N.6 Verification of construction requirements regarding reactive power exchange	P

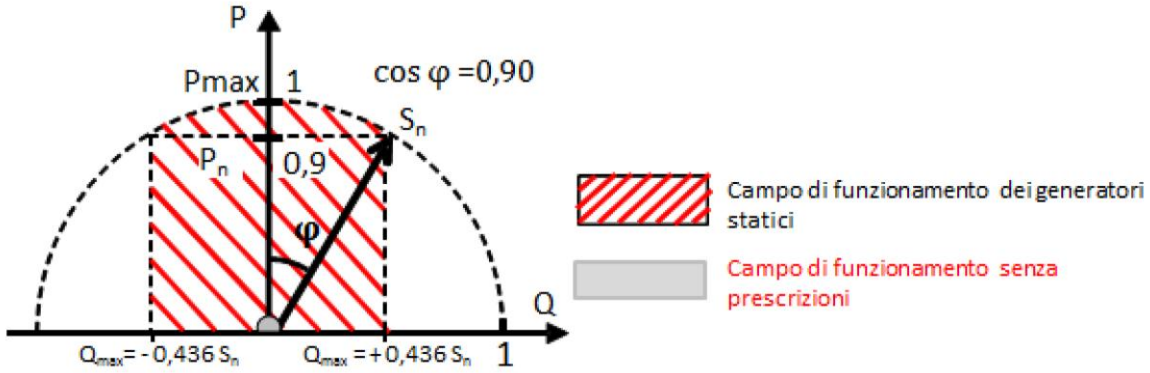
Conditions for laboratory tests

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

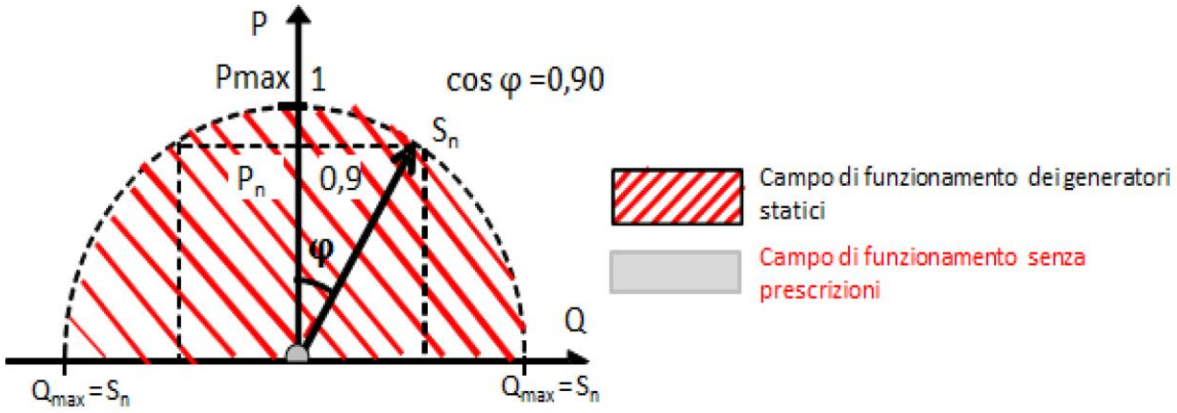
Influencing factors	Reference value	Remarks
Ambient temperature	25°C ± 5°C	Average value during testing: 25°C
Atmospheric pressure	96kPa ± 10kPa	Average value during testing: 94 kPa
Relative humidity	65%RH ±10%RH	Average value during testing: 70%RH
Equipment location	According to the manufacturer's statement	Testing done in laboratory environment, see *Testing Location* 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 *Annex 4 – Test equipment list*) used for testing. Requirements of CEI EN 50160 are met.

N.6.1 Verification of reactive power capability	P

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 cosφ = 0,9 at rated voltage U_n

P_{max} = maximum active power at rated voltage Un (with cosφ = 1)

Q_{max} = maximum reactive power at rated voltage U n (with cosφ = 0,9)

N.6.1.1 Procedure for performing and recording the test for static generators	**P**

Test conditions

Test setup	See section *General remarks for testing*
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 con trol system of the converter under test), the active power for values in the 11 ranges [0±5]%; [10±5]%; ...; [100±5]% 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 (cosφ = 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 cosφ.

