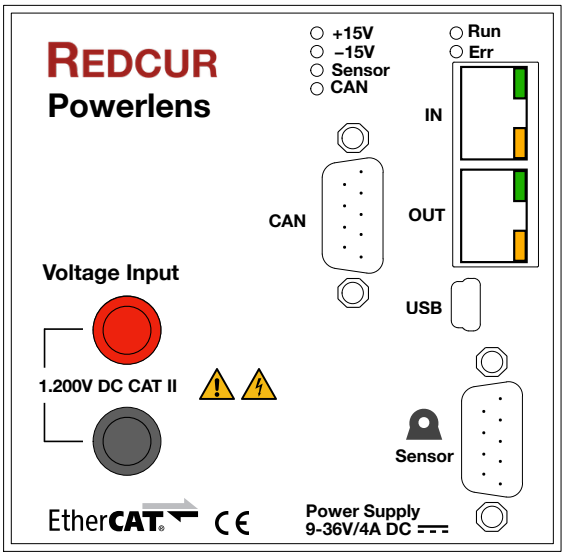
# REDCUR

## Powerlens Manual

Measure Voltage, Current, Charge and Energy based on SIGNALTEC/LEM High Precision Current Transducers and High Precision Voltage Acquisition Technology with **EtherCAT** and **CAN Bus** Interfaces.



# Table of Contents

# General Information

This document is exclusively meant for experts in automation engineering. Please use this document for installation and taking the device into service.

EtherCAT® is a registered trade mark and patented technology licensed by Beckhoff Automation GmbH, Germany.

Redcur GmbH is a member of the EtherCAT Technology Group (ETG) (vendor id Vendor ID 0x00000B19). The conformance of the ECC with the EtherCAT protocol was verified with the EtherCAT Conformance Test Tool (CTT) of Beckhoff.

# Installation Warning

**To prevent possible electrical shock, fire, or personal injury, do not apply more than the rated voltage, between the terminals or between each terminal and earth ground!**

**The Product should only be used to measure sources up to 1.200V DC that are protected from short circuit with current limiting to 200mA or less and comply to Overvoltage Category II.**

# Variants to fit SIGNALTEC/LEM transducers

Redcurs Powerlens is a DC measurement system, dedicated for SIGNALTEC CT series current transducers. The CT series is the ultra high precision derivative of LEM's renown current sensing technology.

**Variants of Powerlens exist to cope the different specifications of SIGNALTEC transducers. Please check if your Powerlens fits the transducer you are using. Improper combination of transducer and Powerlens may seriously damage both components. The following table shows the dependencies:**

| Variant | Suitable Transducer |
|---|---|
| PL-CT100 | CT100 |
| PL-CT200 | CT200 |
| PL-CT400 | CT400 |
| PL-CT500 | CT500 |
| PL-CT1000 | CT1000 |
| PL-CT2000 | CT2000 |

In the PL-xxxx notation the "xxx" stands for the current transducer type.

# Highlights

- 24-Bit ADCs with **Clock-Sync Sampling** of I and U and P
- Counters for Electric Charge (ΔQ, Q+, Q-) and Energy (ΔW, W+, W-)
- $I_{max}$ +/-2.000 A (with CT-2000)
- $U_{max}$ +/-1.200 V - Single Range

- Included Power Supply for Current Transducer
- EtherCAT Interface
- CAN Bus interface
- 5kV Isolation Rating
- Calibration Service (optional)
- Supports SIGNALTEC/LEM high precision CT series
- Transducer Overload Protection
- Power Supply 9-36V DC

# Standards/Compliance

- EtherCAT®
- CAN Bus ISO 11898
- EMC Emission and Immunity: EN 61326-1:2013
- Health and Safety: EN 61010-1:2010 / EN 61010-2-030:2010
- RoHS: EN IEC 63000:2018

