Combustion Analysis

DEWETRON Combustion Analyzer systems 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 supports angle and time based measurement and uses highly improved algorithms for online mathematics and statistics – calculating heat release and further thermodynamic parameters. Offline calculation and the export to several file formats are included.CAN, video, Ethernet and the integration within a testbed is also supported.

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

- *Synchronized multi-channel data acquisition*
- *In-vehicle and testbed application*
- *Crank angle and time domain data acquisition*
- *Direct pressure and angle sensor connection*
- *CAN-out, analog out, testbed interface*
- *Combustion noise calculation*
- *Programmable angle sensor support*
- *Extended combustion and thermodynamic analysis*
- *Cold start testing*
- *Export to different file formats (txt, ifl, ...)*

Testbed interface
Analog/RS-232/
Ethernet

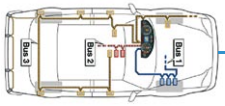
DEWE-VGPS
Position interface

DEWE-CAM
Video

Additional Sensors
Intake pressure
Exhaust pressure
Water temperature
Air volume
Fuelmass
Electrical power
Acceleration

CAN-OUT (ETAS INCA)

DEWE-ORION card



CAN

Counter input

Digital input

Digital output

Industrial PC
PC

DEWESoft

DEWESoft CA
Combustion Analyzer

CA-OPT1
Extended Mathematics

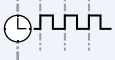
CA-OPT2
Torsional and Rotational Vibration

CA-OPT3
Combustion Noise

DAQP Module
Signal conditioning
Sensor supply

Analog input

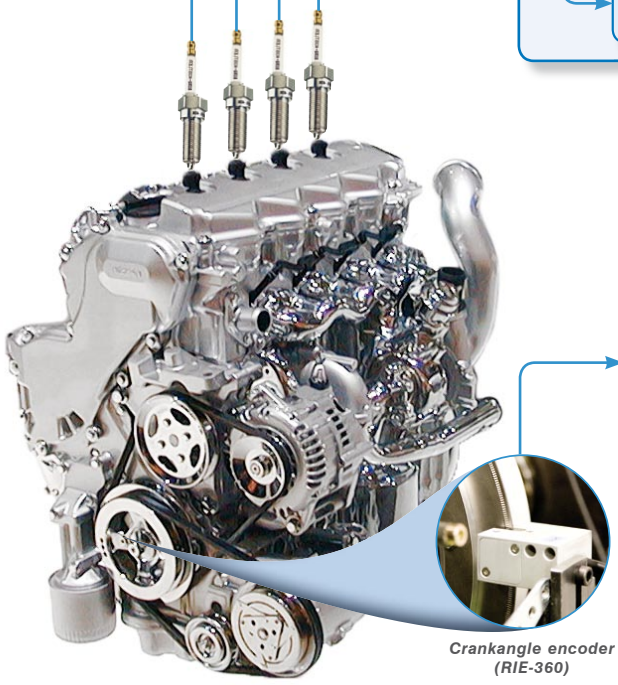
Trigger input



Crankangle CPU

ext. clock

int. clock



Crankangle encoder
(RIE-360)

