Capacitor Value for a Split-Phase Motor (90° Auxiliary Current)

Capacitance that makes the auxiliary winding current of a single-phase motor lead the main winding current by 90° at standstill, with currents and capacitor voltage.

Method: Two-winding single-phase motor at standstill

Input parameters

Unit system: SI

Parameter	Value	Unit
Supply voltage	230.00	V
Supply frequency	50.000	Hz
Main winding resistance (locked rotor)	4.5000	Ω
Main winding reactance (locked rotor)	3.7000	Ω
Auxiliary winding resistance	9.5000	Ω
Auxiliary winding reactance	3.5000	Ω

Calculated results

Parameter	Value	Unit
Capacitor reactance	15.054	Ω
Capacitance	211.44	µF
Main winding current	39.480	A
Auxiliary winding current	15.376	A
Voltage across the capacitor	231.47	V
Line current	42.368	A

Notes for this case

• Starting torque of a single-phase motor is proportional to I_mI_a sin α, where α is the angle between the winding currents. The main winding current lags the voltage by arctan(X_m/R_m); the auxiliary current lags by arctan[(X_a − X_C)/R_a]. Making them 90° apart needs (X_a − X_C)/R_a = −R_m/X_m, so X_C = X_a + R_aR_m/X_m. With the currents in quadrature the line current is √(I_m² + I_a²). The capacitor must be rated for V_C, often well above the supply voltage; use an AC electrolytic start capacitor for short duty or a film capacitor for continuous (run) duty.

Formula and method

$$X_C = X_a + \frac{R_a R_m}{X_m}, \quad C = \frac{1}{2\pi f X_C}$$

Variables

V	Supply voltage	V
f	Supply frequency	1/s
R_m	Main winding resistance (locked rotor)	Ω
X_m	Main winding reactance (locked rotor)	Ω
R_a	Auxiliary winding resistance	Ω
X_a	Auxiliary winding reactance	Ω
X_C	Capacitor reactance	Ω
C	Capacitance	F
I_m	Main winding current	A

I_a	Auxiliary winding current	A
V_C	Voltage across the capacitor	V
I_L	Line current	A

Method and standards

Start capacitor.

Assumptions and limits

- Standstill impedances; sinusoidal supply; magnetic coupling of windings neglected.

References

Two-winding single-phase motor at standstill

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/motors/capacitor-start-motor-capacitor

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Reopens the calculator with the inputs of this report.