# Specification

## Mechanical/Electrical/Environment

| | |
|---|---|
| Power Supply | 9-36V DC - 4A |
| Power Consumption | 5W + Current Sensor see www.signaltec.de (max. 50W) |
| Mounting | DIN Rail |
| Weight | 0.35kg |
| Dimensions (HxWxD) in mm | 100x90x110 |
| Maintenance Interface | Mini USB 2.0 (Type B) - no specific SW required |
| Altitude | maximum 2.000m, operational |
| Temperature operation/storage | +5°C to +40°C / +5°C to +60°C |
| Relative Humidity | 0% to 70%; non-condensing |
| Pollution Degree | 2 |

## EtherCAT

| | |
|---|---|
| EtherCAT Cycle Time | 50µs -100ms |
| Measurement Content | - Current Avg plus max. 8 oversampling values<br>- Voltage Avg plus max. 8 oversampling values<br>- Power Avg<br>- Electrical Charge Counter (Q+, Q-, ΔQ)<br>- Electrical Energy Counter (W+, W+, ΔW) |
| Counter Management | MeterStop (1: Stop Count, 0: Counting)<br>MeterReset (0 -> 1 Reset Counters) |
| Decoding | ESI File |
| Configuration | CoE |
| Interface | 2xRJ45 |

| | |
|---|---|
| Isolation Voltage | 1.5kVrms |
| System Indicators | Operational Status of Current Sensor<br>Overrun Detection of ADCs |

## CAN Bus

| | |
|---|---|
| CAN Bus Speed | Configurable up to 1Mbps |
| Measurement Cycle | Configurable range from 1ms to 2s |
| Measurement Content | - 0x530: Current Avg, Voltage Avg, Sensor Status<br>- 0x540: Power Avg<br>- 0x570: ΔQ, ΔQ<br>- 0x580: Q+, Q-<br>- 0x590: W+, W+<br>- 0x5A0: Runmode (0: Normal Operation, 1: Shows dummy values for Uavg (100V) and Iavg (60A); counters run with dummy values! |
| Counter Management | - 0x550: MeterStop (1: Stop Count, 0: Counting)<br>- 0x560: MeterReset (0 -> 1 Reset Counters) |
| Decoding | DBC File |
| Interface | D-SUB9 Male (Pin 2: CAN_L, Pin 3: CAN_GND, Pin 7: CAN_H) according to CiA DS-102 |
| Isolation Voltage | 5kVrms |
| System Indicators | Operational Status of Current Sensor |
| Configuration | USB interface |

## Current Measurement

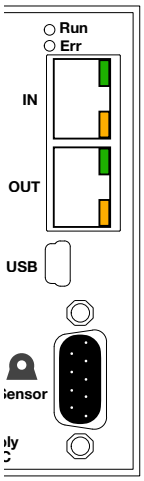
| | |
|---|---|
| A/D Conversion | 24 Bit signed **ΔΣ** (Delta-Sigma) ADC |
| Current Sensor Connection | Proprietary 9-pin D-Sub |
| Accuracy | 0.005% of Measuring Range |
| Filtering | Lowpass ~0.5 x ADC Data Rate (Anti Aliasing) |
| Current Sensors | Please visit www.signaltec.de for specifications |
| | |

## Voltage Measurement

| | |
|---|---|
| Measurement Voltage Range | -1.200VDC to +1.200VDC |
| Overvoltage Category | II |
| Input Impedance | > 10MΩ \|\| 5pF (Freqeuency Compensated) |
| Phase Shift | < 0.2° @ 1200Hz |
| A/D Conversion | 24 Bit signed **ΔΣ** (Delta-Sigma) ADC |

| | |
|---|---|
| Connectors | ⌀ 4mm Sockets - Touch-Protected (IEC/EN 61010-1) |
| Isolation Rating Voltage | 5kVrms |
| Accuracy | 0.005% of Measuring Range |
| Filtering | Lowpass ~0.5 x ADC Data Rate (Anti Aliasing) |

# Hardware Installation




**RJ45 connectors (IN/OUT)**
- IN Connect to the EtherCAT master or previous EtherCAT slave
- OUT Connect to the next EtherCAT slave

Through these connectors only EtherCAT traffic can be handled!
To connect use a standard Ethernet cable.

