Calculation of Motor Power Dissipation for Different Motion Profiles

Symbols:

X = Distance to travel in meter

T_1 = Acceleration time in second

T_2 = Coasting time in second

T_3 = Deceleration time in second

T_4 = Stop time in second

$T = T_1 + T_2 + T_3$ = Time to move

Duty Cycle = $\frac{T}{T+T_4}$

V_{Peak} = Peak velocity in meter / second

a_1 = Acceleration in meter / second^2

a_3 = Deceleration in meter / second^2

F_1 = Force during acceleration in Newton

F_2 = Force during coasting

F_3 = Force during deceleration in Newton

F_4 = Force during stop time

F_{rms} = The Root Mean Square (RMS) of the force

m = Total moving mass, mass of the motor + all other masses attached to it in Kg

I_{rms} = The Root Mean Square (RMS) of current in Amp

K_f = Force constant in Newton / Amp

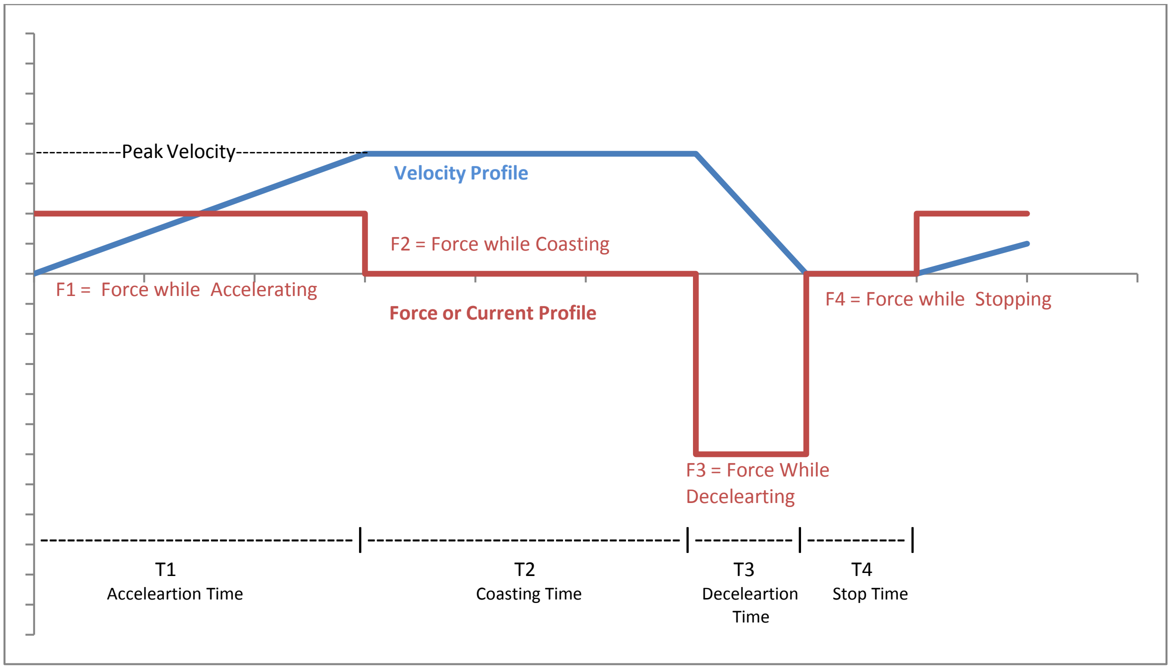
K_e = BEMF constant in Volts / meter / second