pV Diagram

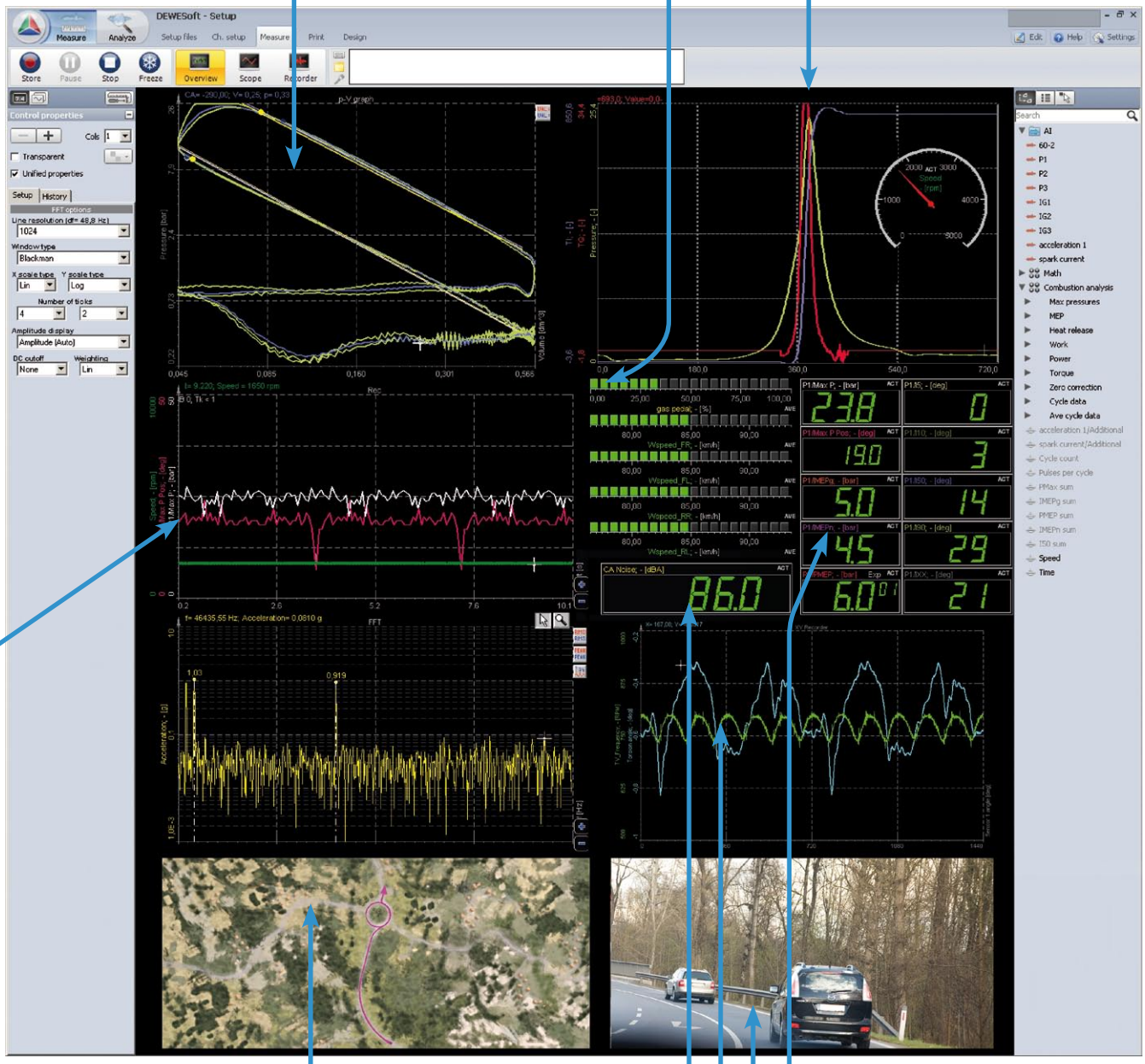
Pressure versus volume graph

CAN

Synchronous data from CAN-bus

CA Scope

Pressure versus angle display, heat release, integrated heat release, speed etc. and the average of all these could be shown.



GPS

Position data

Recorder

Maximum pressure and angle of maximum pressure

Combustion Noise

Calculates the engine noise online

Torsional and Rotational Vibration

For enhanced analysis

Video

Synchronized video information

Extended Mathematics

MEP values, statistics, derivation

Heat release calculation

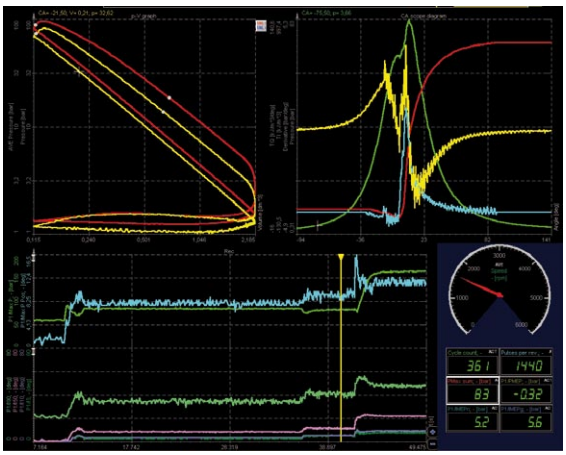
Energy, progression with exact SOC and EOC (start and end of combustion)

Combustion Analyzer Application

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 behavior.

DEWETRON Combustion Analyzer can be used on all types of combustion engines, such as car, truck, ship, motorcycle, power-saw, etc.



Engine Research and Development covers the following tasks:

- *Misfire and knock detection*
- *Friction analysis*
- *Injection and ignition analysis*
- *Valve control system and 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 used to generate professional reports.

Workflow Support

Upload the XML setup and choose the sensors from the sensor database. The setup can be done offline. For measurement you connect your sensors and fine-tune the setup. Some sensors need a zero adjustment before measurement. With a few simple clicks you adjust the prepared visualization screens to your needs – and the test starts.

