Synchronous Generator Capability: Reactive Power Limits

Maximum and minimum reactive power of a round-rotor generator at a real power from its stator current, field current and steady-state stability limits.

Method: Round-rotor capability diagram

Input parameters

Unit system: SI

Parameter	Value	Unit
Rated apparent power	100.00	MVA
Rated power factor (lagging)	85.000	%
Synchronous reactance (per unit)	1.8000	
Terminal voltage (per unit)	1.0000	
Real power output	70.000	MW

Calculated results

Parameter	Value	Unit
Maximum internal EMF (per unit, rated field)	2.4772	
Stator-current limit	71.414	Mvar
Field-current limit	62.933	Mvar
Maximum reactive power (lagging)	62.933	Mvar
Minimum reactive power (leading)	-55.556	Mvar

Notes for this case

• Per unit on the rated MVA. Stator heating limits S = V_tI ≤ V_t (a circle about the origin). Rotor heating limits E to its rated-point value E_max = |V + jX_sI_n|, a circle of radius V_tE_max/X_s centred at Q = −V_t²/X_s. The field limit governs at low power factor lagging; the stator limit near rated power. Leading operation is limited here by the theoretical steady-state stability limit Q = −V_t²/X_s and by stator current; real machines also have end-core heating and practical stability margins, and turbine power caps P.

Formula and method

$$E_{max} = |V + jX_s I_n|\,, \quad Q_{field} = \sqrt{\left(\frac{V_t E_{max}}{X_s}\right)^2 - P^2} - \frac{V_t^2}{X_s}, \quad Q_{stator} = \sqrt{V_t^2 - P^2}$$

Variables

S_n	Rated apparent power	VA
$\cos\varphi_n$	Rated power factor (lagging)	-
X_s	Synchronous reactance (per unit)	-
V_t	Terminal voltage (per unit)	-
P	Real power output	W
E_{max}	Maximum internal EMF (per unit, rated field)	-
Q_{stator}	Stator-current limit	var
Q_{field}	Field-current limit	var
Q_{max}	Maximum reactive power (lagging)	var
Q_{min}	Minimum reactive power (leading)	var

Method and standards

Capability.

Assumptions and limits

- Round rotor; no saturation; resistance neglected; per-unit on rated MVA.

References

Round-rotor capability diagram

Report details

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Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/electrical/power/generator-capability-curve

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Reopens the calculator with the inputs of this report.