TESTING AND COMMISSIONING FORM OF GRID- CONNECTED PHOTOVOLTAIC SYSTEMS

SOLAR SYSTEM ABOVE 30kWAC
(USE OF STRING INVERTER IN THE PV SYSTEM)

Note: This document is prepared by referring to SEDA's procedure for Testing and Commissioning of Grid-Connected Photovoltaic Systems in Malaysia.

RESTRICTED

TESTING AND COMMISSIONING FORM

A. CUSTOMER INFORMATION

Name: _____ Contact No: _____

SESCO Contract Account No: _____ Email address: _____

GCPV Installation Address: _____

_____

B. SOLAR PV INSTALLATION DETAILS

Date of Inspection: ☐☐ / ☐☐ / ☐☐☐☐ until ☐☐ / ☐☐ / ☐☐☐☐ (dd/mm/yyyy)

Time Start: ☐☐ : ☐☐ AM/PM Time Complete: ☐☐ : ☐☐ AM/PM

Date of completion of Installation: ☐☐ / ☐☐ / ☐☐☐☐ (dd/mm/yyyy)

Import meter reading (kWh) at pre-comm session: ☐☐☐☐☐☐☐☐☐☐

Export meter reading (kWh) at pre-comm session: ☐☐☐☐☐☐☐☐☐☐

Remarks

TESTING AND COMMISSIONING FORM

C. CHECKLIST FOR GENERAL INSPECTION

Instructions: This form shall be filled-up for each sub-array connected to one inverter.	Inverter ID:	Sub-array ID:

Note: If the job has been done satisfactory, please tick "/"in the box ; If not applicable, write "N/A" in the box.

Part 1C : General

i.	All necessary safety equipment are available at the site	☐
ii.	Array frame correctly fixed and stable	☐
iii.	All cable entries are weather proof	☐
iv.	PV module location, perimeter, gate, control room & switch yard, plant internal road location as per approved layout drawing.	☐
v.	Components comply with standards and are selected as per design & not damaged	☐
vi.	Equipment accessible for inspection, operation & maintenance	☐
vii.	Equipment & accessories are connected as per approved drawing	☐
viii.	Protective measures for special locations have been addressed (if applicable)	☐
ix.	Equipment & protective measures are appropriate to external influence	☐
x.	System installed to prevent mutual detrimental influence	☐
xi.	All cables are identified and connected as per approved drawing	☐
xii.	All cables are selected for current carrying capacity and voltage drop as per approved design	☐
xiii.	Conductors routed are in safe zone or protected against mechanical damage	☐
xiv.	All tagging are appropriate.	☐
xv.	All signages are appropriate.	☐
xvi.	All relevant documents are available.	☐
xvii.	Emergency procedure displayed at site.	☐
xviii.	PV system schematic displayed at site.	☐

Part 2C : DC Side

i.	Adequate physical separation of AC, DC & communication cables.	☐
ii.	All DC components are sized for rated operation at maximum DC system voltage.	☐
iii.	All DC cables are meant for solar PV applications and as per design document.	☐
iv.	PV string fuse or DC breaker are available in the combiner boxes.	☐

Part 3C : Protection Against Over-voltage & Electric Shock

i.	Live parts are insulated and protected by barrier/enclosure, placed out of reach.	☐
ii.	Surge protection devices are available.	☐
iii.	External lightning protection system is available.	☐
iv.	PV frame grounding correctly integrated with existing installation.	☐

Part 4C : AC Side

i.	Inverter protection setting as per local regulation (labelling & identification mark)	☐
ii.	Protection setting by installers displayed at site (maximum current, range of voltage and frequency)	☐

Comments:

TESTING AND COMMISSIONING FORM

D. CHECKLIST FOR PV MODULE MOUNTING STRUCTURE & CIVIL FOUNDATION

Note: If the job has been done satisfactory, please tick "/"in the box ; If not applicable, write "N/A" in the box.