- *Offline Setup*
- *Sequence Control*
- *Sensor Database*
- *TEDS*
- *Engine Data Setup*
- *Global Header*
- *Data Import and Export*

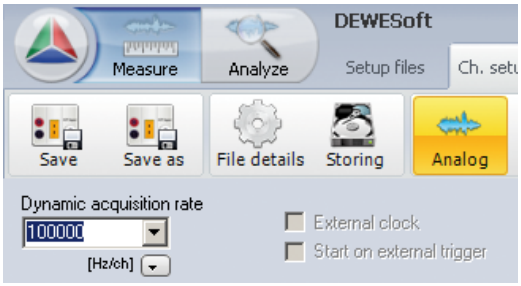
Time and Angle based Measurement

A standard Combustion Analyzer uses external clocking for an 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 DEWETRON Combustion Analyzer uses resampling technology to record in time domain and transfer all the CA related values to angle domain. This technology is needed for:

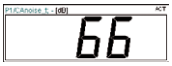
- *Cold start test*
- *CA noise measurement*
- *All benefits of time domain measurement*

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



Fixed sampling rate

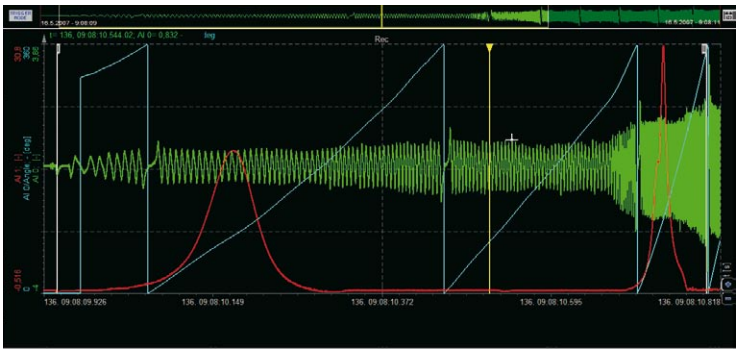
CA Noise

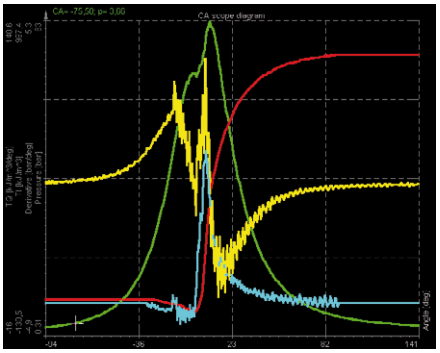


dB(A)

Cold-start testing

The accurate resampling technology with time based measurement and fixed sampling rate allows us to analyze 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.

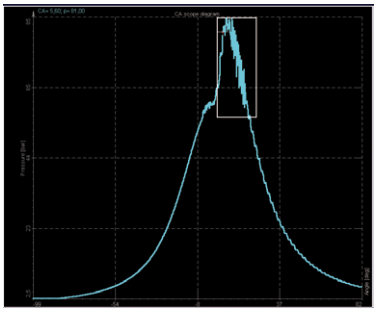




Knock Detection (CA-OPT1)

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.

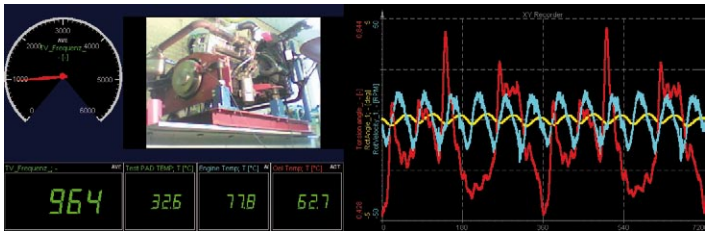
The screenshot shows typical knocking signal of a gasoline engine. The high frequency bouncing after the TDC in the frequency range between 10 to 15 kHz is a typical indicator of engine knock.



Torsional and Rotational Vibration Analysis (CA-OPT2)

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

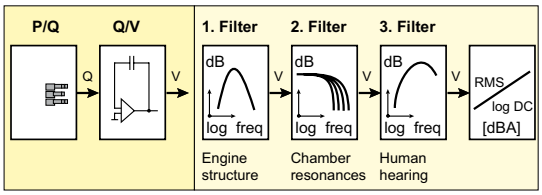
- *Angle resolution up to 0.00075° at 10000 rpm*
- *Supports all incremental position encoders*
- *Definable setting of filters and calculations*
- *Definable display settings*



Combustion Noise (CA-OPT3)