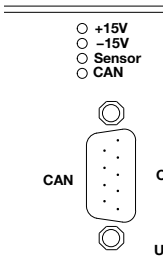
**USB Mini Type B**
For maintenance only - not a end user interface

**9-pin DSUB female connector**
- Power Supply to the current transducer
- Overload Indication/Protection
- Secondary Current Sink Circuitry

To connect use the proprietary D-SUB9 cable delivered with the transducer.
The following restrictions apply to the cable length:

| Length | Wire Cross Section (minimum) |
|---|---|
| ≤ 5 m | 0,34 mm² |
| > 5m ≤ 10m | 0,75 mm² |
| > 10m | **Not supported!** |

**CAN Bus Interface**
The CAN Bus of the Powerlens is exposed through a D-SUB9 male connector. The pinout is according to CiA DS-102:

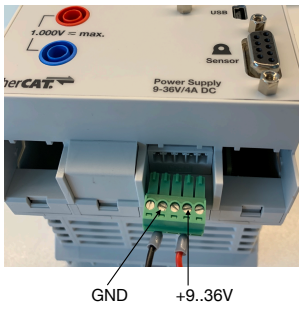



Pin 2: CAN_L
Pin 3: CAN_GND
Pin 7: CAN_H

The solid green CAN LED indicates that a CAN interface is connected and synchronised.
A DBC file is available for integration. As a default Powerlens uses the CAN message ID 0x530 (8 bytes long) as described below:

- Current Average (signed 24 Bit, little endian)
- Voltage Average (signed 24 Bit, little endian)
- Sensor Status (1 Bit): 0 - “Not Connected”, 1 - “Connected”
- Reserverad (15 Bit) Reserved

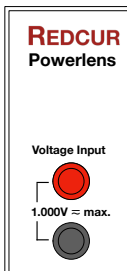
**Power Supply 9-36V DC**
To be installed by authorised and educated personnel only!
**Please use the 5-pin connector (Type Phoenix MC 1,5/ 5-ST-3,5) which is part of the delivery!**



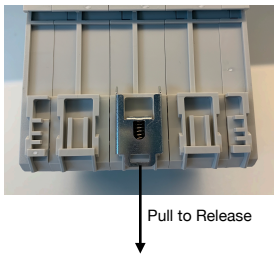

**Pin 2: GND**
**Pin 4: +9..36V**
**Pin 1,3,5: NC**

After powering on the mains power supply the system is active.
For analysis of the Powerlens state please refer to the section “Meaning of LEDs” below.

**Voltage Input**
The voltage measurement input is available as ⌀ 4mm Sockets rated for 1000Vrms. Please use only suitable cables and connectors (e.g. Stäubli XL-410). The voltage measurement system is able to handle up to 1500V peak voltages and is isolated to the rest of the Powerlens system for up to 5kVrms. It can withstand up to 12.8kV surges.




**DIN-Rail Installation**
The Powerless is DIN-rail mountable. Use the rear side to easily snap-on the device.




CAUTION: To allow free convection from top and bottom of the chassis.

**SIGNALTEC/LEM Transducer**
Please refer to the documentation of SIGNALTEC on www.signaltec.de for the proper installation process.

Warning
Primary current in an unpowered current transducer can lead to destruction of the transducer!

The current transducer is to be connected with Powerlens by the delivered proprietary D-SUB9 cable.


# Meaning of LEDs
The Powerlens front has six LEDs with the following meaning:

| LED | Color | Status | Meaning |
|---|---|---|---|
| +15V | green | off | The +15V operating voltage for current sensor is not generated. System not usable. |
| | | on | +15V for current sensor available. Also to be considered as a general “POWER ON” indication. |

| LED | Color | Status | Meaning |
|---|---|---|---|
| -15V | green | off | The -15V operating voltage for Current Sensor is not generated. System not usable.<br>Also to be considered as a general “POWER ON” indication. |
| | | on | -15V for current sensor available. |
| Sensor | green | blinking | Sensor not connected or Operational Error of the Current Sensor |
| | | solid | Sensor connected |
| CAN | green | off | Indicates one of the following<br>- No CAN Bus connected<br>- Not synchronized<br>- CAN Bus congestion |
| | | solid | CAN Bus connected and synchronised |
| RUN | green | off | INIT* |
| | | blinking | PREOP* |
| | | single flash | SAFEOP* |
| | | solid | OP* |
| ERR | red | off | No Error |
| | | blinking | Configuration Error |
| | | single flash | Runtime Error |
| | | double flash | Watchdog Error |

