substantial harmonic content.

1.8. PERIODIC RELAY SETTINGS

Discuss the arrangement for test department to test the IPR relays every two years.

1.9. PLANT ACCESS

Set up procedure for PPL EU access to the various pieces of PPL EU equipment.

1.10. GENERAL OPERATING PROCEDURE GENERATOR

Review the generator's general operating procedure to see if there are any conflicts with the PPL EU system operation.

1.11. VOLTAGES AT GENERATOR

Notify the generator of the expected voltage levels at his location; review with his transformer info, especially transformer taps.

1.12. FAULT DUTIES AND SHORT CIRCUIT LEVELS

Send out the latest estimate of the fault duties at the generator location.

1.13. CONSTRUCTION POWER

The generator is required to contact PPL EU field coordinator to arrange for construction power.

1.14. START UP POWER

Check to see when start up power is required; this is usually several months before the synchronization date.

1.15. IPR CABINET

Send out the list of the specific requirements for this location. Check on the location of the IPR cabinet, switchyard, control room, other? Be sure the generator is able to read and reset the relay targets without unlocking the IPR cabinet.

1.16. IPR RELAYS

Send the generator a list of the preliminary relay ranges and setting, after receipt of the one line from the generator.

1.17. SOLID GROUNDING

Notify the generator the connection for the transformer will be generally be solidly grounded WYE on the high side, unless otherwise agreed to by PPL EU.

1.18. IPR INTERLOCKS

Review the operation of the PPL EU control switch (PCS) on the breaker used to isolate the generator from the system. Be sure that the voltage and frequency relays block closing of the POC breaker if the generator does not use synchronism check relaying on this breaker.

1.19. SYNCH CHECK RELAY

Verify that the generator has implemented the syncheck relay correctly, and that any breaker which can parallel the generator to the PPL EU system has the IPR synch check function in the closing circuit.

1.20. DRAWING REVIEW-ONE LINE

Review the initial generator one line; check for compatibility with the PPL EU system

1.21. DRAWING REVIEW-THREE LINE

Review location of CT's, PT's, metering, and other major equipment. Check the phasing of the generator system and the IPR relays Vs the PPL EU system. Also check the phase names generator Vs PPL EU, on the Terminal pole or dead-end structure.

1.22. DRAWING REVIEW-SITE PLAN

Review the site plan, for location of various major pieces of Equipment; dead-end structure, the last PPL EU pole etc. Review PPL EU line crossings, and the layout of the fence, and the property lines. Whose property is the tap on?

1.23. DRAWING REVIEW-SUBSTATION

Review grounding details, we do not have grounding requirements for 12 kV jobs. The customer neutral/ground must connect to the PPL EU system neutral. The conductors must be capable of handling the fault current. For high voltage installations (69 kV and above, the measured ground resistance prior to the connection of any outside facilities must 5 ohms or less). Check on the location of lighting arrestors, also voltage rating

and class. Review the point of contact switch (POC), location, operation, rating, and manufacturer. Also the switch must be capable of being locked in the open position.

1.24. DRAWING REVIEW-CONTROL ELEMENTARY

Review the IPR DC control elementary, and interlocks. Also the Use of auxiliary or lockout relays. Verify the operation of all breakers, especially breakers that must be interlocked to avoid a misoperation of the synchronism schemes.

1.25. DRAWING REVIEW- POC CB

Type of breaker (oil, air, magnetic, etc.) Ratings (continuous, Duty, fault, operating time). Check tripping and closing logic pay special attention to the synchronizing and synch check circuits.

1.26. DRAWING REVIEW-LOW SIDE GENERATOR BREAKER

Check to see that the above breaker is suitable for the intended operation. Will this breaker withstand 2 per unit voltage in the open condition? Check tripping and closing logic pay special attention to the synchronizing and synch check circuits. CT's must be class C400 or better, also PT's should be dual winding and rated at 200 VA minimum.

1.27. DRAWING REVIEW-POTENTIAL

Review the potential elementary for the correct phasing and Voltage levels to PPL EU IPR equipment. Check the location of the neutral grounds in these circuits and also that there is only one ground per circuit.

1.28. DRAWING REVIEW-CURRENT

Review the current elementary; check CT ratio, and connections To PPL EU equipment (IPR). Check the location of the neutral grounds in these circuits and also that there is only one ground per circuit.

1.29. DRAWING REVIEW-IPR WIRING

Review the IPR wiring of any gross errors. PPL EU does not review or approve the wiring drawings.

