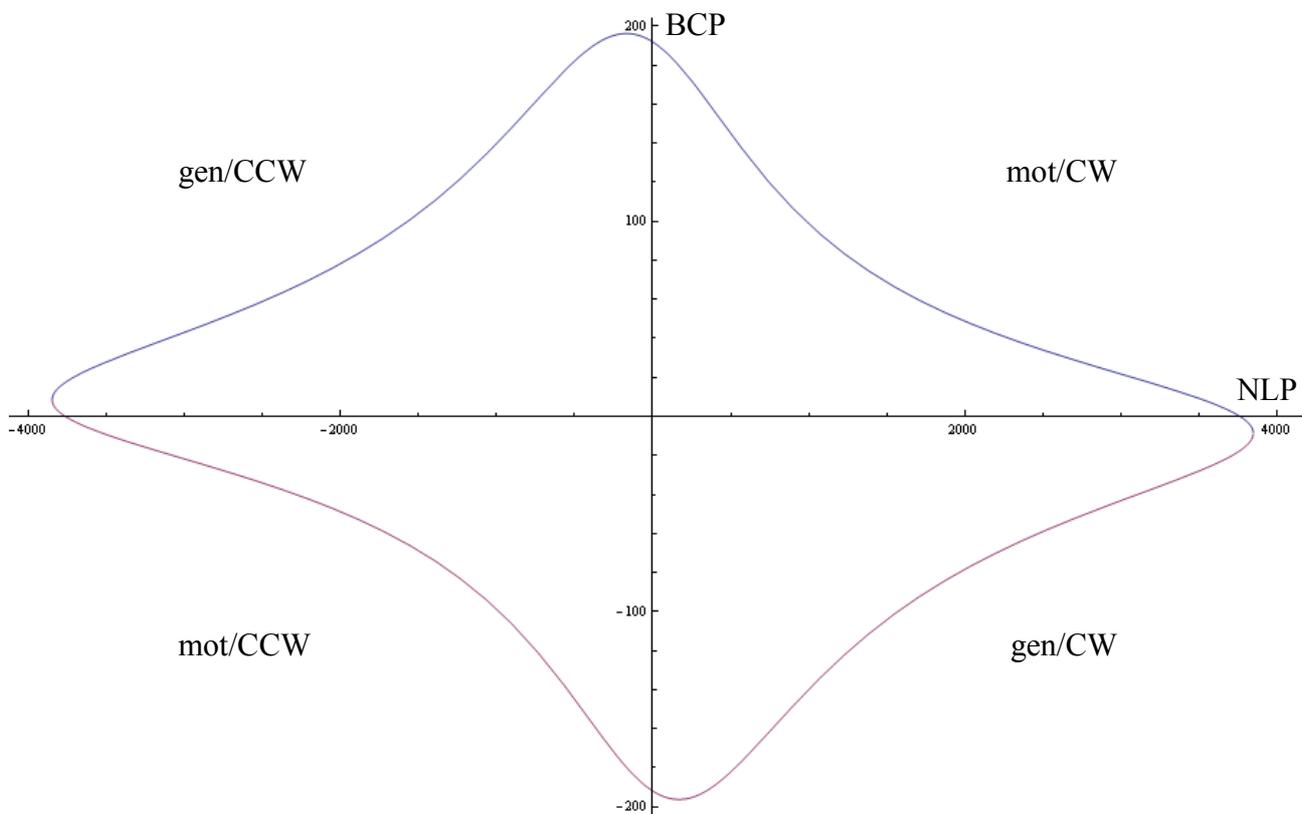


## Option (chargeable) OperationPointLive



(available for all SLS and SLR)

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## 1 Introduction

The first question to be answered before starting a new design for an e-propulsion system is to find the best matching e-motor for this desired system. It should have enough power but also should not be oversized (too heavy, too expensive). Next there might be restrictions or demands in speed at certain voltage, best efficiency (of course!) and after all it maybe shall match with a certain propeller, etc. ...

