ACURO®-DRIVE Absolute-Motorfeedback-Encoder

- **For brushless servo motors**
- **Resolver size 15 compatible**
- **Through hollow shaft 8 mm**
- **19 Bit Singleturn + 12 Bit Multiturn**
- **+ 120°C operating temperature**
- **10.000 rpm continuous operation**
- **Geared optical multiturn**
- **SSI or BiSS interface**
- **Sinewave 1 Vpp**
- **Bandwidth 500kHz**

Contents

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1 General

1.1 Application

The **AD36** is an absolute encoder with a true geared Multiturn, optical sensing technology and 36 mm diameter. Unique is the through hollow shaft which enables an assembly that is compatible with resolver size 15. The mechanical design consists of two ball bearings and a flexible torque support. The AD36 complements the *ACURO®-DRIVE* series and is appropriate for use within BLDC servo motors with small frame sizes.

Fully digital control loop
The new and completely digital OptoAsic technology enables the transition to a truly digital drive system. The conventional absolute encoders still have analog sine wave signals for the feedback of speed and position data. The AD36, however, provides fully digital position data up to 19 Bit (Singleturn) and 12 Bit (Multiturn) over the *BiSS* interface with a variable clock rate up to 10 MHz. *BiSS* is the only open high speed bidirectional sensor interface available on the market.

Backwards Compatible to SSI + sincos
For a smooth design in process in existing environments the **AD36** provides backwards compatibility through 2048 periods /rev. sinewave signals (1Vpp) combined with a standard SSI interface. This enables qualification and testing of the encoder with most existing drives.

More Safety through redundancy of code, self monitoring, CRC and geared multiturn
For redundancy purpose the sinewave output can be used in parallel with the BiSS absolute data channel. A permanent code plausibility check detects any wrong position information caused by any reason. The encoder communicates detected errors via status bits to the drive. The AD36 operates from –15 °C up to 120°C. The encoder monitors its internal temperature in the range –40°C…+140°C. The temperature value is transmitted in 8 bit resolution via multicycle bits. The user can define lower and upper temperature limits. The AD36 sends warnings if the customer defined limits are exceeded. The multiturn mechanism supports safety through use of true geared optical technology, that is not affected by strong magnetic fields.

1.2 Direct shaft coupling and stator coupling

The AD36 comes with an 8mm hollowshaft, that can be mounted with a jam nut or central shaft screw like a resolver. The screw holes of the spring tether are on the same bolt circle as those for a size 15 resolver. This enables an easy upgrade from resolver feedback to multiturn absolute technology without any mechanical modifications.

1.3 The new Hengstler OptoAsic Technology

The central element of the ***ACURO®-DRIVE*** is the latest technology Hengstler OptoAsic, that contains almost all of the electronics. The most outstanding benefits are:

- High signal quality through integrated control and error compensation.
- Unequalled bandwidth of 500 kHz of sinewave signals at full signal quality.
- Highest EMC immunity through signal paths in the µm range.
- Excellent reliability through reduction of parts and integrated diagnosis system.
- Aging compensation through integrated light regulation of the LED.
- Integrated monitoring of:
  - Pollution
  - Disk damage
  - End of LED - live
  - Temperature

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2 Electrical Data

2.1 General Design

Protection Degree III
Pollution Degree 2
Over voltage Category II

according DIN EN 61010 part 1 (03.94)/ EN 61010-1/A2 (05.96) (VDE 0411)

2.2 Supply Voltage (SELV)

DC 5 V –5%/ +10%
DC 7…30 V

2.3 Intrinsic current consumption (w/o output current)

Singleturn: at DC 5 V ≤ 45 mA
Multiturn: at DC 5 V ≤ 85 mA

2.4 Resolution and Accuracy

Incremental Signals (A, B)
2048 Periods / Revolution

Absolute accuracy	≤ ± 0,01°$_{mechanical}$	(± 36“)
Repeatability	≤ ± 0,002°$_{mechanical}$	(± 7,2“)

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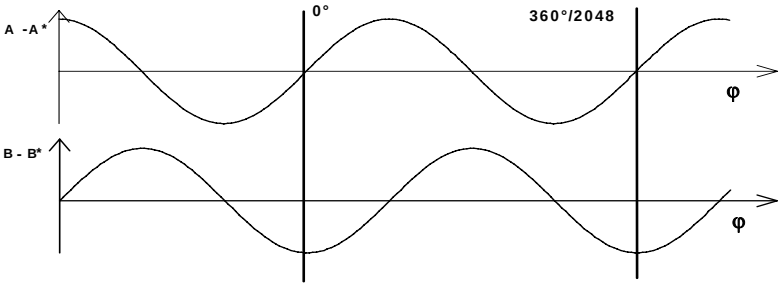
2.5 Output signals

2.5.1 Incremental Signals A, B

Track A leads B by 90° at rotation and view on shaft end.