*)State of EtherCAT State Machine

# Measurement Concepts

## Principal Measurement Inputs

1. **Current Measurement** - the secondary current of the Current Transducer is turned into voltage through a high precision shunt resistor. That voltage is digitized by a 24-Bit **ΔΣ** (Delta-Sigma) ADC. The ADC allows on-chip calibration of offset and gain.
2. **Voltage Measurement** - a frequency compensated voltage divider transfers the input voltage to the appropriate ADC voltage level. The same type of ADC is used as for the Current Measurement. The two ADCs are run from the same clock produce their samples fully synchronized.
3. **Clock** - for the integration of Current over time and Current x Voltage over time a precise clock is required. The on-board oscillator is used that where the deviation is measured during in-house calibration and used in the firmware.

## Creation of Average Measurements for EtherCAT and CAN Bus

**Applies to: Iavg, Uavg, Pavg**

The average values reported via EtherCAT and CAN Bus are created upon every EtherCAT/CAN cycle. That means, the ADC samples between EtherCAT/CAN cycles stored and as soon the reporting of the measurement becomes due, the average value is computed.

**Note:** The Powerlens allows the simultaneous reporting of results via EtherCAT and CAN Bus based on different cycles. But, Powerlens has only one set of ADC samples that will be reset after building averages. In case of simultaneous usage of EtherCAT and CAN the averaged values consist of an unpredictable number of ADC samples. Therefore, the usage of only one interface at a time is recommended.

### Creation of Oversampling Values for EtherCAT

**Applies to: I(ma)[x], U(mV)[x]**
The EtherCAT oversampling values are not averaged but direct ADC values. The algorithm to fill the oversample values is adaptive and ensures that they are timely equidistant.

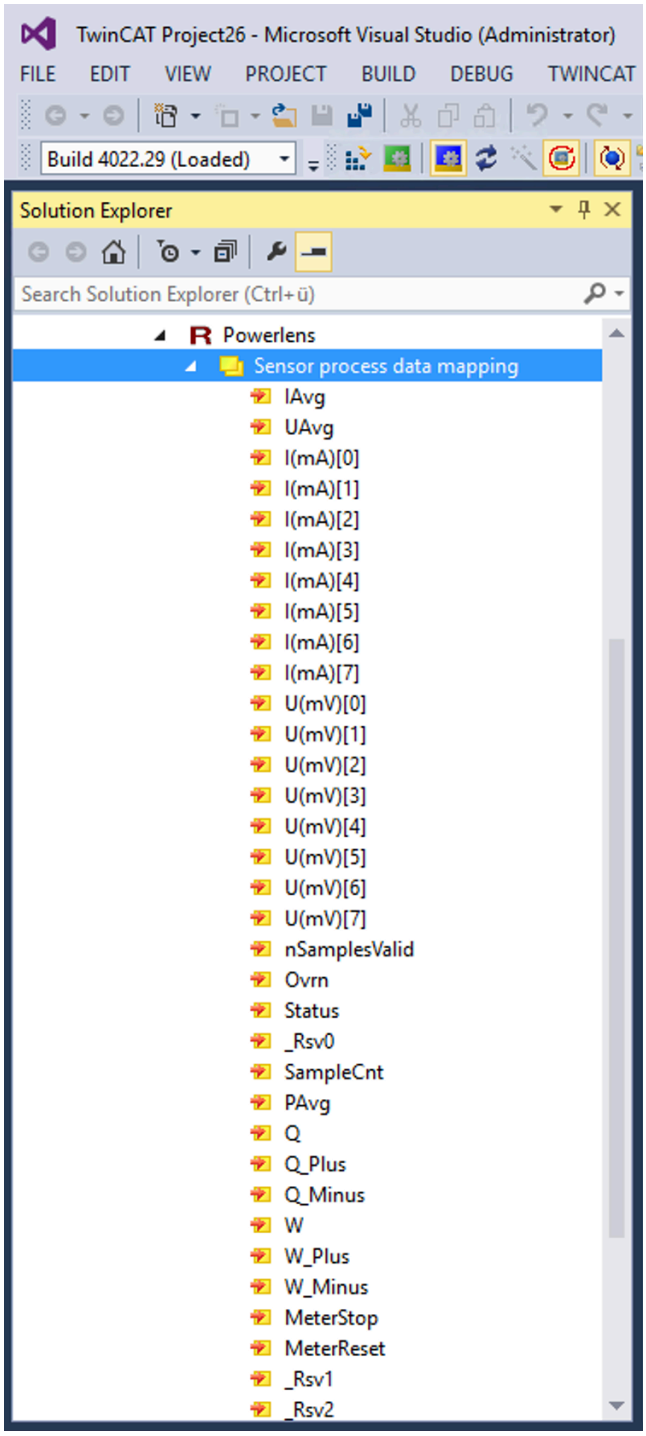
### Creation of Time Integrated Measurements for EtherCAT and CAN Bus

