

N.6 Verification of construction requirements regarding reactive power exchange

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Conditions for laboratory tests

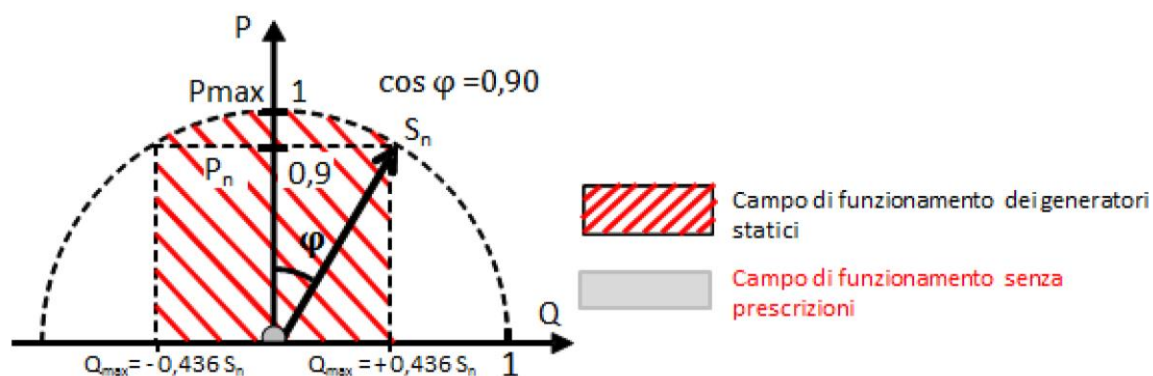
The following tests were performed in laboratory environment under the following conditions:

Influencing factors	Reference value	Remarks
Ambient temperature	25°C ± 5°C	Average value during testing: 24,5°C
Atmospheric pressure	96kPa ± 10kPa	Average value during testing: 102 kPa
Relative humidity	65%RH ± 10%RH	Average value during testing: 66%RH
Equipment location	According to the manufacturer's statement	Testing done in laboratory environment, see <i>Testing Location</i> on p.1
Frequency	50 Hz (in the range 47,5 Hz - 51,5 Hz, where applicable)	50 Hz
Waveform of the reference voltage	Compliant with CEI EN 50160	Stable AC source (see <i>Annex 5 – Test equipment list</i>) used for testing. Requirements of CEI EN 50160 are met.

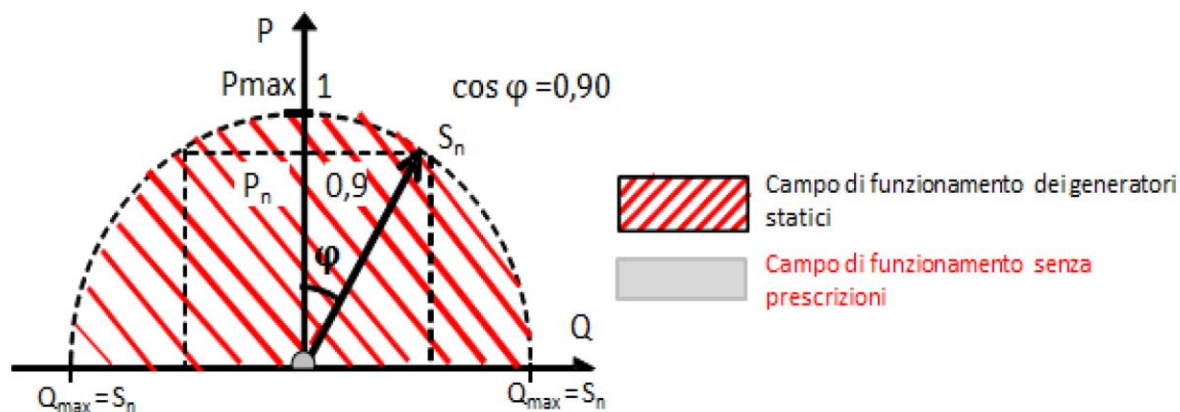
N.6.1 Verification of reactive power capability

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For static generators, there are different capabilities depending on the total power of the installation:



CEI 0-16:2022-03, Figure 74, Capability for static generators in power plants <400 kW (limited semicircular characteristic)



CEI 0-16:2022-03, Figure 74, Capability for static generators in power plants ≥400 kW (semi-circular characteristic)

Legend:
 S_n = rated apparent power at rated voltage U_n
 P_n = active power at $\cos\varphi = 0,9$ at rated voltage U_n
 P_{\max} = maximum active power at rated voltage U_n (with $\cos\varphi = 1$)

 Q_{\max} = maximum reactive power at rated voltage U_n (with $\cos\varphi = 0,9$)

N.6.1.1 Procedure for performing and recording the test for static generators
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Test conditions

Test setup	See section <i>General remarks for testing</i>
Operating mode of the PGU during the measurement	Normal operation, MPP-Tracking active
Q-Setpoint	According to test requirements

Requirements on testing and recording:

- The converter must be set so that it can respectively absorb (inductive behaviour) and deliver (capacitive behaviour) the maximum available reactive power at each level of the active power delivered according to its capability.
- At this point, the DC source is adjusted so that at least the entire rated active power of the generator under test is available; further adjustments are possible during the test, so that the source is not limiting for the performance to be measured.
- Adjust (either by adjustment of the source or by adjustment in the control system of the converter under test), the active power for values in the 11 ranges $[0\pm5]\%$; $[10\pm5]\%$; ...; $[100\pm5]\%$ of the nominal apparent power; measure the active power under steady-state conditions, approx. 1 min after adjustment (average values at 1 min calculated from the values measured at the fundamental frequency over a 200 ms window).
- For each of the 11 active power levels, one value for the inductive reactive power and one for the capacitive reactive power must be recorded, as average values at 1 min calculated based on measurements at the fundamental frequency over a 1s window. The power factor must also be recorded and reported as a 1-minute average.
- In addition to the measurements at the reactive power setting limit values, the measured values should be recorded by setting the reactive power output to 0 ($\cos\varphi = 1$).

