

MOTEON Motor Analysis Tool Help

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Overview

The tool can be used to generate characteristic plots for a permanent magnet synchronous machine (PMSM) with known motor parameters that are commonly provided in the datasheets of motor suppliers.

The screenshot shows the MOTEON Motor Analysis Tool interface. At the top, there is a header with the Infineon Developer Center logo and the tool name. Below the header is a menu bar with options: File, Advanced Plots, License Manager, and Help. The main area is divided into two tabs: "Motor Parameters" (selected) and "Target Operational Points". Under "Motor Parameters", there is a dropdown menu to "Select a motor:" with "default_pmsm" selected. Below this is a table of parameters:

Parameter	Description	Value
name	Motor name	default_pmsm
Ld	Inductance of d-axis in H	0.00027
Lq	Inductance of q-axis in H	0.00027
Psi_PM	Permanent Magnet Flux Linkage in Wb	0.006
R	Phase resistance in Ohm	0.14
p	Pole pair number	4
Unom	Target Supply Voltage in V	24
Is_rated	Maximum rated current in A	6.95

Below the table, there are two sections: "Characteristic Plots" and "Report". The "Characteristic Plots" section has two radio buttons: "Torque Speed Plot" (selected) and "Operational Modes Plot". Below these are two buttons: "Make Plot" and "Generate Report". The "Report" section is currently empty. At the bottom left, it says "Trial Version" and at the bottom center, "MOTEON Motor Analysis Tool - Version 0.2.12".

Tool Features

Basic functionalities

The basic feature set can be used in the trial version (free of charge) for an unlimited time. The only restriction is that generated plots can only be used publicly with a professional license.

List of the most common basic functionalities:

- read data sets from a database delivered along with the application
- customize or define new data sets for analysis (including saving the parameters to a file for later use)

- plot maximum torque versus speed assuming different operational modes
- plot d and q-axis currents needed to realize different operational modes
- specify target operational points (defined as required torque at a certain rotor speed)
- analyze required currents, operational modes and energy efficiency at target operational points
- save and load target operational points to or from a file
- interactive plots with additional information when hovering over it, zoom function and more

Professional functionalities

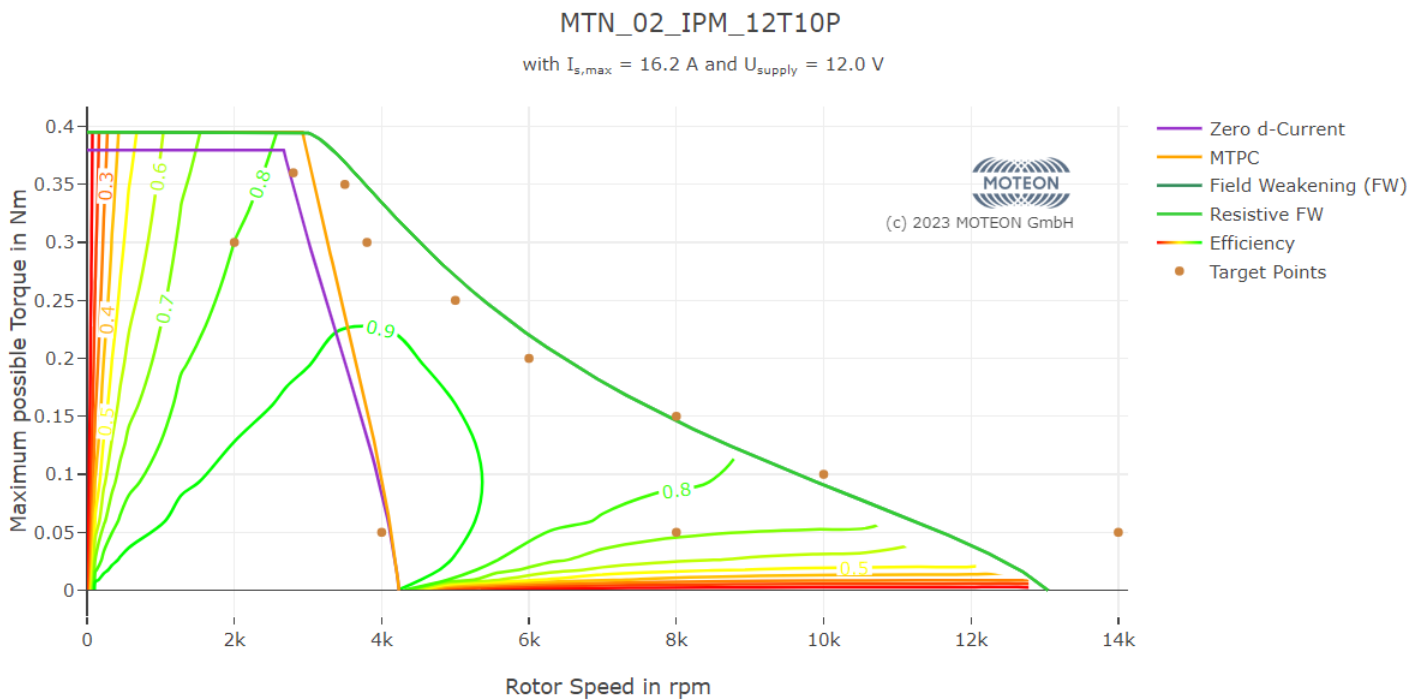
The professional features can be unlocked by requesting and activating a professional license via the "License Manager". More information to the license request can be found in the License Management section.

