

ORCAS POWER AND LIGHT COOPERATIVE

MEMBER SERVICE POLICY 15

INTERCONNECTION OF DISTRIBUTED RESOURCES

15.1 INTRODUCTION

15.1.1 Scope

This interconnection standard for distributed generation specifies the minimum requirements and conditions for medium and large (10,000 kVA maximum) non-utility-owned electric generation that will be interconnected for the purpose of parallel operation with the Orcas Power and Light Cooperative (OPALCO) electrical system. Distributed generation will be permitted to interconnect to OPALCO's transmission or distribution system only after OPALCO determines that the operation of the member's facility will be safe and effective and will not interfere with normal operation of these systems. Small (0-200 kW) distributed generation is covered by Member Service Policy 14 *Interconnection of Member Generators*.

15.1.2 Application

This standard shall be used when planning the installation of medium and large distributed generation greater than 200 kW. OPALCO has different interconnection requirements for the following range of nameplate capacities of generators that a member can select for a distributed generation facility:

200- 500 kVA	Type 1 Interconnections
500- 1000 kVA	Type 2 Interconnections
1000- 2000 kVA	Type 3 Interconnections
2000- 10000 kVA	Type 4 Interconnections

The member may elect to a) operate the generation facility as a completely separate system from OPALCO, b) operate the generation facility only with momentary parallel operation with the OPALCO system or c) operate the generation facility in parallel operation with the OPALCO system. The requirements in this standard generally apply to a member's generation facility that operates in parallel with the OPALCO system. Furthermore, the member may elect to operate the generation facility in parallel with the OPALCO system to a) self generate power with no power export, b) generate power entirely for sale back to OPALCO or c) generate power to be concurrently consumed by site loads with the surplus for sale back to OPALCO. For simplicity, the term member refers to any distributed generator, cogenerator or small power producer, even though they may not be an OPALCO member or purchase power from OPALCO. The member shall complete, sign and submit an *Interconnection Application* and an *Agreement for Interconnection* prior to beginning construction.

15.1.3 Member Responsibility

The minimum required protective relaying and/or safety devices and requirements specified in this standard, are for protecting only OPALCO facilities and the

equipment of other members from damage or disruptions caused by a fault, over current condition, malfunction or improper operation of a distributed generation facility. These requirements are also necessary to ensure the safety of utility workers and the public. Minimum protective relaying and interconnection requirements do not include additional relaying, protective or safety devices as may be required by industry and/or government codes and standards, equipment manufacturer requirements and prudent engineering design and practice to fully protect a member's generation facility; compliance with these additional requirements are the sole responsibility of the member.

This standard contains general information about the interconnection requirements for member-owned distributed generation. In addition to all applicable regulatory, technical, safety, and electrical standards and codes, members also will be subject to contractual and other legal requirements, which are only summarized in this standard. These regulations, requirements, contracts and other materials contain complete information concerning the interconnection and govern over the general provisions in this standard.

15.1.4 Definitions

"Avoided Cost" is defined as cost avoided by OPALCO due to the purchase of the member's energy.

"Interconnection" means the point of electrical connection between the member's generation facility and the OPALCO electrical system.

"Separate Operation" refers to the operation of a member's generation facility that does not have the capability of transferring electrical energy to OPALCO.

"Momentary Paralleling" refers to a member's generation facility that will only operate in parallel with OPALCO for 100 milliseconds or less,

"Parallel Operation" refers to a member's generation facility that is interconnected with OPALCO power system so that electrical power may flow in either direction across the common connection.

"Open Transition" refers to break-before-make type transfer switches for the transfer of power to a load from different sources without momentary or permanently connecting the two sources.

"Closed Transition" refers to make-before-break type momentary transfer switches with a maximum of 100 milliseconds parallel time. Any parallel time greater than 100 milliseconds will not be considered momentary or "closed transition".

"Islanding" refers to the situation where a portion of OPALCO's load becomes isolated from OPALCO's generation sources but remains electrically connected to the member's generation source.

“Back feed” refers to the transfer of power from an emergency energy source to any portion of the normal power system.

“Reclosing” refers to the operation of a system protective device that has the ability to sense and interrupt overcurrents by de-energizing the circuit and to subsequently automatically re-energize the circuit.

“Grid Interactive” refers to an electric power production device that is intended to be operated in parallel with an electric power system to supply power to common loads.

“Stand alone” refers to an electrical power production device that has the capability to operate independently of an electric power system.

“SCADA” refers to the supervisory control and data acquisition system operated by OPALCO.

“Distributed Resources” refers to electrical power generation having a capacity of not more than 10 MVA that are connected to OPALCO’s distribution system (12.5 kV) or sub transmission system (24.9 kV or 69 kV).

“Responsible Party” refers to the owner, operator or any other person or entity that is accountable to OPALCO for the distributed resource.

15.1.5 Acceptable Generation Sources

The member may select any energy efficient generation source such as hydro, solar and wind energy. The end conversion to OPALCO’s system must be three phase 60 Hertz (Hz) alternating current (AC) at a voltage and capacity compatible with OPALCO’s system at the interconnection point as discussed in Section 4. Member generation facilities shall be designed and operated in accordance with this standard and the recognized industry standards listed in section 3.1. Adequate protective devices shall be provided to protect OPALCO’s system and its members from abnormal voltages and frequencies or other disturbances. Medium and large generation facilities shall produce their own reactive power requirements to ensure operation at a machine specified power factor. Reactive power requirements for 200-500 kVA three phase induction generators will be reviewed on a case by case basis.

The member may elect to run generation equipment in parallel with the OPALCO system or as a separate system with either the capability of momentary paralleled or nonparallel load transfer between the two independent systems if the following requirements are met.

15.1.6 Separate Systems

For a member’s facility operating in a separate operation mode to be practical, the member may want the capability to transfer load between the two systems by

making the transfer in an open transition mode. This can be accomplished by either an electrically or mechanically interlocked switching arrangement which precludes operation of both switches in the closed position simultaneously. If the member has a separate system, the member shall permit OPALCO to verify by any reasonable method that the transfer scheme meets the nonparallel requirements. This verification shall be accomplished but is limited to review of drawings and equipment specifications and by field inspection of the transfer scheme. OPALCO will not be responsible for approving the member's generation equipment system design or operation. Most Uninterruptible Power Supply (UPS) systems do not specifically meet the separate operation criteria. However, if they are not capable of back feed, they shall be classified as a separate operation system. If they can back feed, they must meet the requirements of either momentary paralleling or parallel operation.

15.1.7 Momentary Paralleling

Momentary paralleling shall require the use of a closed transition (make-before-break) integrated automatic transfer switch with synchronizing capabilities. The automatic transfer switch shall be incapable of paralleling the member with the OPALCO system longer than 100 milliseconds and shall be tested, verified, and documented by the member for proper operation at least every 2 years. Other protective equipment needed for momentary paralleling shall include equipment capable of sensing a failed closed transition transfer switch operation and subsequent tripping the inter-tie breaker. If the paralleling time is greater than 100 milliseconds then the equipment must open the inter-tie breaker. Momentary paralleling shall be limited to 500 kVA to reduce possible voltage flicker for other members receiving their power from the same distribution feeder as the member. Momentary paralleling of greater than 500 kVA may be permitted following a system study to determine if such an installation will cause adverse effects to other members or members. The cost of the system study shall be borne by the member.

15.1.8 Parallel Operation

The member's generation in parallel operation is electrically connected to the OPALCO power system and must be considered in the electrical protection of OPALCO facilities. OPALCO's ability to provide safety to OPALCO personnel who may need to perform work on a power line is lost when a member facility is operating in an islanded mode. The ability to maintain electrical power within specifications to members is also lost during an islanded operating condition. For these reasons, protection from islanding shall be incorporated into each member's generation facility connected in parallel with OPALCO.

The protection system design incorporated into member facilities shall be performed by a power system engineer qualified to perform such work and who is licensed as a professional engineer in the state of Washington. The protection system design shall be reviewed by OPALCO. Prior to energizing a member facility, any changes to the protection system design requested by OPALCO shall

be made by the member. Smaller inverter type equipment meeting the most recent UL and IEEE standards for interconnecting to utility power systems may have integral protection equipment built into one complete package. All interactive equipment shall be reviewed by OPALCO and any required changes must be implemented by the member.

15.2 GENERAL REQUIREMENTS

15.2.1 Initial Application

The member shall complete the attached OPALCO “*Application for Parallel Operation with Utility Service*” form after the generator nameplate capacity, parallel mode of operation and power export category have been decided. The completed application form shall be submitted to OPALCO along with the following application fees:

<u>DG SIZE</u>	<u>APPLICATION FEE</u>
200-500 kVA	\$500
500-1000 kVA	\$500
1000-2000 kVA	\$1000
2000-10,000 kVA	\$2500

As part of initial application, the member shall submit preliminary plans for the generation facility including a site plan, and one line diagram.

15.2.2 OPALCO Preliminary Review

Within 30 days of receipt of the initial application and preliminary plans, OPALCO will review the information provided and schedule a meeting with the member at the site to discuss the interconnection requirements and the OPALCO modifications that must be charged to the applicant for the interconnection. In addition, OPALCO will provide a detailed list of the final plans, specifications and other information necessary for a complete engineering review of the member’s generation facility and the estimated OPALCO engineering fee for the review.

15.2.3 OPALCO Final Plans and Specifications Review

OPALCO will review the final plans, specifications and other information requested during the preliminary review and will return an interconnection analysis to the member within 60 days of receipt of the final plans and specifications along with the engineering fee payment. If the engineering review reveals that system studies are necessary to model large generation facilities, OPALCO will notify the member of the additional cost in writing. Any modifications of the plans and specifications by the member will extend the time period for review and may require payment for additional costs.

