Name of Model: DC Motor

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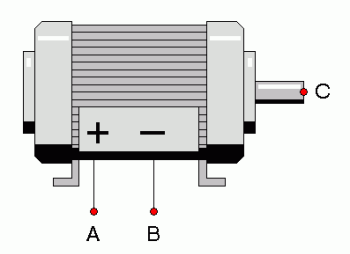

Description

This model represents a permanent magnet DC motor with a rack-and-pinion mechanical drive. Terminals A and B are the electrical nodes as shown in the above figure. Node C is a linear motion node representing the tip of the moving rack. The rack-and-pinion drive dimensions are such that when the rotor turns by on radian the rack moves by one meter. The rack moves in the positive direction when the voltage at node A with respect to node B positive.

Validity Range and Limitations

The following parameters are valid when positive:

- Rated Voltage
- Rated Speed
- Rotor Inertia
- Drag Coefficient
- Armature Resistance
- Armature Inductance

In addition, the drag coefficient may be set as zero.

Connections

Label	Description
A	Electrical terminal (Positive)
B	Electrical terminal (Negative)
C	Mechanical terminal

Adjustable Parameters

Name	Description	Valid Range	Default Value	Units
Rated Voltage	The motor voltage rating	Positive	115	*V*
Rated Speed	The motor rated rotational speed	Positive	125.6	*rad/s*
Armature Resistance	The electrical resistance of the armature winding	Positive	0.4	*O*
Armature Inductance	The inductance of the armature winding	Positive	0.0025	*H*
Rotor Inertia	Rotor inertia	Positive	0.5	kgm^2
Drag Coefficient	The coefficient of viscous friction of the mechanical parts of the model	Positive or zero	0.196	*Nms/rad*

Output Variables

Name	Description	Units
Voltage	Voltage across device. Polarity is VA-VB.	*V*
Current	Electric current through device. Positive flow is from node A to node B	*A*
Electrical_Power	The electric power flowing into the model through the electrical terminals A and B.	*W*
Mechanical_Power	The mechanical power flowing into the device through the mechanical terminal C.	*W*
Electrical_Torque	The torque applied on the rotor due to the magnetic field	*Nm*
Mechanical_Torque	The torque applied on the rotor due to the mechanical load connected to terminal C	*Nm*
Speed	Rotational Speed of the motor shaft (Also numerically equal to rack speed)	*rad/s* *(m/s)*
Position	Angular position of the motor shaft (Also numerically equal to rack position)	*Rad* *(m)*

Model Assumptions

Magnetic circuit is assumed to be linear.

Mathematical Description

$$v(t) = r * i(t) + l\frac{di(t)}{dt} + a * w(t) \quad (1)$$

$$Te = a * i(t) = J\frac{dw(t)}{dt} + b * w(t) + T \quad (2)$$

Where [1][2]:

v is the voltage across the motor electrical terminals (V_A -V_B).
i is the electric current into the motor through terminal A.?
w is the rotor speed.
Te is the electromagnetic torque imposed on the rotor.
T is the mechanical torque due to the mechanical Load connected to terminal C.
J is the rotor/rack/pinion equivalent moment of inertia.
r is the armature electrical resistance.
l is the armature self inductance.
a is equal to the ratio of the motor rated voltage divided by the rated speed.
b is the mechanical drag coefficient. .

Model Validation

Details could be found in reference [1].

Example Application and Model Verification

In the following example, DC motor is driven by a constant voltage source without payload. Simulation schematic is shown in Fig. 1. Voltage source is set as 120V with 1 mΩ internal resistance. DC motor parameters are listed in Fig. 2.

