EWA
هيئة الكهرباء والماء
Electricity & Water Authority
Kingdom of Bahrain

Technical Expert to develop grid connection guidelines and standards for the Kingdom of Bahrain

Inspection and Testing Checklists
for installation of Distributed Solar PV Plants

2.2

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1 SCOPE

This document provides the check-lists to be used to implement the Inspection and Testing procedures as described in the Inspection and testing Guidelines [4] to be adopted after the erection of a solar PV plant in order to connect it to the public Electric Network in Bahrain [1].
The Figure 1 shows the general sequence of the testing activities from the end of construction to its final connection to the electric network. The number and type of tests depends on the size of the solar PV plant and we may see that for plants whose nominal power Pn is up to 100 kW only two test sets are necessary, while for larger plants four test sets are required.

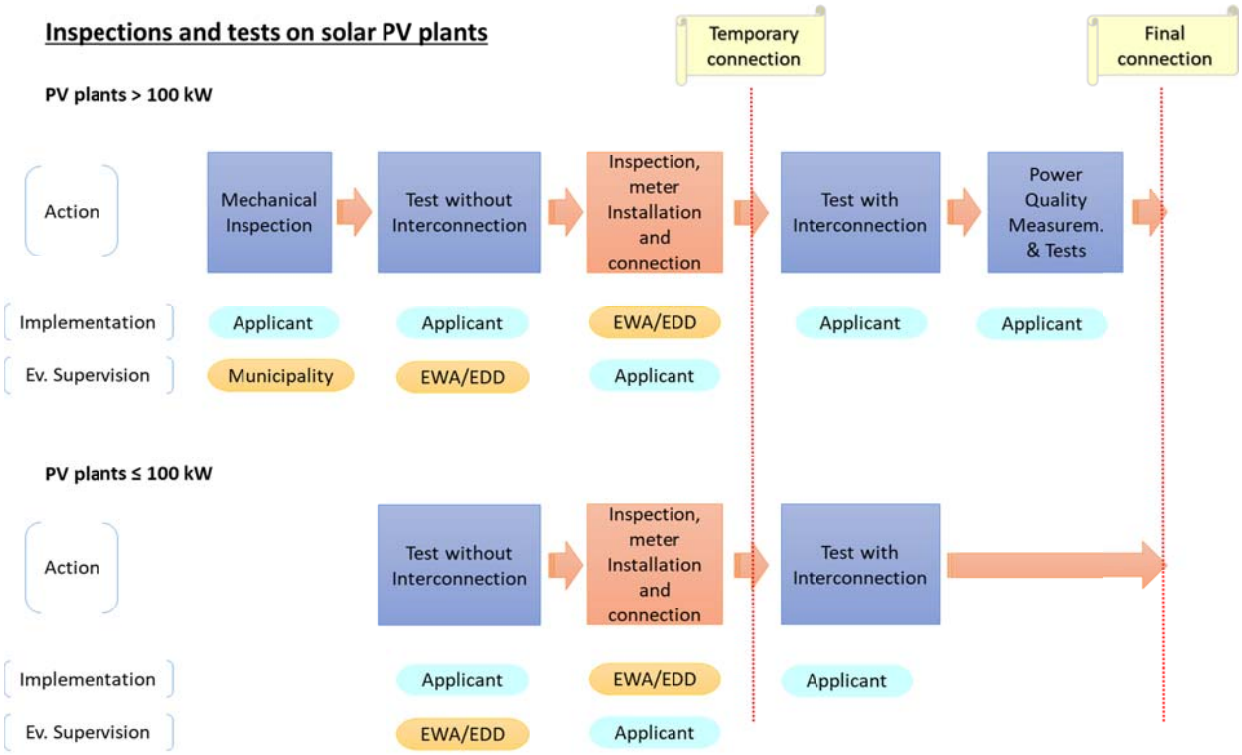

Figure 1 – Sequence of the testing activities for solar PV plants

The Figure 1 shows also that the Applicant - under the eventual supervision of EWA Electricity Distribution Directorate (EDD), or the Municipality for the Mechanical Inspection - shall make all tests. However, EWA/EDD shall:

- Inspect test and approve the installation as per the Regulations for Electrical Installations [2], and
- install the meters

before the solar PV plant can be energized.
Depending on the capacity Pn of the Solar PV plant the Applicant shall carry out the inspections and tests as shown in the following Table 1.

Table 1 – Main steps of the Inspection and Testing of the Solar PV plants

Description	Capacity of the Solar PV plant (Pn)		
	Pn ≤ 11 kW	11 kW < Pn ≤ 100kW	Pn >100kW
System documentation			
Layout, SLD, datasheets, drawings, etc.	X	X	X
Technical report and additional diagrams, drawings, etc.	-	X	X
Mechanical Inspection (§)			
Mechanical inspection (separate inspection)	-	-	X
Test without interconnection (§)			
Inspection – general inspection before all tests are carried out	X	X	X
Category 1 test regime	X	X	X
Category 2 test regime	-	-	Recommended (*)
Additional tests	-	Facultative (*)	Facultative (*)
Test with interconnection (§)			
Interface protection	X	X	X
Performance monitoring functions	X	X	X
Performance ratio	X	X	X
Power Quality measurements and tests (§)			
Assessment of the harmonic content	-	-	X
Additional measurements	-	-	X (^)

(§) report to be delivered with the results of the inspections and tests

(*) no check list is provided in the present document: contractor and customer shall agree on the performance of these tests, as well as on the reporting and the delivery of the results

(^) if required after assessment of the harmonic content in **Error! Reference source not found.**

Furthermore, according to the description in [4], the checklists for the solar PV plant design are also reported.

2 FOREWORD

2.1 Reference documents

[1] EWA – Standards for Solar PV Systems to be connected in parallel with the distribution networks of the Kingdom of Bahrain

[2] Ministry of Electricity and Water, Electricity Distribution Directorate – Regulations for electrical installations (Second edition, 2004)

[3] EWA – Guidelines for Solar PV systems to be Connected ion in parallel with the distribution networks of the Kingdom of Bahrain

[4] EWA – Inspection and Testing Guidelines

[5] IEC 60364-6 – Low voltage electrical installations. Part 6: Verifications

[6] IEC 61010 – Safety requirements for electrical equipment for measurement, control and laboratory use

[7] IEC 61557 – Electrical safety in low voltage distribution systems up to 1000 V a.c. and 1500 V d.c.

