Synchronous Generator Voltage Regulation

Internal EMF, torque angle and percent voltage regulation of a synchronous generator at a load current and power factor angle from its per-phase impedance.

Method: Synchronous impedance (EMF) method

Input parameters

Unit system: SI

Parameter	Value	Unit
Rated line voltage (star)	480.00	V
Load apparent power	60.000	kVA
Power factor angle (+ lagging, − leading)	36.870	°
Armature resistance per phase	0.015000	Ω
Synchronous reactance per phase	0.10000	Ω

Calculated results

Parameter	Value	Unit
Armature current	72.169	A
Internal EMF per phase	282.37	V
Torque angle	1.0398	°
Voltage regulation	1.8918	%

Notes for this case

• Generator: E_A = V_φ + (R_A + jX_s)I_A, with I_A at −φ for lagging load. VR = (E_A − V_φ)/V_φ is the rise in terminal voltage if the load is removed at constant field and speed. Lagging loads give large positive regulation; leading loads can give negative regulation (voltage would fall on load rejection). The synchronous-impedance method ignores saturation and overstates regulation at high field.

Formula and method

$$E_A = V_\phi + (R_A + jX_s)I_A, \quad VR = \frac{E_A - V_\phi}{V_\phi}$$

Variables

V_L	Rated line voltage (star)	V
S	Load apparent power	VA
φ	Power factor angle (+ lagging, − leading)	rad
R_A	Armature resistance per phase	Ω
X_s	Synchronous reactance per phase	Ω
I_A	Armature current	A
E_A	Internal EMF per phase	V
δ	Torque angle	rad
VR	Voltage regulation	-

Method and standards

Regulation.

Assumptions and limits

- Round rotor; unsaturated; star connection; balanced load.

References

Synchronous impedance (EMF) method

Report details

Report reference	FCC-W93Q-XQ9N (the same inputs always give the same reference)
Generated	23 November 2026, 17:50 UTC
Calculator	Synchronous Generator Voltage Regulation
Method last reviewed	17 November 2026
Software release	FireCAD Calc, release of 22 November 2026
Release checks	3 reference cases of this calculator, computed independently, are checked on every release

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/synchronous-generator-voltage-regulation

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.