



KiBOX
TO GO

The Mobile Combustion Analyzer from Kistler

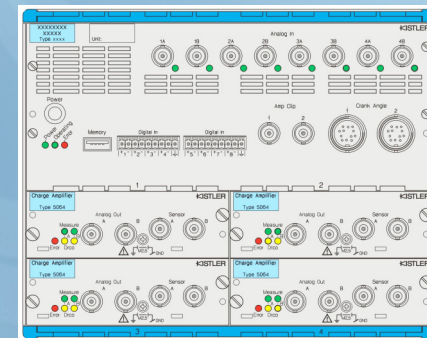
On-Board Combustion Analysis System



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Objective:

- Combustion Analysis System specifically for on-board operation in vehicles
- Real time calculation of combustion analysis data
- Data analysis in FPGA and 'embedded PC'
- Interface for ECU application tool (ETAS-INCA)



USP's:

- Dedicated design for on-board operation
- Quick set-up and simple operation
- New time-/crankangle-based data acquisition for transient engine operation

On-Board Combustion Analysis System-Concept

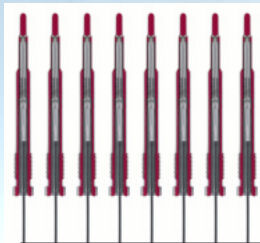


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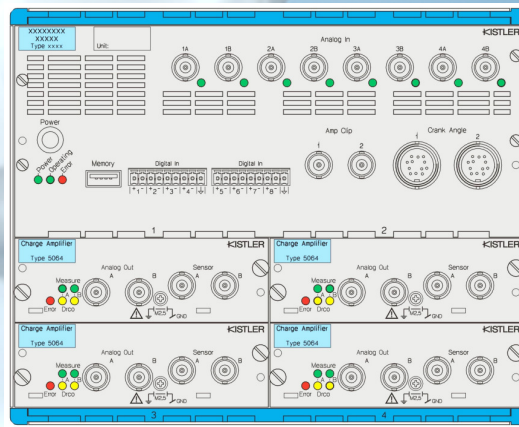
Digitizer Type 285x, 2/4/6/8-Kanal
OCA Software



High temperature cylinder pressure sensors with spark/glow plug adapter



TEDS



Ethernet 100baseT

Supply voltage

Notebook
OCA Software
INCA

From in-vehicle fuel injectors and/or ignition wires



Supply voltage

From separate board battery pack

From in-vehicle crank angle encoder



TEDS

On-Board Combustion Analysis System



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Digitizer
(signal conditioning, data acquisition,
data evaluation)

Aux Power-Box
(USV, Ethernet-Switch)

On-Board Combustion Analysis KiBox to Go – Housing



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Recess

To latch the rubber-feed while stacking

Cable-clip

Fixation and arrange of cables

Bore

For fixation at a ground plate

Crossbar

Fixation of cable

Fitting for safe-belt



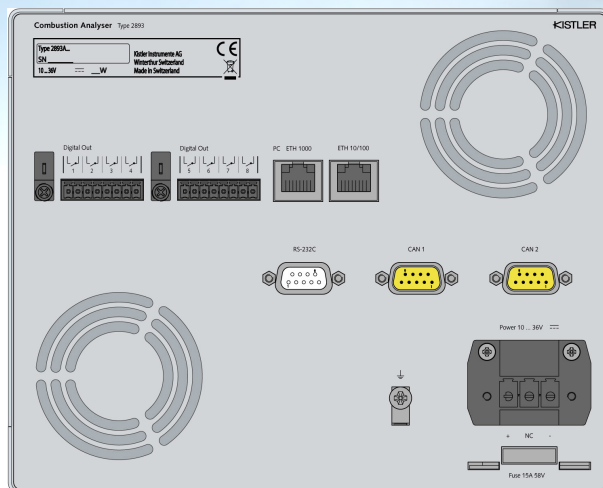
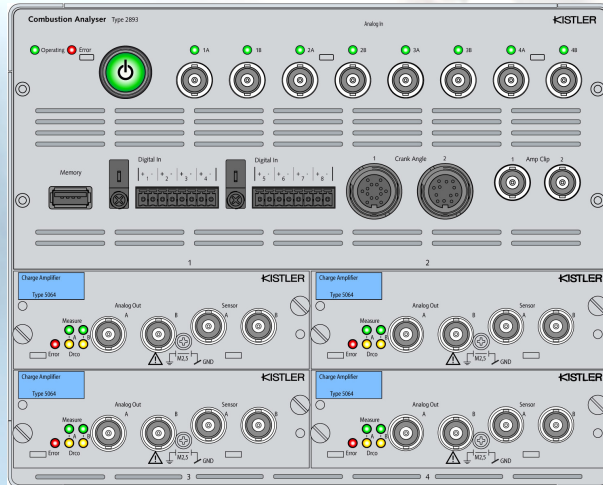
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Interfaces

Analyzer, Type 2893



- SCP slots: **4** (2-Channel Amplifiers)
- SCP measuring channels: **8** (TEDS)
- Voltage channels: **8** (BNC)
- Crank angle inputs: **2**
 - Active Probe (e.g. 60-2, TEDS)
 - Standard (CDM/TRG)
- Current clamp inputs: **2** (BNC)
- Data communication:
 - 1000 baseT Ethernet
 - 100 baseT Ethernet
 - CAN 1 (Analog Output)
 - CAN 2 (Spare)
 - USB (Memory Stick)
- Digital In: **8** (D-Sub)
- Digital Out: **8** (D-Sub)

