Automotive
Energy & Power Analysis
Field Service
Environmental
Research & Development

DEWE-CRANKANGLE-CPU

Technical reference manual

ISO9001

... the precision signal conditioning company

worldwide
DEWETRON
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Content

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Printing History

Please refer to the page bottom for printing version.

Safety instructions

Safety symbols in the manual

	*Indicates hazardous voltages.*

WARNING	*Calls attention to a procedure, practice, or condition that could cause bodily injury or death.*

CAUTION	*Calls attention to a procedure, practice, or condition that could possibly cause damage to equipment or permanent loss of data.*

WARNINGS

The following general safety precautions must be observed during all phases of operation, service, and repair of this product. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the product. DEWETRON Elektronische Messgeraete Ges.m.b.H. assumes no liability for the customer's failure to comply with these requirements.

All accessories shown in this document are available as option and will not be shipped as standard parts.

Safety instructions for all DEWETRON systems

- The DEWETRON data acquisition systems may only be installed by experts.
- Read your manual before operating the system.
- Observe local laws when using the instrument.
- Ground the equipment: For Safety Class 1 equipment (equipment having a protective earth terminal),a non interruptible safety earth ground must be provided from the mains power source to the product input wiring terminals or supplied power cable.
- DO NOT operate the product in an explosive atmosphere or in the presence of flammable gases or fumes.
- DO NOT operate damaged equipment: Whenever it is possible that the safety protection features built into this product have been impaired, either through physical damage, excessive moisture, or any other reason, REMOVE POWER and do not use the product until safe operation can be verified by service-trained personnel. If necessary, return the product to a DEWETRON sales and service office for service and repair to ensure that safety features are maintained.
- Keep away from live circuits: Operating personnel must not remove equipment covers or shields. Procedures involving the removal of covers or shields are for use by service-trained personnel only. Under certain conditions, dangerous voltages may exist even with the equipment switched off. To avoid dangerous electrical shock, DO NOT perform procedures involving cover or shield removal unless you are qualified to do so.
- No modifications are allowed at the instrument. The fuse in the power module has to be replaced by the same type. For continued protection against fire, replace the line fuse(s) only with fuse(s) of the same voltage and current rating and type. DO NOT use repaired fuses or short-circuited fuse holder labels and print on the power module may not be removed.
- DO NOT service or adjust alone. Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.
- DO NOT substitute parts or modify equipment: Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the product. Return the product to a DEWETRON sales and service office for service and repair to ensure that safety features are maintained.
- Before opening the instrument (experts only) or exchanging the fuse in the power module disconnect power!
- Don’t touch internal wiring!
- Don’t use higher supply voltage than specified!
- Use only original plugs and cables for harnessing.
- Install filler-panels in unused slots.
- The power-cable and -connector serve as Power-Breaker. The cable must not exceed 10 feet, disconnect function must be possible without tools.
- Safety of the operator and the unit depend on following these rules.

General System Information

Environmental Considerations

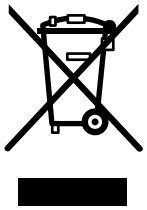
Information about the environmental impact of the product.

Product End-of-Life Handling

Observe the following guidelines when recycling a DEWETRON system:

System and Components Recycling

Production of this components required the extraction and use of natural resources. The substances contained in the system could be harmful to your health and to the environment if the system is improperly handled at it's end of life! Please recycle this product in an appropriate way to avoid an unnecessary pollution of the environment and to keep natural resources.



This symbol indicates that this system complies with the European Union’s requirements according to Directive 2002/96/EC on waste electrical and electronic equipment (WEEE). Please find further informations about recycling on the DEWETRON web site www.dewetron.com

Restriction of Hazardous Substances

This product has been classified as Monitoring and Control equipment, and is outside the scope of the 2002/95/EC RoHS Directive. This product is known to contain lead.

General

- Clock and trigger generator for combustion analyzer application
- Supports a wide range of angle sensors:
  - Quadrature encoder (X1, X2 or X4)
  - Pulses + trigger (CDM)
  - In car with up to 3 gaps
  - In car with double tooth
- Free definable clock multiplying from 1 to 100
- Free definable clock divider from 1 to 100
- Galvanic isolated sensor inputs
- Additional auxiliary I/O signals for customized controlling
- Programmable over RS-232 or RS-485 interface
- Absolute long time stable

