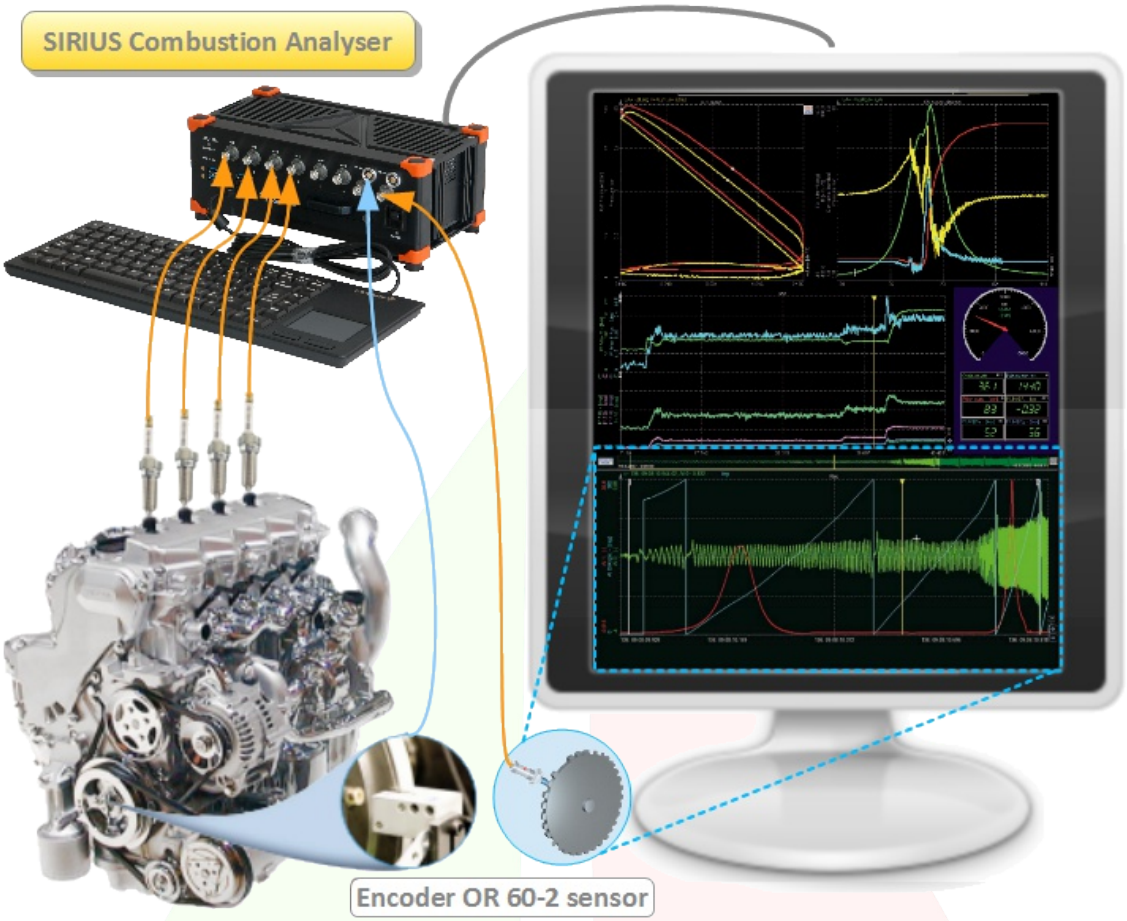
SIRIUS Combustion Analyser



SIRIUSi Combustion Analyser systems from Dewesoft are used for engine research, development and optimization. Also for component development and testing – such as ignition systems, exhaust systems and valve control gear.

The system consists of our top of the notch isolated SIRIUSi hardware and the well-known DEWESoft™ software package for measurement and analysis.

It supports angle and time-based measurement and uses highly sophisticated algorithms for online or offline mathematics and statistics – calculating heat release and other thermodynamic parameters.

The combustion analyser can be fully integrated within a testbed and also supports data from other sources: e.g. Video, CAN, Ethernet, …

If the powerful integrated post processing features of DEWESoft™ are not enough, you can even export the data to several different file formats.

In addition to combustion analysis, the system can be expanded to handle other measurement applications such as hybrid testing on the power train, noise and vibration measurement together with synchronized video or GPS data.

Key Features

- 8 analogue input channels with full galvanic isolation
  - Sampling rate 1MS/s each channel
  - 16 bit resolution
  - Voltage or ICP
- Any sensors with MSI adapters: Thermocouples, RTD, 200V, ...
- 2 super-counters for encoder input
- Direct car angle sensor input: e.g. 60-2
- 1 CAN bus interface

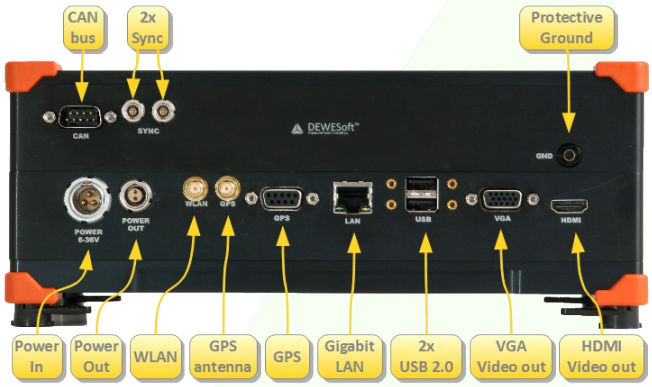
Combustion mode		
# of channels	8	4
0-6000 RPM	up to 1 deg	up to 0.1 deg
0-3000 RPM	up to 0.1 deg	up to 0.1 deg