[8] IEC 61724-1 – Photovoltaic system performance. Part 1: Monitoring

[9] IEC 61724-2 – Photovoltaic system performance. Part 2: Capacity evaluation method

[10] IEC 61724-3 – Photovoltaic system performance. Part 3: Energy evaluation method

[11] IEC 61730-2 – Photovoltaic (PV module safety qualification. Part 2: Requirements for testing

[12] IEC 62446-1 – Photovoltaic (PV) systems. Requirements for testing, documentation and maintenance. Part 1: Grid connection systems. Documentation, commissioning, tests and inspection

[13] IEC 62548 – Photovoltaic (PV) arrays. Design requirements

2.2 Terms and definitions

Active power (P) – under periodic conditions, mean value, taken over one period, of the instantaneous product of current and voltage expressed in W. Under sinusoidal conditions, the active power is the real part of the complex power.

Apparent power (S) – product of the r.m.s. voltage between the terminals of a two-terminal element or two-terminal circuit and the r.m.s. electric current in the element or circuit expressed in VA. Under sinusoidal conditions, the apparent power is the modulus of the complex power.

Cable type – description of a cable to enable its rating and suitability for a particular use or environment to be determined (Note: In many countries this is done via a code number e.g. “H07RNF”)

Data sheet – basic product description and specification (Note: Typically one or two pages, not a full product manual)

Global horizontal irradiance (GHI) – direct plus diffuse irradiance incident on a horizontal surface expressed in W/m^2

$I_{MOD\_MAX\_OCPR}$ – PV module maximum overcurrent protection rating determined by IEC 61730-2 (Note: This is often specified by module manufacturers as the maximum series fuse rating)

Inspection – examination of an electrical installation using all the senses in order to ascertain correct selection and proper erection of electrical equipment

In-plane irradiance (Gi or POA) – the sum of direct, diffuse, and ground-reflected irradiance incident upon an inclined surface parallel to the plane of the modules in the PV array, also known as plane-of-array (POA) irradiance. It is expressed in W/m^2

Interface Protection (IP) - The electrical protection required to ensure that either the generating plant and/or any generating unit is disconnected for any event that could impair the integrity or degrade the safety and reliability of the distribution network.
Inverter – electric energy converter that changes direct electric current to single-phase or polyphase alternating current
Irradiance (G) – incident flux of radiant power per unit area expressed in W/m^2
Irradiation (H) – irradiance integrated over a specified time interval expressed in kWh/m^2
Point of Connection or POC - Is the location at which a solar PV generating plant is connected to the distribution network and where the main electricity meter is installed.
Power factor (λ) – under periodic conditions, ratio of the absolute value of the active power P to the apparent power S
PV array – assembly of electrically interconnected PV modules, PV strings or PV sub-arrays.
PV cell – most elementary device that exhibits the photovoltaic effect, i.e the direct non-thermal conversion of radiant energy into electrical energy
PV module – smallest complete environmentally protected assembly of interconnected PV cells
PV string – circuit of one or more series-connected PV modules
PV string combiner box – junction box where PV strings are connected which may also contain overcurrent protection devices, electronics and/or switch-disconnectors
Record – data recorded and stored in data log, based on acquired samples
Recording interval (τ) – time between records
Report – aggregate value based on series of records
Reporting period – time between reports
Reporting – recording of the results of inspection and testing
Residual current device (RCD) – is a sensitive safety device that switches off when the residual current exceeds the operating value of the device
Sample – data acquired from a sensor or measuring device
Sampling interval – time between samples
Soiling ratio (SR) – ratio of the actual power output of the PV array under given soiling conditions to the power that would be expected if the PV array were clean and free of soiling
Switch – Mechanical device capable of making, carrying and breaking currents in normal circuit conditions and, when specified, in given operating overload conditions. In addition, it is able to carry, for a specified time, currents under specified abnormal circuit conditions, such as short-circuit conditions.
Standard test conditions (STC) – reference values of in-plane irradiance (1 000 W/m^2), PV cell junction temperature (25 °C), and the reference spectral irradiance defined in IEC 60904-3
Testing – implementation of measures in an electrical installation by means of which its effectiveness is proved (Note: It includes ascertaining values by means of appropriate measuring instruments, said values not being detectable by inspection)
Verification – all measures by means of which compliance of the electrical installation to the relevant
standards is checked
Voltage - Unless stated otherwise, voltage refers to the root-mean-square value of phase-to-phase voltages.

3 SOLAR PV DESIGN CHECK-LIST

3.1 PV plants up to 11 kW

3.1.1 Description

The following form is used to validate the documentation at design Approval stage for solar PV plants up to 11 kW as described in the document EWA – Inspection and Testing Guidelines [4].

3.1.2 Pass/fail criteria

A positive final result requires that only *Yes* or *Complete* or *Not Applicable* boxes are checked.

3.1.3 Checklist

Solar PV Design Check-list – Pn ≤ 11 kW		
Basic system information		
Project identification reference	☐ Yes ☐ No ☐ Not applicable	
Rated system power (kW DC and kVA AC)	☐ Yes ☐ No	
PV modules and inverters (manufacturers, models, quantity)	☐ Yes ☐ No	
Installation date	☐ Yes ☐ No	
Commissioning date	☐ Yes ☐ No	
Customer name	☐ Yes ☐ No	
Site address	☐ Yes ☐ No	
System designer information		
System designer, Company	☐ Yes ☐ No	
System designer, contact person	☐ Yes ☐ No	
System designer, postal address, telephone, e-mail	☐ Yes ☐ No	
System installer information		
System installer, Company	☐ Yes ☐ No	
System installer, contact person	☐ Yes ☐ No	
System installer, postal address, telephone, e-mail	☐ Yes ☐ No	
Wiring diagram		
Field	**Result / Value**	**Notes**
Suitable and readable format	☐ Yes ☐ No	
Array – General specifications	☐ Complete ☐ No	
PV string information	☐ Complete ☐ No	
PV array electrical details	☐ Complete ☐ No	
AC system	☐ Complete ☐ No	
Earthing and overvoltage protection	☐ Complete ☐ No	
Other design information		
Field	**Result / Value**	**Notes**
Planimetry and String layout	☐ Yes ☐ No	

Solar PV Design Check-list – Pn ≤ 11 kW		
Datasheet – PV modules, Inverters, IP (if applicable)	☐ Yes ☐ No	
Mechanical design information	☐ Yes ☐ No	
Emergency system	☐ Yes ☐ No ☐ Not applicable	
Shading diagram	☐ Yes ☐ No	
Esteem of the yearly energy production	☐ Yes ☐ No	
Operation and maintenance information		
All applicable items	☐ Yes ☐ No	
Final result	☐ Passed ☐ Not passed	

3.2 Above 11 kW

3.2.1 Description

The following form is used to validate the documentation at design Approval stage for solar PV plants above 11 kW as described in the document EWA – Inspection and Testing Guidelines [4].