This situation is not easy, because each demand is in conflict with all the other demands. One single change which improves one aspect can - Murphy's law tells us: "it will!" - worsen some other demands at the same time!

In most cases people start such design with a motor based on some assumption made by thumb, hoping it will be near an optimum. If not: starting next try with a motor gradually modified (e.g. few windings less or more? thicker copper wires? stronger magnets? other motor type? ... ). That's exactly the way we used earlier, too: "try and error".

Then we were looking for a better, faster and less expensive way ...

## 2 The Idea

After some(!) experience with this "try&error"-method, we found it would be nice and very helpful to concentrate all that numeric information (R, L, KV, DC-voltage, limits, deratings, actual working point, etc.) into a single graphic/diagram. Isn't that a good chance to study dependency and influences between all these variables?

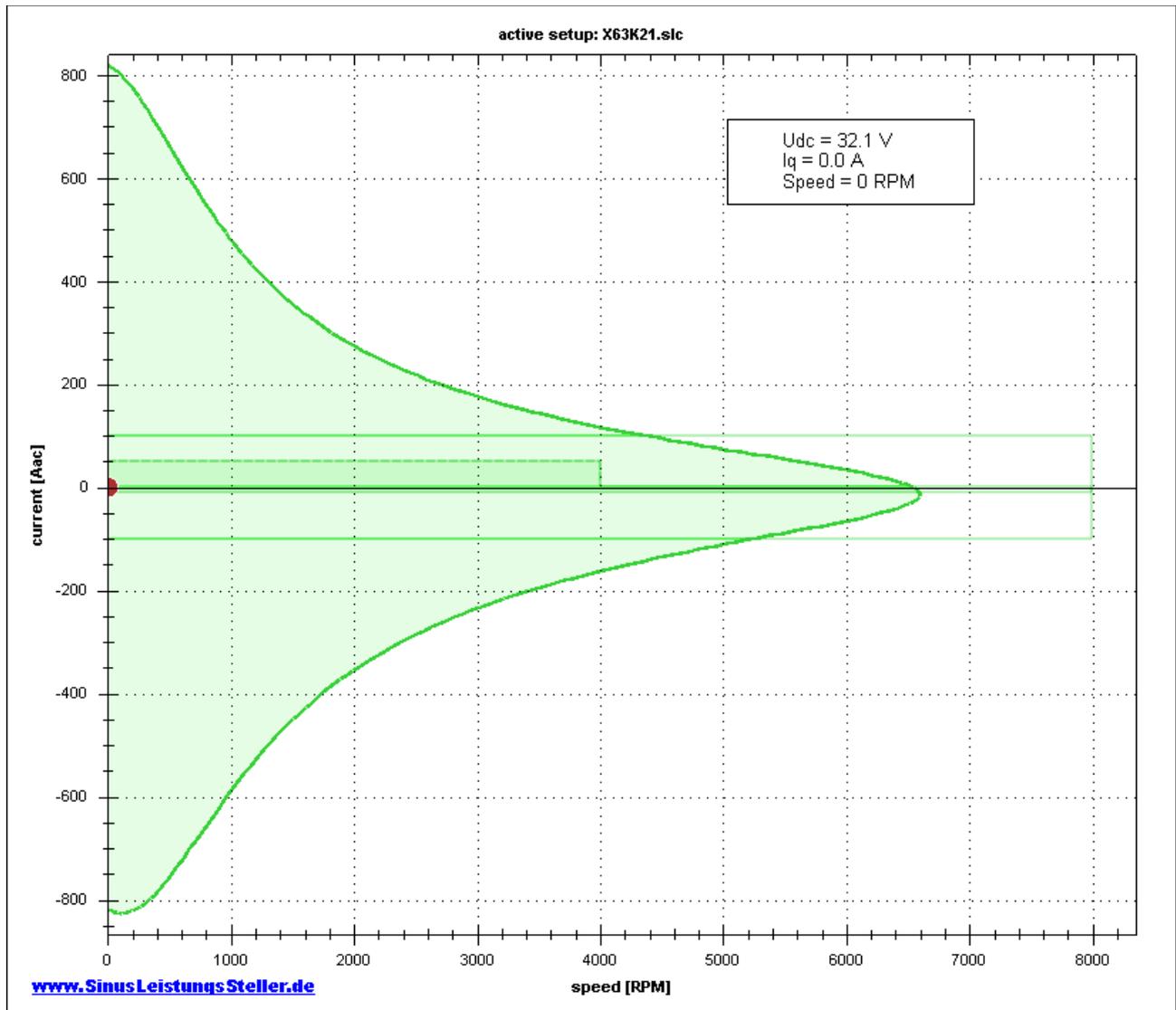
Yes it is! ... and to see all changes in real time (live!) would be really enlightening! So lets do it ...

