Conditions Governing the Connection and Operation of Micro-generation

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Contents

1. Setting the Scene

1.1 About this document

This document sets out ESB Networks policy on the connection and operation of micro-generation.

1.2 Definitions

1.2.1 Micro-generation

For the purposes of this document, Micro-generation is defined as a source of electrical energy and all associated equipment, rated up to and including

- 25A at low voltage[230V], when the DSO network connection is single-phase
- 16A at low voltage [230/400V], when the DSO network connection is three-phase,

and designed to operate in parallel with the ESB Networks LV system.

Where multiple generating sources [of the same or varied technologies] are on the same site and share access to the same ESB Networks connection point, the aggregate rating must not exceed:

- 25A at low voltage, when the DSO network connection is single-phase
- 16A at low voltage, when the DSO network connection is three-phase.

This definition makes no explicit reference to any specific form of generating technology but the interface with the ESB Networks LV system must not be capable of connecting the generation source, to the ESB Networks LV system, if the ESB Networks grid supply is not present and within parameters given in Table 1 below. Any form of generation whose interface with the ESB Networks System does not comply with this provision, is considered outside the scope of this policy.

1.2.1 Cease Energise

No power is delivered from the generator to the ESB Networks. Where the interface comprises a bridge inverter on the ESB Grid side, the solid-state switching

devices are not triggered and remain in a high impedance state such that leakage current is less than 0.1mA @ LV.

2. Applicable Technical Standards

2.1 EN 50438

All installed Micro-Generators must comply with EN 50438 with the specific Irish protection Settings.

2.2 National Deviations

Table 1 below displays the specific Irish Settings as published in EN 50438

Parameter	Trip setting	Clearance time
Over voltage	230 V + 10 %	0,5 s
Under voltage	230 V – 10 %	0,5 s
Over frequency	50 Hz + 1 %	0,5 s
Under frequency	50 Hz - 4 %	0,5 s
An explicit Loss of Mains functionality must be included. Established methods such as, but not limited to, Rate of Change of Frequency, Vector Shift or Source Impedance Measurement may be used. Where Source Impedance is measured, this must be achieved by purely passive means. Any implementation which involves the injection of pulses onto the DSO network, shall not be permitted.		
ROCOF [where used]	0,4 Hz/s	0,5 s
Vector Shift [where used]	6 degrees	0,5 s

Table 1: Micro-generation Interface settings for Republic of Ireland

All type-testing must be carried out with these settings on board.

3. Common considerations

3.1 Metering

ESB Networks will provide Import/Export metering where required.

3.2 Applicable wiring standards

Appropriate ETCI Certification must be produced for each Micro-Generator installation.

3.3 Interface Protection

In accordance with EN 50438, each micro-generator shall have interface protection, as specified, which will include the following elements.

- Over Voltage
- Under Voltage
- Over Frequency
- Under Frequency
- Loss of Mains [LOM].

Settings shall be as specified in Table 1 above.

3.3.1 Cease energize / Disconnection

The interface protection shall cease energize ESB's network when any parameter exceeds the applied operating setting. Disconnection is required in case of any hardware malfunctioning.

3.3.1 Mechanical / solid state switching device

Cease energize in response to an interface protection operation shall be achieved either by the separation of mechanical contacts or by the operation of a suitably rated solid state switching device. Where a solid state switching device is used the micro generator shall monitor the proper functioning of the device. In the event the solid state switching device fails to interrupt the current, the micro-generator shall disconnect. The solid state switching device shall be specified in accordance with the over-voltage category of the micro-generator as specified by the manufacturer and have a leakage current in the off-state of not more than 0.1 mA

3.3.1 Accessibility of isolation switching devices

Under the HD 384 series there is a requirement that means shall be provided to enable a generator set to be isolated from the public supply and the means of isolation shall be accessible to the ESB Networks at all times. However it is recognized that micro-generators are a special case by virtue of their type testing and potentially large numbers, therefore it is acceptable to dispense with the isolator to be accessible at all times, subject to the provision of two means of automatic disconnection, with a single control. At least one of the means of disconnection must be afforded by the separation of mechanical contacts.