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Features

- SCP slots: 4
 - Amplifier types: 5064B1, 4665B1, 5271B1, 5273B1
 - Amplifier bandwidth: 100 kHz
- Measuring channels: 8
 - Sampling rate: 1.25 MS/s
 - ADC Resolution: 16-bit
 - Voltage input range: ± 10 V
- Data acquisition:
 - Angle domain: 0.1/1.0°KW @ 0..15'625 rpm
 - Time domain: 312.5 kHz
- Digital I/O
 - Connector type: D-Sub
 - Opto coupler in: 8
 - Photo MOS relays out: 8
- Crank angle input 1
 - Connector: Binder, 14-pole
 - Interface standard: LVDS
 - Active Probe interface for engine-integrated crank angle encoders: CDM w/ embedded TRG, TEDS
- Crank angle input 2
 - Connector: Binder, 12-pole
 - Interface standard: LVDS
 - Standard encoders: CDM/TRG, A/B quadrature signals, type 2614 encoders, etc.

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Technical Data

■ Current clamp inputs: 2

- Connector: BNC
- Bandwidth: 100 kHz
- Sampling rate: 2.5 MS/s
- ADC Resolution: 12-Bit
- Evaluated output: 2-Bit

■ Ethernet PC interface: 1000baseT

■ Ethernet interface: 10/100baseT

■ CAN Interfaces: 2

- Connector: D-Sub, 9-pole
- Baud rate: 1 MBit/s
- Identifier: 11/29 Bit
- Protocol: tbd.

■ RS-232C

- Connector: D-Sub, 9-pole
- Baud rate: 115 kBit/s max.
- Protocol: tbd.

■ Supply

• Supply voltage:

- 10..32 VDC
- 100..250 VAC w/ external adapter

• Power dissipation:

- 70 W typical
- 120 W max.

■ Environmental

• Protection degree: IP40

• Ambient temperature:

- Operating: -20..50 °C
- No operating: -40..70 °C

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Accessories: technical data

■ Crank Angle Adapter

- Pick-up type: Hall/Magnetic
- Polarity: Positive/Negative
- Oscilloscope: ADC, 12-Bit
- Protection degree: IP65
- Ambient temperature:
-40..85 °C



■ Current Clamps (3rd Party)

- Type: Fluke 80i-110s
- Supply: Battery-powered
- Bandwidth: 100 kHz
- Protection degree: IP??
- Ambient temperature
 - Operating: 0..50 °C
 - No operating: -30..70 °C



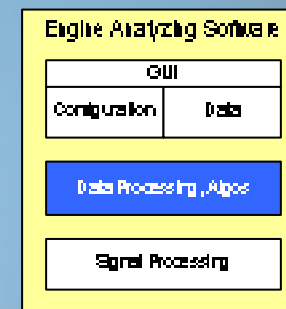
On-Board Combustion Analysis



Software

Base Algos

- Revolutions: RPM
- Digital low-pass filtering per channel
 - Filter type: FIR
 - Cutoff frequency: 5/10/20/30/100 kHz
- Work: p_{miHD} , p_{miGE}
- Burn: $B(\alpha)$, $SUM(B(\alpha))$, $LOC10(\alpha)$, $LOC50(\alpha)$, $LOC90(\alpha)$
- Volume: $V(\alpha)$, $dV/d\alpha$
- Timing events: $x(\alpha)$
- Timing events: $x(t)$
- Signal pegging:
No/TD/ p_{inlet}/p_{const}
- Maximum: p_{max} , $LOC(\alpha)$ @ p_{max}
- Maximum: $dp/d\alpha$
- Maximum: dp/dt
- TDC determination: Yes
- Cycle detection: Yes
- Variation coefficient: COV
- Gas exchange: $MEAN(x(\alpha))$
- Statistics: *tbd.*
- Monitoring: *tbd.*



On-Board Combustion Analysis Software



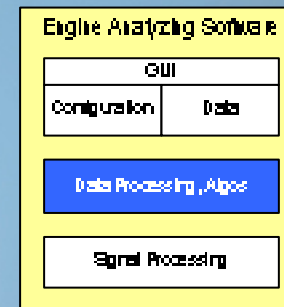
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Algos for Diesel Engines

