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DRAFT TANZANIA STANDARD
(Draft for comments only)

Mini-Grid Systems –

Part 2: Application of Inverters

TANZANIA BUREAU OF STANDARDS

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0 Foreword

This Draft Tanzania Standard specifies minimum technical requirements for the design, manufacture, test and supply of Inverters and their application to mini-grid systems used in decentralized rural electrification for providing safe energy services to consumers . Modern mini-grids may consist of multiple distributed generators, including conventional engine-generators, photovoltaic arrays, wind turbines and energy storage systems.

This Draft Tanzania Standard is part of an integrated set of specifications and standards issued to govern design and construction of mini-grid power systems in Tanzania. The mini-grid standards have been developed to support improved residential, commercial and public services for rural communities in Tanzania. These mini-grid energy systems, when properly designed, will support affordable and reliable energy supply for remote households, community services, commercial and economic activities including shops, workshops, micro-industry, fresh water pumping, secondary schools, health services, public lighting, places of worship or cultural activities, agro-processing activities and other activities.

1 Scope

1.1 This standard covers power electronics (primarily inverters), which are used to connect distributed generation equipment (specifically photovoltaic arrays and battery systems) to mini-grid power systems. This standard primarily deals with safety in construction and operation, including anti-islanding.

1.2 This standard covers all standalone inverters, grid-interactive inverters and multi-mode inverters used in mini-grids ranges between 10 kW and 1MW of total generating capacity. It shall be noted that although the standard applies specifically to power electronics, it "touches on" issues with connected equipment, including wiring, fault protection, transformation and grounding.

1.3 This standard applies to all inverters used in mini-grid systems with total installed inverting capacity between 10 and 1,000kVA-ac. Inverters which are individually of less than 10kVA-ac capacity but are operated in parallel to achieve a total installed capacity equal to or greater than 10kVA-ac are considered to be covered by this standard.

1.4 This standard shall be read in conjunction with other relevant – Tanzania Standards, applicable standards and specifications to have uniformity, compatibility and standardization in the distribution system.

2 Normative references

For the purpose of this Tanzania standard, the following references shall apply:

IEC 62109-1: 2010 Safety of power converters for use in photovoltaic power systems - Part 1: General requirements

IEC 62109-2: 2011 Safety of power converters for use in photovoltaic power systems - Part 2: Particular requirements for inverters

IEC 62116: 2014 Utility-interconnected photovoltaic inverters - Test procedure of islanding prevention measures

IEC 61727: 2004 Photovoltaic (PV) systems - Characteristics of the utility interface in the event of conflict between these standards and this specification, this specification shall govern

3 Terms and definitions

For the purposes of this standard, the following terms and definitions shall apply

3.1 Islanding

Continued operation of part of a distribution grid after the primary grid/mini-grid has experienced failure.

3.2 Intentional Islanding

Intentional operation of an electrical island which has been isolated from the primary grid / mini-grid.

3.3 Unintentional Islanding

Continued unplanned and unintended operation of one or more distributed generation sources imparting energy to the primary grid after it has failed and is assumed to be un-energized.

3.4 Anti-Islanding

A function of a grid-interactive inverter which is designed to prevent the continued existence of an unintentional island.

3.5 Standalone inverter

An inverter which is not intended to be connected to a utility grid, or which forms the sole generator on a mini-grid. Also referred to as a “grid-forming” inverter.

3.6 Grid-interactive inverter

An inverter which is designed to synchronize to and exchange power with a utility grid containing additional generation sources. Also referred to as a “grid-following” inverter.

3.7 Multi-mode inverter

An inverter which may be connected to the grid at times but may also be capable of operating as a standalone inverter.

4 Quality Control

The standalone inverters, grid interactive inverters and multi-mode inverters used in mini-grids shall be fabricated in a plant that has an established and credible past record of production of similar equipment and that holds an ISO 9001 certification for quality management.

5 Environmental Conditions

Standalone inverters, grid interactive inverters and multi-mode inverters used in mini-grids shall be labeled for service under one of the following conditions (IEC 62109-1):

5.1 Outdoor

The equipment may be operated fully or partly exposed to direct rain, sun, wind, dust, fungus, ice, condensation, radiation to the cold night sky and to the full range of outdoor temperature and humidity. Wet location requirements apply.

5.2 Indoor, unconditioned

The equipment is fully covered by a building or enclosure to fully protect it from rain, sun, windblown dust, fungus, and radiation to the cold night sky, but the building or enclosure is not conditioned in terms of temperature, humidity or air filtration, and the equipment may experience condensation. If the equipment is not rated for wet location use, then the installation instructions shall specify that the installation location must be dry except for condensation.

5.3 Indoor, conditioned

The equipment is fully covered by a building or enclosure to fully protect it from rain, sun, windblown dust, fungus, and radiation to the cold night sky, and the building or enclosure is generally conditioned in terms of temperature, humidity and air filtration. Condensation is not expected. If the equipment is not rated for wet location use, then the installation instructions shall specify that the installation location must be dry, including no expected condensation.