List of the most common professional functionalities:

- generate an analysis report with the characteristic plots and additional explanations
- analyze the effect of a range of temperatures or supply voltages towards the range of operation
- analyze the effect of motor parameter tolerances towards the range of operation
- estimate power consumption and efficiency over the range of operation and at specific operational points
- feel free to use the generated documents publicly

Torque-Speed-Plot

The torque-speed-plot will visualize the maximum achievable torque of the machine under analysis at certain rotor speeds. An example plot is shown below.



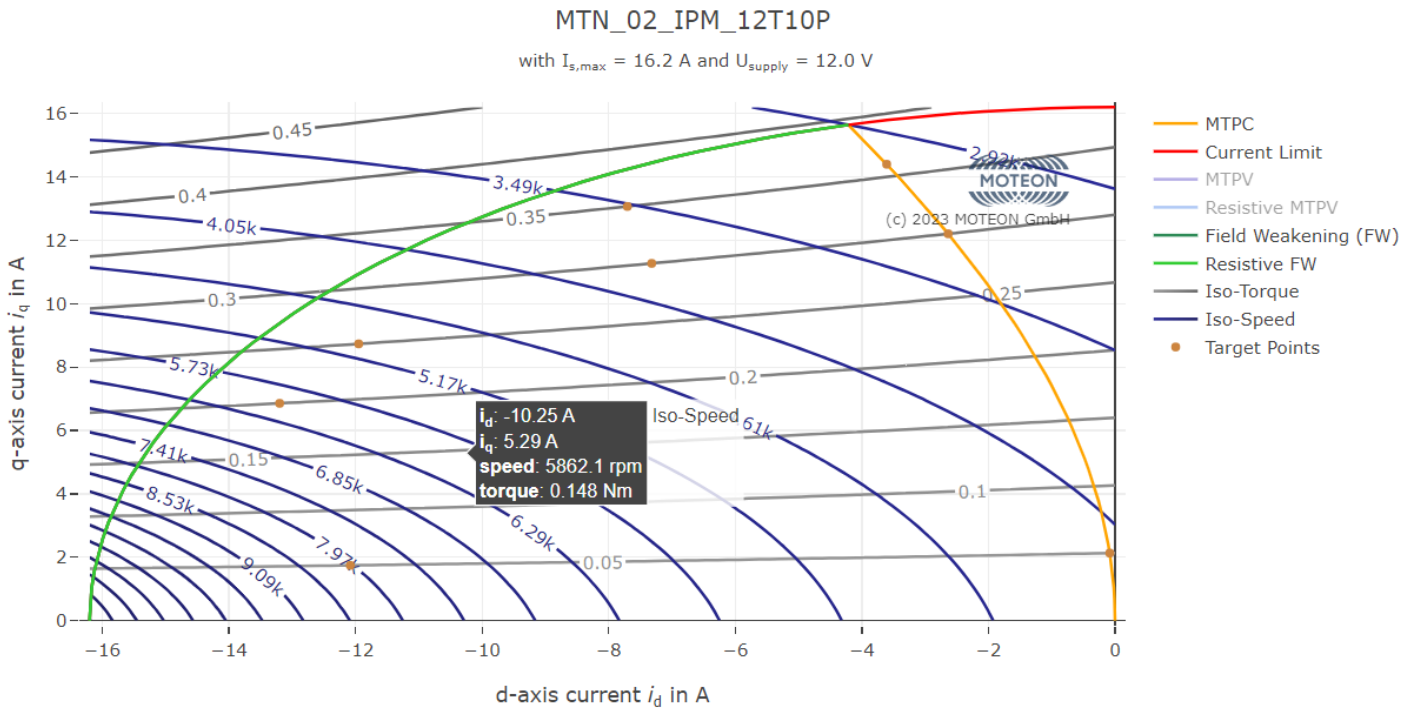
The different plot lines represent different operational modes that are used. The abbreviations are defined as

- **MTPC:** Maximum Torque per Current
- **FW:** Field Weakening
- **Resistive FW:** Field Weakening with consideration of the phase resistance

In addition to the distinct lines there is a contour plot showing the maximum energy efficiency for every operational point within the allowed or reachable operational region. It is discretized to steps of 10% meaning that regions without a line are in the range between the surrounding efficiency contours.