With all these parameters derived from a motor (anyway needed for tuning the FOC controller), some complex formulas needed to be setup, solved and finally fixed into software for visualization.

First result of this process was a static diagram (see picture on page 1), showing the motor's characteristic curve over all 4 quadrants (two motoric and two generatoric, each one CW and one CCW). This enveloping curve contains all possible working points of a motor at a certain DC-voltage – special points like "point of no load" (= transition thru speed-axis, "NLP") or "blocked current point" (=transition thru current-axis, "BCP").

All working points inside this enveloping curve are possible working points for this motor at DC-voltage calculated with. All working points outside this enveloping curve are unreachable. Most of possible working points are theoretical, because too much current would heat-up the motor. So practically we can reduce and focus to a narrow band around speed-axis with max. allowed current as a limit.

The final implementation in SLS-Windows-Monitor shows only 2 quadrants. The motoric and generative quadrant CW. Because CCW quadrants are symmetric with CW quadrants (via point-mirroring thru origin) they don't carry further relevant information and are out.



Working points on the enveloping curve marks the theoretical limit of phase-current vs. speed. The drop in speed vs. load can be readout directly from this diagram following the green line.

Enveloping curve follows (in real-time!) all variations of DC-voltage applied on your screen, when connected to real hardware (SLS/SLR). So it is very easy to determine e.g. minimum DC-voltage needed to reach a certain point of load.