R = Resistance of the motor in Ohm

f = Frequency in Hz

P = Power dissipation in Watt

Trapezoidal Velocity Profile



$$X = 0.5\, V_{peak}\ (T_1 + 2T_2 + T_3)$$

$$V_{peak} = \frac{2x}{(T_1 + 2T_2 + T_3)}$$

$$a_1 = \frac{V_{peak}}{T_1} = \frac{2x}{T_1((T_1 + 2T_2) + T_3)}$$

$$a_3 = \frac{V_{peak}}{T_3} = \frac{2x}{(T_3((T_1 + 2T_2) + T_3))}$$

$$F_1 = a_1 m = \frac{2x\ m}{(T_1 + 2T_2 + T_3)\ (T_1)}$$

F_2 = Friction force

$$F_3 = a_3 m = \frac{2x\ m}{(T_3(T_3 + 2T_2) + T_3)}$$

$$F_{rms} = \sqrt{\frac{F_1^2\ T_1 + F_2^2\ T_2 + F_3^2\ T_3 + F_4^2\ T_4}{T_1 + T_2 + T_3 + T_4}}$$

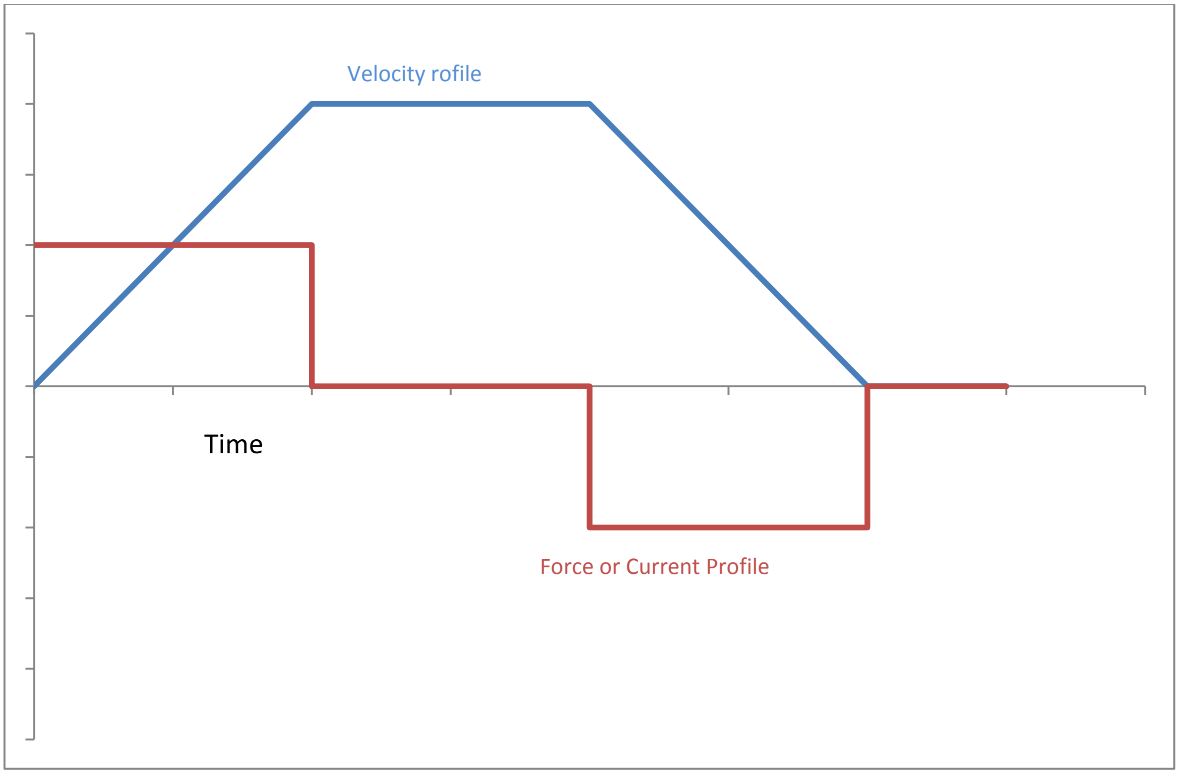
$$I_{rms} = \frac{F_{rms}}{K_f}$$

$$P = R\ I_{rms}^2$$

F_{rms} Should be equal or less than the CONTINUOUS FORCE of the motor.

P should be equal or less than the MAX CONTINOUS POWER of the motor.