Specifications

DEWE-CRANKANGLE-CPU			
Input sources		**System specification**	
Quadrature encoder		Programming interface	R-S232 or RS-485
Modes	X1, X2 and X4	Supply voltage	9 to 15 V
Signal level	TTL, protected to 25 Volt	Power requirements	1 W, without sensor power
Edge sensitivity	rising or falling	Maximum sensor supply	5 W @ 5Volt, 2 W @ ± 15 Volt
Maximum input frequency	1 MHz	Dimensions	165 x 115 x 50 mm (6.5 x 4.5 x 2 in.)
CDM Sensor		Weight	740g (1.63 lbs)
Signal level	TTL, protected to 25 Volt	**Environmental**	
Egde sensitivity	rising, falling or both	Operating temperature	0 °C to 60 °C (standard)
Maximum input frequency	1 MHz	Storage temperature	-20 °C to +70 °C
In car CA sensor		Humidity (operating)	10 % to 80 %, non condensing
Sensor types	Inductive or hall effect (TTL)		5 % to 95 %, rel. humidity
Input voltage, inductive	up to ± 80 Volt	Vibration	
Switching levels	0.5 or 2 Volt	Operating test temperature	MIL-STD 810F 514.5 procedure I
Supported sensor types	Free programmable	Frequency range:	5 to 200 to 5 Hz; 5 x 12 min each direction
Number of "holes"	1, 2 or 3	Displacement amplitude	±3.5 mm (5 to 8.45 Hz)
Number of teeth between holes	3 to 127	Acceleration amplitude	1 g (8.45 to 92 Hz)
Maximum input frequency	100 kHz	Displacement amplitude	92 to 113 Hz: ±0.029 mm
Clock multiplier / divider		Acceleration amplitude	1.5 g (113 to 200 Hz)
Programmable factor	1 to 100 or bypass	Shock	
Programmable divider	1 to 100	non operating test procedure	MIL-STD 810F 516.5 procedure I
Output signals			½ sinus 11 ms 10 g
Maximum output frequncy	1 MHz		3 shocks positive, 3 shocks negative
Output level	TTL/CMOS		
Maximum current	50 mA		

DEWE-CRANKANGLE-CPU

Device overview

The DEWE-CRANKANGLE-CPU offers a universal clock multiplier suited especially for combustion analyzer applications where angle synchronous data acquisition is needed. The clock source can be taken from an additional mounted angle sensor (or encoder) or from the crank angle sensor built in the car.

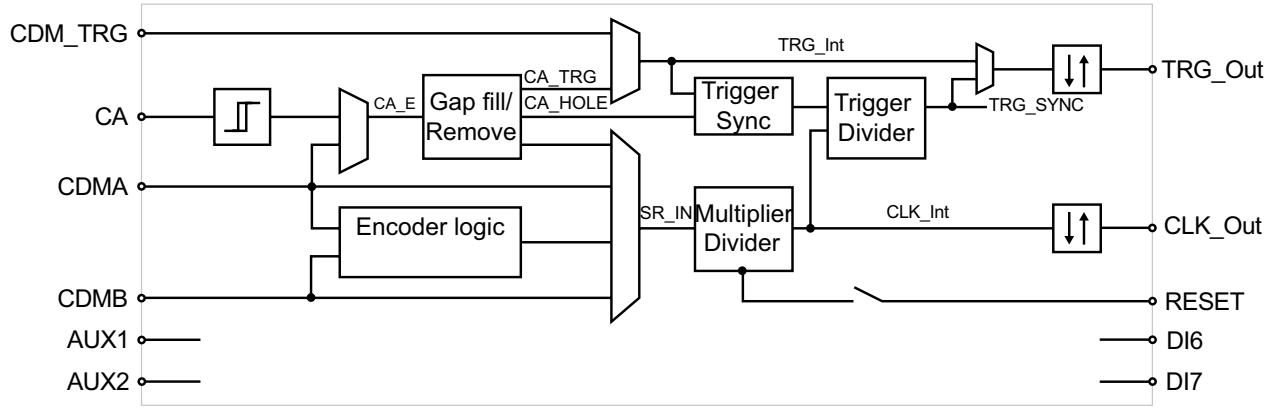
Usually the additional mounted angle sensor serves a defined number of pulses per revolution and one trigger pulse for getting the absolute angle position. With the DEWE-CRANKANGLE-CPU this pulses can be multiplied or divided depending on the sensor configuration. In addition to this standard angle sensor also motion (or quadrature) encoder with X1, X2 and X4 mode is supported.

In-car sensors, such as the 60-2 crank angle sensor, delivers a non-equidistant pulse because a few pulses per revolution are missing to get information about the absolute crank shaft position. To be able to use this sensor signal for a combustion analyzer, the missing teeth have to be filled up in the first step. To increase the resolution, the clock signal has to be multiplied to get more accurate resolution of the angle position. The DEWE-CRANKANGLE-CPU supports sensors with up to three gaps (for example: 60-2-2-2) with free definable number of teeth and missing gaps. The trigger pulse is generated at the first defined gap.

Instead of missing teeth (or gaps) the absolute angle position can be also realized by having one additional tooth (for example 36+1 sensor). Using this signal for combustion analyzer this double tooth needs to be removed before multiplying. The DEWE-CRANKANGLE-CPU supports also these types of sensors. The trigger pulse is generated at the position of the double tooth.

Internal signal processing

The block diagram below shows the basic operation principal of the DEWE-CRANKANGLE-CPU. The heart is the programmable clock multiplier/divider. It is controllable over a simple RS-232/RS-485 interface. One LED indicates the correct operation by flashing approximately once a second. Fast LED flashing indicates wrong settings of the unit. A wrong selected sensor type or noisy input signals are just some examples for a fault. At any error condition, an auto reset (or auto restart) function is implemented for automatic locking the input signal without long interruption. This auto reset function will not clear the internal error flag, indicated by fast flashing of the LED. This functionality allows the user to realize any occurred error during the operation. The reset of the unit, activated by push button or SW command and reading out the status information, will clear the internal error flag. Please refer also to chapter **Software** for getting more information about the status information.