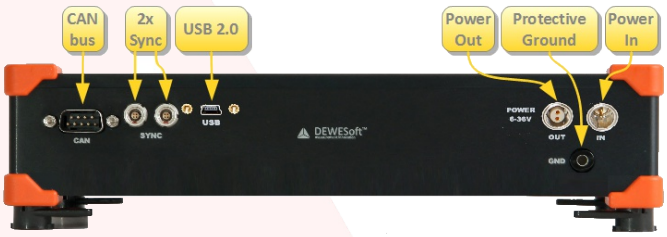
Hardware Systems

SIRIUSi-CA with S-BOX (embedded PC) *OR* *SIRIUSi-CA with external PC*

Display and keyboard are options

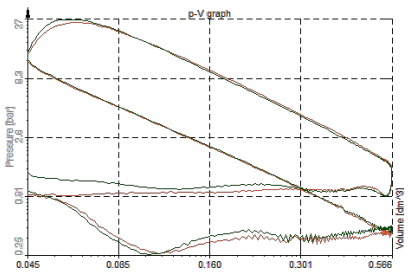
Rear side connectors

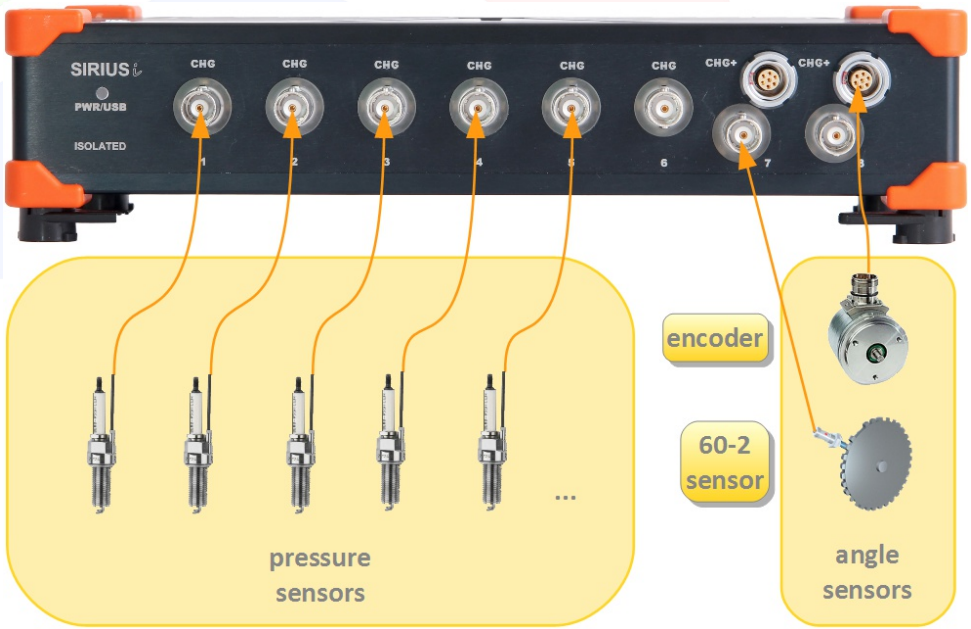




CA-Connection Example

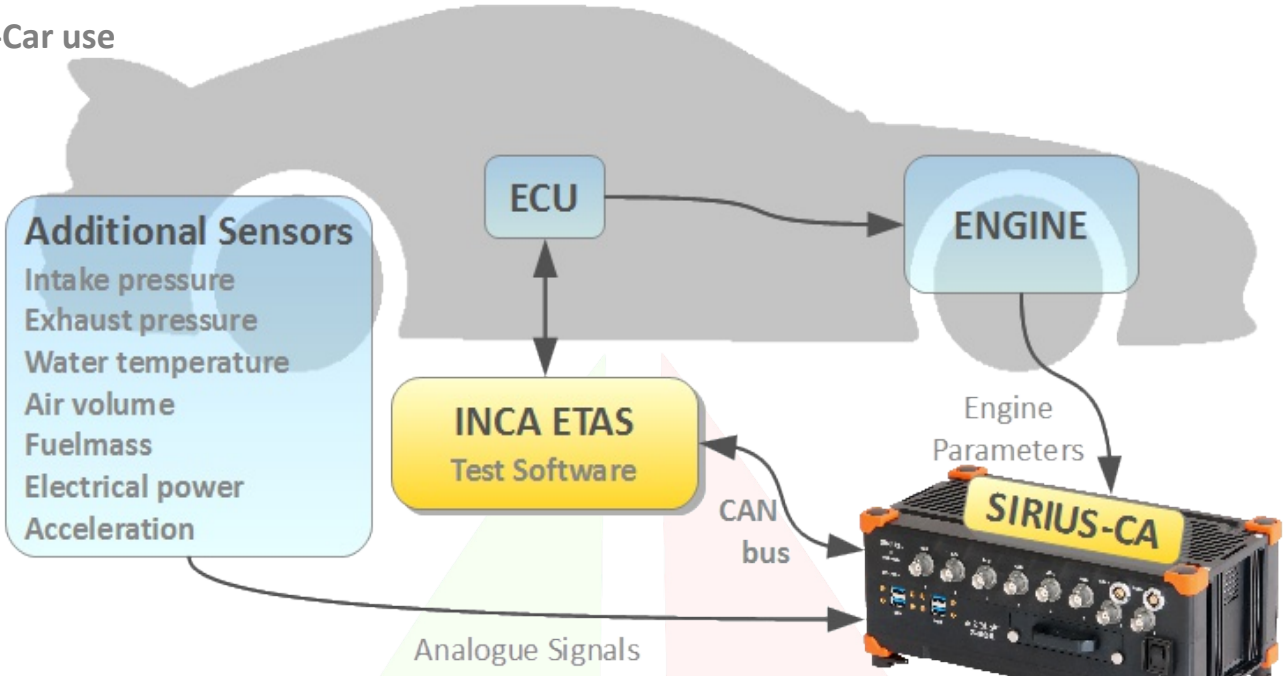
Just can directly connect pressure sensors with SIRIUS CHG (charge) amplifiers and connect angle sensors (Encoder or 60-2 sensor) to get the resulting calculations: e.g. pV-diagram:





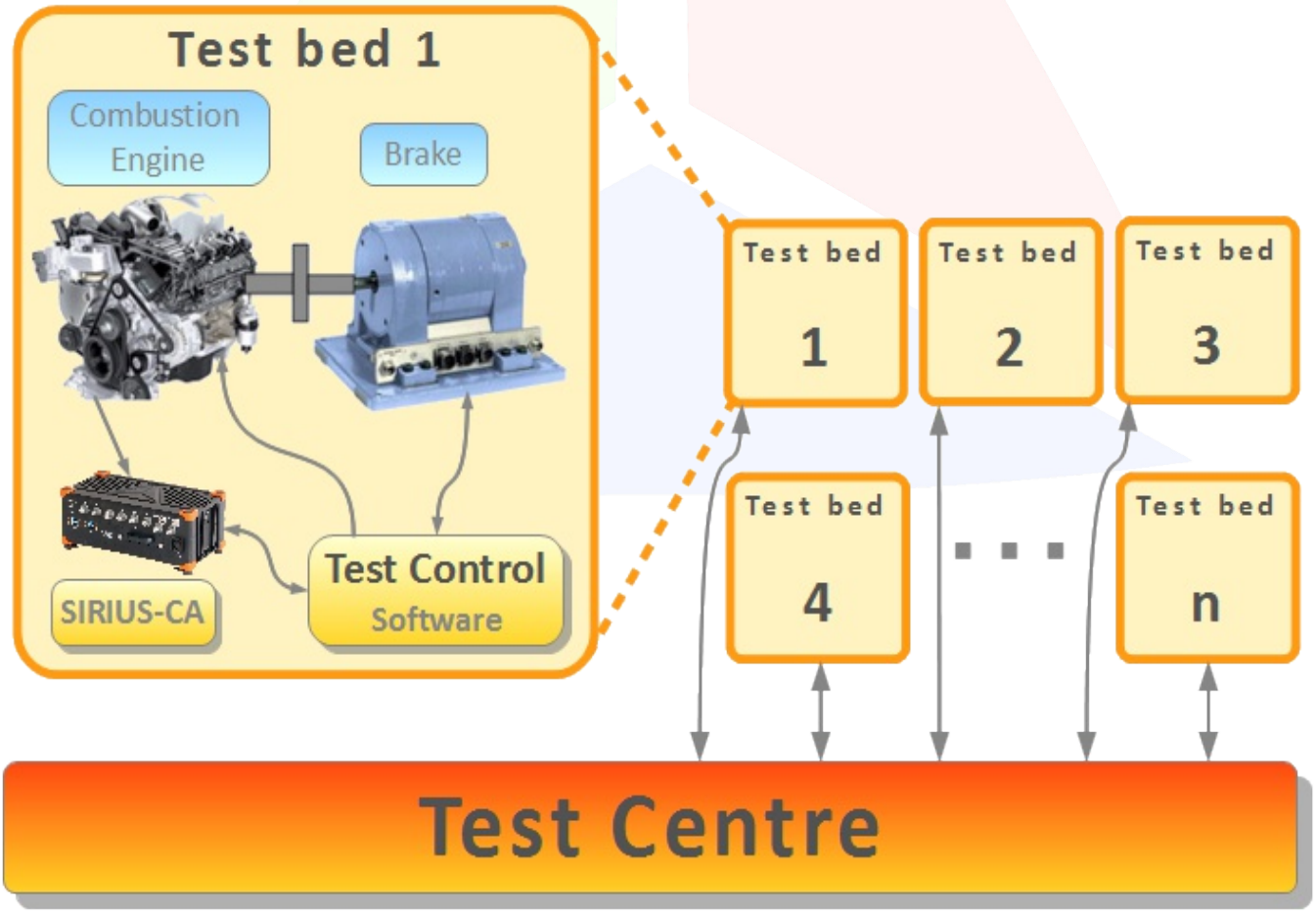
Applications

In-Car use



Testbed application

- Optimization
- Durability tests



CA Software

Combustion analysis is a standard application for all research, development and calibration tasks of a combustion engine and development of exhaust gas after treatment. From the beginning of a prototype - e.g. for friction testing or in research for basic particle or emission analysis, combustion analysis is required.

On the engine testbed, combustion analysis is a standard tool to calculate and visualize relevant physical parameters from the combustion engine and to monitor and protect the unit under test.

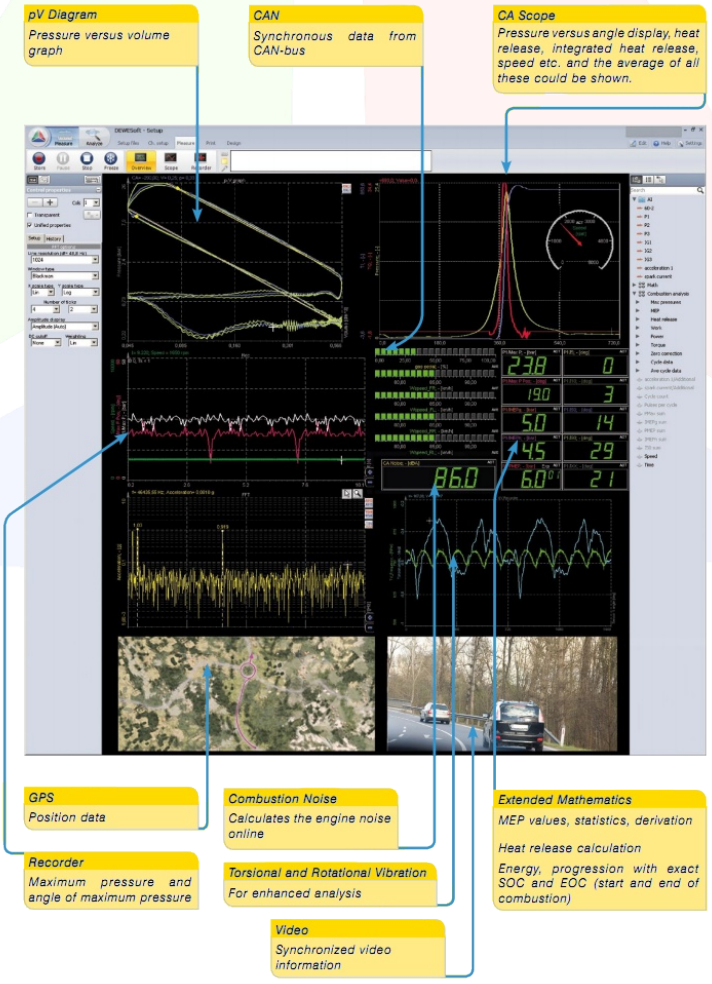
An exact identification of the top dead centre and a calibrated and compensated measurement chain is the key to accurate measurement results. Combustion analysis is often used on a chassis dyno or even for the prototype within the driveability calibration procedure to optimize engine and vehicle behaviour.

Dewesoft Combustion Analyser can be used on all types of combustion engines, such as car, truck, ship, motorcycle, power-saw, …

Engine Research and Development tasks:

- Misfire and knock detection
- Friction analysis
- Injection and ignition analysis
- Valve control system timing
- Combustion noise and vibrations
- Mechanical stress diagnosis
- Energy balance
- Gas exchange analysis
- Residual gas verification
- Exhaust gas after treatment
- Engine mapping

Based on the measured pressure signal, DEWESoft™-CA calculates all important parameters online and can be used for visualization, monitoring and alarm procedures on the testbed. Additional results can be calculated with post-processing and can be used to generate professional reports.