3.3.1 Place of the interface protection

The interface protection can either be incorporated within the micro-generator or afforded by separate devices. In either case the interface protection shall meet the relevant standards and the manufacturer of the micro-generator shall declare that the combined devices fulfil these requirements.

3.3.1 Changing settings of the interface protection

The interface protection settings may only be altered, from those in place at the time of commissioning, with the written agreement of ESB Networks and then only in accordance with the manufacturer instructions. It shall not be permissible for the user to alter the interface protection settings.
Note: Alteration of the settings of the interface protection may cause a breach of the type-certificate making re-testing necessary unless the micro-generator is type-tested on the full setting range of the interface protection.

3.3.1 Loss of Mains (LoM) protection

LoM protection shall use rate of change of frequency or vector shift methods. The trip setting shall ensure cease energizing within the prescribed clearance time irrespective of where, on ESB's network the interruption takes place. This requirement is deemed to be satisfied by passing the test in Section 6.4. Operation of LoM interface protection at any given site shall not in and of itself, disturb or cause spurious operation of LoM interface protection at any other site.

3.3.1 Automatic reconnection after a network outage

The interface protection shall ensure that feeding power to the ESB's network will only commence, after the voltage and frequency on the ESB's network, have been within the limits of the interface protection settings for a minimum of
– 3 min for mechanical ac generation;
– 20 s for inverter based systems.
In order to facilitate such automatic reconnection power input to the interface protection equipment and sensing connections to the interface protection shall be made on the ESB Networks side of the disconnector (but on the micro-generator

side of the isolator) that is initiated by the interface micro-generator protection. Manufacturers should give consideration to limiting the number of attempted reconnections within any one period of time.

3.3.1 Synchronisation

The operation of synchronising a micro-generator with the DSO's network shall be fully automatic i.e. it shall not be possible to manually close the switch between the two systems to carry out synchronisation.

3.4 Type testing and certification for Interface protection

Because of the logistics and numbers involved, it would be impractical and against the spirit and intent of EN 50438, that the existing practice of on-site witnessing of the operational testing of interface protection, for every site, be applied to micro-generation.

Therefore reliance will be placed on a system of type testing and certification, to be operated as outlined below. Every

new micro-generator interface type and model, shall satisfy the following conditions:

- Operational tests to verify the operation of all elements of interface protection, as prescribed in Section 2.1 of this document, shall be carried out.
- During the type-tests, interface protection settings on board shall be as contained in Table 1 below.
- The methodology of these tests shall be carried out as outlined in Appendix A of this document.
- These tests shall be carried out by or under the supervision of a recognised test laboratory.
- Upon successful completion, certification of these tests, shall be supplied to ESB Networks. A copy of the type-test certificates, should also be supplied by the micro-generator suppliers, to each customer. A suggested form indicating the information required, is given in Appendix B of this document.

See Section 4.2 below.

3.5 Safety of ESB Networks personnel

Reliance is placed upon the robustness of existing internal safety rules and procedures, to safeguard and protect against any electrical hazard being presented to persons working on or in close proximity to ESB networks.

3.6 Labelling

Where an item of equipment contains live parts connected to more than one source of supply, a warning notice shall be fitted in such a position that any person gaining access to live parts will be warned in advance of the need to isolate those parts from the various supplies unless an interlocking arrangement is provided to ensure that all circuits concerned are isolated.
Special attention should be paid to the power supply, measuring circuits [sense lines] and other parts, may not be isolated from the grid when the switching device[s] associated with the interface are open.
As a minimum, warning notices should be placed

- At the ESB Networks metering position of a location where a micro-generator is installed
- At the consumer unit position of a location where a micro-generator is installed
- On all switchboards between the consumer unit and the micro-generator itself
- At all points of isolation for the micro-generator

A suggested format is given in Figure 1 below.