$A = U_M + \hat{u}_A \sin(z\varphi_{mech.})$
$A^* = U_M - \hat{u}_A \sin(z\varphi_{mech.})$
$B = U_M - \hat{u}_B \cos(z\varphi_{mech.})$
$B^* = U_M + \hat{u}_B \cos(z\varphi_{mech.})$

z: No. Of signal periods (2048)



- Signal

Amplitudes:[1) 2)] $\hat{u}_{(A-A^*;\,B-B^*)}$ = 0,5V - 25% / + 20% (f ≤ 1kHz)
$\hat{u}_{(A-A^*;\,B-B^*)}$ = 0,35V ... 0,6V (f > 1kHz)

- Limiting frequency: f_{gr} = 500 kHz
- Amplitudes difference [1)]: $\hat{u}_{(A-A^*)} = \hat{u}_{(B-B^*)} \pm 10\ \%$
- Degree of modulation (mech.) [4)]: $m \leq 0{,}1$
- Offset: $|U_{off\,(A-A^*;\,B-B^*)}| < 0{,}1\ \hat{u}_{(A,A^*;\,B,B^*)}$
- Phase A to B [6)]: $\varphi = 90° \pm 3°$
- Harmonic distortion [3)]: k < 2 % (typ. 1 %)
- DC Offset [5)]: U_M = 2,5 V ± 20 %

[1)] : measured with 120 Ω termination resistor at encoder output
[2)] : at f = 1 kHz (corresponds to 30 U/min)

[3)] $k = \dfrac{\sqrt{U1^2 + U2^2 + \ldots + Un^2}}{\sqrt{U0^2 + U1^2 \ldots Un^2}}$ *U0: Basic Signal , U1 ... Un : harmonics*

[4)] $m = \dfrac{\Delta u}{u}$

[5)] U_M same for A and A and for B and B* signals.*
[6)] Average

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2.5.2 Absolute Position-Information over SSI

Resolution standard SSI (25 data bits)

Singleturn	17 Bit
Multiturn	12 Bit

Optional: Resolution SSI with extendable data length (> 25 data bits)

Singleturn	max 19 Bit
Multiturn	12 Bit
*Singleturn in 25-Bit MT-Model	programmable up to 19 Bit

Transmission via SSI bidirectional and synchronous

No. of wires and direction	4 unidirectional (2 for clock and 2 for data)
Driver according to	RS422
Transmission speed	70kHz –2 MHz according to SSI - definition

Data format

MSB first	Monoflop – Timeout 10µs ≤ tm ≤ 14µs

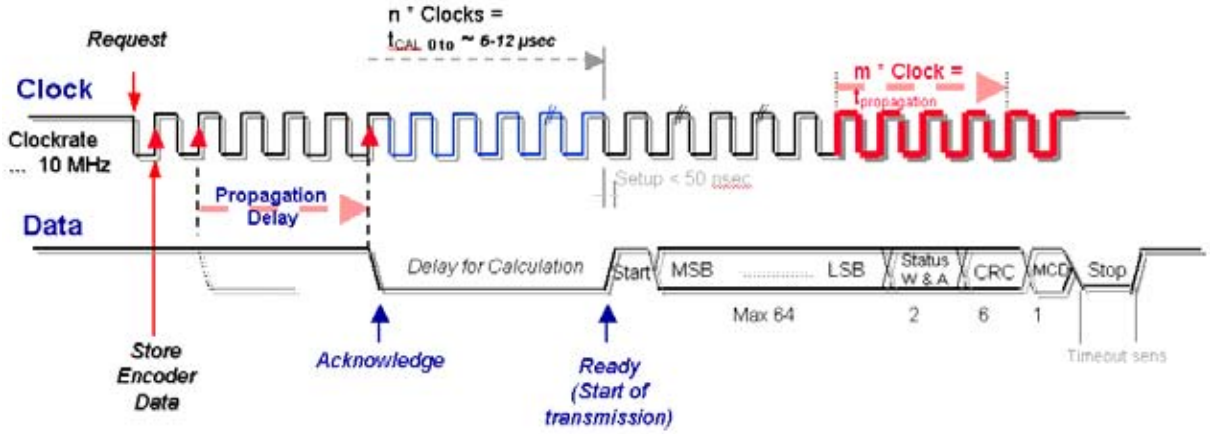
2.5.3 Absolute Position-Information over BiSS (Sensor-Mode)