1.30. SYSTEM DESIGN

Review the length of the CT, PT, and DC cables, the connected Burden, and the calculated voltage drop. Review the DC system, voltage level (24-48-125), minimum Designed operational voltage level, fusing, primary/backup Supply. Check use of the PPL EU synch check relay, and location of the Relay. Review the need for breaker failure protection at the generator, and Review the implementation. Look into the possibility of installing breaker 'a' switch to block voltage and frequency relays when the generator is off line to avoid nuisance trips. Review the functions of the various relays (ov/uv & of/uf are supposed to block if the synch check is not used) etc. Facilities connected at 69 kV and above will need to consider: insulation coordination, equipment ratings, operating considerations. .

1.31. VOLTAGE REGULATOR

Notify the generator of the required modes of operation; check the Voltage regulator for the required functions.

1.32. IPR CABINET

Discuss the location of various pieces of equipment (PPL Control switch, targets, lockouts etc). The cabinet must be set up so the relays can be sealed, the PCS will be

under lock and key, and the generator can read and reset the targets. Review the front view of the IPR cabinet, make sure relay targets can be read and reset.

1.33. IPR RELAYS

Review the list of the specific relays to be supplied for the IPR cabinet, check manufacturer, ranges, etc. Check to see that all relays and IEDs can be isolated by test switches (FT-1 or equal), or use drawout cases.

1.34. USE OF CONTACT MULTIPLYING RELAYS

If contact multiplying relays are used in any schemes associated with PPL EU controls they must be designed for failsafe operation.

1.35. METERING EQUIPMENT

Review with the generator who will supply the various pieces of equipment, and who will install this equipment. Check on the location and type of equipment indoor Vs outdoors, metering cabinet Vs switchgear. Find out when the generator will need the PPL EU metering equipment.

1.36. 27DC - BATTERY MONITOR OR UVT ON AC SCHEME

It may be necessary to add a time delay to the battery monitor, so that it will not operate when various pieces of DC equipment are operated.

1.37. RELAY TARGETS

Make arrangements for test to mark the appropriate targets with a PPL EU id number.

1.38. DESCRIPTION OF OPERATION – NUG/IPP

PPL EU will write up a description of the control facilities, including IPR, DTT, SCADA, and trip and blocking points, based on specific information provided by the generator.

1.39. VOLTAGE/REACTIVE SCHEDULE

Review the voltage/reactive requirements for the NUG/IPP, and see that the generator receives and understands this information.

1.40. VOLTAGE REGULATOR

Obtain a description of the voltage regulator, voltage and VAR control equipment.

1.41. GUIDELINE FOR VOLTAGE/REACTIVE CONTROL

Be sure a guideline is created which details acceptable deviations and the action to be taken for excessive deviations.

1.42. 5% VOLTAGE REDUCTION

Be sure to notify the generator of the possibility of 5% voltage reductions.

1.43. SPARE PARTS - IPR

Inform the generator of PPL EU's position not to carry spare parts for the IPR cabinet, also determine which components are critical to the continued operation of the NUG. List the items for which failure will require the shutdown of the NUG.

1.44. INITIAL SYNCHRONISM

Review the plans for the initial plant synchronism to the PPL EU system. Test will observe but not take an active part.

1.45. EXCITATION SOURCE

Check on the location of the source of excitation power (shaft driven exciter or PTs or other)

1.46. REVIEW OF MAIN TRANSFORMER SPECIFICATION

Check for appropriate taps, impedance, windings, grounding, etc.

1.47. PROJECT SCHEDULE

Get a copy of the proposed project schedule from the generator to see if there are any impact with PPL EU work.

1.48. PPL REVENUE METERING EQUIPMENT

Send out metering equipment information or cut sheets.

1.49. SUBSTATION CONTROL HOUSE VENTILATION

Make sure there is adequate ventilation in the building housing the SCADA and the IPR cabinet. This is especially true if the battery is housed in the same room.

1.50. TECHNICAL CONTACT

Get name, address, and phone number of the contact for the project.

1.51. SCADA

Check on the location of the SCADA cabinet, switchyard Vs control room. Be sure to have 15 amp branch circuit installed near the SCADA unit. Discuss the operation of the PPL EU SCADA with the generator. Send out the typical form letter for ordering SCADA phone circuit. Get the phone circuit identification number. Send the generator the protection requirements for the SCADA phone circuit.

1.52. POINT ASSIGNMENT SHEETS

PPL EU will create the SCADA Point Assignment Sheets for this project, and issue, based on information received from the generator.

1.53. DTT REQUIREMENTS

PPL EU will provide specific information on the DTT to be installed (if this function is required), as the equipment installed at the generator must match equipment installed at PPL EU substation. Also, PPL EU will supply specific information for the telephone line associated with the DTT equipment.

1.54. DRAWING CROSS REFERENCE LIST

PPL EU will issue the 'as built' drawings from the generator as the Drawings of record for the facility. These drawings will be listed by the PPL EU drawing numbers and the generator drawing number will be cross referenced when the final set of drawings are issued.