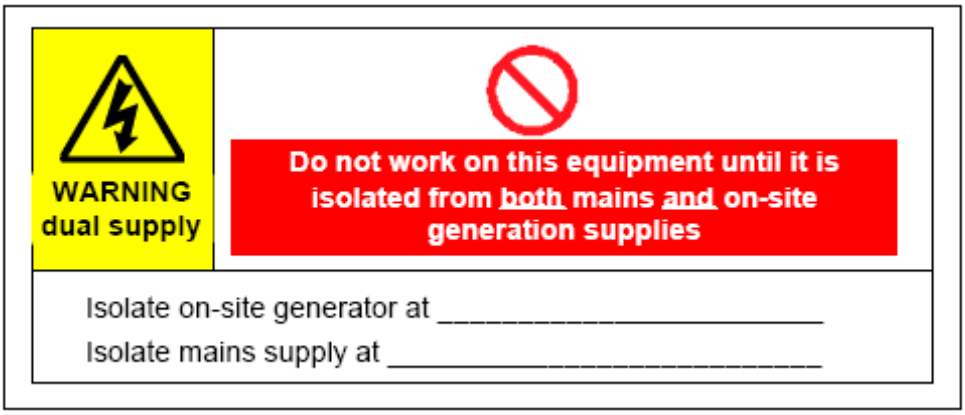


Figure 1

4. Sporadic once-off installations

4.1 Definition

In a great many cases, the installation of a micro-generator, will arise sporadically in locations or households. Alternatively, there may be sporadic take-up in an area, due to an advertising campaign for micro-generation.
A sporadic once-off installation is defined as follows:

- Only one customer is involved
- Only one installation is involved
- Where multiple customers on the same site or housing scheme are involved, and the penetration level achieved is less than that prescribed in 5.1 below.

4.2 Implementation of Inform and Fit principle

For sporadic once-off installations in existing premises, as defined above, the customer shall complete the Micro-Generation Installation Notification Form, see the following link (Application Form NC6). This should be sent to Generator Applications, ESB Networks, P.O. Box 29, Garrycastle, Athlone, Co. Westmeath. Type-test certification for the interface[s] associated with the micro-generator[s] in question should also accompany this notification.

If type-test certificates for the interface associated with the micro-generator[s] in question has not been received by ESB Networks then ESB Networks will formally request such type test certification from the customer and direct that the installation should not proceed until such certification is furnished.

At this early stage in the development of this form of embedded generation, ESB Networks will initially pay close attention to type-test certification received, particularly for an interface model or type where type-test certification has not previously been received. Given that on most micro-generation interface devices, the protection element settings are not accessible to the user, the type-test certification will form the only visible validation available to ESB Networks that the settings applied are those specified in Table 1.

If ESB Networks determines that for a given type-test certificate, further clarification or information is required, then ESB Networks shall:

- Instruct the customer within 20 working days from receipt of the type-test certification, to refrain from installation or suspend installation and commissioning if already begun.
- Contact the suppliers or test laboratory as appropriate.

Upon satisfactory resolution of the issue, ESB Networks will notify any customers concerned and advise that installation may proceed.

If ESB Networks become aware of any other technical or location specific reason why installation should not proceed, then ESB Networks shall inform the customer within 20 working days of receipt of the notification.

If no such notice, or request for type test certification, or instruction to suspend installation, is received by the customer within this time-frame, then the installation can proceed without any further correspondence with ESB Networks.

5. Planned multiple installations

5.1 Definition

This section applies to planned [green field] multiple installations such as new housing schemes, where it is planned to have micro-generation installed in every house or premises.

It shall also apply to existing housing schemes, where a successful advertising and promotional campaign, has resulted in a take-up by householders, to the extent that a penetration level, in terms of total installed micro-generation capacity [kVA], will reach 40% of the capacity in kVA of the existing MV/LV substation that supplies the estate or scheme.

5.2 Application process

For new connections, application for connection will be made in the normal way but the intention to install micro-generation, shall be flagged by the applicant in the application form.

Thereafter, apart from the type certification issues referred to above, the application will be processed in accordance with existing procedures.