3.2.2 Pass/fail criteria

A positive final result requires that only *Yes* or *Complete* or *Not Applicable* boxes are checked.

3.2.3 Checklist

Solar PV Design Check-list – Pn > 11 kW		
Basic system information		
Project identification reference	☐ Yes ☐ No ☐ Not applicable	
Rated system power (kW DC and kVA AC)	☐ Yes ☐ No	
PV modules and inverters (manufacturers, models, quantity)	☐ Yes ☐ No	
Installation date	☐ Yes ☐ No	
Commissioning date	☐ Yes ☐ No	
Customer name	☐ Yes ☐ No	
Site address	☐ Yes ☐ No	
System designer information		
System designer, Company	☐ Yes ☐ No	
System designer, contact person	☐ Yes ☐ No	
System designer, postal address, telephone, e-mail	☐ Yes ☐ No	
System installer information		
System installer, Company	☐ Yes ☐ No	
System installer, contact person	☐ Yes ☐ No	

Solar PV Design Check-list – Pn > 11 kW		
System installer, postal address, telephone, e-mail	☐ Yes ☐ No	
Technical report		
Field	**Result / Value**	**Notes**
Preliminary information	☐ Complete ☐ No	
Foreword (or differently named)	☐ Complete ☐ No	
Input data	☐ Complete ☐ No	
Characteristics of the main devices and equipment	☐ Complete ☐ No	
System architecture and dimensioning	☐ Complete ☐ No	
DC section	☐ Complete ☐ No	
AC section	☐ Complete ☐ No	
Civil and mechanical installation	☐ Complete ☐ No	
Shading diagram	☐ Complete ☐ No	
Performance calculation	☐ Complete ☐ No	
Wiring diagram		
Field	**Result / Value**	**Notes**
Suitable and readable format	☐ Yes ☐ No	
Array – General specification	☐ Complete ☐ No	
PV string information	☐ Complete ☐ No	
PV array electrical details	☐ Complete ☐ No	
AC system	☐ Complete ☐ No	
Earthing and overvoltage protection	☐ Complete ☐ No	
Other design information		
Field	**Result / Value**	**Notes**
Planimetry and String layout	☐ Yes ☐ No	
Datasheet – PV modules, Inverters, IP	☐ Yes ☐ No	
Mechanical design information	☐ Yes ☐ No	
Emergency system	☐ Yes ☐ No ☐ Not applicable	
Operation and maintenance information		
All applicable items	☐ Yes ☐ No	
Final result	☐ Passed ☐ Not passed	

4 MECHANICAL INSPECTION CHECKLISTS

Mechanical Inspection applies to solar PV plants with Pn > 100 kW.

4.1 Overview

The purpose of the Mechanical Inspection is to verify the mechanical integrity of the PV plant as well as the integrity of all equipment and their correct displacement.
It is important to keep this inspection logically separated from the subsequent Test without Interconnection, which is focused on the electrical parts.
The checklist is composed by the following documents:

- General on PV plant and Participants Checklist
- Documents required Checklist
- Civil works and Support structures Checklist
- PV modules Checklist
- Electrical equipment installation and protection Checklist
- Mechanical Inspection Final result

4.2 General on PV plant and Participants

4.2.1 Description

This part refers to the general data of the PV plant and to the data of the participants to the Mechanical Inspection.

4.2.2 Pass/fail criteria

A positive final result requires that all items are filled with correct information, except *P.O. Box* and *Street name and number* that may be alternative each other.
Participants indicated as *Facultative* may be omitted if they are not present. Affiliation shall be indicated if not already present.

4.2.3 Checklist

Mechanical Inspection Check-list	
General on PV plant	
Name of the PV plant	
Nominal Power [kW]	
P.O. Box	
Street name and number	
Location / Area	
City	
Voltage delivery	□ 240 V (1 phase) □ 415 V (3 phases) □ 11 kV (3 phases)
POC	
PV module installation	□ On building □ Other structure (e.g. canopy) □ Ground
Building installation (if applicable)	□ Flat rooftop □ Roof flap □ Façade □ Other

Mechanical Inspection Check-list	
Building type (if applicable)	☐ Villa or small household ☐ Apartment block ☐ Offices ☐ School/University ☐ Healthcare/Hospital ☐ Industrial ☐ Hotel/Restaurant ☐ Entertainment ☐ Agricultural/Stable ☐ Detention/Correctional ☐ Other . . . . .
Area of the PV array [m^2]	
PV technology	☐ Mono-crystalline silicon ☐ Multi-crystalline silicon ☐ Thin-film (specify) . . . . . ☐ Other (specify) . . . . .
Tracking system if any	☐ No tracking ☐ Single-axis tracking ☐ Two-axes tracking

Participants

Role	Name	Affiliation
Test engineer (mandatory)		Independent licensed engineer
Installer (mandatory)		
Designer (facultative)		
Inspector (facultative)		EWA
Inspector (facultative)		
Inspector (facultative)		
Result	☐ Passed ☐ Not passed	

4.3 Documents required

4.3.1 Description

This part refers to the documents required on-site to perform the Mechanical Inspection.

4.3.2 Pass/fail criteria

A positive final result requires that all *Yes* boxes are properly checked.

4.3.3 Checklist

Mechanical Inspection Check-list		
Documents required		
Field	**Result / Value**	**Notes**
Final design or As-built design in case of variations	☐ Yes ☐ No	
Declaration of Conformity	☐ Yes ☐ No	
Communication of available periods from EWA	☐ Yes ☐ No	
Notification of the dates from the Applicant	☐ Yes ☐ No	
Result	☐ Passed ☐ Not passed	

4.4 Civil works and Support structures

4.4.1 Description

With reference to 100% of the installation, this part refers to the verification of the correspondence to the drawings and design documents regarding the quantity, type, sizing, installation and integrity of components and materials. The following checks shall be performed.

4.4.2 Pass/fail criteria

A positive final result requires that only *Yes* or *N/A* boxes are checked.

