Energy Measuring Module with VARAN DEE 021

The energy measuring module is used to record power and energy. This module measures the voltages from the 3 input phases (L1, L2 and L3). Additionally, up to 12 currents are also recorded. The currents can be arbitrarily assigned to the phases

The voltages are connected directly, the currents however, must be connected through the output of a current transformer with 1 A rms output.

With the module, the CAN bus and DIAS bus can communicate using VARAN.

Energy Measuring Module Functions

General calculations

- Current inputs can be enabled/disabled
- Current inputs can be assigned to any voltage input
- Voltage monitor
- Current monitor
- Voltage phase sequence monitor
  Monitoring the phase position (P each configured channel is positive / monitoring can be enabled/disabled through the application)
- Frequency monitor (min/max/actual // min and max can be set to actual on command)
- Calculation of V_{eff} and I_{eff} for each channel
- Detection of short power interruptions (threshold value to V_{eff})
- Indicate 0-crossing for the application (e.g. for synchronized phase measurements, as with monitoring heating currents)
- Energy usage since the initial activation (null voltage memory) [kWh]
- Energy usage can be reset (null voltage memory) [kWh]
- Total value: P and Cos φ with ohmic/inductive load and ohmic/capacitive load
- Indication of whether the load is capacitive or inductive (3)

Contents

Event triggered calculations

The evaluation time windows can be set as desired with the Cycle Run and Cycle Start bits.

The following functions can be analyzed over all channels:
- Cos(Phi) with ohmic/inductive or ohmic/capacitive load
- Energy use [Ws]
- Energy use per shot weight [Ws/g]
- Maximum power [W]

The following functions can be analyzed over every voltage channel:
- Veff [V]

The following functions can be analyzed over every current channel:
- Cos(Phi) with ohmic/inductive and ohmic/capacitive load
- Ieff [A]
- Power [W]
- I_{Peak} [A]

Osci

The oscilloscope function is implemented for 4 selectable channels/parameters with a variable time base.

Trigger functions:
- Positive edge
- Negative edge
- Force trigger
- Buffer full

Technical Data

Performance Data

Interfaces	1 x VARAN In (RJ45) (maximum cable length:100 m) 1 x VARAN Out (optional Ethernet (VtE)) (maximum pipeline length: 100 m) 1 x CAN 2 x DIAS 3 x voltage 12 x current

Electrical Requirements

Supply voltage	18 – 30 V DC	
Current consumption of power supply at +24 V DC	Typically 110 mA	Maximum 130 mA
Current consumption of power supply at +24 V DC (UL)	maximum 120 mA	

USA and Canada only:
The device was tested in accordance with the UL508 Norm as a low voltage limited power circuit (LVLC - limited voltage/limited current).
To meet the standard requirements, the device must be powered from an galvanically separated transformer (24 V DC) with a UL-certified fuse (UL248) in the secondary circuit. The maximum rated current is 4 A. Alternatively, a class 2 power supply can be used.

Voltage inputs

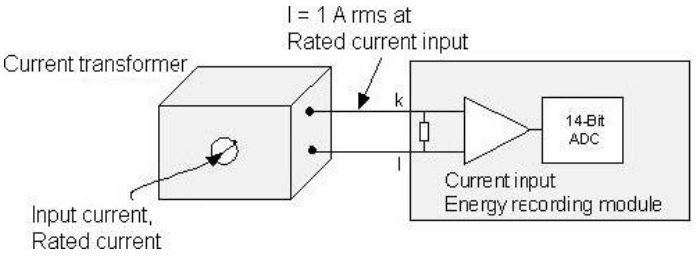
Number of channels	3
Measurement range	up to 500 to V AC
Measurement value	-8000 ... +8000
Resolution	14-bit
Scan rate	50 µs
Analog measurement precision	0.65% of maximum measurement value

The phases can be connected directly to the energy measuring module. Internally, the module has galvanic isolation

Current inputs

Number of channels	12
Measurement range	Up to 1 A rms
Measurement value	-8000 ... +8000
Resolution	14-bit
Scan rate	50 µs
Analog measurement precision	0.6% of maximum measurement value

The current inputs must be connected to the current transformer. The maximum input current of a channel must therefore be limited to 1 A rms.



Miscellaneous

Article number DEE 021	05-068-021
Hardware version	1.x
Standard	UL508 (E247993)

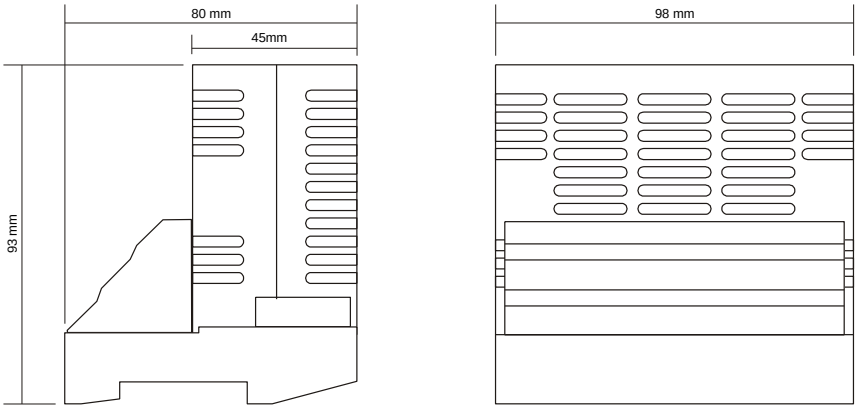
Article number DKL 361	05-024-361
Mechanical coding	| 1 | 2 | 3 | 4 | 5 | | 7 | |

Connector set article number DKL 361-Z	05-024-361-Z1

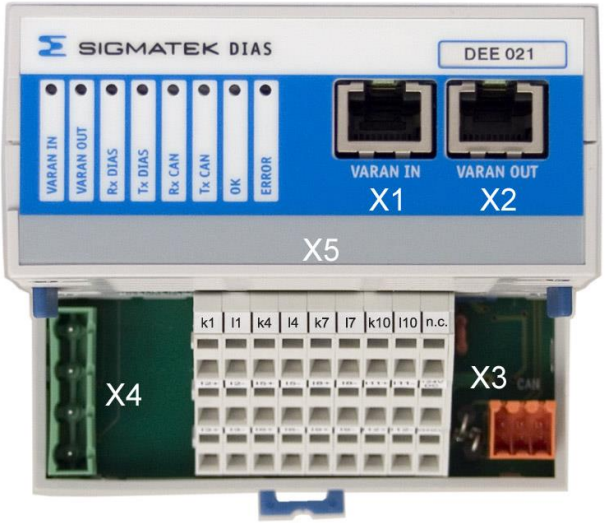
Environmental Conditions

Storage temperature	-20 – +85 °C	
Environmental temperature	0 – +60 °C	
Humidity	0 - 95 %, non-condensing	
EMC stability	in accordance with EN 61000-6-2 (industrial area)	
Shock resistance	EN 60068-2-27	150 m/s²
Protection type	EN 60529	IP 20
Protection Type (UL)	open type device	
Pollution degree	2	

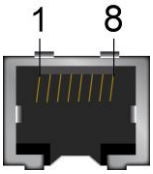
Mechanical Dimensions



Interfaces

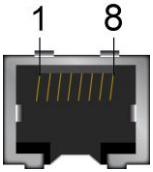


X1: VARAN In 8-pin RJ45



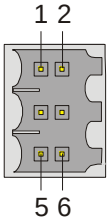
Pin	Function
1	TX+/RX+
2	TX-/RX-
3	RX+/TX+
4	-
5	-
6	RX-/TX-
7	-
8	-

X2: VARAN Out (8-pin RJ45)



Pin	Function
1	TX+/RX+
2	TX-/RX-
3	RX+/TX+
4	-
5	-
6	RX-/TX-
7	-
8	-

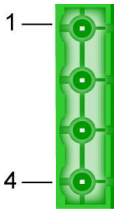
X3: CAN Bus Terminal (6-pin Weidmüller plug)



Pin	Function
1	CAN A
2	CAN B
3	CAN A
4	CAN B
5	GND
6	n.c.

Applicable mating connectors: Weidmüller B2L 3.5/6
Manufacturer article number: 172756

X4: Voltage Inputs (4-pin Phoenix plug 7.5 mm)

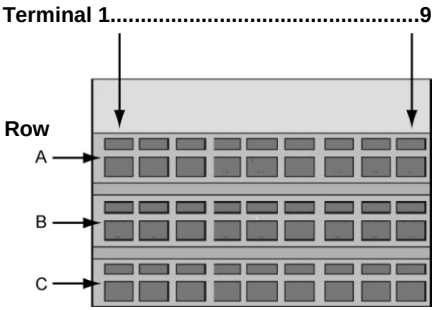


Pin	Function
1	N
2	L1
3	L2
4	L3

Applicable mating connectors: Phoenix GMSTB 2.5/4 ST
Manufacturer article number: 1766903

The complete connector set DKL 361-Z1 is available from Sigmatek under the article number 05-024-361-Z1.

X5: Current inputs / supply voltage (27-pin spring terminal block)

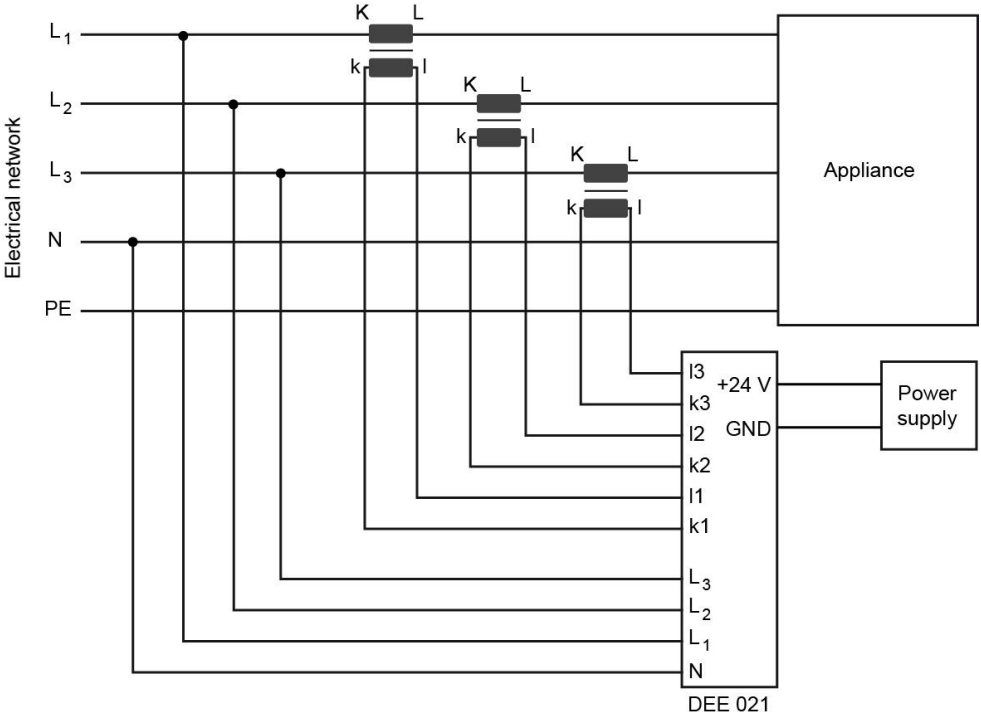


Terminal	1	2	3	4	5	6	7	8	9
Row a	k1	I1	k4	I4	k7	I7	k10	I10	n.c.
Row b	k2	I2	k5	I5	k8	I8	k11	I11	+24 V DC
Row c	k3	I3	k6	I6	k9	I9	k12	I12	GND

To ensure error-free function, all analog signal lines between the current converter and current inputs must be shielded! The shielding must be located at control cabinet entrance!