Planned installation with a total capacity of 50kVA or greater, shall be referred to Network Investments in Asset Management, for more refined network studies.

5.3 Network sizing considerations

No allowance for import reduction will be taken into consideration in the determination of the sizing of network components. All designs will be based upon the MIC stated in the application.

6. Appendix A: Type Testing of Interface Protection

6.1 General

The tests will verify that the operation of the micro-generator grid interface protection shall result in the cessation of energizing the ESB network when the network parameters are exceeded or Loss of Mains event occurs.

Wherever possible the type verification testing of a particular micro-generator should be proved under normal conditions of operation for that technology (unless otherwise noted). This will require that the chosen micro-generator Interface Protection is either already incorporated into the system controls or the discrete device is connected to the micro-generator for the LoM protection test. Testing the voltage and frequency functions may be carried out either on the discrete protection device independently or on the micro-generator unit complete. In either case it will be necessary to verify that a protection operation will cease energize the ESB network.

The manufacturer must declare the ambient operating temperature range of the micro-generator and verify where appropriate that the interface protection control system operates satisfactory throughout this temperature range.

6.2 Under-Over voltage

The operation of the micro-generator under/over voltage protection can be verified either under normal operating conditions (i.e. tripping the generator) or independently of the generator if suitable test attachments are provided. Operation of the under/over voltage protection will be demonstrated for each of the voltage ranges defined in Section 2.2. For each trip setting (upper and lower) the operation of the protection within the specified clearance time shall be demonstrated for an increase or decrease of voltage within 2.3 V around the trip setting. In either case it will be necessary to verify that a protection operation will cease energize the ESB network The test voltages shall be 230 V plus and minus n times 1 % of the nominal voltage for a duration that is longer than the trip time delay, for example 2 s in the case of a delay setting of 1.5 s. It will be necessary to carry out five tests for each trip setting, the longest trip time is to be recorded as the certificated trip time.

6.3 Under-Over frequency

The operation of the micro-generator under/over frequency protection can be verified either under normal operating conditions (i.e. tripping the generator) or independently of the generator if suitable test attachments are provided. In either case it will be necessary to verify that a protection operation will cease energize the ESB network. Operation of the under/over frequency protection will be

demonstrated for an increase or decrease of frequency within ± 0,5 % of the trip settings (e.g. for an over frequency setting of 50,5 Hz the permissible operating range is (50.5 ± 0.2525) Hz. The test frequency shall be applied in steps of 0,5 % of setting for a duration that is longer than the clearance time delay, for example 1 s in the case of a delay setting of 0,5 s. For both the upper and lower limits, the time to trip from the point at which the frequency reaches the limit will be recorded for five separate tests and the longest trip time recorded as the declared trip time.
It should not be necessary to disable LoM protection as the approach rates are deliberately specified to be less than the LoM trip settings.
The highest deviations from the frequency settings are to be recorded as the certificated trip settings.

6.4 Loss of Mains [LoM]

In case of loss of supply from the DSOs network, the LoM protection shall ensure that the microgenerator ceases energize the DSOs network until all DSO protection operations have cleared and normal network supplies have been restored.

Examples of micro-generator protection systems suitable for LoM detection and protection include but are not limited to existing accepted techniques such as Rate of Change of Frequency (ROCOF) and Vector Shift. Irrespective of which protection system is used, protection settings shall be applied that ensure cessation of energy supply within 0.5 s for a change in load at the micro-generator appliance terminals in excess of ± 25 % of maximum rated power.