Operational-Modes-Plot

The operational-modes-plot will visualize the values of d and q-axis currents for the machine under analysis that must be realized to work in a certain operational mode. An example plot is shown below.



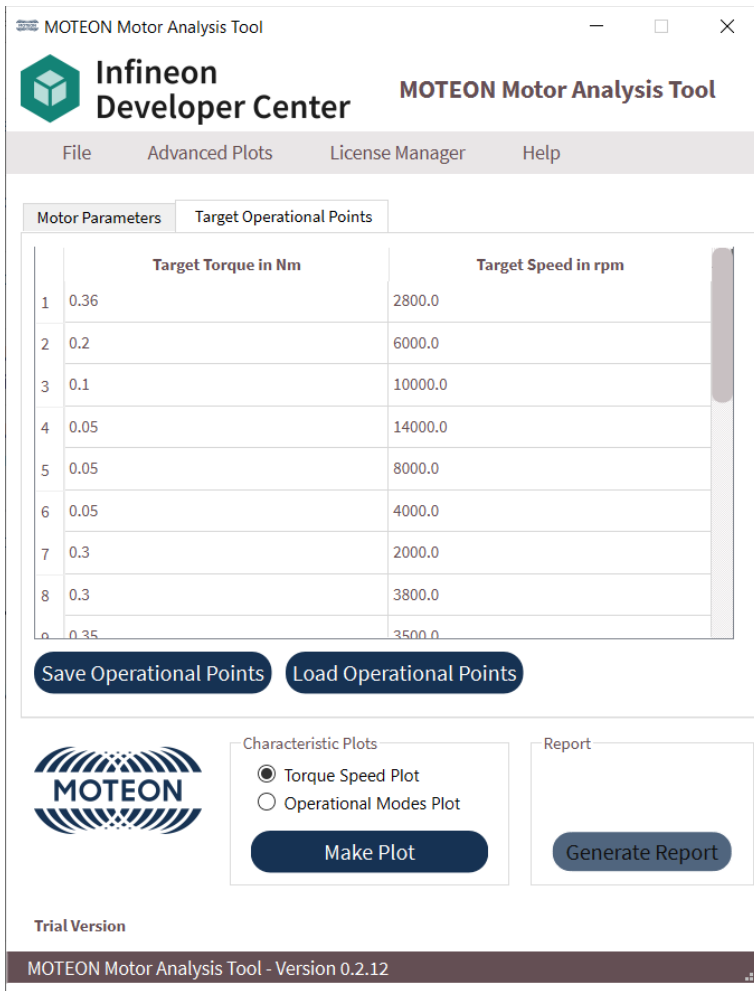
The different plot lines represent different operational modes that are used. The abbreviations are defined as

- **MTPC:** Maximum Torque per Current
- **MTPV:** Maximum Torque per Voltage
- **Resistive MTPV:** Maximum Torque per Voltage with consideration of the phase resistance
- **FW:** Field Weakening
- **Resistive FW:** Field Weakening with consideration of the phase resistance

The two contour plots, **Iso-Torque** and **Iso-Speed**, show lines of d and q-axis currents that result in the same torque or rotor speed, respectively. The generated torque is written to the lines in Nm, the speed is annotated in rpm.

Target-Operational-Points

In the app there is another tab for specifying target operational points (TOPs). Those points are individually defined as a required torque value at a certain rotor speed. The table view is shown below.



By pressing "Make Plot" the selected characteristic will appear on screen including the target points as dots like in the example plots above. The actual plot that is opened will be dynamic with annotations when hovering over the plot region showing for example efficiency and other information about each TOP.

