Renewable Power Plant

Grid Code Compliance Test Guideline

Rev 3.0

Comments to this document can be forwarded to:
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1. Introduction

This document describes the testing procedure to be conducted by the *RPP generator* to verify the performance of the *RPP* compliance to GRID CONNECTION CODE FOR RENEWABLE POWER PLANTS (RPPs) CONNECTED TO THE ELECTRICITY TRANSMISSION SYSTEM (TS) OR THE DISTRIBUTION SYSTEM (DS) IN SOUTH AFRICA (herein referred to as RE Code) compliance, as amended.

The purpose of this test procedure is to guide the *RPP generator to* cover all aspects of the RE Code requirements. The RPP generator shall ensure compliance to clause 14 of the RE Code as amended.

2. Pre-requisites for RETEC Site Tests Witnessing

2.1 Minimum Requirements for RPP Grid Code Compliance Test Scheduling

The following documents shall be submitted at least two weeks before the proposed grid code compliance tests dates.

2.1.1 An official NSP approval certificate, with supporting documents (test results), from the *RPP generator* of a fully commissioned (Signal testing and functionality) *SCADA* from the *NSP/ SO controller* to the *RPP* Power Park Controller.

2.1.2 An official NSP approval certificate with supporting documents (test results and settings) from the RPP generator of a fully commissioned (PGU & PUC) Protection schemes.

2.1.3 An Official NSP approval certificate with supporting documents (test results) from the RPP generator of fully commissioned facility Metering equipment.

2.1.4 Power Park Controller and generator (Inverter/ Turbine) settings.

2.1.5 Dry Run Tests results and a report (as per RPP test procedure) are to be submitted.

2.1.6 Submission of an officially approved System Operating Agreement (SOA) or equivalent.

2.1.7 Weather forecast expressed in active power output (MW). This forecast shall be updated daily until the day of testing (starting two weeks before the scheduled Grid Code Compliance Test dates).

2.1.8 Fully completed checklist for inspections of substations/transformers stations as per RETEC test procedure guideline.

2.2 Format of Data

2.2.1 RPP generators shall submit all data in standard formats to the relevant NSP/ SO where necessary.

2.2.2 Unless otherwise agreed, submissions shall be in the following file formats.

i. Specifications, Statements, Agreements and Technical Reports in PDF format
ii. Signed Documents in scanned PDF format.
iii. Test result data points in CSV (comma separated values) format (e.g. Excel ®)
iv. Performance Charts/Plots PDF and/or XLS format.
v. Drawings in PDF or DWG format that can be opened with Bentley View.

2.2.3 Where documents and diagrams are provided as supporting information, they shall be legible and shall include all relevant data assumptions (for example generator base, p.u, percentage values etc.).

2.2.4 Where testing and monitoring results are provided, they shall be legible, appropriately sized, scaled and labelled.

2.3 Minimum Document Submission on the Day of Testing

2.3.1 Unless otherwise agreed, the following documents shall be provided on the day of testing.

i. Raw Data of Grid Code Compliance Tests.
ii. All tests data must be saved separately (clear definition of signal ID).

2.4 RPP Grid Code Compliance Tests Requirements

2.4.1 Grid Code Compliance Testing shall only be performed on fully commissioned and operational generating units[1]. Before any test can be performed, all turbines/inverters shall be online and generating MW.

2.4.2 The available power (MW) shall be at least 50% of the RPP's power capacity.

2.4.3 The Grid Code Compliance Tests shall be performed from the NSP SCADA unless agreed otherwise by RETEC. Set points shall be changed by an engineer/technician on site if local SCADA testing is required by RETEC.

2.4.4 The lowest sampling rate of the raw data must be at least of 1-second average values.

2.4.5 Each set point for all the tests shall be maintained for 2 minutes, unless stated otherwise.

2.4.6 No optimisation of the RPP during grid code compliance testing will be allowed.

Note[1]: *The tests for early energy operation do not exempt the RPP generator from undertaking the full compliance tests when all the units are operational and intermediate results will not be considered as indicative of full RPP compliance capability.*

2.5 Grid Code Compliance Tests Pass Criteria

2.5.1 The RPP shall conduct tests to demonstrate that the RPP complies with each of the requirements of the RE Code.

2.5.2 The assessment criteria, not limited to, shall be based on reaction time and tolerance[2].

Note[2]:

i. The time measured during the Grid Code Compliance Testing is only an indication, the correct time measured shall be determined from the raw data provided.

ii. The test points given in the test procedure are examples and can be changed by RETEC during the test.

3. Post site testing requirements

3.1 RPP shall submit a detailed grid code compliance test report within 5 working days.

3.2 RETEC shall submit a detailed grid code compliance verification report to the Grid Code Secretariat within 10 working days from receipt of the RPP Grid Code Compliance test report.

