TEST REPORT
IS 17980:2022/IEC 62891:2020
Maximum Power Point Tracking Efficiency of Grid Connected Photovoltaic Inverters

Report reference number.............: Date of issue..................................: Total number of pages....................:	
Testing laboratory name...............: Address...: Accreditation...................................:	
Manufacture's name..........................: Address...:	
Test specification Standard...:	**IS 17980:2022/IEC 62891:2020**
Test Report Form No.......................: TRF Originator.................................: Master TRF.....................................:	
Test item description.....................: Trademark.......................................: Model/Type...................................:	

Testing Location..........................: Address..:
Tested by (name and signature).......................:   Approved by (name and signature).......................:
Manufacturer's name....................: Manufacturer address.....................:

Test item particulars .... : **Maximum Power Point Tracking Efficiency of Grid Connected Photovoltaic Inverters**
Equipment mobility ....: [ ] movable [ ] hand-held [ ] stationary [ ] fixed [ ] transportable [ ] for building-in
Connection to the mains ....: [ ] pluggable equipment [ ] direct plug-in [ ] permanent connection [ ] for building-in
Environmental category .... : [ ] outdoor [ ] indoor unconditional [ ]indoor conditional
Over voltage category Mains ....: [ ] OVC I [ ] OVC II [ ] OVC III [ ] OVC IV
Over voltage category PV ....: [ ] OVC I [] OVC II [ ] OVC III [ ] OVC IV
Mains supply tolerance (%)..:
Tested for power system ....:
IT testing, phase-phase voltage (V) ....:
Class of equipment ....: [ ] Class I [ ] Class II [ ] Class III [ ] Not classified
Mass of equipment (kg) ....:
Pollution degree ....:
IP protection class ....:

Possible test case verdicts:
- test case does not apply to the test object .... : N/A (Not Applicable)
- test object does meet the requirement .... : P (Pass)
- test object was not evaluated for the requirement .... : N/E
- test object does not meet the requirement .... : F (Fail)

Testing
Date of receipt of test item...............:
Date(s) of performance of test.........:

General remarks:
The test results presented in this report relate only to the object tested.
This report shall not be reproduced, except in full, without the written approval of the Issuing testing laboratory.

Copy of marking plate:

General product information:

Differences between the models:

Model tested with-in the family series:

IS 17980:2022/IEC 62891:2020			
Clause	Requirement + Test	Result-Remark	Verdict
4	**MPPT efficiencies**		
4.1	**General description**		
	The MPPT efficiency describes the accuracy of an inverter to set its operating conditions to match the maximum power point on the characteristic curve of a PV generator. The overall MPPT efficiency is divided into static and dynamic efficiency components		
	Because inverters with poor MPPT performance operate at a DC input voltage that is different from MPP voltage, and static power conversion efficiency depends on DC input voltage, the measurements of static MPPT efficiency and static power conversion efficiency according to 4.3 shall be performed simultaneously.		
	a) Static MPPT efficiency The static MPPT efficiency is determined by means of measurement as follows: $\eta_{MPPTstat} = \frac{1}{P_{MPP,PVS} \cdot T_M} \sum_i V_{DC,i} \cdot I_{DC,i} \cdot \Delta T$ The static MPPT efficiency describes the accuracy of an inverter to regulate on the maximum power point on a given static characteristic curve of a PV generator. $V_{DC,i}$ and $I_{DC,i}$ shall be sampled at the same time.		
	b) Dynamic MPPT efficiency Variations of the irradiation intensity and the resulting transition of the inverter to the new operation point are not considered with the static MPPT efficiency. For the evaluation of this transient characteristic the dynamic MPPT efficiency is specified. The dynamic MPPT efficiency is defined as: $\eta_{MPPTdyn} = \frac{1}{\sum_j P_{MPP,PVS,j} \cdot \Delta T_j} \sum_i V_{DC,i} \cdot I_{DC,i} \cdot \Delta T_i$		
4.2	**Test set-up** The generic test set-up for single phase grid connected inverters is depicted in Figure 1. The diagram can also be considered as a single-phase representation of a test-circuit for multi phase inverters.		
4.3	**Static MPPT efficiency**		
4.3.1	**Test conditions** The measurement of the conversion and static MPPT efficiency shall be performed simultaneously with test specifications as defined in Table 1.		
	For test devices with several independent MPPT input terminals, the measurements shall be performed for all input configurations as intended by the manufacturer. Unless otherwise provided by the manufacturer, the total power shall be split equally on the individual input terminals.		
	The measurement shall be performed at nominal grid voltage $V_{AC,r}$ in order to avoid any impact of the grid voltage level on the measurement results. Deviations shall be documented in the measurement report.		
	The measurement should be performed at an ambient temperature of 25 °C ± 5 °C. Other ambient temperatures can be mutually agreed. The actual ambient temperature shall be specified in the test report.		
4.3.2	**Measurement procedure**		
	For each of the above specified test conditions a corresponding I/V characteristic has to be defined which shall be emulated by means of the PV simulator.		
	After commissioning the device under test the stabilization of the MPP tracking shall be awaited firstly.		
	Given the multitude of various MPPT methods and their parameters, a specific waiting period is not defined in this standard. The stabilization		