- Noise: Kistler

Algos for Otto Engines

- Knock: VDO, Kistler



On-Board Combustion Analysis

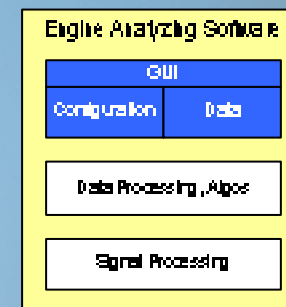


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Software

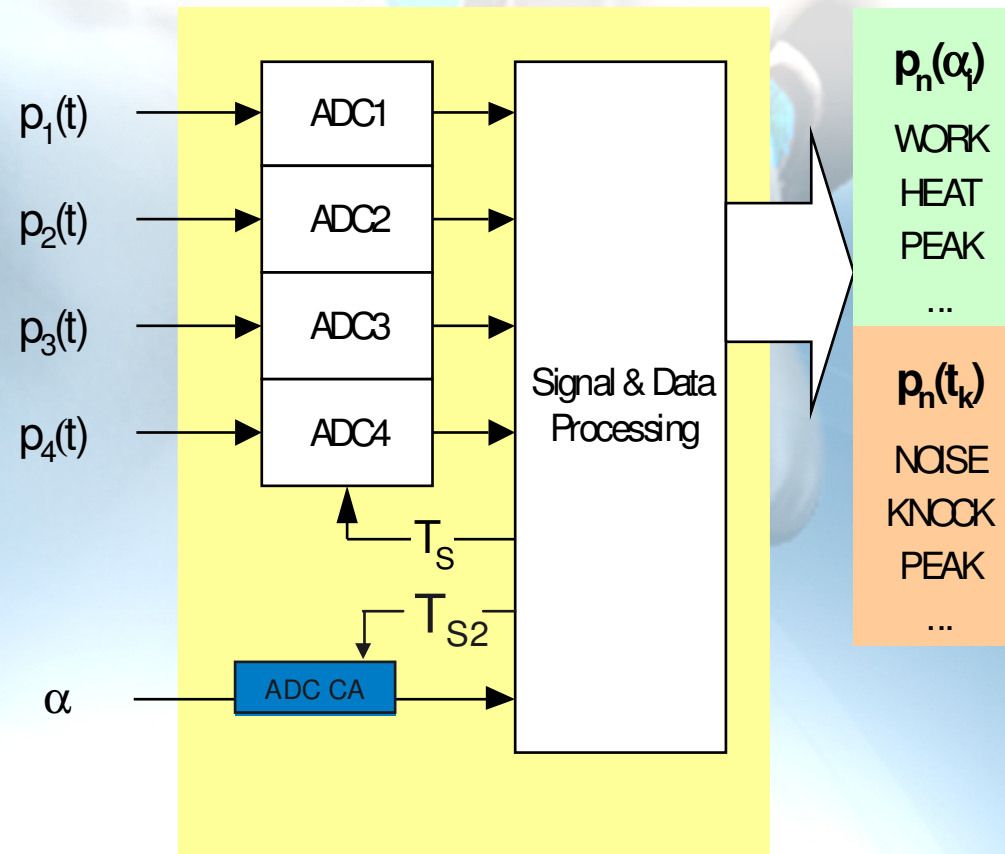
Views

- Configuration setup
 - System
 - Digitizer, algos
 - SCP amplifier
- Raw data x , real-time view
 - $x(\alpha)$ graph
 - $x(V)$ graph
 - $x(t)$ graph
- Cycle-based combustion data z
 - $z(\text{cycle})$ graph
- Offline: Configuration, graphs, analysis
- Table representation, numericals
- Oscilloscope function



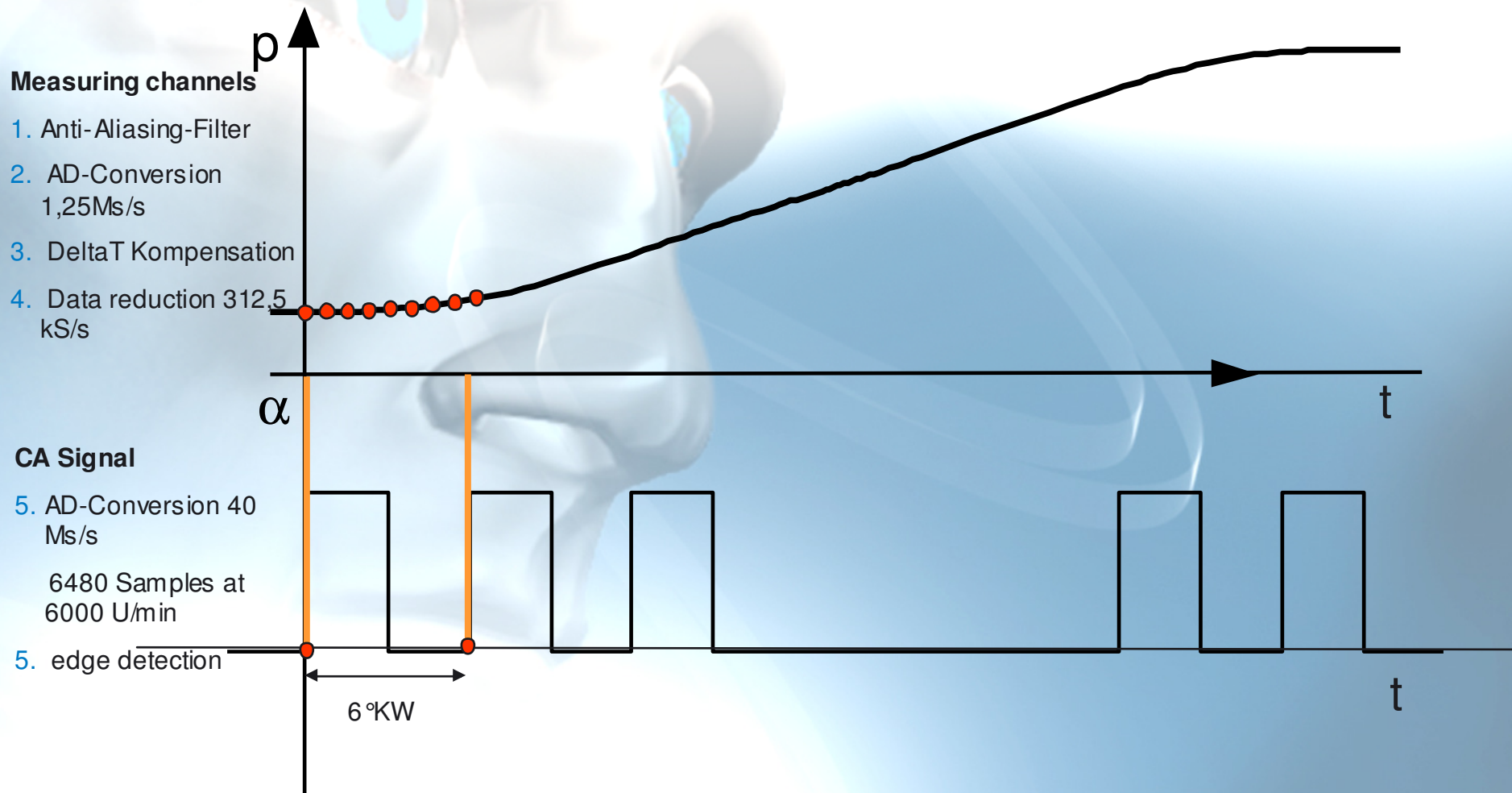
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Innovation - CrankSmart



