

Universal Data Acquisition and Monitoring System for insula- tion condition monitoring of high voltage machines

UDL-8000 V5

Application Manual

**Shaft Voltage / Current Monitoring
(SUI + M8016)**

This publication supersedes all earlier versions, Specifications subject to change.

16.SUI.304.201 Rev 5

Revision History

Rev No	Description	Date	Autor/Approval
0	Initial Release	April 2017	RH/MP
1	Harmonic Ratio inversed	July 2017	RH/MP
2	Parameter Extension	January 2021	RH/FK
3	Update to V5	December 2022	RH/FK
4	New alarm configuration updated	February 2023	RH/FK
5	Updates for UDL-DataClient	August 2024	RH/FK

Table of Contents

Table of Contents	3
List of Figures	4
List of Tables	5
List of Abbreviations.....	6
1 Read This First!	7
1.1 Warranty and Product Support	9
1.2 About this Manual.....	10
2 Introduction	11
3 Application Description	15
3.1 Turbo Generators	17
3.2 Hydro Generators.....	20
3.3 Measurement and Analysis	22
3.3.1 Shaft Voltage Measurement	22
3.3.2 Shaft Current Measurement with CT	22
3.3.3 Shaft Current Measurement with Shunt.....	22
3.3.4 Measurement Circuit using Rogowski Coil.....	23
3.4 Analysis.....	23
3.4.1 Analysis of the shaft voltage	23
3.4.2 Analysis of the shaft current	24
3.5 General parameter handling	25
3.6 Calculated parameters	26
3.6.1 Reference Channel – CH1	26
3.6.2 Shaft Voltage Input – CH2.....	26
3.6.3 Shaft Current Input – CH3.....	26
3.6.4 Process Parameters – CH4..CH8.....	27
4 Hardware & Software Requirements	29
5 Hardware Module M8016.....	33
5.1 Module Description.....	35
5.2 Module Overview and Technical Specifications	35
5.3 Module Function Overview	36
5.4 Module Terminal Connections	36
6 Acquisition Module Configuration	37
6.1 Advanced Acquisition Module Configuration.....	39
6.2 Basic Acquisition Module Configuration.....	40

6.3	Alarm Configuration.....	41
6.4	4-20mA Output Configuration	41
6.5	MIMIC Visualization Configuration.....	41
6.5.1	Local Visualization Mimic example	42
6.5.2	External Visualization Mimic example.....	43
6.6	Data Recording	43
6.6.1	Data Recording based on alarm	43
6.6.2	Data Recording based on Time interval.....	44
7	Acquisition Module Data Presentation	47
8	UDL-DataClient	51
8.1	Typical Window Layouts	53
8.1.1	Layout for the UDL-8000 Pro.....	53
8.1.2	Layout for Desktop Computers	54
8.2	Data Visualizations	55
8.2.1	TIME (Shaft Current and Voltage)	55
8.2.2	HARMONICS	58
8.2.3	Spectrogram.....	59

List of Figures

Figure 1: UDL-8000 System for Shaft Voltage and Shaft Current Monitoring.....	13
Figure 2: Shaft Voltage and Current Monitoring on the generator side	17
Figure 3: Shaft Voltage and Current Monitoring on the generator and turbine side.	18
Figure 4: Example of a shaft voltage pick-up system.....	19
Figure 5: Example of a shaft voltage pick-up system.....	19
Figure 6: Example of a current transformer for shaft current measurement.	20
Figure 7: Example of a shut for shaft current measurement.	20
Figure 8: Shaft Voltage and Current Monitoring on hydro generators.	21
Figure 9: Example of a Rogowski-coil for shaft current measurement.	21
Figure 10: Measurement circuit for shaft voltage measurement.....	22
Figure 11: Measurement circuit with current transformer	22
Figure 12: Measurement circuit with External 4-Wire Shunt	22
Figure 13: Measurement circuit with Rogowski-Coil	23
Figure 14: Analysis of the Shaft Voltage Data	24
Figure 15: Analysis of the Shaft Current Data.....	24
Figure 16: Technical Specifications of the M8009.....	35
Figure 17: M8016 Terminal Connections.....	36
Figure 18: UDL-Configurator – Advanced Acquisition Module Configuration	39
Figure 19: UDL-Configurator – Advanced Acquisition Module Configuration (Fast)	40

Figure 20: SUI Module specific parameters	40
Figure 21: SUI Example of the standard local visualisation mimic	42
Figure 22: SUI Example of the harmonic local visualisation mimic	42
Figure 23: SUI Example of the standard external visualisation mimic	43
Figure 24: SUI Example of the harmonic external visualisation mimic	43
Figure 25: Typical recording configuration for alarm-based recording	44
Figure 26: recording configuration for time interval-based recording of Shaft Voltage	44
Figure 27: recording configuration for time interval-based recording of Shaft Current.....	44
Figure 28: SUI Acquisition Module Data Presentation	49
Figure 29: UDL-8000 Pro local data visualisation (Shaft Voltage and Current)	53
Figure 30: UDL-8000 Pro local data visualisation (Trend).....	54
Figure 31: UDL-DataClient desktop data visualisation (SUI & Trend)	54
Figure 32: Time Data Presentation.....	55
Figure 33: Time Selection.....	55
Figure 34: Shaft Voltage and Current Data Presentation	56
Figure 35: Channel Selection	57
Figure 36: Axis Configuration	57
Figure 37: Reading out datapoints with cursors.....	58
Figure 38: Spectrum of the shaft voltage and shaft current signal	59
Figure 39: Spectrogram of the Shaft Voltage / Current Signal	60
Figure 40: Time Selection - last.....	61
Figure 41: Time Selection – Start – End Time	61
Figure 42: Spectrogram Data	61
Figure 43: Selection of the channel	62
Figure 44: Using Cursors within the spectrogram	63

List of Tables

Table 1: SUI Parameter Table, Reference - Channel 1	26
Table 2: SUI Parameter Table, Shaft Voltage Channel.....	26
Table 3: SUI Parameter Table, Shaft Current Channel.....	26
Table 4: SUI Parameter Table, Flux Density Channel	27
Table 5: Advanced – Acquisition parameters.....	39
Table 6: Basic – Acquisition parameters.....	41
Table 7: Default Alarm Configurations.....	41
Table 8: Default Mimic Channels.....	42
Table 9: Default Mimic Channels.....	42
Table 10: Basic – time interval-based recording.	45
Table 11: Separation of visualisation information	55
Table 12: Time Selection parameters.....	56

Table 13: Calculated Results without cursors	58
Table 14: Calculated Results with cursors results.....	58
Table 15: Separation of visualisation information.....	59
Table 16: Separation of visualisation information.....	59
Table 17: List of Time selections	60

List of Abbreviations

PD	Partial Discharge
A/D	Analogue to Digital Converter
D/A	Digital to Analogue Converter
PRPD	Phase Resolved Partial Discharge Pattern
UTC	Coordinated Universal Time

1 Read This First!

BLANK PAGE

1.1 Warranty and Product Support

It is recommended that you thoroughly inspect the contents of the UDL-8000 Monitoring System packaging immediately upon receipt. Compare the contents to the packing list/invoice shipped with the instrument. Unless is notified promptly of any missing or damaged item, we cannot accept responsibility for its replacement. Contact your nearest Customer Service Center or national distributor immediately.

We warrant the UDL-8000 products for normal use and operation within specifications for a period of two years from the date of shipment. Spares, replacement parts and repairs are warranted for 90 days. The instrument's firmware has been thoroughly tested and is thought to be functional, but is supplied without warranty of any kind covering detailed performance.

Products not made by Manufacturer are covered solely by the warranty of the original equipment manufacturer. Under the warranty, the supplier will repair or, at its option, replace any product returned within the warranty period to a authorized service center. However, this will be done only if the product is determined after examination by the manufacturer to be defective due to workmanship or materials, and not to have been caused by misuse, neglect or accident, or by abnormal conditions or operation.

NOTE: This warranty replaces all other warranties, expressed or implied, including but not limited to any implied warranty of merchantability, fitness, or adequacy for any particular purpose or use. The Manufacturer shall not be liable for any special, incidental, or consequential damages, whether in contract or otherwise. The client will be responsible for the transportation and insurance charges for the return of products to the service facility.

For Further Technical Information and application information of the device, please read the Knowledgebase at the end of this document or to the available/applicable IEC / EN Standards.

1.2 About this Manual

This manual is an extension to the main manual and describes the specific features and functions of the Shaft Voltage and Current Monitoring for rotating machines. The Shaft Voltage/Current Monitoring (SUI) acquisition module is specifically designed such purposes

This manual is built up as follows

- Chapter 2
Introduction of the Shaft Voltage / Current Monitoring
- Chapter 3
Application Description
- Chapter 4
Hardware and Software requirements
- Chapter 5
Hardware Module M8016
- Chapter 6
Acquisition Module Configuration
- Chapter 7
Acquisition Module Data Presentation

2 Introduction

BLANK PAGE

The Shaft Current and Shaft Voltage monitoring is used to monitor the shaft insulation and shaft grounding system of rotating machines.

By measuring the shaft voltage level on the collector side bearing it can be prevented that in case of a possible overvoltage the slider bearings are damaged e.g. due to arcing within the oil film. Measuring the shaft current assures that the shaft grounding system is working and a possible over current, e.g. due to a rotor insulation failure can be detected. On large turbo generator, shaft voltage and shaft currents can also be measured at the turbine side.

The UDL-8000 with the hardware module M8016 and the software module SUI is specially designed for this type of application and allows an easy and simple monitoring of the rotor insulation without any big modification of the machine.

The following illustration show the standard UDL-8000 system with the central controller and one single module, installed in the 28TE DIN Rail enclosure.



Figure 1: UDL-8000 System for Shaft Voltage and Shaft Current Monitoring

BLANK PAGE

3 Application Description

BLANK PAGE

On a typical generator set-up the shaft is grounded at the turbine side, just next to the turbine side bearing where the shaft current is measured, while the shaft voltage is measured at the collector end of the shaft, where the shaft is floating.

While the shaft voltage at the collector end is measured by an additional brush installed at the shaft's end, the shaft current can be measured either through the shaft grounding system, by installing a current transformer (CT) around the grounding lead, by installing a measurement shunt in series to the shaft grounding lead, or by installing a large current transformer around the shaft, typically by using a Rogowski coil.

3.1 Turbo Generators

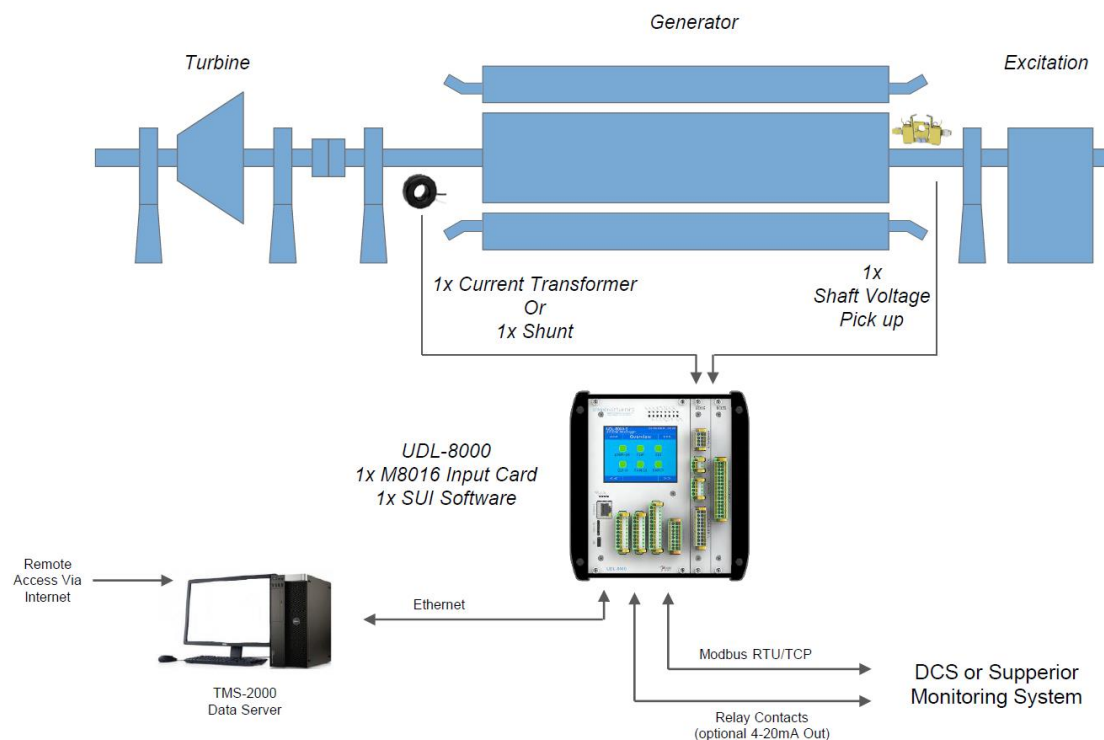


Figure 2: Shaft Voltage and Current Monitoring on the generator side

On customer request, the shaft voltage and current can also be measured at the turbine side, while the current transformers are installed at both shaft grounding locations.