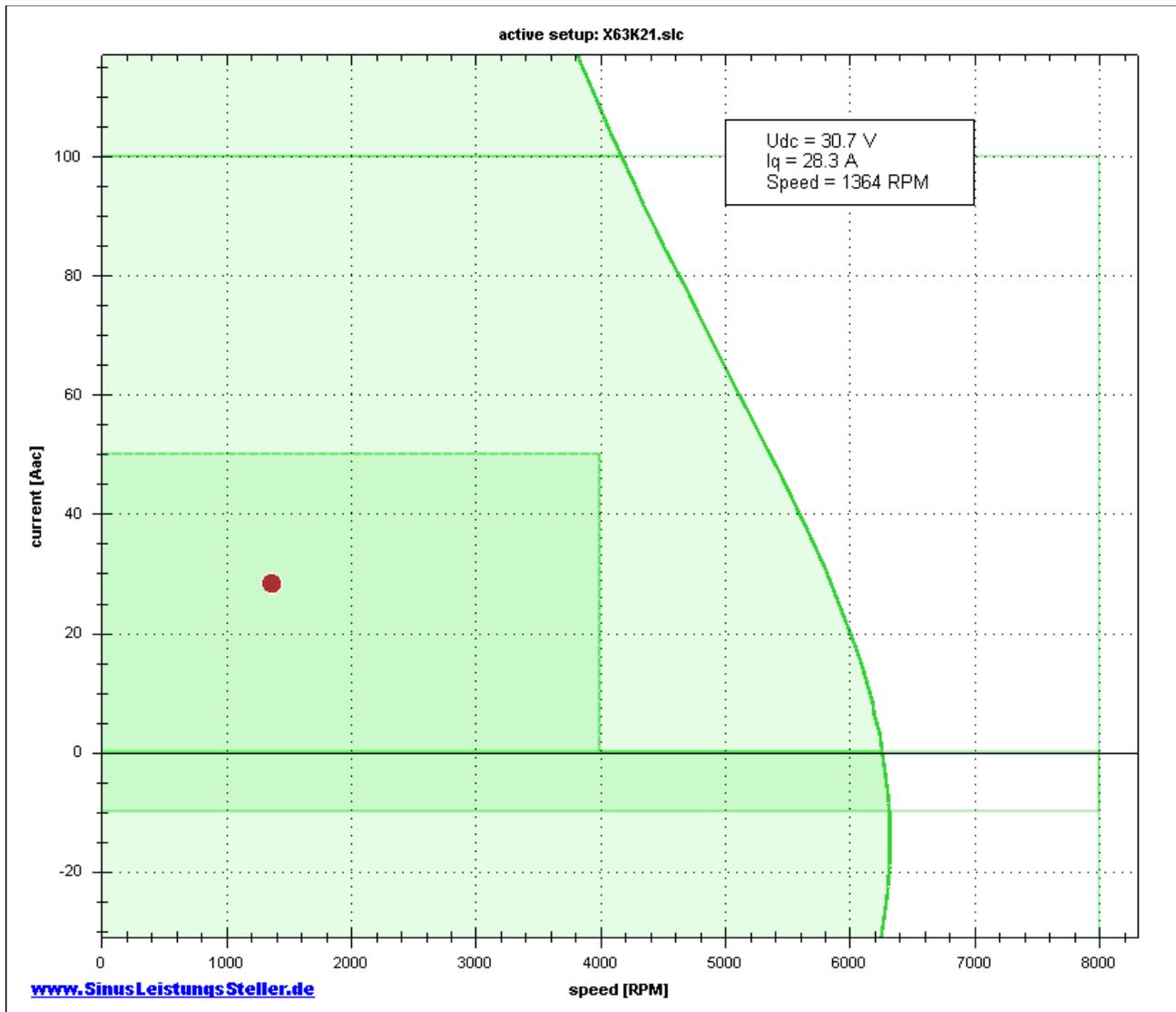
Remember:

This diagram is calculated from motor parameters derived at normal temperature (about 25°C) and without saturation effects. Such non-linear effects are not reflected by the model used for this calculation.

### 3 Elements

#### 3.1 Actual working point

Introducing an actual working point (small red dot) feeds back, where the motor works actually in respect to the motor limits. It follows changes in real-time.



