bepat GmbH & Co. KG

rotabench® PA-3P

Power Analyzer For Automotive Electric Motors

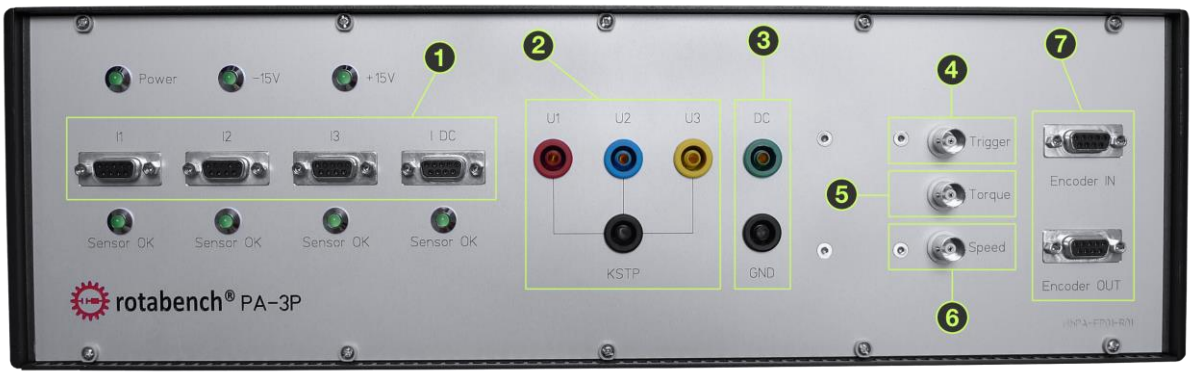
Accuracy Class: 0,1%

rotabench® PA HARDWARE

TECHNICAL DATA

Housing:	19‘‘ 3 RU to 6 RU available as a Desktop or 19‘‘ Rack-Chassis
Product Designation:	rotabench® PA
Type Designation:	rotabench® PA-3P
Weight:	ca. 8 kg (Desktop Version)
Dimensions:	ca. 32 x 45 x 14 cm (L x W x H) (Model 3P, Desktop)
Power Supply:	90 to 260 VAC, 47 to 63 Hz
Elec. Power:	max. 75 Watt
Operating Temperature:	0°C to 60°C
Humidity:	10% to 80% Relative Humidity, Non-Condensing

OVERVIEW



1. Current Inputs (LEM-Transducers)
2. Voltage Input L1-L3, /w Artificial Neutral Point
3. DC Voltage Input
4. Trigger-Input (5 Volt TTL)
5. Torque Input (±10 Volt DC)
6. Analog Speed Input (±10 Volt DC)
7. Digital Speed Input (5 Volt TTL), Digital Speed Output

INPUT PORTS (MODEL 3P)

CURRENT

- 4 Input Ports for LEM IT 200-S ULTRASTAB or LEM IT 400-S ULTRASTAB Current Transducers (Phases L1, L2, L3 and DC), Range 200 or 400 Amp (Peak)
- Integrated Signal Conditioning
- Integrated lowest ripple Power Supply for LEM Transducers (± 15 Volt)
- Accuracy:
  - Sensors: acc. Datasheet LEM IT 200-S / 400-S ULTRASTAB Current Transducer
  - Burden Resistor:
    - Tolerance: 0,01%
    - Temperature Coefficient: 0,02 ppm/°C
  - ADC:
    - Synchronous sampling, isolated and differential 24-bit Delta-Sigma Converter
    - Master-Timebase: 12,8 MHz
    - Output Sample-Rate: 50 kHz (per Channel)
    - Input-Impedance: > 1 GOhm
    - Gain Error: max. ± 0,2%, typ. 0,07% (between 18°C and 28°C)
    - Offset Error: max. ± 0,06%, typ. 0,005% (between 18°C and 28°C)
    - Gain Drift: ± 7 ppm/°C
    - Offset Drift: 1,3 uV/°C
    - Phase Mismatch: 0,13° / kHz max.
    - Phase Non-Linearity: 0,12° max.
    - Integrated Anti-Alias-Filter, Threshold Frequency 22,65 kHz
    - CMMR (f_{in} = 60 Hz): 140 dB

