/ Perfect Welding / Solar Energy / Perfect Charging

ROOFTOP SOLAR PV DEVELOPMENT IN SRI LANKA

RECOMMENDATIONS

Version 10/2017

Business Unit Solar Energy / Systems Technology

TABLE OF CONTENTS

1 GENERAL SITUATION IN SRI LANKA

For Fronius International, the regulations for connecting PV-systems to the low-voltage and the medium-voltage grid are quite unclear in Sri Lanka. Next to individual regulations from utilities, a wide variety of documents exist that influence the assessment and connection of PV-systems to the grid. The following list shows the relevant documents, but it is not clear for Fronius International if this list is complete.

- The “Distribution Code” from the Public Utilities Commission of Sri Lanka (PUCSL)
- The “Manual for Interconnection of Micro Scale Renewable Energy Based Power Generating Facilities at Low Voltage Consumer Feeders of National Grid” from the Government of Sri Lanka (GOSL)
- The “Application for Net Metering of an On-Grid small scale Renewable Energy Facility” from the Lanka Energy Company Limited

The nominal grid voltage (230 V) and frequency (50 Hz) in Sri Lanka are similar to the European Grid and the Grids in Australia and India. All those countries require conformity with IEC standards when it comes to power quality and safety issues concerning PV-systems and especially PV-inverters. In Sri Lanka, conformity with IEEE standards is required. IEEE standards, for example IEEE 1547, are mainly written for applications in the US.
For grids with a nominal voltage of 230 V and a frequency of 50 Hz it is recommended to refer to the requirements of IEC standards, to ensure a sustainable development of the PV-market in Sri Lanka and to reach the governmental goals for the share of renewables in the electric energy sector.
This is also stated in the Distribution code, chapter 3.4.4 ***Equipment Standards***:

“All equipment used at the connection point, overhead lines, underground cables, substations and customer installations ***shall*** *conform to applicable statutory obligations and* ***comply with relevant IEC standards****.”*

The actual situation poses the risk that these goal cannot be reached, because actually manufacturers of inverters produce different products for the US market than for the rest of the world. Inverters, which are produced for the rest of the world, are normally not certified according to US standards.
If the combination of US-standards and rest of world inverters is required by utilities in Sri Lanka, it may happen that some manufacturers do not undertake the effort to certify their rest of world products according to US-standards for the market in Sri Lanka. This would lead to a substantial market decrease.

2 CHANGES

2.1 Resulting changes in "Distribution Code"

2.1.1 Distribution Planning and Operation Standards Code

The chapter 6 "Distribution Planning and Operation Standards Code" of the Distribution code specifies the technical and design criteria for planning and developing the distribution system. It applies to all Distribution Licensees, all system users including the embedded generators and parties who are authorized to carry out distribution/supply activities and are connected to a Licensee distribution system.

For Harmonics, IEEE 519 is defined as the applicable standard. IEEE 519 is a standard that defines harmonic current distortion limits for users connected to transmission/distribution systems. This means that for system voltages rated 120 V through 69 kV, the following limits apply:

Table 1 Current distortion limits for systems rated 120 V through 69 kV; IEEE 519-2014

Maximum harmonic current distortion in percent of I_L						
Individual harmonic order (odd harmonics) [a,b]						
I_{SC}/I_L	$3 \leq h < 11$	$11 \leq h < 17$	$17 \leq h < 23$	$23 \leq h < 35$	$35 \leq h < 50$	TDD
$< 20^c$	4.0	2.0	1.5	0.6	0.3	5.0
$20 < 50$	7.0	3.5	2.5	1.0	0.5	8.0
$50 < 100$	10.0	4.5	4.0	1.5	0.7	12.0
$100 < 1000$	12.0	5.5	5.0	2.0	1.0	15.0
> 1000	15.0	7.0	6.0	2.5	1.4	20.0

[a]Even Harmonics are limited to 25 % of the odd harmonic limits above.

[b]Current distortions that result in a dc offset, e.g., half-wave converters, are not allowed.

cAll power generation equipment is limited to these values of current distortion, regardless of actual I_{SC}/I_L.

Where:

$I_{SC} = maximum\ short-circuit\ current\ at\ PCC$

$I_L = maximum\ demand\ load\ current\ (fundamental\ frequency\ component)$
$at\ the\ PCC\ under\ normal\ load\ operating\ conditions$

Based on the fact that generators for PV-systems cannot be tested for different short circuit levels but only under laboratory conditions by the manufacturer, it is recommended that the reference to IEEE 519 is changed in this clause to a reference to IEC 61000-3-2 (Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current ≤ 16 A per phase) for connected devices with an input current ≤ 16 A per phase and a reference to IEC 61000-3-12 (Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current > 16 A and ≤ 75 A per phase) for connected devices with an input current > 16 A and ≤ 75 A per phase.

