MUSCLE SHOALS ELECTRIC BOARD

REQUIREMENTS FOR DISTRIBUTED GENERATION CONNECTION

SECTION 1. INTRODUCTION

1.0. General Purpose

This document defines the technical requirements for connecting distributed generation to MSEB's electrical distribution or transmission system. The requirements established in this document are intended to assure that facilities connected to the distribution or transmission grid do not have an adverse effect on reliability of service to other consumers and to assure that public safety as well as the safety of persons working on the distribution system is maintained.

It is recognized that while this document does provide guidance to the technical issues that must be considered, it is not, and it should not be considered, a comprehensive identification of all such technical issues, as specific projects present their own issues and must be reviewed on an individual basis. This document is not, and should not be considered a design specification manual. All final designs are subject to the approval of MSEB.

1.1. Application of this Document

The requirements set forth in this guide apply to parties, herein called the Project Participant, desiring to connect generation to MSEB's distribution or transmission system.

SECTION 2. INTERCONNECTION STUDIES AND PARTICIPANT RESPONSIBILITIES

2.0. General

Distributed generation that meets all requirements listed in this document will be subject to engineering studies prior to installation. Engineering studies often must be performed to determine the specific requirements for an individual project. A number of factors determine if a study is required, including the size, type, and design of the distributed generation being installed, the planned method of operation, location of the planned site on the distribution or transmission system, and loading on the distribution or transmission system.

Isolated Generation

Generally, no studies will be required for distributed generation isolated from the distribution or transmission system, i.e., distributed generation that will not operate in parallel with MSEB's distribution system. MSEB shall, in is sole discretion, determine whether a distributed generator is isolated from MSEB's distribution or transmission system.

Paralleled Generation

Generally, no studies will be required for distributed generation with a capacity of 10kW or less.

A System Impact Study will be required for all generation with a capacity greater than 10kW. If the System Impact Study shows that upgrades/modifications to the distribution or transmission system are needed, a Facilities Study will be required.

Study fees vary based on the type of study. The Project Participant is responsible for the cost of all studies.

2.1. Project Participant Responsibilities

It is the responsibility of the Project Participant to obtain all necessary data related to his generator and associated equipment as identified on the application and study forms. Studies cannot commence until the Project Participant provides complete technical data.

SECTION 3. GENERAL CONNECTION REQUIREMENTS

3.0. General

The facilities must meet all applicable safety and code standards as required by federal, state and local agencies. Additionally, the connecting facility must comply with IEEE 1547, as well as all applicable standards from North American Electric Reliability Corporation (NERC) and other applicable authorities.

All cost associated with the required equipment shall be borne by the Project Participant. Specific requirements are identified in the required studies.

3.1. Point of Common Coupling

The Point of Common Coupling (PCC) is defined as the location where the distributed generation equipment and MSEB's distribution or transmission system are electrically interconnected. The requirements defined in the document must be met at the PCC. It is at this point that all performance standards must be met.

3.2. Access and Documentation Requirements

The Project Participant agrees to maintain and provide any documentation that is required for reporting to governing agencies. The Project Participant agrees to provide access to facilities to the extent required for MSEB to comply with such agencies.

3.3. Grounding

The site of the PCC shall have a ground grid for the purpose of solidly grounding all metallic structures. This grid shall limit potential gradients that will ensure the safety of personnel and equipment during faulted conditions in and adjacent to the PCC.

3.4. Equipment Ratings and Requirements

Equipment installed at the PCC shall be suitable for the intended purpose and rated accordingly. Suitability shall be determined through consideration of a range of factors, including load flow, load interruption, and fault interruption.

3.5. Protection of Facilities (General)

Intertie protection will be required for generation that is operated in parallel to the distribution system. The protection requirements vary with the type, size, and mode of operation of the distributed generation. Specific requirements are addressed in greater detail elsewhere in this document.

The objective of the protection system is to provide protection to equipment through the isolation of parts of the system that are damaged or subjected to abnormal conditions. While protective systems cannot assure public safety, properly working protective systems enhance safety. It is, therefore, essential that protective systems are coordinated and functioning properly.

Relaying required to protect the generator(s) is the sole responsibility of the Project Participant. Existing protective relaying may provide some inherent protection of generation equipment, but it should not be relied upon to do so.