VOLTAGE

- 4 Input Ports for Voltage (L1, L2, L3 and DC)
- Input Range: ±60 Volt or ± 1000 Volt
- 250 V RMS CAT2 Isolation – Channel to Channel (with 60 Volt Input Modules)
- Integrated Artificial Neutral Point
  - C = 2200 nF
  - R = 300 kOhm
- ADC:
  - Synchronous Sampling, isolated and differential 24-bit Delta-Sigma Converter
  - Master-Timebase: synchronized with the Power Input Ports (12,8 MHz)
  - Output-Sample-Rate: 50 kHz
  - Input-Impedance: >1 MOhm
  - Accuracy:
    - Gain-Error: max. ±0,13%, typ. ±0,03% (18°C to 28°C)
    - Offset Error: max. 0,05%, typ. ±0,008% (18°C to 28°C)
    - Gain Drift: 5 ppm/°C
    - Offset Drift: 150 uV/°C
    - Phase Mismatch: 0,045°/kHz max.
    - Phase Non-Linearity: 0,11° max
    - Integrated Anti-Alias-Filter, Threshold Frequency 22,65 kHz
    - CMMR (f_{in} = 60 Hz): 115 dB

INPUT PORTS (MODEL 3P)

ROTATIONAL SPEED (ANALOG) AND TORQUE

- One Input each for Analog Speed Signal and Torque Signal
- Input Range: ±10 Volt
- 250 V RMS Channel-to-Earth Isolation
- 16-bit, Synchronous Sampling, Single-Ended, Sample-Rate: 50 kHz, synchronized with the Power and Voltage Input Ports
- Accuracy:
    - Gain Error: max. ±0,2%, typ. ±0,02% (18°C to 28°C)
    - Offset Error: max. ±0,082%, typ. ±0,014% (18°C to 28°C)
    - Gain Drift: 10 ppm/°C
    - Offset Drift: 60 uV/°C
    - Input-Impedance: 1GOhm

ROTATIONAL SPEED (DIGITAL)

- Digital Speed Input for Rotary Encoders (A-, B- and Z-Phase)
- Signal Level: 5 Volt TTL
- Max. input Frequency: 350 kHz
- Input: Single-Ended (A, B, Z + Gnd) or Push-Pull (A + A‘, B + B‘, Z + Z‘) with Encoder Evaluation (direction) or Speed Pulse only.
- The Digital Speed Input is galvanically insulated. The Input Signals are available at the “Speed Out” Connector with a Fixed Output Delay of 70 ns (for each phase).

OPTIONAL

- Burden Resistor for LEM IT-60 ULTRASTAB or LEM IT-1000 ULTRASTAB Transducers
- Extended Measurement Range for the Voltage Input to 1000 VDC – Integrated within the Artificial Neutral Point

COMMUNICATION

The rotabench PA is connected via LAN-cable (CAT 5e or CAT6) to a Gigabit-LAN. If required, larger distances between the measurement device and the Client PC can be covered by using a network switch or an existing network infrastructure. The communication protocol is based on TCP/IP. The measurement data (Current, Voltage, Rotational Speed and Torque) are streamed to the Client PC for analysis and visualization at a 50 kHz sample rate.