	time depends on the characteristics of the device under test and shall be set accordingly in each case. The stabilization time shall be documented in the test report. If a stabilisation of the MPPT can't be observed due to the behaviour of the device under test, a latency of at least 5 min is defined.		
	The measuring time for each test condition as specified in Table 1 amounts to 10 min. For the first power level of each MPP voltage setting, the stabilisation of the MPPT-tracker has to be awaited. If a stabilisation cannot be observed a stabilisation time of at least 5 min is defined.		
	After a change of the power level a general stabilisation period of 2 min should be used. Data recorded during the stabilisation periods are not to be considered for the calculation of the static MPPT and conversion efficiency.		
	After the stabilisation of the MPP tracking the following parameters shall be logged: – $P_{MPP,PVS}$; MPP power provided by the PV simulator; – P_{DC}; measured input power of the device under test; – $V_{MPP,PVS}$; MPP voltage provided by the PV simulator; – $I_{MPP,PVS}$; MPP current provided by the PV simulator; – I_{DC}; measured input current of the device under test. – P_{AC}; measured AC output power of the device under test		
	Both the sampling and recording rate are not specified. However, they shall be sufficiently high in order to map the specific MPP tracking behaviour of the device under test correctly. This covers in particular the fluctuation of the input voltage appearing at PV inverters with a multiple of the grid frequency. V_{DC} may be calculated from P_{DC} and I_{DC}.		
4.3.3	**Evaluation – Calculation of static MPPT efficiency**		
	For each measured power level specified in Table 1, static MPPT efficiency η_{MPPT} shall be calculated as energetic averages according to the definitions 3.4.2 and 3.4.1. The results shall be documented in the measurement report for each test condition according to Table 1.		
	Furthermore, modifications of the internal setting of the device under test, conspicuous behaviour during the measurement, as well as variations from the defined procedure, shall be documented.		
4.4	**Test conditions for dynamic MPPT efficiency**		
4.4.1	**Dynamic MPPT efficiency**		
	The measurement of the dynamic MPPT efficiency shall be performed according to the test conditions as outlined in the tables in Annex B.		
	The dynamics of the test sequences are generated by changes in solar irradiance. Measurements shall be performed with a c-Si PV model as a basis and can additionally be made with a TF model (see Table C.1). The chosen model (PV technology) shall be documented in the report.		
	Dynamic MPPT efficiency test shall be performed at rated DC voltage. For test devices with several independent MPPT input terminals, the measurements shall be performed for all input configurations as intended by the manufacturer. Unless otherwise provided by the manufacturer, the total power shall be split equally on the individual input terminals.		
	The measurement should be performed at an ambient temperature of 25 °C ± 5 °C. Other ambient temperatures can be mutually agreed upon. The actual ambient temperature shall be specified in the test report.		
4.4.2	**Measurement procedure**		
	For each of the test conditions specified in Annex B, a corresponding I/V characteristic shall be defined and shall be emulated by means of the PV simulator. A radiation intensity of 1000 W/m2 is related to the rated DC power $P_{DC, r}$ of the device under test. Prior to each test sequence a waiting period (initial set-up time) shall be implemented to allow the stabilization of the device under test. Values measured during this initial set-up time are not considered for calculation of the dynamic MPPT efficiency according to 4.4.3.		