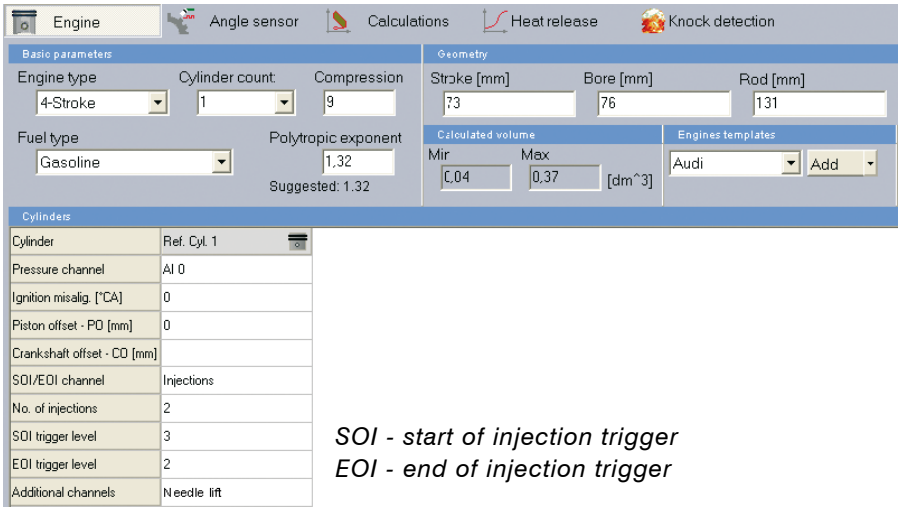
The combustion noise option allows the measurement of noise level caused by an internal combustion engine during operation.

The CA-noise must be calculated in 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).

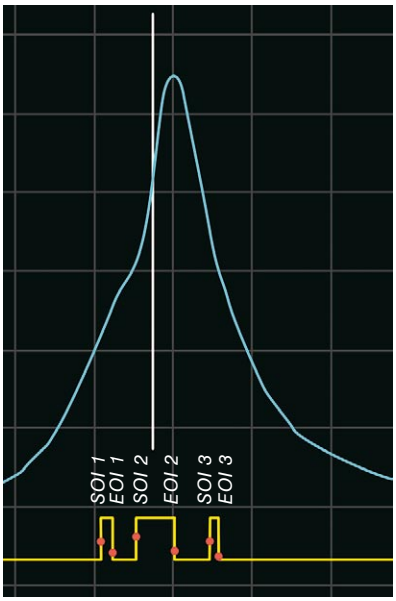


Additional Channels, Multiple Injections

- *Any additional signal can be acquired and referenced 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.*



SOI - start of injection trigger
EOI - end of injection trigger



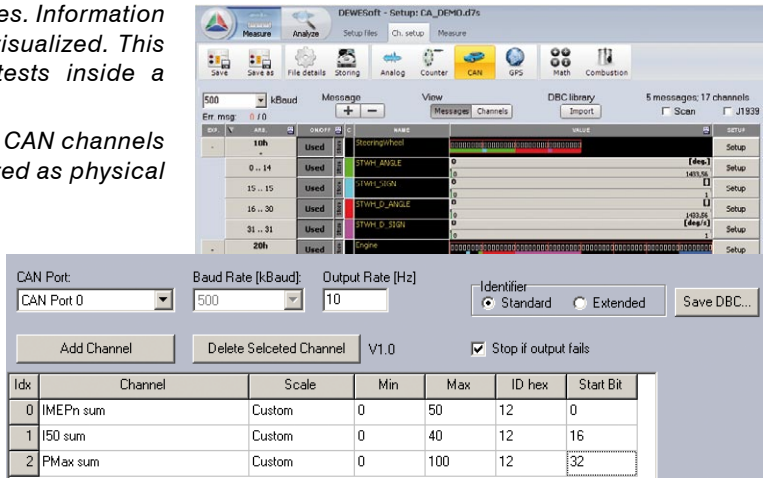
Testbed Interface

A Combustion Analyzer can be integrated within a testbed system, which receives all the calculated results. Different protocols via Ethernet or RS-232 are supported – e.g. AVL PUMA Open. Also analog output channels are supported.

CAN Input (option)

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

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



CAN Output (option)

CA relevant parameters are communicated to an ETAS INCA system via CAN.

DEWESoft Net (option)

DEWESoft Net allows the communication between different DEWETRON systems and a standard PC. The system can be configured as stand alone, as master or as a slave unit. It's also possible to use any PC for remote control. For the CA application it is very useful to have the measurement device in the testbed chamber and remote it by DEWESoft-NET.

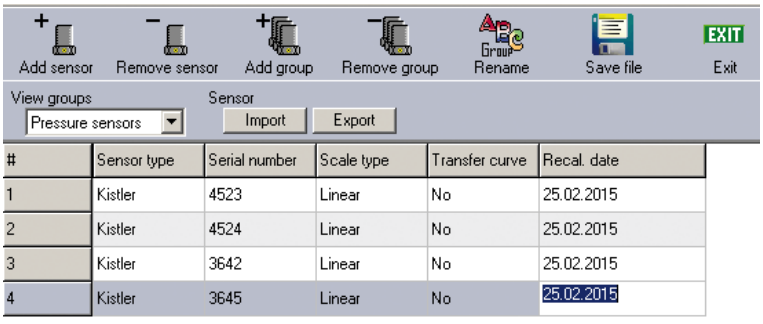
Sequence Control

The sequencer is a tool to predefine process steps in a sequential format. The interface can be graphically programmed or in a code oriented view. The sequence is stored with the system setup so a measurement can be repeated at any time under the same conditions (traceability). So it's possible to manage these sequences centrally to guarantee a standardised and defined measurement procedure.

