9.3 D.C. MOTOR

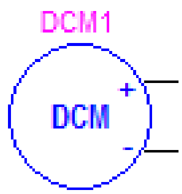
DC Motor	
	
Properties: – The D.C.motor model represents both the static and dynamic behaviours of two types of industrial D.C. motors: shunt and separately excited	Main features: Two common types of industrial motors. Type of connections of either rotoric and statoric circuits: – Parallel connection (shunt) or; – Two distinct circuits

Figure 9 - 12 Icon and diagram DC motor

N – DC Motor Introduction

The following equations govern the voltages of the motor as a function of the currents:

$$v_f = r_f i_f + d\lambda_f/dt$$

$$v_a = r_a i_a + d\lambda_a/dt$$

where

- v_f: voltage at the terminals of the stator winding
- i_f: current in the stator
- r_f: resistance of stator winding
- λ_f: flux in the stator
- v_a: voltage at the terminals of the rotor winding
- i_a: current in the rotor
- r_a: resistance of the rotor winding
- λ_a: flux in the rotor

The fluxes can be expressed as follows:

$\lambda_f = L_{ff}i_f + L_{fa}i_a$

$\lambda_a = L_{af}i_f + L_{aa}i_a$

where

- L_{ff}: inductance in the stator winding
- L_{aa}: inductance in the rotor winding
- L_{af} et L_{fa}: mutual inductances between the rotor and the stator

Also, the mutual inductances can be estimated by a sinusoidal function of the angular speed of the motor Θ_c:

$L_{af} = L_{fa} = -L\cos\Theta_c$

where

- L is a constant

The action of the switch allows the rotor winding to be perceived as a stationary winding with a magnetic axis perpendicular to the axis of the winding field. There is no induced voltage in one of the windings because of the variation of the current crossing the other winding. Consequently, the voltage equations can be reduced to a matrix in a Laplace domain, as follows:

$v_f(s)\ r_f + sL_{ff}i_f(s)$

$v_a(s)\varpi_r L_{af} r_a + sL_{aa}i_a(s)$

It is useful to represent the electromagnetic torque equation that follows:

$T_e = L_{af}i_f i_a$

And finally, using an equation linking the angular speed ϖ_r, a complete relation can be set and allows users to form the representative block diagram:

$T_e = Jd\varpi_r/dt + B_m\varpi_r + T_L$

where

- J: moment of inertia of rotor
- B_m: damping coefficient associated to the mechanical rotation movement
- T_L: load torque

Usually, the damping coefficient B_m is not considered.

The D.C. motor is often represented by Figure 9 - 13. According to the type of motor, the rotoric circuit can be connected in parallel with the statoric circuit, thus Vf=Va, in the case of a shunt motor.

A motor that uses two distinct circuits is referred to as a separately excited motor. The stator has to be supplied with another circuit, since the rotor is connected to the power network. The stator can be supplied using different methods, either using a constant source or with Simulink.

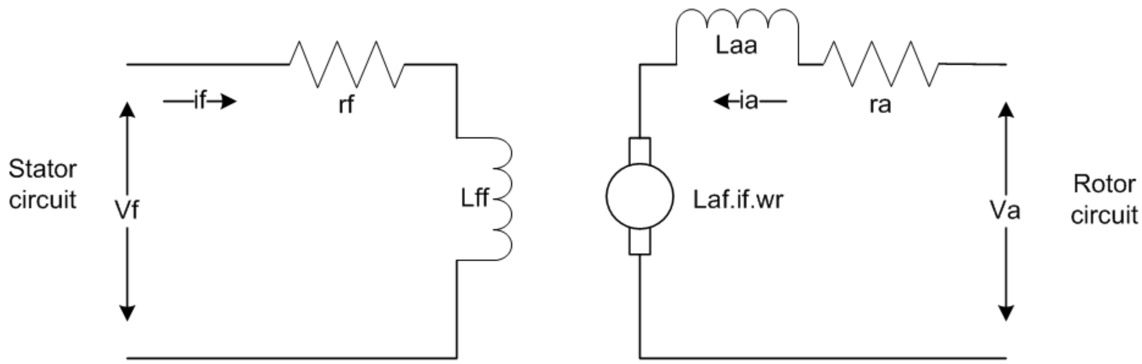


Figure 9 - 13 Simplified diagram of D.C. shunt motor

O –Motor Parameters

- R rotor: (ra) resistance of rotoric winding (ohm)
- L rotor: (Laa) inductance of rotoric winding (henry)
- R stator: (rf) resistance of statoric winding (ohm)
- L stator: (Lff) inductance of statoric winding (henry)
- L mutual: (Laf) mutual inductance between the stator and the rotor (henry)