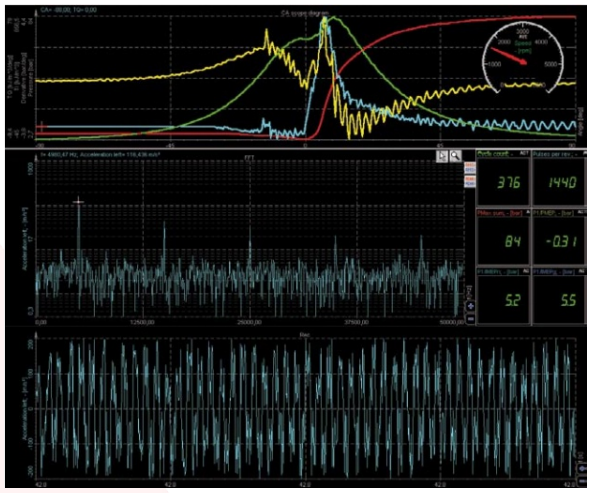
Time & Angle-based Measurement

A standard Combustion Analyser uses external clocking for a angle based displays. The disadvantage of such a setup is that the time information is missing, so only angle based data is shown.

Internal clocking with a fixed sampling rate avoids this problem. The Dewesoft Combustion Analyser uses resampling technology to record data in time domain and transfer all the CA related values to angle domain. This technology is needed for:

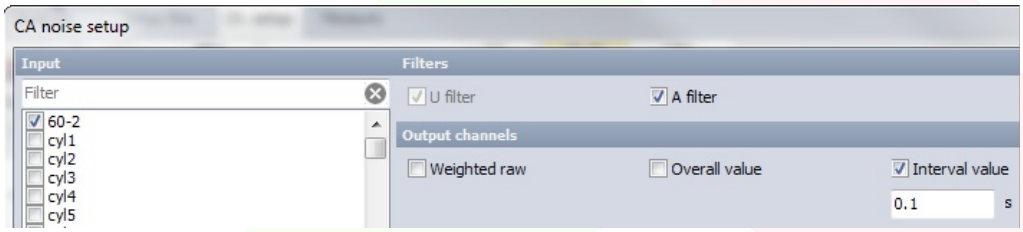
- Cold start test
- CA noise measurement
- All benefits of time domain measurement

CA measurement and time measurement (FFT [Hz]) of a vibration channel



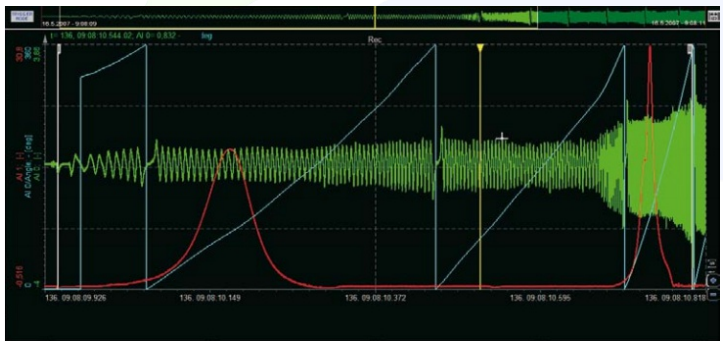
Fixed sampling rate

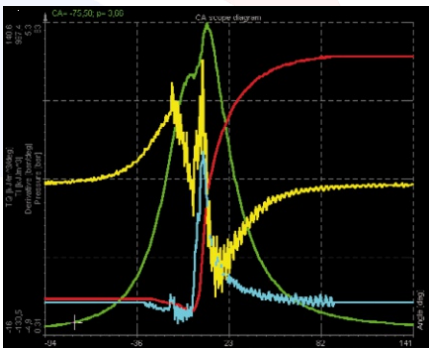
CA Noise



Cold-start testing

The accurate resampling technology with time based measurement and fixed sampling rate allows us to analyse not only the first cycle, but even the first movement of the piston. The example shows the pressure signal based on the resampled analogue (60-2) angle information. This technology can be used for any angle sensor.





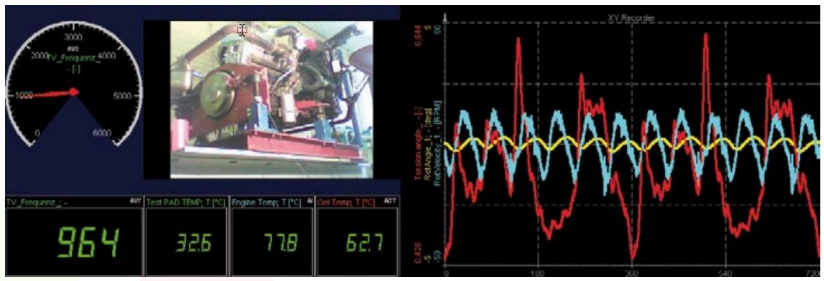
CA-OPT1: Knock Detection

For spark ignition engines, knocking is often a strong limitation for a parameter variation of an engine. Knocking causes damage to the structure of the engine.

The screenshot shows a typical knocking signal of a gasoline engine. The high frequency bouncing after the TDC in the frequency range between 10 to 15 kHz is a typical indicator of engine knocking.

CA-OPT2: Torsional & Rotational Vibration Analysis

This powerful package supports advanced mathematical features for torsional and rotational vibration, including differential revolution and slippage measurements.

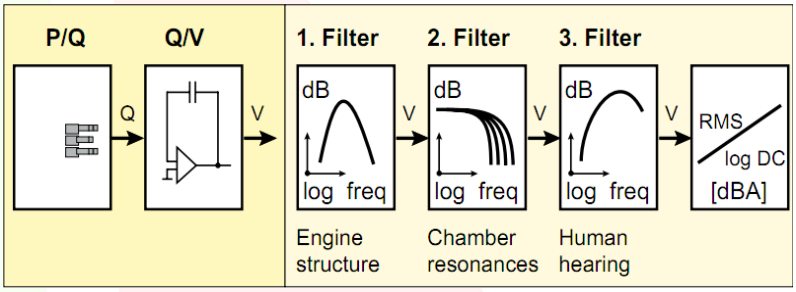


- Angle resolution up to 0.00075° at 10000 rpm
- Supports all incremental position encoders
- Definable setting of filters and calculations
- Definable display settings

CA-OPT3: Combustion Noise

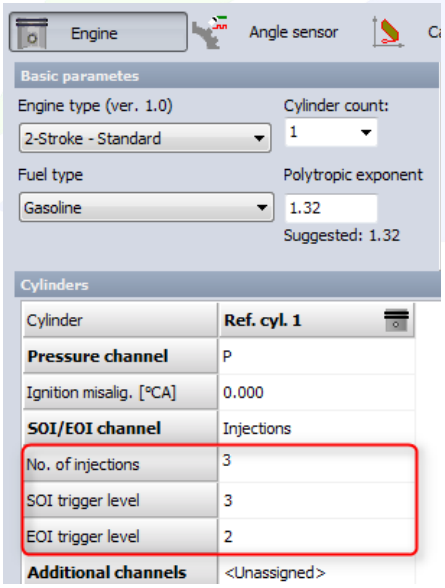
The combustion noise option allows the measurement of noise level caused by an internal combustion engine during operation.