The engineering review will be consistent with this standard and the guidelines established by the current IEEE 1547 “*Standard for Interconnecting Distributed*

Resources with Electric Power Systems” and IEEE 1547.1 “*Standard Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems*”. Any review of distributed generation plans and specifications by OPALCO shall not impose any liability on OPALCO and does not guarantee the adequacy of the member’s equipment to perform its intended function. OPALCO disclaims any expertise or special knowledge relating to the design or performance of generating installations and does not warrant the efficiency, cost effectiveness, safety, durability or reliability of generating installations.

15.2.4 Energy Sales and Purchase

If power import and export to OPALCO is planned, energy flow to OPALCO shall be measured by the net (in/out) metering method. Bi-directional meters shall be installed so that the member consumes all of the energy generated in order to offset the amount of energy purchased from the OPALCO system. Energy flow to the member will be metered separately and billed monthly in accordance with the terms of the purchase agreement and OPALCO’s existing rate tariff. OPALCO shall pay the member on a monthly basis for the energy supplied to the OPALCO system. The rate paid by OPALCO shall be the avoided cost of generation as determined in OPALCO’s existing rate tariff. Avoided cost shall be defined as cost avoided by OPALCO due to the purchase of the member’s energy. The member shall sign a separate approved contract for the sale and purchase of energy including any extra charges for additional billing, meter reading and/or member service costs.

If generally power export to OPALCO is planned, the buy/sell connection method may be used where the member agrees that no less than 51% of available generation is sold to OPALCO under a wholesale rate tariff. Energy delivered into the OPALCO system will be reimbursed on a monthly basis at an established rate based on OPALCO’s yearly average of wholesale power rates. The buy/sell method only applies to energy and OPALCO reserves the right to limit purchases that exceed OPALCO’s ability to resell the power to its members.

OPALCO shall not be required to make any energy purchases that will cause OPALCO to be not in compliance with any applicable contracts or requirements of its wholesale power suppliers.

15.2.5 Additional Metering Requirements

OPALCO generally will procure, install, own, inspect, test, and maintain meters to record flows to and from the OPALCO system. OPALCO will require energy recorders on large generation facilities that indicate the integrated demand. Also, OPALCO will require in/out metering of reactive volt-amps on large generation facilities. The specific installation of this additional metering is discussed in sections 6-8. All costs of complex metering equipment to accommodate large generation facilities will be included in the interconnection costs.

15.2.6 Line Extensions and Modifications to OPALCO Facilities

The interconnect analysis prepared by OPALCO will include estimates of any line extension, line conversion, facility upgrade or other costs to be incurred in order to provide electric delivery service at the interconnection of the member's generation facility. The member shall pay in advance the full cost of construction of any transmission, substation, distribution, transformation, metering and protection facilities or equipment that OPALCO determines is required to serve the member's generation facility. The charges will be in accordance with OPALCO's standard policies governing line extensions and other improvements. If necessary at the time of initial interconnection or at some future time, OPALCO may modify the electric delivery system in order to better serve the member's generation facility and to continue to purchase power from the facility. Furthermore, OPALCO may modify the electric delivery service at any time if the quality of power provided by the member adversely affects the OPALCO system and its members. The member shall be responsible to reimburse OPALCO for all costs of these additional modifications. If future changes to the primary voltage of the member's generation facility are required by OPALCO, all upgrade costs for metering, transformers or other equipment on the member's side of the interconnection shall be the responsibility of the member.

15.2.7 Construction of Distributed Generation

The member shall sign and execute the approved OPALCO contracts for the interconnection and parallel operation of distributed generation. The required interconnection facilities for the members generation shall be constructed as outlined in this standard including, but not limited to, disconnect switch with visible open, primary fuse or circuit breaker protection, dedicated transformer, generator circuit breaker and protective relaying. The member shall comply with all applicable tariffs, policies and procedures of OPALCO and the Rural Utilities Service. Furthermore, the member shall comply with applicable electrical industry standards listed in section 3.1 and all applicable federal, state and local laws, ordinances rules and regulations. After completion of construction, the member shall comply with the test requirements in section 9 before OPALCO will conduct the final inspection.

15.2.8 Liability Insurance

Prior to the final interconnection, the member shall provide a certificate of insurance showing satisfactory liability insurance including contractual liability insurance covering indemnity agreements that insures the member against all claims for damage and for personal injury or death arising out of, resulting from or in any manner connected with the installation, operation and maintenance of the members generating equipment. The member shall hold harmless and indemnify OPALCO, its members, employees and agents from any damage, loss, claim or expense arising out of the member's actions or inaction in conjunction with this policy. OPALCO shall hold harmless and indemnify the member for any loss, claim or expense arising out of the actions or inaction of OPALCO, its employees, or agents

in implementing this policy. The amount of such insurance coverage shall not be less than \$500,000 per occurrence plus an additional \$100,000 for every 500 kVA.

15.2.9 Final Interconnection

After execution of the required agreements and completion of the generation facility, OPALCO will conduct a final inspection of the facilities and interconnection to the OPALCO system. Upon satisfactory completion of the final inspection, OPALCO will issue a written notice to commence parallel operation. OPALCO's review process and final inspection is intended as a means to safeguard OPALCO's facilities, members and personnel. Any review by OPALCO shall not impose any liability on OPALCO and does not guarantee the adequacy of the member's equipment to perform its intended functions or meet required industry safety standards. OPALCO may, at its sole discretion, prevent the interconnection or disconnect the interconnection of any distributed generation facilities due to reasons such as safety concerns, reliability issues, power quality issues, breach of interconnection contract or any other reasonable issue. The disconnection may be made without prior notice.

15.3 GENERAL DESIGN REQUIREMENTS

15.3.1 Required Codes and Standards

The member's generation facility must comply with the following applicable codes and standards:

IEEE Std. 100-2000 "*IEEE Standard Dictionary of Electrical and Electronic Terms*"; IEEE Std 519-1992 "*IEEE Recommended Practices and Requirements for Harmonic Control in Electric Power systems*"; IEEE Std. 929-2000 "*IEEE Recommended Practice for Utility Interface of Photovoltaic (PV) Systems*"; IEEE Std. 1547-2005 "*IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems*"; IEEE Std. 1547.1-2005 "*Standard for Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems*"; IEEE Std. 1547.2-2008 "*Application Guide for IEEE Std. 1547*"; IEEE Std. 1547.3-2007 "*IEEE Guide for Monitoring, Information Exchange Control*"; IEEE Std. C50.13-1977 "*Requirements for 60 Hz Cylindrical Rotor Synchronous Generators*"; IEEE Std. C57.13-2008 "*IEEE Standard Requirements for Instrument Transformers*"; IEEE Std. C62.92-2002 "*Guide for the Application of Neutral Grounding in Power Systems, Part 1-4*"; ANSI Std. C84.1-2006 "*Electric Power Systems and Equipment-Voltage Ratings (60 Hertz)*"; ANSI/IEEE Std. 446-1995 "*Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications*"; ANSI/IEEE Std. 142-2007 "*IEEE Recommended Practice for Grounding of Industrial Commercial Power Systems-Green Book*"; ANSI C2-2007 National Electrical Safety Code; UL Std. 1741 "*Inverters, Converters, and Controllers for Use in Independent Power Systems*"; NFPA 70-2011 *National Electrical Code*

15.3.2 Voltage Requirements

The member shall operate generating equipment in a manner that maintains steady state voltages on the OPALCO system within ANSI Range A requirements as specified in ANSI Standard C84.1. Furthermore, the member shall provide an automatic method of disconnecting the generating equipment from the OPALCO system if a sustained voltage deviation in excess of +5% or -10% from nominal voltage persists for more than 10 seconds, or a deviation in excess of +10% or -30% from nominal voltage persists for more than 1 second. Larger voltage deviations shall be disconnected immediately within 10 cycles. The generating equipment shall not reconnect until at least five minutes after the voltage and frequency is restored to the normal range and the system is stabilized.

OPALCO regulates the system voltage in its substations at the 12.5 kV distribution level. Therefore, large generation facilities that require an interconnection at the 69 kV transmission level shall include voltage regulation equipment to limit voltage excursions to within ANSI Range A tolerances.

15.3.3 Voltage Flicker Requirements

The member's generating equipment shall not cause excessive voltage flicker on the OPALCO system. The voltage flicker at the interconnection point shall not exceed 3% voltage dip and shall be within IEEE Standard 519 limitations.

15.3.4 Frequency Requirements

The operating frequency of the member's generating equipment should not deviate more than +0.5 Hz or -0.7 Hz from a 60 Hz base. The member's generation facility shall have field adjustable frequency relays that automatically disconnect the generating equipment from the OPALCO system within 15 cycles if the frequency tolerance provided by OPALCO cannot be maintained. The generating equipment shall not reconnect until at least five minutes after the voltage and frequency is restored to the normal range and the system is stabilized.

15.3.5 Harmonics

The total harmonic distortion (THD) voltage shall not exceed 5% of the fundamental 60 Hz frequency and the individual harmonic distortion (IHD) voltage shall not exceed 3% of the fundamental 60 Hz frequency in accordance with IEEE Standard 519 limitations.

15.3.6 Maximum Fault Currents and Clearing Times.

The combined fault current from the member's generating equipment and the OPALCO system shall not exceed the capabilities of OPALCO's system protection devices. OPALCO will provide the maximum three phase and line to ground fault currents for the system at the member's interconnection and the interrupt ratings of OPALCO system protection devices. If the member's generating equipment causes

excessive fault currents on the OPALCO system, the member shall install equipment to limit the fault current or compensate OPALCO for the costs of replacing the inadequate system protection devices. Furthermore, the member's primary protection device shall automatically disconnect the generating equipment within 10 cycles for the maximum fault current or within 1 second if the voltage on one or more phases falls below -30% of the nominal voltage. This disconnect timing allows the generator to be disconnected from the utility system prior to an automatic reclose on the OPALCO system. The generating equipment shall not reconnect until at least five minutes after the voltage and frequency is restored to the normal range and the system is stabilized.