The DKL 361 voltage must be turned off before the DEE 021 is connected or disconnected. (X4 … 400 V voltage inputs, X6 … DIAS IN)

Wiring example for record the energy use of a 3-phase load



Connectors	Type	Wire Size	Max. Tightening Torque
X1	RJ 45	-	-
X2	RJ 45	-	-
X3	B2L 3.5/6	0.13 - 1.0 mm^2 28 - 18 AWG (UL/CSA)	Spring terminal
X4	GMSTB2.5/4-ST	0.2 - 2.5 mm^2 30 - 12 AWG (UL), 28 - 12 AWG (CSA)	0.5 – 0.6 Nm
X5	-	0.2 - 2.5 mm^2 26 - 12 AWG (UL), 28 - 12 AWG (CSA)	-

Use copper conductors only!

VARAN-Bus

The VARAN Out port allows the construction of the VARAN bus in a line structure.

The VARAN Out port has automatic Ethernet recognition. If the VARAN Out is connected to an Ethernet participant, it is automatically changed to an Ethernet port.

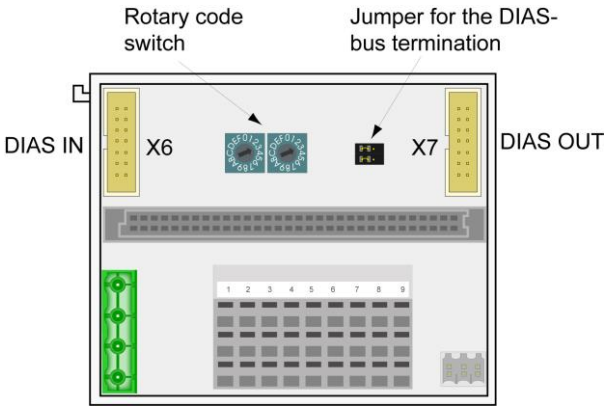
Incoming Ethernet packets are, similar to using a HUB, distributed to all other Ethernet ports in the VARAN bus system and the VARAN manager (and therewith the CPU) with VtE.

DIAS bus

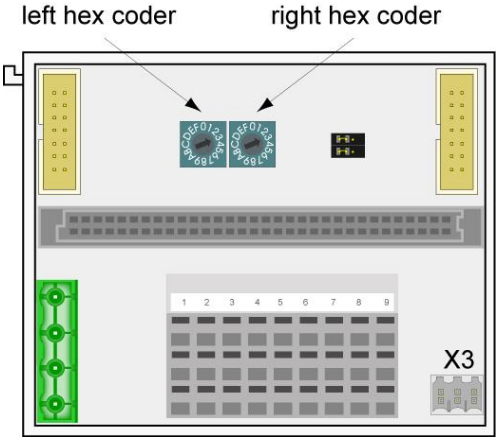
The station number can be set from 1 (16#01) to 60 (16#3C) for each bus system with 2 rotary code switches Each station number can only be assigned once in their respective bus systems.

On the last function module in a DIAS system, the bus must be terminated. This guarantees error-free data exchange without reflection. On the DKL 361 terminal block, these resistors are already available and must be activated using the jumpers.

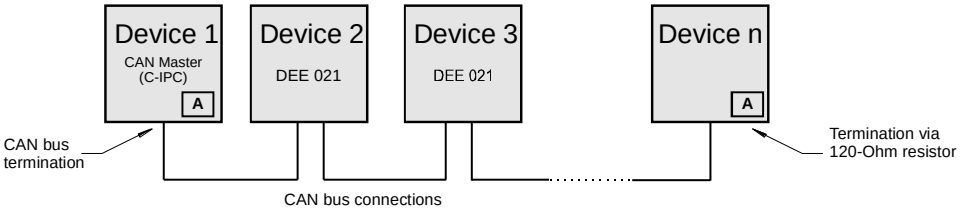
Address high	Address low	Station number
0	1	1
0	2	2
.	.	.
.	.	.
3	A	58
3	B	59
3	C	60



CAN Bus



In a CAN bus system, both end modules must be terminated. This is necessary to avoid transmission errors caused by reflections in the line.



A = termination resistor

If the DEE 021 is the end unit, the DKL 361 must be terminated (connector X3 incl. terminating resistor).

The CAN termination is made with a terminating resistor of 120 Ohms between CAN A and CAN B.

CAN Interface

The CAN interface implements a transport layer according to CiA (CAN in Automation), design specification 301. SDO transfer is supported only.

The standard setting is Baud rate 500000 and Node ID 1.

The Baud rate and Node ID are provided as parameter settings. The setting is made during installation via temporarily setting invalid DIAS addresses in the DKL 361. The micro controller in the DEE 021 analyzes these settings during start-up and permanently stores the changes in an EEProm in the DKL 361.

Setting the Baud Rate

To set the CAN baud rate remove the DEE 021 and set the left HEX switch to the value 'D' and the right HEX switch is then set to a value in the following baud rate table. In the next step, the DEE 021 is remounted and briefly supplied with power so that the micro controller can store the settings.

Switch setting	Baud Rate
0	615000
1	500000
2	250000
3	125000
4	100000
5	50000
6	20000
7	1000000
8	800000
9	Automatic detection

Setting the Node ID

The node ID is a value between 1 and 127. This range is divided into groups of 16 and in a 2-stage process; the group and the node within this group are stored sequentially.

To set the group, remove the DEE 021 and set the left HEX switch to the value ‚E' and the right HEX switch is then set to a value in the following baud rate table.

Switch setting	Node ID
0	0 to 15
1	16 to 31
2	32 to 47
3	48 to 63
4	64 to 79
5	80 to 95
6	96 to 111
7	112 to 127

After the DEE 021 is mounted and briefly supplied with power so that the micro controller could store the setting, the DEE 021 is removed again and the right HEX switch is set to the value 'F'. The left HEX switch is set to the offset, which results from the node ID of the smaller value from table above. Briefly turn the DEE 021 module on once more so that the value can be stored.

Switch setting	Offset
0	0
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
A	10
B	11
C	12
D	13
E	14
F	15

E.g.: Node ID 47:
Step ‚E' + ‚2' => 32 to 47
Step ‚F' + ‚F' => Offset 15

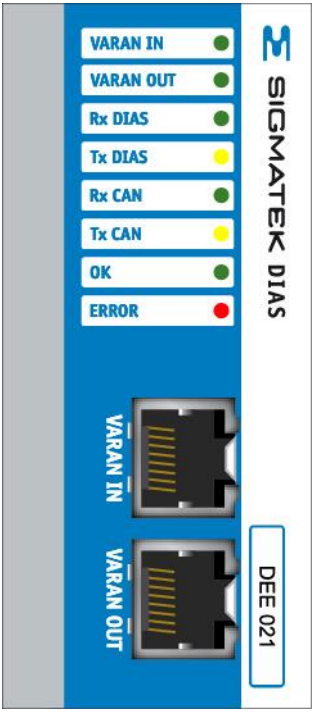
Node ID = 32 + 15 = 47

It is important to keep in mind that through this 2-stage process, invalid nod ID values are generated; these are not stored.

Since electronically, only 3 bits of the left HEX switch are analyzed, the switch settings 5, 6 and 7 are equally as significant as D, E and F.

After this setting procedure, the desired DIAS address can be set.

Status Displays

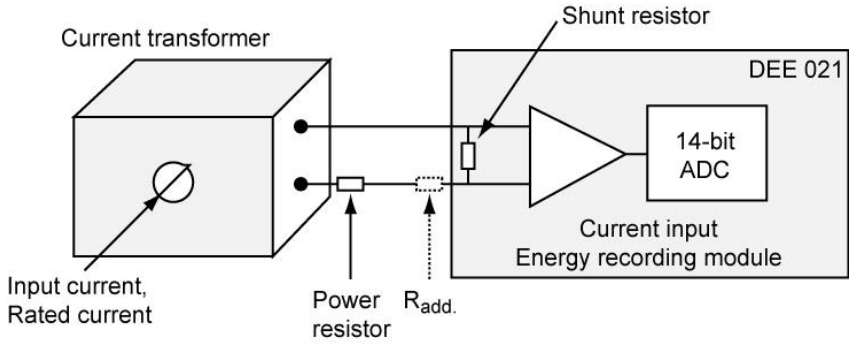


LED	Assignment	Color	Function
1	VARAN IN	green / yellow	Green: Link is established / yellow: VARAN bus active
2	VARAN OUT	Green / yellow	Green: Link is established / yellow: VARAN bus active
3	RX DIAS	green	Data is received on the DIAS bus.
4	TX DIAS	yellow	Data is sent on the DIAS bus.
5	RX CAN	green	Data is received on the CAN bus.
6	TX CAN	yellow	Data is sent on the CAN bus
7	OK	green	Blinks during regular operation
8	ERROR	red	Shines after switch-on/restart as long as regular operation is possible. Blinks slowly in case of internal EEPROM errors (regular operation partially possible). Blinks quickly in case of severe internal errors (no regular operation possible).

Considerations when Selecting the Current Transformer/Connection

In IEC600044-1, the precision of the current transformer is defined in the range of 25 % to 120 % of the nominal load. If the current transformer has less than 25% of the nominal load, the maximum allowed error can be exceeded.

With an additional ohmic load (resistor in series), the measurement precision can be improved.



