DC Series Motor Speed and Torque at Another Load

Back EMF, speed and torque of a DC series motor at a new current from a known operating point, assuming flux proportional to current (unsaturated).

Method: DC series motor equations (linear magnetisation)

Input parameters

Unit system: SI

Parameter	Value	Unit
Terminal voltage	250.00	V
Armature plus series field resistance	0.080000	Ω
Known current	50.000	A
Speed at the known current	1,200.0	rpm
New current	100.00	A
Brush drop	2.0000	V

Calculated results

Parameter	Value	Unit
Back EMF at I_1	244.00	V
Torque at I_1	97.085	N·m
Back EMF at I_2	240.00	V
Speed at I_2	590.16	rpm
Torque at I_2	388.34	N·m

Notes for this case

• E = V_T − V_B − I(R_A + R_S) and E = Kφω with φ ∝ I below saturation, so $n_2/n_1 = (E_2/E_1)(I_1/I_2)$ and torque Kφ I ∝ I^2. Series motors give high starting torque (traction, hoists, starters) and race at light load, so they must never run unloaded. With saturation torque rises more slowly than I^2 and speed falls less at high current.

Formula and method

$$E = V_T - V_B - I(R_A + R_S), \quad \frac{n_2}{n_1} = \frac{E_2}{E_1}\frac{I_1}{I_2}, \quad T = \frac{EI}{\omega}$$

Variables

V_T	Terminal voltage	V
$R_A + R_S$	Armature plus series field resistance	Ω
I_1	Known current	A
n_1	Speed at the known current	rad/s
I_2	New current	A
V_B	Brush drop	V
E_1	Back EMF at I_1	V
T_1	Torque at I_1	N·m
E_2	Back EMF at I_2	V
n_2	Speed at I_2	rad/s
T_2	Torque at I_2	N·m

Method and standards

Series motor.

Assumptions and limits

- Flux proportional to current; constant brush drop; no armature reaction.

References

DC series motor equations (linear magnetisation)

Report details

Report reference	FCC-WVFE-3RNK (the same inputs always give the same reference)
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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/dc-series-motor-characteristic

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.