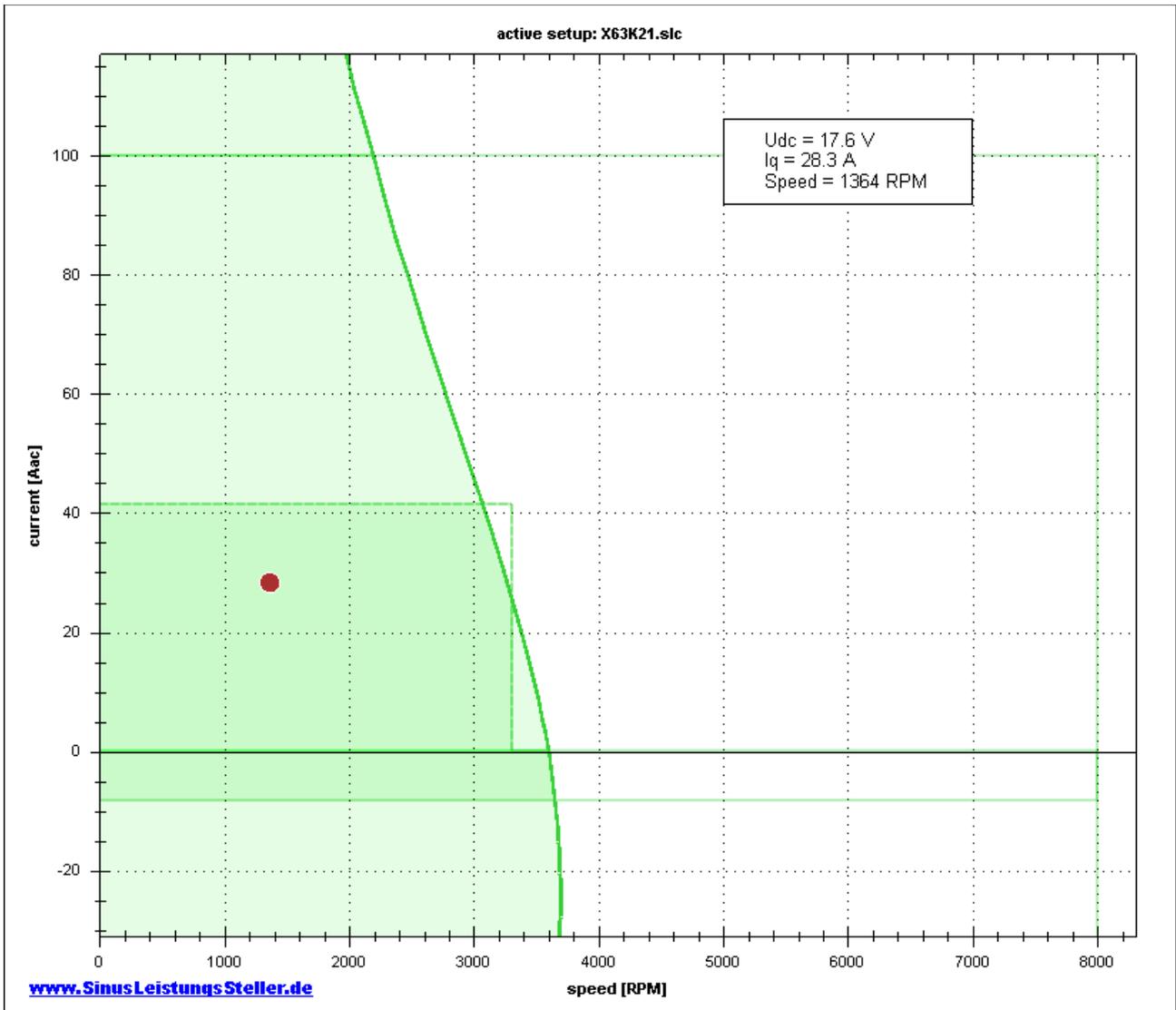
#### 3.2 Controller Limits

The limits set by controller hardware itself and by parameters are shown also in the diagram:

- max motoric current (e.g. hardware-limit +100A, parameter-limit +50A)
- max. generatoric current (e.g. hardware-limit -100A, parameter-limit -10A)
- max speed (shown in pictures: max=8000rpm=100%, set to 4000rpm=50%)

### 3.3 Derating

If any derating (overtemp, over-/undervoltage, etc.), the limits will be fold back in the diagram real-time.



(Udc\_low\_lim = 18.0V → derating is active in picture above, limits are folded back)

Area within enveloping curve is shown in light green color.