3.3 Grid Code Secretariat shall provide a response to the RPP indicating the outcome of the overall grid code compliance.

Checklist for inspections of substations / transformer stations

RRP:

Date:

Inspector:

Maximum Continuous Rating(MCR)	MW
Pmin	MW

PPC information

Serial number	
Make and Model	
Firmware version	
PPC Settings	*Provide on separate document

All installed individual Inverter/WTG/ information

Number of inverters	
Rating/Name plate	
Serial numbers	
Make and Model	
Firmware version	
Inverter/Turbine Settings Download (Format in Pdf)	*Provide all individual inverter setting
Inverter transformer name plate	*Provide on separate document

RPP Substation

POC Transformer Serial Number/s	
POC Transformer name plate	*Provide on separate document
POC Protection Settings Document	*Provide on separate document
Tap Changer name plate	*Provide on separate document

General information:	Name	Contact person	Telephone No.	Picture
Name of Park Controller				--
Operator of Park Controller				--
Operator of transformer station				--
	House No.	Street / field yard	City / post code	--
Address of transformer station				--
Rating plate transformer station				
Gauss Krueger coordinates	RW: HW:			
Date of on-site inspection				--
Name of inspector				--
Name of Independent Engineers				

Notes: _____

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Technical information:				Picture	
		Type/serial no./installation point		Full view	Rating plate
Park controller					
Circuit diagram of substation/transformer station					
Switchgear/circuit breaker		HV MV			
Transformer					
Electric meter					
Counting point designation					
		Serial No.	Ratio		
Transducer Main grid protection	Voltage L1				
	Current L1				
	Voltage L2				
	Current L2				
	Voltage L3				
	Current L3				
Transducer of Park controller	Voltage L1				
	Current L1				
	Voltage L2				
	Current L2				
	Voltage L3				
	Current L3				

Protection relay:											
Protection function		Tripping level	Tripping time	Tripping level	Tripping time	Tripping level	Tripping time	Tripping level	Tripping time	Tripping level	Tripping time
Voltage protection	U>										
	U>>										
	U<										
	U<<										
Current protection	I>										
	I>>										
Frequency protection	f>										
	f>>										
	f<										
	f<<										
	f<<<										
	f<<<<										
Others	Δf/Δt										

PGU Type/SNo.:	Voltage protection							Frequency protection					PGU Transformer Ratio:
	U>	U>>	U<	U<<	U<<<			f>	f>>	f<	f<<		
Tripping level													
Tripping time													

PGU Type/SNo.:	Voltage protection							Frequency protection					PGU Transformer Ratio:
	U>	U>>	U<	U<<	U<<<			f>	f>>	f<	f<<		
Tripping level													
Tripping time													

PGU Type/SNo.:	Voltage protection							Frequency protection					PGU Transformer Ratio:
	U>	U>>	U<	U<<	U<<<			f>	f>>	f<	f<<		
Tripping level													
Tripping time													

PGU Type/SNo.:	Voltage protection							Frequency protection					PGU Transformer Ratio:
	U>	U>>	U<	U<<	U<<<			f>	f>>	f<	f<<		
Tripping level													
Tripping time													

PGU Type/SNo.:	Reconnection					Reactive Current Injection depending on voltage											
	t	U>	U<	f>	f<	U_1	I_1	U_2	I_2	U_3	I_3	U_4	I_4	U_5	I_5	U_6	I_6

PGU Type/SNo.:	Reconnection					Reactive Current Injection depending on voltage											
	t	U>	U<	f>	f<	U_1	I_1	U_2	I_2	U_3	I_3	U_4	I_4	U_5	I_5	U_6	I_6

PGU Type/SNo.:	Reconnection					Reactive Current Injection depending on voltage											
	t	U>	U<	f>	f<	U_1	I_1	U_2	I_2	U_3	I_3	U_4	I_4	U_5	I_5	U_6	I_6

PGU Type/SNo.:	Reconnection					Reactive Current Injection depending on voltage											
	t	U>	U<	f>	f<	U_1	I_1	U_2	I_2	U_3	I_3	U_4	I_4	U_5	I_5	U_6	I_6

PGU Type/SNo.:	Reconnection					Reactive Current Injection depending on voltage											
	t	U>	U<	f>	f<	U_1	I_1	U_2	I_2	U_3	I_3	U_4	I_4	U_5	I_5	U_6	I_6

4. Grid Code Compliance Tests

1. Disclaimer: Depending on the weather condition on site, RETEC shall determine the reference test starting point and may change the set points at their own discretion.

2. Before the commencement of all tests, the internal RPP SCADA shall be tested by switching the plant off (Open POC Breaker/ MV Breakers). Breakers can be opened at any MW generation.