15.3.7 Power Factor

All medium and large distributed generation facilities with stand alone capabilities shall operate near unity power factor and will be required to provide any necessary reactive power for member's loads. Small distributed facilities generation facilities that require reactive power from the OPALCO system shall be operated at a power factor greater than 0.90 or according to a mutual agreement with OPALCO.

15.3.8 Ground Fault Protection

Distributed generation facilities shall have ground fault protection that limits potential over voltages and coordinates with OPALCO ground fault protection. OPALCO distribution feeders are a wye connected four wire multigrounded neutral system that is generally effectively grounded with respect to the substation source. For a single line to ground fault, this arrangement limits the voltage rise on unfaulted phases to about 125 to 135% of the prefault condition according to IEEE Standard C62.92. Therefore, to prevent overvoltages, all medium and large distributed generation facilities on multigrounded neutral systems shall be effectively grounded so that the generating equipment operates as an effectively grounded source on the OPALCO distribution system. If the generator will be resistance grounded, the member shall use appropriate protective relaying to detect primary side ground fault overvoltages and quickly trip the generator off line. This relaying shall instantaneously trip the circuit breaker within 10 cycles to limit overvoltages. OPALCO transmission lines are generally delta connected so the grounding of interconnections at the transmission level will be studied on a case by case basis.

Please note that rocky conditions make effective grounding difficult in many areas. The ground grid for member generation facilities shall be designed in accordance with IEEE Standard 142 and shall be based on the measured soil resistivity at the site.

15.3.9 Negative Sequence Detection

Certain fault conditions on the OPALCO system may cause negative sequence currents to flow in the member's generator. A voltage phase sequence (Type 47) or

similar relay should be installed on all medium and large three phase generators to protect from excessive negative sequence currents.

15.3.10 Three Phase Synchronous Generators

The member is solely responsible for properly paralleling and protecting three phase synchronous generators used for distributed generation. Synchronization of the generator shall not cause a voltage fluctuation at the interconnection greater than +5% or –5% of the prevailing voltage level or cause excessive reactive power flow in either direction. Sufficient generator reactive power capability shall be provided to withstand normal voltage changes on the OPALCO system. The generator's excitation system shall conform to the field voltage versus time criteria specified in ANSI/IEEE Standard C50.13 in order to permit adequate field forcing during transient conditions. Synchronism check relays may be used to manually synchronize generators less than 500 kVA. For synchronous generators greater than 500 kVA, the member shall maintain an automatic voltage regulator (AVR) in operation at all times for each unit. OPALCO shall be notified if the AVR is removed from service for maintenance or repair. The specifications of large synchronous generators should be jointly determined by the member and OPALCO to ensure intersystem coordination and operating capability.

15.3.11 Three Phase Induction Generators and Inverters

The member is solely responsible for properly paralleling and protecting three phase induction generators and inverters used for distributed generation. Induction generators may be connected and brought up to synchronous speed as an induction motor if it can be demonstrated that the voltage fluctuation at the interconnection is within +5% or –5% of the prevailing voltage and within the flicker limits in section 3.3. Otherwise, the member will be required to install step switched capacitors or other techniques to bring voltage fluctuations to acceptable levels. Line commutated inverters do not require synchronizing equipment. Self commuted inverters shall be used in parallel with the OPALCO system only with synchronizing equipment.

The member shall provide a reactive power supply for induction generators and inverters. The installation of capacitors may be required to limit the adverse effects of reactive power flow on OPALCO's distribution system. However, the installation of capacitors for a reactive power supply at or near an induction generator greatly increases the risk that the induction generator will become self-excited if accidentally isolated from the OPALCO system. In order to reduce the possibility of self-excited operation, the reactive power for 200-500 kVA induction generators will be studied by OPALCO on an individual basis. If necessary, the reactive power may be supplied by OPALCO and the cost of capacitors and kVARh metering along with monthly reactive power charges will be billed to the member.

15.4 DESCRIPTION OF INTERCONNECTIONS PERMITTED BY OPALCO

15.4.1 Basic Interconnection Requirements

OPALCO has established basic minimum interconnection requirements for medium and large member owned parallel generation facilities that will be connected to its system. These requirements vary according to the generator type, installed capacity, primary protection, interconnection type, voltage and location on the OPALCO system. Small member owned parallel generation facilities 200 kW or less are covered by OPALCO's "Interconnection Standards for Member Generators with Nameplate Capability No Greater than 200 kW".

15.4.2 Generator Limitations

OPALCO will permit the interconnection of distributed resources having an installed capacity of not more than 10 MVA if the proposed generation facilities are within the capabilities of its transmission and distribution systems. However, certain limitations apply depending on the generator type and size as shown in Table 4.1.

Synchronous generators produce the reactive power necessary for the machine electro-magnetic fields whereas the reactive power for induction generators must be supplied by external capacitors or the utility. Since OPALCO's rural distribution system has limited capacity to transfer reactive power, induction generators will be limited to 500 kVA or less. Furthermore, single phase machines will unbalance OPALCO's three phase system so all medium and large generators must be three phase machines.

15.4.3 Installed Capacity and Primary Protection

Electrical industry standards for operating, metering and protection of generators are generally dependent on the generator nameplate capacity. Small generators can be connected at lower voltages with simpler equipment and protection schemes. OPALCO has grouped medium and large generators into four size classifications: 200-500 kVA, 500-1000 kVA, 1000-2000 kVA, and 2000-10,000 kVA as shown on Table 4-1.

Small generator installations typically have power fuses for protection of the primary bus including the interconnection transformer. Fuses are inherently single pole devices so all three phases of the primary bus of the member's facility are not completely disconnected if a line to ground or a line to line fault occurs. This results in abnormal voltages on the unfaulted phase or phases of a three phase system. Therefore, OPALCO requires a three phase current breaker for primary protection at the member interconnection point on all generators with installed capacity greater than 500 kVA.

15.4.4 OPALCO Transmission and Distribution System

The OPALCO transmission and distribution system is unique because it is situated on six islands of various sizes. The three big islands, San Juan, Lopez and Orcas generally have large distribution substations with 7.5 to 20.0 MVA transformer capacity. Shaw is a medium size island that has an in-between substation with 5.0 MVA transformer capacity. These four islands are interconnected with a 69 kV transmission system. Blakely and Decatur are small islands that have substations with 1.5 MVA or smaller transformer capacities. These two islands and Olga Substation on Orca Island are supplied by a 24.9 kV submarine cable that has limited capacity. OPALCO is planning to replace the 24.9 kV submarine cable with a new 69 kV submarine cable in about three years. Consequently, the interconnection type, voltage and capacity that is presently available for medium and large generation facilities depends on the physical location as shown in Tables 4.2 and 4.3. The capacity limitation on Blakely and Decatur Islands will be modified in 2014.

15.4.5 Interconnection Type and Voltage

Four types of interconnections are available on the OPALCO system. A 480/277 kV three phase connection would be provided for small generators with 200-500 kVA installed capacity from a dedicated OPALCO transformer. The member would have to pay for the transformer and OPALCO would own the transformer and provide the maintenance. Medium size generators would be connected to nearby OPALCO 7.2/12.5 kV three phase distribution feeders. The member would be required to pay for any line upgrades required such as conversion from single phase to three phase distribution line. The member also would be required to furnish medium voltage power transformers 500 kVA or greater required at the interconnection point. Where existing distribution facilities are limited OPALCO prefers that large generators 1000 kVA or greater be connected directly to the 7.2/12.5 kV bus of existing OPALCO 5.0-20 MVA distribution substations or directly to an available OPALCO transmission circuit via a member furnished substation. The member would be required to pay for the new 7.2/12.5 kV substation circuit breaker position and any dedicated three phase line to the generation facility. The four types of connections are shown in Tables 4.2 and 4.3.

15.4.6 Interconnection Location

Since Lopez, Orcas, Shaw and San Juan Islands have existing substations with 5.0-20 MVA transformer capacities and a 69 kV transmission system, larger generators generally can be accommodated on these islands as shown in Table 4.2. However, the existing small substations and the 24.9 kV transmission system on Blakely and Decatur Islands and Olga presently limit the maximum generator size to about 2000 kVA on these islands as shown in Table 4.3. The applicant may submit detailed PSS/E computer simulations to justify a larger generator installation that OPALCO will review before a final decision is made.

15.4.7 Specific Interconnection Design Requirements

The minimum specific design requirements for the following four interconnection classifications are summarized in Table 4.4.

Type 1: 200-500 kVA Grid Interactive, Induction and Synchronous Generators

Type 2: 500-1000 kVA Synchronous Generators w/wo Member Load

Type 3: 1000-2000 kVA Synchronous Generators w/wo Member Load

Type 4: 2000-10,000 kVA Synchronous Generators w/wo Member load

The specific requirements for these four types of interconnections are also discussed in the following four sections.

