Motor RMS Torque for a Move Profile and Inertia Ratio

Acceleration, deceleration, peak and RMS torque of a motor driving a trapezoidal move profile with dwell, and the load-to-motor inertia ratio for servo sizing.

Method: RMS (thermally equivalent) torque of a duty cycle

Input parameters

Unit system: SI

Parameter	Value	Unit
Motor rotor inertia	1.2000e-04	kg·m²
Load inertia reflected to the motor shaft	6.0000e-04	kg·m²
Load (friction and gravity) torque while moving	0.80000	N·m
Running speed	3,000.0	rpm
Acceleration time	0.10000	s
Constant-speed time	0.30000	s
Deceleration time	0.10000	s
Dwell time (at rest)	0.50000	s

Calculated results

Parameter	Value	Unit
Torque during acceleration	3.0619	N·m
Torque during deceleration (braking negative)	-1.4619	N·m
Peak torque	3.0619	N·m
RMS torque over the cycle	1.1590	N·m
Inertia ratio	5.0000	
Peak power (end of acceleration)	961.94	W

Notes for this case

• Accelerating the total inertia J = J_m + J_L to speed n in t_a needs Jn/t_a on top of the load torque; decelerating needs −Jn/t_d plus the load torque (load friction helps braking). Motor heating follows the square of torque, so the thermally equivalent continuous torque is the RMS over the whole cycle including dwell, which must stay below the motor's continuous rating, while the peak must stay within its peak rating. Servo makers recommend inertia ratios below about 10:1 (lower for stiff, fast systems); a gearbox reduces the reflected load inertia by the ratio squared.

Formula and method

$$T_{acc} = \frac{(J_m + J_L)\omega}{t_a} + T_L, \quad T_{rms} = \sqrt{\frac{T_{acc}^2 t_a + T_L^2 t_r + T_{dec}^2 t_d}{t_a + t_r + t_d + t_w}}$$

Variables

J_m	Motor rotor inertia	kg·m²
J_L	Load inertia reflected to the motor shaft	kg·m²
T_L	Load (friction and gravity) torque while moving	N·m
n	Running speed	rad/s
t_a	Acceleration time	s
t_r	Constant-speed time	s
t_d	Deceleration time	s

t_w	Dwell time (at rest)	s
T_{acc}	Torque during acceleration	N·m
T_{dec}	Torque during deceleration (braking negative)	N·m
T_{peak}	Peak torque	N·m
T_{rms}	RMS torque over the cycle	N·m
J_L/J_m	Inertia ratio	-
P_{peak}	Peak power (end of acceleration)	W

Method and standards

RMS torque.

Assumptions and limits

- Trapezoidal speed profile; constant load torque while moving; no torque at rest.

References

RMS (thermally equivalent) torque of a duty cycle

Report details

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