i.	Mounting structure and jointing materials as per approved drawing.	☐
ii.	Foundation dimensions as per approved drawing.	☐
iii.	Switch yard civil foundation as per approved drawing.	☐
iv.	The material for structure has corrosion proof coating (check for availability of factory test certificate).	☐
v.	Structures are correctly fixed at specific tilt and orientation as per design document.	☐
vi.	No crack found in the foundation and/or mounting structure.	☐
vii.	Structures are designed based on the maximum wind load of the location (check for availability of structure engineer certificate).	☐
viii.	No rust (for steel) or discoloration (for aluminium) found in the structure materials (e.g. frame, clamp, bolt and nuts, etc.).	☐
ix.	Water drainage is available.	☐

E. CHECKLIST FOR DC JUNCTION BOX OR STRING MONITORING BOX

Note: If the job has been done satisfactory, please tick "/"in the box ; If not applicable, write "N/A" in the box.

i.	DC Junction/String Monitoring Box connection diagram is available at the inside of the cover.	☐
ii.	Wiring is as per approved schematic.	☐
iii.	String fuses or DC circuit breakers are available.	☐
iv.	Metal casings are earthed as per design document.	☐
v.	All boxes are properly fixed at appropriate locations as per design document.	☐
vi.	Surge protections devices are available inside the box as per design document.	☐
vii.	Box and related component & insulation rating based on maximum DC voltage.	☐
viii.	Boxes for outdoor use should be suitably rated based on Malaysia climate.	☐

F. CHECKLIST FOR EARTHING AND LIGHTNING ARRESTOR

Note: If the job has been done satisfactory, please tick "/"in the box ; If not applicable, write "N/A" in the box.

i.	Earthing location as per approved drawing.	☐
ii.	Earthing conductor properly connected to metal parts of all structures.	☐
iii.	All array frames (for framed modules) and structures are earthed and bonded properly.	☐
iv.	Earthing & lightning arrestor are installed as per design document.	☐

G. CHECKLIST FOR PV MODULE INSPECTION

Note: If the job has been done satisfactory, please tick "/"in the box ; If not applicable, write "N/A" in the box.

i.	PV modules are fixed on the structure as per design drawing.	☐
ii.	PV modules are properly levelled on the structure.	☐
iii.	PV modules conform to relevant IEC standards as per design document.	☐
iv.	Inter-module connectors are properly crimped & securely connected.	☐
v.	PV modules are connected with correct polarity.	☐
vi.	Non-metallic isolator is present between each PV module frame & structure. (if they are made from different metals)	☐
vii.	Installation of PV modules are done as per manufacturer's guidelines.	☐

Comments:

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H. CHECKLIST FOR INVERTER INSPECTION

Note: If the job has been done satisfactory, please tick "/"in the box ; If not applicable, write "N/A" in the box.

i.	Inverter is installed as per manufacturer's guideline.	☐
ii.	Sufficient ventilation is available around the inverter (as per manufacturer's guideline).	☐
iii.	Inverter conforms to relevant IEC standards (or equivalent) as per design document.	☐
iv.	Inverter unit is properly fastened to floor/wall surfaces.	☐
v.	Inverter is properly earthed.	☐
vi.	Inverter incoming/outgoing cables are properly tagged.	☐
vii.	Inverter incoming/outgoing cables are properly connected as per drawing.	☐
viii.	The connections for phase sequence L1, L2 & L3 are in proper order (for three phase inverters).	☐
ix.	The connections for L and N are in proper order (for single phase inverters).	☐
x.	Inverter for outdoor use shall be suitable rated based on Malaysia climate.	☐
xi.	Gap maintained between power cables and signal cables routing as per design document.	☐
xii.	The auxiliary power cables are connected properly.	☐
xiii.	All cable terminations are done properly.	☐
xiv.	Proper labelling of all the cables and components are done.	☐
xv.	Inverter factory settings are as per local utility guidelines.	☐

I. CHECKLIST FOR AC DISTRIBUTION BOX

Note: If the job has been done satisfactory, please tick "/"in the box ; If not applicable, write "N/A" in the box.