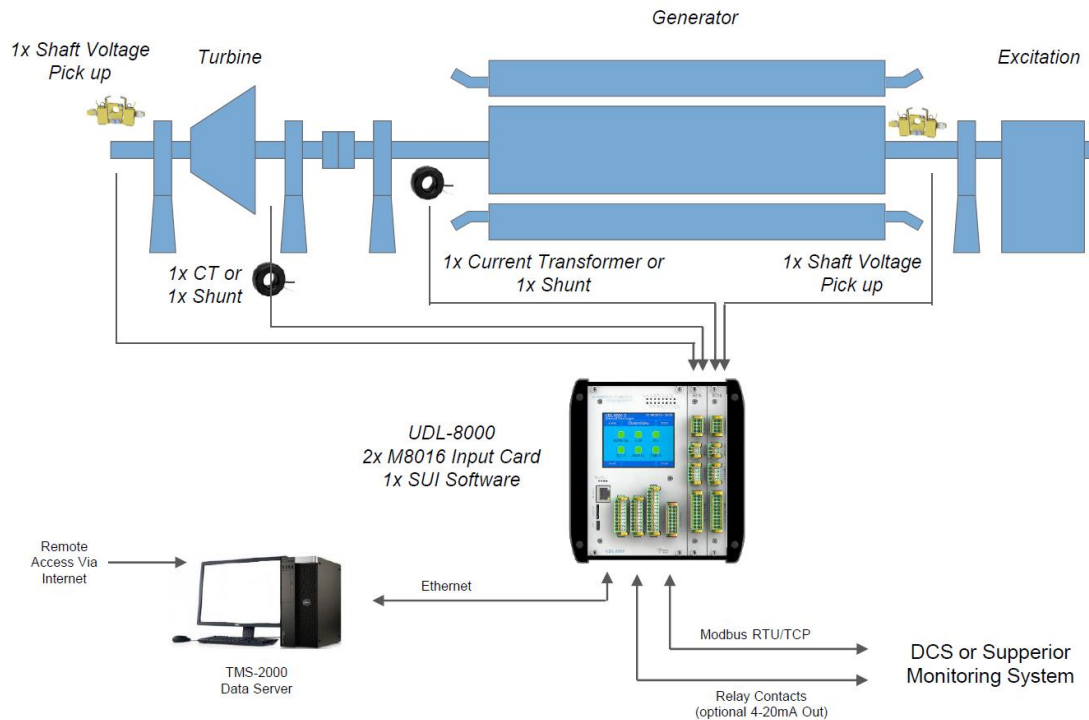


Figure 3: Shaft Voltage and Current Monitoring on the generator and turbine side.

While using a current transformer, the monitoring is fully galvanically separated and it can be assured, that the installed system does not make any effects on the existing installation. Alternatively, a measurement shunt can be used, which allows also to monitor the DC current of the grounding installation.

For the pick-up of the shaft voltage signal, either an existing diagnostic plug can be used, or alternatively a separate pick-up brush must be installed. The installation of such a pickup might be challenging, depending on the design of the collector end and the locations of the Slow-roll motor, the bearing and the collector system. It must be noted, that whenever a brush is installed, that it is NEVER installed on the same trace / location as the shaft vibration sensors, as it might influence the vibration signal measurement.

The example below shows an installation at the end of the shaft, by using 2 single brush holders, 120° apart. Typically metallic brushes are used, half silver and half carbon.

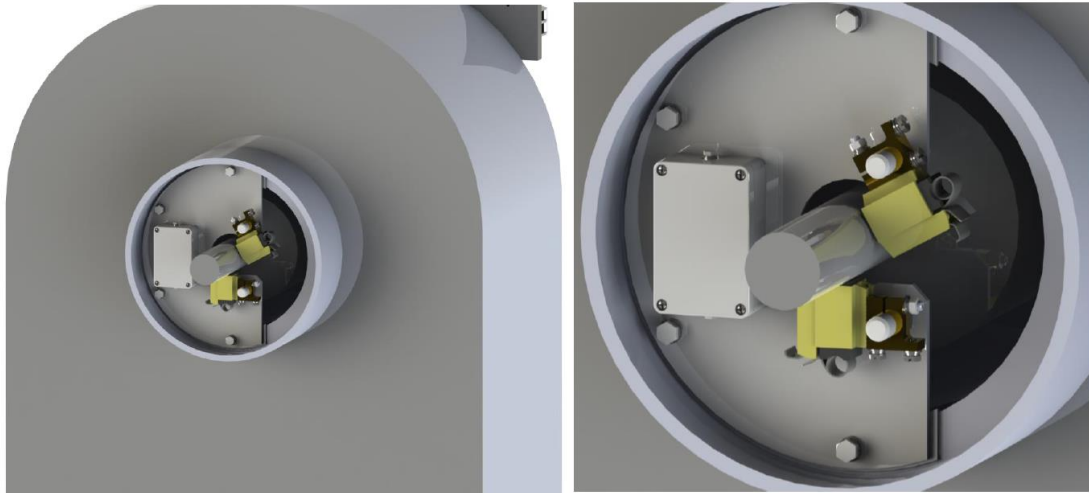


Figure 4: Example of a shaft voltage pick-up system.

For the shaft current pickup, usually an existing shaft grounding pickup can be used. Special attention shall be made, if the shaft is not grounded by brushes, only by using a simple copper strip, as such installations cannot guarantee that the shaft current can be picked up correctly. For installations with a lot of pollution and heavy wear of the metallic brushes, alternatively copper braids can be used to ground the shaft.

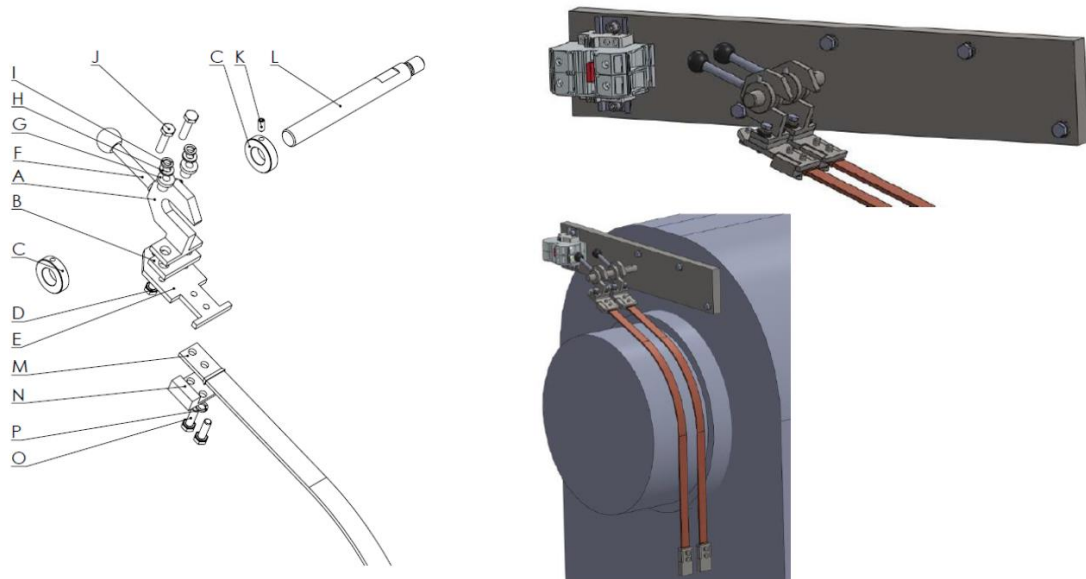


Figure 5: Example of a shaft voltage pick-up system.

When using 2 copper braids in parallel, it allows to change the copper braid even while the machine is running.

For the pickup of the shaft current signal, a current transformer (CT) or a shunt (Measurement resistor) can be installed.

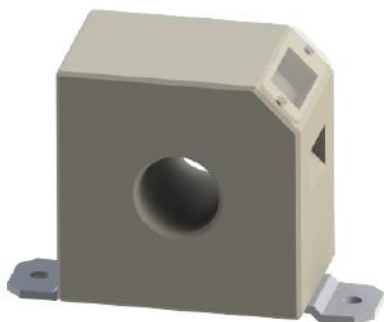


Figure 6: Example of a current transformer for shaft current measurement.

Special attention shall be made when using current transformers, as in case of a fault in the shaft insulation system, currents can rise up to 16A. Sparks instruments recommends to use encapsulated current transformers with a ratio of at least 25A:1A, for CT's with higher ratios, multiple turns of the grounding wire can be used to increase the sensitivity. Important to know is that the current input of the M8016 module is limited to 1Arms.

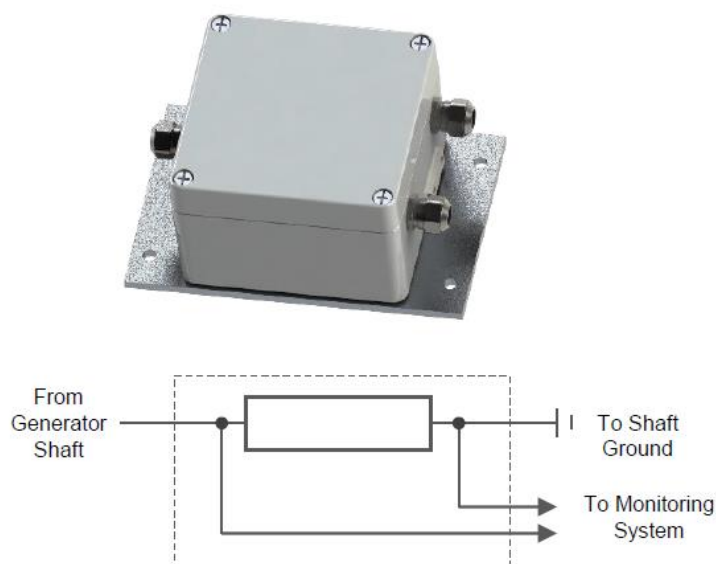


Figure 7: Example of a shunt for shaft current measurement.

Alternatively, a measurement shunt can be installed in series to the shaft grounding system. The measurement shunt is typically between 5 to 20mOhm (Milliohm) and must be able to withstand current peaks up to 100A. Sparks Instruments recommends to use current sensing shunts with 4 terminals and using the 4-Wire measurement technology to measure the shaft current.

3.2 Hydro Generators

Basically, the shaft voltage and shaft current can be measured in the same way as on the turbo generators, except for the shaft current measurement typically Rogowski coils

around the shaft are used. One of the reasons is that the shaft might be additionally grounded through the water from the turbine, which further would influence the current measurement via the shaft grounding point, as maybe not the entire shaft current will flow through the grounding point, as some current might be absorbed by the water.

The Illustration below shows the different possibilities of measuring the shaft voltage / current on a hydro generator.

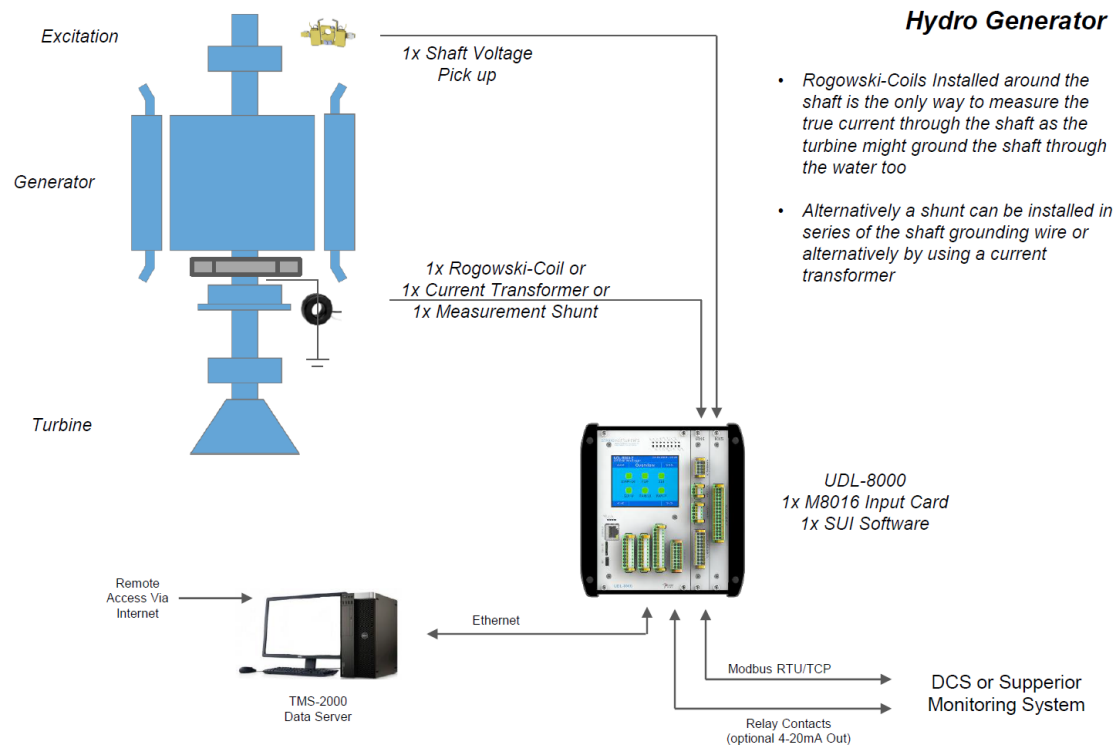


Figure 8: Shaft Voltage and Current Monitoring on hydro generators.