4.1 Absolute active power constraint

Note:

1) *The test can only be performed if the primary energy supply is sufficient to reach the set active power output.*
2) *Reference power ($P_{reference}$) is the value, which the parties on site agree upon.*

3) *Declared MCR and Pmin Values*

Signals for the site testing trends and final report.

- ✓ *P(available)*
- ✓ *P(Actual)*
- ✓ *P(Set point)*

Default value by SO or by the RPP						
Before the start, the available power is measured and a reference value must be agreed between the parties: $P_{reference}$:____ MW						
Reduction/limit	Set point value P [MW]	Start value P [MW]	Actual P [MW] at 30s after setting the value	Measured Accuracy [kW]	Accuracy Max allowed [kW]	Comment
1st test to 80% Preference						
2nd test to 40% Preference						
3rd test to 20% Preference						
4th test to 10% Preference						
5th test Increasing limit to 30% Preference						
6th test to 50% Preference						
7th test to 80% Preference						
8th test only for responds time Preference to ≤0%						
After the 8th test the RPP shall go back to normal operation						

Remark:

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4.2 Delta production active power constraint

a) The parameter of set value (P_{Delta}) from the commission protocols have to be checked if available (optional Request Screenshot remote system).
b) Readings from the display of the *power park controller* have to be captured and documented with photos. A comparison of the actual values can be processed on site.
c) In the testing procedure, the P_{delta} has to be set high enough that the absolute delta value is at least 1 MW and at least 3% of available power ($P_{available)}$. P_{delta} is a percent value according to the grid code RPP [1].
d) After setting this value in the Power Park Controller, the RPP shall operate in this condition for at least 10 minutes.

Signals for the site testing trends and final report.
- ✓ *P(available)*
- ✓ *P(Actual)*

DELTA CONTROL – ($P_{avaiable}$ >20% of P_{max}) **Time for test: 10min**		
Ref No	**Description**	**Comments**
SETUP		
1.	Check $P_{available}$ at least 20% P_{max}	_____ MW
2.	Check PPC control ready	
TEST		
3.	Check P_{delta} control enabled	
4.	Send ___e.g. 10% of $P_{avaiable}$ (> 1 MW)	____% of $P_{avaiable}$
5.	Check if power reduces to set point value on Park Controller, SCADA or better measurement system.	OK?
6.	Hold for at least 10 min	
7.	Further tests as optional. For e.g. longer period if the primary energy do not change during the 10 min test period or other setting like P_{delta} of 3% would be tested	
8.	Disable Pdelta control	

Remark:

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4.3 Active power gradient constraint

Note:

1. *Reference power ($P_{reference}$) is the value, which the parties on site agree upon.*
2. *During dry run tests, establish and test your minimum and maximum ramp rates.*

Signals for the site testing trends and final report.

- ✓ *P(available)*
- ✓ *P(Actual)*
- ✓ *P(Set point)*

Before the start of the tests the available power is measured and used for all test as reference value as fix value: $P_{reference}$ =_____MW				
1st Test: down Ramp rate has to be set to: (0.4 x $P_{reference}$)/min				
Reduction/limit	Set point value P [MW]	Start value P [MW]	Actual P [MW] at 120 **s** after setting the value[1)]	Name of measurement file
1st test from $P_{reference}$ to 20% $P_{reference}$	20% $P_{reference}$	$P_{reference}$		
2nd test: up ramp rate has to be set to : (0.4 x $P_{reference}$)/min				
2nd test from 20% $P_{reference}$ to $P_{reference}$	$P_{reference}$	20% $P_{reference}$		
Reduction/limit	Set point value P [MW]	Start value P [MW]	Actual P [MW] at 4 min after setting the value[2)]	Name of measurement file
3nd test: down ramp rate has to be set to : (0.2 x $P_{reference}$)/min				
3rd Test from $P_{reference}$ to 20% $P_{reference}$	20% $P_{reference}$			
4th test: up ramp rate has to be set to: (0.2 x $P_{reference}$)/min				
4th Test from 20% $P_{reference}$ to $P_{reference}$		20% $P_{reference}$		
After the last test the RPP is allowed to go back to normal operation				

Remark:

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4.4 Power curtailment during frequency

4.4.1 Frequency Controller Response Performance: *Under- frequency*

Note:

1) *All set frequency should be in a range of ± 10 mHz.*
2) *It is recommended to simulate a grid frequency in the power park controller to make the control independent from the real grid frequency.*

Signals for the site testing trends and final report.