i.	ACDB is properly mounted as per design document.	☐
ii.	Sufficient free space available around each ACDB.	☐
iii.	ACDB is properly earthed as per design document (if applicable).	☐
iv.	The connections for phase sequence L1, L2 & L3 are in proper order (for three phase inverters).	☐
v.	The connections for L and N are in proper order (for single phase inverters).	☐
vi.	Incoming/outgoing cables are properly connected as per approved schematic diagram.	☐
vii.	All cable terminations are done properly.	☐
viii.	Proper tagging of all cables and components are done.	☐
ix.	All cable glands are properly secured & tightened.	☐
x.	Boxes for outdoor use shall be suitably rated based on Malaysia climate.	☐

J. CHECKLIST FOR CABLE IDENTIFICATION AND CABLE ROUTING INSPECTION

Note: If the job has been done satisfactory, please tick "/"in the box ; If not applicable, write "N/A" in the box.

i.	All cable routed areas are properly marked on the ground.	☐
ii.	All power cable route & locations are as per drawing.	☐
iii.	All cables are properly tagged.	☐
iv.	All DC cables are meant for solar PV applications and as per design document.	☐
v.	Cable caution tape is used for all underground cables as per design document.	☐
vi.	All trunking and conduits are installed as per design document.	☐

Comments:

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K. CABLE INSULATION TEST

Note: Testing is performed on new cable installations to determine if the insulation condition.

Instructions: 1- **Switch Off / Disconnect** PV AC Main Switch (Isolator), All AC Switches, All DC Switches and All DC Fuses.
2- Isolate all cables except for inter-module connection and earthing cables.

Part K1 : Testing Equipment Detail

Insulation Resistance Tester Model : _____ Calibration Date: _____

Part K2 : Measurements Result

No.	Inverter No.	Cable Starting Point	Cable End Point	Insulation Resistance Value (MΩ)	Pass	Fail
					Please Tick "/" in the box.	

Comments:

TESTING AND COMMISSIONING FORM

L. STRING FUSE CONTINUITY AND STRING OPEN CIRCUIT VOLTAGE TEST

Note: Testing Point is at Each Array Junction Box/String Monitoring Box.

Instructions: 1- **Switch Off / Disconnect** PV AC Main Switch (Isolator), All AC Switches, All DC Switches and All DC Fuses.
2- Solar irradiance should be at least **350Wm^{-2}** when performing this test.

Determine the following:	**ACCEPT** if
1. Measured Open Circuit Voltage (Voc_mea) of each string. 2. Expected Open Circuit Voltage (Voc_exp) of each string. 3. % Difference between measured and expected Voc.	• % difference of Voc (between measured Voc and expected Voc) with respect to expected Voc is within ±5%. • Voc measured of each string is less than the maximum input voltage of the inverter • Polarity of all DC cables (string and array) is correct

Part L1 : Continuity Test of Each String Fuse

Inverter No.	Number of String	Number of String Fuse	Pass	Fail
			Please Tick "/" in the box.	

Part L2 : Measurements Result

String No.	Voc of String at STC (V)	Voc measured (V)	Voc expected (V)	Measured module temp (^{0}C)	Measured Irradiance (Wm^{-2})	% difference of Voc	Accept	Reject
							Please Tick "/" in the box.	

Comments:

TESTING AND COMMISSIONING FORM

M. STRING DC SHORT CIRCUIT CURRENT TEST

Note: Testing Point is at All DC Junction Boxes.

Instructions: 1- **Switch Off / Disconnect** PV AC Main Switch (Isolator), All AC Switches, All DC Switches and All DC Fuses.
2- Solar irradiance should be at least **350Wm^{-2}** when performing this test.

Determine the following: 1. Measured Short Circuit (Isc_mea) of each string. 2. Expected Short Circuit Voltage (Isc_exp) of each string. 3. % Difference between measured and expected Isc.	**ACCEPT** if • % difference of Isc (between measured Isc and expected Isc) with respect to expected Isc is within ±5%. AJB: Array Junction Box SMB: String Monitoring Box
Inverter No.	