Digital coded absolute information

Resolution Singleturn w/IPO	up to 19 Bit
Resolution Multiturn	12 Bit

Transmission via BiSS - bidirectional und synchronous

Signals	Clock unidirectional (from master to encoder) Data unidirectional (from encoder to master)
Driver according to	RS422
No. of wires and direction	4 unidirectional (2 for clock and 2 for data)
Transmission speed	70 kHz – 10 MHz
Transmission security	1 Start Bit, 1 Stop Bit, 6 Bit CRC
Multicycle data (MCD)	8 Bit Sensor temperature (s. Documentation www.biss-interface.com/files/BiSS_b1ds.pdf)
Timeout Sens	12 µsec
Timeout Reg	51 µsec
Delay for Calculation	≤ 14 Bit ST resolution 0 µs ≥15 Bit ST resolution 5 µs



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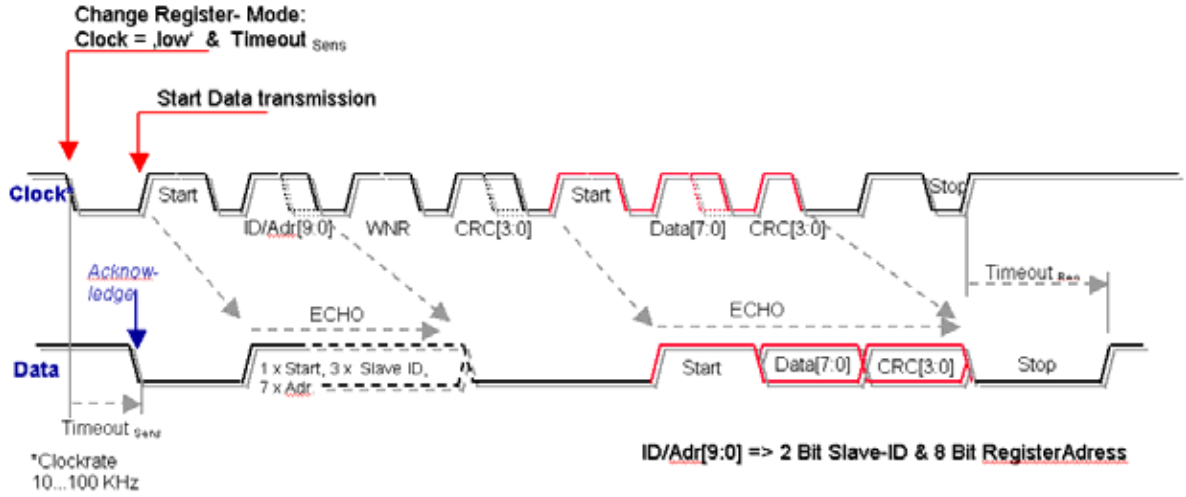
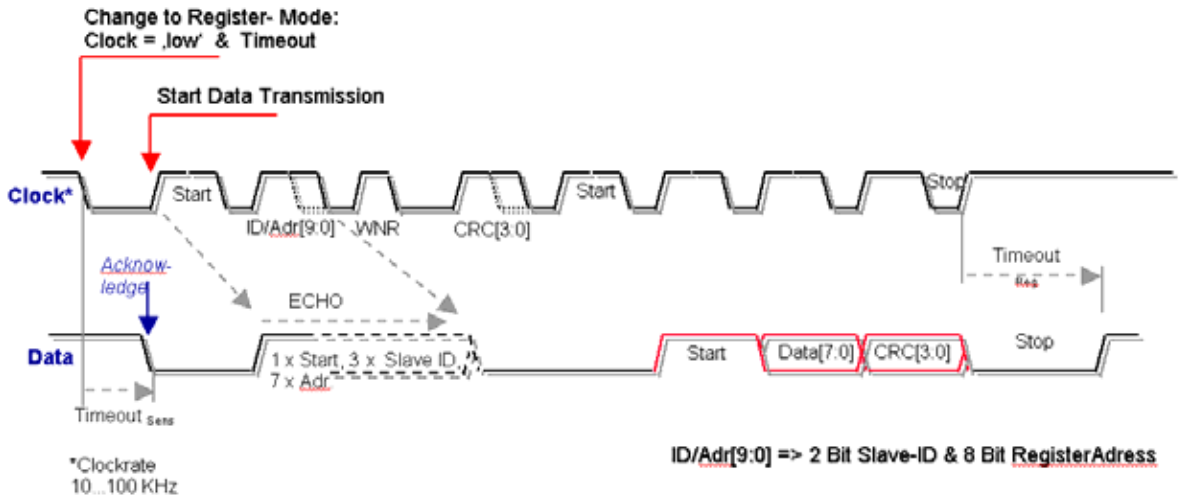
2.5.4 Parametrization, diagnostic function and data storage (BiSS - Register Mode)