**Applies to: Q_plus, Q_minus, Q, W_plus, W_minus, W**
The time integrated values (counters) are updated upon each ADC value independent from any external interface. Upon cycle time from EtherCAT or CAN the current values of the counters are reported.

## Bringing into Service on EtherCAT

The Powerlens device implements an EtherCAT slave device and has no proprietary front end software. For integration into an EtherCAT system a  EtherCAT Slave Information (ESI) file is provided by Redcur. The following screenshots are taken from a TwinCAT 3.1 Master system.

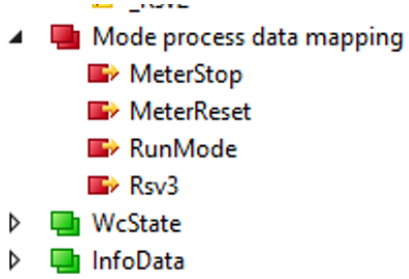
After powering up the system and the proper detection in the EtherCAT master SW the device's data mapping should show up as depicted below.


TwinCAT Project26 - Microsoft Visual Studio (Administrator)
FILE
EDIT
VIEW
PROJECT
BUILD
DEBUG
TWINCAT
Build 4022.29 (Loaded)
Solution Explorer
Search Solution Explorer (Ctrl+ü)
Powerlens
Sensor process data mapping
IAvg
UAvg
I(mA)[0]
I(mA)[1]
I(mA)[2]
I(mA)[3]
I(mA)[4]
I(mA)[5]
I(mA)[6]
I(mA)[7]
U(mV)[0]
U(mV)[1]
U(mV)[2]
U(mV)[3]
U(mV)[4]
U(mV)[5]
U(mV)[6]
U(mV)[7]
nSamplesValid
Ovrn
Status
_Rsv0
SampleCnt
PAvg
Q
Q_Plus
Q_Minus
W
W_Plus
W_Minus
MeterStop
MeterReset
_Rsv1
_Rsv2