When pressing "Generate Report" a report document will be exported. A table will be included into the report summarizing the results for each TOP defined in the table. If a target point is not realizable within the allowed operating regions it will appear as "no solution". An example for the report table is provided below

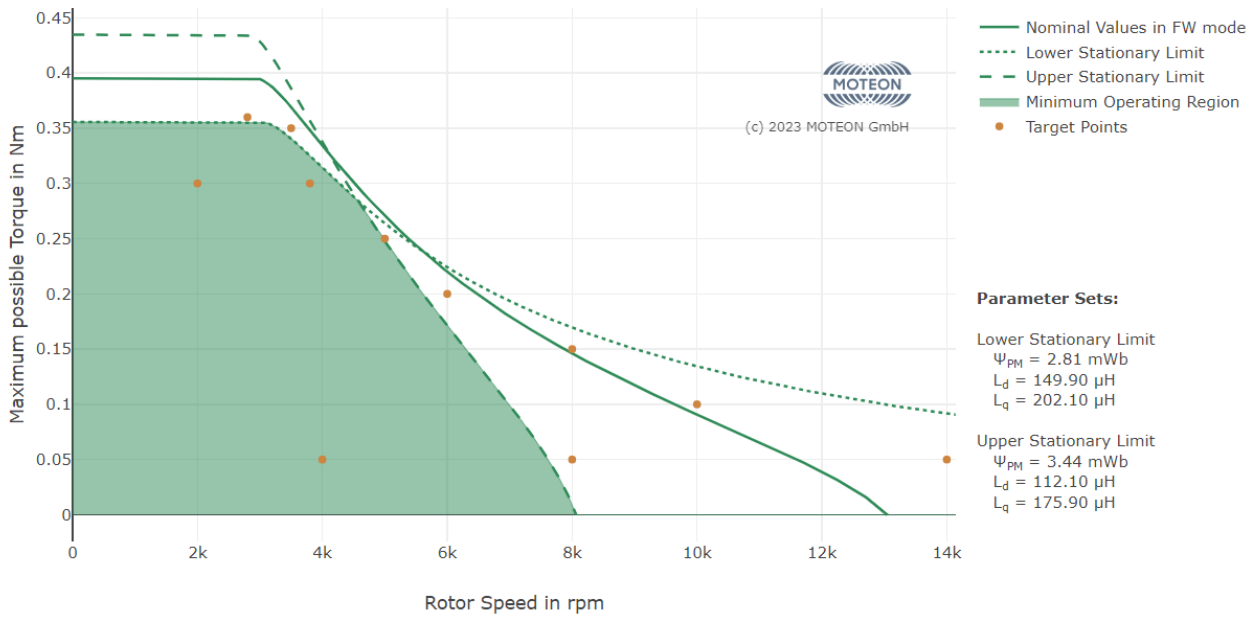
	Speed in rpm	Torque in Nm	Optimal d and q-axis current in A	Required stator current in A	Expected supply current in A ¹	Efficiency in %	Target Operation Mode
1	2800.0	0.36	(-3.608, 14.4)	14.845	10.642	82.7	MTPC
2	6000.0	0.2	(-13.198, 6.856)	14.872	12.324	85.0	FW
3	10000.0	0.1	no solution	-	-	-	
4	14000.0	0.05	no solution	-	-	-	
5	8000.0	0.05	(-12.081, 1.743)	12.206	4.739	73.7	FW
6	4000.0	0.05	(-0.084, 2.131)	2.132	1.783	97.9	MTPC
7	2000.0	0.3	(-2.637, 12.206)	12.488	6.542	80.0	MTPC
8	3800.0	0.3	(-7.32, 11.272)	13.441	11.461	86.8	FW
9	3500.0	0.35	(-7.705, 13.069)	15.171	12.618	84.7	FW
10	8000.0	0.15	no solution	-	-	-	
11	5000.0	0.25	(-11.949, 8.733)	14.8	12.743	85.6	FW

¹ This value corresponds to an ideal inverter having a 100% efficiency.

Tolerance Plot

The tolerance plot will show a torque-speed-plot considering the best and worst-case combination of parameters that show some tolerance. The tolerance value can be specified in a window that will open on plot generation. The resulting plot will look like the one below. If this plot has been generated it will also be included into the report. Just start the report generation afterwards.