The calculation of the pulse multiplication is based on a modified alpha/beta filter. Therefore, in addition to the multiplier and divider value, both, the alpha and beta coefficients, are needed. Since the pulse multiplication is performed in real time, it is needed to predict the value of the frequency for the future to minimize the error because of the multiplication. The alpha coefficient expresses the weighting between the predicted output frequency and the current output frequency. Setting alpha to “0” just the predicted value is outputted. Setting alpha to "15" the current pulse width is used for the next value.

At high variation of the input frequency and due the inaccuracy of the sensors, (not equidistant distance between two teeth) an error during the multiplication may happen. This means that there are too many or too less number of pulses generated within 2 input pulses. The beta value weights how strong a possible error is corrected. Setting beta to “0” means: no error correction.

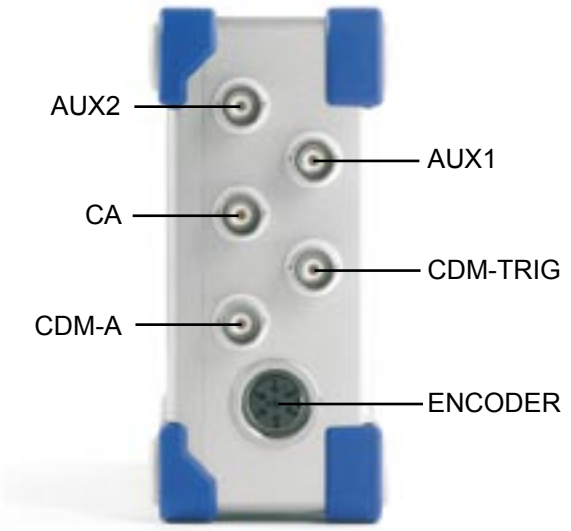
Note: The Standard value of alpha is “7”. Beta should be set to “100”.

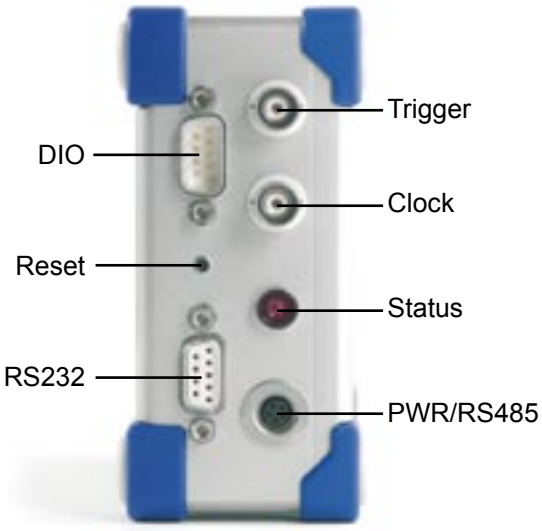
Some applications require exact alignment between trigger and clock. For this purpose the trigger can be defined out of the divided clock (“Trigger Divider” block) or out of the real trigger input. Only the start of this divider is synchronized with trigger input. To be sure, that trigger occurs all the time before clock, the clock output (as well as the trigger output) can be inverted.

The CLK-MUX defines the source of the clock signal. The pulses + trigger sensor and the motion encoder input can be routed over the input names CDM-A or CDM-B. Standard in-car sensors with gaps or double tooth are rooted over the input CDM-A or CA to the “Gap fill / Remove block”. This block also generates the trigger signal giving information about the absolute angle

For test purpose or customized controlling the several internal generated test signals can be outputted of the connectors AUX 1, AUX 2 or over DI6 and DI7.

Connectors





Pin out Encoder:

Pin1: +15VDC
Pin2: -15VDC
Pin3: +5VDC
Pin4: GND _ISO
Pin5: CDM-B
Pin6: CDM-A
Pin7: CDM-TRIG

Pin out DIO:

Pin1: EXT_TRG
Pin2: EXT_CLK
Pin3: DIO_7
Pin4: DIO_6
Pin5: Reserved
Pin6-9: GND

Pinout PWR:

Pin1: RS-485A
Pin2: RS-485B
Pin3: +UB (9..15V)
Pin4: GND
Pin5: Chassis

Pin out RS-232:

Pin2: RxD
Pin3: TxD
Pin 5: GND
Others: NC

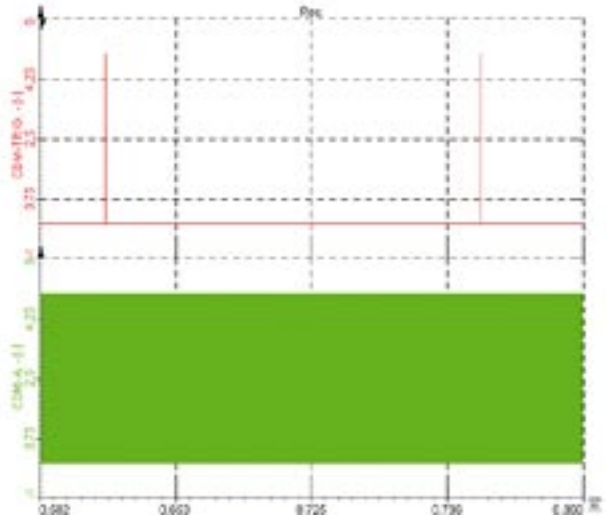
DEWE-CRANKANGLE-CPU

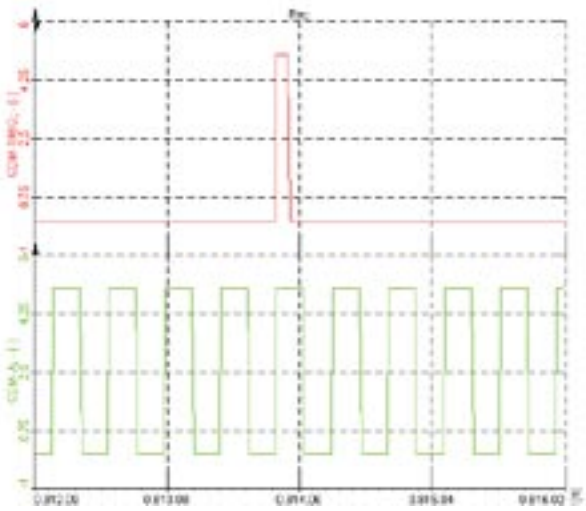
Sensors and their signal shapes

The DEWE-CRANKANGLE-CPU supports a wide range of different angle sensors. The sensor itself is the base for proper working of the unit and finally responsible for the angle synchronous data acquisition system like the DEWE-Combustion-Analyzer. The nature of the sensor needs to be known for the performing the right settings. The following images give an overview of the signal shapes of the supported sensors. These data can be measured in time domain with DEWESoft like the examples are shown below.

Pulses and Trigger

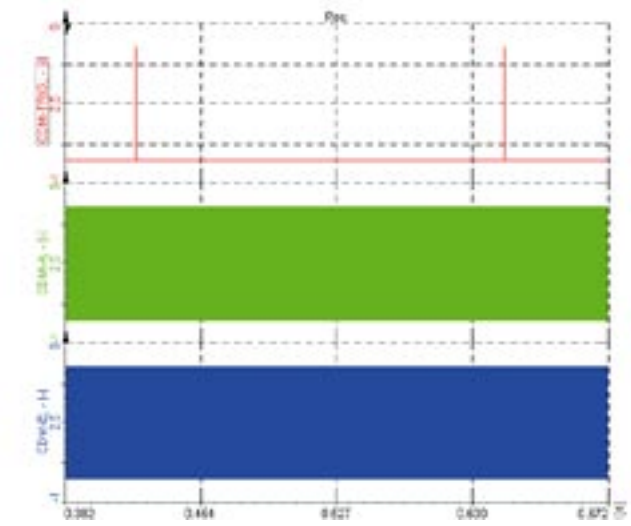
This sensor is characterized with a defined number of pulses per revolution and one trigger mark per revolution. The pulses are accepted at the input CDM-A or CDM-B. The input is TTL/CMOS compatible and can be taken at the positive or negative edge. If the duty cycle of the sensor is exactly 50%, like shown on the example below, it is also possible to detect the falling and the rising edge. This setting will increase the angel resolution of the sensor by a factor of 2.

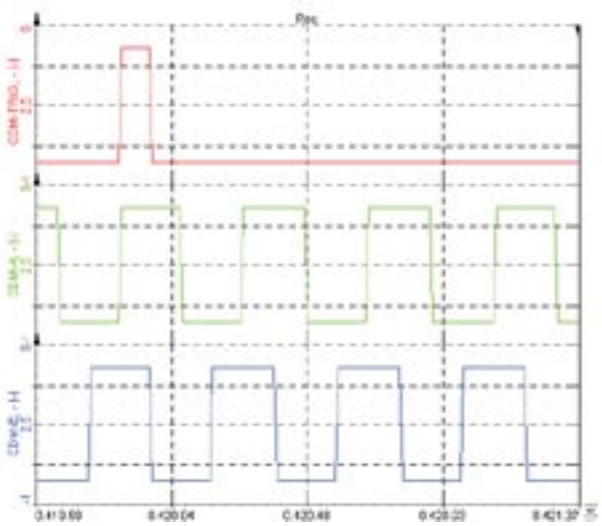




Motion encoder

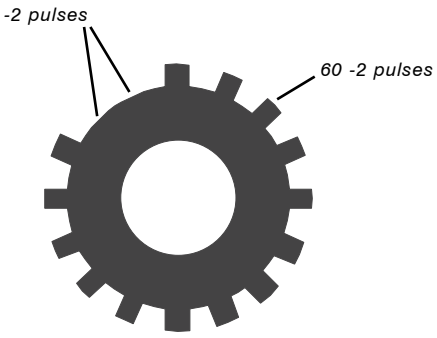
In addition to the Trigger pulse (once per revolution) the motion or quadrature encoder is suited with two 90° phase shifted output signals. This types of sensors are common also used for detecting the direction of the revolution. The advantage of supporting this type of sensor are the several modes called X1, X2 and X4. In the X1 mode the rising edge of the CDM-A input is detected. The X2 mode uses the rising and the falling edge at the CDM-A. The X4 mode uses the rising and falling edge of the CDM-A and CDM-B input to multiply per hardware the input resolution by a factor of 4.