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. 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.



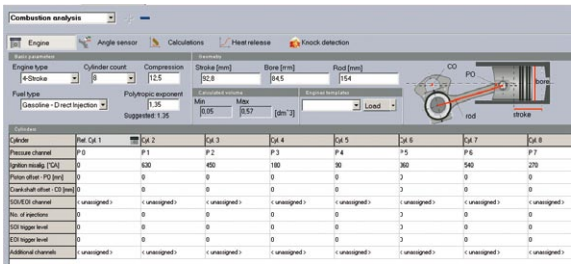
To make the sensor setup even more automated, our signal conditioning modules support TEDS, which is a standardized „smart sensor interface". TEDS is an acronym for Transducer Electronic Datasheet. It is a table of parameters (manufacturer ID, model number, serial number, version, and many more) that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

Engine Setup

Set up the engine type with the number of cylinders and its geometrical parameters. In the Cylinder menu the analog channel and the cylinder specific parameters are defined. Analog channels of each cylinder as well as the alignment of the cylinder angles. 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*

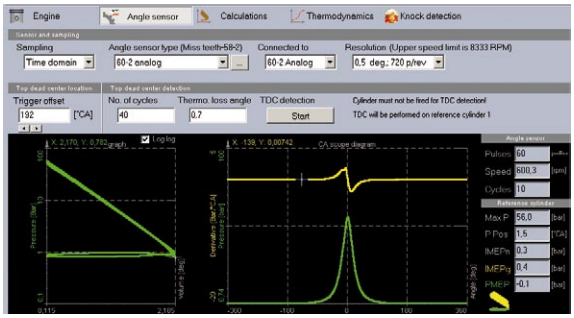


Setup of Angle Sensor

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

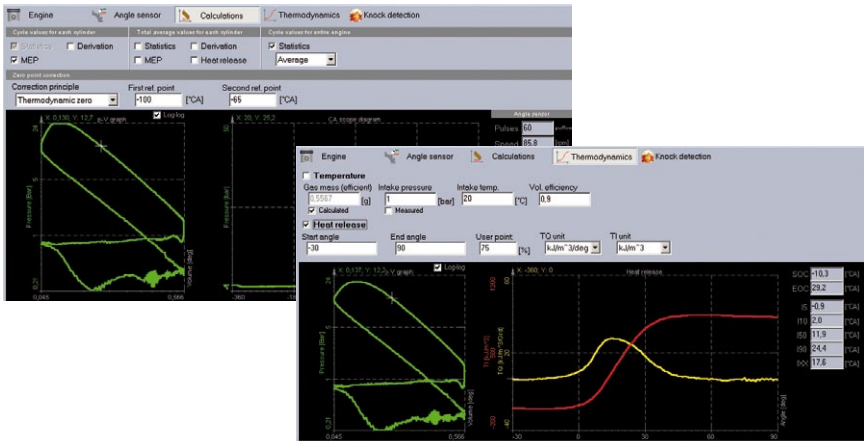


Calculations

MEP values, derivation and heat release

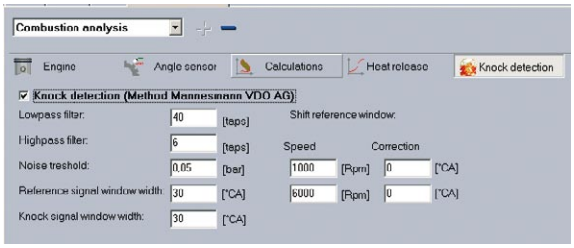
Different methods for thermodynamic zero correction:

- *Thermodynamic zero*
- *From known value*
- *From measured value*



Knock Detection

Knock detection is based on the pressure signal within an area of typical 30 degrees before and after 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).



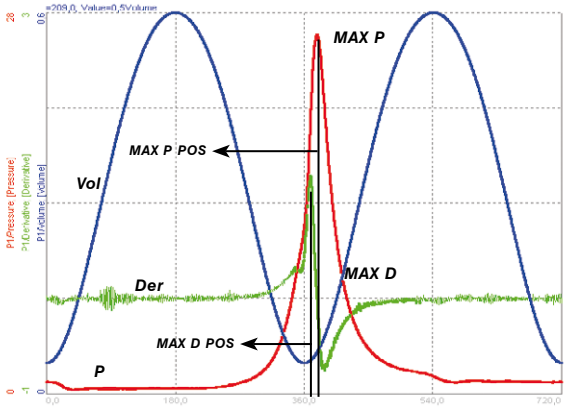
Online Mathematics and Statistics

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.