4.4.3 Checklist

Mechanical Inspection Check-list		
Civil works		
Field	**Result / Value**	**Notes**
Foundations (state, breakage, deterioration of the surface)	☐ Yes ☐ No ☐ N/A	
Structural alignments: within the tolerances set by design	☐ Yes ☐ No ☐ N/A	
Placement of inserts and holes in foundations and precast	☐ Yes ☐ No ☐ N/A	
General conditions of the cabins and related foundations	☐ Yes ☐ No ☐ N/A	
Waterproofing of the cabins	☐ Yes ☐ No ☐ N/A	
Roof integrity and ingress protection (water proof) of mounting system to the roof	☐ Yes ☐ No ☐ N/A	
Access doors of the cabins	☐ Yes ☐ No ☐ N/A	
Ventilation grills / air conditioning of the cabins	☐ Yes ☐ No ☐ N/A	
Integrity and layout of cableways / conduits	☐ Yes ☐ No ☐ N/A	
Support structures		
Field	**Result / Value**	**Notes**
Mounting of supporting structures and of fixation elements	☐ Yes ☐ No ☐ N/A	
Condition of the components (damages, defects, weld quality, loss of galvanic protection, corrosion)	☐ Yes ☐ No ☐ N/A	
Planarity of the PV modules supporting structures (arrows, sags)	☐ Yes ☐ No ☐ N/A	
Inclination of PV modules: within the tolerances set in the design	☐ Yes ☐ No ☐ N/A	
Bolts and tightening torque corresponding to design (sample check)	☐ Yes ☐ No ☐ N/A	
Result	☐ Passed ☐ Not passed	

4.5 PV modules

4.5.1 Description

With reference to 100% of the installation, this part refers to the verification of the correspondence to the drawings and design documents regarding the quantity, type, sizing, installation and integrity of components and materials. The following checks shall be performed.

4.5.2 Pass/fail criteria

A positive final result requires that only *Yes* or *N/A* boxes are checked.

4.5.3 Checklist

Mechanical Inspection Check-list		
Visual inspection of PV modules		
Field	**Result / Value**	**Notes**
Mechanical integrity of the modules (faults, breakdowns or incomplete assembly)	☐ Yes ☐ No ☐ N/A	
Integrity functional parts of the modules (delamination, discoloration, dirt, etc.)	☐ Yes ☐ No ☐ N/A	
Labeling of modules	☐ Yes ☐ No ☐ N/A	
Fixation system	☐ Yes ☐ No ☐ N/A	
Bolts and tightening torques corresponding to design (on a sample basis)	☐ Yes ☐ No ☐ N/A	
No obstructions shading any PV module		
Quality of cabling		
Field	**Result / Value**	**Notes**
Tightening of cable glands	☐ Yes ☐ No ☐ N/A	
Correct installation of DC cables (clamps, sharp edges, folds too narrow, etc.)	☐ Yes ☐ No ☐ N/A	
Assembly and crimping of plug-in connectors	☐ Yes ☐ No ☐ N/A	
Result	☐ Passed ☐ Not passed	

4.6 Electrical equipment installation and protection

4.6.1 Description

With reference to 100% of the installation, this part refers to the verification of the correspondence to the drawings and design documents regarding the quantity, type, sizing, installation and integrity of components and materials. The following checks shall be performed.

4.6.2 Pass/fail criteria

A positive final result requires that only *Yes* or *N/A* boxes are checked.

4.6.3 Checklist

Mechanical Inspection Check-list		
Electrical equipment installation		
Field	**Result / Value**	**Notes**
Positioning and fixation of string combiner boxes for connection of PV strings	☐ Yes ☐ No ☐ N/A	
Installation of raceways and/or cable sheaths string	☐ Yes ☐ No ☐ N/A	
Positioning in the cabins of the equipment: inverters, transformers, switchgear, etc.	☐ Yes ☐ No ☐ N/A	
Mechanical integrity of the said equipment (e.g. faults, breaks)	☐ Yes ☐ No ☐ N/A	
Switch-disconnectors on DC side visible and reachable (all buildings, switch position according to design)	☐ Yes ☐ No ☐ N/A	
Emergency remote control (manual call point) to disconnect a portion of PV plant (ordinary and higher hazard buildings, min. eight 1.1 m above floor)	☐ Yes ☐ No ☐ N/A	
Protection of assembled components (IP degree)		
Field	**Result / Value**	**Notes**
IP degree of equipment, string combiner boxes, etc.	☐ Yes ☐ No ☐ N/A	
Installation of equipment, string combiner boxes, etc.	☐ Yes ☐ No ☐ N/A	
Installation of cable glands and connectors related to the above equipment	☐ Yes ☐ No ☐ N/A	
Positioning of cable ducts / conduits on metallic cableways / ladders	☐ Yes ☐ No ☐ N/A	
Protective measures against rodents (polyurethane foam to obstruct inlets of conduits and of cabins) and insects (anti-insect grilles)	☐ Yes ☐ No ☐ N/A	
Labeling of cables, cable ducts and equipment	☐ Yes ☐ No ☐ N/A	
Result	☐ Passed ☐ Not passed	

4.7 Mechanical Inspection Final result

4.7.1 Description

This part reports the final outcome of the Mechanical Inspection.

4.7.2 Pass/fail criteria

The Mechanical Inspection will be successful (Passed) if all the checklists in the above documents give positive result (Passed).

4.7.3 Final result page

Mechanical Inspection Final result		
Participants		
Role	**Name**	**Signature**
Test engineer (mandatory)		
Installer (mandatory)		
Designer (if present)		
Inspector (if present)		
Inspector (if present)		
Inspector (if present)		
Notes		
Final result	□ Passed □ Not passed	

5 TEST WITHOUT INTERCONNECTION CHECKLIST

Test without interconnection applies to all solar PV plants.

5.1 Overview

The purpose of the Test without Interconnection is to verify and test the safety and the functional requirements of the PV plant before its connection to the grid.
The checklist is composed by the following documents:

- General on PV plant and Participants Check-list
- Documents required Check-list
- DC system inspection Check-list
- AC system inspection Check-list
- Labelling and Identification Check-list
- PV array test report Check-list
- Test without Interconnection final result

5.2 General on PV plant and Participants

5.2.1 Description

This part refers to the general data of the PV plant and to the data of the participants to the Test without Interconnection.

5.2.2 Pass/fail criteria

A positive final result requires that all items are filled with correct information, except *P.O. Box* and *Street name and number* that may be alternative each other.
Participants indicated as *Facultative* may be omitted if they are not present. Affiliation shall be indicated if not already present.