In-car with gaps

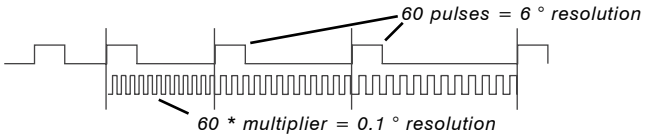
This sensor is usually build inside the vehicle and is used for the ECU to control the engine ignition. The gear tooth has some holes for getting the absolute position. A typical sensor with gaps is the 60-2 sensor and an ideal output signals are shown below:



Typical 60-2 pulse in-car crank angle sensor (symbol image)

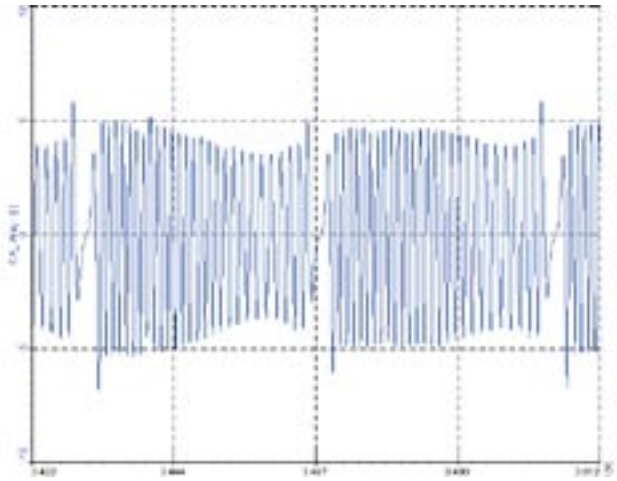
1. Signal of a typical in-car crank angle sensor

2. Find the -2 and interpolate to fill the gap for the DAQ

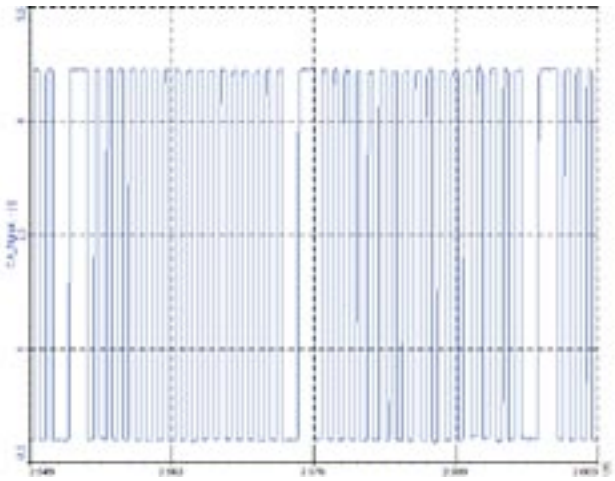


3. Interpolate the angle for higher resolution

The real output signal of this kind of sensors is different. The electrical output signal itself depends on the type of the installed transducer. Some times a magnetic pick up sensor is used. In some cases also a hall effect sensor providing already TTL output signals is installed. A magnetic sensor should be connected to the CA input connector. Sensors providing TTL output signals should be connected to the CDM-A input. On the next page you can see the signal shapes of this different sensor types:

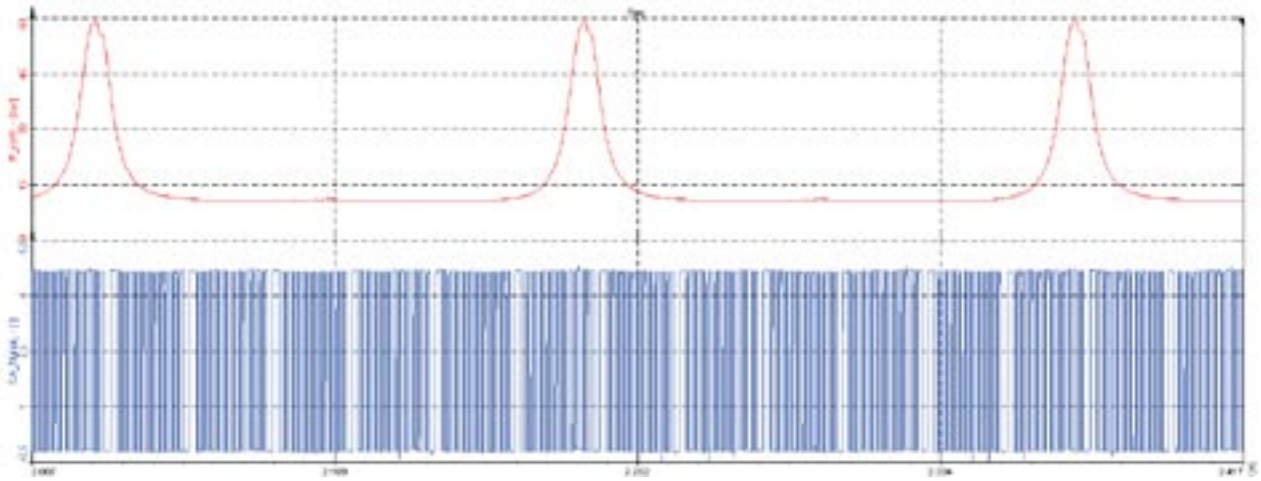


Signal shape of magnetic sensor:
Needs to be connected to CA input!