	Given the multitude of various MPPT methods and their parameters, a specific waiting period is not defined in this standard. The stabilization time depends on the characteristics of the device under test and shall be set accordingly in each case. The stabilization time shall be documented in the test report. If a stabilisation of the MPPT cannot be observed due to the behaviour of the device under test, a latency of at least 5 min is defined.		
	For the evaluation and the determination of the dynamic MPPT efficiency the following parameters are to be recorded during the measurement: – *P*MPPPVS; MPP power provided by the PV simulator; – *P*DC; measured input power of the device under test; – *V*MPP,PVS; MPP voltage provided by the PV simulator; – *V*DC; measured input voltage of the device under test; – *I*MPP,PVS; MPP current provided by the PV simulator; – *I*DC; measured input current of the device under test.		
	Both the sampling and recording rate are not specified. However, they shall be sufficiently high in order to map the specific MPP tracking behaviour of the device under test correctly. This covers in particular the fluctuation of the input voltage appearing at PV inverters with a multiple of the grid frequency. *V*DC and *I*DC shall be sampled at exactly the same time. *P*DC may be calculated from *V*DC and *I*DC.		
4.4.3	**Evaluation - Calculation of the dynamic MPPT efficiency**		
	The overall dynamic MPPT efficiency is the mean value of the single dynamic MPPT efficiencies of the test sequences according to Table B.1 and Table B.2. It is calculated by: $\eta_{\text{MPPTdyn},t} = \frac{1}{N}\sum_{i=1}^{N} a_i \cdot \eta_{\text{MPPTdyn},i}$		
	For each test sequence specified in Annex B the dynamic MPPT efficiency *η*MPPT,dyn is to be calculated based on the recorded data according the definition. The results are to be documented in the measuring report.		
	For each test sequence the calculated MPPT efficiency is to be documented with a table in the measuring report.		
	Furthermore, modifications of the internal setting of the device under test, conspicuous behaviour during the measurement, as well as variations from the defined procedure, shall be documented.		
5	**Calculation of the overall efficiency**		
	The DC power is converted to the AC power *P*AC by means of the conversion efficiency ηconv. The actual DC power *P*DC of the device under test is the product of the static MPPT efficiency ηMPPTstat and the MPP power provided by the PV simulator *P*MPP, PVS: $P_{\text{AC}} = \eta_{\text{conv}} \cdot P_{\text{DC}} = \eta_{\text{conv}} \cdot \eta_{\text{MPPTstat}} \cdot P_{\text{MPP,PVS}} = \eta_t \cdot P_{\text{MPP, PVS}}$ The overall efficiency ηt can also be considered as: $\eta_t = \eta_{\text{conv}} \cdot \eta_{\text{MPPTstat}} = \frac{P_{\text{AC}}}{P_{\text{MPP,PVS}}}$ This Formula is to be applied for each power and voltage level of Table 1. By the application of EUR and CEC weighting factors according to Clause D.1 and Clause D.2, the efficiencies can summarised for each voltage level (*V*MPPmax, *V*DC,r, *V*MPPmin). As a result, the weighted overall efficiencies *η*t,EUR and *η*t,CEC are obtained.		

TABLE 1	**Test specifications for static MPPT efficiency**								
MPP voltage of the simulated I/V characteristic of the PV generator	**Simulated I/V Characteristic (see Annex C)**	**MPP power of the simulated I/V characteristic normalised to rated DC power d, *P*MPP,PVS/*P*DC,r f**							
*V*MPP max or (0,8 · *V*DCmax a,c)	c-Si	0,05	0,10	0,20	0,25	0,30	0,50	0,75	1,00
*V*DC,r e	c-Si								
*V*MPP min	c-Si								
*V*MPP max or (0,7 · *V*DC max a,c)	TF								
*V*DC,r	TF								
*V*MPP min	TF								