TABLE 4.1
GENERAL REQUIREMENTS FOR MEDIUM AND
LARGE GENERATION FACILITIES ACCORDING
TO INSTALLED CAPACITY AND VOLTAGE

REQUIREMENT	TYPE 1	TYPE 2	TYPE 3	TYPE 4
	200 TO 500 kVA	500 TO 1000 kVA	1000 TO 2000 kVA	2000 TO 10,000 kVA
Three Phase Machine	Y	Y	Y	Y
Induction Machine	Y	N	N	Y
Synchronous Machine	Y	Y	Y	Y
Fuse Primary Protection	Y	Y	N	Y
Circuit Breaker Primary Protection	N	Y	Y	Y
Low Voltage Connection	Y	N	N	Y
Medium Voltage Feeder Connection.	N	Y	N	Y
Medium Voltage Bus Connection	N	N	Y	Y
High Voltage Substation Connect.	N	N	N	Y

TABLE 4.2
LOPEZ, ORCAS, SHAW & SAN JUAN ISLANDS
TYPICAL INTERCONNECTION ALLOWED ACCORDING TO
INSTALLED CAPACITY AND INTERCONNECTION VOLTAGE

INTER- CONNECTION TYPE	INSTALLED CAPACITY MVA	TRANSMISSION 69 kV 3PH SUBSTATION	DISTRIBUTION 12.5 kV 3PH EX. SUB BUS	DISTRIBUTION 12.5 kV 3PH EX. FEEDER	SECONDARY 480 V 3PH** EX. TRANSF.
	0.2				
1	0.5				
2	1.0				
3	1.5				
3	2.0				
4	2.5				
4	3.0				
4	3.5				
4	4.0				
4	4.5				
4	5.0				
4	5.5				
4	6.0				
4	6.5				
4	7.0				
4	7.5				
4	8.0				
4	8.5				
4	9.0				
4	9.5				
4	10.0				

TABLE 4.3

**DECATUR, BLAKELY ISLANDS AND OLGA
 TYPICAL INTERCONNECTION ALLOWED ACCORDING TO
 INSTALLED CAPACITY AND INTERCONNECTION VOLTAGE**

INTER- CONNECTION TYPE	INSTALLED CAPACITY MVA	TRANSMISSION 24.9 kV 3PH SUBSTATION	DISTRIBUTION 12.5 kV 3PH EX. SUB BUS	DISTRIBUTION 12.5 kV 3PH EX. FEEDER	SECONDARY 480 V 3PH** EX. TRANSF.
	0.2				
1	0.5				
2	1.0				
3	1.5				
4	2.0				
NA	2.5				
NA	3.0				
NA	3.5				
NA	4.0				
NA	4.5				
NA	5.0				
NA	5.5				
NA	6.0				
NA	6.5				
NA	7.0				
NA	7.5				
NA	8.0				
NA	8.5				
NA	9.0				
NA	9.5				
NA	10.0				

TABLE 4.4
SUMMARY OF MINIMUM REQUIREMENTS
FOR VARIOUS INTERCONNECTION TYPES

REQUIREMENT	TYPE 1	TYPE 2	TYPE 3	TYPE 4
	200-500 kVA	500-1000 kVA	1000-2000 kVA	2000-10,000 kVA
Grid Interactive/Induction Machine	Y	N	N	N
Synchronous Machine	Y	Y	Y	Y
Three Phase Interconnection	Y	Y	Y	Y
Lockable Main Disconnect Switch	Y	Y	Y	Y
Primary Fuse Protection	Y	Y	N	N
Primary Circuit Breaker Protection	Y	Y	Y	Y
Secondary In/Out Metering	Y	N	N	N
Primary In/Out Metering	N	Y	Y	Y
Dedicated Transformer by Utility	Y	N	N	N
Dedicated Transformer by Member	N	Y	Y	Y
Generator Circuit Breaker	Y	Y	Y	Y
Under-Voltage Protection (27)	Y	Y	Y	Y
Over-Voltage Protection (59)	Y	Y	Y	Y
Under-Frequency Protection (81U)	Y	Y	Y	Y
Over-Frequency Protection (81O)	Y	Y	Y	Y
Phase Over Current (50/51)	Y	Y	Y	Y
Neutral Over Current (51N)	Y	Y	Y	Y
Ground Over Voltage Protection(59 N)	Y	Y	Y	Y
Synchronism Check (25)	Y	Y	Y	Y
Directional Power (32)	Y	Y	Y	Y
Phase Sequence (47)	Y	Y	Y	Y
Field Current (40)	N	Y	Y	Y
Transfer Trip	N	TBD	TBD	TBD
Close Permissive Required	N	Y	Y	Y
Automatic Synchronizer	N	Y	Y	Y
Isolation Detection/Anti-Islanding	Y	Y	Y	Y
Communications-Voice	Y	Y	Y	Y
Telemetry	Y	Y	Y	Y
Power Quality Monitoring	N	Y	Y	Y
Energy Recorder	N	N	N	Y
Export Power Control Equipment	N	Y	Y	Y
Operational Data Logging	N	Y	Y	Y
Sequence of Event Reporting	N	Y	Y	Y
Fault Recording	N	Y	Y	Y
PSS/E Modeling	N	N	N	Y
Metering CTs By Utility	Y	Y	Y	N
Metering CTs By Member	N	N	N	Y
Machine Testing	N	N	N	Y
Momentary Paralleling	N	N	N	N

15.5 SPECIFIC REQUIREMENTS FOR 200-500 kVA TYPE 1 INTERCONNECTIONS

15.5.1 Application

The specific requirements for Type 1 interconnections with installed generator capacity of 200-500 kVA are described in this section. A typical one line diagram of a Type 1 interconnection for a grid interactive or induction machine is shown in Figure 11.1 and a typical one line diagram of a Type 1 interconnection for a synchronous machine with member loads is shown in Figure 11.2. Also, the minimum requirements are summarized in Table 4.4 in Section 4.7.

15.5.2 Basic Description

Type 1 interconnections are based on a dedicated OPALCO 480/277 V three phase transformer at the interconnection point. This transformer will be connected by OPALCO to a nearby 7.2/12.5 kV three phase primary distribution feeder. The member will be required to pay for all OPALCO costs for the transformer and primary interconnection. If a distribution line extension or single phase to three line conversion is required, the member also will be required to pay for these improvements in accordance with OPALCO's normal line extension and upgrade policy. OPALCO will provide normal operation and maintenance of the transformer and primary facilities for the member.

15.5.3 Interconnection Transformer

OPALCO will supply and install the 480/277 V interconnection transformer in accordance with OPALCO's standard services policy. The interconnection transformer will be connected in a grounded wye/grounded winding configuration and will provide a 480/277 V three phase four wire supply to the member. The member shall construct a suitable pad mounted transformer base as detailed in this policy. In addition, the member shall be responsible for all costs and materials for the underground primary feeder as outlined in this policy.

15.5.4 Metering

OPALCO will provide a 480/277 V three phase electronic meter and current transformers for revenue metering at the generation facility. The member shall furnish and install the current transformer enclosure, meter socket and junction box at the locations shown in Figures 11.1 and 11.2.

The metering equipment for Type 1 interconnections shall be capable of recording the kWh (in) and kWh (out) separately. Additional metering for kW and kVARh will be determined by the requirements for the individual installation.

15.5.5 Lockable Disconnect Switch

A manual 480 V three pole disconnect switch with provisions for locking and mechanical indication of the "open" position shall be provided at the locations

shown on Figures 11.1 and 11.2. This disconnect switch shall be rated for the installation ampacity and have an interrupt rating adequate for the available fault current at the interconnection. The member shall furnish, install and maintain this switch.

15.5.6 Interconnection Circuit Breaker

A 480 V three pole circuit breaker is required at the interconnection with the OPALCO system. This circuit breaker shall be rated for the maximum generator current and have an interrupt rating adequate for the available fault current at the interconnection. The protective relays shall trip this circuit breaker for excessive phase and neutral over current and a synchronism check relay is required to supervise manual synchronized circuit breaker closing. The member may use the 480 V three pole circuit breaker also as a manual disconnect switch if the enclosure has provisions for locking in the “open” position and visible external mechanical indication of the switch position. The member shall furnish, install and maintain this circuit breaker.

15.5.7 Grounding

The 480/277 V three phase four wire circuit will include a multi-grounded neutral at the interconnection transformer terminals. The member shall adequately ground this circuit in accordance with NEC requirements in order to prevent hazardous conditions.

15.5.8 Generator

Type 1 generators shall be three phase induction or synchronous machines or inverters. Generation equipment used for Type 1 interconnections shall meet the requirements of IEEE 1547-2003 and UL 1741 along with any supporting documents created for testing, clarifications or supplemental information for each article. Generation equipment shall have adequate ratings for the intended application.

15.5.9 Generator Circuit Breaker

All Type 1 generators shall be connected with a three phase generator circuit breaker that has adequate ratings to meet load and short circuit requirements. Furthermore, Type 1 generators without stand alone capability shall have protective relays that trip this circuit breaker for excessive over/under voltage, over/under frequency, phase overcurrent, ground fault and phase sequence protection.

15.5.10 Protective Relays

The member shall submit a one line diagram with the proposed relay protection to OPALCO. Adequate protective devices shall be provided to detect and clear short circuits or grounds on the OPALCO system and to detect and disconnect the generator from abnormal voltages, frequencies and other detrimental conditions.

Instrument transformers shall meet ANSI standards for C200 relay accuracy. Circuit design and specified equipment shall be reviewed by OPALCO prior to installation.

For Type 1 synchronous generators with stand alone capability, protective relays that trip the generator circuit breaker for excessive over/under voltage, over/under frequency, phase and neutral overcurrents, ground fault, directional power and phase sequence protection shall be provided . Also, a synchronism check relay shall be provided to supervise manual synchronized closing of the generator circuit breaker.

15.5.11 Anti-Islanding Protection

The member shall provide isolation detection and anti-islanding protection for Type 1 synchronous generators and coordinate those protection schemes so that OPALCO circuit reclosing will not be adversely affected. Member generation shall not be reparalleled after disconnection unless conditions return to normal and approval is received from the OPALCO control center.

15.5.12 Telephone Communications

The member shall provide and maintain on site, 24 hour voice quality telephone communications with OPALCO so that emergency information can be conveyed to the member.

15.5.13 Telemetry

OPALCO may require minimal telemetry for Type 1 generators to dial-up the installation and verify at a minimum on-line/off-line status and measure amps, watts, vars and voltage output. All costs for communication equipment will be the responsibility of the member.

15.5.14 Harmonics

The harmonic output of Type 1 generators, including power inverters, shall comply with IEEE 1547, IEEE 519, and/or UL 1741. If the generator exceeds IEEE recommended specifications, the member will be required to install filtering to bring the harmonic output to an acceptable level.

