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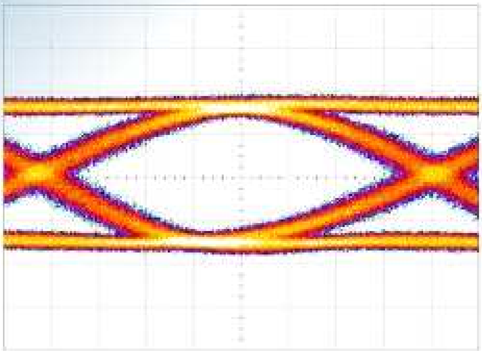

Datasheet
EC-CNT4

Revision History

Revision	Changes	Date	Author
11	-	Mar 15th in 2010	Schammer
12	Correction of max. input voltage (3V input version) correction of input current (5/24V input version)	Nov 9th in 2010	Schammer
13	Description of the behavior after power on	Mar 22nd in 2011	Schammer

Datasheet EC-CNT4

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1. Application Range

The EC-CNT4 module is especially suited for counting fast pulses and accurate measurement of frequencies or cyclic times. The counter results are transmitted by the EtherCAT®[1]-fieldbus. The module is designed for DIN rail assembly.

The EC-CNT4 has four channels for the connection of incremental transducers. It is able to

- count fast pulses for determining positions,
- measure frequencies, e.g. for measuring rotational speed and
- measure cyclic times

Every channel is made of three tracks (A, B and Z). The pulses being counted are at tracks A and B. The track Z is used as zero pulse. Every channel is equipped with one 32bit pulse counter and one 32bit time counter. The pulse counter is counting the chosen edges of the tracks A and/or B:

- continuously (counter mode) or
- during a programmable gate time (frequency measurement).

The time between two chosen edges is determined by the time counter at cyclic time measuring. Furthermore the time counter is used to determine the gate time at frequency measurement mode.

The gate time can be either

- asynchronously in relation to the EtherCAT®-frames, while the duration of the gate time programmed or
- synchronously in relation to the EtherCAT®-frames, while the interval of the frames is determining the gate time.

The time counter is clocked with a constant frequency of 25MHz. Thereby it is possible to measure times up to about 171 seconds at a resolution of 40ns.
The additional input Z is used for zero pulse. The pulse counter is cleared by switching on the additional input Z at mode "counter with zero pulse".

The module EC-CNT4 is available with 3V, 5V or 24V inputs. The connection of peripheral signals is carried out by four 8pin Phoenix connectors.

Differential signals should be preferred for peripheral signals. If differential signals are used broken cables can be detected. This state could be read out by software. The maximal input frequency is 2MHz. Thereby the module can count with 8MHz at quadruple evaluation (s. 5.2.1).

[1] EtherCAT® is registered trademark and patented technology, licensed by Beckhoff Automation GmbH, Germany

The evaluation modes of a channel can be chosen by software. Possible are:

- quadrature (simple, double or quadruple evaluation) or
- pulse and direction or
- track A forward and B backward

The power supply is carried out by a 2-pole threaded connector.

2. Usable Transducers

2.1. Input Pulse Shapes

It is possible to connect incremental transducers with following pulse shapes:

1. Rotary transducer with two pulse sequences with a phase offset of 90°. If track A is advanced to track B the pulse counter counts up. Otherwise it counts down. These cases result in positive or negative frequencies respectively in the mode “frequency measurement”.
2. Rotary transducer with pulse and direction. The pulses are at track A, the direction at track B. The counter counts up if B is low. Otherwise it counts down.
3. Rotary transducer with separated outputs for forward and backward. Track A counts up, track B down.

It is possible to connect transducers with differential outputs (bipolar signals) or with ground based outputs (unipolar signals). **It is recommended to use only transducers with bipolar signals.** These transducers enable a better noise rejection and compensation of signal distortion. Using differential transducers the outputs can be connected to the module inputs in any order according to their polarity. But it must be considered that the transducer signals are assigned suitable to the tracks of the module to obtain the right count direction.

Rotary transducers with unipolar outputs must be connected to the module inputs with their signal outputs to A+ or B+ respectively and ground to A- or B- respectively. These transducers must have a positive output voltage in relation to ground if sending a high signal.
The detection of broken cables (s. 3.2.1) is not possible with unipolar transducers.