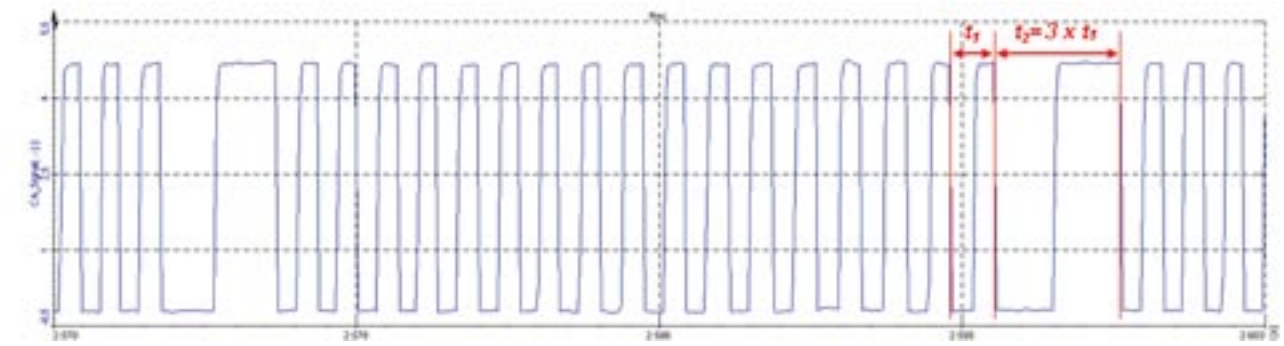


Signal shape of hall effect sensor:
Should be connected to CDM-A input!

After knowing the signal shape the number of pulses and gaps per revolution needs to be find out. If the tooth and gap arrangement of the sensor is completely unknown the pressure of one cylinder should be measured together with the sensor signal. Having a 4 stroke engine, every 2nd revolution (at each cycle) the pressure will have some peaks. The picture below shows 6 longer pulses within two pressure peaks. Therefore the sensor has three gaps per revolution. Now it is needed to find out the number of teeth between the gaps and the gap with itself.



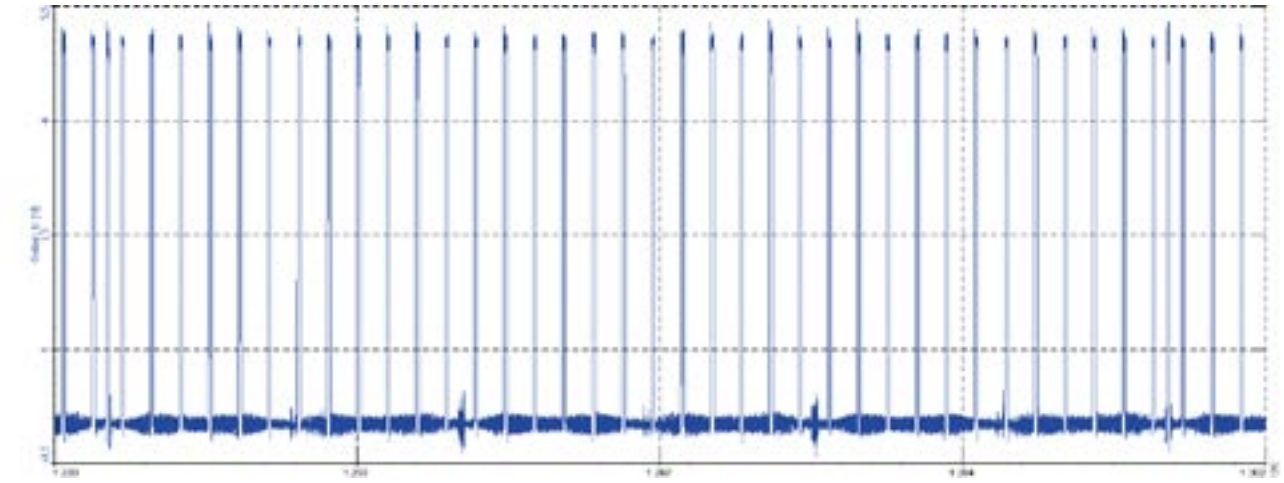
For defining the number of teeth it is not allowed to simple count the number of “small” pulses. You have to count the number of rising or falling edges. The example below shows a 60-2-2-2 sensor. This sensor is organized with 18 teeth and a gap of two teeth, 18 teeth and a gap of two teeth and again 18 teeth with a gap of two teeth. This architecture can be seen if the signal is analyzed by checking the negative edges.



Most of the sensors, used inside the car, are negative edge sensitive. That’s why in this mode the DEWE-CRANKANGLE-CPU inverts the input automatically allowing to use positive logic. Therefore rising edge detection should be used at this sensor.