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

☒ static generator in power plants <400 kW ☒ static generator in power plants ≥400 kW

-Q_{max} (inductive)

Power-Bin (based P_n)	Active power		Reactive power		DC power		Power factor (cosφ)
	[kW]	p.u. (based P_n)	[kVar]	p.u. (based S_n)	[kW]	p.u. (based P_n)	
0% ± 5%	-0,073	-0,002	-32,648	-0,989	1,530	0,051	0,002
10% ± 5%	2,977	0,099	-32,731	-0,992	4,595	0,153	0,091
20% ± 5%	5,997	0,200	-32,669	-0,990	7,630	0,254	0,181
30% ± 5%	9,033	0,301	-31,946	-0,968	10,654	0,355	0,272
40% ± 5%	12,074	0,402	-30,930	-0,937	13,679	0,456	0,364
50% ± 5%	15,063	0,502	-29,575	-0,896	16,643	0,555	0,454
60% ± 5%	18,090	0,603	-27,813	-0,843	19,637	0,655	0,545
70% ± 5%	21,067	0,702	-25,614	-0,776	22,572	0,752	0,635
80% ± 5%	24,060	0,802	-22,795	-0,691	25,508	0,850	0,726
90% ± 5%	27,079	0,903	-19,076	-0,578	28,450	0,948	0,818
100% ± 5%	31,490	1,050	-7,307	-0,221	32,720	1,091	0,953
110% ± 5%	33,002	1,100	-0,537	-0,016	34,125	1,138	0,999

+Q_{max} (capacitive)

Power-Bin (based P_n)	Active power		Reactive power		DC power		Power factor (cosφ)
	[kW]	p.u. (based P_n)	[kVar]	p.u. (based S_n)	[kW]	p.u. (based P_n)	
0% ± 5%	0,806	0,027	33,133	1,004	1,046	0,035	0,024
10% ± 5%	2,980	0,099	33,027	1,001	3,229	0,108	0,090
20% ± 5%	5,959	0,199	32,606	0,988	6,224	0,207	0,180
30% ± 5%	8,930	0,298	31,891	0,966	9,214	0,307	0,270
40% ± 5%	11,979	0,399	30,845	0,935	12,291	0,410	0,362
50% ± 5%	15,015	0,501	29,446	0,892	15,361	0,512	0,454
60% ± 5%	18,041	0,601	27,652	0,838	18,428	0,614	0,546
70% ± 5%	21,049	0,702	25,390	0,769	21,485	0,716	0,638
80% ± 5%	24,038	0,801	22,537	0,683	24,537	0,818	0,730
90% ± 5%	27,032	0,901	18,803	0,570	27,611	0,920	0,821
100% ± 5%	31,479	1,049	6,561	0,199	32,380	1,079	0,955
110% ± 5%	33,005	1,100	-0,532	-0,016	34,124	1,137	0,999

Q = 0							
Power-Bin (based P_n)	Active power		Reactive power		DC power		Power factor (cosφ)
	[kW]	p.u. (based P_n)	[kVar]	p.u. (based S_n)	[kW]	p.u. (based P_n)	
0% ± 5%	-0,003	0,000	-0,036	-0,001	0,162	0,005	0,084
10% ± 5%	2,952	0,098	0,182	0,006	3,145	0,105	0,998
20% ± 5%	5,955	0,199	0,105	0,003	6,200	0,207	0,999
30% ± 5%	8,968	0,299	0,023	0,001	9,272	0,309	0,999
40% ± 5%	11,977	0,399	-0,043	-0,001	12,349	0,412	0,999
50% ± 5%	14,984	0,499	-0,110	-0,003	15,427	0,514	0,999
60% ± 5%	17,992	0,600	-0,177	-0,005	18,517	0,617	0,999
70% ± 5%	20,994	0,700	-0,247	-0,007	21,606	0,720	0,999
80% ± 5%	23,997	0,800	-0,316	-0,010	24,701	0,823	0,999
90% ± 5%	26,992	0,900	-0,386	-0,012	27,818	0,927	0,999
100% ± 5%	29,992	1,000	-0,456	-0,005	30,917	1,031	0,999
110% ± 5%	33,007	1,100	-0,532	-0,006	34,124	1,137	0,999