Transmission over BiSS: Bidirectional and synchronous in PWM format.
Several encoder parameters are set here. In addition to detailed information for warning and alarm also the latest encoder temperature can be read. For storage of data a memory of 128 byte is available by default. More memory space can be provided on request.

Write register



Read register



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Function Preset:
A preset function is set if the value 0x02h is written to the register address 0x60h. With this action preset value is set and the corresponding offset value is saved to EPROM.
Initial situation: preset value = 0

Read temperature value:
In the register 0x67h the temperature is stored and updated. Reading the register a 8 Bit absolute temperature value is received.

Diagnostic function:
If programmable limits are exceeded or under run this is indicated over warning and alarm bits.

Read error status:
If the alarm bit or the warning bit is set within the protocol “read position data” (SSI or BiSS) the cause of the error can be determined over the register 0x68h. Reading this register an 8 bit value is received.

Meaning:
Bit 0 = LED current out of control range
Bit 1 = External Multiturn Error
Bit 2 = Position Code Error (Single Step Error)
Bit 3 = Failure configuration interface
Bit 4 = Position data not valid
Bit 5 = Serial interface failure
Bit 6 = External failure over NERR
Bit 7 = Temperature out of defined range

Reaction on error message
Error messages can be acknowledged in different ways. The message can be displayed one time in the protocol. Alternatively the message can be transmitted until it has been acknowledged via command. The way the error message is acknowledged is set in the register 0x1B Bit 2 and is factory configured according to the OEM customer’s preference.

Function in detail:
Error message one time (monostable):
If one of the error conditions occurs, the alarm bit will be set (logical “1” in the protocol telegram). Reading the position data will reset the alarm bit. Depending on the further presence of the error condition the alarm bit will set again to”1” or stay on “0” in the following cycle.

Error message static (bistable):
If one of the error conditions occurs, the alarm bit will be set (logical “1” in the protocol telegram). Independant on the further presence of the error condition the alarm bit will stay on ”1” until it is reset through reading of the error register (Error register 0x68).

Error conditions
LED current out of defined range
This condition can be caused by critical conditions with respect to:
- Pollution
- Condensation
- Over temperature
- Ageing of LED

Code-Plausibility check error
This can be caused by:
- Disk pollution or disk damage
- mechanical overload

Temperature value out of range
- Warning if user defined temperature range is exceeded