Calculated Results

Online calculated values are required for visualization and monitoring 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.

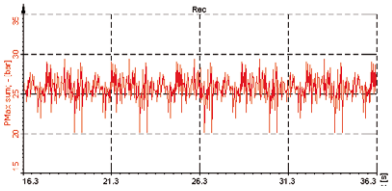
Calculated combustion figures are values that require other information such as engine parameters or crank gear geometry for calculation in addition to the basic pressure curve. Mean Effective Pressure, Start of Combustion, Energy Conversion, Mass Burned Fractions or Combustion Noise are examples of those parameters. These parameters are calculated online up to the limit of processing power - and in DEWESoft-7 you can calculate the values required offline with the recalculation feature.



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

- *Basic statistic channels (max pressure, max pressure position...)*
- *Derivation of pressure and position of maximum derivative*
- *Mean effective pressures*
- *Overall cycle calculations are:*

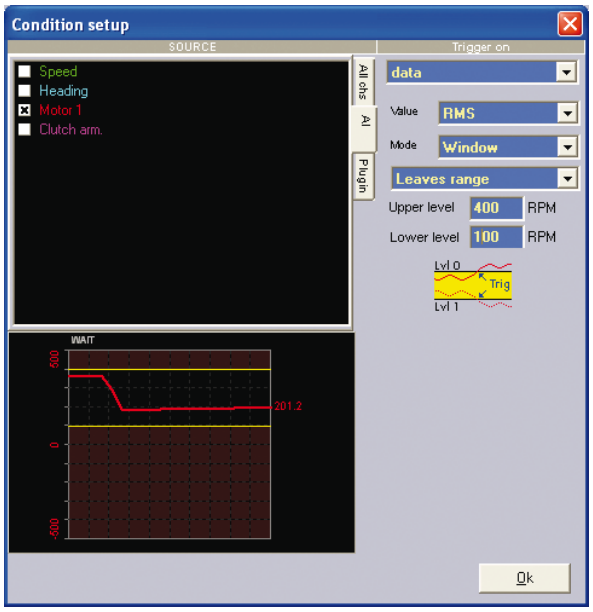
  Cycle count, missed triggers, frequency...



Triggers and Alarms

DEWESoft includes a versatile TRIGGER section for measurement control, which includes the following types of trigger conditions:

- *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.

All of these sources are available also to STOP the acquisition or set a digital alarm channel.

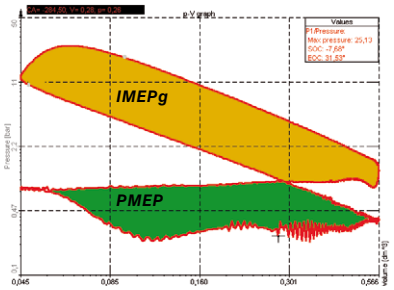
The signal can also be used to control a digital output e.g. to stop the engine.

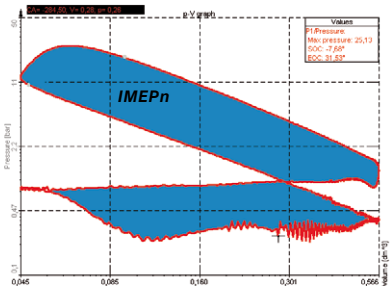
Heat Release

Analyzing 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. Result is furthermore the exact angular progression (5, 10, 50 or 90 %) of the energy. Also the SOC (start of combustion) and EOC (end of combustion) is calculated. All these values are based on the heat release algorithm. The Combustion Analyzer shows all these values as well as relevant mean values IMEPg, PMEP and IMEPn – all these values can be online accessed in a graphical or in a numerical view.

Mean Effective Pressure Values

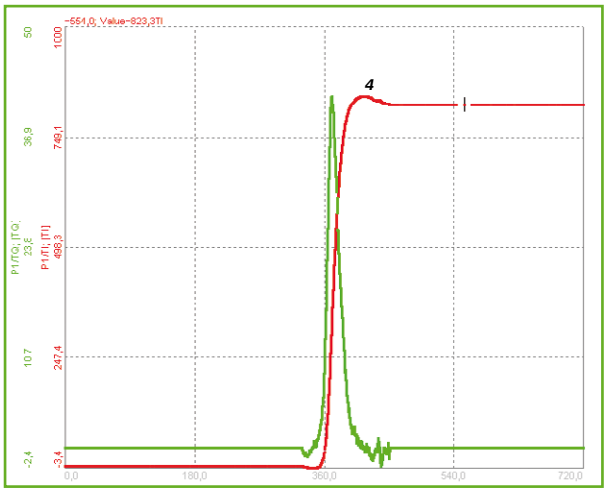
The mean effective pressure is the indicated work done by the gas on the piston using the effective volume. Because it is independent of the engine speed and cylinder size means that it is a good comparison between different engines. Three mean effective pressure values (MEP values) are calculated.