- time base data-acquisition for pressure and crank-angle
- Interpolation for high CA resolution
- Transformation into CA domain
- cycle separation, scaling, zero-line algo
- calculation or combustion values
- display and storage

KiBox to Go Innovation - CrankSmart



KiBox to Go Innovation - CrankSmart

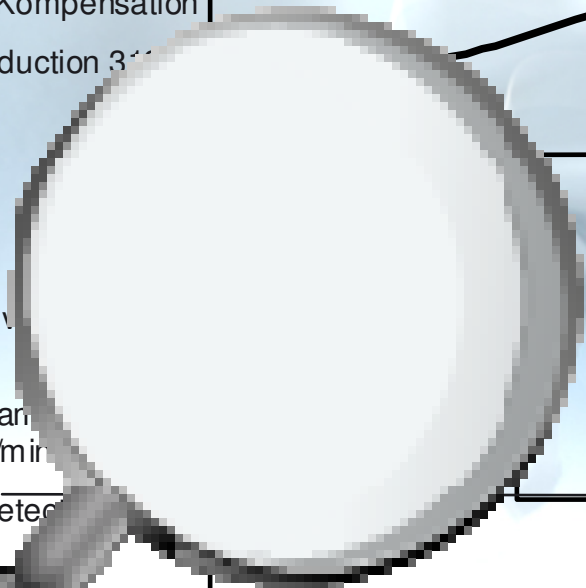
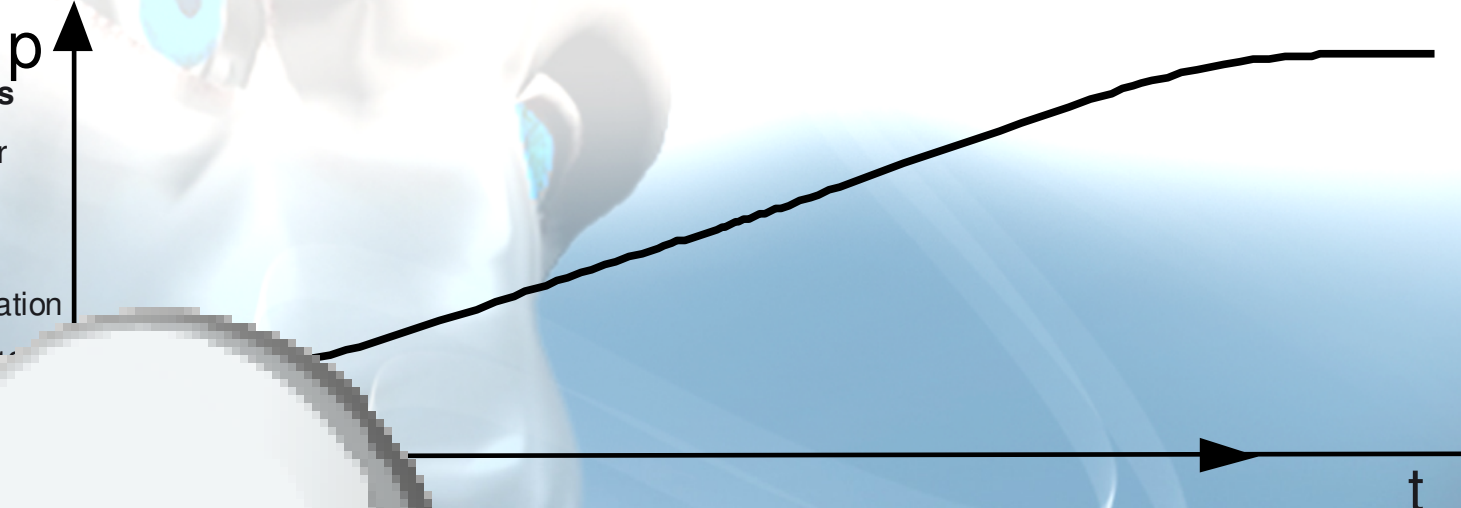