2.2. Transducer Supply

The supply voltage is directed to a diode used as reverse polarity protection. The resulting voltage behind the diode is used for powering the internal logic as well as for the transducer supply. The current maximal allowed for this purpose is 250mA per channel. The “24V-“-pins are connected directly. But the transducers can be supplied separately also.

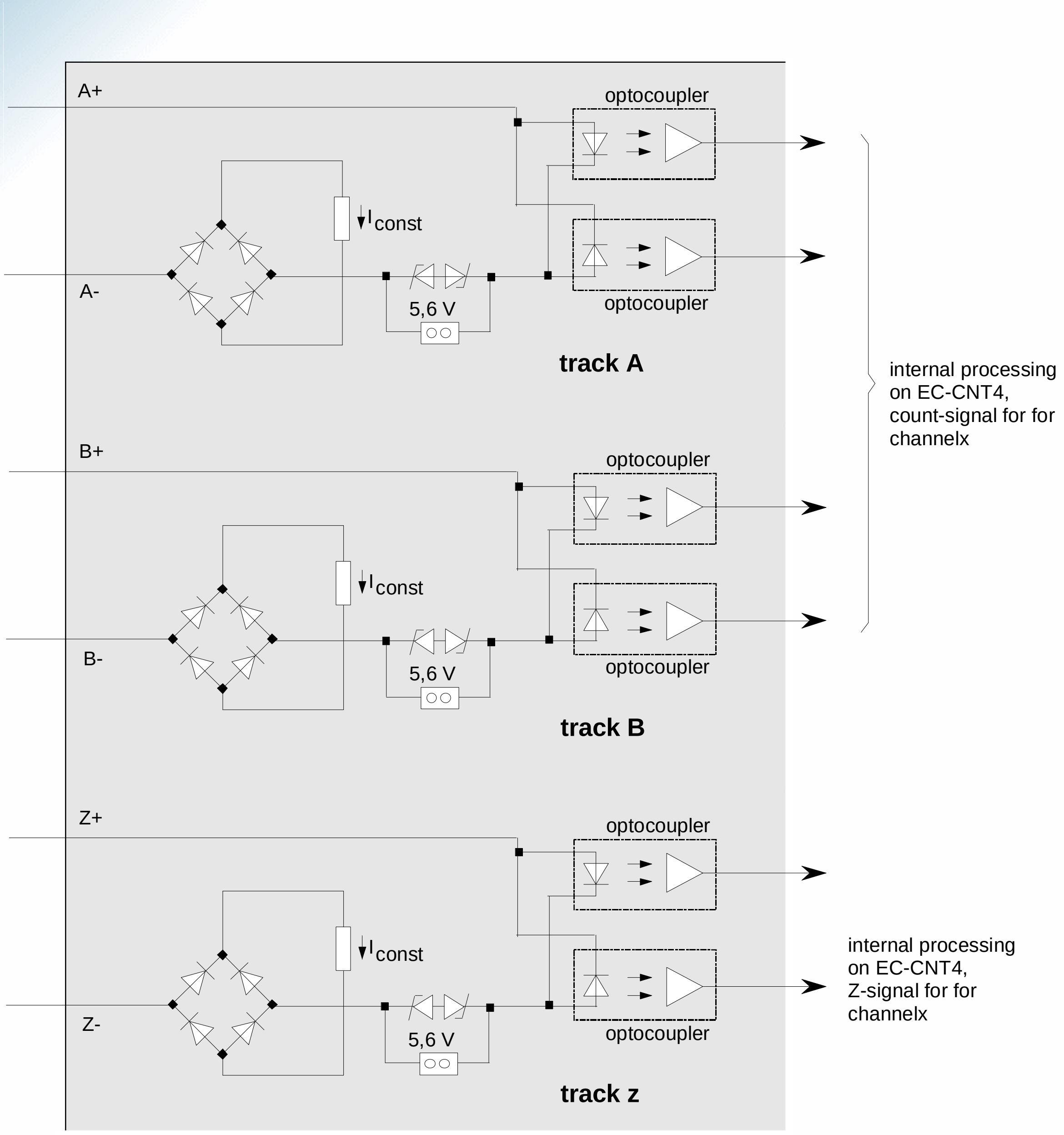
3. Hardware Description

3.1. Behavior after Power on

The optocouplers used on the module have an internal supervisor circuit which is able to suppress oscillations of the output signals while powering on. This supervisor circuit assumes that the supply voltage is decreased to zero Volt before powering on. I. e. if the module should be powered on shortly after having powered off there must be waited for min. 15 seconds.