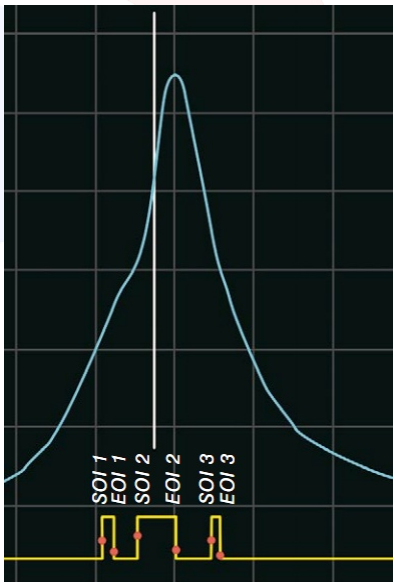
The CA-noise must be calculated in the time domain. First the value is scaled from bar to Pascal. This is followed by the U-filter, which simulates the transfer function of the engine (1. and 2. filter in the overview).



Additional Channels, Multiple Injections

- Any additional signal can be acquired and assigned to the appropriate cylinder channel
- For injector signals (or any other signals) the angle information of SOI and EOI (start of injection and end of injection) is measured. For multiple injections this information is available for all SOI and EOI.





Calculated Results

Online calculated values are required for visualization & monitoring and also for optimization or other automated procedures. For many calculated parameters, the correct determination of the top dead centre and the correct setup of the engine is essential.

Calculated combustion figures are values that require other information such as engine parameters or crank gear geometry for calculation in addition to the basic pressure curve. Mean Effective Pressure, Start of Combustion, Energy Conversion, Mass Burned Fractions or Combustion-Noise are examples of those parameters. These parameters are calculated online up to the limit of the available processing power - and in DEWESoft™ X you can also calculate the required values offline with the recalculation feature.

Based on the engine setup parameters, many online calculations are done:

Group	Name (postfix)	Description
Max pressures	MAX P	Peak pressure value
	MAP P Pos	Peak pressure position [degrees]
	Pressure	Current pressure cycle
Derivates	MAX D	Peak pressure derivate value
	MAX D POS	Peak pressure derivate position
	Derivate	Current pressure derivative
Volume	Volume	Cylinder volume curve
Zero correction	P CORR	Zero correction factor for pressures
MEP	PI	Work delivered to the piston over engine cycle
	PIH	Work performed by cylinder gasses on the piston during compression and expansion
	PIL	Work performed by the piston during exhaust and induction

Group	Name (postfix)	Description
Work, Power, Torque	Work	Work [Joule]
	Power	Power [kWh]
	Torque	Torque [Nm]
Heat release	I5	Position of the heat release at 5% [deg]
	I10	Position of the heat release at 10% [deg]
	I50	Position of the heat release at 50% [deg]
	I90	Position of the heat release at 90% [deg]
	IXX	Position of the heat release at user defined % [deg]
	SOC	Start of cumbustion [deg]
	EOC	End of cumbustion [deg]
	TQ	Heat release during combustion
	TI	Integrated heat release
Knocking	KF	Knocking factor
Injection	SOI	Start of injection
	EOI	End of injection

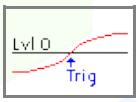
Triggers & Alarms

The versatile trigger condition setup of DEWESoft™ leaves nothing to be desired.

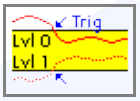
The flexible trigger conditions can be used to start/stop the acquisition or to control a digital alarm channel: i.e. You could use this to to stop the engine in case of certain alarm conditions.

When using the data-trigger conditions you can choose to trigger on

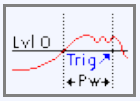
- The real data
- Average
- RMS (root mean square)
- Minimum
- Maximum



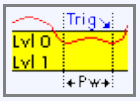
Simple edge: either rising or falling slope
Filtered edge: edge plus a rearm level, either slope



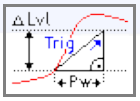
Window trigger: two levels: entering or leaving logic



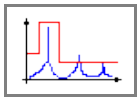
Pulse-width trigger: longer or shorter-than-duration logic



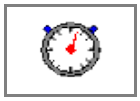
Window and pulse-width: completely selectable as above



Slope trigger: either rising or falling slope



It is possible to define a trigger within the Fourier spectrum using a FFT trigger for a certain range of frequency - so you can trigger from frequency and magnitude.



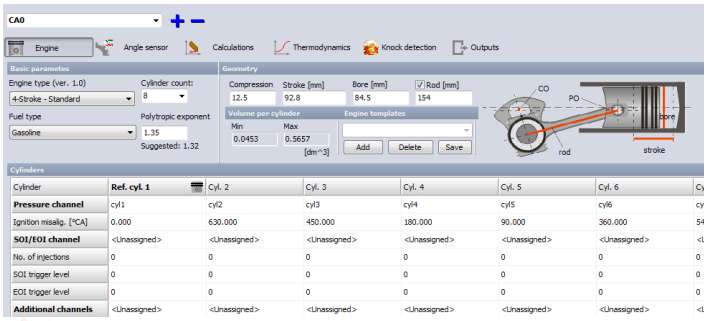
Even relative or absolute time as a trigger source can be set to trigger an action. You can always press the manual TRIG button to force an acquisition at any time.

Engine Setup

Simply define the engine type with the number of cylinders and its geometrical parameters. In the cylinder menu the analogue channel of each cylinder and the the alignment of the cylinder angles can be defined. Different setups and engine parameters can be stored for later use.