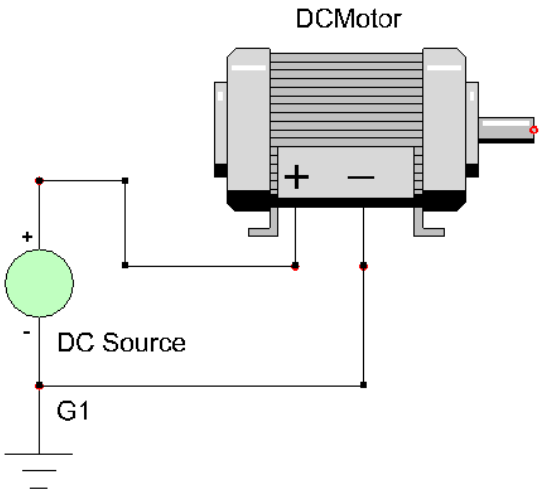

Fig. 1 Schematic of motor driving

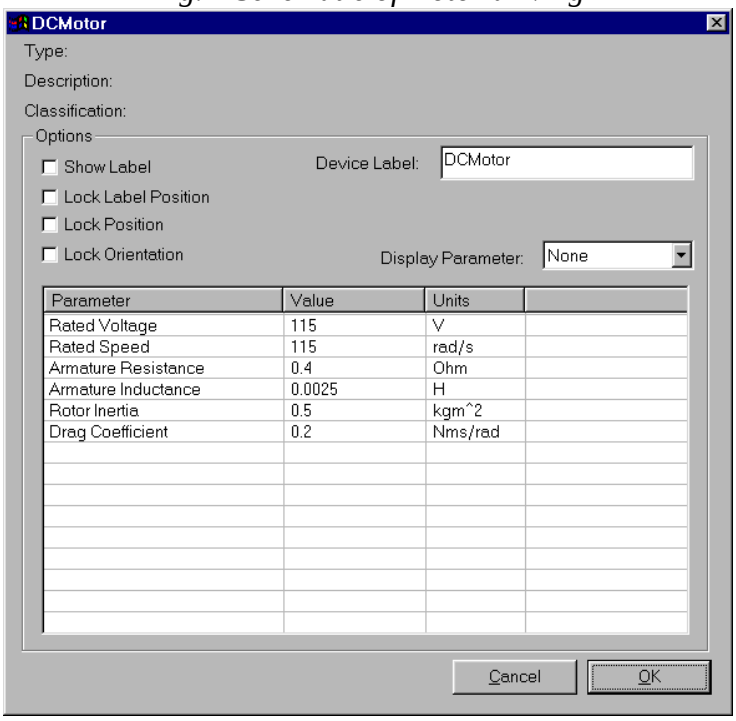

Fig. 2 Parameters of DC motor

According to equation (1) and equation (2) , the steady state current of DC motor should be:

$$i_{steadystae} = \frac{120}{5.401} = 22.218(A) \qquad (3)$$

Fig. 3 shows the simulation result of DC motor current. We can see the steady state current fits the numerical analysis pretty well.

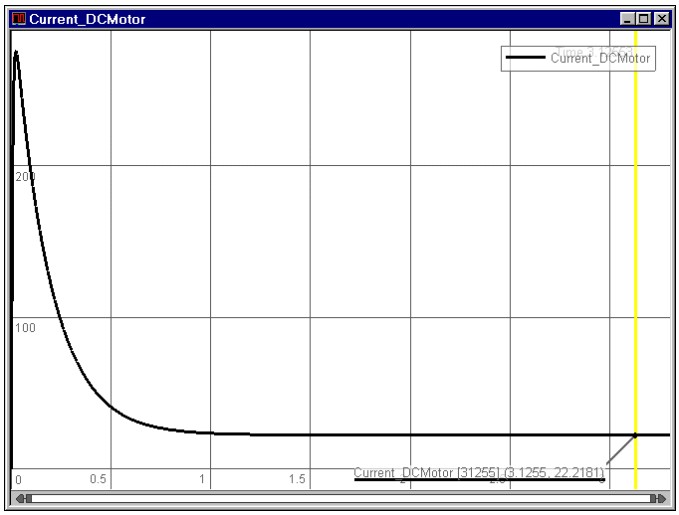

Fig. 3 Simulation result of motor current

References

1. Mulukutla S. Sarma, " Electric Machines: Steady-State Theory and Dynamic Perofrmance", Second edition, ISBN 0-534-93843-4, 1996
2. Morries Driels, "Linear Control Systems Engineering", ISBN 7-302-04242-5/TP.2444, 2000
3. G. Cokkinides and R. A. Dougal, "RC and AC models in the VTB Time Domain Solver", Department of Electrical and Computer Engineering, University of South Carolina, 1998.