Measuring channels

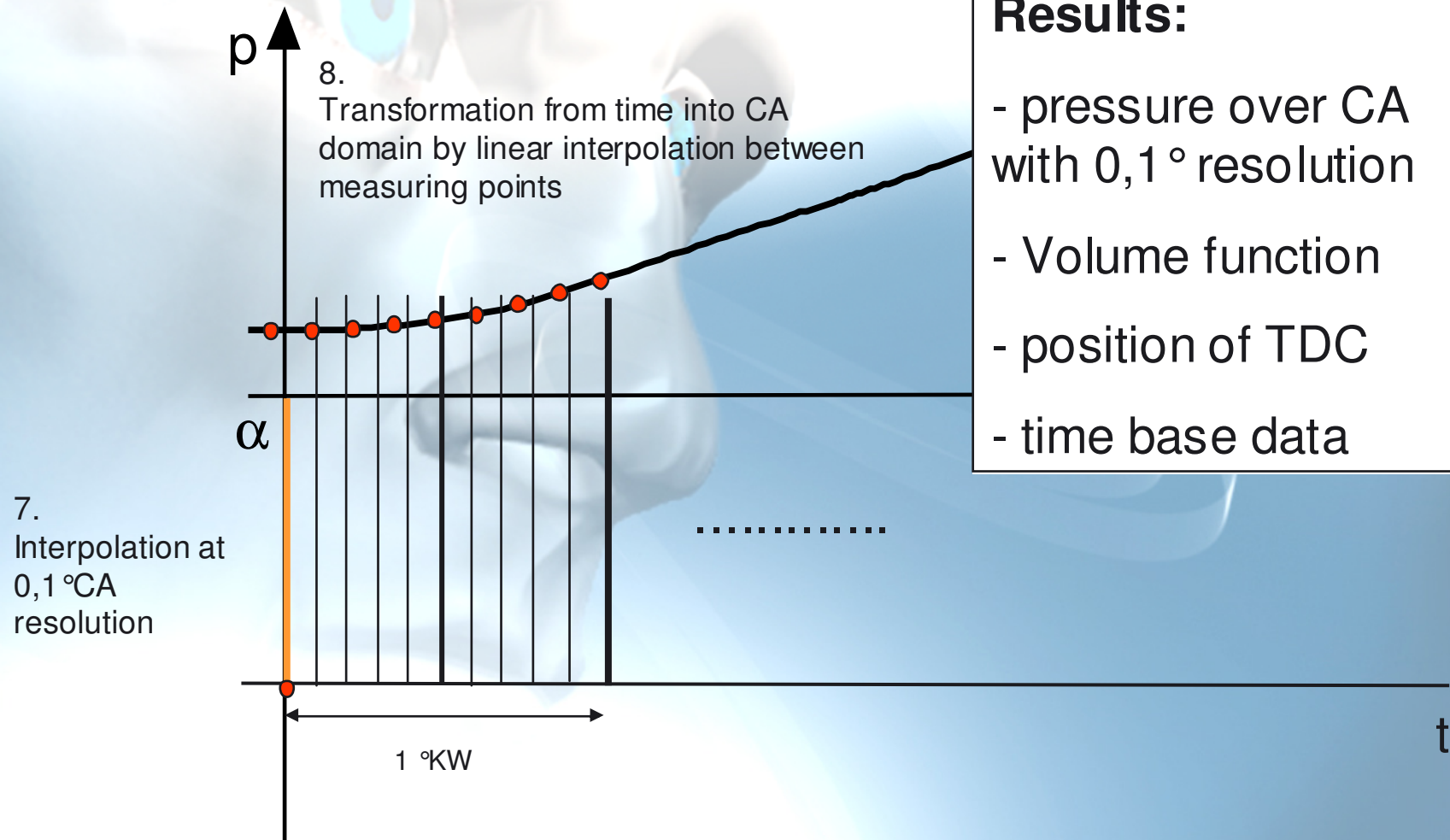
1. Anti-Aliasing-Filter
2. AD-Conversion
1,25Ms/s
3. DeltaT Kompensation
4. Data reduction 31
kS/s

CA Signal

5. AD-Conv
Ms/s
6480 Sam
6000 U/min
5. edge detec



KiBox to Go Innovation - CrankSmart



- Results:**
- pressure over CA with 0,1 ° resolution
 - Volume function
 - position of TDC
 - time base data



KiBox to Go

Data format – Data export

Data storage in:

- Kistler .open – Format, contains selectable CA-based data, time-based data and/ or combustion values
- Kistler .open – Format is open and described, high-level access function are within a DLL available
- Data export in I-File and CSV format
- Concerto Plug-in available

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Capture – Trigger



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Capture/ Trigger events for storage data :

- Manuel Trigger
- Trigger Event: Engine start/ Engine Stop
- Multiple Trigger events are possible
- Trigger on levels on combustion values e.g. $P_{max} > \text{Level1}$
- Trigger on events in calibration software INCA