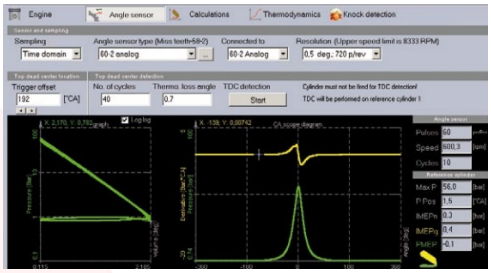
Engine relevant parameters:

- Geometry
- Engine type
- Cylinder count
- Fuel Type
- Polytropic exponent
- Additional channels



Setup of Angle Sensor

- Sampling method (time or angle based)
- Angle sensor type (encoder, CDM or 60-2)
- Angle resolution
- TDC (top dead centre) setup



Two possibilities to define the TDC:

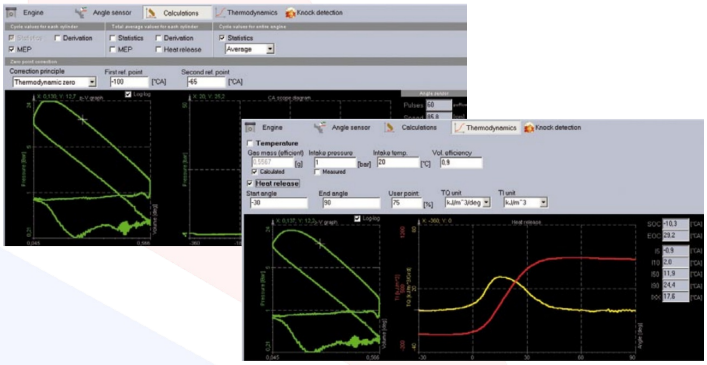
- Measure the cylinder pressure without firing the engine, and the peak pressure will be at the TDC (must be corrected with the thermodynamic loss angle)
- Use TDC detection sensor, this sensor will provide the exact TDC position

Calculations

MEP (Mean Effective Pressure) values, derivation and heat release.

Different methods for thermodynamic zero correction:

- Thermodynamic zero
- From known value
- From measured value

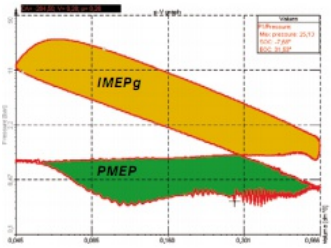


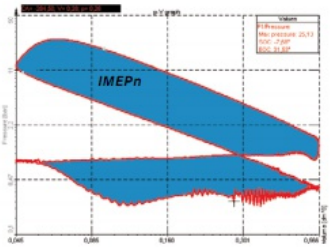
Heat Release

Analysing the measured pV diagram is a proven method to gather information for each cycle. The online heat release calculation gives you the energy for each cycle and various parameters. Another result is the exact angular progression (5, 10, 50 or 90%) of the energy. Also the SOC (start of combustion) and EOC (end of combustion) are calculated. All these values are based on the heat release algorithm. The combustion analyser shows all these values as well as relevant mean values IMEPg, PMEP and IMEPn – all these values can online be visualised in a graphical or in numerical view.

Mean Effective Pressure Values

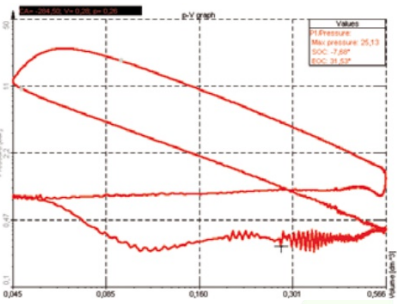
The mean effective pressure is the indicated work done by the gas on the piston using the effective volume. Since it is independent of the engine speed and cylinder size, it is a good comparison between different engines. Three mean effective pressure values (MEP values) are calculated.





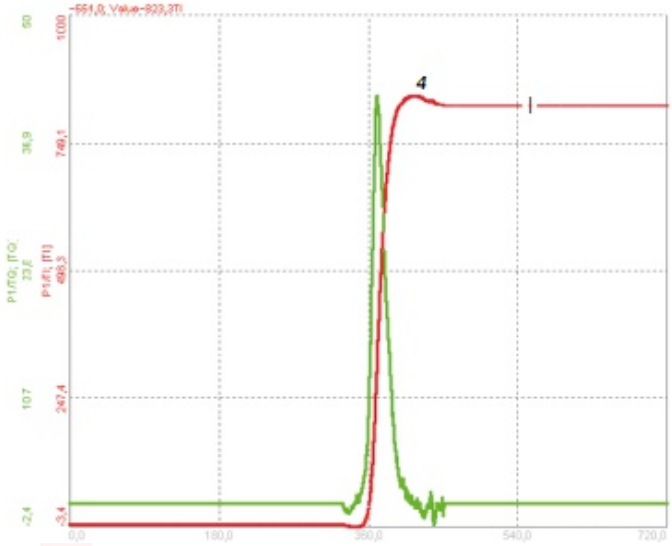
Heat Release

TQ shows the calculated heat release and corresponds to the indicated moment. TI is the integrated TQ over a cycle. The CA module calculates the interesting points at 5%, 10%, 50%, 90%, 95% of heat release analysis.



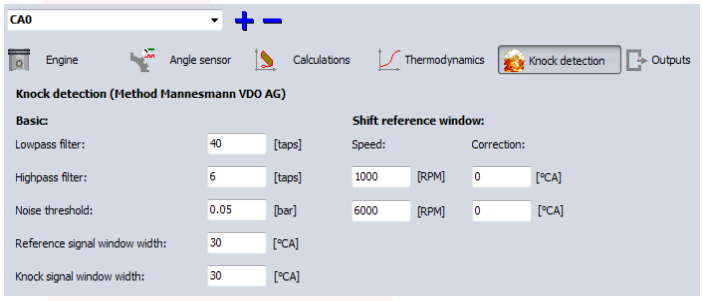
Start and end of the combustion can be shown in the pV diagram (calculated out of heat release).

The start of the combustion in diesel engines is defined as the zero crossing and in gasoline engines as the 5% crossing of the heat release. The end of the combustion is set to 95% of the heat release.



Knock Detection

Knock detection is based on the pressure signal within an area of typical 30 degrees before and after the TDC. The integrated signals of these two areas are an online comparison of these two areas. The result is shown as the knock factor (Kf).



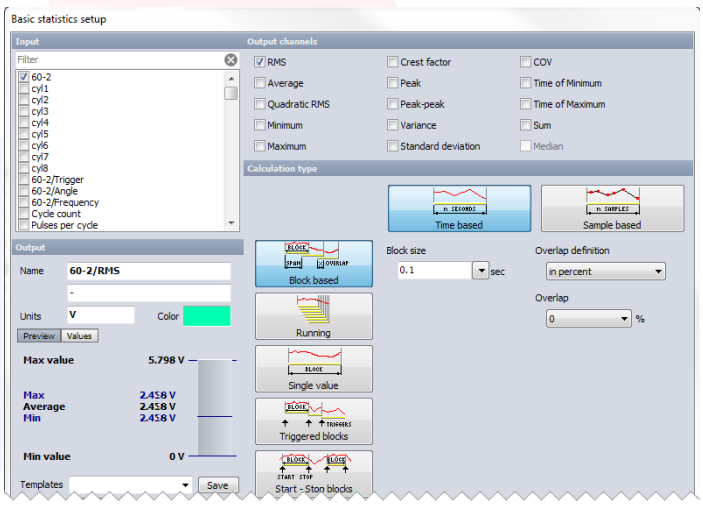
Mathematics and Statistics

The physical channels can be expanded with the online mathematics, filters and statistics (sample-based and block-based).

