Synchronous Motor Excitation for a Power Factor

Armature current, internal EMF, torque angle and field current of a synchronous motor for a power and power factor, from synchronous reactance and the OCC slope.

Method: Synchronous machine phasor equations

Input parameters

Unit system: SI

Parameter	Value	Unit
Line voltage (star)	480.00	V
Input power	80.000	kW
Power factor	80.000	%
Leading (+1) or lagging (−1)	1.0000	
Synchronous reactance per phase	2.5000	Ω
Armature resistance per phase	0	Ω
Phase EMF on the OCC	277.00	V
Field current for that EMF	4.0000	A

Calculated results

Parameter	Value	Unit
Armature current	120.28	A
Internal EMF per phase	516.94	V
Torque angle	27.734	°
Field current needed	7.4648	A
Reactive power (+ supplied to the system)	60.000	kvar

Notes for this case

• Motor convention: V_φ = E_A + (R_A + jX_s)I_A, so E_A = V_φ − (R_A + jX_s)I_A with I_A at +φ for leading. Over-excited motors (E_A larger) draw leading current and supply reactive power, which is why synchronous motors are used to correct plant power factor. Field current from a linear (unsaturated) open-circuit characteristic I_F = I_F0·E_A/E_0; with saturation more field is needed. δ is the angle by which E_A lags V_φ.

Formula and method

$$E_A = V_\phi - (R_A + jX_s)I_A, \quad I_F = I_{F0}\frac{E_A}{E_0}$$

Variables

V_L	Line voltage (star)	V
P	Input power	W
$\cos\varphi$	Power factor	-
$\pm$	Leading (+1) or lagging (−1)	-
X_s	Synchronous reactance per phase	Ω
R_A	Armature resistance per phase	Ω
E_0	Phase EMF on the OCC	V
I_{F0}	Field current for that EMF	A
I_A	Armature current	A
E_A	Internal EMF per phase	V

δ	Torque angle	rad
I_F	Field current needed	A
Q	Reactive power (+ supplied to the system)	var

Method and standards

Excitation.

Assumptions and limits

- Round rotor; unsaturated OCC; star connection.

References

Synchronous machine phasor equations

Report details

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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/motors/synchronous-motor-excitation

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.