The protective schemes and the settings placed on those relays must coordinate with relaying on the distribution system. The application of protective relays and the settings placed on protective relays must allow disturbances to be cleared in a timely manner. Considering these factors, the selection of the protective relays and the settings applied to those devices are subject to the approval of MSEB. Likewise, MSEB will work with the Project Participant to coordinate protective relaying to allow the isolation of individual generator units rather than isolating the entire facility when it is appropriate to do so.

Temporary distribution system conditions may require the Project Participant to make temporary changes to settings applied to protective relays to assure coordination and to provide adequate protection. The Project Participant shall make these changes as necessary to assure system reliability.

3.6. Quality of Service (General)

The installation and operation of the distributed generation shall not cause the degradation of the quality of service provided to other consumers. Specific limits and requirements are identified in a separate section in this document. The Project Participant agrees to meet those requirements at the time of installation and to make modifications as necessary in the future to maintain those requirements.

Failure to meet and/or maintain these requirements may result in the facility being disconnected from MSEB's distribution or transmission system.

3.7. Future Changes

The Project Participant shall notify MSEB of planned changes to the facility that may affect the distribution system. Changes to the loading as well as changes to load characteristics may have an impact on the distribution system. Significant changes may require additional engineering studies to be performed.

Changes to the distribution system may require modifications to the Project Participant's facilities due to fault availability, stability, or other issues. The Project Participant shall make necessary

modifications to facilities and/or the manner in which the facility may operate. Such modifications shall be made at the Project Participant's expense.

Failure of the Project Participant to make required changes may result in the facility being disconnected from MSEB's distribution or transmission system.

SECTION 4. SPECIFIC CONNECTION REQUIREMENTS

4.0. General

Three types of generation are discussed in this section:

- Isolated
- Momentarily Paralleled
- Paralleled (Non Exporting & Exporting)

Specific issues relevant to each of these are addressed in this section.

4.1. Isolated Generation

Isolated generation is considered to be standby generation that is not operated in parallel to the distribution grid. As such, the generation is only utilized when the distribution system is disconnected from the facility. A "break before make" transfer switch shall be installed on the load-side of the meter. The transfer device must provide a means for visual inspection by distribution workers of the disconnect- transfer contacts without the use of tools to remove covers, etc.

4.2. Momentarily Paralleled Generation

Generation classified as momentarily paralleled is generation that supplies power while being connected to the distribution system for no more than 100 milliseconds. Unless specific conditions warrant use of special protection schemes, none will be required. However, the Project Participant is required to meet all power quality requirements defined in this guide (Power Quality Requirements). Furthermore, the Project Participant is responsible for all synchronization to the distribution system and for assuring that quality of service to other consumers is not adversely affected during the transition.

As with isolated generation, a transfer switch shall be installed on the load side of the meter. The transfer device must provide a means for visual inspection by distribution workers of the disconnect-transfer contacts without the use of tools to remove covers, etc.

4.3. Paralleled Generation

Generation that is operated in parallel to MSEB's distribution or transmission system is defined as generation that is supplying power while being connected to the distribution or transmission system for more than 100 milliseconds. Generation of this type may be exporting or non-exporting. By definition, exporting generation is generation that provides the load requirements of the Project Participant and has excess power to flow onto the distribution or transmission grid. Non-exporting

generation is defined as generation that can provide only the load of the Project Participant and does not result in power flowing onto the distribution or transmission system. Whether or not the facility is capable of exporting power greatly affects the specific requirements for connecting to the grid.

Topics related to the required protection are discussed in the following sections.

Isolation Switch

A switch shall be installed at the PCC for the purposes of isolation.

- This switch shall be capable of being locked in the closed and open positions.
- Switch position must be capable of being verified upon visual inspection without the use of tools to remove covers, etc.
- On three-phase systems, this switch shall normally be a gang-operated device.
- In the event that the Project Participant owns the device, MSEB shall be granted access for the purposes of locking open the device for the personal protection of employees.

Synchronization, Inadvertent Energizing, and Utility Reclosing

The distributed generation shall under no circumstance energize the PCC after it has been de-energized for any reason. Therefore, protective relaying and/or control schemes must be installed that will detect and prevent the Project Participant from closing onto a de-energized (dead) distribution line.

Synchronization of the generator to the distribution grid is the responsibility of the Project Participant. Synchronization is required to be automatic or manually supervised by a sync-check relay.