Trapezoidal Velocity Profile with Minimum Power Dissipation



If $F_2 = F_4 = 0 \; and \; T_1 = T_2 = T_3 = \frac{T}{3}$

Then $a_1 = a_3 = a = \frac{(4.5\,X)}{T^2}$

$F_{rms} = 3.67\,m \left(\frac{X}{T^2}\right) \sqrt{Duty\ Cycle}$

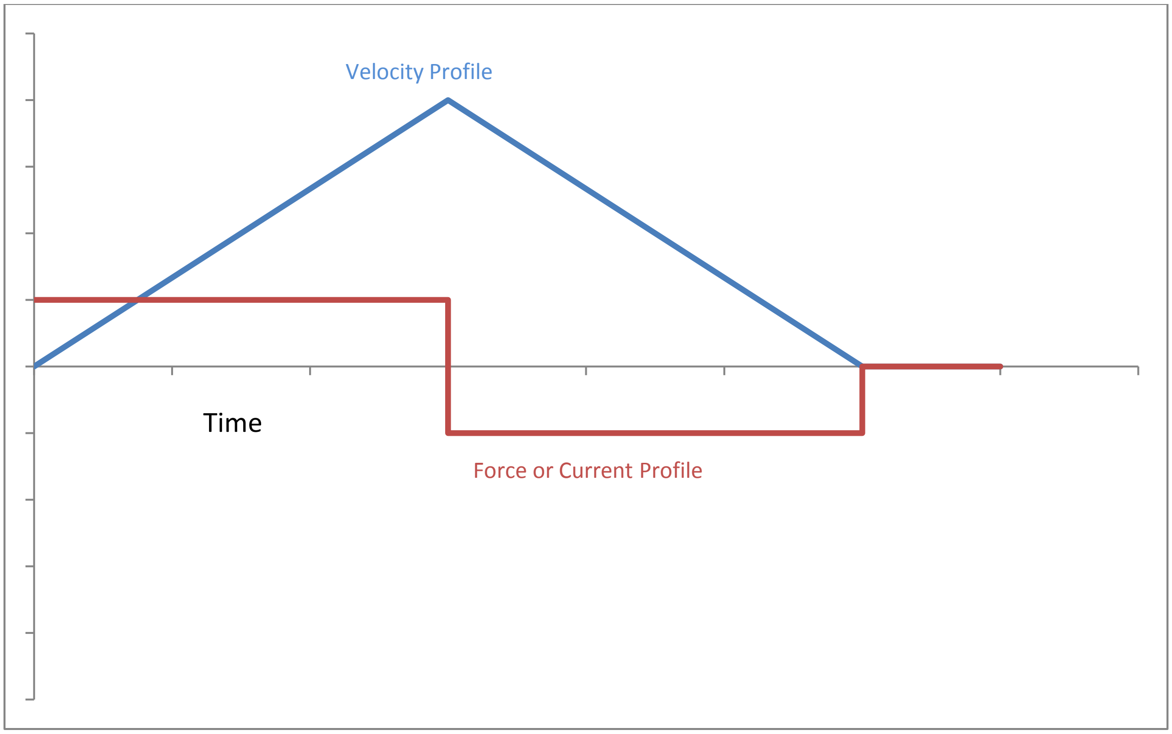
$I_{rms} = \frac{3.67\,m\left(\frac{X}{T^2}\right)}{K_f} \sqrt{Duty\ Cycle}$