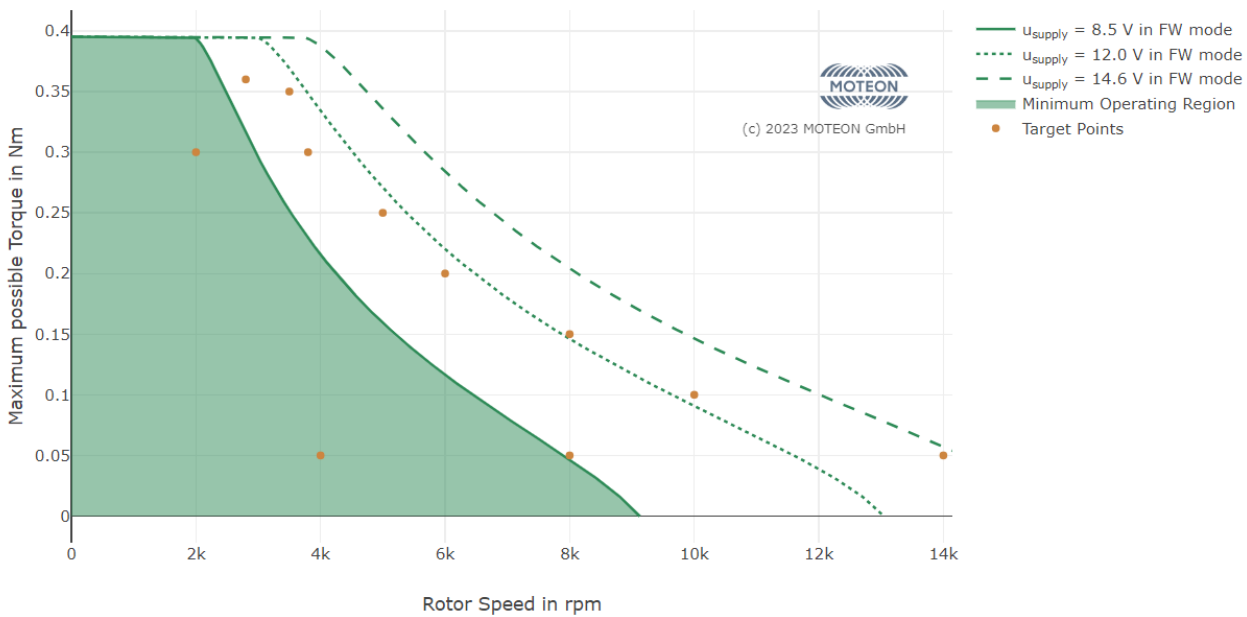
MTN_02_IPM_12T10P in FW mode with motor parameter tolerance of 10.0%



Variable Supply Voltage Plot

This plot will show a torque-speed-plot considering different supply voltage levels. The level values can be specified in a window that will open on plot generation. The resulting plot will look like the one below. If this plot has been generated it will also be included into the report. Just start the report generation afterwards.

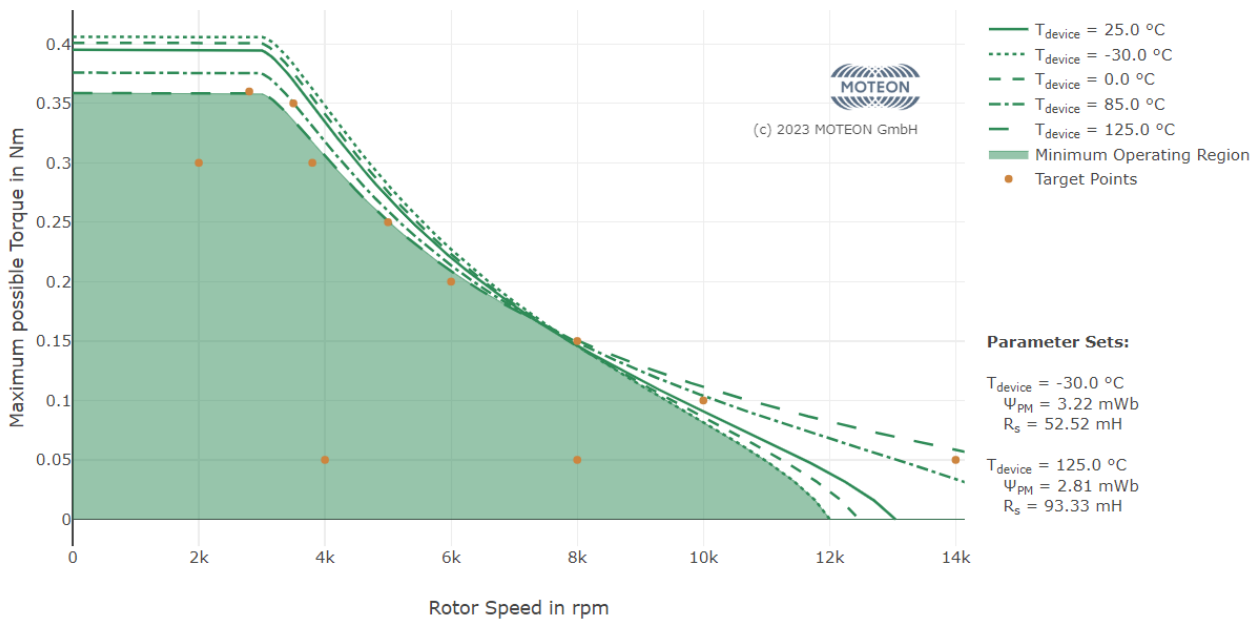
MTN_02_IPM_12T10P in FW mode using different supply voltage levels



