Nemo V1.0 - User manual

Contents

1 Introduction

Nemo is a tool to compare motors and actuators. The notion of motor and actuator is actually merged into one: for the software, a 'motor' is a real motor, plus a reduction ratio (only simple transmissions are supported).

Nemo is made of several independant tabs, each with a configuration sidebar and a plot. Each tab is described below.

General remark: Because Matplotlib is quite slow, the plot is only updated on demand: whenever the user does a modification, a 'Update plot' button appears: this allows the user to do several modifications before asking for a plot update.

2 Defining a motor

A motor (actuator) is parametrized in Nemo by 8 parameters:

- R, the per-phase resistor
- L, the per-phase inductance
- k_e, the (single phase) BEMF constant
- n, the number of poles
- I_{max}, the maximum quadrature current
- $I_{nominal}$, the nominal quadrature current
- ρ, the reduction ratio
- U, the input voltage

Additionnaly, a motor also has a name, used to create a legend.

These parameters can be set manually through the GUI, in the motor configuration widget shown below.

Motor properties

Name	MyActuator RMD-X6 V3						
R (Ohm)	0.275	−	+	L (mH)	0.090	−	+
Ke (V.s/rad)	0.0900	−	+	N poles	28	−	+
Iq max(A)	10.8	−	+	Iq nom(A)	3.6	−	+
Reduction ratio	8.0	−	+	U (V)	48.0	−	+
Reset from template			▼		Helper		

To help you enter these values correctly, clicking on the "Helper" button will bring a dialog which will compute the corresponding per-phase value from datasheet information (e.g. line to line values, delta motors, magnet caracterized in terms of k_v, k_t or k_e...)

Nemo - Motor creation helper ✕

Motor creation helper

Input

Connection type   ⦿ Star (wye)   ◯ Delta

Resistance and Inductance

R (Ohm)   0.275   —   +   ◯ Terminal (aka. line to line or phase to phase)

L (mH)   0.090   —   +   ⦿ Single phase

Magnetic field strength (choose one)

⦿ Ke   ◯ V.s/rad, phase to phase

◯ KV   0.0900   —   +   ⦿ V.s/rad, single phase

◯ Kt   ◯ V/rpm, phase to phase

                  ◯ V/rpm, single phase

Iq nominal   3.600   —   +

                     ⦿ A   ◯ Arms

Iq max   10.800   —   +

Poles   14   —   +   ⦿ poles   ◯ pairs

Battery voltage (V)   48.000   —   +

Parameter summary: equivalent star motor

R phase (Ohm)   0.2750   L phase (mH) 0.0900

Ke phase (V.s/rad) 1.0000   N poles   14

Iq nominal (A)   3.60   Iq max (A)   10.80

Verification

Check that the computed values are reasonably close to the datasheet (differences can exist due to approximations in the datasheet, or because Nemo neglects non-linearities that may affect motor performance).

	Unit	
Km, articular	Nm/√W	2.335
	W /Nm²	0.183
Power (non defluxing)	W	400.8
Ke phase-phase	V/rad.s	1.732
	V/krpm	181.380
KV	rpm/V	6
Ktq, articular	Nm/A	1.500
Max RMS current	A	7.6
Max torque, articular	Nm	16.2
No load speed, articular	rad/s	27.7
	rpm	265
Max speed @ max torque	rad/s	24.7
	rpm	236

Cancel   Create

Additionally, a 'motor library' provides pre-configured motors for faster, error-free loading. These motor are then available from a drop-down menu in the motor creation widget.
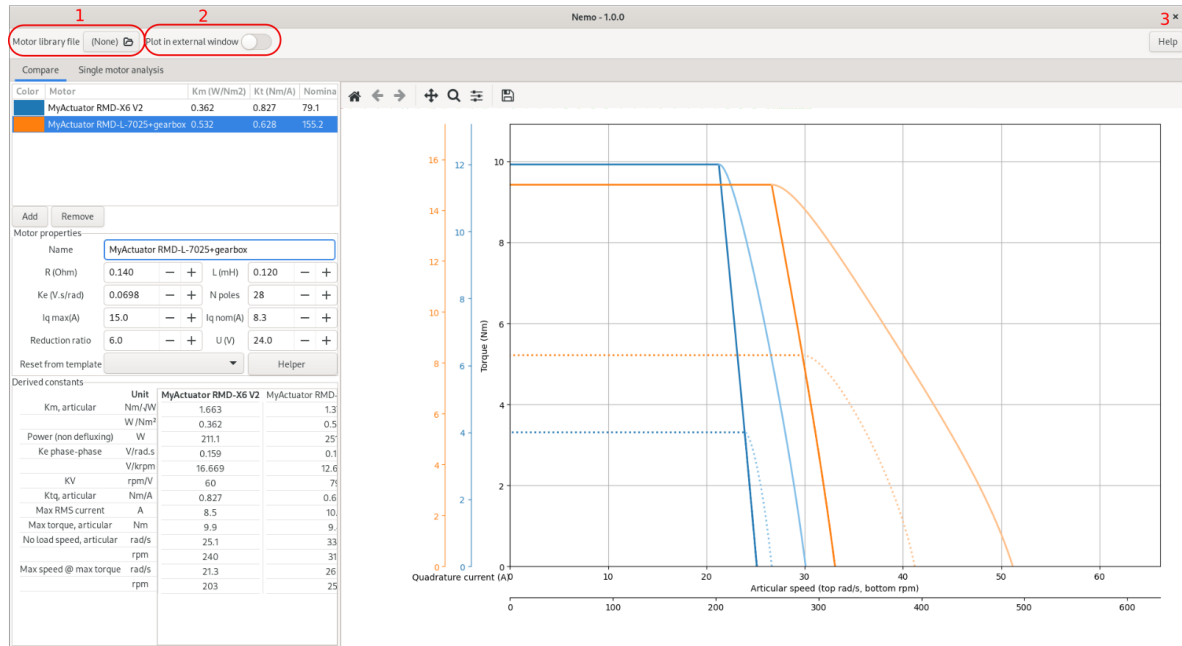
2.1   Adding a motor to the library