Shunt resistance = 0.1 Ω

Nominal load at ideal nominal current = circuit resistance + shunt resistance (+ possible $R_{add.}$)

Example:

Current transformer with:
Secondary nominal current = 1 A rms
Maximum rated power = 1 VA
Nominal load = 1 Ω (0.1 Ω Shunt + 0.9 Ω line)

$$\text{Nominal load} = \frac{\text{Rated power}}{\text{Secondary current}^2} = \frac{1\ \text{VA}}{1\ \text{A}^2} = 1\ \Omega$$

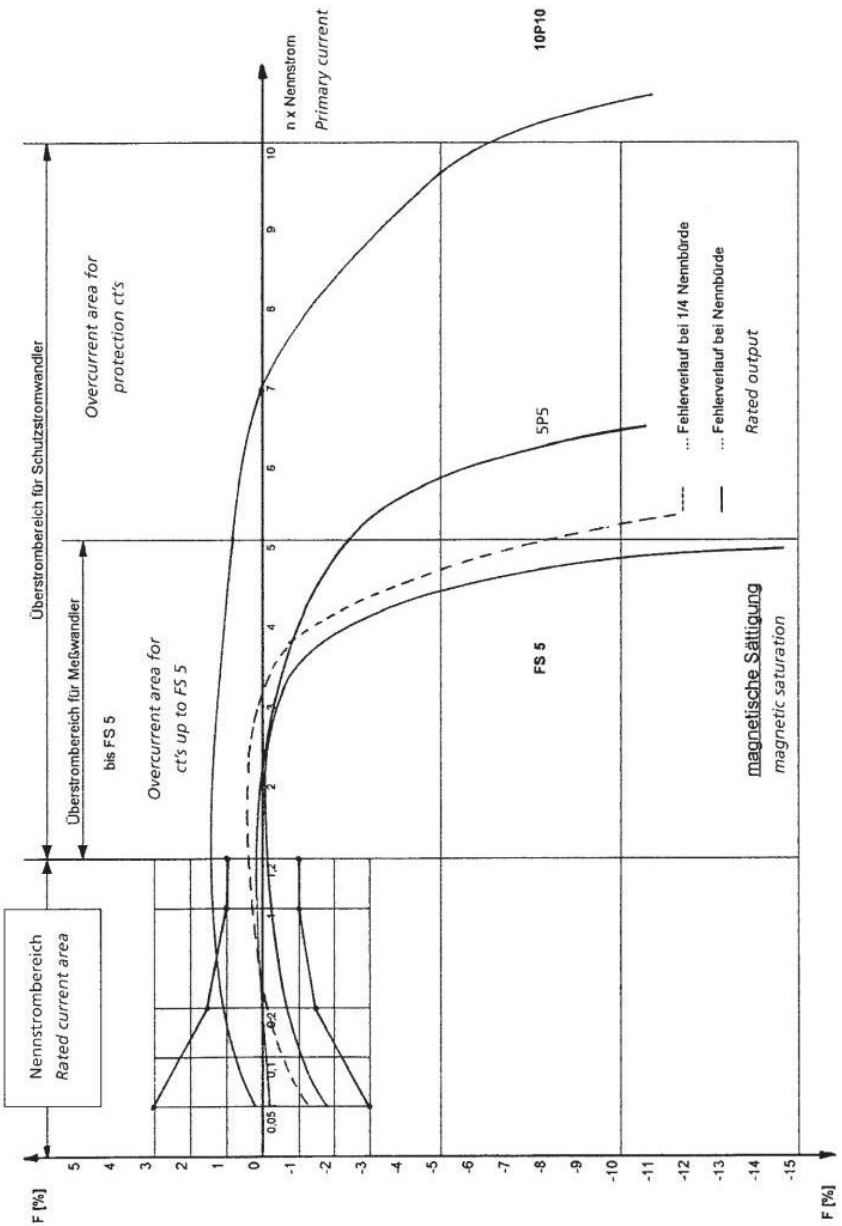
$$\text{Power resistance} = \frac{2 \times \text{wire length in m (forware and reverseline)}}{56 \times \text{wire cross section in mm}^2\ \text{(Copper)}}$$

$R_{\text{additional resistor}}$ = nominal load– circuit resistance- shunt resistance

$P_{add.}$ resistance = I_{N^2} * $R_{add.\ resistance}$

a

Error Curve of Low-Voltage Current Transformers



Description of the Current Transformer Terminals

The terminals for all primary windings are labeled with "K-P1" and "L-P2", the terminals for all secondary windings are labeled with the corresponding lower-case letters "k-s1" and "l-s2"

For current transformers with several secondary leads, the winding end "l" is then assigned an extra digit "l1", the leads are assigned sequential numbers "2", "3", etc. as the number of turns reduce. For differential transformers, with several independent primary windings, the individual windings before those identified with the capital letters "K" and "L" must be labeled with the capital letters "A", "B", "C", etc.

For example, "AK" – "AL" for the highest primary circuit, "BK" – "BL" for the second primary circuit etc.; or the transformation or transformation ratio of the individual primary windings to one another must be specified.

Recommended Shielding for VARAN

The VARAN real-time Ethernet bus system exhibits a very robust quality in harsh industrial environments. Using IEEE 802.3 standard Ethernet physics, the potentials between an Ethernet line and sending/receiving components are separated. In the event of an error, the VARAN Manager resends messages to a bus participant immediately. The shielding described below is mainly recommended.

For applications in which the bus is operated outside the control cabinet, the correct shielding is required. This is especially important, if due to physical requirements, the bus cables must be placed next to sources of strong electromagnetic noise. It is recommended to avoid placing VARAN bus lines parallel to power cables whenever possible.

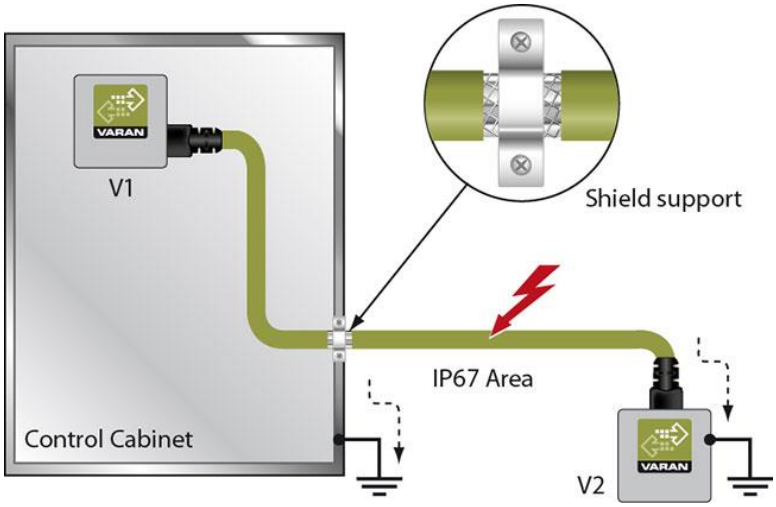
SIGMATEK recommends the use of CAT5e industrial Ethernet bus cables.

An **S-FTP bus cable**, which is a symmetric, multi-wire cable with unshielded pairs, is recommended for the shielding variants. For the entire shielding, a combination of foil and braiding is used. A non-laminated variant is recommended.

The VARAN cable must be secured at a maximum distance of 20 cm from the connector to protect against vibration!

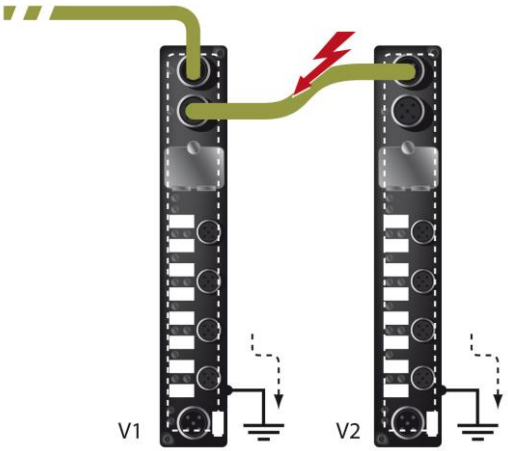
1. Wiring from the Control Cabinet to External VARAN Components

If the Ethernet lines are connected from a VARAN component to a VARAN node located outside the control cabinet, the shielding should be placed at the entry point of the control cabinet housing. All noise can then be deflected from the electronic components before reaching the module.



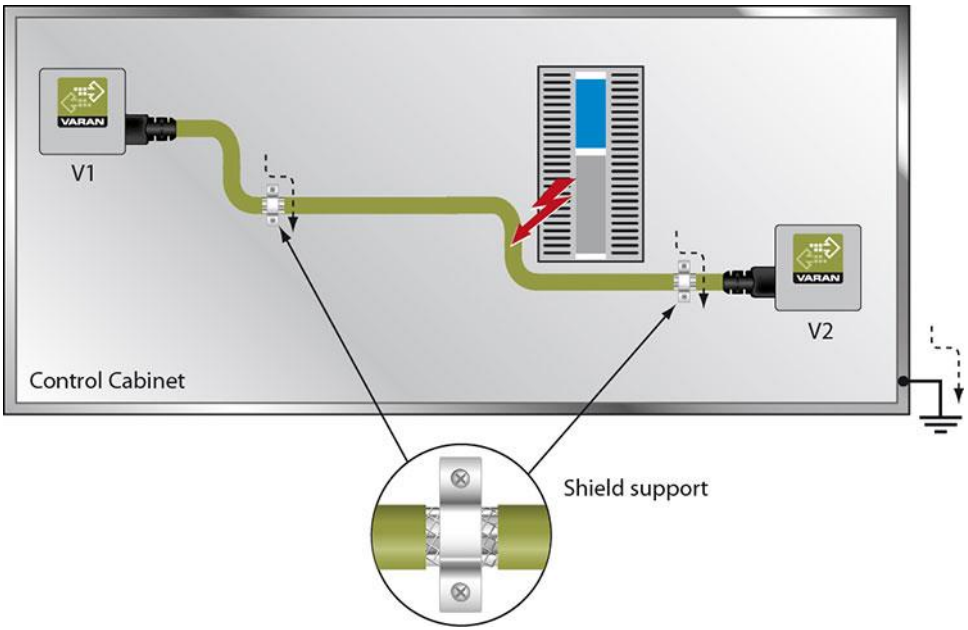
2. Wiring Outside of the Control Cabinet

If a VARAN bus line must be connected outside of the control cabinet only, no additional shield support is required. A requirement therefore, is that only IP67 modules and connectors can be used outside the control cabinet. These components are very robust and noise resistant. The shielding for all sockets in IP67 modules are electrically connected internally or over the housing, whereby voltage spikes are not dissipated through the electronics.



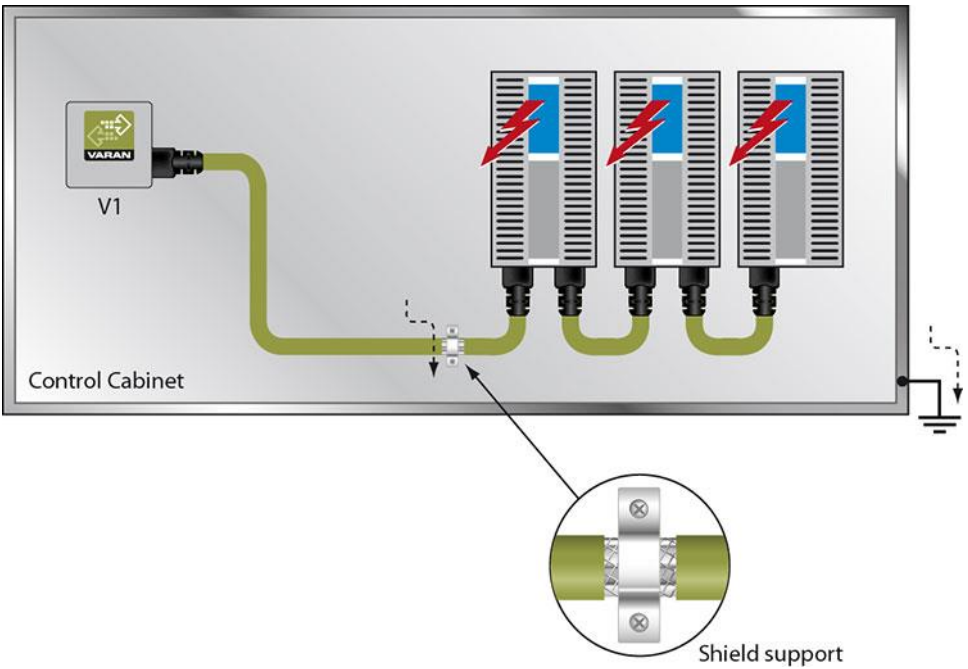
3. Shielding for Wiring Within the Control Cabinet

Sources of strong electromagnetic noise located within the control cabinet (drives, Transformers, etc.) can induce interference in a VARAN bus line. Spike voltages are dissipated over the metallic housing of a RJ45 connector. Noise is conducted through the control cabinet housing without further action from the electronic components. To eliminate sources of noise during data exchange, it is recommended that the shielding for all electronic components be connected within the control cabinet.