rotabench® PA SOFTWARE

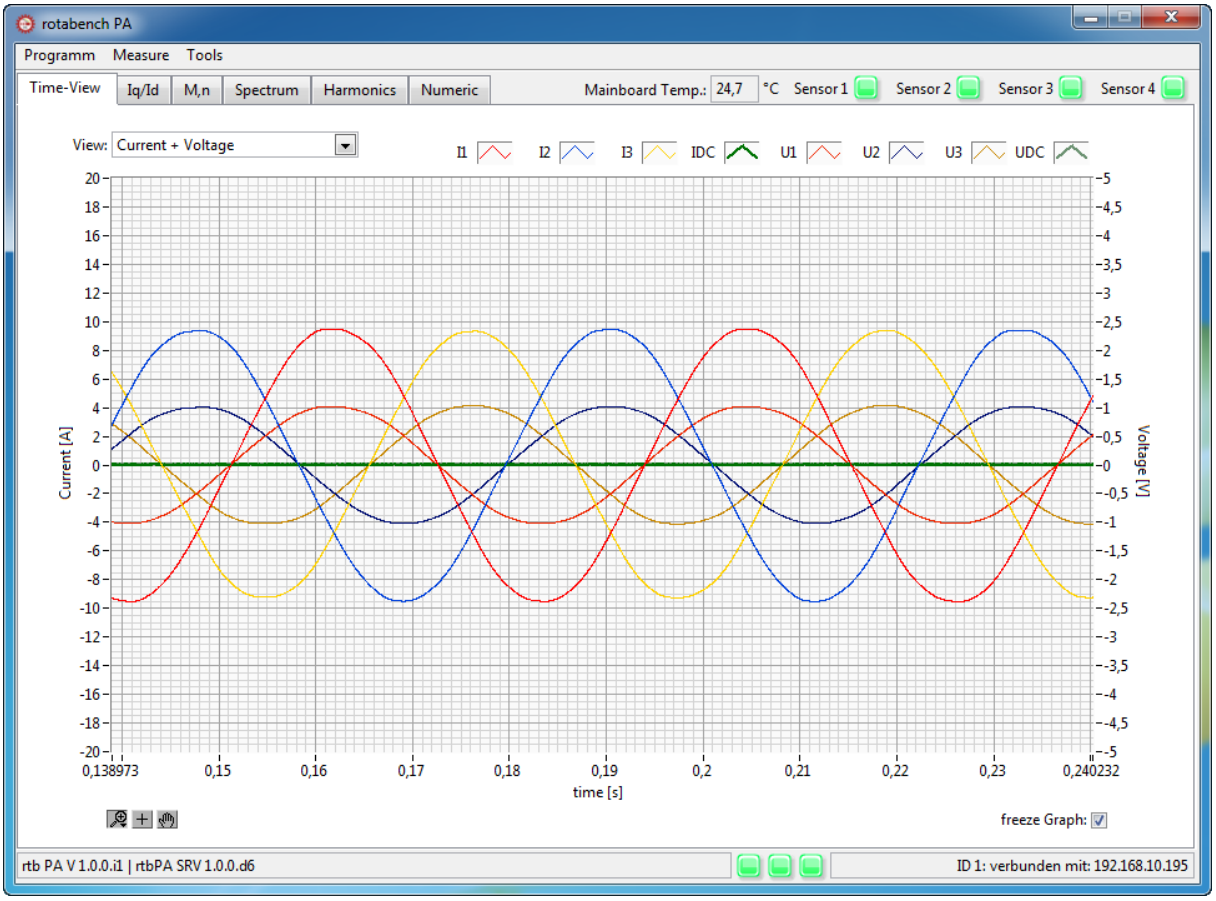
OVERVIEW

The rotabench PA software suite consists of two parts, namely firmware running on the measurement hardware, and client-software, which can be installed on any common Windows PC (“Client PC”). The connection between these two parts is established through an (Gigabit) ethernet network and a proprietary protocol based on TCP/IP. This allows the user to benefit from a distributed system setup, where the measurement hardware is close to the measurement position, and the Client PC can be at a remote location.

Measurement data, acquired by the measurement hardware, are streamed via TCP/IP to the Client PC at 50 kHz per channel. The Client PC is used for calculation, evaluation, analysis and visualization of the measured data.

DATA ACQUISITION AND PROCESSING

TIME DATA VISUALIZATION



The current and voltage data (L1 – L3, DC) that are streamed to the Client PC are displayed graphically as time data with an adjustable memory depth. The time frame length is fully adjustable. The view can be switched to current + voltage, only current, or only voltage.