## Sensor process data mapping

| Data Field | Data Type | Description |
|---|---|---|
| **IAvg** | DINT | Averaged current measurement in **mA**. The value is calculated as an arithmetic mean value of ADC samples of one EtherCAT cycle. |
| **UAvg** | DINT | Averaged voltage measurement in **mV**. The value is calculated as an arithmetic mean value of ADC samples of one EtherCAT cycle. |
| **I(mA)[x]** | DINT | A list of 8 current measurements in **mA**. **nSamplesValid** tells how many of them are valid and usable. The value is a single ADC sample - no average calculation applies. The values are equidistantly created within one EtherCAT cycle. |
| **U(mV)[x]** | DINT | A list of 8 voltage measurements in **mV**. **nSamplesValid** tells how many of them are valid and usable. The value is a single ADC sample - no average calculation applies. The values are equidistantly created within one EtherCAT cycle. |
| **nSamplesValid** | BYTE | Shows how many of the oversample values are valid. |
| **Ovrn** | BYTE | Indicator to if measured current is above limits. |
| **Status** | BYTE | Indicates the health of the Powerlens and current transducer<br>**0x00**: Busy - Powerlens is initialising, booting or calibrating; no measurement data is produced; this state should be non-permanent<br>**0x01**: OK - normal operation mode<br>**0x02**: Transducer offline - current transducer not connected or shows error on status pins (see SIGNALTEC/LEM documentation for details)<br>**0x03**: Out of range - One or both AD converters indicate overrun, i.e. the input current or the voltage on the Powerlens is too high |
| **_RSV0** | BYTE | Used for data alignment - not to be used |
| **SampleCnt** | DINT | Number of samples since device start |
| **Pavg** | REAL | Averaged power measurement. This value is provided for convenience and build from **Iavg** x **Uavg**. |
| **Q** | REAL | Difference of **Q_Plus** and **Q_Minus** in **As** |
| **Q_Plus** | REAL | Accumulated positive electrical charge since last reset in **As** |
| **Q_Minus** | REAL | Accumulated negative electrical charge since last reset in **As** |
| **W** | REAL | Difference of **W_Plus** and **W_Minus** in **Wh** |
| **W_Plus** | REAL | Accumulated positive electrical energy since last reset in **Wh** |
| **W_Minus** | REAL | Accumulated negative electrical energy since last reset in **Wh** |
| **MeterStop** | BYTE | Reflects the current value of the **MeterStop** variable |
| **MeterReset** | BYTE | Reflects the current value of the **MeterReset** variable |
| **_RSV1, _RSV2** | BYTE | Used for data alignment - not to be used |

## Mode Process Data Mapping




| Data Field | Data Type | Description |
|---|---|---|
| **MeterStop** | BYTE | Writable parameter to start/stop the Q,W counters. |
| **MeterReset** | BYTE | Writable parameter to control the Q,W counters. |

The principle function and system behavior of MeterStop / MeterReset are shown in the following table:

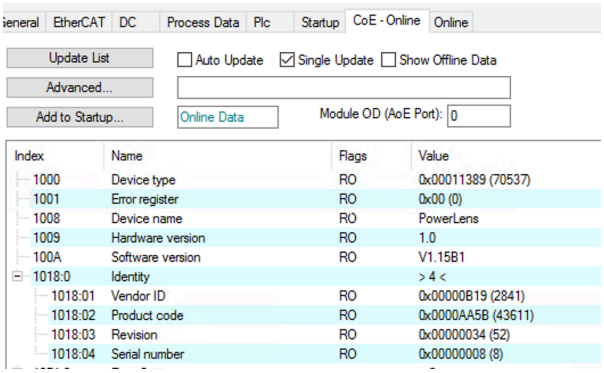
| | Counters running | Counters stopped |
|---|---|---|
| **MeterStop : 0** | Counters keep running | Counter start running based on the last values. |
| **MeterStop : 1** | Counters stop and keep reporting the last values | No effect |
| **MeterReset : 0->1** | Counters reset to 0 and immediately start counting again | Counters reset to 0 |
| **MeterReset : 1->0** | No effect | No effect |

| Data Field | Data Type | Description |
|---|---|---|
| **RunMode** | BYTE | 0 : Normal Operation<br>1 : Device shows dummy values for all U (100V) and all I (60A) to support integration of Powerlens devices; counters for Q and W run with the dummy values |

# CoE Parameters

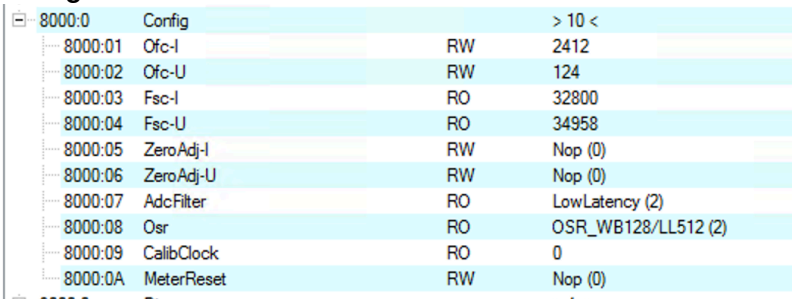
Below the meaning of the Powerlens specific CoE parameters are explained. Where possible the values of the parameters and variables are defined in ENUM types and relevant information can be obtained on the graphical user interface.