5.2.3 Checklist

Test without Interconnection Check-list	
General on PV plant	
Name of the PV plant	
Nominal Power [kW]	
P.O. Box	
Street name and number	
Location / Area	
City	
Voltage delivery	□ 240 V (1 phase) □ 415 V (3 phases) □ 11 kV (3 phases)
POC	
PV module installation	□ On building □ Other structure (e.g. canopy) □ Ground
Building installation (if applicable)	□ Flat rooftop □ Roof flap □ Façade □ Other
Building type (if applicable)	□ Villa or small household □ Apartment block □ Offices □ School/University □ Healthcare/Hospital □ Industrial □ Hotel/Restaurant □ Entertainment □ Agricultural/Stable □ Detention/Correctional □ Other . . . . .
Area of the PV array [m^2]	

Test without Interconnection Check-list			
PV technology	□ Mono-crystalline silicon □ Multi-crystalline silicon □ Thin-film (specify) . . . . . □ Other (specify)		
Tracking system if any	□ No tracking □ Single-axis tracking □ Two-axes tracking		
Participants			
Role	**Name**	**Affiliation**	
Test engineer (mandatory)		Independent licensed engineer	
Installer (mandatory)			
Designer (facultative)			
Inspector (facultative)		EWA	
Inspector (facultative)			
Inspector (facultative)			
Result	□ Passed □ Not passed		

5.3 Documents required

5.3.1 Description

This part refers to the documents required on-site to perform the Test without Interconnection

5.3.2 Pass/fail criteria

A positive final result requires that only *Yes* or *N/A* boxes are checked.

5.3.3 Checklist

Test without Interconnection Check-list		
Documents required		
Field	**Result / Value**	**Notes**
Final design or As-built design in case of variations	□ Yes □ No	
Declaration of Conformity	□ Yes □ No	
Communication of available periods from EWA	□ Yes □ No	
Notification of the dates from the Applicant	□ Yes □ No	
Mechanical Inspection Report (if Pn>100 kW)	□ Yes □ No □ N/A	
Result	□ Passed □ Not passed	

5.4 DC system inspection

5.4.1 Description

The purpose of this document is to check that the entire DC system has been inspected according to IEC 60364-6 and IEC 62548.

5.4.2 Pass/fail criteria

A positive final result requires that only *Yes* or *N/A* boxes are checked unless differently indicated.

5.4.3 Checklist

Test without Interconnection Check-list		
DC system – general		
Field	**Result / Value**	**Notes**
The DC system has been designed, specified and installed to the requirements of IEC 60364 and IEC 62548	☐ Yes ☐ No	
The maximum PV array voltage is suitable for the array location	☐ Yes ☐ No	
All system components and mounting structures have been selected and erected to withstand the expected external influences such as wind, sandstorm, temperature and corrosion	☐ Yes ☐ No	
Roof fixings and cable entries are weatherproof (where applicable)	☐ Yes ☐ No ☐ N/A	
DC system – Protection against electric shock		
Field	**Result / Value**	**Notes**
Protective measure provided by extra low voltage (SELV / PELV)	☐ Yes ☐ No (alternative to the next one)	
Protection by use of class II or equivalent insulation adopted on the DC side	☐ Yes ☐ No (Alternative to the previous one)	
DC system – Protection against the effects of insulation faults		
Field	**Result / Value**	**Notes**
Galvanic separation in place inside the inverter or on the AC side	☐ Yes ☐ No (informative)	
Functional earthing of any DC conductor	☐ Yes ☐ No (Informative)	
PV Array Earth Insulation Resistance detection and alarm system is installed – to the requirements of IEC 62548	☐ Yes ☐ No	
PV Array Earth Residual Current Monitoring detection and alarm system is installed – to the requirements of IEC 62548	☐ Yes ☐ No	
DC system – Protection against overcurrents		
Field	**Result / Value**	**Notes**
For systems without string overcurrent protective device: $I_{MOD\_MAX\_OCPR}$ (the module maximum series fuse rating) is greater than the possible reverse current	☐ Yes ☐ No ☐ N/A	
For systems without string overcurrent protective device: string cables are sized to accommodate the maximum combined fault current from parallel strings	☐ Yes ☐ No ☐ N/A	

Test without Interconnection Check-list		
For systems with string overcurrent protective device: string overcurrent protective devices are fitted and correctly specified to the requirements of IEC 62548	☐ Yes ☐ No ☐ N/A	
For systems with array / sub-array overcurrent protective devices: overcurrent protective devices are fitted and correctly specified to the requirements of IEC 62548	☐ Yes ☐ No ☐ N/A	
For systems where the inverter(s) can produce a DC back-feed into the PV array circuits: any back-feed current is lower than both the module maximum fuse rating and the string cable ampere rating	☐ Yes ☐ No ☐ N/A	
DC system – Earthing and bonding arrangements		
Field	**Result / Value**	**Notes**
Where the PV system includes functional earthing of one of the DC conductors: the functional earth connection has been specified and installed to the requirements of IEC 62548	☐ Yes ☐ No ☐ N/A	
Where a PV system has a direct connection to earth on the DC side: a functional earth fault interrupter is provided to the requirements of IEC 62548	☐ Yes ☐ No ☐ N/A	
Array frame bonding arrangements have been specified and installed to the requirements of IEC 62548	☐ Yes ☐ No	
Where protective earthing and/or equipotential bonding conductors are installed: they are parallel to, and bundled with, the DC cables	☐ Yes ☐ No ☐ N/A	
DC system – Protection against the effects of lightning and overvoltage		
Field	**Result / Value**	**Notes**
To minimize voltages induced by lightning, the area of all wiring loops has been kept as small as possible	☐ Yes ☐ No	
Measures are in place to protect long cables (e.g. screening or the use of SPDs)	☐ Yes ☐ No	
Where SPDs are fitted, they have been installed to the requirements of IEC 62548	☐ Yes ☐ No	
DC system – Selection and erection of electrical equipment		
Field	**Result / Value**	**Notes**
The PV modules are rated for the maximum possible DC system voltage	☐ Yes ☐ No	
All DC components are rated for continuous operation at DC and at the maximum possible DC system voltage and current as defined in IEC 62548	☐ Yes ☐ No ☐ N/A	

Test without Interconnection Check-list		
Wiring systems have been selected and erected to withstand the expected external influences such as wind, temperature, UV and solar radiation	☐ Yes ☐ No ☐ N/A	
Means of isolation and disconnection have been provided for the PV array strings and PV sub-arrays – to the requirements of IEC 62548	☐ Yes ☐ No ☐ N/A	
A DC switch disconnector is fitted to the DC side of the inverter to the requirements of IEC 62548	☐ Yes ☐ No ☐ N/A	
If blocking diodes are fitted, their reverse voltage rating is at least 2 × Voc (stc) of the PV string in which they are fitted (see IEC 62548)	☐ Yes ☐ No ☐ N/A	
Plug and socket connectors mated together are of the same type and from the same manufacturer and comply with the requirements of IEC 62548	☐ Yes ☐ No ☐ N/A	
Result	☐ Passed ☐ Not passed	

5.5 AC system inspection

5.5.1 Description

The purpose of this document is to check that the AC system has been inspected according to IEC 60364-6 and IEC 62548.