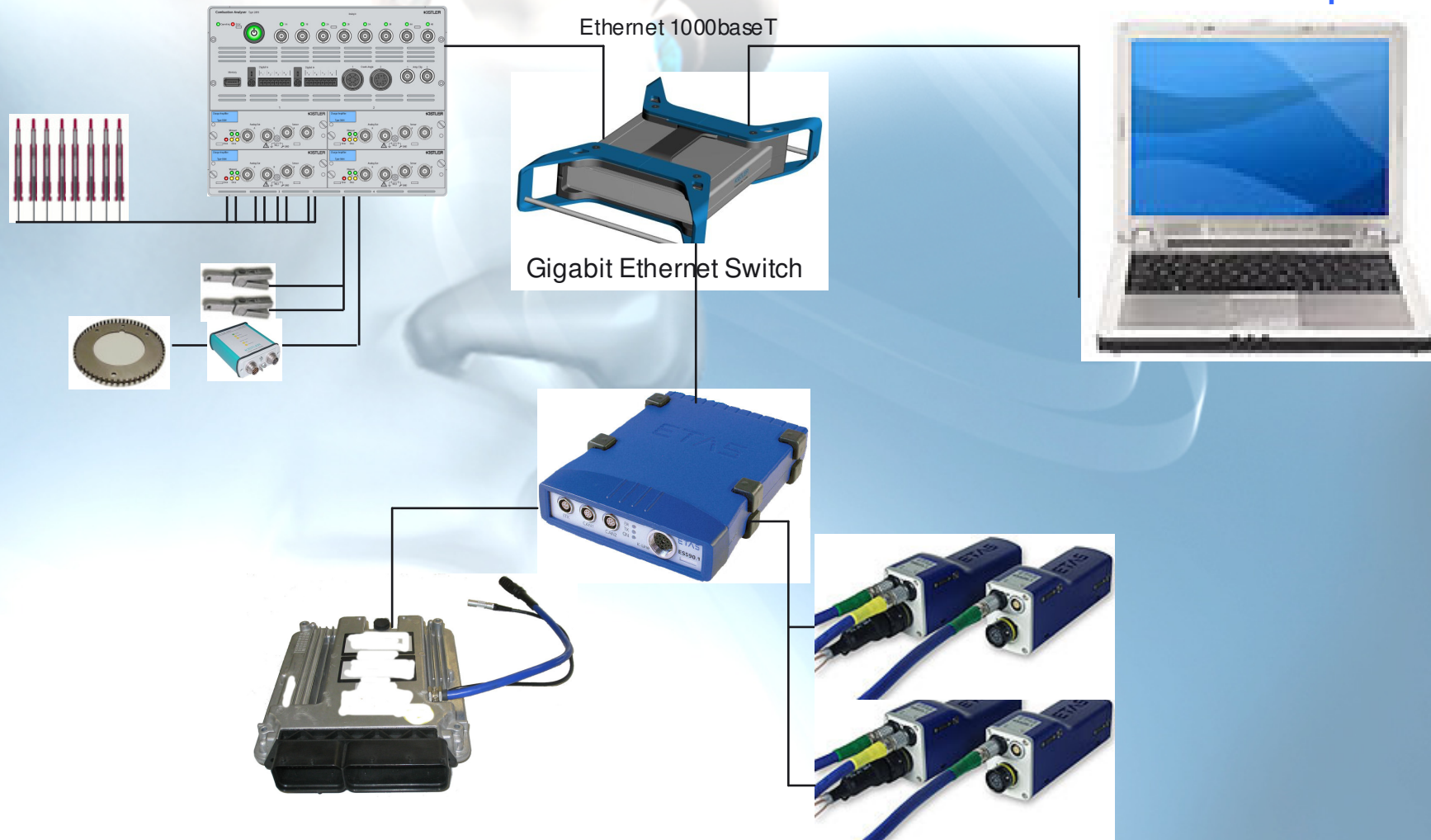
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Combustion analysis and ECU calibration System