15.5.15 Safety Practices

The member shall design and install an adequate facility and equipment grounding system that conforms to NEC, NESC and IEEE standards and current OPALCO and RUS practices for safe utility grounding. The member's facilities shall be fenced and secure to prevent unauthorized personnel access.

15.6 SPECIFIC REQUIREMENTS FOR 500-1000 kVA TYPE 2 INTERCONNECTIONS

15.6.1 Application

The specific requirements for Type 2 interconnections with installed generator capacity of 500-1000 kVA are described in this section. A typical one line diagram of a Type 2 interconnection for a synchronous machine with consumer loads is shown in Figure 11.3 and a typical one line diagram of a Type 2 interconnection for a synchronous machine without consumer loads is shown in Figure 11.4. Also, the minimum requirements for Type 2 interconnections are summarized in Table 4.4 in section 4.7.

15.6.2 Basic Description

Type 2 interconnections are based on a tap of an existing OPALCO 7.2/12.5 kV three phase primary distribution feeder with sufficient capacity for the proposed generation. OPALCO will furnish a metered 7.2/12.5 kV four wire three phase supply to the member's 500-1000 kVA three phase interconnection transformer that steps the voltage down to the generator level. The member will be required to pay for all OPALCO costs for the primary distribution feeder connection. If a 7.2/12.5 kV distribution line extension or single phase to three phase line conversion is required, the member also will be required to pay for these improvements in accordance with OPALCO's normal line extension and upgrade policy.

15.6.3 Metering

OPALCO will furnish and install the 7.2/12.5 kV three phase primary feeder connection and primary metering in accordance with OPALCO's standard services policy. The member shall be responsible for all costs and materials required for the primary connection and metering as outlined in this policy.

The primary metering equipment for Type 2 interconnections shall be capable of recording the kWh (in) and kWh (out) separately. Additional metering for kW and kVARh will be determined by the requirements of the individual installation.

15.6.4 Lockable Disconnect Switch

A manual 15 kV three pole lockable disconnect switch with visible open or mechanical indication of the "open" position shall be provided at the location shown on Figures 11.3 and 11.4. The 15 kV disconnect switch shall be rated to open the magnetizing current of the transformer and the full load current of the generator. Also, this disconnect switch shall simultaneously open all three phases and have an interrupt rating adequate for the available fault current at the interconnection location. The 15 kV disconnect switch shall be new, conform to the RUS List of Approved Materials (Pub. 202.1) and shall be furnished with an effectively grounded switch operator's platform.

15.6.5 Interconnection Transformer

If the generation facility has a standalone synchronous generator that will be resistance grounded, a dedicated transformer with a grounded wye primary winding configuration and a delta secondary winding configuration shall be provided to protect the generator from ground faults. The interconnection transformer shall be protected from excessive phase and neutral overcurrents by a primary 15 kV circuit breaker as shown in Figures 11.3 and 11.4. The interconnection transformer shall be furnished, installed and maintained by the member. It should be energy efficient.

15.6.6 Interconnection Circuit Breaker

A three phase circuit breaker with external trip and close shall be provided on the primary side of the transformer to protect the transformer from over-currents and to synchronize a generator with stand alone capability to the OPALCO distribution system. The protective relays shall trip either circuit breaker for excessive phase and neutral overcurrents. Also, an automatic synchronizer and a synchronism check relay is required to supervise the circuit primary breaker closing. The primary circuit breaker shall be furnished, installed and maintained by the member.

15.6.7 Grounding

The member shall ground the winding wye points and case of the interconnection transformer so that the transformer is effectively grounded. Furthermore, the member shall adequately ground secondary circuits in accordance with NEC requirements to prevent hazardous conditions.

15.6.8 Generator

All Type 2 generators shall be three phase synchronous machines. Generation equipment used for Type 2 interconnections shall meet the requirements of IEEE 1547-2003 and UL 1741 along with any supporting documents created for testing, clarification or supplemental information for each article. Generation equipment shall have adequate ratings for the intended application.

15.6.9 Generator Circuit Breaker

All Type 2 generators shall be connected to a three phase generator circuit breaker that has adequate ratings to meet load and short circuit requirements. Synchronous generators with or without consumer loads shall have protective relays that trip this circuit breaker for excessive over/under voltage, over/under frequency, phase and neutral overcurrent, ground fault, loss of field, directional power and phase sequence protection. Also, an automatic synchronizer and a synchronism check relay shall be provided to supervise synchronized closing of the circuit breaker.

15.6.10 Protective Relays

The member shall submit a one line diagram with proposed relay protection to OPALCO for review. In addition, member relays shall be coordinated with OPALCO relays to ensure proper function. Adequate protective devices shall be provided to detect and clear short circuits or grounds on the OPALCO system and to detect and disconnect the generator from abnormal voltages, frequencies and other detrimental conditions. If necessary, OPALCO may require additional protective devices, depending on specific system conditions at the member's generation facility.

Utility grade protective relays shall be furnished for all Type 2 interconnections. Protective relays shall be equipped with operation indicators (targets) or shall be connected to an annunciator or event recorder in order to determine the cause of misoperations. Instrument transformers shall meet ANSI Standards for C200 relay accuracy. Circuit design and specific equipment shall be reviewed by OPALCO prior to installation.

15.6.11 Anti-Islanding Protection

The member shall provide isolation detection and anti-islanding protection for Type 2 synchronous generators and shall coordinate those protection schemes so the OPALCO circuit reclosing will not be adversely affected. Furthermore, the method to prevent reparalleling of member generation shall be provided. Member generation shall not be reparalleled after disconnection unless conditions return to normal and approval is received from the OPALCO control center.

15.6.12 Telephone Communications

The member shall provide and maintain on site, 24 hour voice dedicated telephone facilities for communications with the OPALCO control center so that emergency information can be conveyed to the member.

15.6.13 Remote Control

Remote control of member equipment or devices by OPALCO control center shall be required for Type 2 interconnections. Type of OPALCO control includes: close permissive control, transfer trip capabilities, interconnect breaker tripping and SCADA. OPALCO shall require telemetry capability to "dialup" the installation to verify at a minimum on-line/off-line status and to measure amps, watts, vars and voltage output. All costs for communications equipment will be the responsibility of the member.

The member shall furnish and install a Remote Terminal Unit (RTU) compatible with OPALCO's SCADA system along with any necessary transducers. Transducers shall be utility grade and subject to OPALCO approval. Space for

communication and control equipment and all necessary communications lines shall be provided by the member.

15.6.14 Harmonics

The harmonic output of Type 2 generators shall comply with IEEE 1547, IEEE 519, and/or UL 1741. If the generator exceeds IEEE recommended specifications, the member will be required to install filtering to bring the harmonic output to an acceptable level.

15.6.15 Operational Records

The member will be required to install equipment for export power control, operational data logging, sequence of event reporting and fault recording on Type 2 interconnections. OPALCO will review the member's generation to determine what equipment will be required. All costs for necessary equipment will be the responsibility of the member.

15.6.16 Safety and Practices

The member shall design and install an adequate facility and equipment grounding system that conforms to NEC, NESC and IEEE recommended standards and current OPALCO and RUS practices for safe utility grounding. The member's facilities shall be fenced and secure in order to prevent unauthorized access.

15.7.0 SPECIFIC REQUIREMENTS FOR 1000-2000 kVA TYPE 3 INTERCONNECTIONS

15.7.1 Application

The specific requirements for Type 3 interconnections with installed generator capacity of 1000-2000 kVA are described in this Section. A typical one line diagram of a Type 3 interconnection for a synchronous machine with consumer loads is shown in Figure 11.5 and a typical one line diagram of a Type 3 interconnection for a synchronous machine without consumer loads is shown in Figure 11.6. Also, the minimum requirements for Type 3 interconnections are summarized in Table 4.4 in section 4.7.

15.7.2 Basic Description

Type 3 interconnections are based on a 7.2/12.5 kV three phase circuit breaker position at the nearest existing OPALCO substation with sufficient capacity for the proposed generation. This circuit breaker position will be dedicated to the member's generation facility. OPALCO will furnish and install the new 7.2/12.5 kV circuit breaker position including buswork, disconnect switches and 15 kV circuit breaker or recloser. OPALCO will review the available capacity of the existing substation transformers and establish acceptable generation limits for Type 3 interconnections at substations.

The member will be required to pay for the new circuit breaker position. OPALCO will provide normal operation and maintenance of the new circuit breaker.

15.7.3 Primary Line

A dedicated 7.2/12.5 kV three phase primary distribution line using wood poles or URD cables will be required between the new substation circuit breaker position and the member's generation facility. The member will be required to pay all OPALCO's costs for the primary distribution line in accordance with OPALCO's normal line extension policy. The line must be constructed to RUS standards using new materials from the RUS List of Approved Materials (Pub. 202.1). OPALCO will provide normal operation and maintenance of the new line.

15.7.4 Metering

A metered 7.2/12.5 kV three phase four wire supply will be provided to the member's 1000-2000 kVA three phase transformer that steps the voltage down to the generator level. OPALCO will furnish and install 7.2/12.5 kV three phase primary metering at the site in accordance with OPALCO's standard service policy. The member shall be responsible for all OPALCO costs for the primary connection and metering at the member's facility.

Primary metering for Type 3 interconnections shall be capable of recording the kWh (in) and kWh (out) separately. Additional metering for kW and kVARh will be determined by the requirements of the individual installations.

15.7.5 Lockable Disconnect Switch

A manual 15 kV three pole lockable disconnect switch with visible open or mechanical indication of the "open" position shall be provided at the location shown on Figures 11.5 and 11.6. The 15 kV disconnect switch shall be rated to open the magnetizing current of the transformer and the full load current of the generator. Also, this disconnect switch shall simultaneously open all three phases and have an interrupt rating adequate for the available fault current at the interconnection location. The 15 kV disconnect shall be new, conform to the RUS List of Approved Materials (Pub. 202.1) and shall be furnished with an effectively grounded switch operators platform.