Rogowski coils are split-type or flexible type and can be relatively easy installed around the shaft. As the shafts do have different diameters, and the fixing is typically different from each machine type, the Rogowski-coils are typically custom built.



Figure 9: Example of a Rogowski-coil for shaft current measurement.

3.3 Measurement and Analysis

As shown on the overview diagrams on the previous chapters, different signal pick-ups are possible to measure the shaft voltage and shaft current. In order to ensure, that there are no wrong signal flows, as e.g. moving the main potential grounding of the generator towards the instrumentation, the input module M8016 offers a fully galvanic insulated input.

3.3.1 Shaft Voltage Measurement

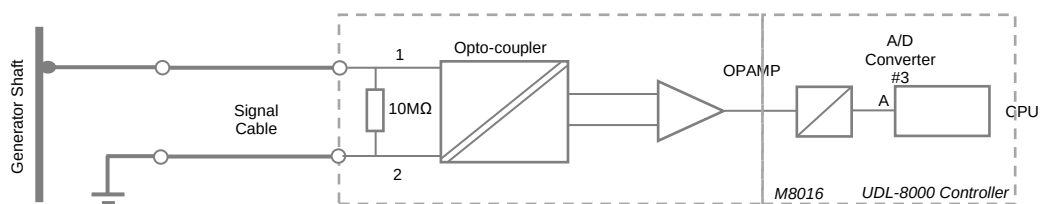


Figure 10: Measurement circuit for shaft voltage measurement

3.3.2 Shaft Current Measurement with CT

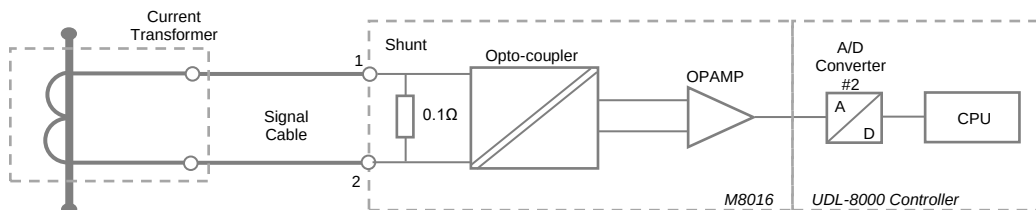


Figure 11: Measurement circuit with current transformer

3.3.3 Shaft Current Measurement with Shunt

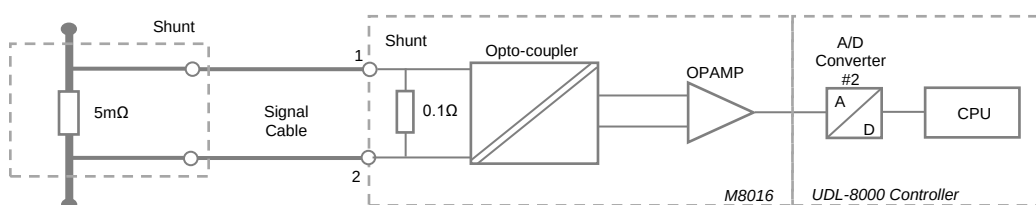


Figure 12: Measurement circuit with External 4-Wire Shunt

3.3.4 Measurement Circuit using Rogowski Coil

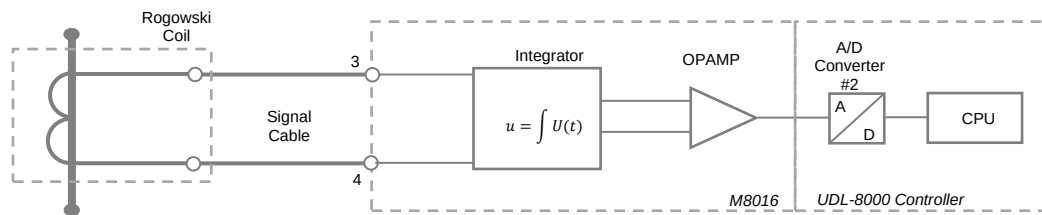


Figure 13: Measurement circuit with Rogowski-Coil

3.4 Analysis

As most of the system on the market, the UDL-8000 uses the RMS values of the shaft voltage and shaft current for the primary evaluation. Additionally, the system provides positive and negative peak values for enhanced trending.

One of the biggest advantages of the UDL-8000 system is the implementation of the harmonic analysis. The system calculates typically the shaft voltage and shaft current up to the 10th harmonic. Based on these harmonics, the system uses an enhanced calculation to determine any changes within the shaft voltage and shaft current signal, which might not be detectable by the simple RMS measurement.

For any installation and while the generator is in good condition, the odd harmonics are dominant, means the 1st and 3rd harmonic are much larger than the 2nd and 4th harmonic.

By using this approach, the system calculates the harmonic ratio parameter, which is a result of the calculation of:

$$R = \frac{2nd + 4th}{1st + 3rd}$$

This calculation will result in a value below 1 whenever the machine is in a good condition and a value above 1 if the even harmonics are higher, indicating that there is a problem with the shaft current or shaft voltage measurement.

3.4.1 Analysis of the shaft voltage

The system performs 3 types of calculation of the measured shaft voltage

- Overall RMS Value (for a time block of 0.5s)
- Overall Max & Min Peak Value (for a time block of 0.5s)
- Harmonic Calculation of the first 4 Harmonics and comparison between odd and even harmonics

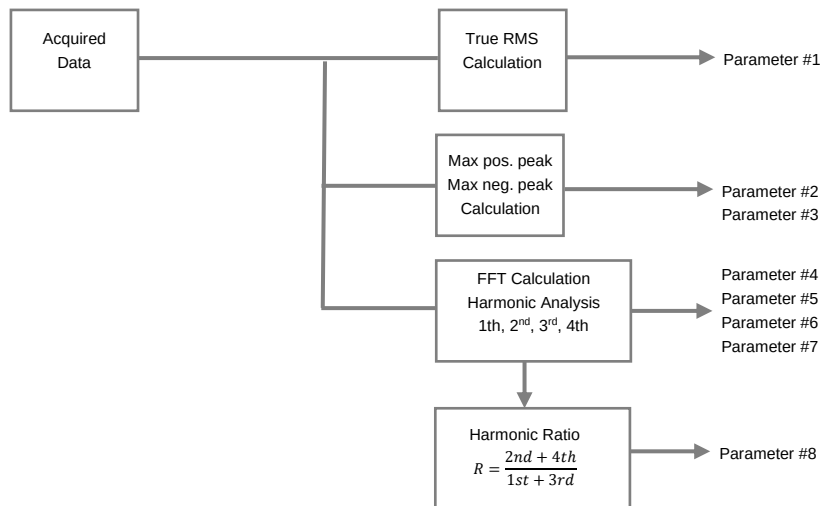


Figure 14: Analysis of the Shaft Voltage Data

3.4.2 Analysis of the shaft current

The system performs 3 types of calculation of the measured shaft current

- Overall RMS Value (for a time block of 0.5s)
- Overall Max & Min Peak Value (for a time block of 0.5s)
- Harmonic Calculation of the first 4 Harmonics and comparison between odd and even harmonics

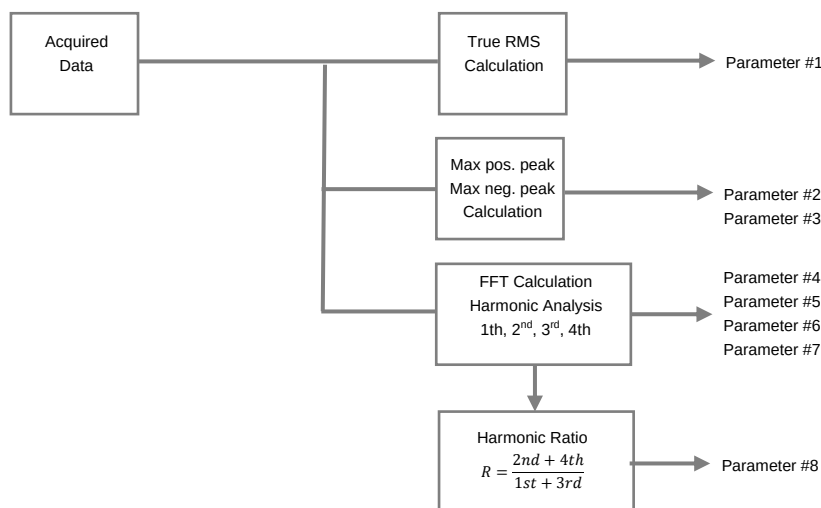


Figure 15: Analysis of the Shaft Current Data

3.5 General parameter handling

The UDL-8000 system is capable to handle 8 Channels with 8 parameters per channel. This gives a total of 64 parameters.

The addressing of the parameters is fixed and depends on the acquisition module, input channel and parameter channel. Refer to the general user manual for a complete addressing information of the UDL-8000 system.

The first 64 channels (0..63) are reserved for the controller, channels 64..127 are for the acquisition module 1, 128..191 for the software module 2 etc.

These channels are called channel ID's and the structure is kept identical for the Modbus RTU interface and for the UDL-DataServer.

In order to identify the location of the specific parameter, simply add the following numbers depending on the software module ID:

- Acquisition module ID 1: 64
- Acquisition module ID 2: 128
- Acquisition module ID 3: 192
- Acquisition module ID 4: 256
- Acquisition module ID 5: 320
- Acquisition module ID 6: 384
- Acquisition module ID 7: 448

3.6 Calculated parameters

Note: Add the offset depending on the Acquisition module ID. Channels not listed up here are not used. One of the two reference inputs can be selected to trigger the acquisition.

The Shaft Voltage input is the signal from the shaft voltage pick up, either from the collector end of the generator or of the end of the turbine, where the shaft is floating. The Shaft Current input is the signal and the shaft grounding end (turbine side), either provided by CT, Shunt or Rogowski coil.

The M8016 input module also offers additionally 5x 4-20mA inputs (Channel 4 to 8), which can be used to provide operation parameters from the machine.

3.6.1 Reference Channel – CH1

The following parameters are calculated from channel 1

CH ID	Calculation Type	Unit	Remarks
0	Frequency of Reference	Hz	
1	RPM of Reference	rpm	CH1 * 60s
2	RMS Amplitude	V	

Table 1: SUI Parameter Table, Reference - Channel 1

3.6.2 Shaft Voltage Input – CH2

The following parameters are calculated from channel 2

CH ID	Calculation Type	Unit	Remarks
8	Shaft Voltage RMS	Vrms	
9	Shaft Voltage Max Positive Peak	Vp	
10	Shaft Voltage Max Negative Peak	Vp	
11	Shaft Voltage RMS 1 st Harmonic	Vrms	
12	Shaft Voltage RMS 2 nd Harmonic	Vrms	
13	Shaft Voltage RMS 3 rd Harmonic	Vrms	
14	Shaft Voltage RMS 4 th Harmonic	Vrms	
15	Shaft Voltage Harmonic Ratio		

Table 2: SUI Parameter Table, Shaft Voltage Channel

3.6.3 Shaft Current Input – CH3

The following parameters are calculated from channel 3

CH ID	Calculation Type	Unit	Remarks
16	Shaft Current RMS	Vrms	
17	Shaft Current Max Positive Peak	Vp	
18	Shaft Current Max Negative Peak	Vp	
19	Shaft Current RMS 1 st Harmonic	Vrms	
20	Shaft Current RMS 2 nd Harmonic	Vrms	
21	Shaft Current RMS 3 rd Harmonic	Vrms	
22	Shaft Current RMS 4 th Harmonic	Vrms	
23	Shaft Current Harmonic Ratio		

Table 3: SUI Parameter Table, Shaft Current Channel

3.6.4 Process Parameters – CH4..CH8

The following parameters are calculated from channel 4-8

CH ID	Calculation Type	Unit	Remarks
24	Mean – CH4	A*	
32	Mean – CH5	A*	
40	Mean – CH6	A*	
48	Mean – CH7	A*	
56	Mean – CH8	A*	

Table 4: SUI Parameter Table, Flux Density Channel

* by default all process parameter channels are set as input of 4-20mA with the unit “A”. The channel rescaling (e.g. 4-20mA = 0..300MW) and the Unit assignment must be done in the parameter channel config at the specific channel ID.