The following table shows the synchronization parameter limits for synchronous interconnection to the distribution grid as stated in IEEE 1547 when this document was written. Should IEEE 1547 be changed, the latest version of IEEE 1547 is applicable.

Generator KVA	Frequency Difference (Hz)	Voltage Difference	Phase Angle Difference
0 – 500	0.3	10%	20°
>500 - 1500	0.2	5%	15°
>1500 – 10,000	0.1	3%	10°

It is MSEB's practice to use automatic reclosing on distribution and transmission circuits. Therefore, it is imperative that the Project Participant remove all generation in the event that the line serving the facility become de- energized. Generation that is not removed from a de-energized line may be damaged, and it is exclusively the responsibility of the Project Participant to protect its distributed generation facilities from such damage. MSEB cannot and does not guarantee that connected equipment will not be damaged during reclosing actions, and disavows any responsibility should connected distributed generation equipment be so damaged. Therefore, it is recommended that the Project

Participant have an interlocking scheme in place to prevent the inadvertent energizing of the distributed generation facilities.

Intertie Protection Requirements

When generation is operated in parallel to the distribution or transmission system, intertie protective relaying will be required. The entire cost of the intertie protection shall be borne by the Project Participant. The intertie protection shall normally consist of the following:

- Anti-Islanding Protection
- Fault Current Protection (when required)
- Reverse Power (when non exporting)

Power Quality Requirements related to intertie protection shall be met at the PCC. The intertie protection will be set to meet those requirements unless the Project Participant can demonstrate that protective settings on individual generators allow the requirements to be met at the PCC. In those instances, the intertie protection may be set to coordinate as backup, allowing generation to be isolated without opening the intertie breaker.

Anti-Islanding

Distributed generation is not permitted to "island" the distribution or transmission grid. Islanding occurs when the distributed generation continues to energize part of the distribution or transmission grid even though power from MSEB is not present. An example of islanding is when a utility breaker that normally feeds radial loads is opened and the generator attempts to support those radial loads.

When the distributed generation is small compared to the load on the isolated section, the frequency and voltage will decay and the condition can be detected with voltage and frequency relays. Note: the aggregate capacity of all distributed generation on the isolated section must be considered.

If the aggregate distributed generation capacity is approximately equal to the load on the isolated section, then other relaying schemes (possibly including transfer trip schemes) may be required. Note: such schemes usually require communication equipment.

Fault Current

Additional fault protection, beyond the anti-islanding requirements, is required when the distributed generation is capable of supplying a significant amount of fault current to the utility grid - referred to as the "stiffness" of the generation. While each case must be reviewed on its own, the general rule of tMSEBmb for determining the need for this intertie protection is as follows:

- When the stiffness ratio is less than 10, the DG facility must have current-based phase protection and current or voltage-based ground protection.

  Stiffness Ratio=(SC KVA (distribution grid)+SC KVA (DG))/SC KVA (DG) Where: DG = distributed generation
  SC = short circuit

Note: In addition to fault current sensing relays, protective schemes may be required to protect the distribution or transmission system from adverse effects of neutral shifts caused by an unintended ground on an ungrounded transformer.

Reverse Power

Reverse power protection may be required at the intertie to prevent inadvertent power flow onto the distribution or transmission system.

SECTION 5. SCADA, METERING, AND COMMUNICATIONS

5.1. SCADA

Remote monitoring through SCADA is not normally required. However, monitoring may be required in certain instances. These instances are generally limited to locations where the distributed generation aggregated capacity is 250KW or more, or where the distributed generation penetration ratio is, in MSEB's judgment, significant.

All costs associated with SCADA monitoring of the distributed generation facilities shall be borne by the Project Participant.

5.2. Communication

Special communication systems are not required unless a SCADA system is installed or protective relaying schemes require communication between devices. The required communication equipment will depend upon location and existing infrastructure.

All costs associated with communications equipment required for the distributed generation facilities shall be borne by the Project Participant.

5.3. Metering

Bi-directional metering may be required if the power flow under normal conditions is two-way. The revenue metering shall be owned by MSEB and shall meet the current specifications of MSEB.

All costs associated with metering of the distributed generation facilities shall be borne by the Project Participant.