**Informational Parameters**




| Parameter | Description |
|---|---|
| **Device type** | Defines the CoE profile |
| **Error register** | Error code register |
| **Device name** | “PowerLens” |
| **Hardware version** | Numeric version of the hardware |
| **Software version** | Version of the FW |
| **Vendor ID** | Redcur EtherCAT Vendor ID 0xB19 |
| **Product code** | Numeric code of the Powerlens product (0xAA5B) |
| **Revision** | Numeric revision of the FW used for ESI file |
| **Serial number** | Serial number of the device |

### Config Parameters



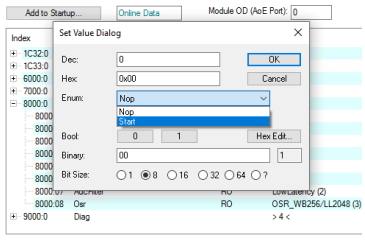

| Parameter | Description |
|---|---|
| **Ofc-I** | Offset of the measured current. The unit is in ADC values. This value can be edited by the user. Changing this value takes immediate effect. See “Adjusting the offsets” for details. |
| **Ofc-U** | Offset of the measured voltage. The unit is in ADC values. This value can be edited by the user. Changing this value takes immediate effect. See “Adjusting the offsets” for details. |
| **Fsc-I** | Gain setting for measured current. This value is set properly upon manufacturing to calibrate the device for the shunt resistor, operational amplifiers etc.. |
| **Fsc-U** | Gain setting for measured voltage. This value is set properly upon manufacturing to calibrate the device for the shunt resistor, operational amplifiers etc.. |

| Parameter | Description |
|---|---|
| **ZeroAdj-I** | Trigger for automated offset setting for current measurment. User should use this parameter to adjust the offset instead of the **Ofc** parameter. See “Adjusting the offset” for details. |
| **ZeroAdj-U** | Trigger for automated offset setting for voltage measurment. User should use this parameter to adjust the offset instead of the **Ofc** parameter. See “Adjusting the offset” for details. |
| **AdcFilter** | Shows the activated filter in the circuitry. This value is set during manufacturing. In the case shown above the “Low Latency” Filter is used. |
| **Osr** | Oversampling Rate of the ADC. In the given case we use a 2048 oversampling rate as the Low Latency (LL) filter is active |
| **CalibClock** | Calibration of the internal clock - currently no exposed via CoE |
| **MeterReset** | Trigger the reset of the Q,W counters. |

**Adjusting the offset for current measurement (ZeroAdj-I)**
Over time or when replacing the SIGNALTEC/LEM transducer it might be necessary to adjust the offset. In principal there are two ways to do that.
1. Editing the CoE parameter **Ofc-I.**
2. Using the Automated offset setting capability of the Powerlens, using the **ZeroAdj-I** parameter.

For both ways it is important to prepare the system by a) attaching the current transducer and check that it is properly powered on and b) to make sure there primary current is 0.

For method 2 double click on **ZeroAdj-I** and set the value in the Enum field to “Start”.

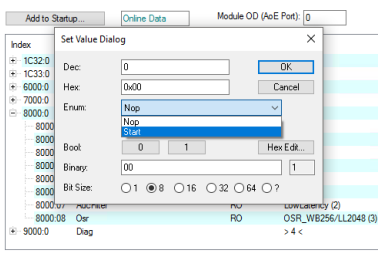



Powerlens will basically do what is described as method 1 in the background.

**Adjusting the offset for voltage measurement (ZeroAdj-U)**
Over time it might be necessary to adjust the offset for the voltage measurement system.
1. Editing the CoE parameter **Ofc-U.**
2. Using the Automated offset setting capability of the Powerlens, using the **ZeroAdj-I** parameter.