BLANK PAGE

4 Hardware & Software Requirements

BLANK PAGE

The UDL-8000 monitoring system used for Shaft Voltage and Shaft Current monitoring can be equipped with up to 7 hardware modules, providing a system with up to 56 analogue input channels.

For the complete monitoring, the following equipment is required for the acquisition:

- 1x UDL-8000 Controller
- 1x Hardware Module M8016
- 1x Software Module SUI
- UDL-Configurator Software for the configuration of the system
- UDL-Monitor Software for instant data presentation on a windows computer
- UDL-DAQ Software (optional) for direct data acquisition control of the rotor flux measurement

For automatic long-term trending and data storage, the UDL-DataServer is required. The UDL-DataServer offers continuous data recording simultaneously over multiple devices across an ethernet network (LAN/WAN). All data is stored within an SQL database and are presented on a windows-based application software. Further Details about the functions of the rotor flux monitoring within the UDL-DataClient can be found within the documentation of the UDL-DataServer.

BLANK PAGE

5 Hardware Module M8016

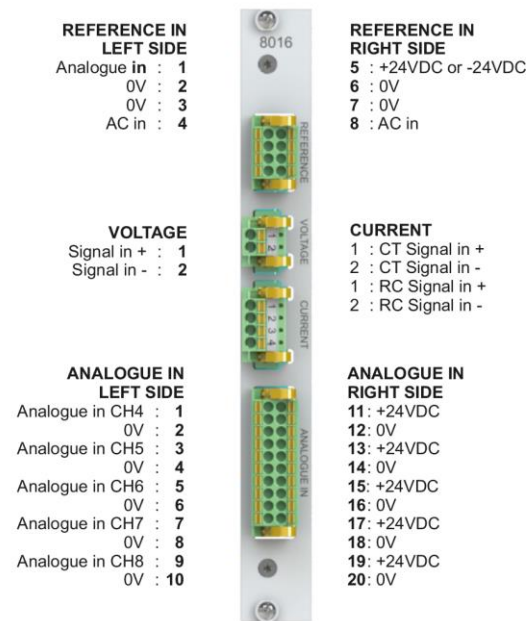
BLANK PAGE

5.1 Module Description

For the measurement of the shaft voltage and shaft current, the interface module M8016 is used. The Module has the following key features:

- Reference / Trigger input +/-24V or 240VAC Line with +24VDC or -24VDC Power supply
- Galvanic Insulated Voltage Input, input range up to 100Vrms
- Galvanic Insulated Current Input, input range up to 1Arms (0.1Ohm Shunt)
- Voltage input for Rogowski Coils, Max 5Vrms with integrated integrator
- 5x 4-20mA Inputs for data recording of operation data of the generator.

5.2 Module Overview and Technical Specifications



REFERENCE IN LEFT SIDE
 Analogue in : 1
 0V : 2
 0V : 3
 AC in : 4

VOLTAGE
 Signal in + : 1
 Signal in - : 2

ANALOGUE IN LEFT SIDE
 Analogue in CH4 : 1
 0V : 2
 Analogue in CH5 : 3
 0V : 4
 Analogue in CH6 : 5
 0V : 6
 Analogue in CH7 : 7
 0V : 8
 Analogue in CH8 : 9
 0V : 10

REFERENCE IN RIGHT SIDE
 5 : +24VDC or -24VDC
 6 : 0V
 7 : 0V
 8 : AC in

CURRENT
 1 : CT Signal in +
 2 : CT Signal in -
 1 : RC Signal in +
 2 : RC Signal in -

ANALOGUE IN RIGHT SIDE
 11: +24VDC
 12: 0V
 13: +24VDC
 14: 0V
 15: +24VDC
 16: 0V
 17: +24VDC
 18: 0V
 19: +24VDC
 20: 0V

Analogue Reference Input

Function	Description
Input Range	+/-24V
Input Impedance	100 kOhm

AC reference Input

Function	Description
Input Range	50..300Vrms
Input Impedance	10MOhm

Shaft Voltage Input

Function	Description
Input Range	100Vrms
Input Impedance	10MOhm, optically insul.

Shaft Current Input

Function	Description
Input Range	1Arms
Input Impedance	0.1Ohm, optically insul.

4-20mA Inputs

Function	Description
Input Range	0..20mA
Input Impedance	200Ohm

Terminals

Function	Description
Section	0.25 .. 1.5mm ²
Max Voltage	250VAC
Max Current	8A

Module

Function	Description
Width	4TE (20.32mm)
Height	4 HU (177.8mm)
Power Consumption	24V, ~100mA (without Load on 24VDC Outputs)

Figure 16: Technical Specifications of the M8009

5.3 Module Function Overview

The M8016 includes 2 reference inputs with different voltage ranges one for Generator AC Voltage up to 300Vrms with optical insulation and a second one with an input range of +/-30V, typically used for signals from a proximity probe.

The rotor flux signal input includes an overvoltage protection and a signal conditioning interface for the acquisition of the flux probe data.

The channels 4-8 are 4-20mA input channels with 200 Ohm input impedance. All 5 Channels share same ground connection.

5.4 Module Terminal Connections

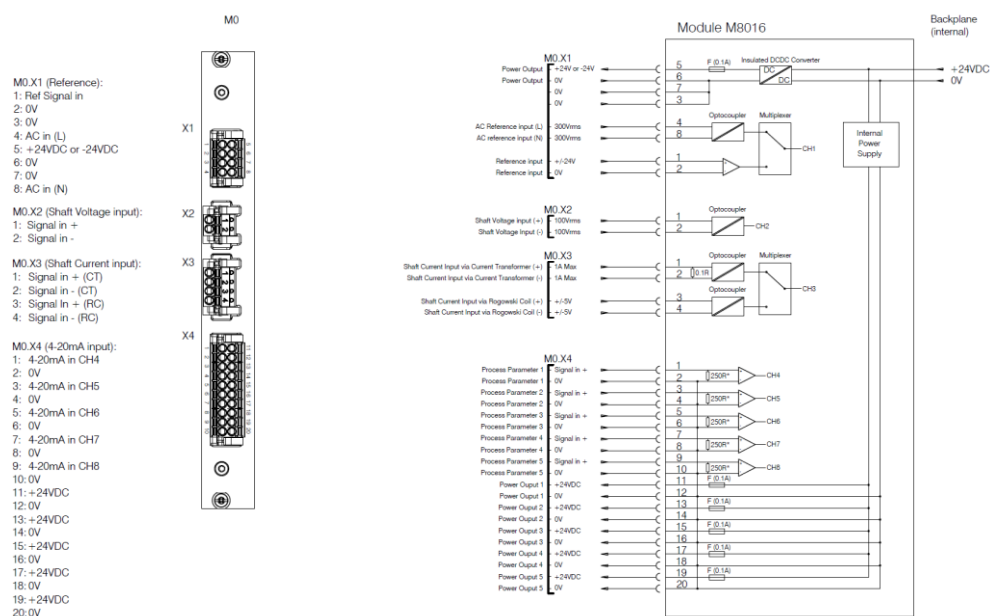


Figure 17: M8016 Terminal Connections

6 Acquisition Module Configuration

BLANK PAGE

The main acquisition configuration is supplied by a template which can be loaded under “Acquisition Modules” → “Change” → button “Load” (SUI) – “Shaft Voltage / Current Monitoring”.

Whenever possible, do not change the advanced acquisition parameter settings, unless it is known what should be done. In any doubts, please contact Sparks Instruments for advice for any changes of the Advanced Acquisition Settings

6.1 Advanced Acquisition Module Configuration

The screenshot displays the 'Advanced Acquisition Module Configuration' window. At the top, a table lists acquisition modules, with 'SUI' (Shaft Voltage / Current Monitoring) selected. Below this, the 'Advanced' tab is active, showing various configuration parameters. The 'Acquisition Parameters' section includes fields for Sampling Rate (51200), ACQ Blocksize (25600), Calc Blocksize (25600), last_X-Samples (last_X-Samples), Sampling Mode (0), and ACQ Time. The 'Trigger Parameters' section includes fields for Module (-1), Level (2.5), Min Level (0.1), Rising Edge, Mode (-1), Edge Control (1), and Divider (1). The 'Filter Parameters' section includes fields for CH 1, 2, 3, and 4, with options for Bandpass or Lowpass filters, Fg L, Fg H, and Order. A note on the right explains the Nyquist Criteria and the relationship between ACQ Blocksize and Calc Blocksize.

Figure 18: UDL-Configurator – Advanced Acquisition Module Configuration

The above configuration will acquire the input voltages with a sampling Rate of 10'240 Samples/second. The Acquisition is started as soon 20'480 Samples are ready from the Analogue Digital Converter. The Trigger signal is only used for data presentation and has no impact on the measurement results, therefore it is not mandatory to provide a trigger signal.

Parameter	Description
Module	Reserved Parameter
Level	Threshold Level, the way of direction is determined by the “mode”
Min Level	Min Level determines if a reference signal is valid
Mode	Defines the edge control of the trigger. Generally, this parameter is only used on generators with change their sensor of rotation. However, in case the pulse of the reference sensor is negative, use falling edge to trigger the system
Denoising Tf	Filter Parameter Tf
Denoising Ts	Filter Parameter Ts

Table 5: Advanced – Acquisition parameters

For applications, where it is required to detect transients on the shaft voltage or shaft current measurement results, a separate configuration template is available “SUI – Shaft Voltage / Current Monitoring (fast)”. This configuration uses different sampling parameters and does not use signal filtering. It shall be understood, that for those applications, which require a higher bandwidth, also the base noise level is slightly higher.

Figure 19: UDL-Configurator – Advanced Acquisition Module Configuration (Fast)

6.2 Basic Acquisition Module Configuration

Within the basic acquisition module configuration, the main acquisition parameters can be defined.

Each Software module has its application specific parameters.

Figure 20: SUI Module specific parameters

Parameter	Description
Base Frequency	Defines the network Frequency, 16 2/3, 50 or 60 Hz, the base for the harmonics calculation.
No of Harmonics	Defines the number of harmonics to be calculated.
Current Source	Selection of the Current source: <u>CT</u> Use the Current input (with 0.1Ohm Shunt) <u>Rogowski Coil</u> Use the input for Rogowski coils with the integrated integrator.
Reference Source	Selection of the Reference source: <u>AC Reference</u>

	Use the AC input terminals, supporting reference voltages up to 300Vrms <u>LV Reference</u> Use the LV Reference input with an input range of +/-30Vpp
Min U	Determines the minimum for the shaft voltage input, if the shaft voltage signal is below the threshold, the system skips the calculation
Min I	Determines the minimum for the shaft current input, if the shaft current signal is below the threshold, the system skips the calculation
CT Ratio	Defines the Ratio of the current Transformer, this can be 100 (100:1) or 50 (50:1), this is all based on the input shunt of 0.1Ohm. In case an external shunt is used, the CT ratio can also be used to rescale the input value. As the system is calibrated with the 0.1Ohm shunt, a shunt value of 5mOhm will result a much lower current value, and the CT ratio can be used to rescale the value to a correct value. As both shunts will be in parallel, the resulting shunt value will be 4.762mOhm, or ~21 times smaller than 0.1Ohm shunt → put the CT Ratio to 21 in that case to correct the measured value to the new shunt size.

Table 6: Basic – Acquisition parameters

6.3 Alarm Configuration

By default, the following alarms are configured, note that the channel id needs to be calculated based on the acquisition module number.

CH ID	Calculation Type	Alarm Mode	Threshold AL1 low lvl	Delayed	Threshold AL2 low lvl	Delayed
8	Shaft Voltage Level RMS	outside	5V	Yes, 10s	10V	Yes, 10s
16	Shaft Current Level RMS	outside	0.5A	Yes, 10s	1A	Yes, 10s

Table 7: Default Alarm Configurations

Notes: If the harmonic ratio shall be used for alarming, typically the ratio value of 1 (odd and even harmonics are identical) are used for alarm AL1 and 2 for AL2.