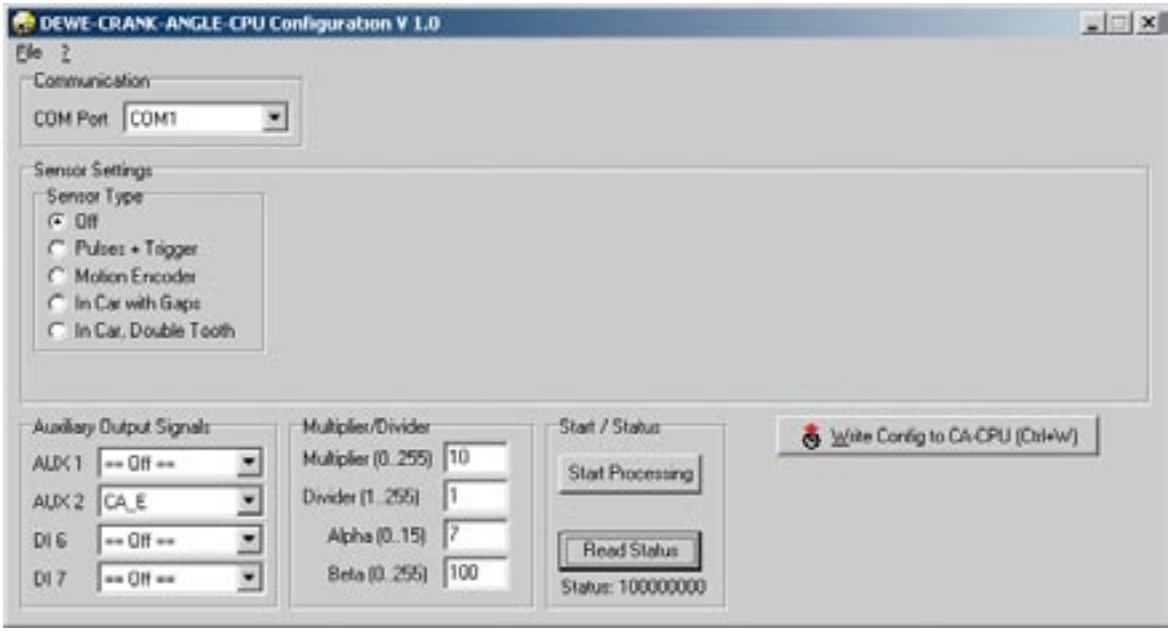
In-car, double tooth

Instead of the above described holes this gear tooth has at one position a double tooth for recognizing the absolute angle position. Below, the signal wave of a 36+1 sensor is displayed. 36+1 means, after 36 teeth there is one additional small one. This one needs to be removed before the pulse multiplication starts.



Software

The DEWE-CRANK-ANGLE-CPU is shipped with a small configuration SW. Simply one free COM-Port is needed for the communication with the DEWE-CRANKANGLE-CPU.



Sensor settings

The settings of the sensors are described below. The sensor type “Off” means the Trigger and Clock output are switched to tri-state or high impedance mode.

Auxiliary output signals

Optionally, the user can assign up to four additional output signals from the dropdown menus. The signal source is described in the block diagram in chapter **Internal signal processing**. "Off" means the related output is switched to tri-state or high impedance mode.

Multiplier / Divider

The values for the multiplier and divider, as well as the weighting and error correction can be set here. The maximum factor for the multiplier/divider is 255. Setting the multiplier to “0” bypasses the multiplier block completely. The setting should be used if a high resolution angle sensor is connected to the unit (for example 1800 pulses revolution) and no pulse multiplication is required.

The meaning of the Alpha and Beta coefficient is described in chapter **Internal signal processing**. The standard value for Alpha is 7 and for Beta it is 100.

Start / Status

The Start Processing button resets the internal processor and clears also the internal error flag. This command has the same function like the “Reset” button on the unit itself. Please note the settings needs to be written at first to DEWE-CRANKANGLE-CPU by pressing the button <Write Config to CA-CPU>.

The internal error flags can be red out with pressing <Read Status>. A response showing at the screen shot above “10000000” indicates a correct operation. The meaning of the numbers are described below. The letters in the description are labelled from “a” to “h”. As soon as a related processing abnormality occurs the number is set to “1”. Otherwise the response is “0” – except the first number is always set to “1”.

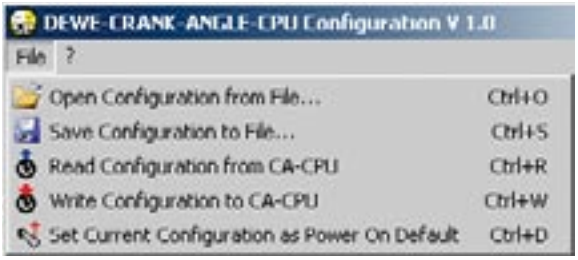
a: Always set to 1
b: Auto restart because of signal lost in the prediction filter – maybe filter is set too low. [1)]
c: Auto restart because of spike in the prediction filter – increase the filter value.[1)]
d: Overflow in block “Gap fill/Remove” -> check the right sensor “In car sensor” settings
e: Wrong Hole in block “Gap fill/Remove” -> check the right sensor “In car sensor” settings
f: Always set to “0”
g: Auto restart, no input signal detected.
h: Always set to “0”
i: Always set to “0”

Note: reading out the status, automatically clears all error flags. Therefore if the answer is received like shown above, no internal abnormality has been occurred since the last read out of the status or reset.

[1)] The filter settings are described below.

Write configuration

The <Write Config to CA-CPU> button writes the entered settings temporary to the unit. All settings are lost with removing the power supply. Like shown below, the settings can be written permanently to the CRANKANGLE-CPU.



Sensor configuration

The principals of settings are similar for each sensor. After the input selection the edge sensitivity can be defined. Having noisy sensor signals the input filter can be set to avoid multiple pulse recognition.
Setting the filter time to 100 nsec means the pulse high or low time must be longer than 100 nsec. Otherwise the signal is blocked. Default settings of the filter is 100 nsec.