3.2. Input Circuit

The module has four counter channels. Every channel is made of three tracks A, B and Z. All inputs are to each other and to the Ethernet potential isolated. The inputs are achieved as a constant current drain.



The version with 5V input signals (part number 100 43 02) is achieved by short-circuiting the 5.6V Z-diodes with a soldering bridge.
The version with 3V input signals (part number 100 43 04) is achieved by bypassing the 5.6V Z-diodes, the bridge rectifier and the constant current drain with a 330Ohm resistance (not illustrated in the figure).

3.2.1. Detection of Broken Cable

Every input has a supervisor circuit which is able to detect a missing input signal. Then a bit will be set in the broken cable register. The software can read out these registers and react accordingly. The supervisor circuit is working only with transducers with differential outputs. The assignment of the bits in the broken cable register to the inputs is as follows:

State register broken cable:

D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
-	Z3	B3	A3	-	Z2	B2	A2	-	Z1	B1	A1	-	Z0	B0	A0

Meaning of bits of state register broken cable
High: broken cable
Low: no broken cable

3.2.2. Detection of Input Signal Type

Every input has a detection circuit for bipolar or unipolar (ground based) signals. Often a bipolar signal is called differential signal. If there are connected unipolar signals with strong noise the automatic detection of the signal type is not guaranteed, i.e. a unipolar signal could be detected as a bipolar one. That would result in wrong counter values. That’s why there is the possibility to force a channel to unipolar by programming the channel control word (s. 5.2.1) accordingly. This affects all three tracks of a channel simultaneously.

Remark: It is only a makeshift to force the inputs to unipolar type. It is advised to eliminate the reason of the noise.

The allocation of the inputs to the bits in the state register unipolar is as follows:

State register unipolar:

D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
-	Z3	B3	A3	-	Z2	B2	A2	-	Z1	B1	A1	-	Z0	B0	A0

Meaning of the bits of the state register unipolar
High: unipolar input signal
Low: bipolar input signal

The bits of state register unipolar are only valid at inputs where no broken cable was detected.

3.2.3. Digital Input Filter

Every input is provided with a digital filter for noise suppression. The length of the filters is programmable (s. 5.2.1). A short filter may be usable if the input pulses are short. Longer filters should be used in an environment with strong electromagnetic disturbances.

3.2.4. Suppression of Vibrations

Vibrations at the tracks A and B can occur if the transducer stops. There would be for instance a steady signal at track A and an oscillating one at track B due to the fact that the transducer is at a commutating position. These vibrations would be suppressed normally by the input logic. But it is possible to switch off this logic for special cases (s. 5.2.1).

3.3. Programmable Logic

The module is assembled with a programmable logic IC. It serves as a link between EtherCAT® slave controller and the input circuit.

3.4. EtherCAT®-Connection

The module has two Ethernet interfaces each with one yellow and one green LED. The yellow LED signalizes an Ethernet connection with 100MB, the green data transfer.
One interface serves as input, the other as output to the next EtherCAT® slave or is unconnected if the module is the last inside the chain. Both interfaces support auto crossover (MDI/MDIX).
Furthermore there is a green LED at the front side displaying the EtherCAT® state with different blink sequences.

3.5. Power Supply

The module is supplied with 24V±30%. All necessary supply voltages for the different functional blocks are generated internally. The power needed is about 3W plus transducer supply.

4. Counter Modes

The EC-CNT4 module has four counter channels. Every channel can be programmed independently from each other for one of four counter modes. The counter values according to the mode chosen are transferred to the output memory of the EtherCAT® slave controller cyclically. The content of the output memory is transferred with the next EtherCAT® frame to the master and can be accessed by the application software afterwards.