6.4 4-20mA Output Configuration

The 4-20 mA output range shall be defined based on the actual measurement results. However, typically it is set as follows:

Shaft Voltage: 4mA = 0V 20mA = 20V

Shaft Current: 4mA = 0A 20mA = 5A

6.5 MIMIC Visualization Configuration

Use one of the templates representing the machine and it is recommended to use the following channels:

CH ID	Calculation Type	Si Notation	Digits
8	Shaft Voltage Vrms	yes	1
9	Shaft Voltage Max Pos Peak	yes	1
10	Shaft Voltage Max Neg Peak	yes	1
11	Shaft Voltage Harmonic Ratio	no	2
12	Shaft Current Vrms	yes	1
13	Shaft Current Max Pos Peak	yes	1

14	Shaft Current Max Neg Peak	yes	1
15	Shaft Current Harmonic Ratio	no	2

Table 8: Default Mimic Channels

Alternatively, an additional MIMIC visualisation can be added for the harmonic values only:

CH ID	Calculation Type	Si Notation	Digits
8	Shaft Voltage Harmonic #1	yes	1
9	Shaft Voltage Harmonic #2	yes	1
10	Shaft Voltage Harmonic #3	yes	1
11	Shaft Voltage Harmonic #4	yes	1
12	Shaft Current Harmonic #1	yes	1
13	Shaft Current Harmonic #2	yes	1
14	Shaft Current Harmonic #3	yes	1
15	Shaft Current Harmonic #4	no	2

Table 9: Default Mimic Channels

6.5.1 Local Visualization Mimic example

As the visualization is fully customizable, the graphics below show an example of a possible visualization layout:

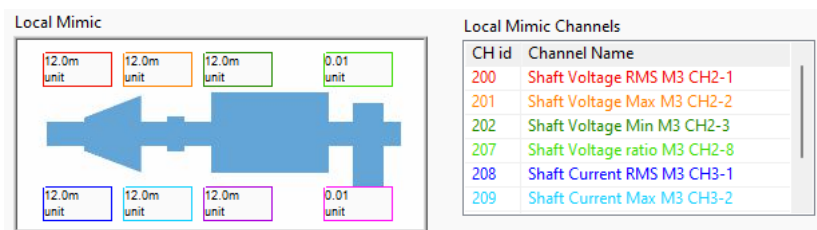


Figure 21: SUI Example of the standard local visualisation mimic

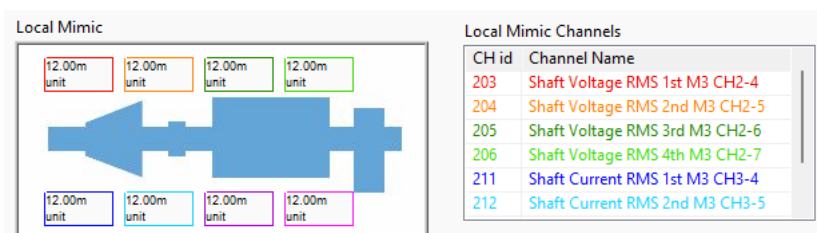


Figure 22: SUI Example of the harmonic local visualisation mimic

6.5.2 External Visualization Mimic example

A similar visualization layout can be used to present the mimic within the UDL-Monitoring Software.

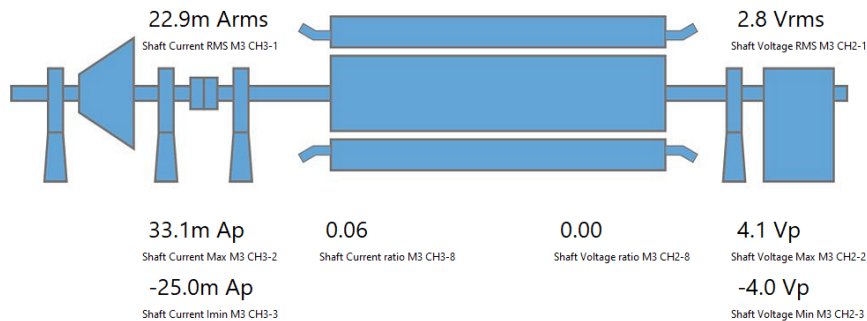


Figure 23: SUI Example of the standard external visualisation mimic

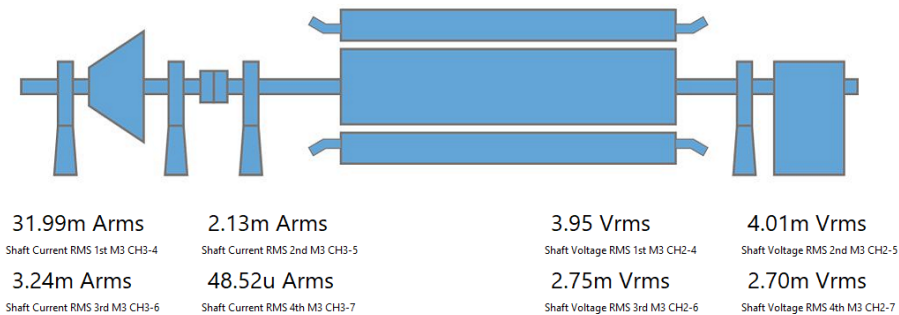


Figure 24: SUI Example of the harmonic external visualisation mimic

6.6 Data Recording

In order to avoid excessive data recording which will occupy a lot of disk space, it is recommended to use the following recording options.

6.6.1 Data Recording based on alarm

It shall be evaluated, if in case of an alarm other acquisition parameters should also be recorded. Typically this is especially required, if the data other acquisition modules are linked together with the shaft voltage / current monitoring.

Figure 25: Typical recording configuration for alarm-based recording

Whenever an alarm of the specific acquisition module is active, 5 recordings with an interval of 10 minutes are saved. The counter for the number of recordings is restarted once all of the recorded data are saved.

6.6.2 Data Recording based on Time interval

In order to avoid a lot of recordings of the same data, a time intervalled recording shall be activated. The time intervalled recording will save only the raw data with the highest magnitude within the defined time interval. This type of recording shall be activated for the shaft voltage and for the shaft current (in case both functions are used)

The shown channel ID 200 refers to the shaft voltage RMS value, where channel ID 208 refers to the shaft current RMS value.

Figure 26: recording configuration for time interval-based recording of Shaft Voltage

Figure 27: recording configuration for time interval-based recording of Shaft Current

Parameter	Description
Channel ID	Define the channel id of the Shaft Voltage / Current RMS Value

Max/min	Define the “memory mode” of the interval. Data are memorized if a new parameter value is larger (max) or smaller (min) of the previous data
Intervall hour	Define the time interval for the recording interval.
Condition	Define, if the data shall be acquired only while a parameter condition is met, e.g. record data if the machine runs at a minimum active power.
Channel ID	Define the channel id of the condition parameter
Value	Define the threshold of the condition parameter

Table 10: Basic – time interval-based recording.

BLANK PAGE

7 Acquisition Module Data Presentation

BLANK PAGE

The measured shaft voltage and shaft current signal is acquired simultaneously and is visualized as time signal on the top of the window.

The harmonic analysis of the shaft voltage and shaft current is shown in individual graphs within the middle of the screen.

At the bottom of the window, the numeric values of the measurement results are shown.

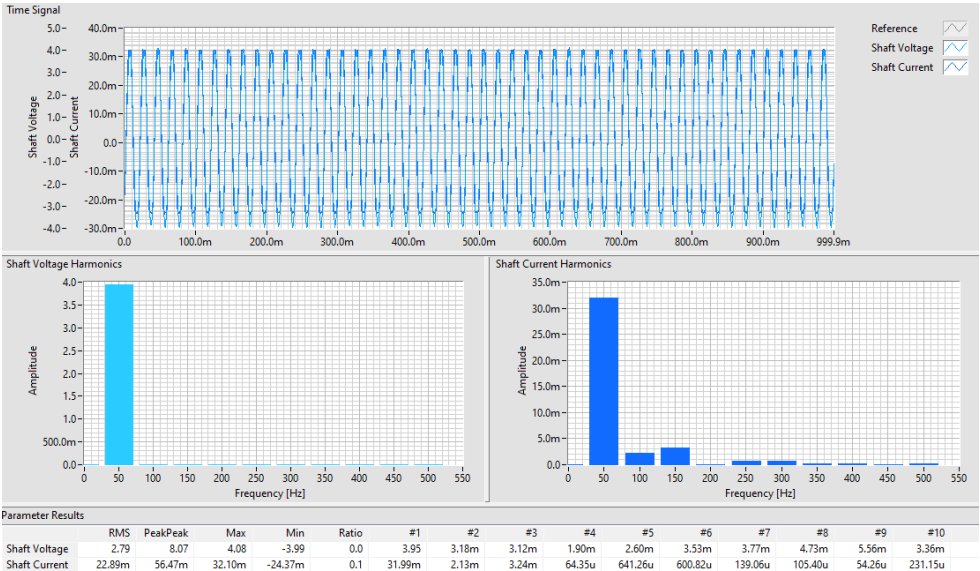


Figure 28: SUI Acquisition Module Data Presentation

BLANK PAGE

8 UDL-DataClient

BLANK PAGE

This chapter covers the information for the visualization of the measured data within the centralized data server / client software UDL-DataClient.

While the basic version of the UDL-DataClient presents only one visualization at a time, the UDL-DataClient Pro supports multi window data presentation while the content and the operation of the windows remain the same.

The measured shaft voltage and shaft current values are updated once the complete acquisition module is finished, and the update rate depends on the number of used modules

8.1 Typical Window Layouts

While the window layout depends greatly on the used monitor resolution, the number of windows presented at the same time also on the operator's preference. The layouts shown within this manual shall give some ideas about the possibilities provided by this software.

8.1.1 Layout for the UDL-8000 Pro

Screen Resolution: 1280 x 800 - WXGA

Using the touchpanel PC for data visualisation allowing to use the benefit of multiple data presentation. However, generally data analysis will then be performed on a connected Desktop computer with a larger screen.

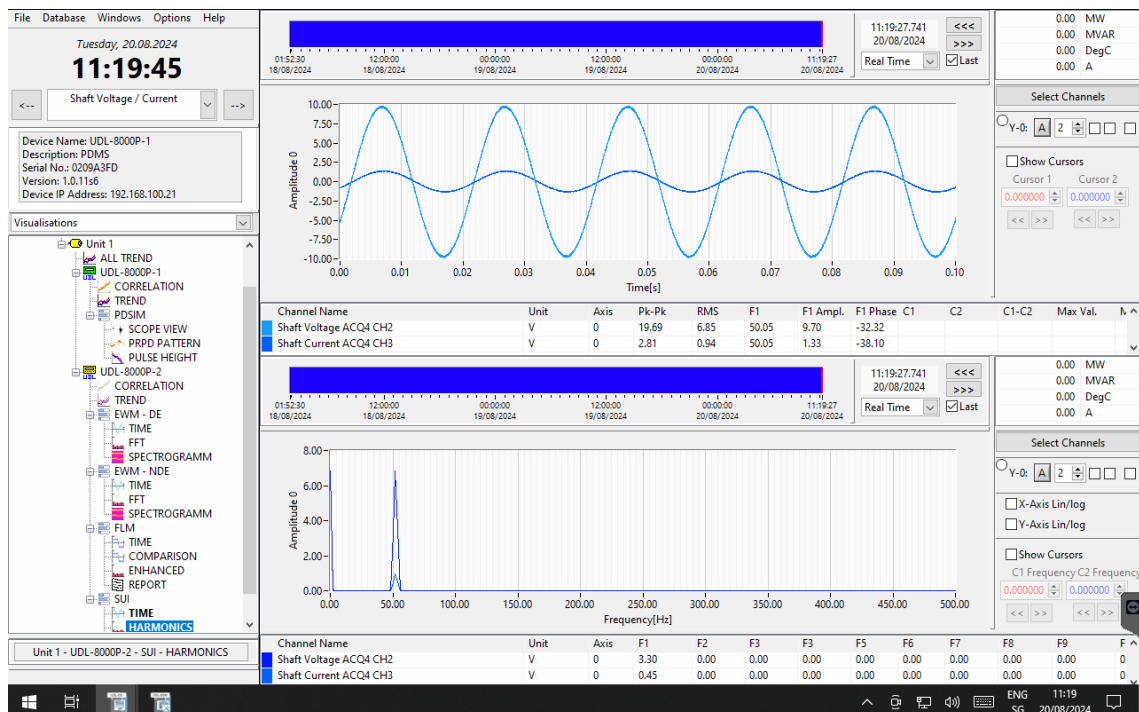


Figure 29: UDL-8000 Pro local data visualisation (Shaft Voltage and Current)

As with the limited screen size, the time series data (trend) is placed as a separate view