5.5.2 Pass/fail criteria

A positive final result requires that only *Yes* or *N/A* boxes are checked unless differently indicated.

5.5.3 Checklist

Test without Interconnection Check-list		
AC system – General		
Field	**Result / Value**	**Notes**
Means of isolating the inverter has been provided on the AC side	☐ Yes ☐ No	
All isolation and switching devices have been connected such that PV installation is wired to the "load" side and the public supply to the "source" side	☐ Yes ☐ No	
Where an RCD is installed to the AC circuit feeding an inverter, the RCD type has been verified to ensure it has been selected according to the requirements of IEC 62548	☐ Yes ☐ No ☐ N/A	
Inverters are fully compliant to the *standards for Solar PV Systems*	☐ Yes ☐ No	

Test without Interconnection Check-list		
Interface protection (IP) is external to inverter(s)	☐ Yes ☐ No (informative)	
Interface protection (IP) is fully compliant to the *standards for Solar PV Systems*	☐ Yes ☐ No	
Interface device is compliant to the *standards for Solar PV Systems*	☐ Yes ☐ No	
Backup interface device is compliant to the *standards for Solar PV Systems*	☐ Yes ☐ No ☐ N/A	
An UPS to support the Interface protection system is present	☐ Yes ☐ No ☐ N/A	
Result	☐ Passed ☐ Not passed	

5.6 Labelling and identification

5.6.1 Description

The purpose of this document is to check that the labels and warning sign have been properly used according to IEC 60364-6 and IEC 62548.

5.6.2 Pass/fail criteria

A positive final result requires that only *Yes* or *N/A* boxes are checked unless differently indicated.

5.6.3 Checklist

Test without Interconnection Check-list		
Labelling and identification		
Field	**Result / Value**	**Notes**
All circuits, protective devices, switches and terminals suitably labelled to the requirements of IEC 60364 and IEC 62548	☐ Yes ☐ No	
All DC junction boxes (PV generator and PV array boxes) carry a warning label indicating that active parts inside the boxes are fed from a PV array and may still be live after isolation from the PV inverter and public supply	☐ Yes ☐ No ☐ N/A	
Means of isolation on the AC side is clearly labelled	☐ Yes ☐ No	
Dual supply warning labels are fitted at point of interconnection	☐ Yes ☐ No	
A single line wiring diagram is displayed on site	☐ Yes ☐ No	
Installer details are displayed on site	☐ Yes ☐ No	
Shutdown procedures are displayed on site	☐ Yes ☐ No	
Emergency procedures are displayed on site (where relevant)	☐ Yes ☐ No ☐ N/A	
All signs and labels are suitably affixed and durable	☐ Yes ☐ No	

Test without Interconnection Check-list	
Result	☐ Passed ☐ Not passed

5.7 PV array test report

5.7.1 Description

The purpose of this document is to report the tests made on all the strings of the PV array.
Each copy of the document may contain tests on up to five strings. In case of more than five stings in parallel on the same PV array a progressive *Sheet number* and the same *PV array number* for each PV array shall be indicated in the heading.
In case of more than one independent PV array be present, a number of documents equal to the number of independent PV arrays, or to a multiple of them if more than five strings per each independent PV array are present, will be used. A different progressive *PV Array number* shall be indicated for each PV array.

5.7.2 Pass/fail criteria

An analysis of the measured data shall be made in order to check the following:

- All check boxes are checked *Y* or *N/A*
- Sting overcurrent protection devices fit the specific application
- Array isolators fit the specific application
- String wiring fit the specific application
- Voc reading matches the expected value
- The array insulation resistance is higher than the minimum value required

5.7.3 Checklist

Test without Interconnection Check-list

PV Array number: **Sheet number:**

PV array test report

String	String reference	1	2	3	4	5
	PV module					
	Quantity					
Array parameters (as specified)	Voc-stc [V]					
	Isc-stc [A]					
String overcurrent protective device	Type					
	Rating [A]					
	DC rating [V]					
	Capacity [kA]					
String wiring	Type					
	Cross-sect [mm^2]					
String test	Voc [V]					
	Isc [A]					

Test without Interconnection Check-list						
PV Array number:		**Sheet number:**				
PV array test report						
	Irradiance [W/m^2]					
Polarity check OK		☐ Y ☐ N	☐ Y ☐ N	☐ Y ☐ N	☐ Y ☐ N	☐ Y ☐ N
Array insulation resistance	Test voltage [V]					
	Pos – Earth [MΩ]					
	Neg – Earth [MΩ]					
Earth continuity (where fitted) ☐ N/A		☐ Y ☐ N	☐ Y ☐ N	☐ Y ☐ N	☐ Y ☐ N	☐ Y ☐ N
Array isolator	Rating [A]					
	Rating [V]					
	Location					
	Functional check					
Inverter	Manuf. and model					
	Serial number					
	Functioning OK					
Result		☐ Passed ☐ Not passed				

5.8 Test without Interconnection Final result

5.8.1 Description

This part reports the final outcome of the Test without Interconnection.

5.8.2 Pass/fail criteria

The Test without Interconnection will be successful (Passed) if all the checklists in the above documents give positive result (Passed).

5.8.3 Final result page

Test without Interconnection Final result		
Participants		
Role	**Name**	**Signature**
Test engineer (mandatory)		
Installer (mandatory)		
Designer (if present)		
Inspector (if present)		
Inspector (if present)		
Inspector (if present)		

Test without Interconnection Final result	
Notes	
Final result	☐ Passed ☐ Not passed

6 TEST WITH INTERCONNECTION CHECKLIST

Test with interconnection applies to all solar PV plants. However, performance test only applies to solar PV plants > 100 kW.