SECTION 6. POWER QUALITY AND DISTURBANCE CLEARING

6.0. General

The connection of a distributed generation facility shall not have an adverse effect on the distribution or transmission system or degrade the quality of service to existing customers. To assure that there are no such adverse effects, the following parameters are established related to performance. It is understood that these limits are to be met, and will be measured, at the PCC. Note: In instances where a dedicated substation is provided to serve the end user, it may be appropriate for these limits to be applied to the high voltage side of the substation transformer.

6.1. Voltage and Flicker

Normal voltage excursions (steady state) shall be limited to ± 5% at the PCC.

Voltage variations due to motor starting or other sudden load changes shall be limited based on the frequency of occurrence and shall conform to limits in IEEE 519-1992. Fluctuations that occur at a frequency of less than eight (8) per hour shall conform to the Irritation Curve (IEEE 519-1992 Maximum Permissible Voltage Fluctuation) but in no case shall fluctuations exceed 3%. Fluctuations that occur at a frequency greater than eight (8) per hour shall conform to the Visibility Curve (IEEE 519-1992 Maximum Permissible Voltage Fluctuation).

Voltages at the PCC shall be reasonably balanced and shall not exceed 1.5% unbalance. Voltage unbalance is defined by the maximum deviation from the average of the voltages.

The following table shows the required response to abnormal voltage conditions as stated in IEEE 1547 when this document was written. Should IEEE 1547 be changed, the latest version of IEEE 1547 is applicable.

Voltage Range Percentage of Base Voltage	Max Clearing Time (seconds)
50 V	0.16
50 V < 88 V	2.00
110 V < 120 V	1.00
120 V	0.16

Note: For Distributed Generation > 30 KW, the clearing time and setpoints shall be field adjustable. The default setting is given.

6.2. Harmonic Limits

The following table shows the acceptable harmonic limits as stated in IEEE 1547 when this document was written. Should IEEE 1547 be changed, the latest version of IEEE 1547 is applicable.

Maximum Harmonic Current Distortion in Percent of Current*

Individual Harmonic Order h (odd harmonics)	h < 11	11 < or=17	17 < or=23	23 < or=35	h > or=35	Total demand distortion (TDD)
Percent	4.0	2.0	1.5	0.6	0.3	5.00

Note: Even harmonics are limited to 25% of the odd harmonics shown above.

*** Current is defined as the greater of the maximum load current without the distributed generation, or the rated current capacity of the distributed generation.**

6.3 Frequency Disturbances

The following table shows the parameters within which the distributed generation shall cease to energize the utility grid as stated in IEEE 1547 when this document was written. Should IEEE 1547 be changed, the latest version of IEEE 1547 is applicable.

DG Size	Frequency Difference (Hz)	Clearing Time
<or = 30 kW	>60.5 <59.3	0.16 seconds
>30 kW	>60.5 Adjustable set points between 59.8 - 57.0	Adjustable from 0.16 to 300 seconds.
>30 kW	<57.0	0.16 seconds

Note: For Distributed Generation > 30 kW, the clearing time and set points shall be field adjustable. The default setting is given.

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SECTION 7. COMMISSIONING AND MAINTENANCE

7.0. General

Prior to connecting the distributed generation to the distribution grid, the facility must be properly commissioned to assure that all systems are functioning correctly. In addition, periodic maintenance must be performed to assure that the systems remain functioning properly.

7.1. Initial Testing and Inspection

The Project Participant may not connect the generation to the distribution grid until all testing has been completed and MSEB authorizes the connection in writing. The following commissioning testing must be successfully completed prior to energizing:

- Verification of functionality of protective relaying schemes.
- SCADA and metering verification.
- Synchronization scheme verification (and inadvertent energizing protection).
- Verification of interlocks used in protective schemes.

Qualified persons must perform all tests. MSEB reserves the right to witness or oversee any of the acceptance testing that may affect the reliability or performance of the distribution grid and to request the written results/reports of any of the commissioning tests.

7.2. Maintenance

The Project Participant shall be obligated to perform, or cause to be performed by qualified individuals, regular maintenance on the distributed generation facilities in manners consistent with industry practices.

MSEB reserves the right to oversee the maintenance performed on any distributed generation equipment that may have an adverse effect on MSEB's distribution or transmission system reliability or performance.

MSEB shall be notified when planned maintenance is scheduled. The Project Participant shall make available to MSEB maintenance records as needed to demonstrate compliance.

MSEB has the right to require the Project Participant to perform such actions as necessary to resolve power quality complaints that could be attributed to the facility.