- ✓ *P(available)*
- ✓ *P(Actual)*
- ✓ *Simulated Frequency*

	Set value of P_{delta}:				_____% of $P_{avaiable}$		Photo
	Set value of Droop 1:				4%		
	at start; direct before setting			at 10 s after setting the new frequency value[2)]			
	Actual P [MW]	Grid Frequency [Hz]	$P_{available}$ [MW]	Actual P [MW]	Grid Frequency [Hz]	$P_{available}$ [MW]	Name of measurement file
1st test Frequency from 50 Hz to 49.85 Hz							
2nd test Frequency from 49.85 Hz to 49.5 Hz							
3rd Test Frequency from 49.5 Hz to 49.0 Hz							
4th Test Frequency from 49.0 Hz to 48.0 Hz							
5th Test Frequency from 48.0 Hz to 50 Hz							

4.4.2 Frequency Controller Response Performance: Over- frequency

Signals for the site testing trends and final report.

- ✓ *P(available)*
- ✓ *P(Actual)*
- ✓ *Simulated Frequency*

Set value of P_{delta}:				_____MW			Photo
Set value of Droop 2:				_____MW/Hz			
	at start; direct before setting			at 10 s after setting the new frequency value[2)]			
	Actual P [MW]	$P_{available}$ [MW]	Frequency [Hz]	Actual P [MW]	$P_{available}$ [MW]	Frequency [Hz]	Name of measurement file
1st test Frequency from 50 Hz to 50.50 - 50.55 Hz							
2nd test Frequency to 51.00 - 51.05 Hz							
3rd Test Frequency to 51.10 - 51.20 Hz							
4th Test Frequency to 51.35 to 51.45 Hz							
5th Test Frequency to Back to 50 Hz							

Remark:

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4.5 Reactive power control function category B and C

4.5.1 Reactive power (Q) Control

Note

1. *The test shall be repeated with a power curtailment of 20% of P_{Max}.*
2. *During the reactive power test, the full capability of Q has to be checked.*
3. *It is not recommended to jump from full reactive power overexcited to full reactive power under excited and vice versa due to resulting imbalances in the grid.*

Signals for the site testing trends and final report.

- ✓ *P(Actual)*
- ✓ *V(Actual)*
- ✓ *Q (actual)*
- ✓ *Q set point*

4.5.1.1 Reactive power control at Pmax

	Set point	Actual value		Response time	Measurement file
	Q [Mvar]	Q [Mvar]	P [MW]	[s]	
Q = 0 Mvar	0				
$+Q_{max}$ over excited					
Q = 0 Mvar					
$-Q_{min}$ under excited					
Q = 0 Mvar					

4.5.1.2 *Reactive power control at fixed Power of 20% P_{max}*

	Set point	Actual value		Response time	Measurement file
	Q [Mvar]	Q [Mvar]	P [MW]	[s]	
Q = 0 Mvar	0				
$+Q_{max}$ over excited					
Q = 0 Mvar					
$-Q_{min}$ under excited					
Q = 0 Mvar					

Remark:

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4.5.2 Power factor control

Note

1. *It is not recommended to jump from full reactive power overexcited to full reactive power under excited and vice versa due to resulting imbalances in the grid.*

Signals for the site testing trends and final report.

- ✓ *P(Actual)*
- ✓ *V(Actual)*
- ✓ *Q (actual)*
- ✓ *PF (Actual)*
- ✓ *PF set point*

Pf_ Setpoint	Actual value Q [Mvar]	Actual value P [MW]	Actual value cos ϕ	Response time [s]
PF= 1				
Pf_Lagging(max)				
PF= 1				
Pf_Leading(min)				
PF= 1				

Remark:

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4.5.3Voltage Control Function

4.5.3.1 Test 1: Set the Droop to 4%: (Qmax)/4% Un

Signals for the site testing trends and final report.

- ✓ *P(Actual)*
- ✓ *V(Actual)*
- ✓ *Q (actual)*
- ✓ *V set point*

Reactive power control – Q (U) characteristic Reactive power testing at different values of active power					
Voltage set point at the PPC	Set point	Actual value		Response time [s]	Measurement file
	Q [Mvar]	U [kV]	Q [Mvar]		
Reference voltage					
1.02 of Uref					
Reference voltage					
0.98 of Uref					
Reference voltage					

4.5.3.2 Test 2: Set the Droop to 8%: (Qmax)/8% Un

Reactive power control – Q (U) characteristic Reactive power testing at different values of active power					
Voltage set point at the PPC	Set point	Actual value		Response time [s]	Measurement file
	Q [Mvar]	U [kV]	Q [Mvar]		
Reference voltage					
1.02 of Uref					
Reference voltage					
0.98 of Uref					
Reference voltage					

Remark:

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4.6 Testing of SCADA Grid Code Compliance:

4.6.1 The following tests shall be performed for *Grid code* compliance verification from the *NSP* to the *RPP* Power Park Controller on the day of the grid code compliance tests.

i. Capability to change the mode of operation at the RPP.
ii. Capability to change the set point in any mode of operation such that the *RPP* adjusts accordingly.

Remark:

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Place, date Signature of inspector