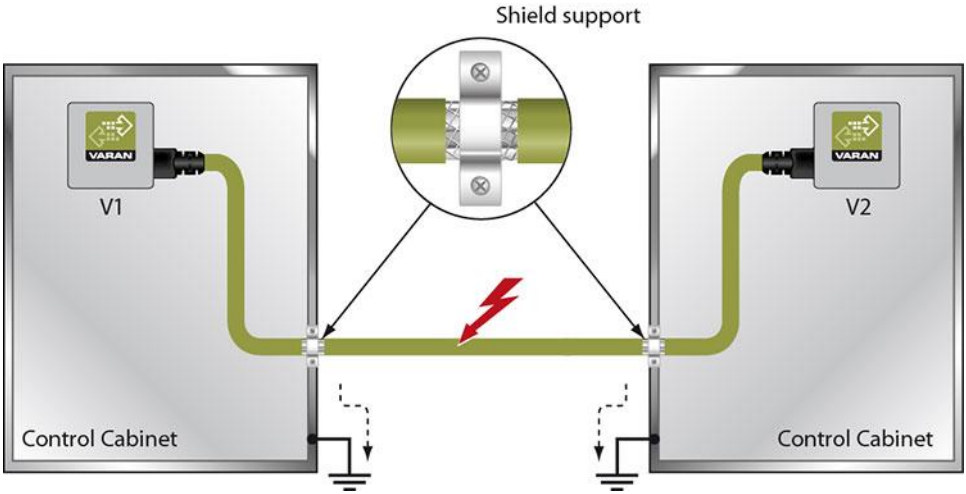
4. Connecting Noise-Generating Components

With the connection of power components that generate strong electromagnetic interference, it is also critical to ensure correct shielding. The shielding should be placed before a power element (or group of power elements).



5. Shielding Between Two Control Cabinets

If two control cabinets must be connected over a VARAN bus, it is recommended that the shielding be located at the entry points of both cabinets. Noise can thereby be prevented from reaching the electronics within the control cabinet.



DEE 021 CANopen Interface

General

For controlling the DEE 021 over the CAN interface, the CANopen protocol CIA301 is used. However, only the SDO data transfer is supported and not PDOs.

In addition to the CANopen-defined objects, which must support all CANopen devices, four application-specific objects are provided in the object directory for the user.

Standard Objects

Of the standard objects defined in CIA301, the objects listed in the following table are supported.

0x1000	Device Type
0x1001	Error Register
0x1008	Manufacturer Device Name
0x1009	Manufacturer Hardware Version
0x100A	Manufacturer Software Version
0x100C	Guard Time
0x100D	Life Time Factor
0x1017	Producer Heartbeat Time
0x1018	Identity Object
0x1200	1st Server SDO Parameter

Executable Actions - Object 0x2000

The 0x2000 object is used to trigger actions in the DEE 021. By writing to sub index 0x01 of the object, the function selected from the data of the write process is called in the DEE 021. The return value of this function call is provided in Sub Index 0x02 of the object, the result data of the object call in Sub Index 0x03. the data in Sub Index 0x02 and Sub Index 0x03 are available until the next function call (writing to Sub Index 0x01).

By writing to sub index 0x04, a new cycle is started (see section “Trigger Functions“).

Status Query - Object 0x2001 / 0x2002 / 0x2003

The status and measurement values of the DEE 021 are provided over the CAN interface in three different densities. the meaning of the data can be seen in the table below.

the object 0x2001 provides the status and measurement values in a large data block through Sub Index 0x00. The object 0x2002 provides the same data distributed in Total Values", Event Values", Voltage Channel Values" and Current Channel Values".

the Object 0x2003 also provides the same data on the value plane so that for access, Expedited SDO Transfers is sufficient. This is an advantage in that only one CAN object must be sent and received for each request.

Parameter Documentation

The following tables show the structure and type of data that can be exchanged with the DEE 021 over the CAN bus. the sequence of the data in the table corresponds to the actual data structure. the respective data is transferred over the object number or the Sub Index.

Total Values

Object number: **2002 h** Sub index: **1 h**

This object provides general energy information which is recorded with the DEE 021.

Size (bytes)	Access type	Name	Description
3	r	status	Indicates whether the phase sequence (U1, U2, U3) is maintained. Bit 0: 0 .. Phase sequence maintained 1 .. Phase sequence not maintained Bit 1..23: reserved
1	r	Cos(Phi) (1)	Displays the Cosine of the phase difference angle [0.01]
4	r	Actual Power (2)	Displays the actual power measured [0.01 W].
4	r	Total energy consumption since the first activation	Displays the energy consumption since the initial activation [0.1 kWh]
4	r	Total energy consumption since the last reset	Displays the energy use since the last reset. For the Reset, see item "Reset energy consumption [0.1 kWh]

Event Values

Object number: **2002 h** Sub index: **2 h**

the following data is measured at the time the trigger is set. For more information on the trigger function see the item "Trigger Functions".

Size (bytes)	Access type	Name	Description
3	r	status	Bit 0: Displays the trigger status of Cycle Start. If the trigger is set, this bit is "1" Bit 1: displays the trigger status of Cycle Run. If this bit is "1", the trigger function is activated Bit 2..23: Reserved
1	r	Cos(Phi) (1)	Displays the triggered Cosine of the phase difference angle [0.01].
4	r	Energy consumption over set time range	Displays the triggered energy [1 Ws].
4	r	Energy consumption per shot weight over set time range	Displays the triggered energy per shot weight [1 Ws/g]. (the injection mass can be defined under the item "Set Shot Weight").
4	r	Max. Power	Displays the triggered maximum power [0.01 W].

Voltage Channel Values

Data voltage channel 1: Object number: **2002 h** Sub index: **3 h**
Data voltage channel 2: Object number: **2002 h** Sub index: **4 h**
Data-voltage channel 3: Object number: **2002 h** Sub index: **5 h**

Over this object number, the voltage input channels 1 to 3 can be called. The triggered values are based on the time at which the trigger was set (see item "Trigger functions")

Data structure of voltage channel 1 to 3

Size (bytes)	Access type	Name	Description
2	r	Status Voltage	Displays the respective status: Bit 0: 1 .. Veff error (voltage below 50V) Bit 1: 1 .. Veff Warning Voltage exceeds the threshold setting To set the threshold, see item "Set Ueff Threshold". Bit 2: 1 .. the actual voltage value is positive 0 .. the actual value of the voltage is negative (for zero crossing detection) Bit 3: 15reserved
2	r	Veff	Shows the measured effective voltage [0.1V].
2	r	Ueff Event triggered	Shows the event-triggered measured effective voltage [0.1V].
2	r	Frequency Actual	Displays the actual measured frequency [0.01 Hz].
2	r	Frequency Min	Displays the smallest measured frequency [0.01 Hz]. (to reset, see item "Reset Phase Frequency").
2	r	Frequency Max	Displays the largest measured frequency [0.01 Hz]. (to reset, see item "Reset Phase Frequency").

Current Channel Values

Data current channel 1: Object number: **2002 h** Sub index: **6 h**
Data current channel 2: Object number: **2002 h** Sub index: **7 h**
Data current channel 3: Object number: **2002 h** Sub index: **8 h**
Data current channel 4: Object number: **2002 h** Sub index: **9 h**
Data current channel 5: Object number: **2002 h** Sub index: **A h**
Data current channel 6: Object number: **2002 h** Sub index: **B h**
Data current channel 7: Object number: **2002 h** Sub index: **C h**
Data current channel 8: Object number: **2002 h** Sub index: **D h**
Data current channel 9: Object number: **2002 h** Sub index: **E h**
Data current channel 10: Object number: **2002 h** Sub index: **F h**
Data current channel 11: Object number: **2002 h** Sub index: **10 h**
Data current channel 12: Object number: **2002 h** Sub index: **11 h**

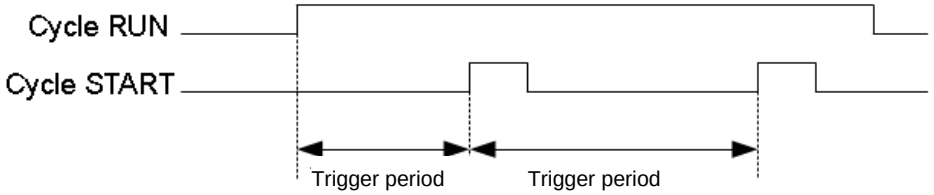
Over this object number, data can be called from the current channels 1 to 12. The triggered values are based on the time at which the trigger was set (see item "Trigger functions")

Data structure of current channels 1 to 12

Size (bytes)	Access type	Name	Description
1	r	Status Current	Displays the respective status: Bit 1..0: Displays the selected phase 0 = Inactive 1 = Phase 1 2 = Phase 2 3 = Phase 3 Bit 2: 1 .. Ieff warning (current below 1A) Bit 3: 1 .. V-I Phase error (energy is positive) Bit 4..5: LoadType (3) Bit 6..7: reserved
1	r	Cos(Phi) (1)	Displays the Cosine of the phase difference angle [0.01].
4	r	Ieff	Display of the actual effective current measured [0.1 A].
4	r	Power (2)	Displays the actual power measured [0.01 W].
4	r	Energy consumption since the first activation	Displays the total measured energy since the initial activation [0.1 kWh]
4	r	Energy consumption since the last reset	Displays the recorded energy use since the last reset [0.1 kWh]. To reset the values, see item "Reset energy consumption"
1	r	Reserved	
1	r	Cos(Phi) Event triggered	Displays the triggered Cosine of the phase difference angle [0.01].
4	r	Ieff Event triggered	Displays the triggered effective current [0.1 A].
4	r	Power Event triggered	Displays the triggered power [0.01 W].
4	r	Ipeak Event triggered	Displays the triggered peak current [0.1 A] (actual value, not effective value)

Trigger Functions

If the trigger is set, all trigger-dependent data are updated with the calculated value at the time of triggering. To activate the trigger functions, the "Cycle Run" bit must be set to "1" (see item "Start Cycle Command"). The trigger even can be initiated by setting the "Cycle Start" bit to "1" (see item "Start Cycle Command"). All trigger data are updated with the current measured data. To deactivate the trigger function, the "Cycle Run" bit must be set to "0".



General Command

Commands (Send Command) are always sent from the object with the object number 2000_h and Sub index 1_h The Command" and Sub Command" parameters determine the type of command. Over the objects with object number 2000_h, data is collected for checking and return data with Sub Index 2_h (General Command Result Code) and 3_h (General Command Response).

Set Shot Weight

Send Command

Object number: **2000 h** Sub index: **1 h**

the energy consumption information can also be determined according to the shot weight. The shot weight must be thereby defined via this object (e.g.: for injection molding machines).