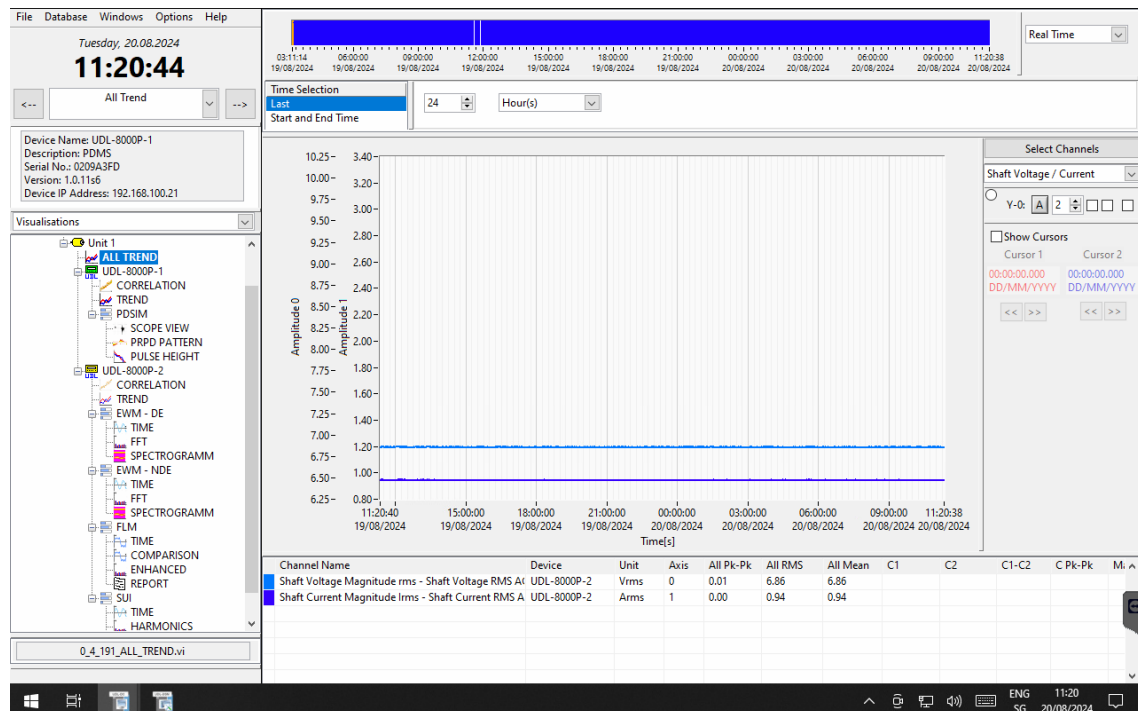


Figure 30: UDL-8000 Pro local data visualisation (Trend)

8.1.2 Layout for Desktop Computers

Screen Resolution: 2560 x 1440 – WQHD - recommended

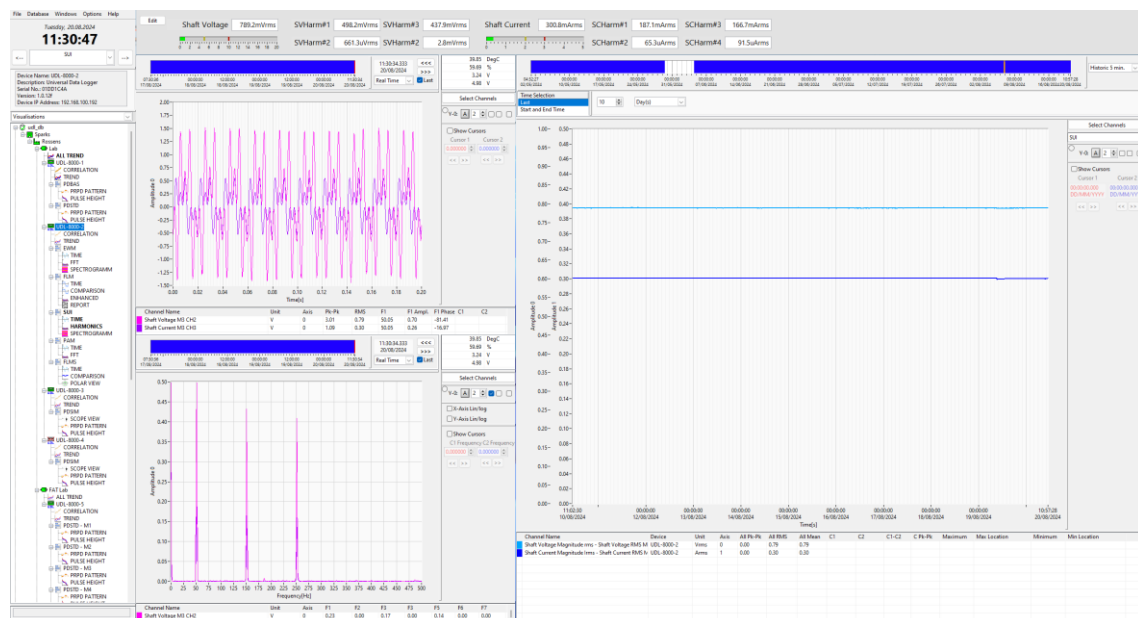


Figure 31: UDL-DataClient desktop data visualisation (SUI & Trend)

8.2 Data Visualizations

The functions, use and configuration of overview pages and trend are common for all types of acquisition modules and are described in the general user manual of the UDL-DataClient. The Update Rate of the windows depend on the number of acquisition modules used.

8.2.1 TIME (Shaft Current and Voltage)

The Time view shows the raw data of the shaft voltage and shaft current over the defined acquisition time.

The visualization is separated into 3 parts:

Window Part	Description
Top	The Top Part contains the time selection of the shown dataset
Middle	In the middle the selected data is presented
Bottom	At the bottom of the window, calculated results are shown

Table 11: Separation of visualisation information

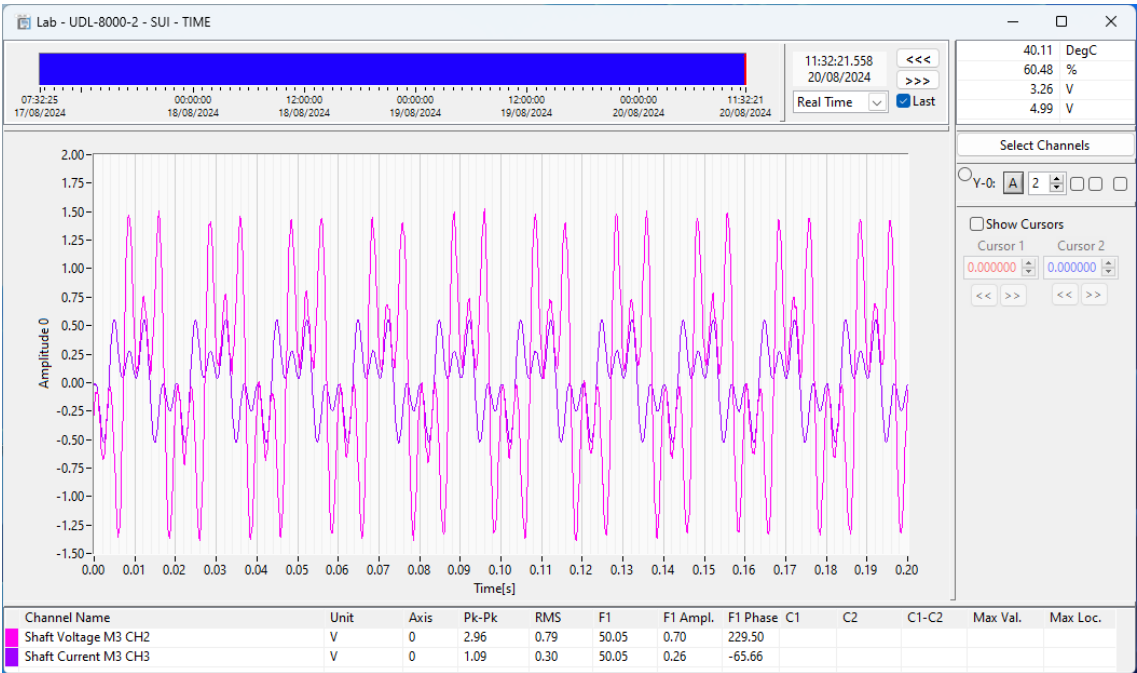


Figure 32: Time Data Presentation

8.2.1.1 Time Selection

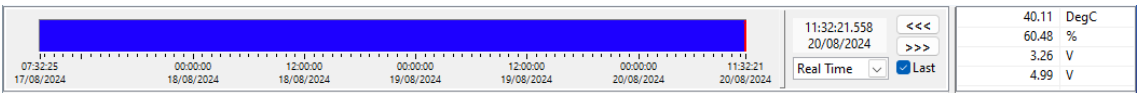


Figure 33: Time Selection

The blue bar shows all the available data records within the database, and the specific dataset can be picked by moving the red cursor at the time of interest.

The time selection in the middle allows to select the time more precisely as

Element	Description
Time Stamp	Enter the timestamp of interest manually. It is also possible to copy/paste the timestamp from another window or from a cursor timestamp. Right click into the timestamp field and assign the timestamp to the “master timestamp 1” or “master timestamp 2” in order to select the dataset of multiple windows with one single time definition.
Button left / right	Jump one record to the left (earlier) or right (later)
Data table selection	Choose between Realtime Data- and Historic Datasets
Last dataset	Select the last data record

Table 12: Time Selection parameters

At the very right side of the time selection view are the operating parameters shown. Up to 4 parameters can be assigned to the “recording header” which will be shown on every raw data visualisation window.

8.2.1.2 Data Presentation

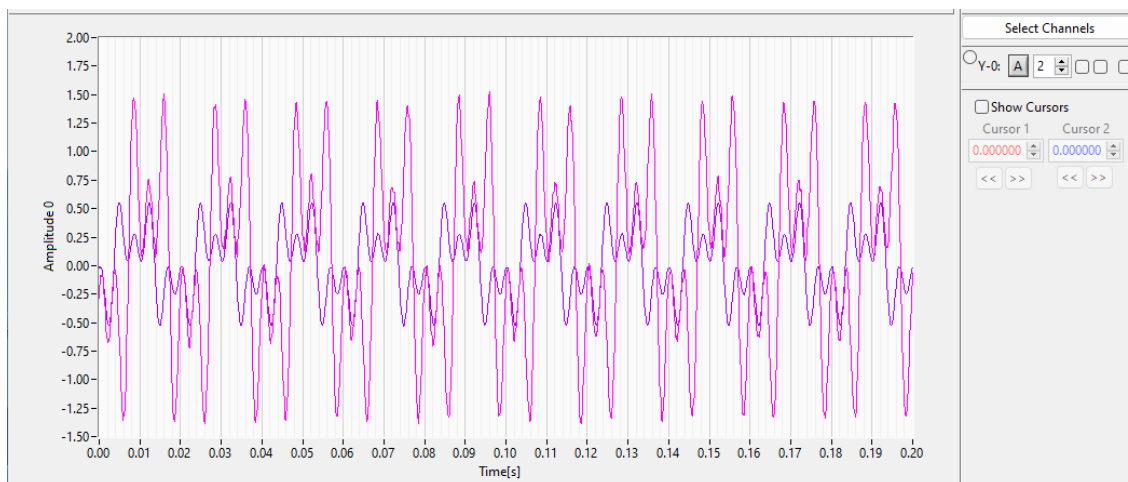


Figure 34: Shaft Voltage and Current Data Presentation

With the button “select channels” the channels of the specific module can be activated. Generally, there is a reference signal (to trigger the acquisition), the shaft voltage and the shaft current signal.

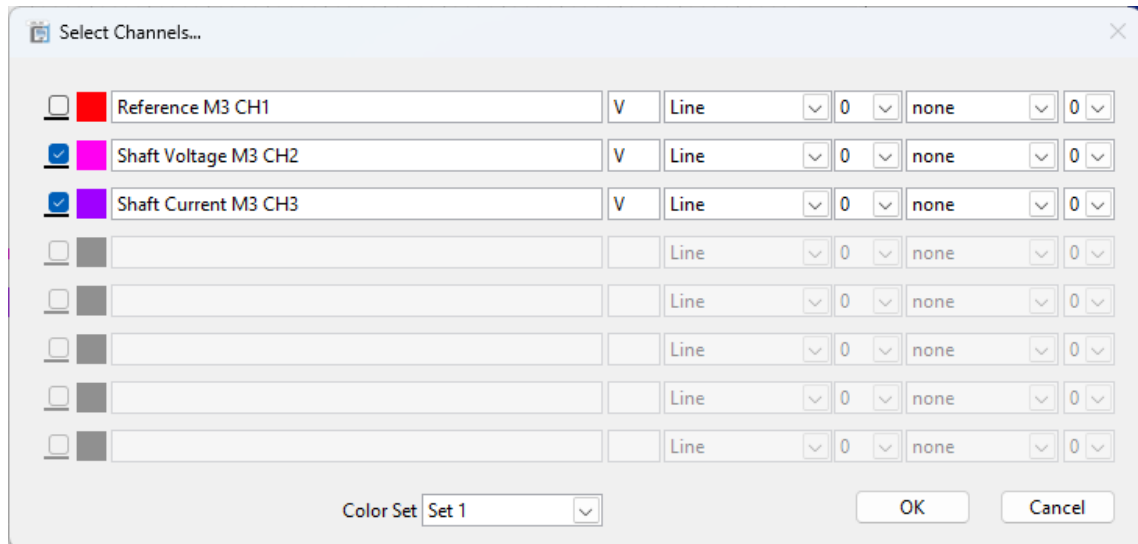


Figure 35: Channel Selection

Mark the Checkbox to activate the channel, click on the color box to change the color of the trace. Select the line type, the line thickness and sample points if wanted. At the very right side, assign the trace to the specific axis, this is especially used, whenever data with different scaling's are shown in the same graph. At the bottom of the window, a new color set can be assigned. Press the “OK” button to accept new changes and close the window.