6.1 Overview

The purpose of the Test with Interconnection is to verify and test the performance requirements of the PV plant after its connection to the grid.
The checklist is composed by the following documents:

- General on PV plant and Participants Check-list
- Documents required Check-list
- Measurement system check-list
- Performance Test Check-list (for PV plants > 100 kW)
- Test with Interconnection final result

6.2 General on PV plant and Participants

6.2.1 Description

This part refers to the general data of the PV plant and to the data of the participants to the Test without Interconnection.

6.2.2 Pass/fail criteria

A positive final result requires that all items are filled with correct information, except *P.O. Box* and *Street name and number* that may be alternative each other.
Participants indicated as *Facultative* may be omitted if they are not present. Affiliation shall be indicated if not already present.

6.2.3 Checklist

Test with Interconnection Check-list	
General on PV plant	
Name of the PV plant	
Nominal Power [kW]	
P.O. Box	
Street name and number	
Location / Area	
City	
Voltage delivery	□ 240 V (1 phase) □ 415 V (3 phases) □ 11 kV (3 phases)
POC	
PV module installation	□ On building □ Other structure (e.g. canopy) □ Ground
Building installation (if applicable)	□ Flat rooftop □ Roof flap □ Façade □ Other
Building type (if applicable)	□ Villa or small household □ Apartment block □ Offices □ School/University □ Healthcare/Hospital □ Industrial □ Hotel/Restaurant □ Entertainment □ Agricultural/Stable □ Detention/Correctional □ Other . . . . .
Area of the PV array [m^2]	

Test with Interconnection Check-list			
PV technology	☐ Mono-crystalline silicon ☐ Multi-crystalline silicon ☐ Thin-film (specify) . . . . . ☐ Other (specify)		
Tracking system if any	☐ No tracking ☐ Single-axis tracking ☐ Two-axes tracking		
Participants			
Role	**Name**	**Affiliation**	
Test engineer (mandatory)		Independent licensed engineer	
Installer (mandatory)			
Designer (facultative)			
Inspector (facultative)		EWA	
Inspector (facultative)			
Inspector (facultative)			
Result	☐ Passed ☐ Not passed		

6.3 Documents required

6.3.1 Description

This part refers to the documents required on-site to perform the Test with Interconnection

6.3.2 Pass/fail criteria

A positive final result requires that only *Yes* or *N/A* boxes are checked.

6.3.3 Checklist

Test with Interconnection Check-list		
Documents required		
Field	**Result / Value**	**Notes**
Final design (or As-built design in case of variations)	☐ Yes ☐ No	
Test without Interconnection report	☐ Yes ☐ No	
OK for Test with Interconnection from EWA	☐ Yes ☐ No	
Result	☐ Passed ☐ Not passed	

6.4 Sensors

6.4.1 Description

This part describes the sensors used to perform the Test with Interconnection.

6.4.2 Pass/fail criteria

A positive final result requires that only *Yes* or *N/A* boxes are checked.
Furthermore, depending on the Class of the monitoring system or the measurement system adopted (A, B, or C) the cells related to the used sensors shall be properly filled.

6.4.3 Checklist

Test with Interconnection Check-list				
List of sensors				
Sensor	**Type**	**Accuracy**	**Manufacturer and model**	**Calibration**
In-plane irradiance (POA)	☐ Pyranometer ☐ PV Cell ☐ Photodiode ☐ Esteemed			☐ Yes ☐ No
Global Horizontal Irradiance	☐ Pyranometer ☐ PV Cell ☐ Photodiode ☐ Esteemed ☐ N/A			☐ Yes ☐ No ☐ N/A
PV module temperature	☐ Measured ☐ Esteemed ☐ N/A			☐ Yes ☐ No ☐ N/A
Ambient air temperature	☐ Measured ☐ Esteemed			☐ Yes ☐ No
Wind speed	☐ Measured ☐ Esteemed ☐ N/A			☐ Yes ☐ No ☐ N/A
Wind direction	☐ Yes ☐ No ☐ N/A			☐ Yes ☐ No ☐ N/A
Soiling ratio	☐ Yes ☐ No ☐ N/A			☐ Yes ☐ No ☐ N/A
Array voltage (DC)	☐ Yes ☐ No ☐ N/A			☐ Yes ☐ No ☐ N/A
Array current (DC)	☐ Yes ☐ No ☐ N/A			☐ Yes ☐ No ☐ N/A
Array power (DC)	☐ Yes ☐ No ☐ N/A			☐ Yes ☐ No ☐ N/A
Output voltage (AC)	☐ Yes ☐ No ☐ N/A			☐ Yes ☐ No ☐ N/A
Output current (AC)	☐ Yes ☐ No ☐ N/A			☐ Yes ☐ No ☐ N/A
Output power (AC)	☐ Yes ☐ No			☐ Yes ☐ No
Output energy	☐ Yes ☐ No			☐ Yes ☐ No
Output power factor	☐ Yes ☐ No ☐ N/A			☐ Yes ☐ No ☐ N/A
Reduced load demand	☐ Yes ☐ No ☐ N/A			☐ Yes ☐ No ☐ N/A
System output power factor request	☐ Yes ☐ No ☐ N/A			☐ Yes ☐ No ☐ N/A
Result	☐ Passed ☐ Not passed			

6.5 Performance test

6.5.1 Description

This part refers to the results of the Test with Interconnection calculated in the period considered.

6.5.2 Pass/fail criteria

A positive final result requires that all items are filled with correct information, except those indicated as *facultative*.
Only *Yes* or *N/A* boxes are checked in their cells.
PV plants with a Pn > 100 kW may use only a Class A or B monitoring system.