$V_{peak} = \frac{1.5\,X}{T}$

P = R I_{rms}^2

Triangular Velocity Profile with Fastest Move Time

If $F_2 = F_4 = 0 \, and \, T_2 = 0$



Then $a_1 = a_3 = a = \frac{4X}{T^2}$

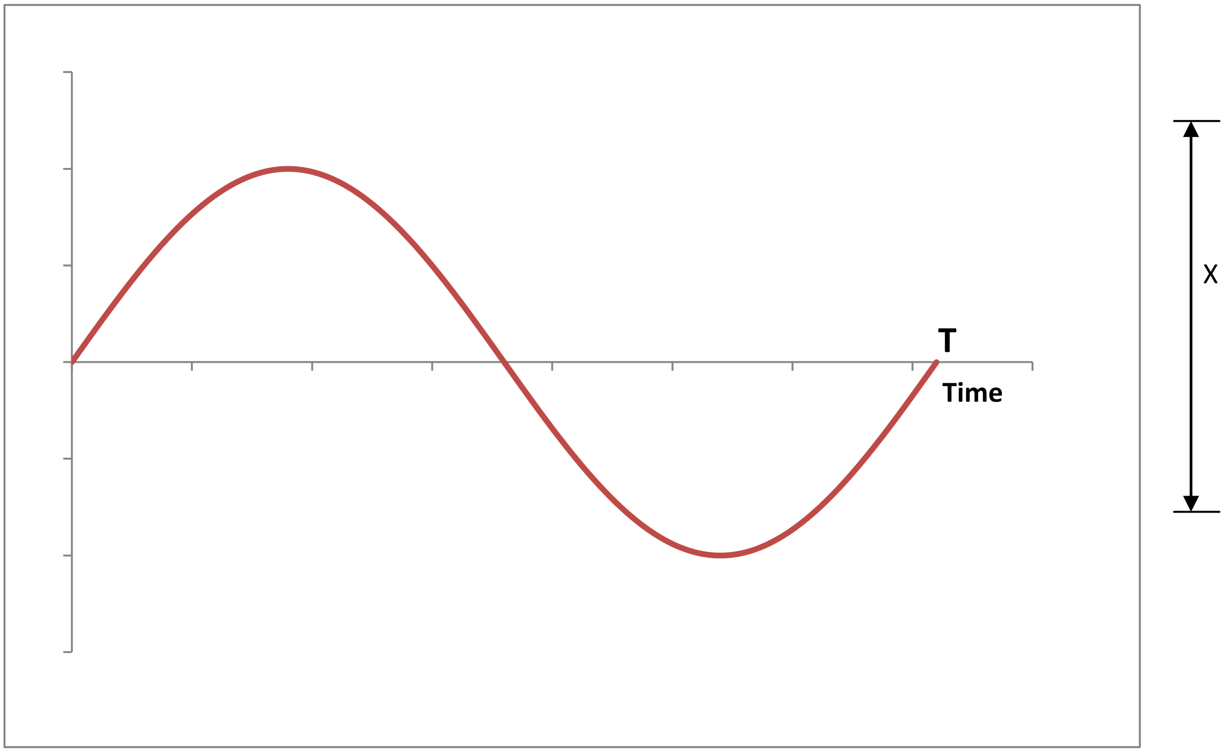
F_{rms} = 4 $m \left(\frac{X}{T^2}\right) \sqrt{Duty\ Cycle}$

$I_{rms} = \frac{4\, m \left(\frac{X}{T^2}\right)}{K_f} \sqrt{Duty\ Cycle}$

$V_{peak} = \frac{2X}{T}$

P = R I_{rms}^2

Sinusoidal Profile



$x(\mathrm{t}) = \frac{X}{2} \sin(\omega t)$ Position Equation

$v(t) = \frac{X}{2}\,\omega \cos(\omega t)$ Velocity Equation

$a(t) = -\frac{X}{2}\,\omega^2 \sin(\omega t)$ Acceleration Equation

$$a_{peak} = +\frac{X}{2}\,\omega^2$$

$$a_{rms} = \frac{\sqrt{2}}{2}\frac{X}{2}4\pi^2 f^2$$

$$a_{rms} = 13.956\, X f^2$$

$$F_{rms} = 13.956\, m\, X f^2 = \frac{13.956\, m\, X}{T^2}$$

$$I_{rms} = \frac{13.956\, m\, X}{K_f T^2}$$

$$Velocity_{peak} = \frac{\Pi X}{T}$$

$$P = R\, I_{rms}^2$$