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

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Trademark
Model/Type

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

	r Point Tracking Efficiency of Grid Connected Photovoltaic Inverters
	ble [ ] hand-held [ ] stationary [ ] fixed [ ] transportable [ ] for building-in
Connection to the mains	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 obj	ect tested.
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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:		
	$\eta_{\text{MPPTstat}} = \frac{1}{R_{\text{MPP,PVS}} \cdot T_{\text{M}}} \sum_{i} V_{\text{DC},i} \cdot I_{\text{DC},i} \cdot \Delta T$		
	$\eta_{\text{MPPTstat}} = \frac{1}{R_{\text{MPPPVS}} \cdot T_{\text{M}}} \sum_{i} \eta_{\text{DC},i} \cdot \eta_{\text{DC},i} \cdot \Delta T$		
	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.		
	VDC, i and IDC, 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:		
	$\eta_{\text{MPPTdyn}} = \frac{1}{\sum R_{\text{MPP,PVS},j} \cdot \Delta T_j} \sum_{i} V_{\text{DC},i} \cdot I_{\text{DC},i} \cdot \Delta T_i$		
	$MPPTdyn = \sum R_{MPP, PVS, i} \Delta T_i = \sum_i PDC_i DC_i \Delta T_i$		
	<u></u> j		
4.2	Test set-up		
7.2	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 VAC,r in		Ī
	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:	
	– <i>P</i> MPP,PVS; MPP power provided by the PV simulator;	
	– PDC; measured input power of the device under test;	
	– VMPP, PVS; MPP voltage provided by the PV simulator;	
	– /MPP,PVS; MPP current provided by the PV simulator;	
	– /DC; measured input current of the device under test.	
	– <i>P</i> 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.	
4.2.2	VDC may be calculated from PDC and IDC.	
4.3.3	Evaluation – Calculation of static MPPT efficiency	
	For each measured power level specified in Table 1, static MPPT	
	efficiency $\eta$ 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 $\pm$ 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 <i>P</i> 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.	

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<ul> <li>– /MPP,I</li> <li>– /DC; r</li> <li>Both the shall be behavio</li> <li>This cov at PV inv be samp</li> <li>PDC main at PV construction of the structure of the samp</li> <li>PDC main at PDC main and Tab</li> <li>PMPF</li> <li>For each efficience according measuri</li> <li>For each docume</li> <li>Furtherr</li> </ul>	VS; MPP current provided by the PV simulator; teasured input current of the device under test. sampling and recording rate are not specified. However, they ufficiently high in order to map the specific MPP tracking irr of the device under test correctly. ters in particular the fluctuation of the input voltage appearing erters with a multiple of the grid frequency. VDC and /DC shall ed at exactly the same time. be calculated from VDC and /DC. on - Calculation of the dynamic MPPT efficiency all dynamic MPPT efficiency is the mean value of the single MPPT efficiencies of the test sequences according to Table B.1 e B.2. It is calculated by: Tdyn, $t = \frac{1}{N} \sum_{i=1}^{N} a_i \cdot \eta_{MPPTdyn,i}$ test sequence specified in Annex B the dynamic MPPT
<ul> <li>– /DC; r</li> <li>Both the shall be behavio</li> <li>This cov at PV inv be samp PDC mains</li> <li>4.4.3</li> <li>Evaluati and Tab</li> <li>MPF</li> <li>For each efficience accordin measuri</li> <li>For each docume</li> <li>Furtherr</li> </ul>	neasured input current of the device under test.sampling and recording rate are not specified. However, they ufficiently high in order to map the specific MPP tracking ir of the device under test correctly.ers in particular the fluctuation of the input voltage appearing erters with a multiple of the grid frequency. VDC and IDC shall ed at exactly the same time.be calculated from VDC and IDC.on - Calculation of the dynamic MPPT efficiencyall dynamic MPPT efficiency is the mean value of the single MPPT efficiencies of the test sequences according to Table B.1 e B.2. It is calculated by:Tdyn, $t = \frac{1}{N} \sum_{i=1}^{N} a_i \cdot \eta_{MPPTdyn,i}$ test sequence specified in Annex B the dynamic MPPT
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4.4.3 Evaluati The ove dynamic and Tab //MPF For each efficienc accordir measuri For each docume Furtherr	on - Calculation of the dynamic MPPT efficiency       Image: mail of the dynamic MPPT efficiency is the mean value of the single         MPPT efficiencies of the test sequences according to Table B.1       Image: mail of the dynamic mail of the dynamic mean value of the single         MPPT efficiencies of the test sequences according to Table B.1       Image: mail of the dynamic mean value of the single         Tdyn,t       = $\frac{1}{N} \sum_{i=1}^{N} a_i \cdot \eta_{MPPTdyn,i}$ test sequence specified in Annex B the dynamic MPPT       Image: mail of the dynamic mean value of the dynamic mean value of the single
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For each efficienc accordir measuri For each docume Furtherr	$Tdyn,t = \frac{1}{N} \sum_{i=1}^{N} a_i \cdot \eta \text{MPPTdyn},i$ test sequence specified in Annex B the dynamic MPPT
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For each efficienc accordir measuri For each docume Furtherr	test sequence specified in Annex B the dynamic MPPT
efficienc accordir measuri For each docume Furtherr	
accordir measuri For each docume Furtherr	unMPDT due is to be calculated based on the recorded data
measuri For each docume Furtherr	$\eta$ MPPT, dyn is to be calculated based on the recorded data
For each docume Furtherr	g the definition. The results are to be documented in the
docume Furtherr	g report.
Furtherr	test sequence the calculated MPPT efficiency is to be
	ited with a table in the measuring report.
test, cor	nore, modifications of the internal setting of the device under
	spicuous behaviour during the measurement, as well as
	s from the defined procedure, shall be documented.
5 Calculat	on of the overall efficiency
The DC I	ower is converted to the AC power PAC by means of the
conversi	on efficiency ηconv.
The actu	al DC power PDC of the device under test is the product of the
	PPT efficiency nMPPTstat and the MPP power provided by the
	ator <i>P</i> MPP, PVS:
$P_{AC} = r$	$p_{DC} = \eta_{conv} \cdot \eta_{MPPTstat} \cdot P_{MPP,PVS} = \eta_t \cdot P_{MPP,PVS}$
The ove	all efficiency nt can also be considered as:
	P
$\eta_t = \eta_t$	PAC.
	$\text{conv} \cdot \eta \text{MPPTstat} = \frac{I' \text{AC}}{D}$
	$P_{\text{MPPTstat}} = \frac{P_{\text{AC}}}{P_{\text{MPP,PVS}}}$
11. DV LIIG	nula is to be applied for each power and voltage level of Table
	nula is to be applied for each power and voltage level of Table application of EUR and CEC weighting factors according to
Clause D	nula is to be applied for each power and voltage level of Table
$\eta_t = \eta_t$ This For	