6.5.3 Checklist

Test with Interconnection Check-list		
General		
Field	**Result / Value**	**Notes**
Sampling interval [s]		
Recording interval [min]		
Start test: date and time [dd/mm/yyyy hh:mm]		
Stop test: date and time [dd/mm/yyyy hh:mm]		
Valid data in the time interval [%]		
Class of the monitoring system used	☐ A ☐ B ☐ C	
Test report		
Relevant data on the Test Engineer	☐ Yes ☐ No	
Description of the site being tested	☐ Yes ☐ No	
Description of the system being tested	☐ Yes ☐ No	
Definition of the meteorological data taken during the test	☐ Yes ☐ No	
definition of the system output data collected during the test	☐ Yes ☐ No	
Description of raw data that were collected during the test	☐ Yes ☐ No	
List of any deviations from the test procedure	☐ Yes ☐ No ☐ N/A	
Summary of the correction factors for the filtered data	☐ Yes ☐ No ☐ N/A	
Uncertainty analysis	☐ Yes ☐ No ☐ N/A	
Summary of the test results	☐ Yes ☐ No	
Performance ratios		
Test Duration (when applicable)		
Performance Ratio (PR) [%]		
Temperature-corrected Performance Ratio (PR) [%] (facultative)		
Reference correction temperature [°C] (facultative)		

Test with Interconnection Check-list	
Result	☐ Passed ☐ Not passed

6.6 Inspection and Test of the Interface Protection

6.6.1 Description

This part refers to the inspection and test of the Interface Protection and its related devices.

6.6.2 Pass/fail criteria

A positive final result requires that only *Yes* or *N/A* boxes are checked.

6.6.3 Checklist

Test with Interconnection Check-list		
Inspection and Test of the Interface Protection		
Field	**Result / Value**	**Notes**
The enabled functions of the Interface Protection are those required by EWA	☐ Yes ☐ No	
The thresholds are those required by EWA	☐ Yes ☐ No	
The times of intervention are those required by EWA	☐ Yes ☐ No	
Interface device switches off in case of power failure on command of the Interface Protection	☐ Yes ☐ No	
After a power recovery the Interface Protection recloses the Interface device	☐ Yes ☐ No	
Result	☐ Passed ☐ Not passed	

6.7 Test with Interconnection Final result

6.7.1 Description

This part reports the final outcome of the Test with Interconnection.

6.7.2 Pass/fail criteria

The Test with Interconnection will be successful (Passed) if all the checklists in the above documents give positive result (Passed).

6.7.3 Final result page

Test with Interconnection Final result		
Participants		
Role	**Name**	**Signature**

Test with Interconnection Final result		
Test engineer (mandatory)		
Installer (mandatory)		
Designer (if present)		
Inspector (if present)		
Inspector (if present)		
Inspector (if present)		
Notes		
Final result	☐ Passed ☐ Not passed	

7 POWER QUALITY MEASUREMENTS AND TESTS CHECKLIST

Power Quality Measurements and Tests applies to solar PV plants with Pn > 100 kW.

7.1 Overview

The purpose of the Quality Measurements and Test is to verify and test that the harmonic content of the power delivered by the PV plant is not harmful for the grid and is under the limits specified in the standards.
The checklist is composed by the following documents:

- General on PV plant and Participants Check-list
- Documents required Check-list
- Harmonic Tests Check-list
- Power Quality Measurements and Test final result

7.2 General on PV plant and Participants

7.2.1 Description

This part refers to the general data of the PV plant and to the data of the participants to the Power Quality Measurements and Test.

7.2.2 Pass/fail criteria

A positive final result requires that all items are filled with correct information, except *P.O. Box* and *Street name and number* that may be alternative each other.
Participants indicated as *Facultative* may be omitted if they are not present. Affiliation shall be indicated if not already present.

7.2.3 Checklist

Power Quality Measurements and Tests Check-list	
General on PV plant	
Name of the PV plant	
Nominal Power [kW]	
P.O. Box	
Street name and number	
Location / Area	
City	
Voltage delivery	□ 240 V (1 phase) □ 415 V (3 phases) □ 11 kV (3 phases)
POC	
PV module installation	□ On building □ Other structure (e.g. canopy) □ Ground
Building installation (if applicable)	□ Flat rooftop □ Roof flap □ Façade □ Other
Building type (if applicable)	□ Villa or small household □ Apartment block □ Offices □ School/University □ Healthcare/Hospital □ Industrial □ Hotel/Restaurant □ Entertainment □ Agricultural/Stable □ Detention/Correctional □ Other . . . . .
Area of the PV array [m^2]	
PV technology	□ Mono-crystalline silicon □ Multi-crystalline silicon □ Thin-film (specify) . . . . . □ Other (specify) . . . . .

Power Quality Measurements and Tests Check-list			
Tracking system if any	☐ No tracking ☐ Single-axis tracking ☐ Two-axes tracking		
Participants			
Role	**Name**	**Affiliation**	
Test engineer (mandatory)		Independent licensed engineer	
Installer (mandatory)			
Designer (facultative)			
Inspector (facultative)		EWA	
Inspector (facultative)			
Inspector (facultative)			
Result	☐ Passed ☐ Not passed		

7.3 Documents required

7.3.1 Description

This part refers to the documents required on-site to perform the Power Quality Measurement and Tests.

7.3.2 Pass/fail criteria

A positive final result requires that only *Yes* or *N/A* boxes are checked.

7.3.3 Checklist

Power Quality Measurements and Tests Check-list		
Documents required		
Field	**Result / Value**	**Notes**
Final design (or As-built design in case of variations)	☐ Yes ☐ No	
Test with Interconnection report	☐ Yes ☐ No	
Preliminary Authorization from EWA	☐ Yes ☐ No	
Result	☐ Passed ☐ Not passed	

7.4 Harmonic Tests

7.4.1 Description

This part refers to the harmonic tests made at Point of Connection of the PV plant with the public network.

7.4.2 Pass/fail criteria

A positive final result requires that all the measured values are below those indicated in the Standards for the Connection of PV Plants.

7.4.3 Checklist

Power Quality Measurements and Tests Check-list					
Voltage harmonics					
Field	**F1 (Red)**	**F2 (Yellow)**	**F3 (Blue)**	**N (Black)**	**Notes**
THD					
3rd					
5th					
7th					
9th					
11th					
13th					
15th					
Current harmonics					
THD					
3rd					
5th					
7th					
9th					
11th					
13th					
15th					
Result		☐ Passed ☐ Not passed			

7.5 Power Quality Measurements and Tests Final result

7.5.1 Description

This part reports the final outcome of the Power quality Measurements and Tests.

7.5.2 Pass/fail criteria

The Test with Interconnection will be successful (Passed) if all the checklists in the above documents give positive result (Passed).

7.5.3 Final result page

Power Quality Measurements and Tests Final result		
Participants		
Role	**Name**	**Signature**
Test engineer (mandatory)		
Installer (mandatory)		
Designer (if present)		
Inspector (if present)		

Power Quality Measurements and Tests Final result		
Inspector (if present)		
Inspector (if present)		
Notes		
Final result		☐ Passed ☐ Not passed