Size (bytes)	Access type	Name	Description
1	w	Space	Must always be null
1	w	Command Counter	The command counter must be incremented with each command sent.
1	w	Command	0x01 (= Set Shot Weight)
1	w	Sub Command	0x01 (= Set Shot Weight)
4	w	Shot Weight	Sets the shot weight as the initialization value [g].

General Command Result code

Object number: **2000 h** Sub index: **2 h**

From this object, information over the status of the data transfer and the length of possible return data can be collected.

Size (bytes)	Access type	Name	Description
2	r	Status Code and Buffer Handshake	Bit 0 = '1' Status OK
2	r	Length of Result Data	Length of the data sent from the DEE. In this case null, since no data is sent.

General Command Response

Object number: **2000 h** Sub index: **3 h**

the data of this object is used to check whether data has been received and is valid.

Size (bytes)	Access type	Name	Description
1	r	Status Code and Buffer Handshake	Status Code Bit 0..6: Error Code 0 = OK, no errors <> 0 = an error has occurred Bit 7: not relevant for CAN
1	r	Command Counter	Command counter status of the last command received (to check control the actuality of the sent command).
1	r	Command	0x01 (= Set Shot Weight)
1	r	Sub Command	0x01 (= Set Shot Weight)
2	r	Length of Result	Length of the data sent from the DEE. In this case null.
2	r	Reserved	
0	r	Data	In this case, no data is set from the DEE.

Setup command

Send Command

Object number: **2000 h** Sub index: **1 h**

the Setup command should be sent before the first measurements and used to define the current channel parameter.

Size (bytes)	Access type	Name	Description
1	r/w	Space	Must always be null
1	r/w	Command Counter	the command counter must be incremented with each command sent.
1	r/w	Command	0x01 (= Setup Command)
1	r/w	Sub Command	0x00 (= Setup Command)
1	r/w	ADC 1 Channel Enable Control:	0x3F (for DEE 021)
1	r/w	ADC 2 Channel Enable Control:	0x3F (for DEE 021)
Current Setup I1 to I12			
2	r/w	I1 Control	Bit 0..1: Selection of the voltage phase based on the measurement: 0 = Inactive 1 = Phase 1 2 = Phase 2 3 = Phase 3 Bit 2..15: reserved
2	r/w	I1 Current Converter	Selects the conversion ratio of the current converter. [0.1 A] (= primary current in [0.1 A] with a secondary current of 1 A rms)
I2 to I11 …			
2	r/w	I12 Control	Bit 0..1: Selection of the voltage phase based on the measurement: 0 = Inactive 1 = Phase 1 2 = Phase 2 3 = Phase 3 Bit 2..15: reserved
2	r/w	I12 Current Converter	Selects the conversion ratio of the current converter. [0.1 A] (= primary current in [0.1 A] with a secondary current of 1 A rms)

Current converter example: Translation ratio of 1:50
=> Current converter = 500 [0.1A]

General command Result code

Object number: **2000 h** Sub index: **2 h**

From this object, information over the status of the data transfer and the length of possible return data can be collected.

Size (bytes)	Access type	Name	Description
2	r	Status Code and Buffer Handshake	Bit 0 = 1 … Status OK
2	r	Length of Result Data	Length of the data sent from the DEE. In this case null, since no data is sent.

General Command Response

Object number: **2000 h** Sub index: **3 h**

the data of this object is used to check whether data has been received and is valid.

Size (bytes)	Access type	Name	Description
1	r	Status Code and Buffer Handshake	Status Code Bit 0..6: Error Code 0 = OK, no errors <> 0 = an error has occurred Bit 7: not relevant for CAN
1	r	Command Counter	Command counter status of the last command received (to check control the actuality of the sent command)
1	r	Command	0x01 (= Setup Command)
1	r	Sub Command	0x00 (= Setup Command)

2	r	Length of Result	Length of the data sent from the DEE. In this case null.
2	r	Reserved	
0	r	Data	In this case, no data is set from the DEE.

Reset Energy Consumption

Send Command

Object number: **2000 h** Sub index: **1 h**

With this command, the resettable measured energy consumption and total consumption can be reset.

Size (bytes)	Access type	Name	Description
1	r/w	Space	Must always be null.
1	r/w	Command Counter	Must be incremented with each command sent.
1	r/w	Command	0x01 = Reset energy consumption
1	r/w	Sub Command	0x02 = Reset energy consumption
1	r/w	Total energy consumption	Bit 0: 1 .. Resets the measured total energy consumption since the initial activation or last reset. Bit 1..7: reserved
2	r/w	Reset energy consumption Channel	Bit 0: 1 .. Reset the measured energy of current channel 1. Bit 1: 1 .. Reset the measured energy of current channel 2. … Bit 11: 1 .. Reset the measured energy of current channel 12.

General command Result code

Object number: **2000 h** Sub index: **2 h**

From this object, information over the status of the data transfer and the length of possible return data can be collected.

Size (bytes)	Access type	Name	Description
2	r	Status Code and Buffer Handshake	Bit 0 = 1 … Status OK
2	r	Length of Result Data	Length of the data sent from the DEE. In this case null, since no data is sent.

General Command Response

Object number: **2000 h** Sub index: **3 h**

the data of this object is used to check whether data has been received and is valid.

Size (bytes)	Access type	Name	Description
1	r	Status Code and Buffer Handshake	Status Code Bit 0..6: Error Code 0 = OK, no errors <> 0 = an error has occurred Bit 7: not relevant for CAN
1	r	Command Counter	Command counter status of the last command received (to check control the actuality of the sent command).
1	r	Command	0x01 (= Reset energy consumption)
1	r	Sub Command	0x02 (= Reset energy consumption)
2	r	Length of Result	Length of the data sent from the DEE. In this case null, since no data is sent.
2	r	Reserved	
0	r	Data	In this case, no data is set from the DEE.

Reset Phase Frequency

Send Command

Object number: **2000 h** Sub index: **1 h**

With this command, the maximum and minimum frequency measurement values of the Voltage Channel Values" data structure can be reset.

Size (bytes)	Access type	Name	Description
1	r/w	Space	Must always be null.
1	r/w	Command Counter	Must be incremented with each command sent.
1	r/w	Command	0x01 (= Reset Phase Frequency)
1	r/w	Sub Command	0x03 (= Reset Phase Frequency)
1	r/w	Phase Select	Bit 0: 1 .. Reset Phase 1 Bit 1: 1 .. Reset Phase 2 Bit 2: 1 .. Reset Phase 3 Bit 3..7: Reserved

General command Result code

Object number: **2000 h** Sub index: **2 h**

From this object, information over the status of the data transfer and the length of possible return data can be collected.

Size (bytes)	Access type	Name	Description
2	r	Status Code and Buffer Handshake	Bit 0 = 1 … Status OK
2	r	Length of Result Data	Length of the data sent from the DEE. In this case null, since no data is sent.

General Command Response

Object number: **2000** $_{h}$ Sub index: **3** $_{h}$

the data of this object is used to check whether data has been received and is valid.

Size (bytes)	Access type	Name	Description
1	r	Status Code and Buffer Handshake	Status Code Bit 0..6: Error Code 0 = OK, no errors 1 = an error has occurred Bit 7: not relevant for CAN
1	r	Command Counter	Command counter status of the last command received (to check control the actuality of the sent command).
1	r	Command	0x01 (= Reset Phase Frequency)
1	r	Sub Command	0x03 (= Reset Phase Frequency)
2	r	Length of Result	Length of the data sent from the DEE. In this case null.
2	r	Reserved	
0	r	Data	In this case, no data is set from the DEE.

Set Veff Threshold

Send Command

Object number: **2000 h** Sub index: **1 h**

With this command, threshold voltages can be defined, by which a low voltage warning is given (see item "Voltage Channel Values").

Size (bytes)	Access type	Name	Description
1	r/w	Space	Must always be null.
1	r/w	Command Counter	Must be incremented with each command sent.
1	r/w	Command	0x01 (= Set Veff Threshold)
1	r/w	Sub Command	0x04 (= Set Ueff Threshold)
2	r/w	Phase 1 Veff Threshold for Warning	there, the threshold voltage for voltage channel 1 is defined. If exceeded, the “Veff Warning” status is set. (See section “Voltage Channel”) [V]
2	r/w	Phase 2 Veff Threshold for Warning	there, the threshold voltage for voltage channel 1 is defined. If exceeded, the “Veff Warning” status is set. (See section “Voltage Channel”) [V]
2	r/w	Phase 3 Veff Threshold for Warning	there, the threshold voltage for voltage channel 1 is defined. If exceeded, the “Veff Warning” status is set. (See section “Voltage Channel”) [V]

General Command Result code

Object number: **2000 h** Sub index: **2 h**

From this object, information over the status of the data transfer and the length of possible return data can be collected.

Size (bytes)	Access type	Name	Description
2	r	Status Code and Buffer Handshake	Bit 0 = 1 … Status OK
2	r	Length of Result Data	Length of the data sent from the DEE. In this case null, since no data is sent.

General Command Response

Object number: **2000 h** Sub index: **3 h**

the data of this object is used to check whether data has been received and is valid.

Size (bytes)	Access type	Name	Description
1	r	Status Code and Buffer Handshake	Status Code Bit 0..6: Error Code 0 = OK, no errors <> 0 = an error has occurred Bit 7: not relevant for CAN
1	r	Command Counter	Command counter status of the last command received (to check control the actuality of the sent command).
1	r	Command	0x01 (= Set Veff Threshold)
1	r	Sub Command	0x04 (= Set Ueff Threshold)
2	r	Length of Result	Length of the data sent from the DEE. In this case null.
2	r	Reserved	
0	r	Data	In this case, no data is set from the DEE.