Measurements Result

No.	AJB/SMB ID No.	No. of Strings per AJB/SMB	String No.	Solar Irradiance (Wm^{-2})	Measured module temp (^{0}C)	Measured Isc of String (A)	Expected Isc of String (A)	% difference of Isc	Accept	Reject
									Please Tick "/" in the box.	

Comments:

TESTING AND COMMISSIONING FORM

N. ISOLATION DEVICE FUNCTIONAL TEST

Note: Testing Point is at All Isolator, Switches and Fuses.

Instructions: 1- **Switch Off / Disconnect** PV AC Main Switch (Isolator), All AC Switches, All DC Switches and All DC Fuses.
2- Solar irradiance should be at least **350Wm^{-2}** when performing this test.

No.	Description	Accept	Reject	Note
		Please Tick "/" in the box.		
1	Confirm voltage is NOT present at array cable terminal at AJB before all fuses are engaged.			
2	Confirm voltage is present at array cable terminal at AJB after all fuses are engaged.			
3	Confirm voltage is NOT present at the outgoing terminal of PV DC Main Switch when the switch is in OFF position.			
4	Confirm voltage is present at the outgoing terminal of PV DC Main Switch when the switch is in ON position.			
5	Confirm voltage is NOT present at the outgoing terminal of AC Switch when the switch is in OFF position.			
6	Confirm voltage is present at the outgoing terminal of AC Switch when the switch is in ON position.			
7	Confirm voltage is NOT present at the outgoing terminal of PV AC Main Switch when the switch is in OFF position.			
8	Confirm voltage is present at the outgoing terminal of PV AC Main Switch when the switch is in ON position.			

Comments:

TESTING AND COMMISSIONING FORM

O. INFORMATION ABOUT PV MODULE

Number of Panel Installed		Capacity	

No.	ITEM	DETAILS		Check	NA
				Please Tick "/" in the box.	
1	Module Manufacturer & Model				
2	Power at Maximum Power Point (Pmp_stc)		Wp		
3	Open Circuit Voltage (Voc_stc)		V		
4	Short Circuit Current (Isc_stc)		A		
5	Fill factor at STC		-		
6	Module efficiency at STC		%		
7	Temperature coefficient for Pmp (at STC)		% per deg C		
8	Temperature coefficient for Voc (at STC)		% per deg C		
9	Temperature coefficient for Isc (at STC)		% per deg C		
10	Maximum System Voltage		V		
11	Maximum Reverse Current		A		

O1. INFORMATION ABOUT PV ARRAY

Note: This form shall be filled-up for each connection to each inverter.

Inverter No.	

No.	ITEM	DETAILS		Check	NA
				Please Tick "/" in the box.	
1	No. of modules per string		pcs		
2	Total no. of strings		pcs		
3	Total array power at STC		Wp		
4	PV array inclination		deg		
5	PV array orientation (azimuth angel from South)		deg		
6	No. of strings per Array Junction Box/String Monitoring Box		pcs		
7	No. of Array Junction Box/String Monitoring Box		pcs		

Comments:

TESTING AND COMMISSIONING FORM

P. INFORMATION ABOUT INVERTER

Note: This form shall be filled-up for each connection to each inverter.

Number of Inverter Installed		Capacity	

No.	ITEM	DETAILS		Check	NA
				Please Tick "/" in the box.	
1	Inverter Manufacturer & Model				
2	Inverter Type (Single Phase or Three Phase)				
3	AC/DC Ratio				
4	Nominal AC Power Rating		W		
5	Maximum AC Power Rating		W		
6	Maximum DC Voltage		V		
7	DC Voltage Range		V		
8	MPPT Voltage Range		V		
9	No. of MPPT Trackers		unit		

P1. INVERTER FUNCTIONAL TEST

Note: Testing must be done to all installed inverter.

Instructions: 1- **Switch ON** the system and ensure that the inverter is operating.
2- Solar irradiance should be at least **350Wm^{-2}** when performing this test.