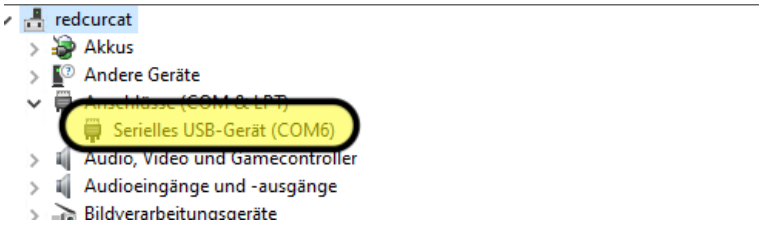
For both ways it is important to prepare the system by shorting the voltage input to ensure exactly 0V.

For method 2 double click on **ZeroAdj-U** and set the value in the Enum field to “Start”.

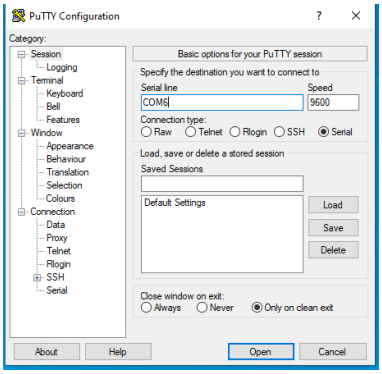


# Bringing into Service on CAN Bus

To connect Powerlens to a CAN bus system you need to connect the CAN bus interface. The parameters for CAN can be configured via the USB interface of Powerlens. Set up a connection with a USB cable to your desktop computer. After connecting the USB a serial device should show up in the system device manager - COM6 in the example below.




To access Powerlens via USB use a SW application to set up a serial communication, e.g. PuTTY using the serial device.




The application window will pop up and after typing <RET> you will see the greeting "`PLNS App Version: xxx`" command prompt >>.

```
PLNS App Version:V1.15B1/30.03.2021 Sn:00000009

>>
```

```
PLNS App Version:V1.15B1/30.03.2021 Sn:00000009

>> set
VERSION V1.15B1
ADCCLK 16000300
SERIAL 9
FILTER 2
OSR 2
UFSC 0x8889
UOFC -143
UMULT 1478823
IFSC 0x8041
IOFC 3712
IMULT 1250000
RATIO 1500
SHUNT 750
CANID 0x530
CANBAUD 500
CANMODE 0
CANCYCLE 100
IZERO 0
UZERO 0
>>
```

The command SET is used to read and write system parameters. A SET command without argument shows all system parameters.

The following CAN parameters can be configured:

- Baudrate
- Message ID
- Measurement Cycle

**Baudrate - CANBAUD**
To change the CAN baud rate enter `SET CANBAUD <xxx>` while `xxx` ist the baud rate in kbps.
For example `SET CANBAUD 1000` sets the baud rate to 1000kbps.
The following baud rates are possible: 50k…1000k whereas to avoid congestion on the CAN bus the minimum baud rate should be 160kbps!
The command will take immediate effect.

**Message ID - CANID**
The default base message ID is 0x530 which can be changed with the command `SET CANID <xxx>`.
For example `SET CANID 230` will set the CAN base ID to 0x230.
**Please note that the other message IDs (0x540 - 0x590) will be moved accordingly!**
In the above example they would be 0x240 - 0x290. Upon changing the base ID the DBC-File needs to be adapted to ensure proper decoding.
After changing the CAN message id the system needs a power cycle to activate the change.

**Measurement Cycle - CANCYCLE**
The default measurement cycle is 500ms. It can be changed with the command `SET CANCYCLE <xxx>` while xxx is the cycle time in milliseconds.
For example `SET CANCYCLE 50` will change the measurement cycle to 50 ms.
The range of valid cycle times is 1…2000.
The command will take immediate effect.

**Note:** The Messages 0x530 and 0x540 are sent upon every cycle defined in CANCYCLE. But, with every cycle only one of the messages 0x570, 0x580 and 0x590 are sent - in turn.

**Redcur GmbH**
**Reutersbrunnenstraße 27**
**90429 Nürnberg**
**Germany**

**info@redcur.com**
**www.redcur.com**