Cl. 4.3	**TABLE: Static MPPT efficiency**								
	Ambient temperature:								
Grid simulator voltage:									
Partial MPP power $P_{MPP,PVS}/P_{DC,r}$ [%]		5	10	20	25	30	50	75	100
☒ c-Si									
V_{mppmax}.	$P_{MPP,PVS}$ [W]								
	P_{DC} [W]								
	V_{DC} [V]								
	$I_{MPP,PVS}$ [A]								
	I_{DC} [A]								
	P_{AC} [W]								
	Time [s]								
	W_{AC} [Wh]								
	W_{DC} [Wh]								
	η_{conv} [%]								
	η_{t} [%]								
	η_{MPP} [%]								
	$\eta_{MPPTstat,EUR}$ [%]								
	$\eta_{t,EUR}$ [%]								
	$\eta_{MPPTstat,CEC}$ [%]								
	$\eta_{t,CEC}$ [%]								
$V_{DC,r}$	$P_{MPP,PVS}$ [W]								
	P_{DC} [W]								
	V_{DC} [V]								
	$I_{MPP,PVS}$ [A]								
	I_{DC} [A]								
	P_{AC} [W]								
	Time [s]								
	W_{AC} [Wh]								
	W_{DC} [Wh]								
	η_{conv}								
	η_{t}								
	η_{MPP} [%]								
	$\eta_{MPPTstat,EUR}$ [%]								
	$\eta_{t,EUR}$ [%]								
	$\eta_{MPPTstat,CEC}$ [%]								
	$\eta_{t,CEC}$ [%]								
	$P_{MPP,PVS}$ [W]								

	P_{DC} [W]								
	V_{DC} [V]								
	$I_{MPP,PVS}$ [A]								
	I_{DC} [A]								
	P_{AC} [W]								
V_{mp} pmin .	Time [s]								
	W_{AC} [Wh]								
	W_{DC} [Wh]								
	η_{conv}								
	η_t								
	η_{MPP}								
	$\eta_{MPPTstat,\mathit{EUR}}$ [%]								
	$\eta_{t,EUR}$ [%]								
	$\eta_{MPPTstat,\mathit{CEC}}$ [%]								
	$\eta_{t,CEC}$ [%]								

Note:

c-Si : cSi-technology TF: Thin film technology

$P_{MPP,PVS}$: MPP power provided by the PV simulatorP_{DC}: measured input power of the device under test V_{DC}: measured input voltage of the device under test$I_{MPP,PVS}$: MPP current provided by the PV simulator I_{DC}: measured input current of the device under test

$\eta_{MPPTstat,\mathit{EUR}}$ = 0,03x$\eta_{MPP_5\%}$ + 0,06x$\eta_{MPP_10\%}$ + 0,13x$\eta_{MPP_20\%}$ + 0,1x$\eta_{MPP_30\%}$ + 0,48x$\eta_{MPP_50\%}$ + 0,2x$\eta_{MPP_100\%}$

$\eta_{MPPTstat,\mathit{CEC}}$ = 0,04x$\eta_{MPP_10\%}$ + 0,05x$\eta_{MPP_20\%}$ + 0,12x$\eta_{MPP_30\%}$ + 0,21x$\eta_{MPP_50\%}$ + 0,53x$\eta_{MPP_75\%}$ +0,05x$\eta_{MPP_100\%}$

η_t= P_{AC}/ $P_{MPP,PVS}$

Cl. 4.4	TABLE: Test conditions for dynamic MPPT efficiency							
Ambient temperature:								
Test sequence with ramps 10%-50%								
From-to W/m²	Delta W/m²		Dwell time s			Waiting time s		
100-500	400					300		
No.	Slope W/m²/s	Ramp ups	Dwell time	Ramp down	Dwell time	Duration	ηMPP,dyn,I %	Overall efficiency
2	0.5	800	10	800	10	3540		
2	1	400	10	400	10	1940		
3	2	200	10	200	10	1560		
4	3	133	10	133	10	1447		
6	5	80	10	80	10	1380		
8	7	57	10	57	10	1374		
10	10	40	10	40	10	1300		
10	14	29	10	29	10	1071		
10	20	20	10	20	10	900		
10	30	13	10	13	10	767		
10	50	8	10	8	10	660		

Test sequence with ramps 30%-100%								
From-to W/m²	Delta W/m²		Dwell time s			Waiting time s		
300-1000	700					300		
No.	Slope W/m²/s	Ramp ups	Dwell time	Ramp down	Dwell time	Duration	ηMPP,dyn,I %	Overall efficiency
10	10	70	10	70	10	1900		
10	14	50	10	50	10	1500		
10	20	35	10	35	10	1200		
10	30	23	10	23	10	967		
10	50	14	10	14	10	780		
10	100	7	10	7	10	640		
Start up and shut-down test with slow ramps								
From-to W/m²	Delta W/m²		Dwell time s			Waiting time s		
10-100	90					300		
No.	Slope W/m²/s	Ramp ups	Dwell time	Ramp down	Dwell time	Duration	ηMPP,dyn,I %	Overall efficiency
1	0.1	980	30	980	30	2320		
Note:								

Photographs of Equipment

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