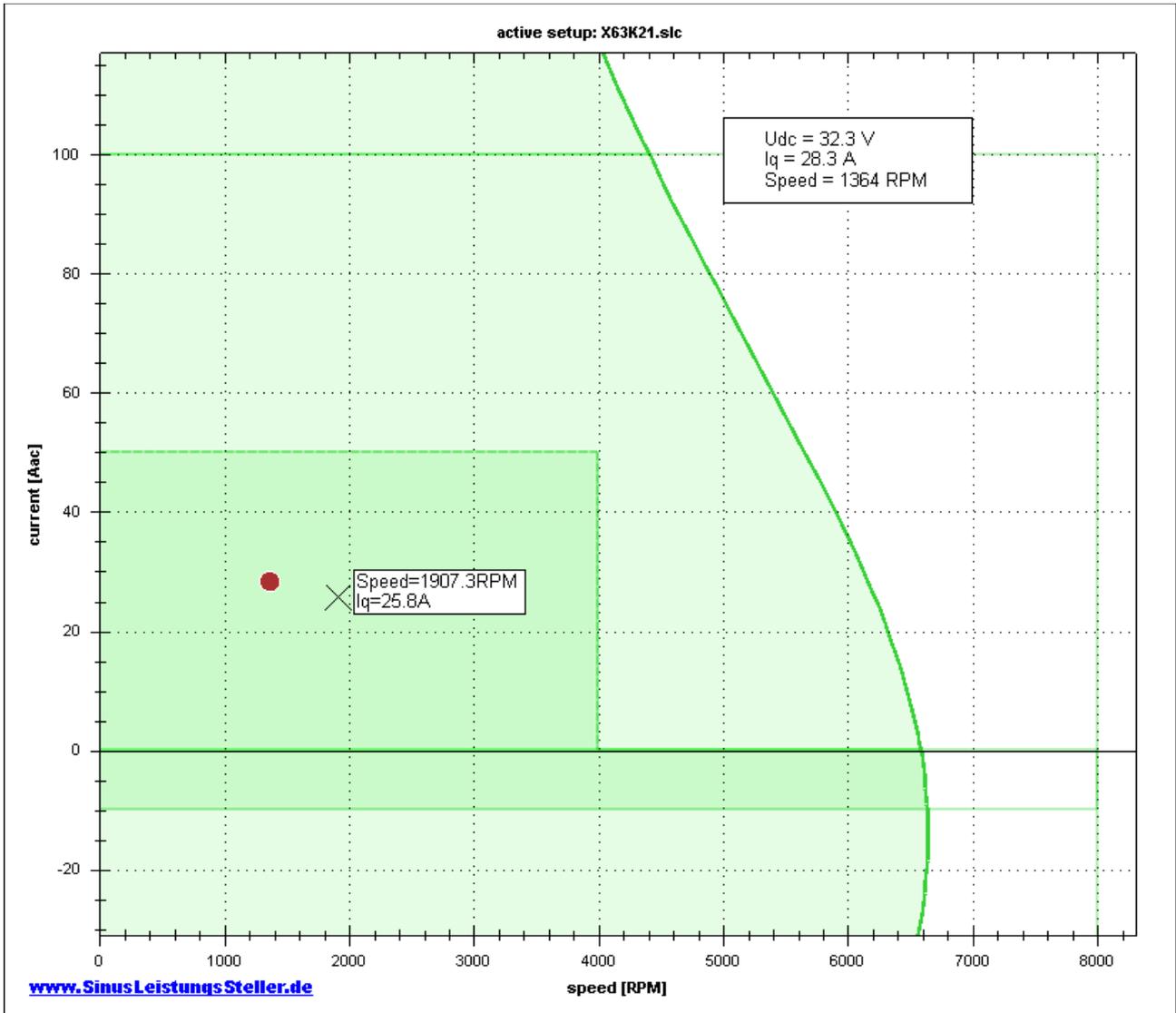
Area within limits is shown in slightly darker green color, that's the range, the motor can actually operate.

### 3.4 Status

Main status information (Uzk, Iq and speed) is shown numeric in a small status-window. This status-window can be moved (by catching it with the mouse left button) to any position.