15.7.6 Interconnection Circuit Breaker

A 15 kV three pole circuit breaker is required on the primary side of the interconnection transformer for overcurrent protection of the transformer and synchronizing with the OPALCO distribution system. This circuit breaker shall be rated for the maximum generator current and have an interrupt rating adequate for the available fault current at the interconnection. The protective relays shall trip this circuit breaker for excessive phase and neutral overcurrent. Also, a synchronism check relay and automatic synchronizer is required to supervise the

primary circuit breaker closing. The 15 kV primary circuit breaker shall be furnished, installed and maintained by the member.

15.7.7 Interconnection Transformer

If the generation facility has a standalone synchronous generator that will be resistance grounded, a dedicated transformer with a grounded wye primary winding configuration and a delta secondary winding configuration shall be provided to protect the generator from ground faults. The interconnection transformer shall be protected from excessive phase and neutral overcurrents by the primary (15 kV) circuit breaker. The interconnection transformer shall be furnished, installed and maintained by the member. It should be energy efficient.

15.7.8 Grounding

The member shall ground the winding wye points and case of the interconnection transformer so that the transformer is effectively grounded. Furthermore, the member shall adequately ground secondary circuits in accordance with NEC requirements to prevent hazardous conditions.

15.7.9 Generator

All Type 3 generators shall be three phase synchronous machines. Generation equipment used for Type 3 interconnections shall meet the requirements of IEEE 1547-2003 and UL 1741 along with any supporting documents created for testing, clarification or supplemental information for each article. Generation equipment shall have adequate ratings for the intended application.

15.7.10 Generator Circuit Breaker

All Type 3 generators shall be connected to a three phase generator circuit breaker that has adequate ratings to meet load and short circuit requirements. Synchronous generators with or without consumer loads shall have protective relays that trip this circuit breaker for excessive over/under voltage, over/under frequency, phase and neutral overcurrents, ground fault, loss of field, directional power and phase sequence protection. Also, an automatic synchronizer and a synchronism check relay shall be provided to supervise synchronized closing of the circuit breaker.

15.7.11 Protective Relays

The member shall submit a one line diagram with the proposed relay protection to OPALCO for review. In addition, member relays shall be coordinated with OPALCO relays to ensure proper function. Adequate protective devices shall be provided to detect and clear short circuits or grounds on the OPALCO system and to detect and disconnect the generator from abnormal voltages, frequencies and other detrimental conditions. If necessary, OPALCO may require additional

protective devices, depending on specific system conditions at the member's generation facility.

Utility grade protective relays shall be furnished for all Type 3 interconnections. Protective relays shall be equipped with operation indicators (targets) or shall be connected to an annunciator or event recorder in order to determine the cause of misoperations. Instrument transformers shall meet ANSI Standards for C200 relay accuracy. Circuit design and specific equipment shall be reviewed by OPALCO prior to installation.

15.7.12 Anti-Islanding Protection

The member shall provide isolation detection and anti-islanding protection for Type 3 synchronous generators and shall coordinate those protection schemes so the OPALCO circuit reclosing will not be adversely affected. Furthermore, the method to prevent reparalleling of member generation shall be provided. Member generation shall not be reparalleled after disconnection unless conditions return to normal and approval is received from the OPALCO control center.

15.7.13 Telephone Communications

The member shall provide and maintain on site, 24 hour voice dedicated telephone facilities for communication between the generating station and the OPALCO control center so that emergency information can be conveyed to the member.

15.7.14 Remote Control

Remote control of member equipment or devices by OPALCO control center shall be required for Type 3 interconnections. Type of OPALCO control includes: close permissive control, transfer trip capabilities, interconnect breaker tripping and SCADA. OPALCO shall require telemetry capability to "dialup" the installation to verify at a minimum on-line/off-line status and to measure amps, watts, vars and voltage output. All costs for communications equipment will be the responsibility of the member.

The member shall furnish and install a Remote Terminal Unit (RTU) compatible with OPALCO's SCADA system along with any necessary transducers. Transducers shall be utility grade and subject to OPALCO approval. Space for communication and control equipment and all necessary communications lines shall be provided by the member.

15.7.15 Harmonics

The member is required to install power quality monitoring equipment on Type 3 interconnections. If the harmonic output exceeds recommended specifications in IEEE 519, the member will be required to install filtering to bring the harmonic output to an acceptable level.

15.7.16 Operational Records

The member is required to install equipment for export power control, operational data logging, sequence of event reporting and fault recording on Type 3 interconnections. OPALCO will review the member's generation to determine what equipment will be required. All costs for necessary equipment will be the responsibility of the member.

15.7.17 Safety and Practices

The member shall design and install an adequate facility and equipment grounding system that conforms to NEC, NESC and IEEE recommended standards and current OPALCO and RUS practices for safe utility grounding. The member's facilities shall be fenced and secure in order to prevent unauthorized personnel access.

15.8 SPECIFIC REQUIREMENTS FOR 2000-10,000 kVA TYPE 4 INTERCONNECTIONS

15.8.1 Application

The specific requirements for Type 4 interconnections with installed generator capacity of 2000-10,000 kVA are described in this section. A typical one line diagram of a Type 4 interconnection for a synchronous machine with consumer loads is shown in Figure 11.7 and a typical one line diagram of a Type 4 interconnection for a synchronous machine without member loads is shown in Figure 11.8. Also, the minimum requirements for Type 4 interconnections are summarized in Table 4.4 in section 4.7.

15.8.2 Basic Description

Type 4 interconnections are based on a tap of an existing OPALCO 69 kV three phase transmission line and a 69 kV substation with high voltage disconnect switch, circuit breaker and step down transformer at the member's generation facility. Any proposed generation that exceeds the capacity of a Type 3 connection directly to the 7.2/12.5 kV bus of the nearest existing OPALCO substation must be connected at the 69 kV transmission level. OPALCO will require PSS/E modeling of the 69 kV transmission system with the proposed generation and an independent design review before a Type 4 project is approved.

All costs for the 69 kV transmission tap and substation will be the responsibility of the member. OPALCO will provide normal operation and maintenance of the 69 kV transmission tap.

15.8.3 Primary Line

If the member's generation is not in close proximity to an existing OPALCO 69 kV transmission line, a dedicated 69 kV three phase underground or wood pole transmission line will have to be built to the site. OPALCO may require a 69 kV

three pole disconnect switch to sectionalize the new line from OPALCO's transmission line in case of an emergency. The member will be required to pay all OPALCO's costs for the 69 kV tap and line extension to the site in accordance with OPALCO's normal line extension policy. The line will be constructed according to RUS standards using new materials that conform to the RUS List of Acceptable Materials (Pub.202.1). OPALCO will provide normal operation and maintenance of the new line.

15.8.4 Metering

OPALCO will furnish and install the 69 kV three phase primary metering and make the final connection at the applicant's line termination structure in accordance with OPALCO's standard services policy. The member shall include provisions for mounting the metering equipment on the line termination structure. The member shall be responsible for all OPALCO costs for the primary connection and metering at the member's facility.

Primary metering equipment for Type 4 interconnections shall be capable of recording the kWh (in) kWh (out), kVARh (in) and kVARh (out) separately. A backup energy recording device and the capability to do load profiling also is required. Demand metering will be determined by the requirements of the individual installations.

15.8.5 Lockable Disconnect Switch

A manual 69 kV three pole lockable disconnect switch with visible open shall be provided at the location shown in Figures 11.7 and 11.8. The 69 kV disconnect switch shall be rated to open the magnetizing current of the transformer and the full load current of the generator. Also, this switch shall simultaneously open all three phases and have an interrupt rating adequate for the available fault current at the interconnection location. The 69 kV disconnect switch shall be new, conform to the RUS List of Approved Materials (Pub. 202.1) and shall be furnished with an effectively grounded switch operator's platform.

15.8.6 Interconnection Circuit Breaker

A 69 kV three pole circuit breaker is required on the primary side of the interconnection transformer for differential and overcurrent protection of the transformer and synchronizing with the OPALCO transmission system. This circuit breaker shall be rated for the maximum generator current and have an interrupt rating adequate for the available fault current at the interconnection. The protective relays shall trip this circuit breaker for excessive differential current and phase and ground overcurrents. Also, a synchronism check relay and automatic synchronizer is required to supervise the primary circuit breaker closing. The 69 kV circuit breaker shall be furnished, installed and maintained by the member.

15.8.7 Interconnection Transformer

The dedicated transformer for a Type 4 interconnection shall have a grounded wye primary winding configuration and a delta secondary winding configuration to protect the generator from ground faults. The transformer should be new and energy efficient. The interconnection transformer shall be protected from excessive phase and neutral currents and differential transformer current by the high side 69 kV circuit breaker. The dedicated interconnection transformer shall be furnished, installed and maintained by the member.

15.8.8 Grounding

The member shall ground the winding wye point and case of the interconnection transformer so that the transformer is effectively grounded. Furthermore, the member shall adequately ground secondary circuits in accordance with NEC requirements to prevent hazardous conditions.

15.8.9 Generator

All Type 4 generators shall be three phase synchronous machines. Generation equipment used for Type 4 interconnections shall meet the requirements of IEEE 1547-2003 and UL 1741 along with any supporting documents created for testing, clarification or supplement information for each article. Generation equipment shall have adequate ratings for the intended application.

15.8.10 Generator Circuit Breaker

All Type 4 generators shall be connected to a three phase generator circuit breaker that has adequate ratings to meet load and short circuit requirements. Synchronous generators with or without consumer loads shall have protective relays that trip this circuit breaker for excessive over/under voltage, over/under frequency, phase and neutral overcurrent, ground fault, loss of field, directional power and phase sequence protection. Also, an automatic synchronizer that supervises all circuit breaker closing and a synchronism check relay shall be provided. OPALCO may require additional protective relays for large generators.