The maximum capability in absorption (Q_{\min}) and delivery (Q_{\max}) of reactive power resulting from the above sequence of measurements and that for $Q = 0$ must be documented in tabular form by showing, for each level of delivered active power between 0% and 100% of the rated apparent power, the corresponding level of absorbed (and delivered) reactive power, expressed both in absolute value and in p.u. of the rated apparent power and in terms of $\cos\varphi$.

Assessment criterion:

- For each measured point, a maximum deviation of the reactive power $\Delta Q \leq \pm 5\% S_n$
- For values of $P \leq 10\% S_n$
 - Power plants <400 kW:
maximum deviation of the reactive power $\Delta Q \leq \pm 10\% S_n$
 - Power plants ≥ 400 kW:
recording of the available capability values for delivered active power values lower than $10\% S_n$ is required, but the results do not constitute a prescriptive performance constraint.

Test results							
<input checked="" type="checkbox"/> static generator in power plants <400 kW				<input checked="" type="checkbox"/> static generator in power plants ≥400 kW			
-Q _{max} (inductive)							
Power-Bin (based S _n)	Active power		Reactive power		DC power		Power factor (cosφ)
	[kW]	p.u. (based S _n)	[kvar]	p.u. (based S _n)	[kW]	p.u. (based S _n)	
0% ± 5%	0,797	0,006	-125,132	-1,001	3,761	0,030	0,006
10% ± 5%	12,599	0,101	-124,389	-0,995	15,527	0,124	0,101
20% ± 5%	25,024	0,200	-122,569	-0,981	27,905	0,223	0,200
30% ± 5%	37,629	0,301	-119,296	-0,954	40,468	0,324	0,301
40% ± 5%	50,006	0,400	-114,657	-0,917	52,799	0,422	0,400
50% ± 5%	62,626	0,501	-108,305	-0,866	65,387	0,523	0,501
60% ± 5%	75,199	0,602	-100,006	-0,800	77,926	0,623	0,601
70% ± 5%	87,705	0,702	-89,241	-0,714	90,415	0,723	0,701
80% ± 5%	99,997	0,800	-75,188	-0,602	102,689	0,822	0,799
90% ± 5%	112,492	0,900	-54,782	-0,438	115,195	0,922	0,899
100% ± 5%	125,083	1,001	-2,161	-0,017	127,487	1,020	0,999
+Q _{max} (capacitive)							
Power-Bin (based S _n)	Active power		Reactive power		DC power		Power factor (cosφ)
	[kW]	p.u. (based S _n)	[kvar]	p.u. (based S _n)	[kW]	p.u. (based S _n)	
0% ± 5%	1,145	0,009	125,111	1,001	4,644	0,037	0,009
10% ± 5%	12,481	0,100	124,493	0,996	15,948	0,128	0,100
20% ± 5%	25,094	0,201	122,588	0,981	28,509	0,228	0,201
30% ± 5%	37,687	0,301	119,318	0,955	41,065	0,329	0,301
40% ± 5%	50,070	0,401	114,670	0,917	53,396	0,427	0,400
50% ± 5%	62,634	0,501	108,306	0,866	65,913	0,527	0,501
60% ± 5%	75,067	0,601	100,141	0,801	78,284	0,626	0,600
70% ± 5%	87,514	0,700	89,449	0,716	90,673	0,725	0,699
80% ± 5%	100,088	0,801	75,121	0,601	103,162	0,825	0,800
90% ± 5%	112,642	0,901	54,575	0,437	115,639	0,925	0,900
100% ± 5%	125,071	1,001	1,336	0,011	127,482	1,020	0,999

Q = 0							
Power-Bin (based S_n)	Active power		Reactive power		DC power		Power factor ($\cos\varphi$)
	[kW]	p.u. (based S_n)	[kvar]	p.u. (based S_n)	[kW]	p.u. (based S_n)	
0% \pm 5%	0,348	0,003	1,897	0,015	0,548	0,004	0,177
10% \pm 5%	12,563	0,101	-1,062	-0,008	12,844	0,103	0,999
20% \pm 5%	25,029	0,200	-0,924	-0,007	25,478	0,204	0,999
30% \pm 5%	37,631	0,301	-0,821	-0,007	38,284	0,306	0,999
40% \pm 5%	50,079	0,401	-1,094	-0,009	50,956	0,408	0,999
50% \pm 5%	62,634	0,501	-1,151	-0,009	63,797	0,510	0,999
60% \pm 5%	75,156	0,601	-1,294	-0,010	76,621	0,613	0,999
70% \pm 5%	87,620	0,701	-1,456	-0,012	89,380	0,715	0,999
80% \pm 5%	100,094	0,801	-1,658	-0,013	102,180	0,817	0,999
90% \pm 5%	112,529	0,900	-1,877	-0,015	114,946	0,920	0,999
100% \pm 5%	125,195	1,002	-2,313	-0,019	127,932	1,023	0,999