The motor library is simply a json file describing each motor: the format is given below. A custom json file can be loaded using the "motor library file" button at the top.

```
"MyActuator RMD-X6 V3":
{
    "R": 0.275,
    "L": 0.090,
    "ke": 0.0900,
    "i_quadrature_max": 10.8,
    "i_quadrature_nominal": 3.6,
    "np": 28,
    "U": 48,
    "reduction_ratio": 8
},
```
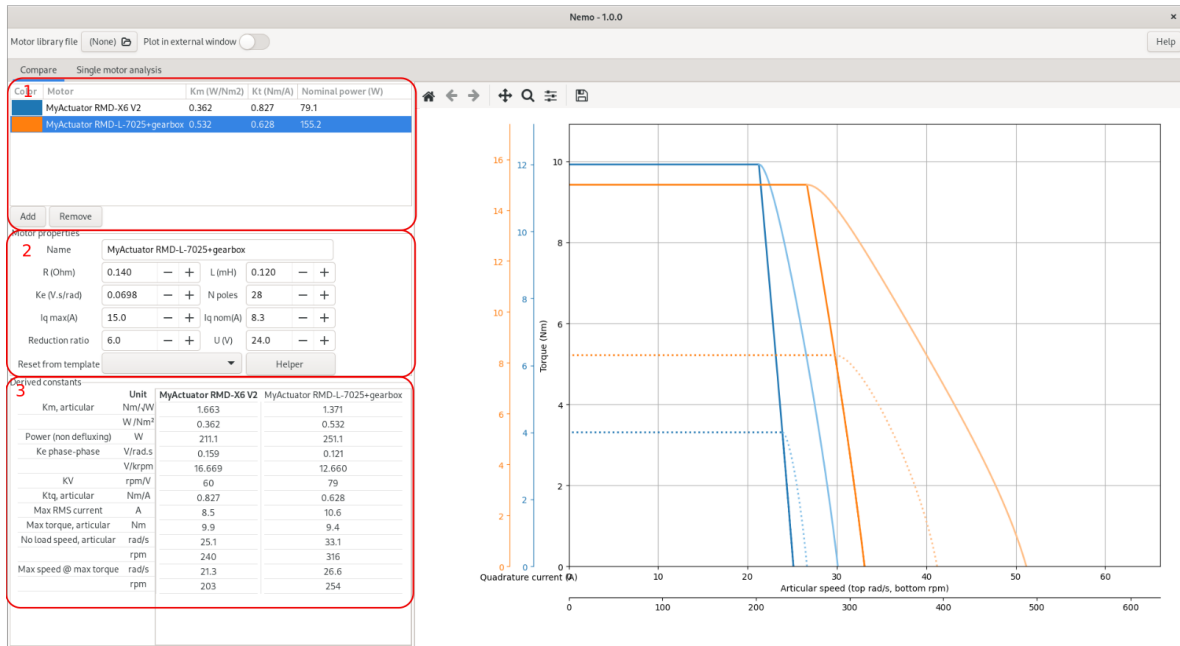
3   The main window

The top of the main window gives access to several functions:

- 1: *library loading button*: use this to replace the default library by another library json file

- 2: *external plot switch*: The main objective of Nemo is to plot graphs. But because part of the screen is taken the GUI, the plot is not that big. To overcome this issue, the plot can be done in its own floating window, by activating this switch. When the 'external plot' switch is on, the plot is done on another window, wich can be maximized / move to another screen. To return to the single window mode, you can either deactivate the switch, or minimize the external window (*note that the external window cannot be closed, only minimized*)

- 3: *help* A drop-down menu, with a link to this user manual, and the mathematical documentation explaining the underlying model and computations.

