

APPENDIX F

Process for Connecting an Embedded Generator

**APPENDIX F -
PROCESS FOR CONNECTING AN EMBEDDED GENERATOR**

F.1 SUMMARY OF POTENTIAL CONTRACTS

Contract Name	Parties	Purpose
Construction Agreement	Distributor, Generator	Describes obligations of distributor and embedded generator to complete connection, including terms of cost recovery.
Construction Agreement	Distributor, Transmitter	In the event a transmission system requires modifications to connect embedded generator, this document describes the obligations of distributor and transmitter to complete connection, including terms of cost recovery.
Customer Account Contract	Distributor, Transmitter	In event the embedded generator is a load customer of distributor, this document describes terms and applicable rates for firm and backup power, and conditions under which backup power is granted and revoked.
Connection Agreement	Distributor, Generator	Identifies language and procedures to be used for normal and emergency situations, installed protection equipment, ownership and operating control of equipment, expected levels of maintenance and testing by both parties, contact names and telephone numbers, definitions, and containing all necessary schematic diagrams for proper communication between the distributor and embedded generator.
Additional Operations Agreement (if required) ¹	Distributor, Transmitter	Modifications as necessary to existing Connection Agreement to include provisions for safe and effective operation in presence of embedded generator on distribution system.
Confidentiality Agreement	As required by Distributor, Generator, Transmitter	Maintain confidentiality of information exchange. Confidentiality requirements could be incorporated into other documents.

¹ Additional Operations Agreement(s) or Construction Agreement(s) may be required where other parties are affected by generation connection, e.g.: embedded distributors.

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F.2 PROTECTION REQUIREMENTS GUIDE

1 Disclaimer

This guide is not intended to take the place of design and review of a proposed embedded generation installation by a competent person. Such design and review should include consideration of proposed power and protective equipment, and local conditions, including existing and future equipment, loading, and operating conditions. The requirements shall be included in the Connection Agreement.

2 Introduction

This guide outlines typical protection requirements for connecting an embedded generator to a distributor system to ensure safe and reliable distribution system operation. The guide focuses on protections required to detect and isolate the embedded generator from the distributor system when faults/disturbances occur on the distribution system, to protect the distribution system and other users of the distribution system. The embedded generator should consider these typical requirements when preparing the proposed protection package for a distributor's review. Normally, the protection features are required by the distributor at the interface point. However, some protection features may be included in the generator protection package.

The embedded generator should provide protection systems to cover the following conditions:

- (1) Internal faults to provide adequate protections to detect and isolate generator and station faults (details are not covered in this guide).
- (2) External faults such as distribution system or interconnected transmission system phase faults/ground faults.
- (3) Islanding/Abnormal Conditions.
- (4) Additional Protection Features, such as Remote Trip and Generator end open signal, may be required in some applications.

This guide addresses protections requirements associated with items 2, 3 and 4.

3 External Faults

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The protection system should be designed to provide full feeder coverage complete with a reliable DC supply. In some cases redundancy in protection schemes may be required.

Normally the following fault detection devices are required for synchronous generator(s) installation(s). For protection of induction generator, see section 4.1 in this document.

3.1 Ground Faults

When the HV winding of the embedded generator station transformer is wye connected with the neutral solidly grounded, then ground overcurrent (64) protection in the neutral is required to detect ground faults.

If the Embedded generator station transformer HV winding connected to the Distributor system is ungrounded wye or delta, then ground undervoltage 64-27 and ground overvoltage 64-59 protections are required to detect ground faults.

Depending on the size, type of generator and point of connection, a distributor may require the relaying system to be duplicated, complete with separate auxiliary trip relays and separately fused DC supplies to ensure reliable protection operation and successful isolation of the embedded generator.

3.2 Phase Faults

To detect phase faults, at least one of the following protections should be installed with acceptable redundancy where required depending on fault values:

- C Distance (21)
- C Phase directional overcurrent (67)
- C Voltage-restrained overcurrent (51V)
- C Overcurrent (51)
- C Undervoltage (27)

Example:

To provide reliable phase fault protection and successful isolation of fault current from the embedded generator station 21 feature (set to cover 125 percent of the longest connected feeder) timed at (1.0 s) will normally be acceptable together with generator voltage/frequency protections as back-up.

4 Islanding/Abnormal Condition

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Voltage and frequency protections are required to separate the embedded generator from the distribution system for an islanded condition and thus maintain the quality of supply to distribution system customers. This also will enable speedy restoration of the distribution system.

Typically, the protections required to detect islanding/abnormal conditions are:

- C Overvoltage (59)
- C Undervoltage (27)
- C Overfrequency (81O)
- C Underfrequency (81U)
- C Voltage balance (60)

The above protections should be timed to allow them to ride through minor disturbances.

4.1 Induction Generator

Due to the operating characteristics of the induction generator the protection package required is normally less complex than the synchronous generator. An embedded generator should design the protection scheme to trip for the same conditions as stated for synchronous generators.

An induction generator is an asynchronous machine that requires an external source such as a healthy distribution system to produce normal 60 hz power. Alternatively, if there is an outage in the distribution system then there is unlikely to be 60 hz output from the induction generator. In certain instances, an induction generator may continue to generate electric power after the source is removed. This phenomenon, known as self excitation, can occur whenever there is sufficient capacitance in parallel with the induction generator to provide the necessary excitation and when the connected load has certain resistive characteristics.

5 DC Remote Tripping/Transfer Tripping Between Embedded Generator and Feeder Circuit Breaker

Remote or transfer tripping may be required between the embedded generator and the feeder circuit breaker because the embedded generator is connected at a critical location in the distribution system. This feature will provide for isolation of the embedded generator when certain faults or system disturbances are detected at the feeder circuit breaker location. The use of this feature may be restricted by physical limitations or economics.

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NOTES:

1. The Embedded generator is responsible for providing suitable embedded generator equipment to protect his plant and equipment for any conditions on the distributor and interconnected transmission systems such as reclosing, faults and voltage unbalance.
2. To incorporate the connection of embedded generator to the distribution system, the line/feeder protection including settings and breaker reclosing circuits must be reviewed and modified if necessary by the distributor or transmission authority. This process may be complex and may require significant time.
3. The embedded generator must submit a proposed single line diagram and protections for review to the distributor contact as identified by the distributor.
4. Based on the transformer connection proposed by embedded generator additional significant protection cost may be incurred (e.g. delta HV transformer winding may require 3 phase HV breaker/recloser device). The embedded generator should not order the protection equipment and transformer until the station line diagram is reviewed and accepted by the distributor.

The purpose of the distributor review is to establish that the embedded generator electrical interface design meets the distributor requirements.

5. The protection schemes should incorporate adequate facilities for testing/maintenance.
6. Negative phase sequence (46) protection may be desirable for some applications to detect abnormal system condition as well as to protect the generator.
7. The embedded generator may be required to install utility grade relays for those protections which could affect the distributor or transmission authority system.
8. The embedded generator may be required to submit a Ground Potential Rise study for review by the distributor, if telecommunications circuits are specified for remote transfer trip protection.