To model the interaction between local load and multiple parallel connected micro-generator units the micro-generator unit under test shall be connected to a network combining two identical microgenerator units and a variable load; the value of the load should have a power factor of 0.95 lagging. See Figure1. To facilitate the test for LoM there shall be a switch (S) placed between the test load and micro-generator combination and the ESB network, as shown below:

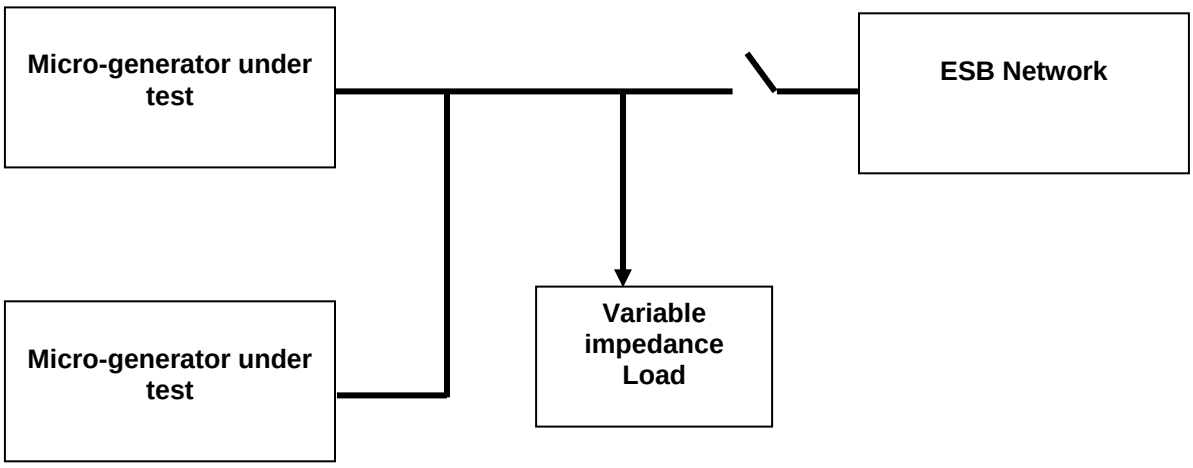


Figure 1: LOM Test Arrangement

The purpose of the test is to demonstrate the LoM protection equipment is able to recognize a change in load condition associated with a LoM event and to cease energizing within the required time.

The micro-generator equipment should be started in the usual manner and operated until steady state conditions have been achieved. If the micro-generator equipment is designed to operate at different power levels i.e. a modulating design then the micro-generator equipment is to be tested at three levels of output power: minimum load, maximum load and at a point midway between the two. If the micro-generator equipment is designed to operate at one output power level then only the maximum load test is carried out.

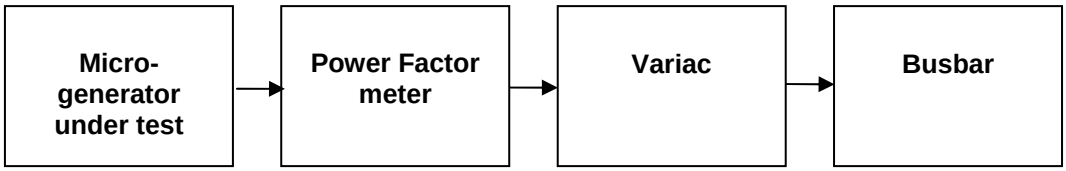
Each test is to be repeated five times. The micro-generator and the supporting micro-generator on the test shall be of a similar type and size. The LoM protection of each unit shall be enabled and the units to be expected to load share during the test.

For positive load change the variable impedance load is set at 125 % (± 1 %) of load match of the above power levels. For negative load change the variable impedance load is set at 75 % (± 1 %) of load match of the above power levels. Load match conditions are defined as being when the power from the micro-generator appliance connected generator meets the requirements of the test load i.e. there is no appreciable export or import of power to or from the ESB distribution system.

The tests will record the micro-generator output voltage and frequency from at least 2 cycles before the switch is opened. The time from the test switch opening until cease energizing occurs is to be measured and must comply with the requirements of Appendix A, under all conditions of output power.