15.8.11 Protective Relays

The member shall submit a one line diagram with the proposed relay protection to OPALCO for review. In addition, member relays shall be coordinated with OPALCO relays to ensure proper function. Adequate protective devices shall be provided to detect and clear short circuits or grounds on the OPALCO system and to detect and disconnect the generator from abnormal voltages, frequencies and other detrimental conditions. If necessary, OPALCO may require additional protective devices, depending on the specific system conditions at the member's generation facility.

Utility grade protective relays shall be furnished for all Type 4 interconnections. Protective relays shall be equipped with operation indicators (targets) or shall be connected to an annunciator or event recorder in order to determine the cause of misoperations. Instrument transformers shall meet ANSI Standards for C200 relay accuracy. Circuit design and specific equipment shall be reviewed by OPALCO prior to installation.

15.8.12 Anti-Islanding Protection

The member shall provide isolation detection and anti-islanding protection for Type 4 synchronous generators and shall coordinate those protection schemes so that OPALCO circuit reclosing will not be adversely affected. Furthermore, the method to prevent reparalleling of member generation shall be provided. Member generation shall not be reparalleled after disconnection unless conditions return to normal and approval is received from the OPALCO control center.

15.8.13 Telephone Communications

The member shall provide and maintain on site, 24 hour voice dedicated telephone facilities for communication between the generating station and the OPALCO control center so that emergency information can be conveyed to the member.

15.8.14 Remote Control

Remote control of member equipment or devices by the OPALCO control center shall be required for Type 4 interconnections. Types of OPALCO control includes: close permissive control, transfer trip capabilities, interconnect breaker tripping and SCADA. OPALCO shall require telemetry capability to allow continuous monitoring of the installation and to verify at a minimum on-line/off-line status of the tie point circuit breaker and measurement of amps, watts, vars and voltage output.

The member shall furnish and install a Remote Terminal Unit (RTU) compatible with OPALCO's SCADA system along with any necessary transducers. Transducers shall be utility grade and subject to OPALCO approval. Space for communication and control equipment and all necessary communications lines shall be provided by the member.

15.8.15 Harmonics

The member is required to install power quality monitoring equipment on Type 4 interconnections. If the harmonic output exceeds recommended specifications in IEEE 519, the member will be required to install filtering to bring the harmonic output to an acceptable level.

15.8.16 Operational Records

The member is required to install equipment for export power control, operational data logging, sequence of event reporting and fault recording on Type 4

interconnections. OPALCO will review the member's generation facility to determine what equipment is necessary. All costs for this equipment will be the responsibility of the member.

15.8.17 Safety and Practices

The member shall design and install an adequate facility and equipment grounding system that conforms to NEC, NESC and IEEE recommended standards and current OPALCO and RUS practices for safe utility grounding. The member's facilities shall be fenced and secure in order to prevent unauthorized personnel access.

15.9 GENERATION FACILITY TESTING AND INSPECTION

15.9.1 Testing Standards

Generation equipment used for Type 1-4 interconnections shall meet the requirements of IEEE 1547.1-2005 "Standard Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems" and UL 1741 "Inverters, Converters, Controllers and Interconnection System Equipment for use with Distributed Energy Resources". Also, any supporting documents created for testing, clarification or supplemental information for each article shall be included.

15.9.2 Relay Settings

After review of the member's one line diagram with the proposed relay protection, OPALCO will provide a range of basic relay specifications that are appropriate for each protective relay. The member shall set all relays within the specified ranges in the OPALCO specifications and coordinate these relays with upstream OPALCO relays. A certified test report shall be submitted to OPALCO prior to the preparallel inspection.

15.9.3 Power Flow and Transient Stability Modeling

OPALCO may request that the member provide PSS/E power flow and transient stability modeling for large generators. The test results provided to OPALCO shall include generator, governor and automatic voltage regulator parameters needed for the relay coordination.

15.9.4 Preparallel Inspection

The member shall notify OPALCO after the generation facilities are ready to energize but before the generator is paralleled with the OPALCO system. The preparallel inspection includes but not limited to the following initial checks: a) proper relay settings, b) appropriate relay tripping of each circuit breaker, c) proper secondary voltage applied to voltage and frequency relays, d) proper operation of

the synchronizer e) verification of generator phase rotation, and f) proper grounding.

15.9.5 Generator Load Tests

The following load tests shall be performed after the generator picks up load: a) correct load current in all relay current coils, b) proper generator operation at 0.90 power factor lag and 0.95 power factor lead c) proposed generator operation at 0.95% to 105% nominal voltage, d) proper load balance of differential relays and e) proper operation of impedance and directional relays.

15.9.6 Relay Testing and Adjustment

The member shall be responsible to ensure that all relays and other protective devices are adjusted and working properly for the preparallel inspection. After completion of this test, the member shall notify OPALCO that the generating facility is ready for a parallel operation test and the OPALCO control center will schedule the test at a convenient time.

15.9.7 Parallel Operation Tests

The parallel operation tests consists of procedures to functionally test all protective equipment including: a) proper synchronizing with the OPALCO system, b) proper tripping of the interconnection and generator circuit breakers and c) testing the anti-islanding protection and d) proper shutdown after loss of power on the OPALCO system.

15.9.8 Commencement of Operation

The member shall not begin parallel operation of the generation facility until written permission is received from OPALCO.

15.10 OPERATING PROCEDURES

15.10.1 OPALCO Permission

The member shall obtain written permission from OPALCO to begin parallel operation of the generation facility and shall be familiar with the procedures and conditions of parallel operation with OPALCO.

15.10.2 Equipment Maintenance

The member is responsible for the maintenance of the generator and control and protective equipment. The member shall maintain records of all maintenance activities that OPALCO may review upon request.

15.10.3 Operation Log

A log of generator operations shall be kept that OPALCO may review upon request. The log shall include date, generator time on, generator time off, generator output and unusual events.

15.10.4 Communications with OPALCO

The member shall maintain telephone communications with the OPALCO control center and shall provide a 24 hour per day access phone number.

The member shall notify the OPALCO control center prior to paralleling or separating from the OPALCO system. For unexpected separations, the member shall inform the OPALCO control center of the nature of the problem and any relay operations that have occurred. Also, the member shall report any unusual operating conditions that affect the output, reliability or safety of the generation facility.

15.10.5 Automatic Reparalleling of Generator

For unattended facilities, automatic reparalleling must be accomplished in less than 5 minutes after the initial trip. If the reparallel attempt was unsuccessful, the equipment shall lock out and no subsequent reparallel attempt shall be made without permission from the OPALCO control center.

15.10.6 Event Recorder

All unattended generation facilities greater than 500 kVA shall have an event recorder that will give OPALCO the ability to make an after-the-fact determination of the status of the facility. The event recorder shall provide the targets of the relay that caused the generator to separate and the time of all paralleling and separations.

15.10.7 Operating Reports

Unattended facilities greater than 1000 kVA shall provide daily operating reports of delivered energy and power to OPALCO via telemetry.

15.11 INTERCONNECTION ONE LINE DIAGRAMS

Figure 11.0 IEEE Protective Device Numbers (Typical protective device numbers per ANSI C37.2)

4	Master Contactor	51V	Voltage Restrained/Controlled Time
25	Synchronism Check		Phase Over-current
25A	Automatic Synchronizer	52	Circuit Breaker
27	Under-voltage	59	Over-voltage
32	Directional Power	59N	Residual Over-voltage (Ground Fault Detection)
40	Loss of Field Detection	79	Reclosing Relay
46	Phase Balance Current	81O	Over-frequency
47	Voltage Phase Sequence	81U	Under-frequency
50	Instantaneous Overcurrent	86	Lockout
51	Phase Time Over-current	87	Current Differential
51G	Ground Time Over-current		
51N	Neutral Time Over-current		

Figure 11.1 Type 1 Grid Interactive or Induction machine with customer load 200-500 kVA installed capacity at secondary voltages