2.1.2 Appendix 4: Sri Lanka Guide for Net Metered Generating Facilities

This chapter of the Distribution Code describes the procedure for the customer's request to participate in the Net Energy Metering Program. In the described Application process (Page 58) the following points need adaption in order to successfully achieve the government policy targets:

- *"3.10 The applicant may then purchase equipment that complies with the technical details given in the Net Energy Metering Agreement and IEC 61727 (2004-12),* ***IEEE 1547-2003****, or the latest available equivalent standards."*
- *"3.11 The applicant may then install the generating facility, and arrange the commissioning and testing of the generating facility and the interconnection facilities by an Accredited Chartered Electrical Engineer. Such commissioning tests shall be conducted in accordance with IEC 61727 (2004-12),* ***IEEE 1547-2003****,* ***IEE 17th Edition Wiring regulations*** *or the latest available equivalent standards. All such testing and commissioning shall be conducted at the applicant's cost."*

As already mentioned in the introduction, all equipment shall comply with relevant IEC standards. IEEE 1547-2003 defines requirements for interconnecting distributed resources with electric power systems. But some parts of IEEE 1547-2003 are not applicable for Sri Lanka, for example frequency protection and reconnection limits, which are based on a grid frequency of 60 Hz.
IEC 61727 covers all the points that are mentioned in IEEE 1547-2003. The limits for individual harmonic currents are equal. Therefor we recommend to delete IEEE 1547-2003 from point 3.10.
If additional safety and power quality requirements are wanted by PUCSL, it is possible to quote the following standards:

- **IEC 62109-1:** Safety of power converters for use in photovoltaic power systems – Part 1: General requirements
- **IEC 62109-2:** Safety of power converters for use in photovoltaic power systems – Part 1: Particular requirements for inverters
- **IEC 61000-3-2:** Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current ≤ 16 A per phase
- **IEC 61000-3-12:** Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current > 16 A and ≤ 75 A per phase
- **IEC 61000-3-3:** Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤ 16 A per phase
- **IEC 61000-3-11:** Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤ 75 A per phase

Based on the points stated above, Fronius International request to change point 3.10 on page 58 in the Distribution Code as follows:

- *"3.10 The applicant may then purchase equipment that complies with the following standards:*
  - ***IEC 62109-1:** Safety of power converters for use in photovoltaic power systems – Part 1: General requirements*
  - ***IEC 62109-2:** Safety of power converters for use in photovoltaic power systems – Part 1: Particular requirements for inverters*
  - ***IEC 61000-3-2:** Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current ≤ 16 A per phase; **or***
    ***IEC 61000-3-12:** Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current > 16 A and ≤ 75 A per phase; **whichever applies**.*
  - ***IEC 61000-3-3:** Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤ 16 A per phase; **or***
    IEC 61000-3-11:** Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤ 75 A per phase; **whichever applies.

Due to the fact that already existing voltage distortion in the grid may lead to enhanced current distortion, IEEE 1547-2003 suggests the following:

"The harmonic current injections shall be exclusive of any harmonic currents due to harmonic voltage distortion present in the area EPS (Electric power system) without the DR (Distributed resource) connected."

This implies that it is almost impossible to measure uninfluenced harmonic current injection by the distributed resource in a real grid. IEC 61727 gives a similar recommendation:

"Testing harmonics is very problematic, since voltage distortion may lead to enhanced current distortion. The harmonic current injection should be exclusive of any harmonic currents due to harmonic voltage distortion present in the utility grid without the PV system connected. Type tested inverters meeting the requirements in Table 1 of IEC 61727:2004 should be deemed to comply without further testing."

Whether or not the recommendations for 3.10 are accepted, both IEEE 1547-2003 and IEC 61727:2004 imply that harmonic measures at the connection point of the distributed resource do not show the realistic contribution of the distributed resource to harmonic current distortions in the grid. Therefor it is recommended to change 3.11 as follows:

/ *"3.11 The applicant may then install the generating facility, and arrange the commissioning of the generating facility and the interconnection facilities by an Accredited Chartered Electrical Engineer. Installation of the PV-system shall be in accordance with IEC 60364-7-712.*

2.2 Resulting changes in "Manual for Interconnection of Micro Scale Renewable Energy Based Power Generating Facilities at Low Voltage Consumer Feeders of National Grid"

The procedure described in 2.1.2 is listed once again in the "Manual for Interconnection of Micro Scale Renewable Energy Based Power Generating Facilities at Low Voltage Consumer Feeders of National Grid" of the GOSL (Government of Sri Lanka). It is recommended to replace points 5.1 and 5.7 on page 6 of the "Manual for Interconnection of Micro Scale Renewable Energy Based Power Generating Facilities at Low Voltage Consumer Feeders of National Grid" by the proposal for 3.10 and 3.11.

Furthermore, all references to functions defined in IEEE 1547 should be changed to the similar functions defined in IEC 61727.

2.3 Resulting changes in "Application for Net Metering of an On-Grid small scale Renewable Energy Facility"

The "Application for Net Metering of an On-Grid small scale Renewable Energy Facility" from Lanka Electricity Company Limited defines in chapter 7, "Installer and Chartered Engineering Declaration", that the Installer has to declare that the PV system fully complies with the Grid Code, IEEE 1547 and IEC 61727.
This is misleading, because the Distribution Code of Sri Lanka and not the Grid Code is applicable for small scale renewable energy facility. This is also mentioned on the first page of the "Application for Net Metering of an On-Grid small scale Renewable Energy Facility". The Grid Code defines requirements for the Transmission system.

It is recommended to delete the reference to the Grid Code, IEEE 1547 and IEC 61727, and insert a reference to the Distribution Code instead. The applicable Standards are defined in the Distribution Code and should not be listed here again.