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INCA
KiBox Cockpit



KiBox to Go Interface to INCA



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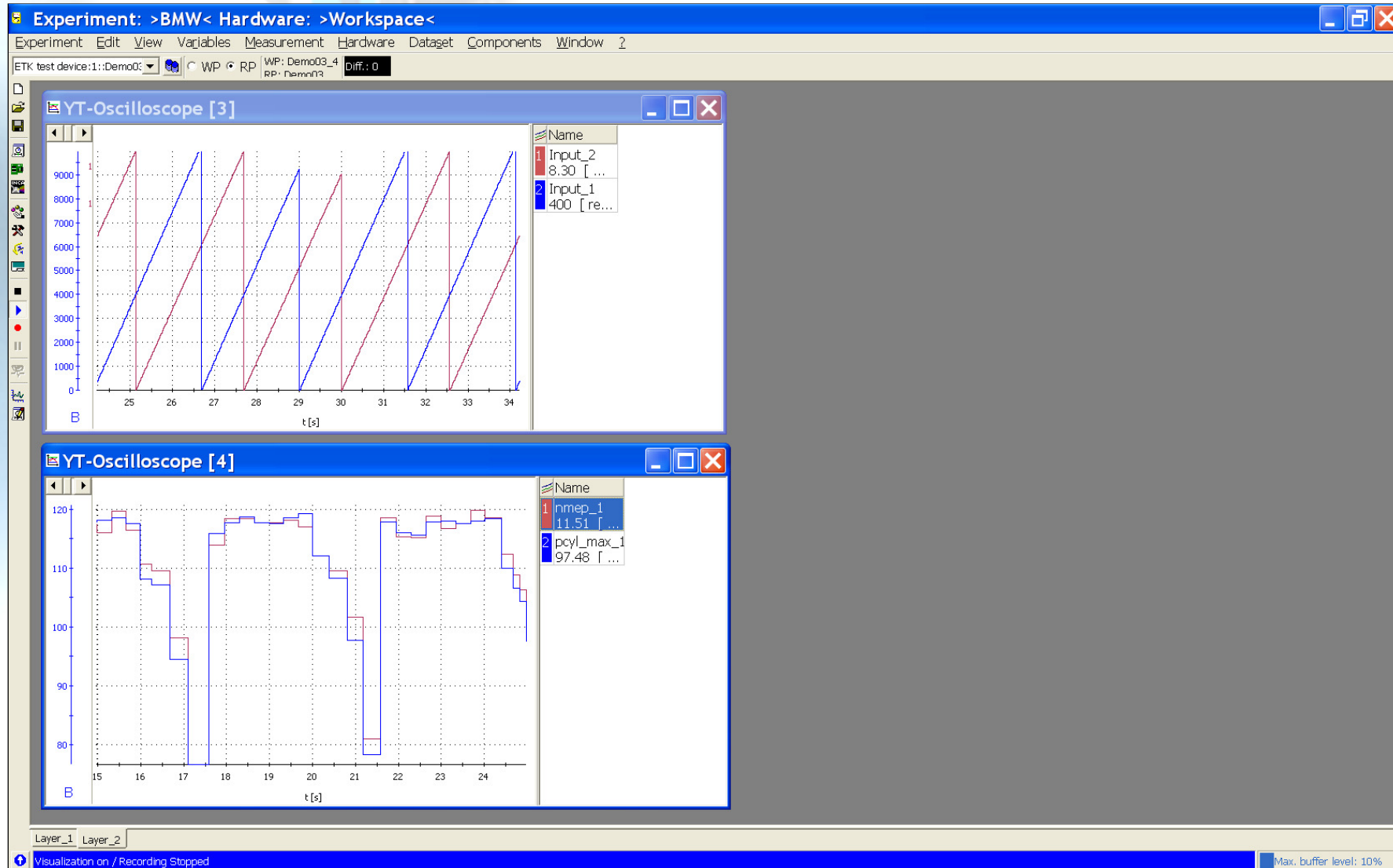
Features:

- With INCA the KiBox is in remote modus
- Combustion values calculated by the KiBox, could be used in INCA like common ECU values
- Combustion values and ECU values are displayed and stored together on the same timeline in INCA
- INCA time-stamp is allocated by the KiBox
- Synchronization of individual Clocks is better then 10ms , better one engine-cycle

In vehicle indication use cases



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In vehicle indication use cases



Experiment: >Kistler < Hardware: >Arbeitsumgebung <

Experiment Bearbeiten Ansicht Variablen Messung Hardware Datensatz Werkzeuge Fenster ?

Bereichsschwellen für release maps [92]

InjCrv_stRlsOpRngThres2_MAP <Kennfeld> [-]: x: InjSys_tEng [deg C] 77.7 y: InjSys_tAir [deg C] 25.0

y \ x	20	25	55	65	70	75	80	85
-20	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3
-10	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3
0	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3
15	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3
17	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3
20	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3
25	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3
30	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3
35	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3
40	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3
50	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3
60	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3
70	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3
80	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3	RLSMAP3

release maps [91]

InjCrv_stPIRlsOpRng33_MAP <Kennfeld> [-]: x: Epm_nEng [rpm] 1256.500 y: InjCt_qSetUnBal [mg/hub] 10.5000

y \ x	1000	1250	1500	1750	2000	2250	2500	2750	3000	3250
5.00	4	4	4	4	4	4	4	4	4	4
10.00	4	4	4	4	4	4	4	4	4	4
15.00	4	4	4	4	4	4	4	4	4	4
20.00	4	4	4	4	4	4	4	4	4	4
30.00	4	4	4	4	4	4	4	4	4	4
40.00	4	4	4	4	4	4	4	4	4	4
50.00	4	4	4	4	4	4	4	4	4	4
60.00	4	4	4	4	4	4	4	4	4	4

Luftmassen_1 [294]

AirCt_mDesVal	249 [mg/hub]
AFS_mAirPerCyl	251 [mg/hub]
AirCt_mEngTempCor_mp	0 [mg/hub]

Ansaugtemp. [275]

EnvT_t	25.0 [deg C]
Air_tCACDs	24.9 [deg C]
Epm_nEng	1257 [rpm]

Messfenster [1]

speed	3047.79 [rpm]
imep_1	11.37 [bar]
imep_2	11.69 [bar]
imep_3	11.42 [bar]
imep_4	11.62 [bar]
heat_max_1	43.07 [J/°CA]
heat_max_2	52.43 [J/°CA]
heat_max_3	44.91 [J/°CA]
heat_max_4	45.43 [J/°CA]
heat_intstart_1	1.00 [°CA]
heat_int50_1	16.00 [°CA]
heat_intend_1	34.00 [°CA]
heat_intdur_1	33.00 [°CA]

Einspritzstrategie [16]

InjCrv_stInjCharDes_mp

InjCrv_stInjCharSetVal

InjCrv_stInjCharActVal

YT-Oszilloskop [299]