Osci Setup

Send Command

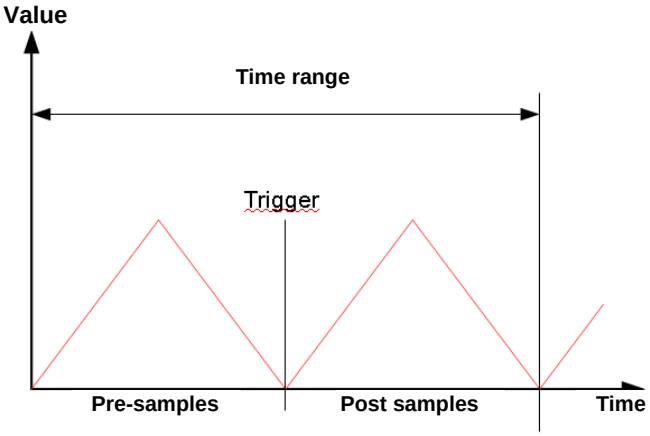
Object number: **2000** $_{h}$ Sub index: **1** $_{h}$

With the oscilloscope set command, the necessary parameters for the DEE can DEE loaded. For the measurement parameters and examples thereof, see item "Oscilloscope parameter numbers" and " Examples of Oscilloscope parameter numbers"

Size (bytes)	Access type	Name	Description
1	r/w	Space	Must always be null.
1	r/w	Command Counter	Must be incremented with each command sent.
1	r/w	Command	0x03 (= Osci Setup)
1	r/w	Sub Command	0x00 (= Osci Setup)
4	r/w	Time Base	Time base selection (time per measurement step).
1	r/w	Trigger Setup	Trigger type selection Bit 0: rising edge Bit 1: falling edge Bit 2: until buffer is full Bit 3..7 : reserved
1	r/w	Trigger on Channel (0 to 3)	Selection of the channel, on which to trigger. The number 0 to 3 corresponds to the channels 1 to 4. The flanks on which to trigger must be set.
4	r/w	Trigger Value	Trigger value. The flanks on which to trigger must be set.
2	r/w	Pre-samples	Select the point in time span on which to trigger [0.1 %] (see schematic below).
1	r/w	Capture Mode Channel 1	Set channel 1 of the measuring module. 0: Current value 1: Average value over the time base value
1	r/w	Capture Mode Channel 2	Set channel 2 of the measuring module. 0: Current value 1: Average value over the time base value

1	r/w	Capture Mode Channel 3	Set channel 3 of the measuring module. 0: Current value 1: Average value over the time base value
1	r/w	Capture Mode Channel 4	Set channel 4 of the measuring module. 0: Current value 1: Average value over the time base value
4	r/w	Channel 1 Parameter number	Recording parameter settings for channel 1. (see table Oscilloscope Parameter Numbers")
4	r/w	Channel 2 Parameter number	Recording parameter settings for channel 2. (see table Oscilloscope Parameter Numbers")
4	r/w	Channel 3 Parameter number	Recording parameter settings for channel 3. (see table Oscilloscope Parameter Numbers")
4	r/w	Channel 4 Parameter number	Recording parameter settings for channel 4. (see table Oscilloscope Parameter Numbers")

The following diagram shows the function of the "Pre-samples" parameter of the Oscilloscope setup. With the parameter, where in the time span (in %) the trigger should be activated or how much data should be recorded before the trigger event.



General Command Result code

Object number: **2000 h** Sub index: **2 h**

From this object, information over the status of the data transfer and the length of possible return data can be collected.

Size (bytes)	Access type	Name	Description
2	r	Status Code and Buffer Handshake	Bit 0 = 1 … Status OK
2	r	Length of Result Data	Length of the data sent from the DEE.

General Command Response

Object number: **2000 h** Sub index: **3 h**

the data of this object is used to check whether data has been received and is valid. Return data is also included.

Size (bytes)	Access type	Name	Description
1	r	Status Code and Buffer Handshake	Status Code Bit 0..6: Error Code 0 = OK, no errors 1 = Page error 2 = Recording error 3 = Error in the parameter settings Bit 7: Not used with CAN
1	r	Command Counter	Command counter status of the last command received (to check control the actuality of the sent command).
1	r	Command	0x03 (= Osci Setup)
1	r	Sub Command	0x00 (= Osci Setup)
2	r	Length of Result	Length of the data sent from the DEE.
2	r	Reserved	
4	r	Minimal Time Base	Minimum time base (dependent on the µC tasks)

4	r	Time Base Set	Selected time base (a multiple of the µC cycle time)
4	r	Maximal Sample Points	Maximum number of scan points
1	r	Parameter Signed	Displays the sign setting: Bit 0: 1 = channel 1 parameter with sign 0 = channel 1 parameter without sign Bit 1: 1 = channel 2 parameter with sign 0 = channel 2 parameter without sign Bit 2: 1 = channel 3 parameter with sign 0 = channel 3 parameter without sign Bit 3: 1 = channel 4 parameter with sign 0 = channel 4 parameter without sign Bit 4..7: reserved

the following table show the recording parameter of the oscilloscope function, with are loaded in the DEE with the oscilloscope setup.

Structure of the oscilloscope parameter numbers.

Bit	Size (bits)	Description
31	1	Value type selection 0 .. Current value 1 .. Internal value
30..24	7	Data structure that contains the parameter to record (found in this document) 0 = Total Values 1 = Event Values 2 = Voltage Channels 3 = Current Channels
23..16	8	Channel number to which the measurement data should be sent (1 to 4).
15..8	8	Selection of the parameter of the selected data structure that should be recorded: 0 = Status 1 = next parameter of the selected data structure 2 = … 3 = ...
7..0	8	Data format selection: Bit 7: with sign Bit 6..5: Data size 0 = Bit 1 = 1 byte 2 = 2 bytes 3 = 4 bytes Bit 4..0: bit selector (when data size = Bit)

In the following tables are several examples for the selection of recording parameters.

Example of Oscilloscope Parameter Numbers

Parameter number (hex)	Description
Fast internal signals U (XX = 0 for U1, 1 for U2, 2 for U3)	
0x82XX00E0	Actual voltage value
Fast internal signals U (XX = 0 for I1, 1 for I2,…)	
0x83XX00E0	Actual current value
Total Values	
0x00000000	Indicates whether the phase sequence (U1, U2, U3) is maintained: 0: Phase sequence maintained 1: Phase sequence not maintained
0x000001A0	Displays the Cosine of the phase difference angle [0.01].
0x000002E0	Displays the actual power measured [0.01 W].
0x00000360	Displays the measured energy since the initial activation [0.1 kWh].
0x00000460	Displays the energy use since the last reset. For the Reset, see item "Reset energy consumption [0.1 kWh].
Event Values	
0x01000000 0x01000001	Bit 0: displays the trigger status or Cycle start. If the trigger is set, this bit is "1" Bit 1: displays the trigger status of Cycle Run. If this bit is "1", the trigger function is activated. Bit 2..23 : Reserved
0x010001A0	Displays the triggered Cosine of the phase difference angle [0.01].
0x01000260	Displays the triggered energy [1 Ws].
0x01000360	Displays the triggered energy per shot weight [1 Ws/g].
0x010004E0	Displays the triggered maximum power [0.01 W].
Voltage Channels (XX = 0 for U1, 1 for U2, 2 for U3)	
0x02XX0000 0x02XX0001 0x02XX0002	Displays the respective status: Bit 0: Veff error (voltage below 50V) Bit 1: Veff Warning Voltage exceeds the threshold setting. To set the threshold, see item "Set Ueff Threshold". Bit 2: The actual value of the voltage is positive (0 = negative) (for detecting the null crossing) Bit 3: 15reserved

0x02XX0140	Shows the measured effective voltage [0.1V].
0x02XX0240	Shows the event-triggered measured effective voltage [0.1V].
0x02XX0340	Displays the actual measured frequency [0.01 Hz].
0x02XX0440	Displays the smallest measured frequency [0.01 Hz].
0x02XX0540	Displays the largest measured frequency [0.01 Hz].
Current Channels (XX = 0 for I1, 1 for I2, …)	
0x03XX0002 0x03XX0003	Displays the respective status: Bit 1..0: Displays the selected phase 0 = Inactive 1 = Phase 1 2 = Phase 2 3 = Phase 3 Bit 2: Ieff warning (current below 1A) Bit 3: U-I phase error (energy is positive) Bit 4..7: reserved
0x03XX01A0	Displays the Cosine of the phase difference angle [0.01].
0x03XX0260	Display of the actual effective current measured [0.1 A].
0x03XX03E0	Displays the actual power measured [0.01 W].
0x03XX0460	Displays the total measured energy since the initial activation [0.1 kWh]
0x03XX0560	Displays the recorded energy use since the last reset [0.1 kWh]. To reset the values, see item "Reset energy consumption"
0x03XX06A0	Displays the triggered Cosine of the phase difference angle [0.01].
0x03XX0760	Displays the triggered effective current [0.1 A].
0x03XX08E0	Displays the triggered power [0.01 W].
0x03XX09E0	Displays the triggered peak current [0.1 A] (actual value, not effective value)

Osci Get Status and Force Trigger

Send Command

Object number: **2000 h** Sub index: **1 h**

With this command, the recording status is queried as to whether the data is ready to be retrieved. the trigger can also be forced or the recording can also be stopped.

Size (bytes)	Access type	Name	Description
1	r/w	Space	Must always be null.
1	r/w	Command Counter	Must be incremented with each command sent.
1	r/w	Command	0x03 (= Osci Get Status and Force Trigger)
1	r/w	Sub Command	0x01 (= Osci Get Status and Force Trigger)
1	r/w	Mode	0 = No forced trigger. Continue recording 1 = Force trigger and continue recording 2 = Force trigger and stop recording

General command Result code

Object number: **2000 h** Sub index: **2 h**

From this object, information over the status of the data transfer and the length of possible return data can be collected.

Size (bytes)	Access type	Name	Description
2	r	Status Code and Buffer Handshake	Bit 0 = 1 … Status OK
2	r	Length of Result Data	Length of the data sent from the DEE.

General Command Response

Object number: **2000 h** Sub index: **3 h**

the data of this object is used to check whether data has been received and is valid. Return data can also be included.

Size (bytes)	Access type	Name	Description
1	r	Status Code and Buffer Handshake	Status Code Bit 0..6: Error Code 0 = OK, no errors 1 = Page error 2 = Recording error 3 = Error in the parameter settings Bit 7: Not used with CAN
1	r	Command Counter	Command counter status of the last command received (to check control the actuality of the sent command).
1	r	Command	0x03 (= Osci Get Status and Force Trigger)
1	r	Sub Command	0x01 (= Osci Get Status and Force Trigger)
2	r	Length of Result	Length of the data sent from the DEE.
2	r	Reserved	
1	r	status	Status of the recording 0 = Pre-recording active (Pre-sample) 1 = Wait for trigger 2 = Post recording active (Post sample) 3 = Ready => data can be read 4 = Not initialized
4	r	Bytes in Buffer	Bytes in the buffer
4	r	Samples in Buffer	Scanning in buffer

Osci Read Buffer

Send Command

Object number: **2000 h** Sub index: **1 h**

With this command, recorded data can be retrieved by the DEE. The oscilloscope status must be set to "Ready" (data can be read). the data is available in blocks of up to 96 bytes each. The structure of a block can be seen in "Structure of the Oscilloscope Data for an Entry".

Size (bytes)	Access type	Name	Description
1	r/w	Space	Must always be null.
1	r/w	Command Counter	Must be incremented with each command sent.
1	r/w	Command	0x03 (= Osci Read Buffer)
1	r/w	Sub Command	0x02 (= Osci Read Buffer)
2	r/w	Page Selector	Selection of the block, from which the DEE should be sent [in 96-byte blocks]. 0 = 1st 96 Bytes (oldest data) 1 = 2nd 96 Bytes …

General Command Result Code

Object number: **2000 h** Sub index: **2 h**

From this object, information over the status of the data transfer and the length of possible return data can be collected.

Size (bytes)	Access type	Name	Description
2	r	Status Code and Buffer Handshake	Bit 0 = 1 … Status OK
2	r	Length of Result Data	Length of the data sent from the DEE.

General Command Response

Object number: **2000 h** Sub index: **3 h**

the data of this object is used to check whether data has been received and is valid. Return data is also included.