Device Temperature Plot

This plot will show a torque-speed-plot considering different operating temperatures. The temperature values can be specified in a window that will open on plot generation. The resulting plot will look like the one below. If this plot has been generated it will also be included into the report. Just start the report generation afterwards.

MTN_02_IPM_12T10P in FW mode at different operating temperatures

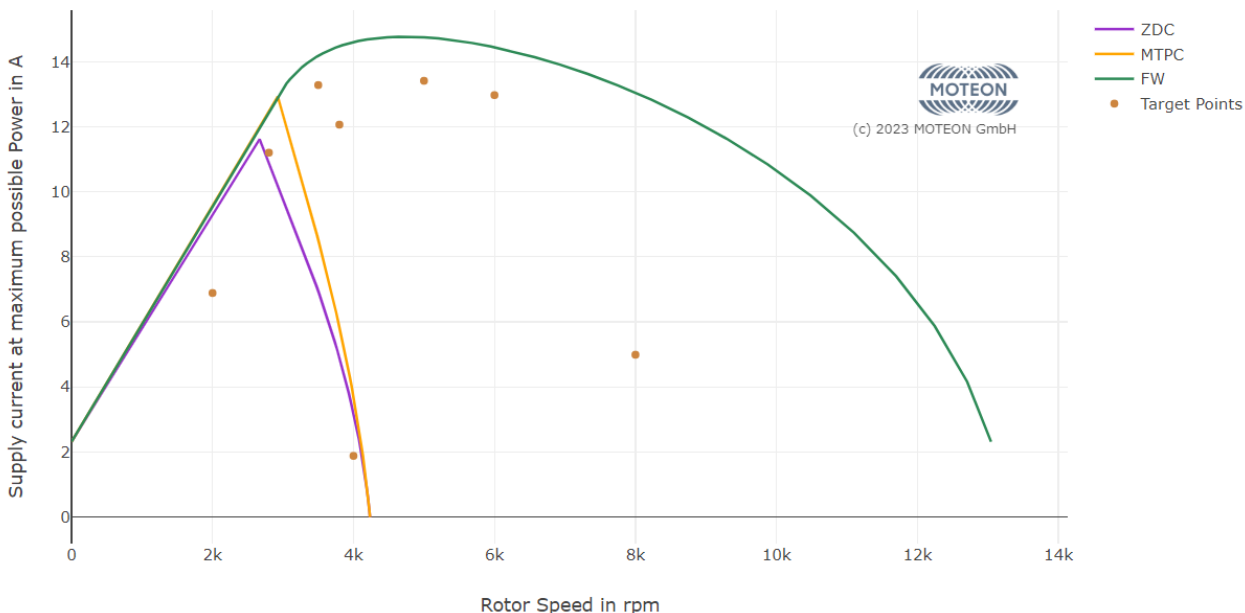


Supply Current Plot

The supply current plot will show the expected supply current over the maximum operating range. For many applications the amount of current a motor is allowed to consume is limited. With this plot an early evaluation is possible. The inverter efficiency can be provided in a window that will open on plot generation.

Supply Current of MTN_02_IPM_12T10P with 95.0% inverter efficiency

at $U_{supply} = 12.0\text{ V}$



Actions

Make Plot

Pressing "Make Plot" will run a motor analysis and open the selected characteristic plot in the default web browser. The plot will be dynamic allowing for zooming, panning and scaling. It will show annotations when hovering over the plot region. By clicking on a legend entry plot traces can be unselected and (re-)selected to hide or show them, respectively. If such a plot is desired to be stored to disk it is highly recommended to not use the browser's save option but to click on "Generate Report". It will save all characteristic plots as dynamic and static file as one file each. An alternative approach would be to copy the plot file from the temporary directory where it has been generated.

If there are points specified in the Target Operational Points table those will be gathered and plotted along with the generic characteristic lines.

Generate Report

The "Generate Report" button triggers the export process of a report file. It will open a file dialog to select where to export files to. It will only accept folders. Specifying file names is not possible. The export process will save the characteristic plots as both dynamic (html) and static (png) objects and it will generate a report also as html file. The report includes the most relevant information from the analysis like the Target Operation Points table described above and the plots that have been generated before.