At the right side of the graph are the settings for the individual used axis, press the little circle next to the “A” button to enlarge the axis configuration

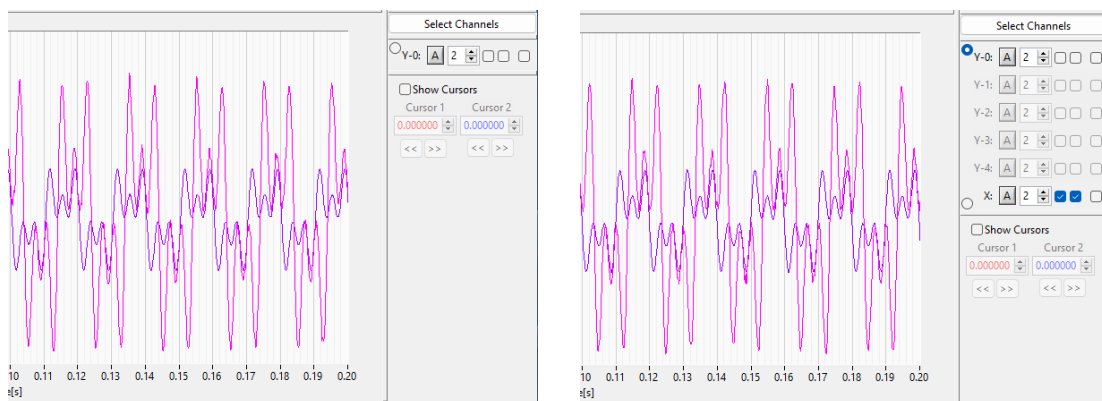


Figure 36: Axis Configuration

Depending on the assigned channels to the traces, more axis can be configured. Press the little “A” button to autoscale the specific axis. The number is used to select the number of digits in the axis and also in the calculation result table. The checkboxes next to it, allows to activate the major and minor grid lines. The checkbox at the very right is used to show the data either as floating point (unchecked) or in Si notation (checked). Si

notation allows to automatically convert any number into k, m, M instead of exponents. It is also possible to manually adjust the axis range by entering the minimum and maximum value of the specific axis. Press the round circle at the bottom of the axis configuration to minimize this view.

Below the axis configuration 2 cursors can be activated in order to read out values of the shown traces. Mark the checkbox to activate the cursors:

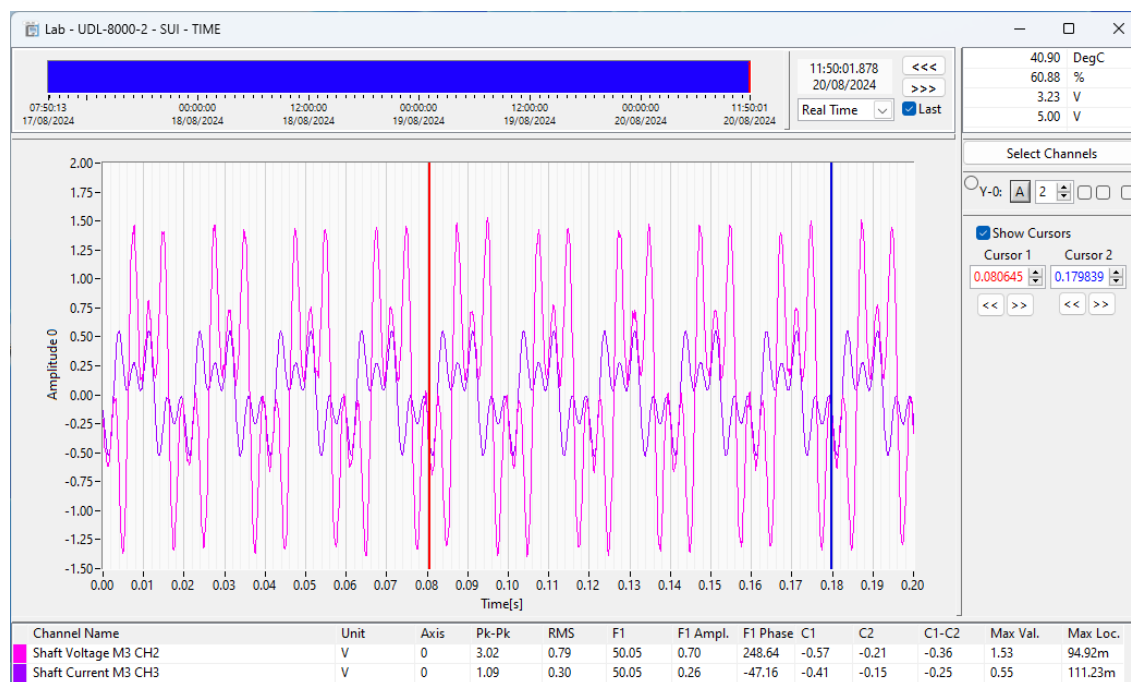


Figure 37: Reading out datapoints with cursors.

8.2.1.3 Calculated Results

At the bottom of the visualisation window are the results calculated from the shaft voltage and shaft current signal shown.

Channel Name	Unit	Axis	Pk-Pk	RMS	F1	F1 Ampl.	F1 Phase	C1	C2	C1-C2	Max Val.	Max Loc.
Shaft Voltage M3 CH2	V	0	3.00	0.79	50.05	0.71	216.14					
Shaft Current M3 CH3	V	0	1.09	0.30	50.05	0.26	-79.11					

Table 13: Calculated Results without cursors

If the cursors are activated, the calculation results table is showing calculated values between the 2 cursors

Channel Name	Unit	Axis	Pk-Pk	RMS	F1	F1 Ampl.	F1 Phase	C1	C2	C1-C2	Max Val.	Max Loc.
Shaft Voltage M3 CH2	V	0	3.02	0.79	50.05	0.70	248.64	-0.57	-0.21	-0.36	1.53	94.92m
Shaft Current M3 CH3	V	0	1.09	0.30	50.05	0.26	-47.16	-0.41	-0.15	-0.25	0.55	111.23m

Table 14: Calculated Results with cursors results

8.2.2 HARMONICS

The Harmonics view shows the spectrum of the shaft voltage and shaft current signal.

The handling of the visualization is done in the same way as the TIME view. Refer to the chapters before for details of the usage.

The visualization is separated into 3 parts:

Window Part	Description
Top	The Top Part contains the time selection of the shown dataset
Middle	In the middle the selected data is presented
Bottom	At the bottom of the window, calculated results are shown

Table 15: Separation of visualisation information

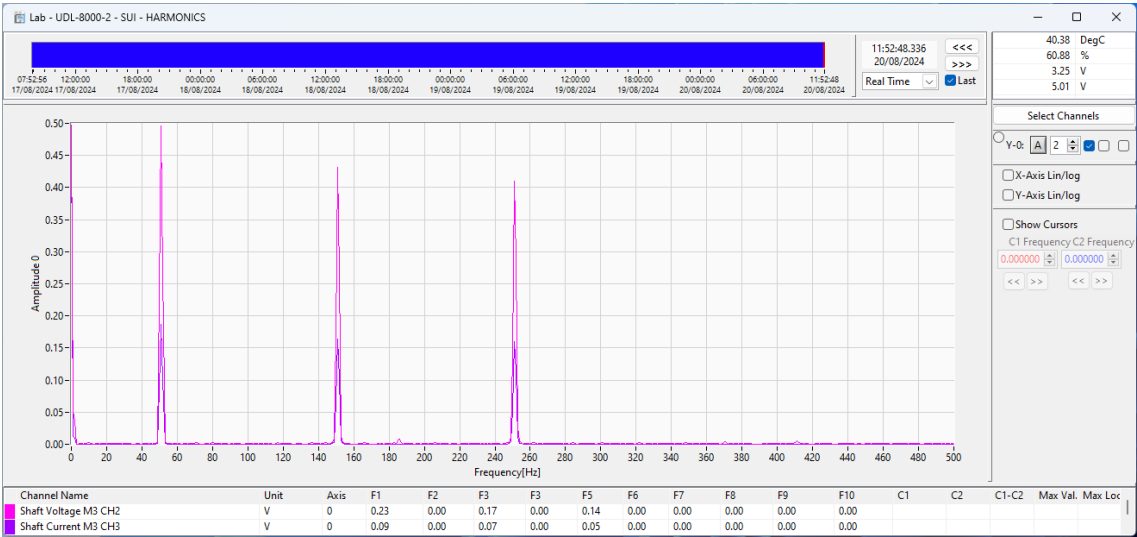


Figure 38: Spectrum of the shaft voltage and shaft current signal

8.2.3 Spectrogramm

The spectrogram is used to show the Harmonics / Spectrum over time.

The visualization is separated into 4 parts:

Window Part	Description
Top	The Top Part contains the time selection of the shown dataset range
Middle left	The Spectrogramm graph
Middle right	Color coding of the spectrogram, cursor activation
Bottom	Values at the cursor position

Table 16: Separation of visualisation information

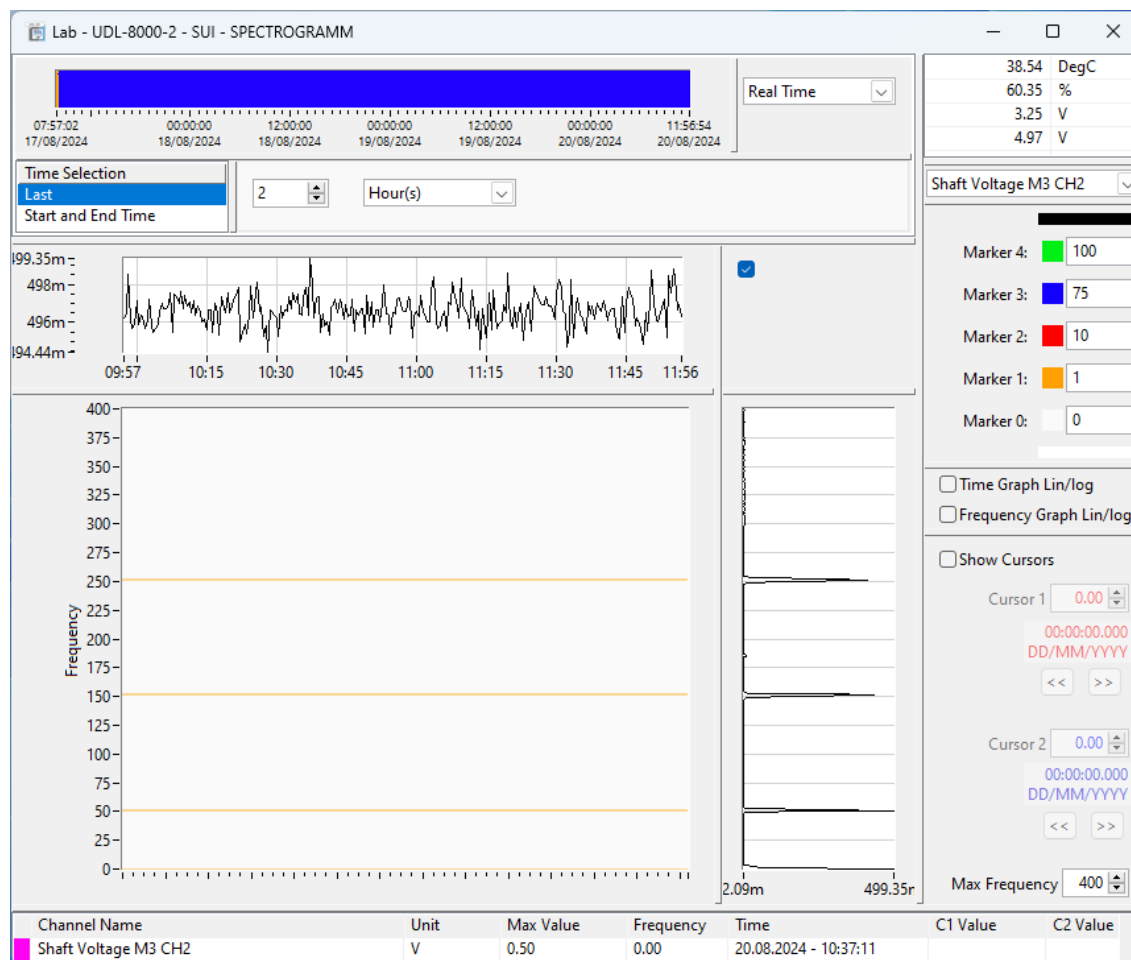


Figure 39: Spectrogram of the Shaft Voltage / Current Signal

8.2.3.1 Time Selection

The top blue bar, represents all the available data within the database, blue represents a dataset and at the times where no data is available the area is kept white.