Size (bytes)	Access type	Name	Description
1	r	Status Code and Buffer Handshake	Status Code Bit 0..6: Error Code 0 = OK, no errors 1 = Page error 2 = Recording error 3 = Error in the parameter settings Bit 7: Not used with CAN
1	r	Command Counter	(Mirrored from Command)
1	r	Command	0x03 (= Osci Read Buffer)
1	r	Sub Command	0x02 (= Osci Read Buffer)
2	r	Length of Result	Length of the data sent from the DEE.
2	r	Reserved	
96	r	Oscilloscope Data	Data packet x See: "Structure of the Oscilloscope Data for an Entry"

Structure of the Oscilloscope Data for an Entry (16 Bytes)

Size (bytes)	Access type	Name
4	r	Recorded data from channel 1 **
4	r	Recorded data from channel 2 **
4	r	Recorded data from channel 3 **
4	r	Recorded data from channel 4 **

** Sign is attached

A data packet consists of 6 entries or 6 measurement values per channel respectively (6*16 bytes = 96 bytes).

Start Cycle Command

Object number: **2000 h** Sub index: **4 h**

This command is used to control the trigger functions (see the section “Trigger Functions“).

Size (bytes)	Access type	Name	Description
1	w	Fast Write Control Block	Bit 0: Cycle Start If this bit is set to “1”, all trigger-dependent values are set at the time of triggering. Triggering is only possible when the "Cycle Run" bit was first set to "1". Bit 1: Cycle Run To activate the trigger functions, this bit must be set to „1“. Bit 2..7: reserved

Expedited SDO Transfer Data / Exchange Data Block

The following data (see table below) can be collected over the object number **2003_h** and the respective sub index with “Expedited SDO” directly (see CIA301). A 4-byte payload can be sent Per “Expedited SDO“. Some values are sent combined in an "Expedited SDO". The Sub Indexes are then labeled with the "an" reference.

Through the **2001_h**object with the Sub Index 0_h, the entire data block (according to the following table) can be sent.

Sub Index (hex)	Size (bytes)	Access type	Name	Description
Total				
1	3	r	status	Indicates whether the phase sequence (U1, U2, U3) is maintained: Bit 0: 0 .. Phase sequence maintained 1 .. Phase sequence not maintained Bit 1..23: reserved
an 1	1	r	Cos(Phi) (1)	Displays the Cosine of the phase difference angle [0.01].
2	4	r	Actual Power (2)	Displays the actual power measured [0.01 W].
3	4	r	Total energy consumption since the first activation	Displays the energy consumption since the initial activation [0.1 kWh]
4	4	r	Total energy consumption since the last reset	Displays the energy use since the last reset. For the Reset, see item "Reset energy consumption [0.1 kWh]
Event triggered Calculations				
5	3	r	status	Bit 0: Displays the trigger status of Cycle Start. If the trigger is set, this bit is "1" Bit 1: displays the trigger status of Cycle Run. If this bit is "1", the trigger function is activated Bit 2..23: Reserved
an 5	1	r	Cos(Phi) (1)	Displays the triggered Cosine of the phase difference angle [0.01]
6	4	r	Energy consumption over set time range	Displays the triggered energy [1 Ws]
7	4	r	Energy consumption per shot weight over set time range	Displays the triggered energy per shot weight [1 Ws/g]. (the injection mass can be defined under the item "Set Shot Weight").
8	4	r	Max. Power [0.01 W]	Displays the triggered maximum power [0.01 W].

Voltage Channels U1				
9	2	r	Status Voltage	Displays the respective status: Bit 0: 1 .. Veff error (voltage below 50V) Bit 1: 1 .. Veff Warning Voltage exceeds the threshold setting To set the threshold, see item "Set Ueff Threshold". Bit 2: 1 .. the actual voltage value is positive 0 .. the actual value of the voltage is negative (for zero crossing detection) Bit 3..15: reserved
an 9	2	r	Veff	Shows the measured effective voltage [0.1V].
A	2	r	Ueff Event triggered	Shows the event-triggered measured effective voltage [0.1V].
an A	2	r	Frequency Actual	Displays the actual measured frequency [0.01 Hz].
B	2	r	Frequency Min	Displays the smallest measured frequency [0.01 Hz]. (to reset, see item "Reset Phase Frequency").
an B	2	r	Frequency Max	Displays the largest measured frequency [0.01 Hz]. (to reset, see item "Reset Phase Frequency").
Voltage Channel U2				
C	2	r	Status Voltage	Displays the respective status: Bit 0: 1 .. Veff error (voltage below 50V) Bit 1: 1 .. Veff Warning Voltage exceeds the threshold setting. To set the threshold, see item "Set Ueff Threshold". Bit 2: 1 .. the actual voltage value is positive 0 .. the actual value of the voltage is negative (for zero crossing detection) Bit 3: 15reserved
an C	2	r	Veff	Shows the measured effective voltage [0.1V].
D	2	r	Ueff Event triggered	Shows the event-triggered measured effective voltage [0.1V].
an D	2	r	Frequency Actual	Displays the actual measured frequency [0.01 Hz].
E	2	r	Frequency Min	Displays the smallest measured frequency [0.01 Hz]. (to reset, see item "Reset Phase Frequency").
an E	2	r	Frequency Max	Displays the largest measured frequency \ [0.01 Hz]. (to reset, see item "Reset Phase Frequency").

Voltage Channel U3				
F	2	r	Status Voltage	Displays the respective status: Bit 0: 1 .. Veff error (voltage below 50V) Bit 1: 1 .. Veff Warning Voltage exceeds the threshold setting. To set the threshold, see item "Set Ueff Threshold". Bit 2: 1 .. the actual voltage value is positive 0 .. the actual value of the voltage is negative (for zero crossing detection) Bit 3: 15reserved
an F	2	r	Veff	Shows the measured effective voltage [0.1V].
10	2	r	Ueff Event triggered	Shows the event-triggered measured effective voltage [0.1V].
an 10	2	r	Frequency Actual	Displays the actual measured frequency [0.01 Hz].
11	2	r	Frequency Min	Displays the smallest measured frequency [0.01 Hz]. (to reset, see item "Reset Phase Frequency").
an 11	2	r	Frequency Max	Displays the largest measured frequency [0.01 Hz]. (to reset, see item "Reset Phase Frequency").
Current Channels I1				
12	1	r	Status Current	Displays the respective status : Bit 1..0: Displays the selected phase 0 = Inactive 1 = Phase 1 2 = Phase 2 3 = Phase 3 Bit 2: 1 .. Ieff warning (current below 1A) Bit 3: 1 .. V-I Phase error (energy is positive) Bit 4..5: LoadType (3) Bit 6..7: reserved
an 12	1	r	Cos(Phi) (1)	Displays the Cosine of the phase difference angle [0.01].
13	4	r	Ieff	Display of the actual effective current measured [0.1 A].
14	4	r	Power (2)	Displays the actual power measured [0.01 W]
15	4	r	Energy consumption since the first activation	Displays the total measured energy since the initial activation [0.1 kWh]
16	4	r	Energy consumption since the last reset	Displays the recorded energy use since the last reset [0.1 kWh]. To reset the values, see item "Reset energy consumption"
-	1	r	reserved	

17	1	r	Cos(Phi) Event triggered	Displays the triggered Cosine of the phase difference angle [0.01].
18	4	r	Ieff Event triggered	Displays the triggered effective current [0.1 A].
19	4	r	Power Event triggered	Displays the triggered power [0.01 W].
1A	4	r	Ipeak Event triggered	Displays the triggered peak current [0.1 A] (actual value, not effective value)
Current Channels I2				
1B	1	r	Status Current	Displays the respective status: Bit 1..0: Displays the selected phase 0 = Inactive 1 = Phase 1 2 = Phase 2 3 = Phase 3 Bit 2: 1 .. Ieff warning (current below 1A) Bit 3: 1 .. V-I Phase error (energy is positive) Bit 4..5: LoadType (3) Bit 6..7: reserved
an 1B	1	r	Cos(Phi) (1)	Displays the Cosine of the phase difference angle [0.01].
1C	4	r	Ieff	Display of the actual effective current measured [0.1 A].
1D	4	r	Power (2)	Displays the actual power measured [0.01 W].
1E	4	r	Energy consumption since the first activation	Displays the total measured energy since the initial activation [0.1 kWh]
1F	4	r	Energy consumption since the last reset	Displays the recorded energy use since the last reset [0.1 kWh]. To reset the values, see item "Reset energy consumption"
-	1	r	reserved	
20	1	r	Cos(Phi) Event triggered	Displays the triggered Cosine of the phase difference angle [0.01]
21	4	r	Ieff Event triggered	Displays the triggered effective current [0.1 A].
22	4	r	Power Event triggered	Displays the triggered power [0.01 W].
23	4	r	Ipeak Event triggered	Displays the triggered peak current [0.1 A] (actual value, not effective value)
Current Channels I3				
24	1	r	Status Current	Displays the respective status: Bit 1..0: Displays the selected phase 0 = Inactive 1 = Phase 1 2 = Phase 2 3 = Phase 3 Bit 2: 1 .. Ieff warning (current below 1A) Bit 3: 1 .. V-I Phase error (energy is positive) Bit 4..5: LoadType (3) Bit 6..7: reserved

an 24	1	r	Cos(Phi) (1)	Displays the Cosine of the phase difference angle [0.01].
25	4	r	Ieff	Display of the actual effective current measured [0.1 A].
26	4	r	Power (2)	Displays the actual power measured [0.01 W].
27	4	r	Energy consumption since the first activation	Displays the total measured energy since the initial activation [0.1 kWh]
28	4	r	Energy consumption since the last reset	Displays the recorded energy use since the last reset [0.1 kWh] To reset the values, see item "Reset energy consumption"
-	1	r	reserved	
29	1	r	Cos(Phi) Event triggered	Displays the triggered Cosine of the phase difference angle [0.01].
2A	4	r	Ieff Event triggered	Displays the triggered effective current [0.1 A].
2B	4	r	Power Event triggered	Displays the triggered power [0.01 W].
2C	4	r	Ipeak Event triggered	Displays the triggered peak current [0.1 A] (actual value, not effective value)
Current Channels I4				
2D	1	r	Status Current	Displays the respective status: Bit 1..0: Displays the selected phase 0 = Inactive 1 = Phase 1 2 = Phase 2 3 = Phase 3 Bit 2: 1 .. Ieff warning (current below 1A) Bit 3: 1 .. V-I Phase error (energy is positive) Bit 4..5: LoadType (3) Bit 6..7: reserved
an 2D	1	r	Cos(Phi) (1)	Displays the Cosine of the phase difference angle [0.01].
2E	4	r	Ieff	Display of the actual effective current measured [0.1 A].
2F	4	r	Power (2)	Displays the actual power measured [0.01 W].
30	4	r	Energy consumption since the first activation	Displays the total measured energy since the initial activation [0.1 kWh]
31	4	r	Energy consumption since the last reset	Displays the recorded energy use since the last reset [0.1 kWh]. To reset the values, see item "Reset energy consumption"
-	1	r	reserved	
32	1	r	Cos(Phi) Event triggered	Displays the triggered Cosine of the phase difference angle [0.01].
33	4	r	Ieff Event triggered	Displays the triggered effective current [0.1 A].
34	4	r	Power Event triggered	Displays the triggered power [0.01 W].