4 The 'Compare' Tab

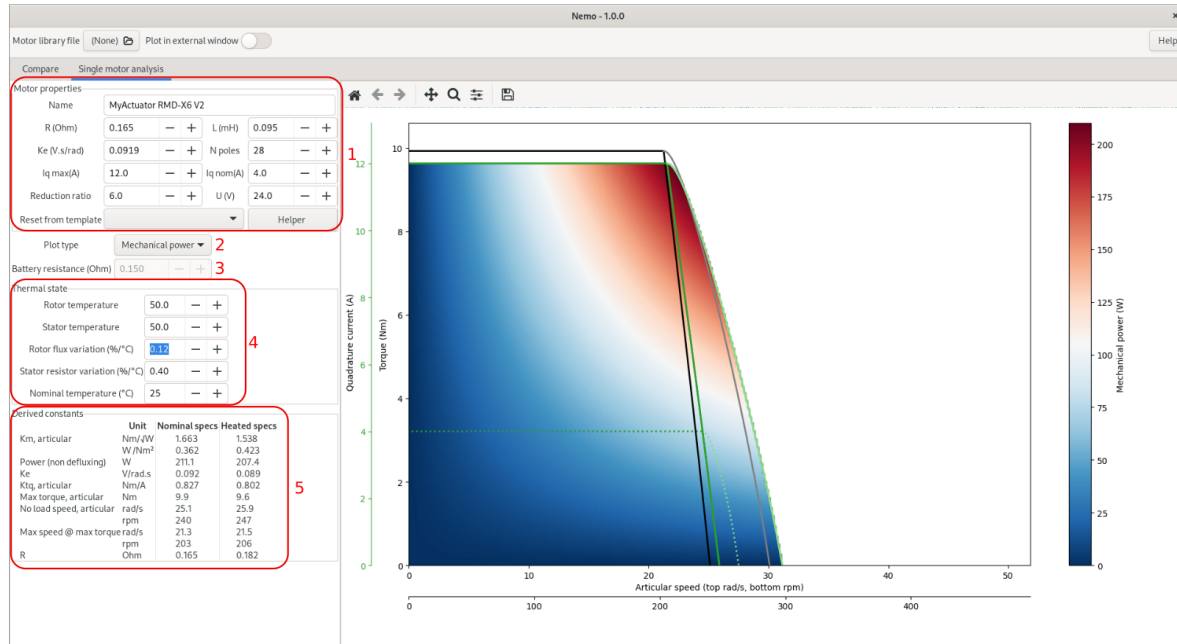**Objective**: to compare the theoretical caracteristics of several motors

GUI

- 1: *motor list* this lists the motors being compared. Elements in the list can be selected ; the selected element can be removed by the 'Remove' button, while the 'Add' button adds a new motor to the list.
- 2: *motor properties*: this indicates the properties of the selected motor, which can thus be editted and modified.
- 3: *derived constants*: this passive list shows a set of constants derived from the motor parameters. See the mathematical documentation for an explaination of each constant.

Plot: each motor is plotted in the specified color:

- the full line plot is the caracteristic, at the specified max torque & battery voltage
- the dotted line indicates the nominal current (thus nominal torque) limit
- the lighter-colored curve is the defluxing limit of the motor.

5   The 'Single motor analysis' Tab

Objective: study more in details the behavior of a single motor - including efficiency thermal variation, battery power draw...

GUI

- 1: *motor properties*: the properties of the plotted motor, at the nominal temperature
- 2: *plot type*: the type of information being plotted in the color plot:
    - the mechanical power
    - the thermal power
    - the total (mecanical + thermal) power
    - the efficiency (mecanical / total power)
    - the battery state (drawn battery current, predicted battery voltage, obtained by modeling the battery as a constant voltage source + serie resistor)
- 3: when plotting the battery state, the battery's internal resistance
- 4: *temperature information*: coefficient of the simple linear thermal model applied:
    - the stator's resistance increases linearly with temperature, with a given coefficient (0.4%/°C is the nominal value for copper)
    - the rotor's magnetic flux decreases linearly with temperature, with a given coefficient (-0.12%/°C is a typical value for Nd magnet)
- 5: *derived constants*: several derived constants, with their variation between nominal and heated value.

Plot

- In black, the caracteristic of the motor at nominal temperature
- In green, the heated motor caracteristic
- The color map depends on the plot type

Example: in this picture, the rotor and stator are both heated by 25°C from their nominal temperature. As a result, the torque decreases (due to a lower k_e). The increase in R reduces the max velocity at max torque, while the reduction of k_e decreases the back EMF, hence a larger no-load speed.