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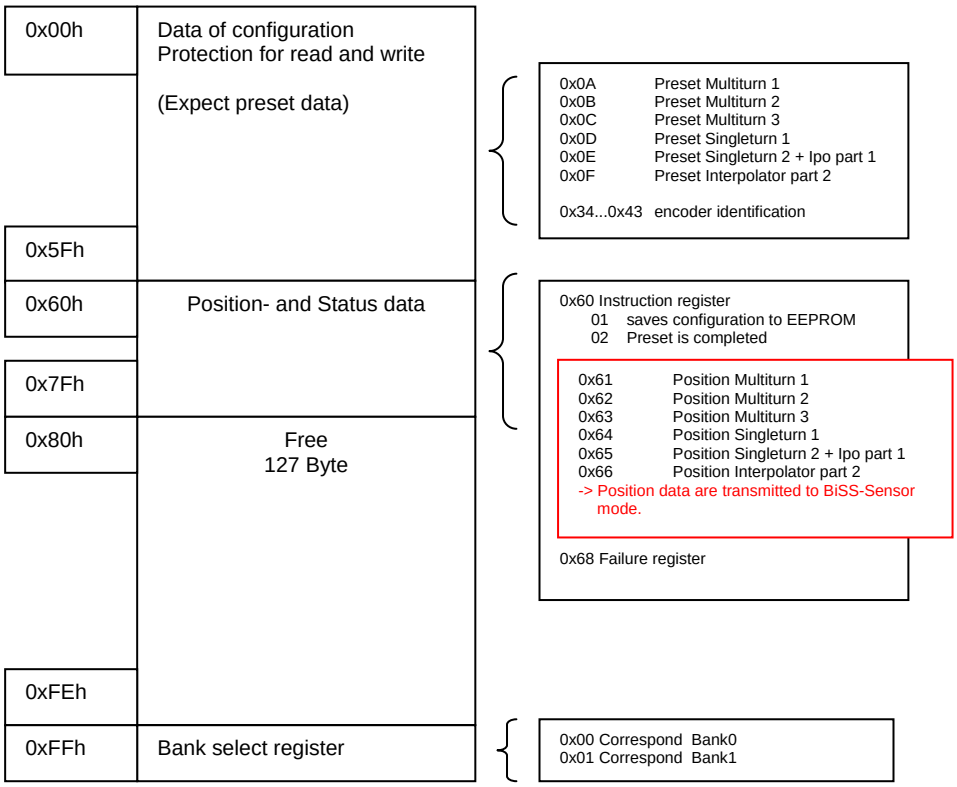
Reading and writing of the freely accessable memory
From the register address 0x80h to 0xFEh (0xFF is reserved for bank select register) 127 byte can be used in the bank “0” and 255 byte can be used in the bank “1”.
The bank select is activated via the register 0xFFh. If bank “0” is required than the value 0x00h has to be written in the address 0xFFh and if bank “1” is required then 0x01h has to be written in the address 0xFFh. With “read register” and “write register” memory access is performed.

Memory allocation (Memory Map)



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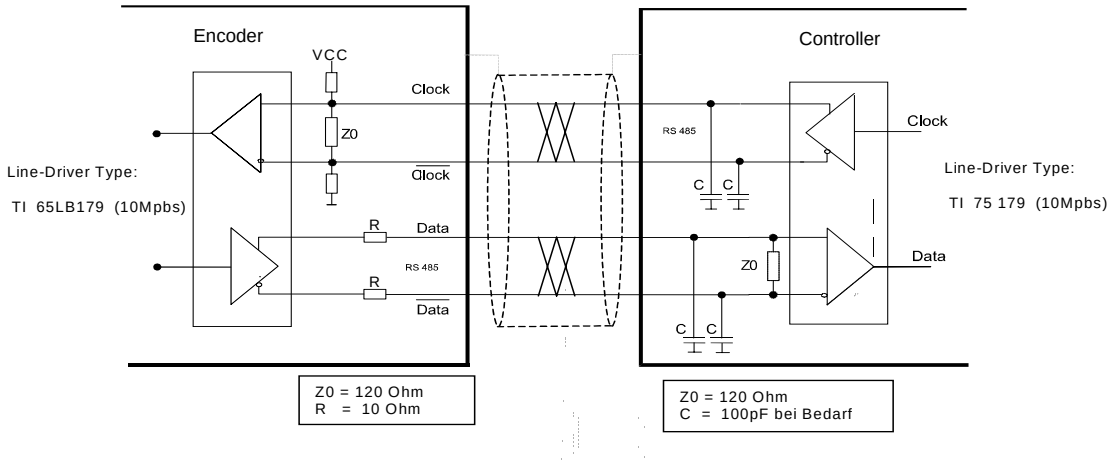
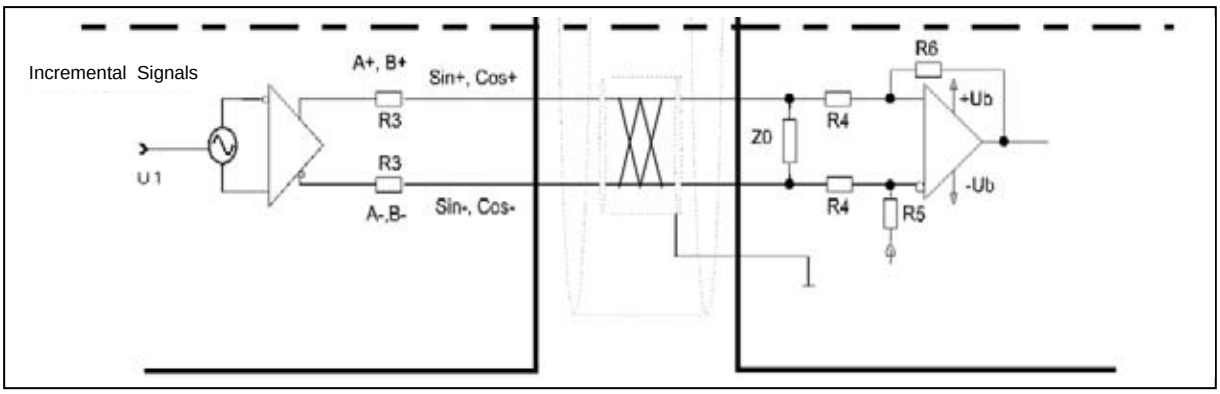
Encoder Identification (Manufacturing data, Resolution)