35	4	r	Ipeak Event triggered	Displays the triggered peak current [0.1 A] (actual value, not effective value)
Current Channels I5				
36	1	r	Status Current	Displays the respective status: Bit 1..0: Displays the selected phase 0 = Inactive 1 = Phase 1 2 = Phase 2 3 = Phase 3 Bit 2: 1 .. Ieff warning (current below 1A) Bit 3: 1 .. V-I Phase error (energy is positive) Bit 4..5: LoadType (3) Bit 6..7: reserved
an 36	1	r	Cos(Phi) (1)	Displays the Cosine of the phase difference angle [0.01].
37	4	r	Ieff	Display of the actual effective current measured [0.1 A].
38	4	r	Power (2)	Displays the actual power measured [0.01 W].
39	4	r	Energy consumption since the first activation	Displays the total measured energy since the initial activation [0.1 kWh]
3A	4	r	Energy consumption since the last reset	Displays the recorded energy use since the last reset [0.1 kWh]. To reset the values, see item "Reset energy consumption"
-	1	r	reserved	
3B	1	r	Cos(Phi) Event triggered	Displays the triggered Cosine of the phase difference angle [0.01].
3C	4	r	Ieff Event triggered	Displays the triggered effective current [0.1 A].
3D	4	r	Power Event triggered	Displays the triggered power [0.01 W].
3E	4	r	Ipeak Event triggered	Displays the triggered peak current [0.1 A] (actual value, not effective value)
Current Channels I6				
3F	1	r	Status Current	Displays the respective status: Bit 1..0: Displays the selected phase 0 = Inactive 1 = Phase 1 2 = Phase 2 3 = Phase 3 Bit 2: 1 .. Ieff warning (current below 1A) Bit 3: 1 .. V-I Phase error (energy is positive) Bit 4..5: LoadType (3) Bit 6..7: reserved
an 3F	1	r	Cos(Phi) (1)	Displays the Cosine of the phase difference angle [0.01].
40	4	r	Ieff	Display of the actual effective current measured [0.1 A].
41	4	r	Power (2)	Displays the actual power measured [0.01 W].

42	4	r	Energy consumption since the first activation	Displays the total measured energy since the initial activation [0.1 kWh]
43	4	r	Energy consumption since the last reset	Displays the recorded energy use since the last reset [0.1 kWh]. To reset the values, see item "Reset energy consumption"
-	1	r	reserved	
44	1	r	Cos(Phi) Event triggered	Displays the triggered Cosine of the phase difference angle [0.01].
45	4	r	Ieff Event triggered	Displays the triggered effective current [0.1 A].
46	4	r	Power Event triggered	Displays the triggered power [0.01 W].
47	4	r	Ipeak Event triggered	Displays the triggered peak current [0.1 A] (actual value, not effective value)
Current Channels I7				
48	1	r	Status Current	Displays the respective status: Bit 1..0: Displays the selected phase 0 = Inactive 1 = Phase 1 2 = Phase 2 3 = Phase 3 Bit 2: 1 .. Ieff warning (current below 1A) Bit 3: 1 .. V-I Phase error (energy is positive) Bit 4..5: LoadType (3) Bit 6..7: reserved
an 48	1	r	Cos(Phi) (1)	Displays the Cosine of the phase difference angle [0.01].
49	4	r	Ieff	Display of the actual effective current measured [0.1 A].
4A	4	r	Power (2)	Displays the actual power measured [0.01 W].
4B	4	r	Energy consumption since the first activation	Displays the total measured energy since the initial activation [0.1 kWh]
4C	4	r	Energy consumption since the last reset	Displays the recorded energy use since the last reset [0.1 kWh] To reset the values, see item "Reset energy consumption"
-	1	r	reserved	
4D	1	r	Cos(Phi) Event triggered	Displays the triggered Cosine of the phase difference angle [0.01].
4E	4	r	Ieff Event triggered	Displays the triggered effective current [0.1 A].
4F	4	r	Power Event triggered	Displays the triggered power [0.01 W].
50	4	r	Ipeak Event triggered	Displays the triggered peak current [0.1 A] (actual value, not effective value)

Current Channels I8				
51	1	r	Status Current	Displays the respective status: Bit 1..0: Displays the selected phase 0 = Inactive 1 = Phase 1 2 = Phase 2 3 = Phase 3 Bit 2: 1 .. Ieff warning (current below 1A) Bit 3: 1 .. V-I Phase error (energy is positive) Bit 4..5: LoadType (3) Bit 6..7: reserved
an 51	1	r	Cos(Phi) (1)	Displays the Cosine of the phase difference angle [0.01].
52	4	r	Ieff	Display of the actual effective current measured [0.1 A].
53	4	r	Power (2)	Displays the actual power measured [0.01 W].
54	4	r	Energy consumption since the first activation	Displays the total measured energy since the initial activation [0.1 kWh]
55	4	r	Energy consumption since the last reset	Displays the recorded energy use since the last reset [0.1 kWh]. To reset the values, see item "Reset energy consumption"
-	1	r	reserved	
56	1	r	Cos(Phi) Event triggered	Displays the triggered Cosine of the phase difference angle [0.01].
57	4	r	Ieff Event triggered	Displays the triggered effective current [0.1 A].
58	4	r	Power Event triggered	Displays the triggered power [0.01 W].
59	4	r	Ipeak Event triggered	Displays the triggered peak current [0.1 A] (actual value, not effective value)
Current Channels I9				
5A	1	r	Status Current	Displays the respective status: Bit 1..0: Displays the selected phase 0 = Inactive 1 = Phase 1 2 = Phase 2 3 = Phase 3 Bit 2: 1 .. Ieff warning (current below 1A) Bit 3: 1 .. V-I Phase error (energy is positive) Bit 4..5: LoadType (3) Bit 6..7: reserved
an 5A	1	r	Cos(Phi) (1)	Displays the Cosine of the phase difference angle [0.01].
5B	4	r	Ieff	Display of the actual effective current measured [0.1 A].
5C	4	r	Power (2)	Displays the actual power measured [0.01 W].
5D	4	r	Energy consumption since the first activation	Displays the total measured energy since the initial activation [0.1 kWh]

5E	4	r	Energy consumption since the last reset	Displays the recorded energy use since the last reset [0.1 kWh]. To reset the values, see item "Reset energy consumption"
-	1	r	reserved	
5F	1	r	Cos(Phi) Event triggered	Displays the triggered Cosine of the phase difference angle [0.01].
60	4	r	Ieff Event triggered	Displays the triggered effective current [0.1 A].
61	4	r	Power Event triggered	Displays the triggered power [0.01 W].
62	4	r	Ipeak Event triggered	Displays the triggered peak current [0.1 A] (actual value, not effective value)
Current Channels I10				
63	1	r	Status Current	Displays the respective status: Bit 1..0: Displays the selected phase 0 = Inactive 1 = Phase 1 2 = Phase 2 3 = Phase 3 Bit 2: 1 .. Ieff warning (current below 1A) Bit 3: 1 .. V-I Phase error (energy is positive) Bit 4..5: LoadType (3) Bit 6..7: reserved
an 63	1	r	Cos(Phi) (1)	Displays the Cosine of the phase difference angle [0.01].
64	4	r	Ieff	Display of the actual effective current measured [0.1 A].
65	4	r	Power (2)	Displays the actual power measured [0.01 W].
66	4	r	Energy consumption since the first activation	Displays the total measured energy since the initial activation [0.1 kWh]
67	4	r	Energy consumption since the last reset	Displays the recorded energy use since the last reset [0.1 kWh]. To reset the values, see item "Reset energy consumption"
-	1	r	reserved	
68	1	r	Cos(Phi) Event triggered	Displays the triggered Cosine of the phase difference angle [0.01].
69	4	r	Ieff Event triggered	Displays the triggered effective current [0.1 A].
6A	4	r	Power Event triggered	Displays the triggered power [0.01 W].
6B	4	r	Ipeak Event triggered	Displays the triggered peak current [0.1 A] (actual value, not effective value)

Current Channels I11				
6C	1	r	Status Current	Displays the respective status: Bit 1..0: Displays the selected phase 0 = Inactive 1 = Phase 1 2 = Phase 2 3 = Phase 3 Bit 2: 1 .. Ieff warning (current below 1A) Bit 3: 1 .. V-I Phase error (energy is positive) Bit 4..5: LoadType (3) Bit 6..7: reserved
an 6C	1	r	Cos(Phi) (1)	Displays the Cosine of the phase difference angle [0.01].
6D	4	r	Ieff	Display of the actual effective current measured [0.1 A].
6E	4	r	Power (2)	Displays the actual power measured [0.01 W].
6F	4	r	Energy consumption since the first activation	Displays the total measured energy since the initial activation [0.1 kWh]
70	4	r	Energy consumption since the last reset	Displays the recorded energy use since the last reset [0.1 kWh]. To reset the values, see item "Reset energy consumption"
-	1	r	reserved	
71	1	r	Cos(Phi) Event triggered	Displays the triggered Cosine of the phase difference angle [0.01].
72	4	r	Ieff Event triggered	Displays the triggered effective current [0.1 A].
73	4	r	Power Event triggered	Displays the triggered power [0.01 W].
74	4	r	Ipeak Event triggered	Displays the triggered peak current [0.1 A] (actual value, not effective value)
Current Channels I12				
75	1	r	Status Current	Displays the respective status: Bit 1..0: Displays the selected phase 0 = Inactive 1 = Phase 1 2 = Phase 2 3 = Phase 3 Bit 2: 1 .. Ieff warning (current below 1A) Bit 3: 1 .. V-I Phase error (energy is positive) Bit 4..7: reserved
an 75	1	r	cos(phi)	Displays the Cosine of the phase difference angle [0.01].
76	4	r	Ieff	Display of the actual effective current measured [0.1 A].
77	4	r	Power	Displays the actual power measured [0.01 W].
78	4	r	Energy consumption since the first activation	Displays the total measured energy since the initial activation [0.1 kWh]

79	4	r	Energy consumption since the last reset	Displays the recorded energy use since the last reset [0.1 kWh]. To reset the values, see item "Reset energy consumption"
-	1	r	reserved	
7A	1	r	Cos(Phi) Event triggered	Displays the triggered Cosine of the phase difference angle [0.01].
7B	4	r	Ieff Event triggered	Displays the triggered effective current [0.1 A].
7C	4	r	Power Event triggered	Displays the triggered power [0.01 W].
7D	4	r	Ipeak Event triggered	Displays the triggered peak current [0.1 A] (actual value, not effective value)

Notes

(1) **Note** on Cos(Phi) measurement

Due to the rounding process, a sign change can occur for very small residual active power during the calculation with pure reactive power.
Cos(phi) goes toward null, the value of the active power is distributed around the null point. An evaluation of the energy direction (generator, load) is therefore impractical with pure reactive power.

(2) **Note** on active power measurement

The calculated active power can be positive (load) as well as negative (generator). A negative value can also be caused by a wiring error (reversed poles of a current converter).

(3) **Note** on difference between inductive/capacitive loads

In the status byte of each current channel, the **LoadType** is also sent.

Bit 5 and Bit 4:

0	No entry	
1	Capacitive load	(cos(phi) = 0 .. 0.99)
2	Inductive load	(cos(phi) = 0 .. 0.99)
3	Pure ohmic load	(cos(phi) = 1.00)

Caution:
With a very small Cos(Phi), the sign change ((1) Note) can cause a change (capacitive ← → inductive) in the display of the LoadType.