CAUTION : Before switching on the inverter, make sure Voc measured at the inverter input terminal must be LESS THAN the maximum allowable input DC voltage of the inverter.

Inverter No.							
No.	Description		Value		Accept	Reject	Reasons
					Please Tick "/" in the box.		
1	Check whether the measured DC voltage falls within the allowable MPPT voltage range of the inverter.						
2	Check whether the measured grid voltage and frequency are within the acceptable limit.						
3	Anti-Islanding Functional Test (Inverter Turn OFF when grid voltage is not present or outside the operating range.)	Disconnection Time		sec			
		Reconnection Time		min			

Comments:

TESTING AND COMMISSIONING FORM

Q. ACCEPTANCE TEST

Determine the following:

1. Measured AC output power of inverter, Pac_mea
2. Expected AC output power of inverter, Pac_exp
3. Please declare the following:
   - Tolerance due to module mismatch : _____
   - Soiling index : _____
   - Ageing factor : _____
   - Cable loss : _____
   - Maximum inverter efficiency : _____
   - Shading factor : _____
4. Acceptance Ratio (AR) : _____

Note: AR is the ratio of Pac_mea to Pac_exp.

Instructions:

1- **Switch Off / Disconnect** PV AC Main Switch (Isolator), All AC Switches, All DC Switches and All DC Fuses.

2- Solar irradiance should be at least **350Wm^{-2}** when performing this test.

ACCEPT if

- AR is greater than or equal to 0.9.

Measurements Result

Inv. No.	Irradiance (Wm^{-2})	Measured module temp (^0C)	Temperature de-rating factor	Pac expected (W)	Pac measured (W)	AR	Accept	Reject
							Please Tick "/" in the box.	

*If AR is not acceptable, pleae troubleshoot the system, rectify the fault and repeat the test until all parties are satisfied.

Comments:

TESTING AND COMMISSIONING FORM

R. PERFORMANCE RATIO TEST

Using the logged data for one day during the reliability test period, determine the following parameters for the entire system:

1. Energy Yield, Y_f
2. Specific Yield, SY
3. Perf

$$PR = \frac{Y_f}{\eta_{mod} \times A_{PV} \times H}$$

η_{mod} = is efficiency of module (decimal)
A_{PV} = is area of array (m^2)
H = solar irradiation (kWh/m^2)

ACCEPT if

- PR is greater than or equal to 0.8

Note: 1. Testing point is at Monitoring Station/Grid Injection Point.

2. Inverter failure **shall NOT occur more than once (1)** within the reliability test period of one day (excluding forced outages). If this happens, the test should be repeated.

3. If the PR Test is passed the first day, it is **not** necessary to continue to the second day.

During the Performance Ratio (PR) test, the following real time parameters must be sampled at a maximum of **five-minute** intervals for **AT LEAST ONE COMPLETE daylight beginning one hour before sunrise and ending at least one hour after sunset**:

1. Solar irradiance
2. Ambient temperature
3. Module temperature
4. DC voltage of each central inverter or group of string inverters
5. DC current of each central inverter or group of string inverters
6. AC voltage from each central inverter or group of string inverters
7. AC current from each central inverter or group of string inverters

Measurements Result

Day no.	Energy Yield (kWh)	Specific Yield (kWh kWp^{-1})	Performance Ratio (AR)	Accept	Reject	Remarks
				Please Tick "/" in the box.		
1						
2						
3						
4						
5						
6						
7						
One Week Value						

Comments:

TESTING AND COMMISSIONING FORM

S. POWER QUALITY - HARMONICS *(The requirement is specific in Section 6.1 Grid Performance Characteristics)*

Harmonic	50% of rated output	100% of rated output	Limit in Engineering Recommendation G5/5 (in %)
	Measured value in %	Measured value in %	
2			
3			
4			
5			
6			
7			
8			
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TESTING AND COMMISSIONING FORM

S1. POWER QUALITY – FLICKER *(The requirement is specific in Section 6.1 Grid Performance Characteristics)*