P – Mechanical Load Parameters

- Load Torque: mechanical torque of the load driven by the motor (N.m)
- Moment of inertia: value of total inertia driven by the motor. This value consists of the inertia of the motor and the inertia of the driven mechanical load ($kg.m^2$)
- Viscous friction: value of viscous friction or damping. This corresponds to a friction loss varying with the speed (N.m.s)
- Dry friction: value of dry friction. This corresponds to constant friction loss (N.m)

Q – D.C. Motor Type

Allows users to specify the origin of the statoric circuit power supply:

- “Shunt connection”: the stator voltage is the same as the rotor voltage, since both are connected in parallel.
- “Internal”: separately excited motor, the stator is supplied by a constant internal source.
- “External”: separately excited motor, the stator is supplied by an external source originating from an A/D.
- “Simulink”: separately excited motor, the stator is supplied by a source originating from Simulink.

R –List of Available Signals

At acquisition, the following signals are made available by the sensors:

- I_label: total current of the D.C. motor (A)
- E_label: voltage generated by the armature circuit as a counter electromotive force (V)
- wr_label: speed of the D.C. motor rotor (rad/s)
- Vp_label: voltage at the positive terminal of the motor with respect to the ground (V)
- Vn_label: voltage at the negative terminal of the motor with respect to the ground (V)
- V_ext_label: voltage of the D.C. motor, or voltage of armature Va (V)
- Vf_label: excitation voltage at the terminals of stator (rf+Lff) (V)
- Vlink_label: voltage originating from Simulink to supply the stator, in the case of a separately excited motor supplied by a Simulink circuit (V)
- Tm_label: mechanical torque of the motor load (N.m)
- If_label: current in the stator circuit or field current.

S – D.C. Motor Control Panel

Figure 9 - 14 shows the control panel of a D.C. motor.

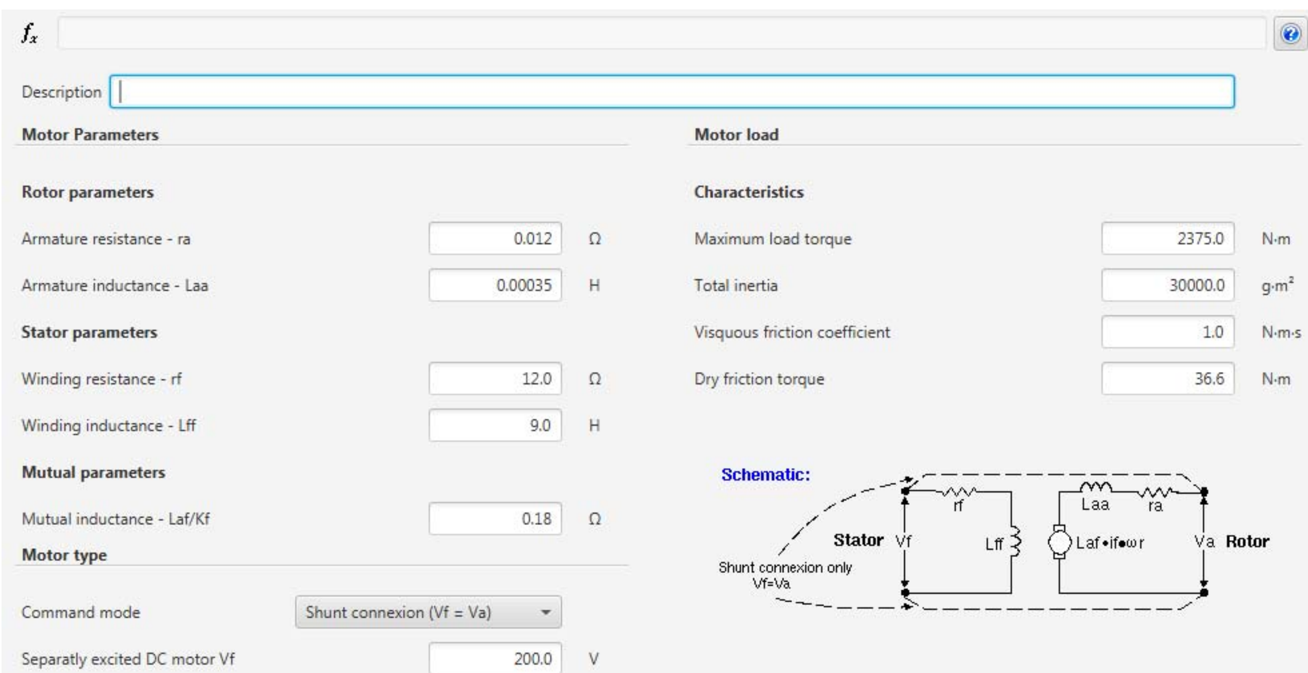


Figure 9 - 14 DC motor control panel

Figure 9 - 15 shows typical example using a DC Motor.

