

AC Motor Cheat Sheet

Induction & synchronous motors: speed, slip, torque and power

ENGINEERING
CHEAT SHEET

Key equations

Quantity	Equation	Notes
Synchronous speed	$N_s \text{ (RPM)} = 60 f / P$	f = supply frequency (Hz), P = pole pairs . 4 poles at 60 Hz: 1,800 RPM
Slip	$s = (N_s - N) / N_s$	N = actual rotor speed. Slip is what induces rotor current and torque
Rotor current frequency	$f_r = s \cdot f$	Falls toward zero as the rotor speeds up
Force on a rotor bar	$F = B L I_r$	B = flux density, L = conductor length, I_r = induced rotor current
Mechanical output power	$P = T \cdot \omega$	T in N·m, ω in rad/s, P in W
3-phase electrical input	$P = \sqrt{3} \cdot V_L \cdot I_L \cdot \cos \phi$	V_L, I_L = line voltage and current, $\cos \phi$ = power factor
Efficiency	$\eta = P_{\text{out}} / P_{\text{in}}$	The gap between input and output is internal losses
Unit conversion	$1 \text{ HP} \approx 0.746 \text{ kW}$	Nameplate ratings are given in kW or HP
Constant V/f control	$V / f = \text{constant}$	Holds air-gap flux (and torque capability) steady across the speed range

Key takeaways

- An AC motor has a stator that makes a rotating magnetic field and a rotor that follows it. Most induction motors need **no brushes or commutator**.
- The two families are **induction (asynchronous)** and **synchronous** motors. Synchronous motors run at exactly synchronous speed.
- A three-phase motor has windings spaced 120° apart. Squirrel-cage rotors use slanted bars short-circuited by end rings.
- Run at low slip to keep the speed-torque relationship near linear and efficiency high.
- Speed control needs power electronics: vary stator voltage, or vary frequency. Variable stator voltage gives low starting torque and extra harmonics.
- VVVF drives (variable voltage, variable frequency) keep V/f constant to avoid core saturation.
- AC motors win on ruggedness and low maintenance. DC motors win on simple speed control and starting torque.

Speed vs. poles (60 Hz supply)

Poles	2	4	6	8
Sync. speed (RPM)	3,600	1,800	1,200	900