Test Start Date:				
Test End Date:				
Test Location:				
Description	50%		100%	
	Short Term Flicker	Long Term Flicker	Short Term Flicker	Long Term Flicker
Measured Value				
Limit set under Engineering Recommendation P28				

T. VOLTAGE DETAILS

Description	RED Phase		YELLOW Phase		BLUE Phase	
	V	%	V	%	V	%
Steady State Voltage Measurement (30mins)						
Step Voltage Change During Energization						
Step Voltage Change During Disconnection						
Voltage Unbalance Measurement (30mins)						

U. VOLTAGE PROTECTION AND FREQUENCY PROTECTION TEST *(The is specific in Section 6.1 Grid Performance Characteristics)*

Function	Setting		Trip Test		Limit		Pass / Fail
	Frequency (Hz)	Time Delay	Frequency (Hz)	Time Delay	Setting	Time Delay	
UnderVoltage Stage 1					-13%	2.5s	
UnderVoltage Stage 2					-20%	0.5s	
Overvoltage Stage 1					13%	2.5s	
Overvoltage Stage 2					20%	0.5s	
Underfrequency Stage 1					47.5Hz	9.0s	
Underfrequency Stage 2					47Hz	0.25s	
Overfrequency Stage 1					51.5Hz	2.0s	
Overfrequency Stage 2					52Hz	0.25s	

V. PROTECTION RECONNECTION TIMER

- Test should prove that the reconnection sequence starts after a minimum delay of 2 minutes for restoration of volage and frequency to within stage 1 setting

Description	Check on no reconnection when voltage or frequency is brought to just outside Stage 1 limits					
	Single Phase		Three Phase		Frequency	
	192V	288V	332V	498V	47Hz	52Hz
Time delay setting						
Measured delay						

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W. Self Monitoring Solid State Switching For Inverter

Description	Yes or No
It has been verified that in the event of the solid state switching device failing to disconnect the PV solar, the voltage on the output side of the siwthcing device is reduced to value below 50V within 0.5 seconds	

X. Fault Level Contribution ***(from OEM Datasheet)***

Parameter	Symbol	Value
Peak Short Circuit Current	i_p	
Initial Symmetrical Short-Circuit Current	I_k	
Decaying (aperiodic) component of short-circuit current	i_{DC}	
Reactance / Resistance Ratio of source	X/R	

Y. Testing and Commissioning Acceptance

We, the undersigned, hereby declare and confirm that all information provided in this Testing and Commissioning Form is true, accurate, and complete, and has been submitted in full compliance with the requirements of the MS1837 and the associated IEC standards stipulated within it, Net Energy Metering (NEM) Guideline or Self-Consumption (SELCO) Guideline and Electricity (State Grid Code) Rules 2003.

We further affirmed that the installed PV system has been tested and verified, and is in full compliance with all applicable power quality standards and requirements as outlined in the NEM guidelines or SELCO guideline, thus the system is considered passed and safe to be energized.

We acknowledge and accept that the installed system shall not cause any disturbance, interference, or adverse impact to adjacent customers or Syarikat SESCO Berhad (SESCO) grid network. SESCO reserves the right to disconnect the Grid-Connected Photovoltaic (GCPV) system or the electricity supply to the premises in the event of any safety concerns, interference with other customers, or disruption to SESCO's supply network.

We accept full responsibility for any discrepancies, inaccuracies, misrepresentations, or non-compliance arising from the submitted information or the performance of the installed system.

Furthermore, we agree that SESCO shall not be held liable for any indirect, incidental, punitive, exemplary, special, or consequential damages, including but not limited to loss of profits or revenue, business interruption, loss of use or goodwill, data loss, corruption or deletion (or failure to delete), or costs of substitute goods, arising from any discrepancies, inaccuracies, misrepresentations, or non-compliance related to the submitted information or the performance of the installed system.

Signature and Stamp	
Date	
Name	
Designation	Tested by EIU Certified GCPV Designer

End of Document