5.4 Specific Requirements

The specific requirements necessary for meeting the environmental classifications shall be as follows:

Table 1 – Nominal values for anti-islanding protection

Rating	Environmental Conditions		
	Outdoor	Indoor, unconditioned	Indoor, conditioned
Pollution Degree	Min PD3	Min PD3	Min PD2
Wet Location	Yes	No	No
Ingress Protection	Min IP34	Min IP20	Min IP20
Ambient Service Temp	-20°C to +50 °C	-20°C to +50 °C	+0°C to +40 °C
Ambient Humidity Range	4% to 100% (Condensing)	5% to 95% Non-condensing	5% to 95% Non-condensing
UV Exposure	Required	Not required	Not required

6 Electrical System Parameters

System parameters of mini-grids for low voltage power distribution networks are as follows:

a) Nominal system low voltage (U): 230/400V (±10%)
b) Maximum permissible system low voltage (U_m): 253/440 V
c) Minimum permissible system low voltage: 215/374 V
d) System frequency: 50 Hz
e) Neutral grounding arrangement: multi-grounded
f) Single or three phase configurations: allowed

7 Requirements

7.1 Construction

Construction should follow IEC 62109 Parts 1 and 2 including:

a) Marking (section 5)
b) Environmental (section 6)
c) Protections against shock and electrical hazards (Section 7)
d) Protection against mechanical hazards (Section 8)
e) Protection against fire hazards (section 9)
f) Protection against sonic pressure hazards (Section 10)
g) Protection against liquid hazards (Section 11)
h) Chemical Hazards (Section 12)
i) General physical requirements (Section 13)
j) Components (Section 14)
k) Software and firmware performing safety functions

It shall be noted that although Section 14.8 addresses batteries, this is only for batteries that are a direct part of the power electronics equipment.

8 Tests

8.1 General Testing

8.1.1 Anti-islanding Testing

Testing of anti-islanding circuits shall be performed as specified in IEC 62116.

8.1.2 Anti-Islanding Set Points

The nominal values for anti-islanding protection are as follows:

Table 1 – Nominal values for anti-islanding protection

Parameter	Max. Clearance time*	Trip setting
Over voltage (level 2)	0,05s	230V +35% (311V)
Over voltage (level 1)	2,0s	230V +4,3% (240V)
Under voltage (level 1)	2,0s	230V -13% (200V)
Under voltage (level 2)	0,1s	230V -50% (115V)
Over frequency	0,1s	50Hz +2% (51,0Hz)
Under frequency	0,1s	50Hz -2% (49,0Hz)
Reconnection time	At least 120s	
Permanent DC-injection	0,5% of rated inverter output current	
Loss of main IEC 62116	Inverter shall detect and disconnect within 0,3s	

The trip setting values and clearance times shall be adjustable by a qualified user and may be relaxed up to the followi ng table to ensure proper operation on a mi ni - grid. If setti ngs are changed from the nominal, this must be documented and kept i n

a secure location near the i nverter and with other maintenance documents. (Ref Annex A)

Table 2 – Maximum permissible values for anti-islanding protection

Parameter	Max. Clearance time*	Trip setting
Over voltage (level 2)	0,2s	230V +35% (311V)
Over voltage (level 1)	5,0s	230V +4,3% (240V)
Under voltage (level 1)	30,0s	230V -13% (200V)
Under voltage (level 2)	1,0s	230V -50% (115V)
Over frequency	10,0s	50Hz +5% (52,5Hz)
Under frequency	10,0s	50Hz -10% (45,0Hz)
Reconnection time	At least 30s	
Permanent DC-injection	0,5% of rated inverter output current	
Loss of main IEC 62116	Inverter shall detect and disconnect within 0,3s	

It is recommended that mi ni-grid operators check for proper anti-islanding when the system is commissioned and whenever set-point values are changed or i nverter firmware is updated.

Annex A

(normative)

Inverter Anti-Islanding Set Point Form

System Description	*[insert sys description and location here]*	
Reason for test	*[commissioning, addition of generation, etc.]*	
Date of Test	*[insert date here]*	
Result of test	*[pass, fail, comments]*	
Parameter	***Max. clearance time****	***Trip setting***
Over voltage (level 2)	X s	230V Y% (XXX V)
Over voltage (level 1)	X s	230V +4,3% (XXX V)
Under voltage (level 1)	X s	230V -13% (XXX V)
Under voltage (level 2)	X s	230V -50% (XXX V)
Over frequency	X s	50Hz +X% (XXX Hz)
Under frequency	X s	50Hz -X% (XXX Hz)
Reconnection time	at least X s	
Permanent DC-injection	0,5% of rated inverter output current	
Loss of main IEC 62116	Inverter shall detect and disconnect within X s	