4.1. Frequency Measurement

The pulses sent by the transducer are counted during the gate time set. The gate time can either be asynchronously in relation to the EtherCAT® frames, whereas the duration of the gate time is determined by the content of the gate time register (s. 5.2.2). Or secondly the gate time can be synchronized with the EtherCAT® frames, whereas the interval of the EtherCAT® frames including output data determines the duration of the gate time.
The pulse and the time counter are transferred into the output memory of the EtherCAT® slave controller after the expiration of the gate time. The pulse counter indicates the number of pulses occurred during the gate time. The time counter contains the corrected gate time. So the frequency is calculated as follows:

f = pulse counter / (time counter * 40ns)

Please consider: There is a difference between the programmed (synchronous or asynchronous) and the automatically corrected gate time. For an accurate calculation of frequencies it should ever be used the corrected one, i.e. the gate time determined by the EC-CNT4 in the time counter register.

If there wasn't any input pulse during programmed gate time the pulse counter=0x0 and the time counter continues counting until the next input pulse is detected, i.e. the gate time would be expanded. Thereby very low frequencies can be measured also. Only the maximum time counter value of about 171 seconds limits. But that should not have any practical relevance. A time counter overflow is avoided by hardware and needn't be handled by software.

4.2. Cyclic Time Measurement

The time between two signal edges is measured with the mode "cyclic time measurement" using the time counter. The time counter is transferred to a temporary latch at every edge of the input signal. Afterwards the time counter is cleared and begins to count again. The content of the temporary latch is transferred to the output memory of the EtherCAT® slave controller every 10µs cyclically. It is possible to measure a maximum cyclic time of about 171 seconds. The resolution is 40ns. The cyclic time is calculated as follows:

T = time counter * 40ns

A time counter overflow is avoided by hardware, i.e. it stops at 0xFFFF.FFFF.

4.3. Counter without Zero Pulse

The counter mode serves for determining positions of rotating or linear moving machines by counting pulses of incremental transducers. Therefore the pulse counter is used. A counter over- or underflow is not avoided by hardware. That's why software is responsible for such an event.
The current counter value is transferred into the output memory of the EtherCAT® slave controller every 10µs cyclically.
The pulse counter can be preloaded by a load command in the channel control word (s. 5.2.1). Another possibility is to reset the pulse counter by a clear command in the counter control word. The load command is prioritized in relation to the clear command.

4.4. Counter with Zero Pulse

The function of the counter with zero pulse is similar to the counter without zero pulse. There is only one difference. Track Z is evaluated in addition to the tracks A and B. Track Z serves as zero pulse. If it is active the pulse counter is cleared. The zero pulse is prioritized in relation to load- (and clear-) command in the channel control word.

5. Programming and Memory Mapping of the EtherCAT®-Slave Controller

5.1. Summary

The integrated circuit ET1100 of Beckhoff Automation GmbH is used as EtherCAT® –slave controller. It is responsible for the data exchange between application layer and counter logic. There for two SyncManagers (SM) of the ET1100 are used. One serves for the output of data (channel control words, gate times and preset values), the other is used for reading counter values and state registers. Both SMs operate in 3 buffer mode ensuring data consistency. The SM for data output activates the interrupt line of the process data interface if there new output data were transmitted with the last frame. The counter logic will serve the interrupt by reading the new output data. The counter values and state registers are written to the slave controller by the counter logic every 10µs cyclically. Regarding the necessary transfer time the input data are maximum 20µs old at the beginning of data frame.

5.1.1. Programming of SyncManagers

SM	Address	Value	Explanation
SM0	0x800	0x2000	Start address of input data
	0x802	0x0024	Length of input data in Byte
	0x804	0x0010	read, 3buffer, ECAT IRQ
	0x806	0x0001	Enable (set after 0x800..804 are programmed)
SM1	0x808	0x2100	Start address of output data
	0x80A	0x0020	Length of output data in Byte
	0x80C	0x0024	write, 3buffer, PDI IRQ
	0x80E	0x0001	Enable (set after 0x808..80C are programmed)

5.1.2. Data Fields

Input data:

Address	Content
0x2000	Pulse counter low-Part, Channel0
0x2002	Pulse counter high-Part, Channel0
0x2004	Time counter low-Part, Channel0
0x2006	Time counter high-Part, Channel0
0x2008	Pulse counter low-Part, Channel1
0x200A	Pulse counter high-Part, Channel1
0x200C	Time counter low-Part, Channel1
0x200E	Time counter high-Part, Channel1
0x2010	Pulse counter low-Part, Channel2
0x2012	Pulse counter high-Part, Channel2
0x2014	Time counter low-Part, Channel2
0x2016	Time counter high-Part, Channel2
0x2018	Pulse counter low-Part, Channel3
0x201A	Pulse counter high-Part, Channel3
0x201C	Time counter low-Part, Channel3
0x201E	Time counter high-Part, Channel3
0x2020	state: broken cable
0x2022	state: unipolar