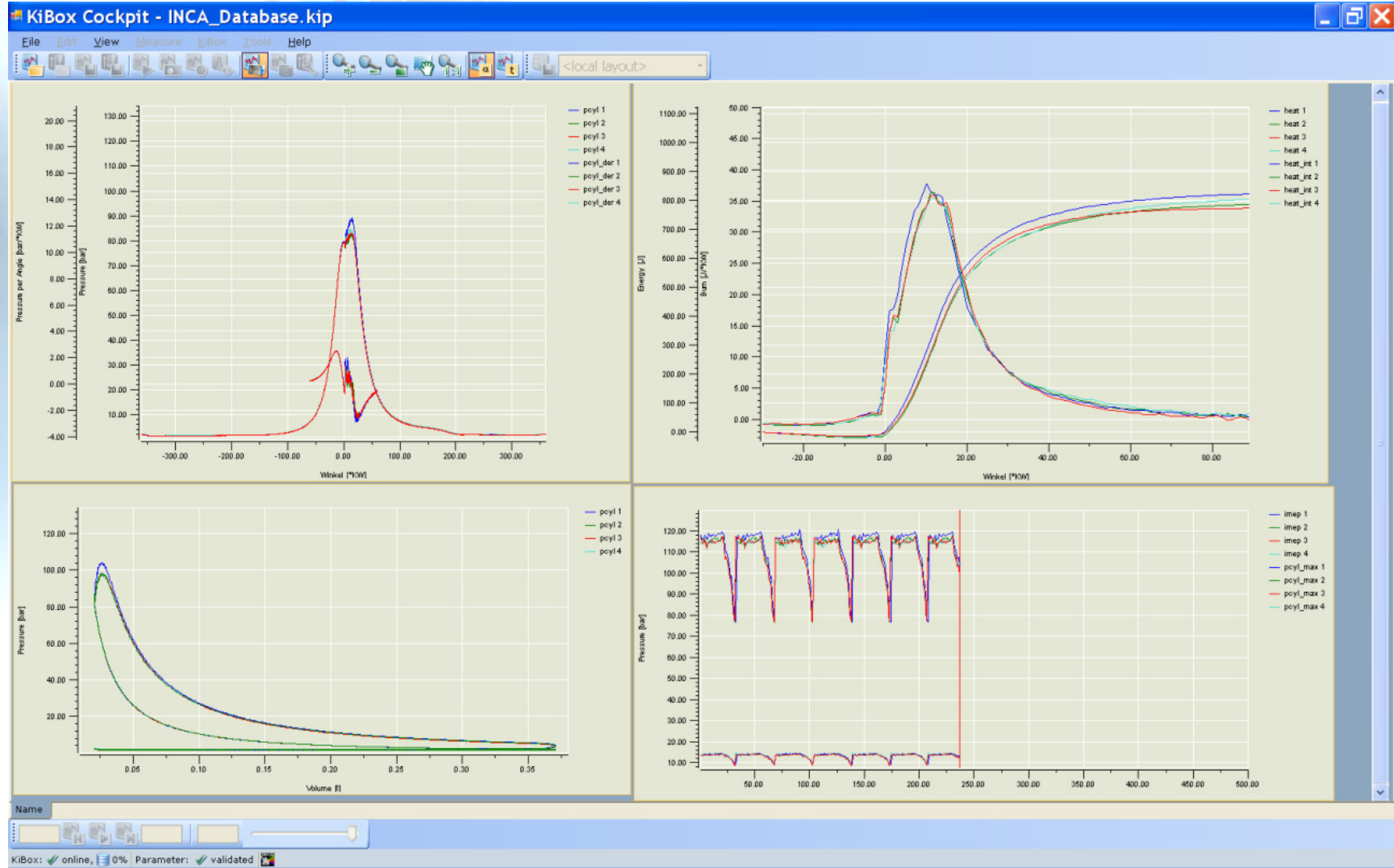
Name

- AirCt_rDesVal 249.400 [mg/hub]
- AFS_mAirPerCyl 250.400 [mg/hub]
- AirCt_rOutI_mp -3.0273 [%]
- AirCt_rOUP_mp -0.1831 [%]

Messung gestoppt

Max. Pufferfüllstand: 0%

KiBox to Go ECU Calibration



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ECU Calibration



Use cases for combustion analysis in ECU calibration:

- Combustion Analysis is the only possibility to get information about combustion as an result of the ECU control-functions
- Fast and efficient ECU calibration
 - optimization of idle, detection of misfiring
 - exhaust after treatment concepts need to switch between combustion concepts
 - nitrogen catalyst converter
 - catalyst heating
- cold-start, general engine start and stop
- Diagnose and troubleshooting
- evaluations under realistic environmental conditions, like altitude, temperature, humidity and fuel quality
- Injection-, ignition – timing evaluation

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Conclusion



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First combustion analyzer dedicated to the in-vehicle use:

- compact housing, integrated amplifier, fast installation
- safe and robust operation with the in-vehicle CA Sensor e.g. 60-2 Sensor with CrankSmart
- Interpolation instead of critical Extrapolation in transient conditions with CrankSmart
- reliable and entire measurement of engine-start/ stop, thanks combined time- and CA based data acquisition
- time-right/ time-synchrony interface to calibration software INCA



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***Thank You
For Your Attention!***