Generator Short-Circuit Current: Subtransient to Steady State

Three-phase short-circuit current of a synchronous generator over time from its rating and subtransient, transient and synchronous reactances and time constants.

Method: Chapman; Electric Machinery Fundamentals; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Generator rating	10.000	MVA
Rated line voltage	11.000	kV
Subtransient reactance (per unit)	0.15000	
Transient reactance (per unit)	0.25000	
Synchronous reactance (per unit)	1.8000	
Subtransient time constant	0.035000	s
Transient time constant	1.0000	s
Time after fault	0.10000	s
Internal voltage before fault (per unit)	1.0000	

Calculated results

Parameter	Value	Unit
Rated current	524.86	A
Initial subtransient current	3.4991	kA
Transient current	2.0995	kA
Sustained current (no AVR boost)	0.29159	kA
Symmetrical rms current at t	2.0078	kA

Notes for this case

- Symmetrical rms envelope; DC offset is extra. With an AVR and field forcing, sustained current can be 2–4 times rated instead of E/x_d.

Formula and method

$$I(t) = (I'' - I')e^{-t/T''_d} + (I' - I_{ss})e^{-t/T'_d} + I_{ss}, \quad I'' = \frac{E}{x''_d} I_r$$

Variables

S	Generator rating	VA
V	Rated line voltage	V
x''_d	Subtransient reactance (per unit)	-
x'_d	Transient reactance (per unit)	-
x_d	Synchronous reactance (per unit)	-
T''_d	Subtransient time constant	s
T'_d	Transient time constant	s
t	Time after fault	s
E	Internal voltage before fault (per unit)	-
I_r	Rated current	A
I''	Initial subtransient current	A

I'	Transient current	A
I_{ss}	Sustained current (no AVR boost)	A
$I(t)$	Symmetrical rms current at t	A

Method and standards

Decrement curve.

Assumptions and limits

- Three-phase fault at terminals; constant field voltage.
- One internal voltage E for all three periods (the textbook simplification for a fault from no load); from loaded conditions E″ and E′ differ.

References

- Chapman
- Electric Machinery Fundamentals
- 5th ed. (McGraw-Hill, 2012)
- ch. 4 (short-circuit transients in synchronous generators)

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/protection/generator-fault-current

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.