Output Data:

Address	Content
0x2100	Preset value Pulse counter low-Part, Channel0
0x2102	Preset value Pulse counter high-Part, Channel0
0x2104	Channel control word Channel0
0x2106	Gate time Channel0
0x2108	Preset value Pulse counter low-Part, Channel1
0x210A	Preset value Pulse counter high-Part, Channel1
0x210C	Channel control word Channel1
0x210E	Gate time Channel1
0x2110	Preset value Pulse counter low-Part, Channel2
0x2112	Preset value Pulse counter high-Part, Channel2
0x2114	Channel control word Channel2
0x2116	Gate time Channel2
0x2118	Preset value Pulse counter low-Part, Channel3
0x211A	Preset value Pulse counter high-Part, Channel3
0x211C	Channel control word Channel3
0x211E	Gate time Channel3

5.2. Channel Registers

Every channel has one channel control word and one gate time register. They are used to determine the function of every channel separately. Above all there is a preset register for every channel.

5.2.1. Channel Control Word

The function of the counter channels are programmed by channel control words. The channel control words are composed identically for every channel. Not all possible combinations are reasonable. For instance the determination of the polarity of zero pulse at mode "cyclic time measurement" is not useful and would be ignored. The channel control words are 16bit long.

Channel control word:

D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
FL1	FL0	LD	CLR	SV	SM	UNI	NPOL	CE	M1	M0	INV	QN	DC2	DC1	DC0

DC(2..0) edge evaluation at quadrature mode (QN = 0)
- 000: Ap, simple
- 001: An, simple
- 010: Bp, simple
- 011: Bn, simple
- 100: A, double
- 101: B, double
- 110: quadruple
- 111: A forward, B backward

QN quadrature
- 0: quadrature mode or A forward and B backward respectively
- 1: A pulse, B direction

INV direction of counting
- 0: normal
- 1: inverse

M(1..0) counter mode
- 00: frequency measurement
- 01: cyclic time measurement
- 10: counter without zero pulse
- 11: counter with zero pulse

CE counter enable (counter modes 10 and 11)
- 0: counter disabled
- 1: counter enabled

NPOL polarity of zero pulse (counter mode 11)
- 0: normal
- 1: inverse

UNI force unipolar
- 0: automatic detection of unipolar/bipolar
- 1: channel (tracks ABZ) is forced to unipolar

SM synchronous mode
- 0: gate time asynchronously in relation to the EtherCAT®-frames
- 1: gate time synchronously in relation to the EtherCAT®-frames

SV suppression of vibrations
- 0: suppression of vibrations enabled
- 1: suppression of vibrations disabled

CLR clear pulse counter register
- 0: normal function
- 1: clear counter

  CLR is reset automatically after clearing pulse counter register.

LD load pulse counter register
0: no function
1: counter is preloaded with content of preset register
LD is reset automatically after loading pulse counter register.
LD is prioritized in relation to CLR

FL(1..0) length of input filter
00: 1 clock (= 40ns)
01: 2 clocks (= 80ns)
10: 3 clocks (= 120ns)
11: 4 clocks (= 160ns)

Explanations:

- The signal edges are the triggering events for frequency measurement, cyclic time measurement or counting. Often it is commonly called counting.
- All edge evaluations (simple, double, quadruple) are possible at quadrature mode. The counter counts up, if track A is advanced to track B.
  There must be two signals with an offset of 90° in quadrature mode. Otherwise a wrong result occurs.
  - Simple evaluation Ap/An/Bp/Bn: The positive or negative edges at track A or B are counted.
  - Double evaluation A/B: The positive and negative edges at track A or B are counted.
  - Quadruple evaluation: The positive and negative edges at track A and B are counted.
- A simple evaluation is made if direct counting mode is used (A forward and B backward). In addition the track of the inactive count direction must be low.
- If a rotary transducer with pulse and direction outputs is used the pulses must be connected to track A, the direction signal to track B. Only a simple evaluation is made. The counter counts up if there is a low at direction signal and vice versa.
- The time between two consecutive edges is measured if cyclic time measurement is used. Simple, double and quadruple evaluation is possible for the relevant edges.
- The suppression of vibrations at the input signals can be manually controlled. Vibrations can occur if the transducer is stopped resulting for instance in a steady signal at track A and an oscillating one at track B. These vibrations can lead to wrong counter values. That’s why the suppression of vibrations should normally be switched on.
- CLR and LD are activated only for one time directly after transferring channel control words.
- Every input is provided with a digital filter. The length of the filters is programmable. If there are very short input signals a short filter should be chosen also. A longer filter could be helpfully in an environment with strong electromagnetic disturbances.