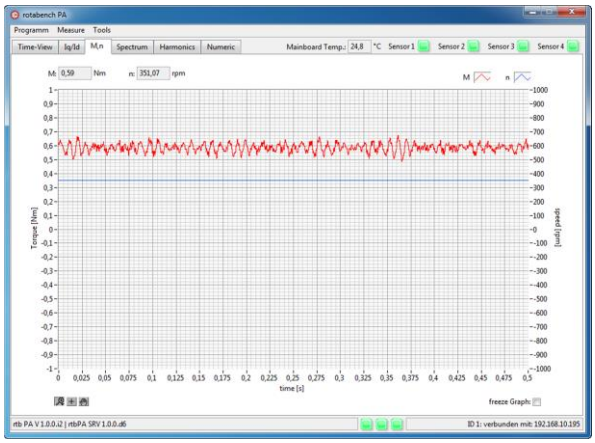
DATA ACQUISITION AND PROCESSING

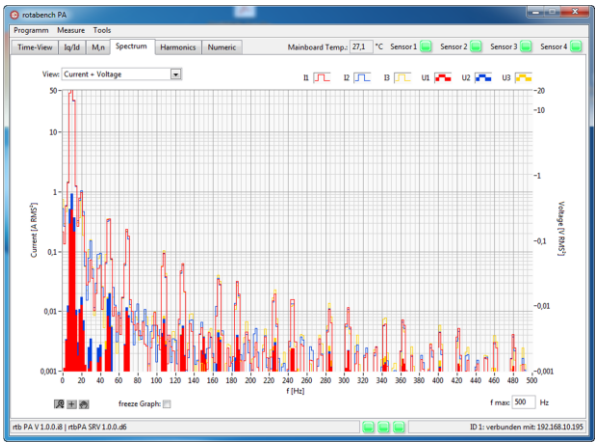
VISUALIZATION OF I_q AND I_d

The Direct Current (Field Building Current) and the Cross Current (Torque Building Current) are shown graphically over the time scale. Iq and Id are only correctly calculated when an electronic rotor position sensor is connected, and the Rotor Angle Offset (Offset between the electric 0° of the machine and the zero angle of the position sensor), the number of pole pairs, and the rotational direction of the machine are known. These data values can be entered in a dialogue window or can be determined through the measurement instrument's "Induced Voltage" measuring function.

VISUALIZATION OF ROTATION SPEED AND TORQUE

The deviation of Rotation Speed and Torque are shown graphically over the time scale.





ONLINE FFT AND ONLINE ORDER SPECTRUM

The Frequency and Order Spectrum of the currents and voltages for L1 – L3 are calculated online and shown graphically.

NUMERICAL MEASUREMENT DATA

The following are calculated for the currents and voltages of L1 to L3, on a broadband level as well as in parallel for the fundamental wave:

- The RMS value per phase
- The average value per phase
- Cumulative and average value of the RMS values
- L0

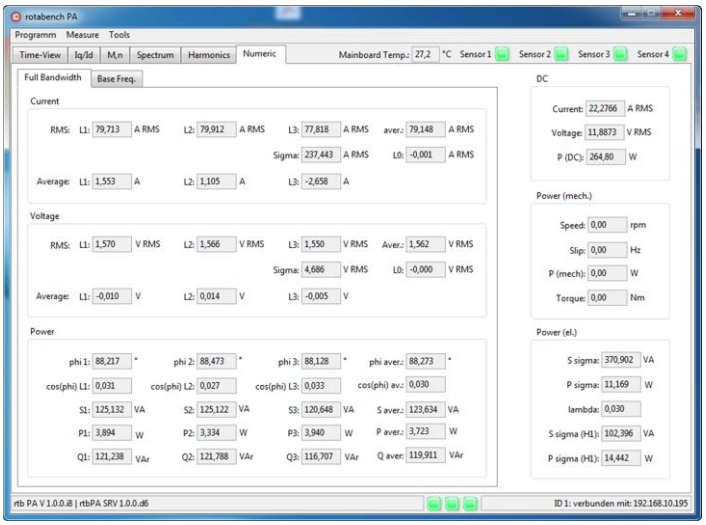
This facilitates measurement results for the following:

- Complex apparent, active and reactive power
- Phi and cos(phi)
- The average values of the above on all 3 phases

NUMERICAL MEASUREMENT DATA

In addition, the following is calculated:

- The DC power
- The mechanical power (from the average values of rotational speed, torque and slip where applicable)
- The sums of complex apparent, reactive and active power, as well as the broadband signal's efficiency factor
- The sums of complex apparent and active power for the fundamental wave



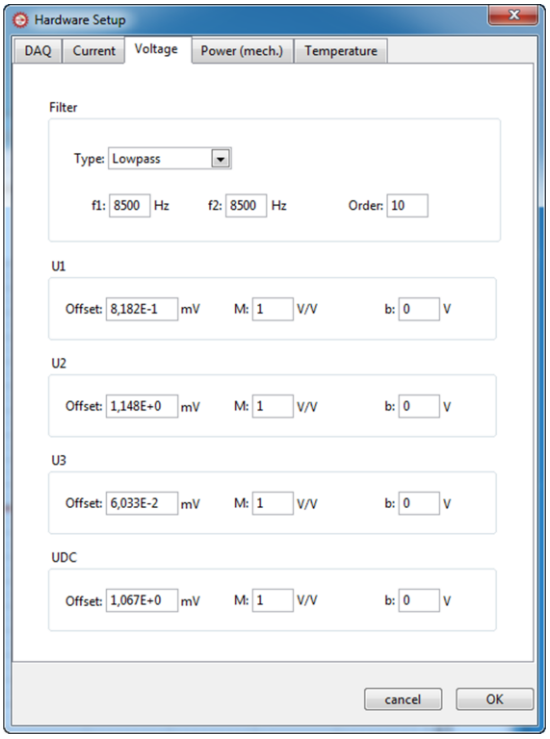
SCALING AND FILTERING

SCALING

Every input channel can be scaled separately:

- Currents L1-L3, and DC
- Voltages L1-L3 and DC
- Rotational speed (analog) and Torque

For the digital rotational speed input, the number of tics per rotation of the incremental encoder can be set. The encoder's rotational direction can be reversed.



FILTERING

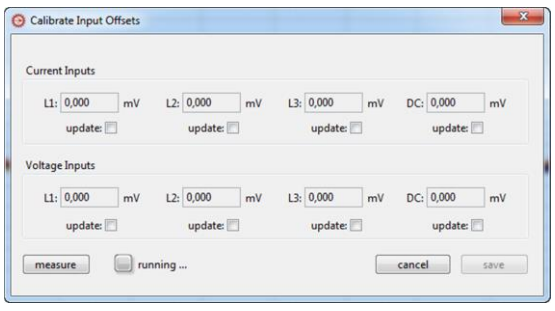
A low, high or band-pass filter are available in the hardware settings for:

- Current and voltage
- The torque input

These filters can be fine tuned with adjustable parameters for threshold frequencies and filter order.

OFFSET COMPENSATION

The Offset of the input channels can be compensated and determined through a simple procedure.



MEASUREMENT DATA CAPTURE

SAVING SCREENSHOTS

Screenshots can be captured similarly to the screenshot function of an oscilloscope, one mouse-click saves visualized data (Screenshots of all Graphs) for current & voltage, rotational speed and torque, I_q and I_d, as well as the frequency- and order-spectrum as a PNG file on the hard disk of the Client PC.

CSV FILE

Time data and spectrums can be saved to a CSV file with one mouse-click for further processing in Excel.

BINARY FILE

Measurement data can be streamed and saved to the hard disk as raw data for a predetermined and fully adjustable time frame. The file format of the raw data can be disclosed if requested.

CUSTOMIZING

If requested, we can modify or extend the software so that your specific requirements are shown 1:1. These could for example be:

- Raw data streams in your pre-defined data format
- Client specific measurement functions
- A DLL allowing full integration of our measurement and streaming functionality, so that it can be seamlessly integrated in your very own software