If plots from the advanced plots menu are desired to appear in the report file, they have to be generated before starting the report generation.

Save Database File and Load Database File

Within the "File" menu in the menu bar there are options to save and load a database file. If a device parameter set has been appropriately defined inside the parameters table, the data set can be stored with the "Save" option. If the program will be executed another time, this data set can be restored by the "Load" option. As long as the file is formatted compatibly, there is no restriction to adding items via a text editor to have one file including several specific machines.

Save Operational Points and Load Operational Points

Within the tab "Target Operational Points" there are buttons to save and load TOPs. If a list of TOPs is specified in the table the "Save" option can be used to export them to a file. This file can be loaded again after re-execution of the program or after changes have been made that should be reverted.

Note, that TOPs do not have to be saved to be included in the plots that are generated.

Advanced plots

In the advanced plots section of the menu bar you can generate plots that show advanced characteristics. Possible options are presented above.

Help

The "Help" menu in the menu bar contains options to open this help page or to get in touch with the Support (see Contact Support section).

Motor Parameter Help

This tool is designed to take only datasheet parameters to provide insights of a motor's range of operation. However, not every datasheet includes the same parameters. In this section, some guidance is provided about how to come to the parameters in the tool by converting typical other datasheet values.

Permanent Magnet Flux Linkage

In most motor datasheets instead of the permanent magnet flux linkage, there are other parameters provided like a torque constant or a voltage constant. Those values can be converted to the PM flux linkage as follows.

From a torque constant

The torque constant k_τ can be converted to the permanent magnet flux linkage using the torque equation

$$\tau_e = \frac{3p}{2} i_q (\Psi_{PM} + (L_d - L_q) i_d)$$

For some motor construction types, especially in case of surface-mounted PMSM, the d and q-axis inductances are basically identical. In this case the equation simplifies to

$$\tau_e = \frac{3p}{2} \underbrace{\Psi_{PM}}_{=k_\tau} i_q$$

leading to

$$\Psi_{PM} = \frac{2}{3p} k_\tau$$

From a voltage constant

The voltage constant k_v can be converted to the permanent magnet flux linkage using the d-axis current dynamics. When the terminals are only connected to a voltage measurement device no currents are flowing, consequentially simplifying the equation to

$$u_q = p\omega \Psi_{PM} = \underbrace{p \Psi_{PM}}_{=k_v} \omega$$

leading to

$$\Psi_{PM} = \frac{1}{p} k_v$$

If the voltage constant is given with a rms-measured value a scaling factor of $\sqrt{2}$ needs to be added. Also, often the speed is measured in krpm which again needs to be converted to base SI units. This leads to

$$\Psi_{PM} = \frac{3}{100\pi p} k_v \begin{cases} 1 & \text{if peak voltage, measured between terminal and star} \\ \sqrt{2} & \text{if rms voltage, measured between terminal and star} \\ \frac{1}{\sqrt{3}} & \text{if peak voltage, measured between two terminals} \\ \frac{\sqrt{2}}{\sqrt{3}} & \text{if rms voltage, measured between two terminals} \end{cases}$$

if the voltage constant is provided in V/krpm.

Stator Phase Resistance

Some datasheets provide the actual phase resistance, but most of them specify a value measured from one to another terminal, mostly called line-to-line resistance. This value needs to be halved to get to the phase resistance, i.e.

$$R_S = \frac{R_{LL}}{2}$$

D and Q-Axis Inductances

Some datasheets might provide the actual d and q axis inductances, but most of them specify an inductance value measured from one to another terminal, mostly called line-to-line inductance. This value needs to be halved to get to the phase inductance. If specified as one single value there is no way of differentiating between d and q axis value, so it is just

$$L_d = L_q = L_S = \frac{L_{LL}}{2}$$

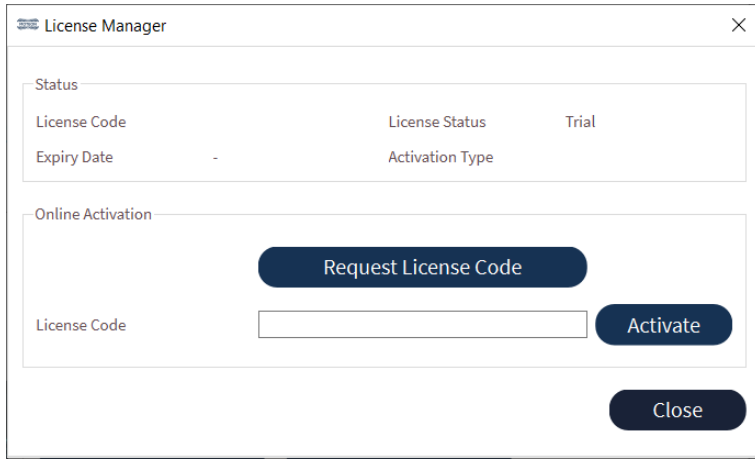
If there is a characteristic of line-to-line inductance for a given angle one can determine the d and q axis inductances as the values at certain angles, more specifically