5.2.2. Gate Time Register

Gate time register:

D15..11	D9..0
-	GT9..0

The gate time is asynchronously in relation to the EtherCAT® frames if the frequency measurement is made with asynchronous mode. Then the gate time is determined by the gate time register. GT0-9 contains the gate time in 100µs-steps. If the frequency measurement is made in synchronous mode the content of the gate time register is ignored.

GT9-0 = 0x000 → 1 * 100µs
GT9-0 = 0x3FF → 1024 * 100µs

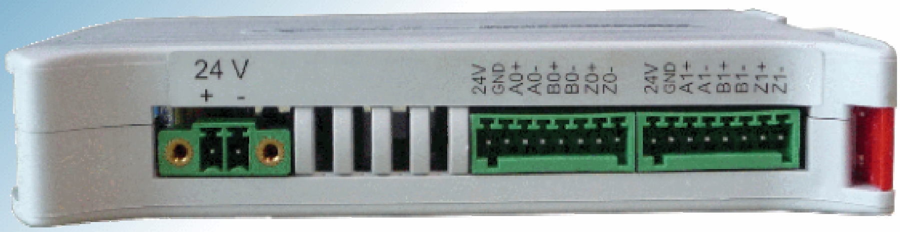
5.2.3. Preset Register

The preset register has a length of 32 bit. It is used to set the pulse counter register to a certain value. This could be usefully if a counter mode for position determination is chosen.

5.3. Version

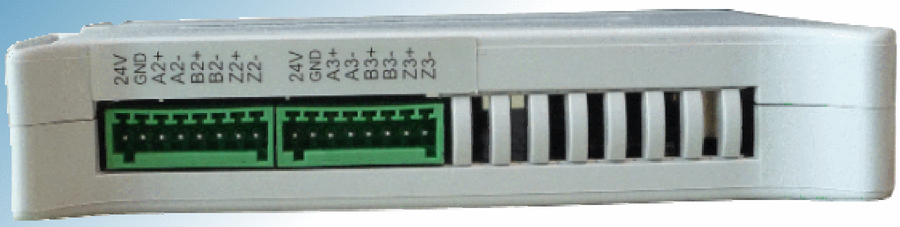
The version of logic implemented can be determined by reading the memory cell 0xFE0 of the EtherCAT® slave controller. The cell is written by the slave logic while the slave is in the Init state.

6. Connector Pin Assignment



View to the bottom side of the module

24V+	Power supply +
24V-	Power supply ground
24V	Transducer supply + (=24V+ - 0,7V)
GND	Transducer supply - (=24V-)
A0+	Counter input Channel 0, Track A+
A0-	Counter input Channel 0, Track A-
B0+	Counter input Channel 0, Track B+
B0-	Counter input Channel 0, Track B-
Z0+	Counter input Channel 0, Track Z+
Z0-	Counter input Channel 0, Track Z-
24V	Transducer supply + (=24V+ - 0,7V)
GND	Transducer supply - (=24V-)
24V	Geberversorgung + (=24V+ - 0,7V)
GND	Geberversorgung Masse (=24V-)
A1+	Counter input Channel 1, Track A+
A1-	Counter input Channel 1, Track A-
B1+	Counter input Channel 1, Track B+
B1-	Counter input Channel 1, Track B-
Z1+	Counter input Channel 1, Track Z+
Z1-	Counter input Channel 1, Track Z-



View to the top side of the module

24V	Transducer supply + (=24V+ - 0,7V)
GND	Transducer supply - (=24V-)
A2+	Counter input Channel 2, Track A+
A2-	Counter input Channel 2, Track A-
B2+	Counter input Channel 2, Track B+
B2-	Counter input Channel 2, Track B-
Z2+	Counter input Channel 2, Track Z+
Z2-	Counter input Channel 2, Track Z-
24V	Transducer supply + (=24V+ - 0,7V)
GND	Transducer supply - (=24V-)
A3+	Counter input Channel 3, Track A+
A3-	Counter input Channel 3, Track A-
B3+	Counter input Channel 3, Track B+
B3-	Counter input Channel 3, Track B-
Z3+	Counter input Channel 3, Track Z+
Z3-	Counter input Channel 3, Track Z-