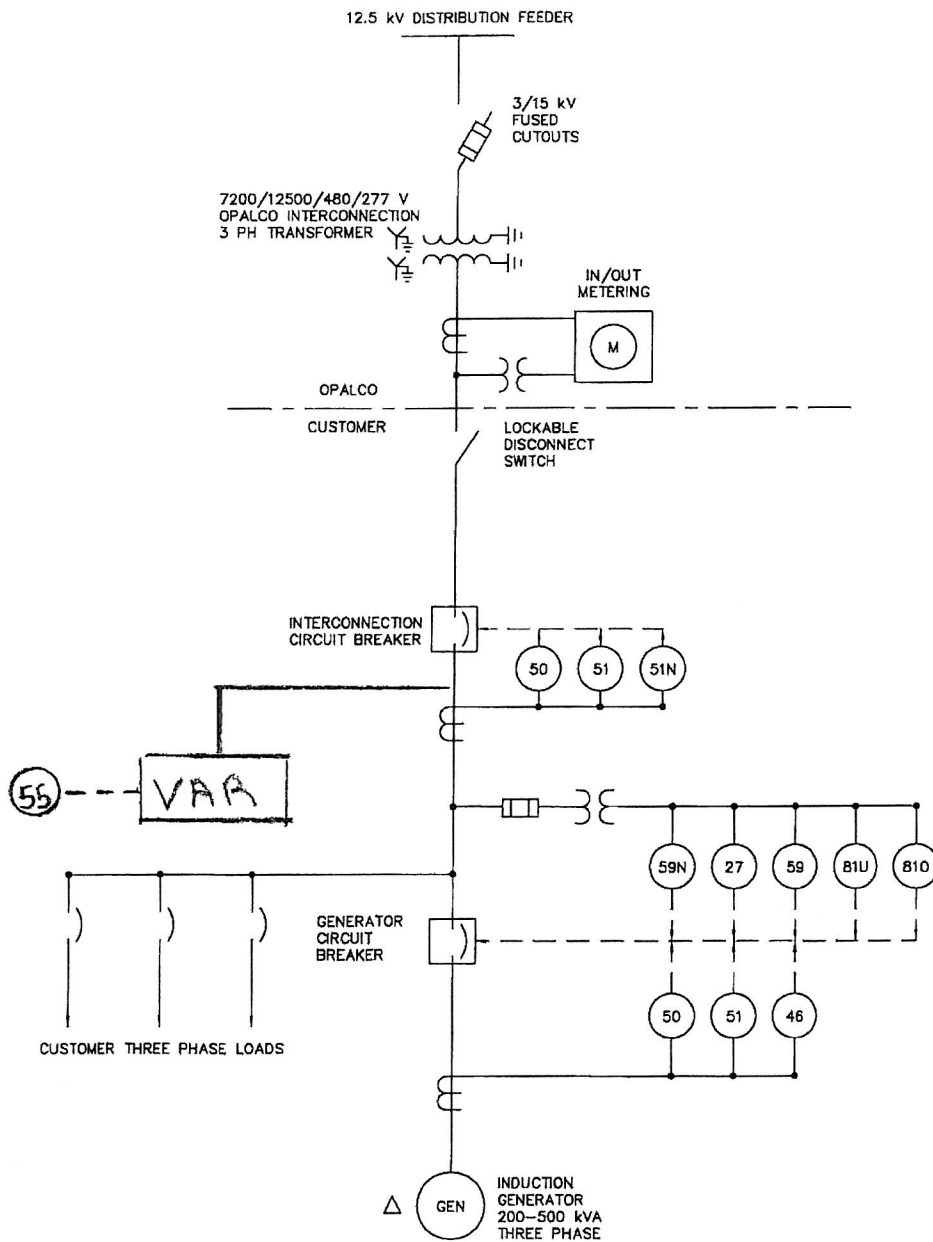


Figure 11.2 Type 1 Synchronous machine with customer load 200-500 kVA installed capacity at secondary voltages

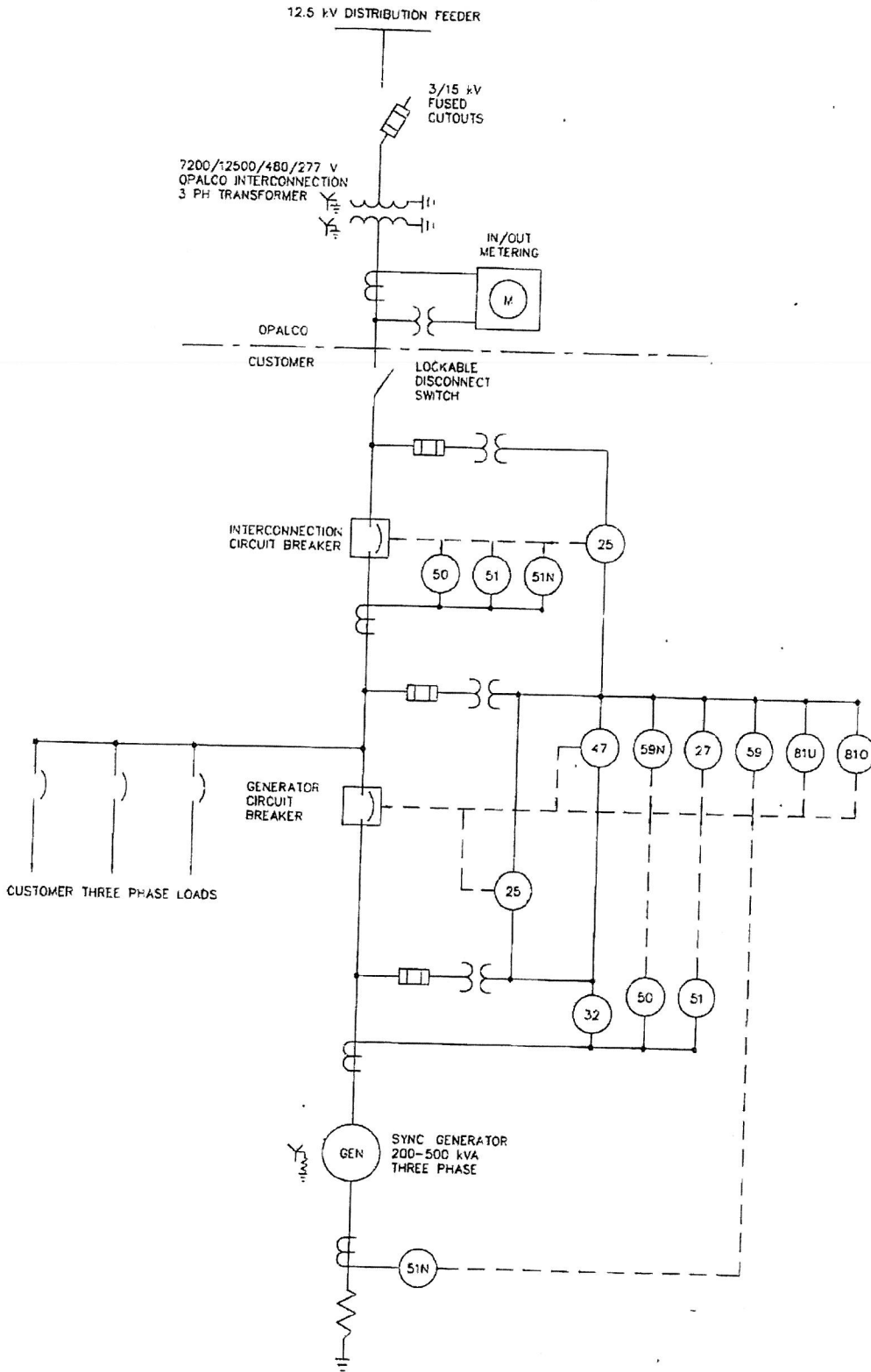
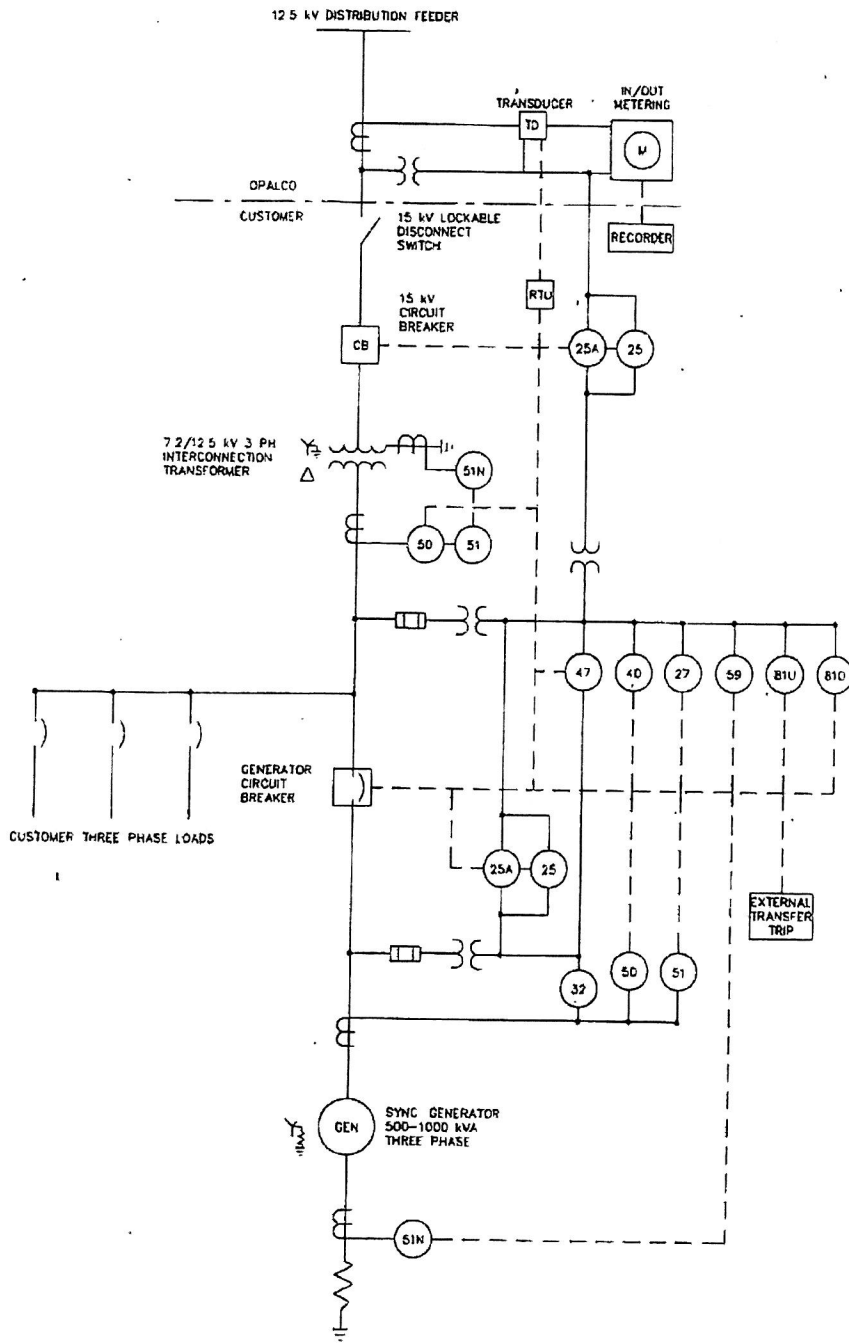


Figure 11.3 Type 2 Synchronous machine with customer load 500-1000 kVA installed capacity at distribution voltages



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