Math channels can be used and displayed like any other channel, e.g. for triggering.

Online calculated values may be used for optimization or other automated procedures.

With the new post-processing feature of DEWESoft™ version X, all the powerful mathematical and analysis functions can now also be used for the already stored data.



DEWESoft™ postprocessing

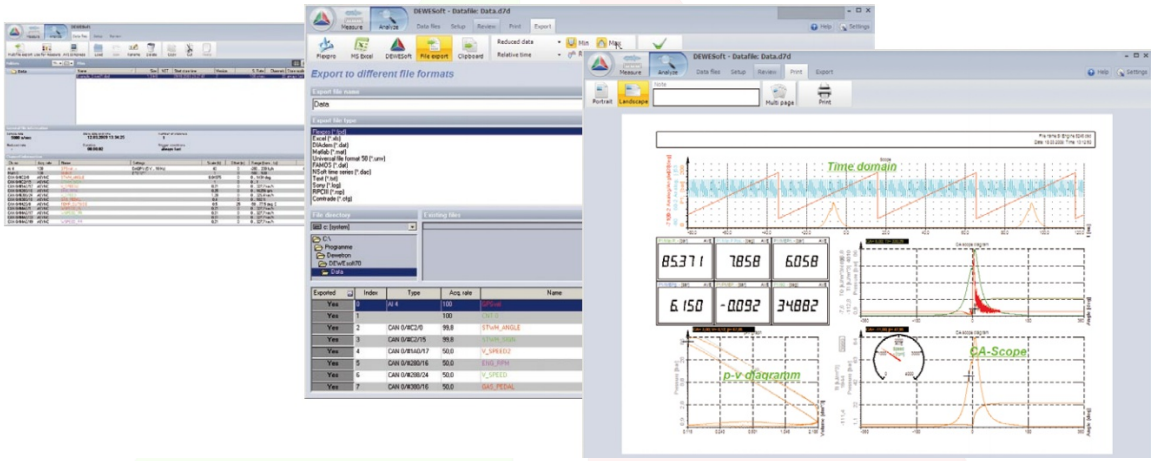
In DEWESoft™ X calculations (i.e. mathematical channels) can be added to datafiles after the measurement has been finished. It can even resample the settings of the encoder or of the engine. Those parameters are then recalculated and saved in the datafile.

This powerful feature allows to delay CPU intense calculations until after the measurement has finished. i.e. during the measurement you only store the relevant raw measurement data. And after the measurement is done, you can run all the mathematical calculations on a powerful PC in your office.

Analyse mode: Replay, Export & Share Data

You can replay any captured data file, zoom-in with the recorder graph cursors, make measurements, print in full colour to any printer. You can export the data to a wide variety of formats compatible with today's most popular analysis software package, like: FlexPro®, MATLAB®, Excel®, AVL CONCERTO™ and many more. You can even export the whole measurement view to an AVI video file to create dynamic documentation.

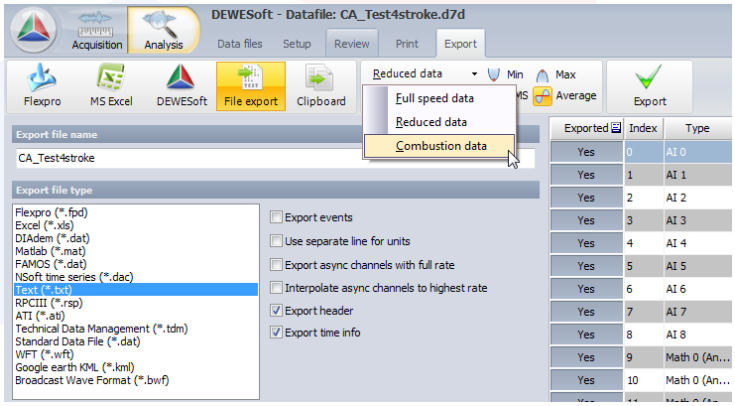
No license is needed to use DEWESoft™ in the Analyse mode. So you can install the software on all your computers, or even distribute it to your customers, and they can view the results. In this way, all of your colleagues and customers can replay your data files – just by sharing the data file!



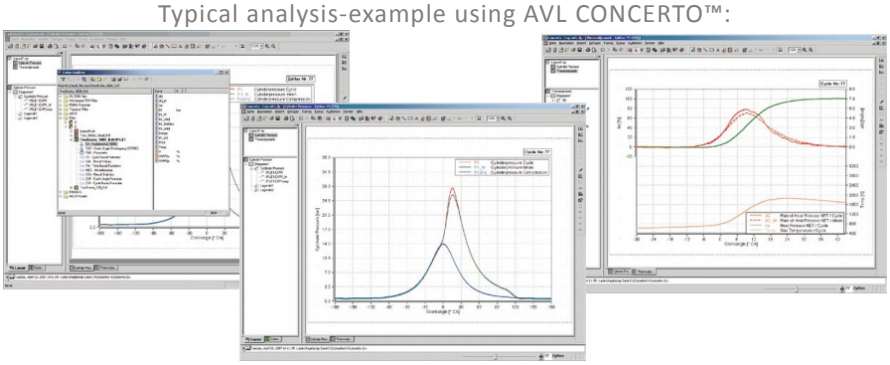
The export dialogue allows selecting different export file formats in time and angle based format. For angle based data export you select the Combustion data option. Choose the format and start the export.

Supported export formats:

- FlexPro®
- Excel®
- CONCERTO™
- DIAdem™
- MATLAB®
- UNV
- FAMOS
- nSoft
- Text
- ...



Typical analysis-example using AVL CONCERTO™:



Communication

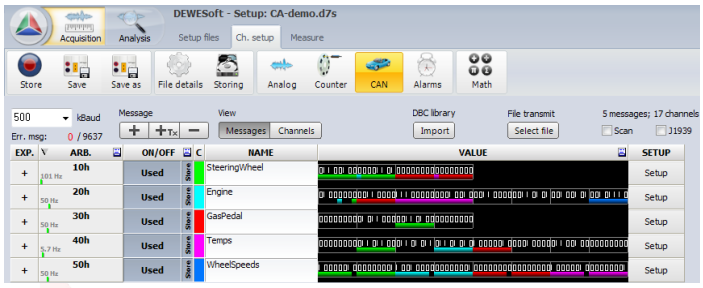
Testbed Interface

The Combustion Analyser can be integrated within a testbed system, so that the testbed receives all the calculated results during the measurement. Different communication protocols via Ethernet or RS-232 are supported: e.g. AVL PUMA Open. Analogue output channels are of course also supported.