7. Technical Data

EtherCAT®-Connection:

2 x RJ45 with two LED yellow and green
Every connection with MDI/MDIX (auto crossover)
1 x state-LED, green

Counter Inputs:

Number of Channels:	4
Type:	ABZ

Evaluation:
- quadrature (simple, double, quadruple evaluation)
- A forward and B backward
- pulse and direction

Modes:
- frequency measurement
- cyclic time measurement
- counter without zero pulse
- counter with zero pulse

Performance:

deviation:	<0,01%typ (frequency measurement)
counter range:	32bit (counter modes, cyclic time measurement)
resolution:	40ns (cyclic time measurement)

Input Frequency:	<=2MHz
Input Type:	bipolar or unipolar
Input Voltage:	3V, 5V or 24V
Input Current:	2 - 4mA
Galvanic Isolation:	to each other, to digital electronic and to Ethernet
Isolation Voltage:	250Vrms (channel to channel) 500Vrms (inputs to digital electronic) 1500Vrms (digital electronic to Ethernet)

Power Supply:

Input Voltage:	24V +-30%
Power Consumption:	<3W

Housing:

Dimensions:	120 x 101 x 22,5 mm
Material:	Blend PC/ABS self-extinguishing
Color:	grey (other on request)
Assembly:	DIN rail
Weight:	135 g incl. connectors

Connector Power Supply:

Type:	Phoenix FK-MC 1,5/2-STF-3,5
Type of Connection:	screw connection
Color:	green
No. of Positions:	2
Conductor Cross-Section:	0.14 – 1.5mm^2
Stripped Insulation Length:	7 mm

Connector Peripheral Signals:

Type:	Phoenix FK-MC 0,5/12-ST-2,5
Type of Connection:	spring-cage
Color:	green
No. of Positions:	8
Pieces:	4
Conductor Cross-Section:	0.14 - 0.5mm^2
Stripped Insulation Length:	8 mm

There must be used twisted pair conductors for every track. Using a cable from the transducer to the connector with 2 or 3 twisted pairs with an overall shielding is recommended. The type of cable Li2YCY 4 × 2 × 0.5 mm^2 is recommended. The overall shielding should be connected all around to PE/ground.
Depending on the special conditions a different grounding method can be usefully, especially if the potential difference between transducer and the EtherCAT®-module is very high.

The cable resistance and capacity between transducer and EtherCAT®-module should be considered.

Signal Inputs 24V (Part Number 100 43 00)

|Ue1| > 12 V:	|Ie1| = 4mA ± 30%
|Ue0| < 5 V:	|Ie0| <= 10µA
|Uemax| = 40V	

Signal Inputs 5V (Part Number 100 43 02)

|Ue1| > 3.5 V:	|Ie1| = 4mA ± 30%
|Ue0| < 1.8 V:	|Ie0| <= 10µA
|Uemax| = 30V	

Signal Inputs 3V (Part Number 100 43 04)

|Ue1| > 2.5 V:	|Ie1| = (|Ue1|-1.5V) / 470Ω
|Ue0| < 1.5 V:	|Ie0| <= 10µA
|Uemax| = 4.5V	

Tolerances

Two Tracks with an Offset of 90°: 90° el. +/-45° (applies to all transitions)
Mark-Space Ratio: 180°el. +/-10°
For a Sequence of Single Pulses:
t_high > 0.2 µs
t_low > 0.2 µs

Ambient Conditions

Humidity:	5% until 95% without condensation
Operating Temperature:	0°C to + 55° C
Storage Temperature:	-40°C to +85° C

Electromagnetic Compatibility

Emissions:	EN61000-6-2:2001
Immunity:	EN61000-6-4:2001

8. Ordering Information

EC-CNT4 with 24V-inputs:	**100 43 00**
EC-CNT4 with 5V-inputs:	**100 43 02**
EC-CNT4 with 3V-inputs:	**100 43 04**

All necessary connectors are included.