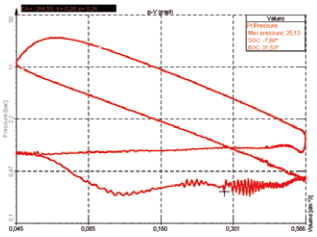


Heat Release

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% - these are usually the interesting points in heat release analysis.



Start and end of combustion can be shown in the pV diagram (calculated out of heat release). Start of combustion in diesel engines is defined as zero crossing of heat release and in gasoline engines it is the 5% of heat release. End of combustion is set to 95 % of the heat release.



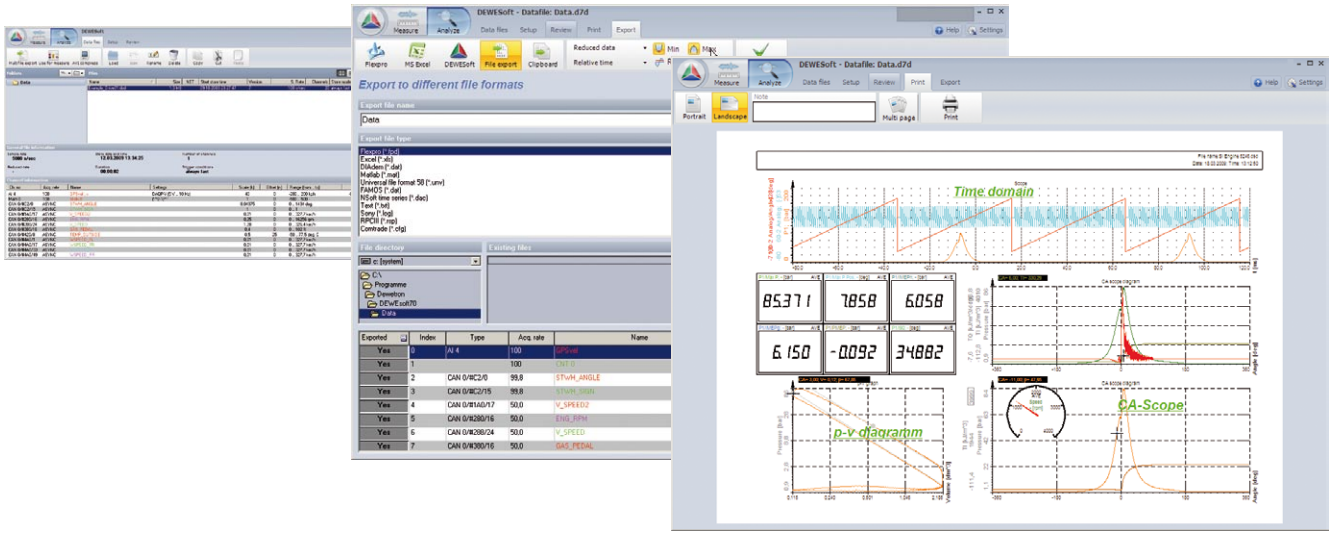
DEWESoft Postprocessing

DEWESoft 7 allows you to recalculate additional mathematical channels. Add new channels and resample the settings of the encoder or of the engine. All parameters are recalculated and saved in the datafile. Using this feature it's possible to avoid CPU consuming calculation during the measurement – the channels can be produced in the office after the measurement procedure.

Analyze Mode - Replay, Export, Share Data

You can replay any captured data file, zoom in with the recorder graph cursors, make measurements, print in full color to any printer.Export the data to a wide variety of formats compatible with today's 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.

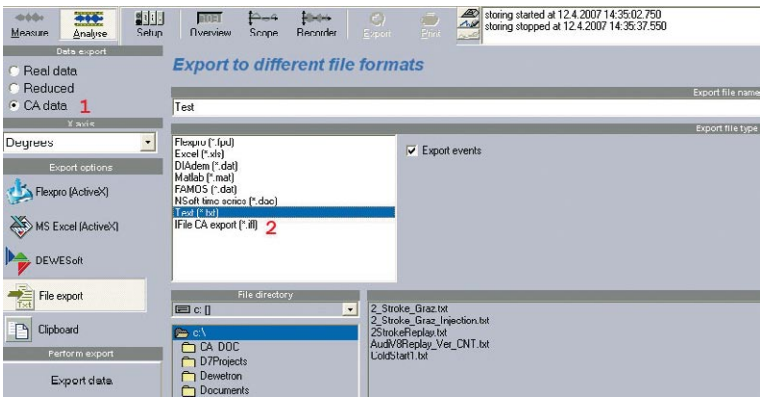
No license is needed to use DEWESoft in the ANALYZE mode. So you can install the software on all your computers, or even distribute it to your customers, and they can view to the results. In this way, all of your colleagues and customers can replay your data files – just by sharing the data file!