### 3.5 Cursor

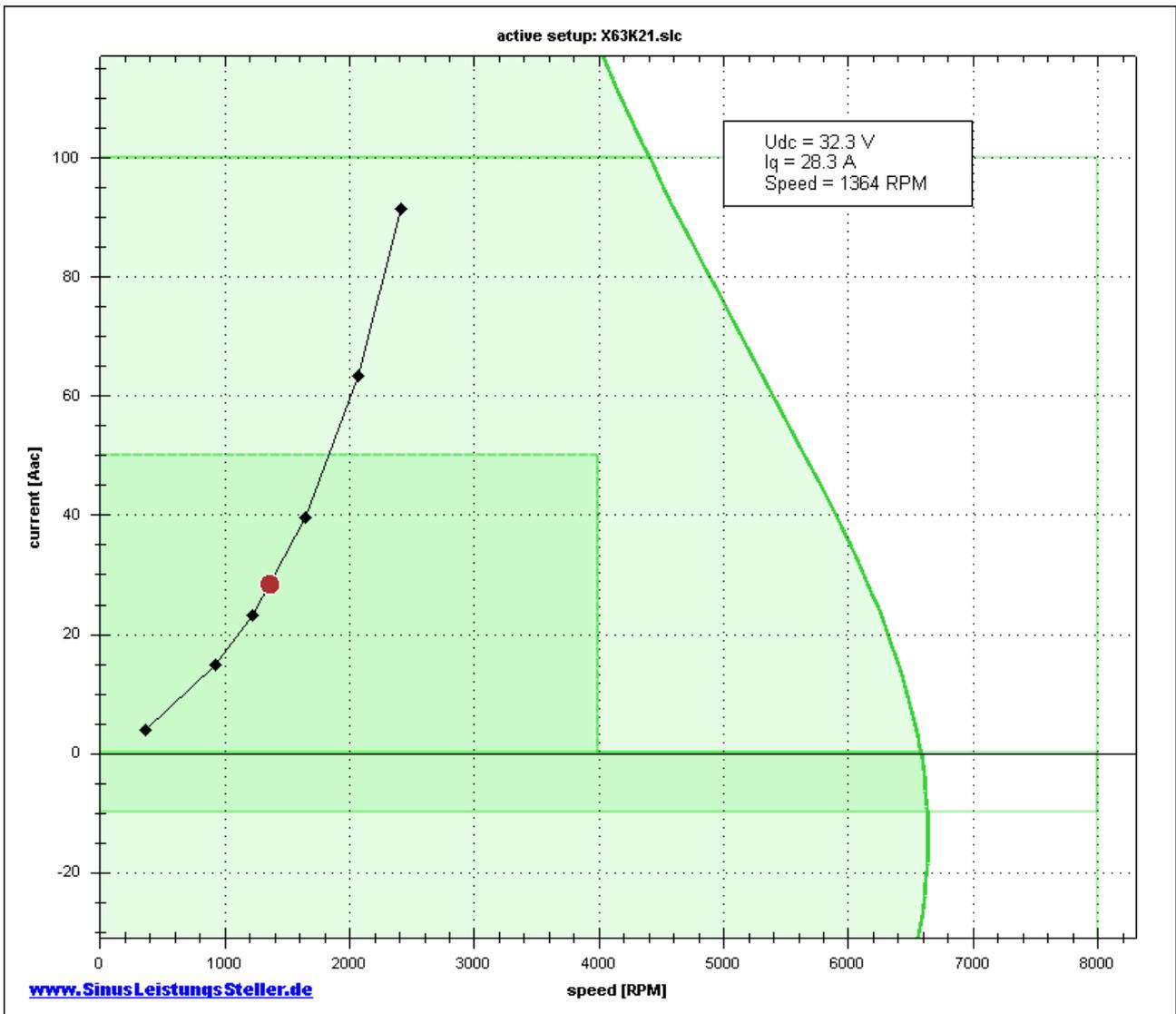
The mouse cursor can be set active (right mouse click) to show extra information for its actual position (current, speed). Actual position can be fixed (and released) with the “space”-button on your keyboard.



### 3.6 Track manager

Both, cursor position and actual operation point, can be tracked. Single positions will be combined by lines to record characteristic curve (of e.g. a propeller ) as samples of [I, speed].

Such propeller characteristic curve can be saved to a file (\*.SLK) and re-imported later e.g. to another motor characteristic curve in order to find best matching combination out of a set of propellers and motors. This is a very easy to use and time saving method to find an optimum!



## 4 Control and Processing

### 4.1 Processing

A powerful zoom function allows to set focus on each area of diagram you like. Finished diagrams with all elements can be saved as picture to be used for later documentation or printout.

### 4.2 Control

All control elements are documented in detail within the User-Manual for the SLS-Windows-Monitor: [Manual\\_WMon\\_en.pdf](#)

## 5 Option order

User can order this option together with SLS/SLR device. Then this option will be enabled on your device before shipping.

If you need this option later, it can be enabled via an enable-key. This enable-key will be generated by us (we need type and serial number of your SLS/SLR) and send to you by email.

