Start-Up Procedure for a DC Shunt Motor & Dynamic Modeling

Problem: Start up a SM341100 DC permanent magnet motor. Assume it is driving a 20kg car with 3cm radius wheels while limiting the current draw to 40A

SM341100E500S \$245 CA
500 CPR, single ended Encoder
Latching connector, cable 4'

SM341100 \$145 CA
Brushed DC motor only

Contact us for Viper 95 Driver & all required Connectors

SM341100 Servo Motor Specification Download SM341100.pdf	
Frame Size	Nema34
Constant Torque	225 oz/in – 1.6 N.M
Peak Torque	1100 oz/in – 8.0 N.M
Continuous Current	6.6 Amp
Peak Current	40 Amp
Maximum Speed	3100 RPM ±10 % at 90V 1750 RPM ±10 % at 50V
Resistance	0.408 ohm
Inductance	3.185 mh
Inertia	3.47 kg/cm^2
Terminal Voltage	90 VDC
US Digital E5 Encoder single end	

Note: At startup (speed = 0), the motor willd draw

$$I_a = \frac{90V}{0.408\Omega} = 220A$$

which is more than the allowable peak current. To limit the starting current to 40A, add a 1.842 Ohms resistor in series at startup.

$$R_{total} = \frac{90V}{40A} = 2.25\Omega = 1.842\Omega + 0.408\Omega$$

You can remove the 1.842 Ohm resistor when the motor gets up to speed:

$$I_a = \frac{V_t - E_a}{R_a}$$

$$40A = \frac{90V - E_a}{0.408\Omega}$$

$$E_a = 73.68V = K_t\omega$$

From the datasheet

$$K_t = \frac{1.6Nm}{6.6A} = 0.2424\frac{Nm}{A} = 0.2424\frac{V}{rad/\sec}$$

so you take out the 1.842 Ohm resistor when the speed is

$$\omega = \frac{73.68V}{0.2424\frac{V}{rad/\sec}} = 303.93\frac{rad}{\sec}$$

Simulating:

Note that intertia goes through a gear as the turn ratio square. A wheel is a gear that converts rotational to translational motion:

$$x = r\theta$$

Relative to the motor, the 20kg looks like an intertia of

$$J = (20kg)(0.03m)^2 = 0.018\ kg \cdot m^2$$

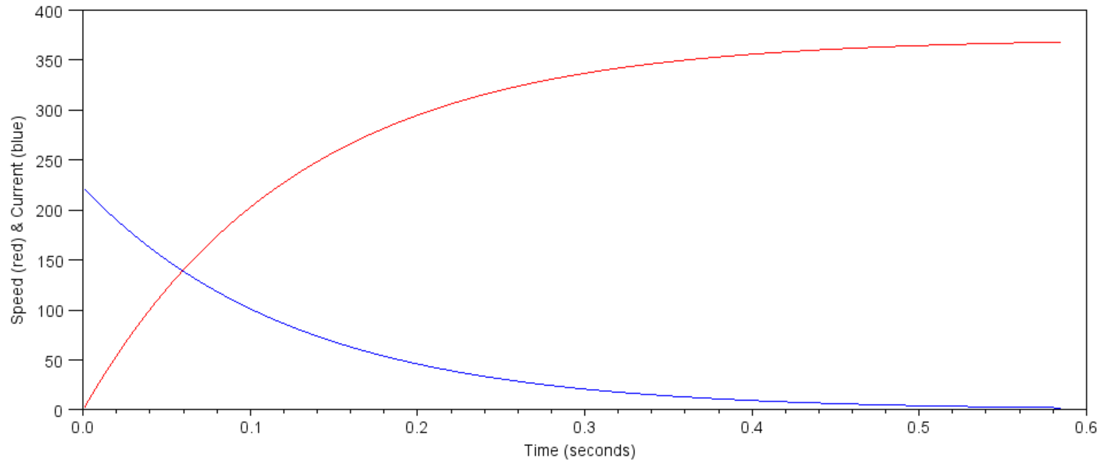
This adds to the motor's inertia

$$J_{motor} = 3.47kg \cdot cm^2 = 0.000347\ kg \cdot m^2$$

$$J_{total} = 0.018347\ kg \cdot m^2$$

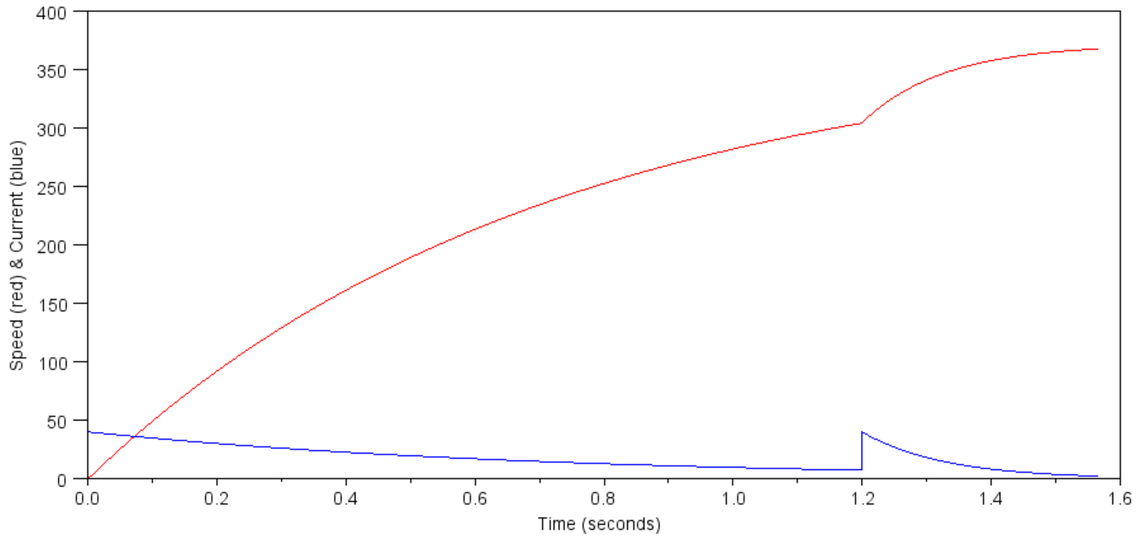
In SciLab:

First, if you don't add the extra resistance:




```
Kt = 0.2424;
Vt = 90;
r = 0.03;
Ra = 0.408;
J = 0.018347;

Wmax = Vt / Kt;

dt = 0.001;
w = 0;
W1 = [];
I1 = [];
t = 0;

while(w < 0.99*Wmax)
 t = t + dt;
 Ea = Kt * w;
 Ia = (90 - Ea) / Ra;
 T = Kt * Ia;

 dw = T/J;

 w = w + dw*dt;

 W1 = [W1; w];
 I1 = [I1; Ia];

 end
t = [1:length(W1)]' * dt;
plot(t,W1, 'r');
```

Now, add in 1.8 Ohms during startup:




```
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Vt = 90;
r = 0.03;
Ra = 0.408;
J = 0.018347;

Wmax = Vt / Kt;

dt = 0.001;
w = 0;
W1 = [];
I1 = [];
t = 0;

while(w < 0.99*Wmax)
 t = t + dt;
 Ea = Kt * w;

 if (w < 303.93) Ra = 2.25;
 else Ra = 0.408;
 end

 Ia = (90 - Ea) / Ra;
 T = Kt * Ia;

 dw = T/J;

 w = w + dw*dt;

 W1 = [W1; w];
 I1 = [I1; Ia];

 end
t = [1:length(W1)]' * dt;
plot(t,W1, 'r');
```

Splitting this 1.8 Ohms into two smaller resistors:

1.842 Ohms for speed < 202.64 rad/sec

0.614 Ohms for speed < 202.64 rad/sec < speed < 303.93 rad/sec

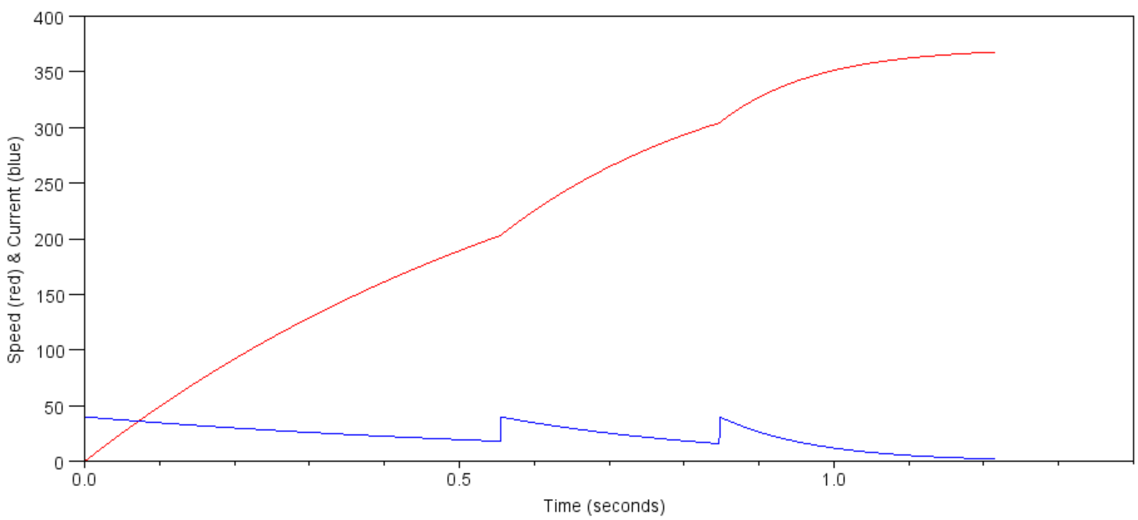
0 Ohms for speed < 303.93 rad/sec

When Ra = 1.022 Ohms, (0.408 + 0.614) the current is 40 A at a speed of:

$$I_a = 40A = \frac{90V - E_a}{1.022\Omega}$$

$$E_a = 49.12V$$

$$\omega = \frac{E_a}{K_t} = 202.64 \frac{rad}{\sec}$$



The SciLab code is the same as before excetpt for computations for Ra:

```
while(w < 0.99*Wmax)
 t = t + dt;
 Ea = Kt * w;

 if (w < 202.64) Ra = 2.25; end

 if ( (w > 202.64) & (w < 303.93) ) Ra = 1.022; end

 if (w > 303.93) Ra = 0.408;  end

 (etc.)
```