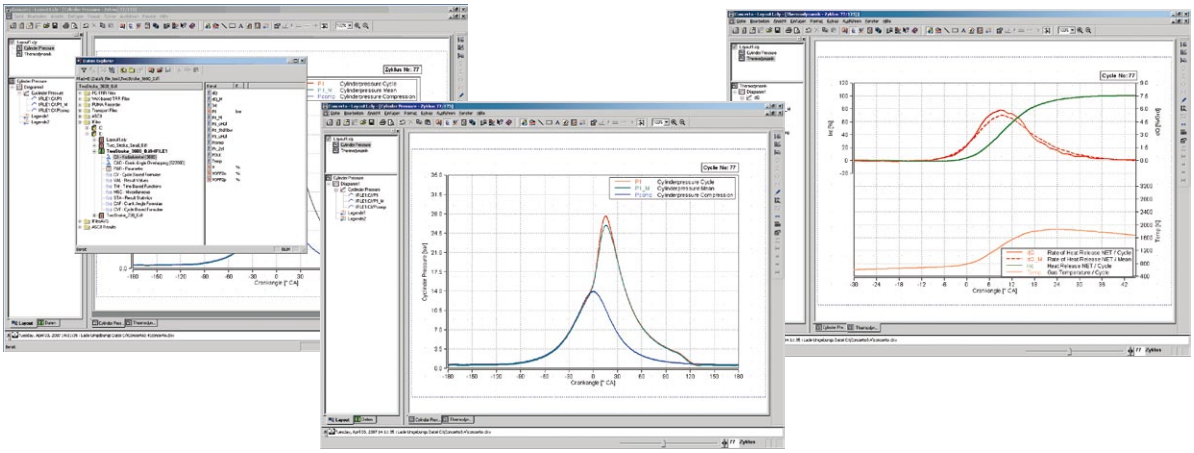
The export dialog allows selecting different export file formats in time and angle based format. For angle based data export you select the CA data option. Choose the format and start the export.

DEWESoft supports a wide range of export file formats:

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



Typical analysis-example using AVL CONCERTO™:



DEWETRON CA Hardware Configuration




	DEWE-211-CA	DEWE-800-CA	DEWE-2600-CA	DEWE-5000-CA
Application	Smallest CA system, typically motorcycle	Testbed, rack mounted	In-car-use, fully battery powered	Portable or testbed
Analog input channels	2 x charge 6 x voltage	16 DAQ series modules[1)] e.g. charge, voltage	16 DAQ series modules[1)] e.g. charge, voltage	16 DAQ series modules[1)] e.g. charge, voltage
Digital channels	8 x DIO + 2 CTR or 8 DI	8 x DIO + 2 CTR or 8 DI	8 x DIO + 2 CTR or 8 DI	8 x DIO + 2 CTR or 8 DI
Channel expansion	No	Yes	Yes	Yes
CAN interfaces	2	Up to 4 (opt.)	Up to 4 (opt.)	Up to 4 (opt.)
Video	DEWE-CAM or USB DirectX	DEWE-CAM or USB DirectX	DEWE-CAM or USB DirectX	DEWE-CAM or USB DirectX
Display	External MOB-DISP-x	External	15" 1024 x 768	17" 1280 x 1024
Power supply	8 – 30 V_{DC}, external AC adapter	115 / 240 V_{AC}	Battery powered, 18 – 24 V_{DC}, ext. AC power supply	115 / 240 V_{AC}
Dimensions (W x D x H)	317 x 252 x 92 mm 12.48 x 9.92 x 3.62 in.	437 x 443 x 181 mm 17.2 x 17.44 x 7.13 in.	417 x 246 x 303 mm 16.42 x 9.69 x 11.93 in.	460 x 351 x 192 mm 18.11 x 13.82 x 7.76 in.
Weight	Typ. 5 kg (11 lb.)	Typ. 12 kg (26.4 lb.)	Typ. 14 kg (31 lb.)	Typ. 17 kg (37.4 lb.)

[1)] DAQ series modules are isolated signal amplifiers and are available for almost all kinds of sensors

Re-inventing Data Acquisition

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