TABLE 1	Test specifications for static MPPT efficiency									
simulated I/V	Simulated I/V Characteristic (see Annex C)	MPP power of the simulated I/V characteristic normalised to rated DC power d, PMPP,PVS/PDC,r f								
VMPP max or (0,8 · VDCmax a,c)	c-Si	0,05	0,10	0,20	0,25	0,30	0,50	0,75	1,00	
<i>V</i> DC,r e	c-Si									
VMPP min	c-Si									
VMPP max or (0,7 · VDC max a,c)	TF									
VDC,r	TF									
VMPP min	TF									

Cl. 4.3	TABLE: Static MPPT efficie	ency							
	Ambient temperature:								
Grid simula	ator voltage:			T	1	1	1	1	r
	ial MPP power	5	10	20	25	30	50	75	100
	PP,PVS <sup>/P</sup> DC, r [%]								
🛛 c-Si						1	1	1	
	PMPP,PVS [W]								
-	P <sub>DC</sub> [W]								
-	V <sub>DC</sub> [V]								
	I <sub>MPP,PVS</sub> [A]								
	I <sub>DC</sub> [A]								
V <sub>mp</sub>	P <sub>AC</sub> [W]								
pma	Time [s]								
х.	WAC [Wh]								
	WDC [Wh]								
	η <sub>conv</sub> [%]								
-	η <sub>t</sub> [%]								
	η <sub>MPP</sub> [%]								
	ባMPPTstat <i>,EUR</i> [%]					•	•	1	
	ባt,EUR [%]								
	ባMPPTstat, <i>CEC</i> [%]								
-	٩t,CEC [%]								
	PMPP,PVS [W]								
-	P <sub>DC</sub> [W]								
-	V <sub>DC</sub> [V]								
-	IMPP,PVS [A]								
V <sub>DC,r</sub>	I <sub>DC</sub> [A]								
-	P <sub>AC</sub> [W]								
-	Time [s]								
-	WAC [Wh]								
-	WDC [Wh]								
ŀ	ηconv								
ŀ	η <sub>t</sub>								
-	η <sub>мрр</sub> [%]								
-	ካMPPTstat, <i>EUR</i> [%]			1	1	1	1	1	<u> </u>
ŀ	nt,EUR [%]								
ŀ	nMPPTstat, <i>CEC</i> [%]								
-	nt,CEC [%]								
	PMPP,PVS [W]								

1		 	1	1	r	 r	
	P <sub>DC</sub> [W]						
	V <sub>DC</sub> [V]						
	IMPP,PVS [A]						
	I <sub>DC</sub> [A]						
V <sub>mp</sub> pmin	P <sub>AC</sub> [W]						
	Time [s]						
	WAC [Wh]						
	W <sub>DC</sub> [Wh]						
	ηconv						
	η <sub>t</sub>						
	ηmpp						
	ካMPPTstat <i>,EUR</i> [%]						
	٩t,EUR [%]						
	nMPPTstat,CEC [%]						
	٩t,CEC [%]						

Note:

c-Si : cSi-technology TF: Thin film

technology

 $P_{MPP,PVS}$ : MPP power provided by the PV simulator  $P_{DC}$ : measured input

power of the device under test V<sub>DC</sub>: measured input voltage of the

device under test  $I_{\text{MPP,PVS}}$ : MPP current provided by the PV simulator  $I_{\text{DC}}$ :

measured input current of the device under test

nMPPTstat,*EUR* = 0,03xnMPP\_5% + 0,06xnMPP\_10% + 0,13xnMPP\_20% + 0,1xnMPP\_30% + 0,48xnMPP\_50% + 0,2xnMPP\_100% nMPPTstat,*CEC* = 0,04xnMPP\_10% + 0,05xnMPP\_20% + 0,12xnMPP\_30% + 0,21xnMPP\_50% + 0,53xnMPP\_75% + 0,05xnMPP\_100% nt = PAC/ PMPP,PVS

Cl. 4.4 TABLE: Test conditions for dynamic MPPT efficiency												
			Am	bient temperat	ture:							
	Test sequence with ramps 10%-50%											
From-to W/m <sup>2</sup>	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	ባMPP,dy n,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/m <sup>2</sup>	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	ካMPP,dy n,l %	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 sl	hut-down test v	vith slow ramp	S						
From-to W/m <sup>2</sup>	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	ካMPP,dy n,l %	Overall efficiency				
1	0.1	980	30	980	30	2320						
				Note:								

Photographs of Equipment

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