Pulses + Trigger

Beside the right selection of the input source the input field Pulses per Rev. is important if multiplication is used. The DEWE-CRANKANGLE-CPU supports multiplications of sensor signals up to 1800 pulses/ revolution. Sensors with higher resolution can not be multiplied. Connecting this high resolution sensor the multiplier needs to be bypassed by setting the Multiplier to “0”. For example, connecting a sensor with 1000 pulses and triggering on both edges already gives 2000 pulses. This number can not be multiplied. So bypassing the multiplier is needed.

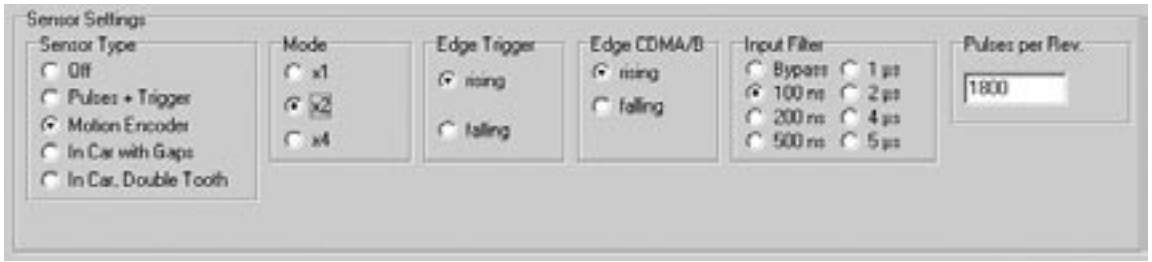
The number of pulses per revolution is usually printed on the sensor itself or is shown at the datasheet of the sensor.

Motion encoder

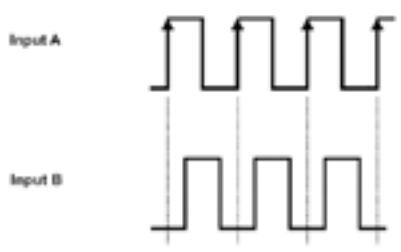
The motion encoder allows, instead of the settings of the input selection, the mode settings X1, X2 and X4. In the X1 mode the rising edge of the CDM-A input is detected. The X2 mode uses the rising and the falling edge at the CDM-A. The X4 mode uses the rising and falling edge of the CDM-A and CDM-B input to multiply per hardware the input resolution by a factor of 4.

Using additional multiplication with the CPU also the total number of pulses is important. The maximum number of pulses is limited to 1800. Using sensors with higher effective resolution the multiplier needs to be bypassed by setting the Multiplier to “0”. For example, connecting an encoder with 500 pulses in X4 mode gives already 2000 pulses. This number can not be multiplied. So bypassing the Multiplier is needed.

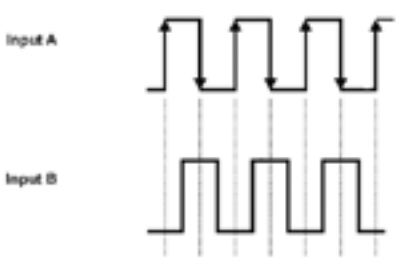
The number of pulses per revolution is usually printed on the sensor itself or is shown at the datasheet of the sensor.



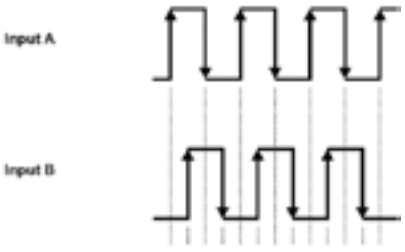
Below the signal generation at the different modes are shown:



X1: rising edge of CDM-A



X2: rising and trailing edge of CDM-AX4:



both edges of CDM-A and CDM-B

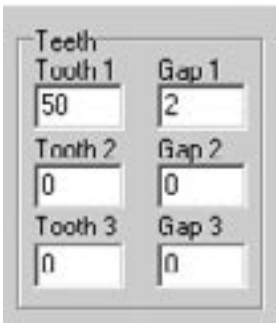
In-car with gaps

Sensors serving TTL signal level should be connected to the CDM-A input. Inductive sensor must be connected to CA input. This input includes the signal conditioning for this types of sensor with settable trigger level of 0.4 and 2 Volt. The input voltage must be higher than this threshold level to be recognized. Please refer to chapter **Sensors and the signal shapes** for getting more information about this sensor type.

Up to 3 pairs with tooth and gaps can be defined in the settings. The maximum number of teeth is limited to 127 per pair. Above the settings of a 60-2-2-2 sensor are shown. This sensor is organized with 18 teeth and a gap of two teeth, 18 teeth and a gap of two teeth and again 18 teeth with a gap of two teeth. This is also the order how the sensor needs to be defined for the DEWE-CRANKANGLE-CPU.

Using an 60-2 Sensor “Tooth 1” needs to be set to 58 and “Gap 1” to 2. All other inputs have to be set to “0”. Some examples are shown below:

60-2-2 settings



60-2 settings

36-1 settings

In-car, double tooth

Sensors serving TTL signal level should be connected to the CDM-A input. Inductive sensor must be connected to CA input. This input includes the signal conditioning for this types of sensor with settable trigger level of 0.4 and 2 Volt. The input voltage must be higher than this threshold level to be recognized. Please refer to chapter **Sensors and the signal shapes** for getting more information about this sensor type.

Sensors with one double tooth (or multiple teeth) can be defined just by typing in the number of teeth (without the doubles) and number of doubles. Above the settings for a 36+1 sensor are done.