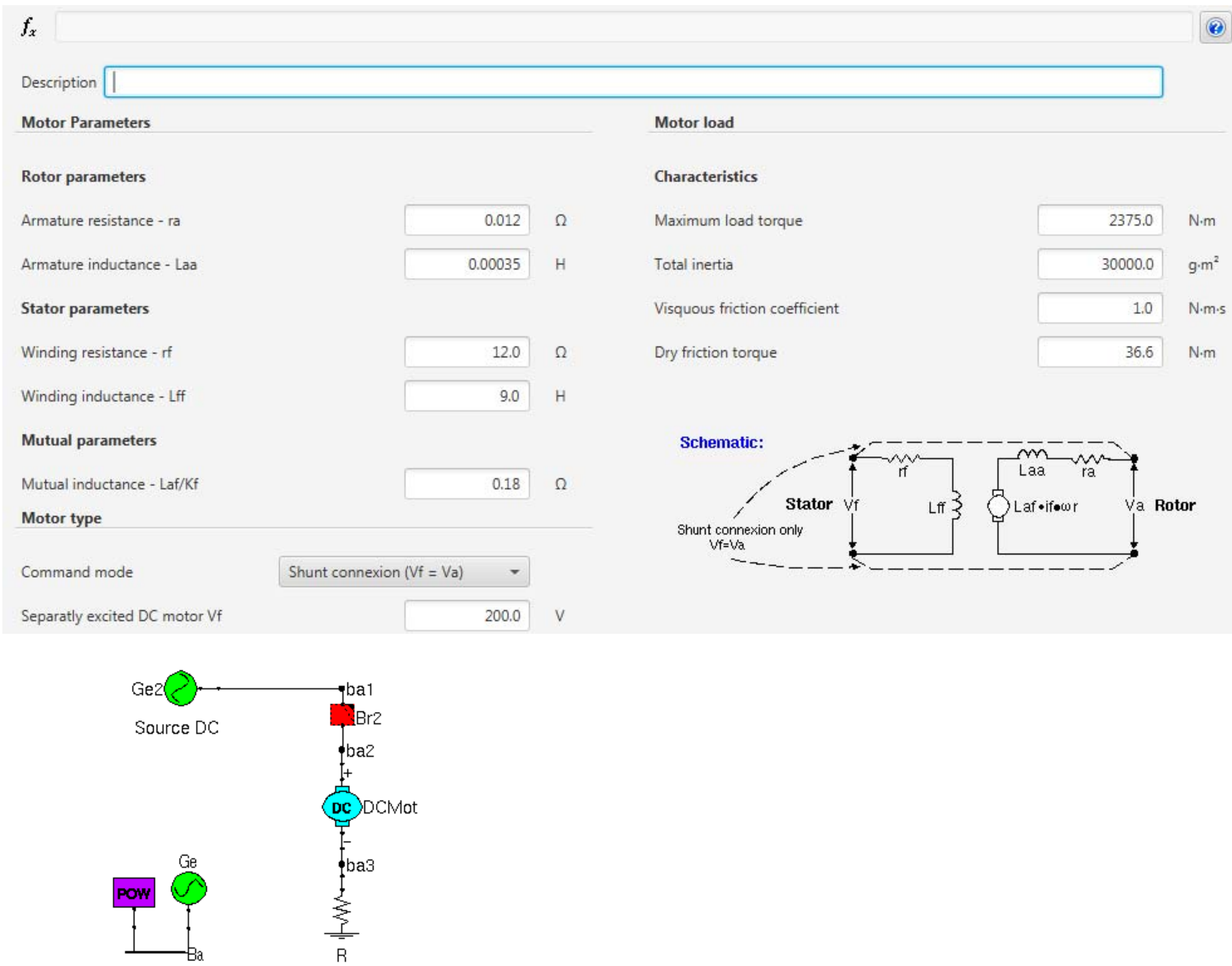


Figure 9 - 15   Example using a D.C. motor