$$L_d = \left. \frac{L_{LL}(\phi)}{2} \right|_{\phi_e=0} \quad \text{and} \quad L_q = \left. \frac{L_{LL}(\phi)}{2} \right|_{\phi_e=\pi/2}$$

License Request to Activate the Tool

In order to request a license, open the "License Manager" and click on "Request License Code". A prefilled e-Mail will open, ready to be sent.

Alternatively, you can manually write to support@moteon.com to ask for a license code.



The screenshot shows a 'License Manager' window. At the top, there's a title bar with a close button. Below it, a 'Status' section contains a table with columns: License Code, Expiry Date, License Status, Activation Type, and Trial. The Expiry Date field contains a hyphen. Below the status section is an 'Online Activation' section. It features a dark blue button labeled 'Request License Code'. Underneath is a text input field labeled 'License Code' and a dark blue button labeled 'Activate'. At the bottom right of the window is a dark blue button labeled 'Close'.

After receiving the license code, paste it in the text field and click "Activate". Your app should now switch to the professional version. If not, please contact the support again.

Customer Support

In order to get technical support open the "Help" menu and select "Contact Support". A prefilled e-Mail will open that already includes some information of your system configuration and the log. Please describe your problem in sufficient detail that it can be reproduced.

Alternatively, you can manually send a message to support@moteon.com describing your issue.

Legal Statements

Data Protection

No personal data is stored in the MOTEON Motor Analysis Tool.

Export Control Classification

The Software contained in this package may be subject to export control:

ALNR: N

ECCN: N

US: ECCN-US: EAR99

SICLASS: N

MYCLASS: N

MXCLASS: N

HKCLASS: N

Software classified with "ALNR not equal to N" are subject to European or German export authorization when being exported out of the EU.

Software classified with "ECCN not equal to N" are subject to US re-export authorization.

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Even without a label, or with label "ALNR:N" or "ECCN:N" authorization may be required due to the final whereabouts and purpose for which the goods are to be used.

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Included Third Party Licenses

The package to which this Agreement forms part of contains Open Source Software located in the following directories/files: Default directory is:

C:\Infineon\Tools\%ToolName%\%Version%\

Installation folder of the Software may vary according to Licensee's selection during installation process.

For copyright information, licensing terms and additional information (e.g. on how to obtain the source code of such Open Source Software), please refer to "licenses" folder.

Default directory is: C:\Infineon\Tools\%ToolName%\%Version%\licenses

Complete directory may vary according to Licensee's selection during installation process.

Python:

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The Python version included in the tool files is 3.8.5.

No changes have been made in the Python Source Code.

Qt package:

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The Qt Toolkit is Copyright (C) 2015 The Qt Company Ltd.

Contact: <http://www.qt.io/licensing/>

You may use, distribute and copy the Qt Toolkit under the terms of GNU Lesser General Public License version 3, which is displayed below. This license makes reference to the version 3 of the GNU General Public License, which you can find in the LICENSE.GPLv3 file.

This application's graphical user interface (GUI) is implemented using the Open Source Library Qt6 distributed by the PySide6 Python package. This package is provided under the LGPLv3 license which requires to include the library's source code or link to it.

The currently used PySide version is 6.2.0

The source code of Qt6 can be downloaded at

<https://www.qt.io/product/qt6>

Alternatively, you can download the PySide6 Qt distribution at

<https://pypi.org/project/PySide6/>

To exchange the Qt library used by this tool all Qt dll files in the executable folder need to be replaced by the files of the target version. Note, that certain function calls may not work when using a different version of Qt.

No changes have been made in the Qt library by the author of the Motor Analysis tool.

Pillow package:

The Python Imaging Library (PIL) is

Copyright © 1997-2011 by Secret Labs AB

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Pillow is the friendly PIL fork. It is

Copyright © 2010-2022 by Alex Clark and contributors

Like PIL, Pillow is licensed under the open source HPND License:

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