Below the blue bar, 2 modes are available to select the data frame:

Parameter	Description
Last	Show the last x seconds/hours/days.
Start / End Time	Define a start and end time of the data

Table 17: List of Time selections

Under normal operation, the data is usually selected as last “week” or last “month” this is to show any progress over the measured values.

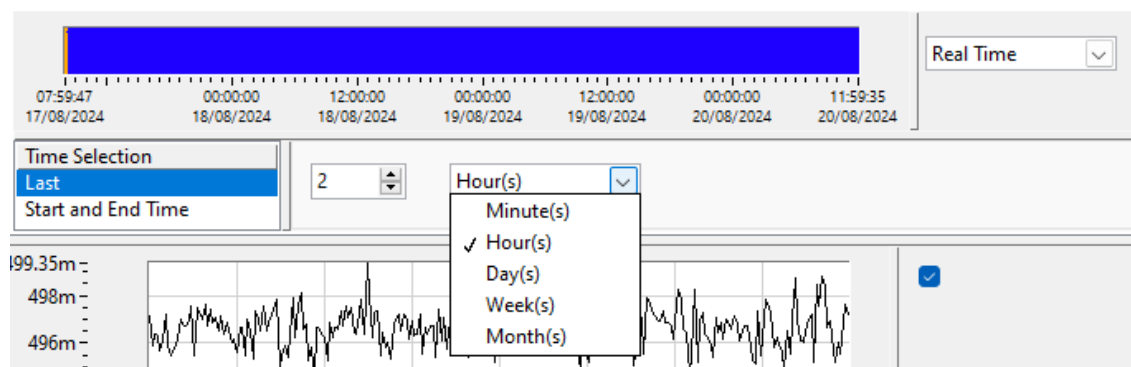


Figure 40: Time Selection - last

It is also possible to select a specific time range, by choosing “start and End time and further the timestamps

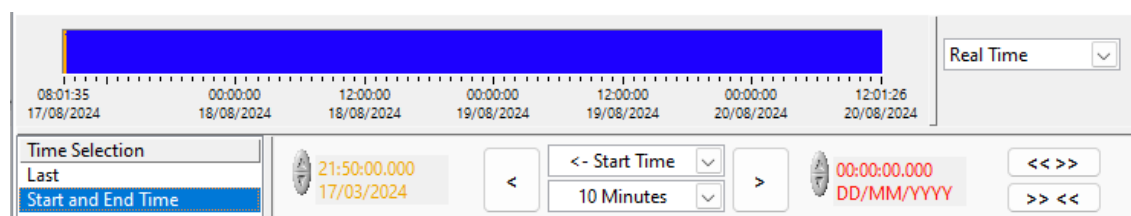


Figure 41: Time Selection – Start – End Time

Enter the times manually at the time stamp fields or use the cursor buttons to move the start or end times by the time defined within the pull down menu. Use the buttons at the very right to zoom in or out. It is also possible to select the timeframe by moving the cursors within the blue bar as shown below

8.2.3.2 Data Presentation

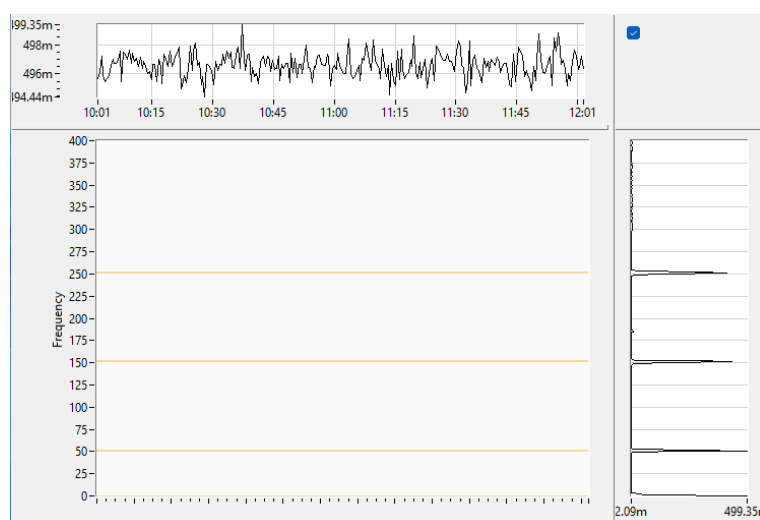


Figure 42: Spectrogram Data

In the center the spectrogram graph is shown, with the selected time range in the X-Axis and the frequency in the Y-Axis. The Z-Axis is shown in color and represent the amplitude.

At the top of the spectrogram, and additional graph is showing the overall enveloped signal over the entire time frame, while at the right side of the spectrogram, the overall envelope of all frequencies is shown.

At the top right side, the channel can be selected, choose between shaft voltage and shaft current.

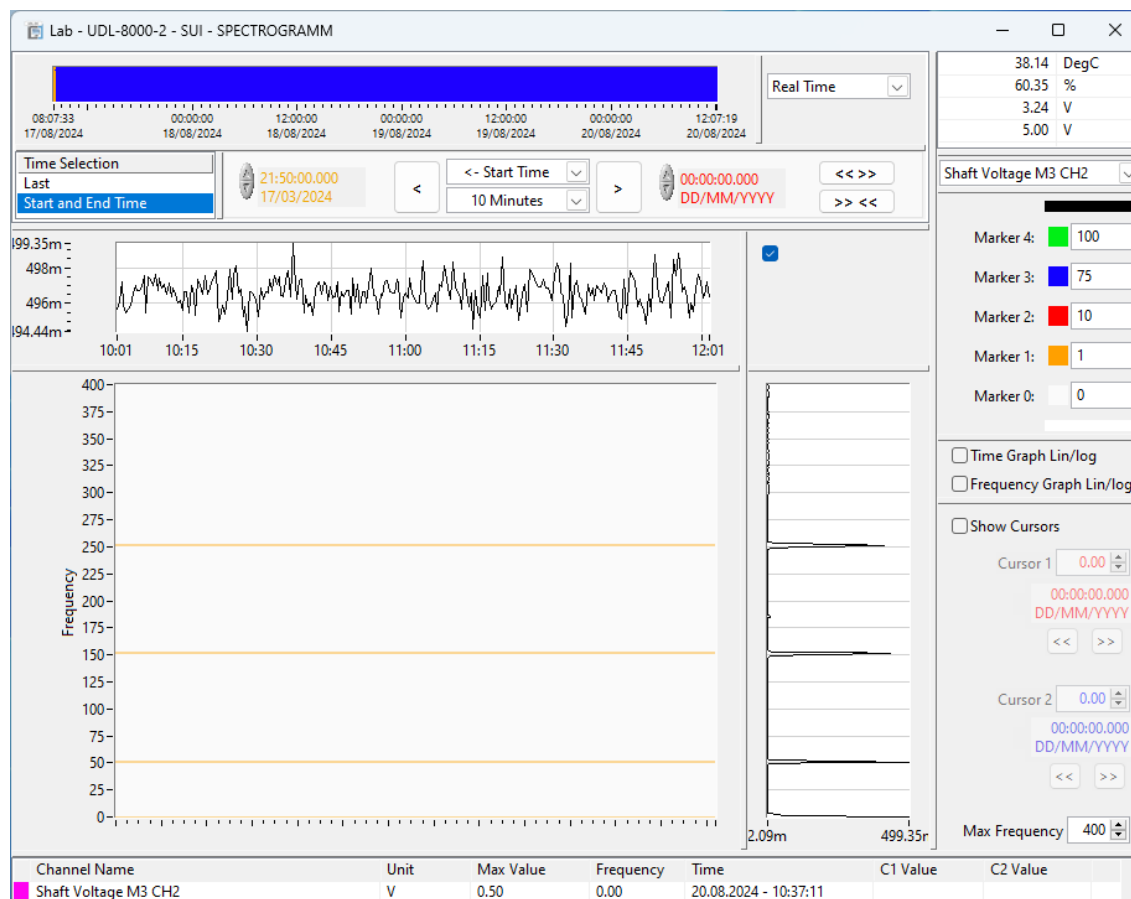


Figure 43: Selection of the channel

Below the channel selection the color coding of the spectrogram can be defined. Use the marker 0 up to Marker 4 to define the color and the associated value. Below and above the marker colors, two additional color bars are available. These are used to set a color of values outside the marker values.

Below the markers, the overall graphs at the top and the right can be configured for linear or logarithmic scale.

Below that, the cursors can be activated, there are 2 cursors available to read our values within the spectrogram

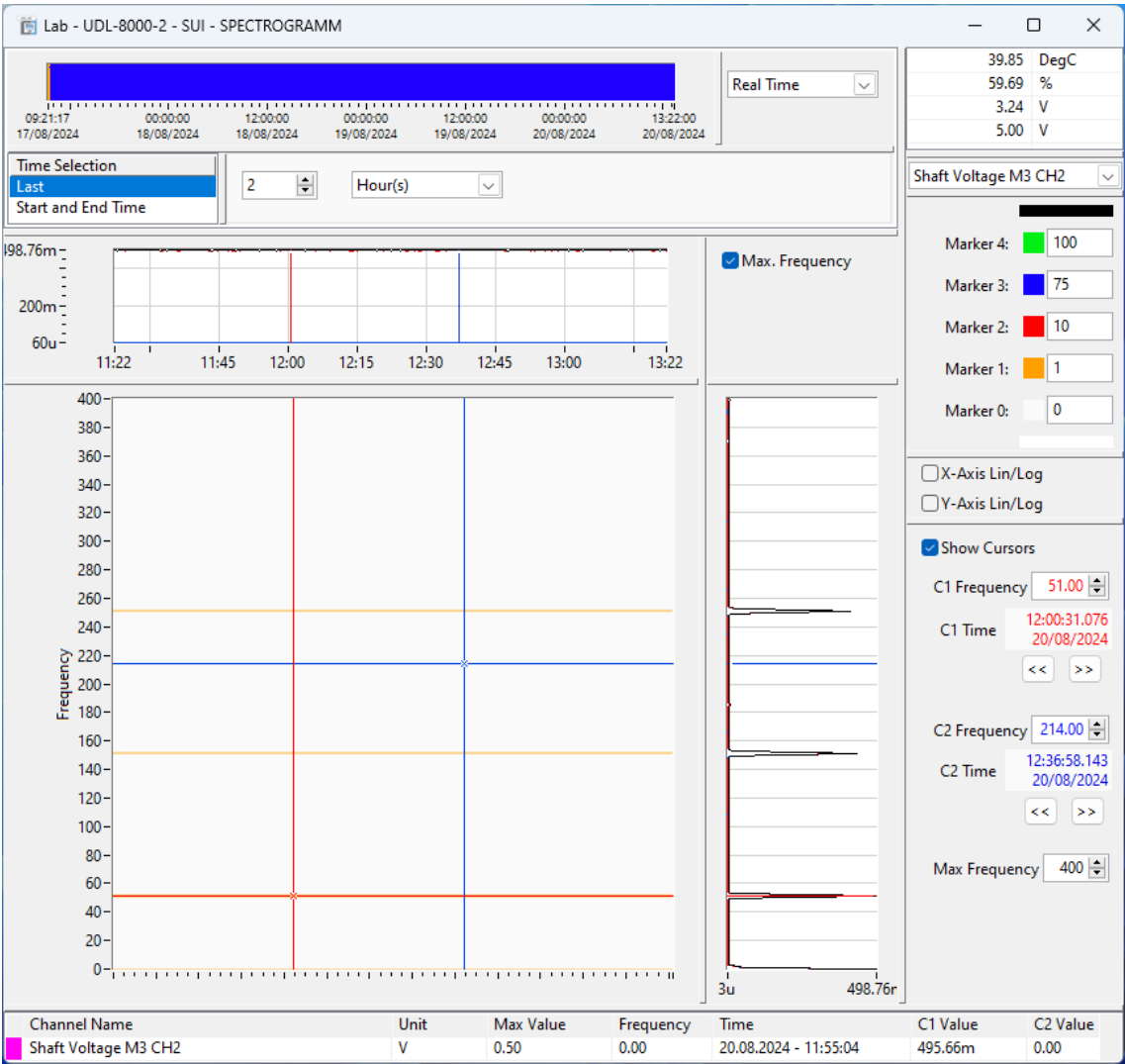


Figure 44: Using Cursors within the spectrogram

When the cursors are activated, the overall graphs at the top and at the right side of the spectrogram will show the information from the cursors

The “Max Frequency” will define the maximum frequency used for the calculation of the spectrogram.