CAN Input

The CAN option adds a high speed CAN interface. Information from the CAN bus is recorded synchronously and visualized. This feature is especially useful while performing tests inside a vehicle or when using CAN sensors.

After importing existing dbc libraries, the required CAN channels are set up as measurement channels and are treated like all other measurement channels.

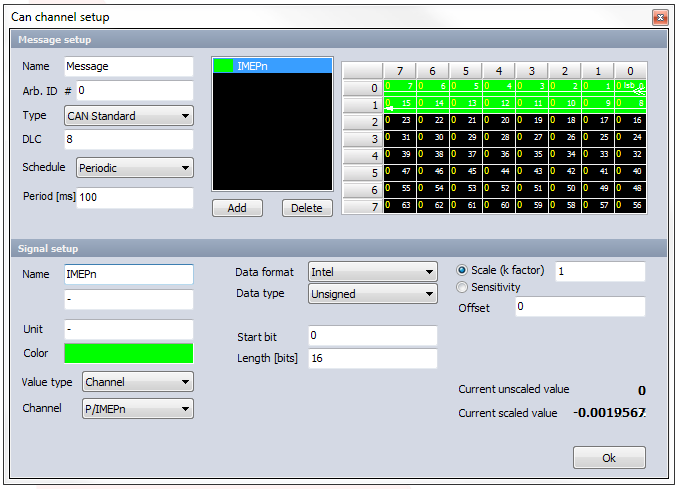


CAN Output

Combustion Analysis relevant parameters can be communicated to an ETAS INCA system via CAN.

The DEWESoft™ CAN output function can also be used to transmit the data of any measurement channel during the measurement to any other CAN device whenever you want (e.g. on start of the measurement, periodically every x ms, on a trigger condition or when the user clicks a button).

You can specify different data types and formats and even apply a scaling and offset to the data that you want to transmit.



DEWESoft™ NET (option)

DEWESoft™ NET allows Ethernet based communication between different systems running the DEWESoft™ software and can thus be used as a full remote control of the system:

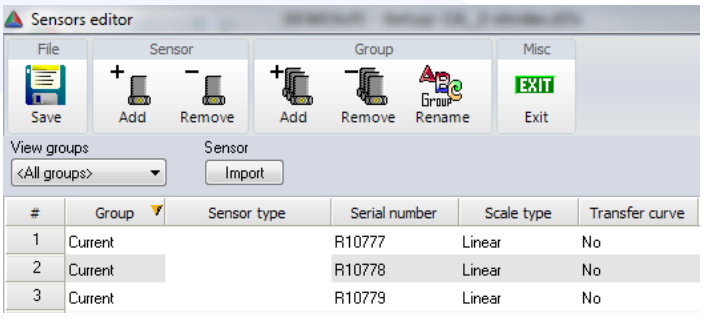
For example: If the DEWESoft™ Combustion Analyser is located in the testbed chamber and connected to your LAN, you can remote-control it from any other PC (typically outside of the testbed chamber) which runs DEWESoft™ and is connected to the same LAN.

You can start/stop the measurement, change the setup and even look at all the data during the measurement.

Sensor Database and TEDS

All sensor data is stored and maintained in the sensor database. This database keeps a comprehensive list of sensors and all their parameters, including scaling, units and calibration date info.

One click and the entire channel is set up and scaled correctly. If necessary, it's possible to zero the sensor or even to renew the calibration parameters. This guarantees the reproducibility, traceability and quality of the measurement results.



To make the sensor setup even more automated, our signal conditioning modules support TEDS, which is a standardized „smart sensor interface". TEDS is an acronym for Transducer Electronic DataSheet . It is a table of parameters (manufacturer ID, model number, serial number, version, and many more) that identifies the transducer.

CA-System

The Dewesoft Combustion Analyser system combines the software processing capabilities of DEWESoft™ with the best hardware available on the market: SIRIUS*i*. The isolated measurement system has a sample rate of 1MS/s per channel with a vertical resolution of 16bit, CAN Input/Output and synchronous real-time super counters.

Hardware

SIRIUS S-BOX

- BASE STATION (embedded PC) with 6xUSB, HDMI, VGA, GLAN, WLAN, 1Hz GPS
- PC: i7 2.0 GHz, Intel QM57, 4 GB RAM
- Storage : 128 GB removable SSD
- Including DEWESoft™ X Professional Edition and
- Windows® 7 Ultimate version (multilang. support)
- 9-36V_{DC} supply

SIRIUS*i*-HS 6xCHG,2xCHG+

- 8 analogue inputs: Charge, IEPE or Voltage
- Voltage range: ±10 V to ±200 mV
- Charge range: 100 000 pC to 1000 pC
- IEPE sensor supply: 4 or 8 or 12 mA
- Input coupling: DC, AC (0.1, 1, 10 or 100 Hz)
- A/D converter: 1 MS; 16bit
- TEDS support: for IEPE sensors, BNC connector
- 2 synchronized real time counters (LEMO 7)
- 1x CAN bus 2.0b isolated
- All I/O fully galvanically isolated 1kV
- USB2 interface, 6-36V_{DC} supply, 2x sync. connector

DS-BP2

Battery Pack
OPTION

- Input Voltage: 9-36V_{DC}
- Output Voltage: 11-16.8 V_{DC}
- Hot-swappable batteries
- Status display
- Capacity: 180 Wh for a supply duration of:
  - over 12 hours for a single SIRIUS*i*-CA slice
  - over 2 hours for a SIRIUS*i*-CA slice& S-BOX

Software

CA-BASE

- Online mathematics, statistics, standard derivation
- Fast online displays: pressure/ pv-diagram, …
- Time domain sampling, especially for cold start tests
- Includes on-line fast combustion "scope", configurable as pressure-volume diagram (pressure vs. crank angle)
- Includes basic statistics, off-line display, data storing, data export to ASCII (also Excel®) and export to FlexPro® and Concerto (AVL)

CA-OPT 1

Extended mathematics, including online calculation of

- Heat release
- Standard deviation
- IMEP, PMEP, NMEP
- Thermodynamics
- Knock detection

CA-OPT 2

Torsional vibration and rotational vibration analysis software (software only !)

- Torsional vibration and static torsion measurement
- Differential revolution and slippage measurement
- Angle resolution up to 0.00075° at 10000 rpm
- Supports all incremental position encoders
- Rotational vibration analysis: requires only 1 encoder
- Torsional vibration analysis: requires two encoders!

CA-OPT 3

Combustion noise analysis (software only !)
Online dB noise calculation based on the CA noise special filtering

Contact Information

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