6.5 Power Factor

For this test, the micro-generator supplies full load at steady state conditions to a busbar lower or equal to the reference impedance in IEC 60725 via the power factor (pf) meter and a Variac of rating equal to or greater than the micro-generator as shown below. The micro-generator pf should be in the range 0,95 lagging and 0,95 leading inclusive, for three test voltages 230 V – 8 %, 230 V and 230 V + 8 %. The test circuit is shown below:



6.6 Verification of disconnection in the event of failure of solid-state switching device.

Where cease energise in response to interface protection is achieved by the operation of a suitably rated solid-state switching device, clause 4.2.1.3 stipulates that disconnection shall be achieved in the event that the solid-state switching device fails to interrupt current if called upon to do so. The achievement of disconnection in such circumstances should be verified by the deliberate simulation of a static 1 failure mode, on the solid-state devices while housed in the interface. This should be explicitly recorded on the type-test certificate.

If the intended means of disconnection for the micro-generator is not an integral part of the interface unit, then as per clause C.1, any discrete separate devices which comprise the intended means of disconnection in such circumstances should be submitted for compliance testing and connected in series with the micro-generator and interface during the test.

6.7 Verification of leakage current of solid-state switching devices on off state.

Where cease energise in response to interface protection is achieved by the operation of a suitably rated solid-state switching device, clause 4.2.1.3 stipulates that such devices shall have a leakage current of not more than 0.1mA in the off state. The leakage current of these devices should be measured as part of the type test. The measurement should take place with the interface energised at rated voltage and the devices in question, housed in their normal position. The measured value of leakage current should be recorded on the type test certificate.

7. Appendix B: Type Certification Test Result Sheet

Micro-generator details

MICRO-GENERATOR Type reference		
Maximum continuous rating		
Manufacturer	Tel	Address
	Fax	
Technical file reference No.		

Test house or laboratory details

Name and address of test house or laboratory	
Telephone number	
Facsimile number	
E-mail address	

Test details

Date of test	
Name of test Engineer	
Signature of test Engineer	
Test location if different from above	

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Power quality

Harmonic current emission								
	Maximum permissible harmonic current as per EN 61000-3-2 Class A							
Harmonic	2nd	3rd	5th	7th	9th	11th	13th	15th = n = 39th
Limit	1,08	2,3	1,14	0,77	0,4	0,33	0,21	0,15 [a] (15/n)
Test value								
[a] 50 % or some other declared value close to the mid point between minimum and maximum.								

Voltage fluctuations and flicker				
	Maximum permissible voltage fluctuation (expressed as a percentage of nominal voltage at 100 % power) and flicker as per EN 61000-3-3			
	Starting	Stopping	Running	
Limit	3,3 %	3,3 %	P_{st}= 1,0	P_{lt}= 0,65
Test value				

	DC injection			**Power factor**		
Protection limit	20 mA, tested at three power levels			+ 0,95 – 0,95 at three voltage levels		
	Min.	Medium [a]	Max.	210 V	230 V	250 V
Test value						
[a] 50 % or some other declared value close to the mid point between minimum and maximum.						

	Under frequency		Over frequency	
Parameter	Frequency [Hz]	Time [s]	Frequency [Hz]	Time [s]
Protection limit (from table 1)				
Actual setting (as applied to interface protection)				
Trip value (test result)				

Under / Over voltage tests (single stage protection)

	Under voltage		Over voltage	
Parameter	Voltage [V]	Time [s]	Voltage [V]	Time [s]
Protection limit (from table 1)				
Actual setting (as applied to interface protection)				
Trip value (test result)				

LoM test

Method used			
Output power level [a]	Min.	Medium	Max.
Trip setting clearance time			
Trip value clearance time			

[a] Indicative values are shown for minimum, medium and maximum power levels.

Fault level contribution

Short-circuit current at micro-generator terminals
Short-circuit applied to micro-generator at normal running condition 0 – 2,0 s plot

Parameter	**Symbol**	**Value 1**	**Value 2**	**Value 3**	**Value 4**	**Value 5**
Peak short-circuit current	i_p					
Initial value of aperiodic component	A					
Initial symmetrical short-circuit current	I_k					
Decaying (aperiodic) component of short -circuit current	i_{DC}					
Reactance/Resistance ratio of source	X/R					

Signed_____ Position/Title_____

Date_____