Reg. Addr.	Description	Length	Format	1.	2.	3.	4.
Reg. 0x34	Serial number	4 Byte	Ser.-No. BCD format	SS	SS	SS	LL
Reg. 0x38	Date of manufacture	4 Byte	Date BCD format	DD	MM	YY	YY
Reg. 0x3C	Article code	4 Byte	Article code BCD format	XX	XX	XX	0
Reg. 0x40	MT-Resolution	1 Byte	MT BCD format (0...12-Bit)	12			
Reg. 0x41	ST-Resolution	1 Byte	ST BCD format (9...13-Bit)	14			
Reg. 0x42	IPO-Resolution	1 Byte	IPO BCD format (0...11-Bit)	3			
Reg. 0x43	SinCos Periods	2 Byte	SinCos BCD format	20	48		

2.5.5 Recommended input circuit Standard SSI or BiSS to 10 MHz clock rate





2.5.6 Recommended input circuit with incremental track 1 Vpp

Dimensions:
R1 = 91 Ω , R2 = 100 Ω , R3 = 10 Ω , R4 = 10kΩ ,R5 = R4*, Z0 = 120 Ω
C1 = 1nF

U1 = 2,5 V ± 0,5V (relating to supply voltage).
*1) Alternative mounting for high transmission rates (> 2MHz) and for operating with several encoders simultaneously (i.e. shared clock, split data line).

2.6 CE-Compliance

2.6.1 EMC- Immunity

ENV 50140	Class 3, 10 V/m
EN 61000-4-2	Class 4, 15 kV (air discharge), 8kV (contact discharge)
ENV 50141	Class 3, 10 V
ENV 61000-4-4	Class 4, 4000 V *

* Remark: *Direct coupling on the power supply needs limitation of the distortion pulses to max. 1000V*

Test standard: EN 50082-2

Cover:

ENV 50140	Electromagnetic HF-Field, amplitude modulated
ENV 50140	Electromagnetic HF-Field, pulse modulated
EN 61000-4-2	Electrostatic Discharge (ESD)

Terminations:

ENV 50141	High frequency, non symmetric, amplitude modulated
EN 61000-4-4	Transients (Burst) Mains input and outputs Data-, measuring-, control lines

2.6.2 EMC Emission

Class B

Test standard: EN 50081-2

Cover:

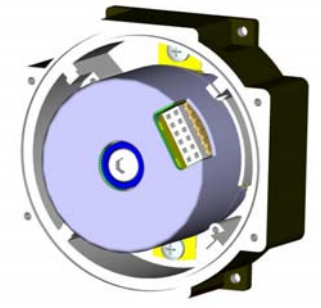
EN 55011	Radio frequency emission

2.7 Pinout PCB – Connector

Row b	**5 or 7-30 V** (U_B) gr/pk	**Clock** wt	**B-** rd	**0V (U_N)** wt/gn	**A-** ye	**Data** bk
Row a	**Data/** vio	**A+** gn	**0V Sens** bn/gn	**B+** bl	**Clock/** bn	**5 V Sens** rd/bl
PIN	1	2	3	4	5	6

Hint :
5 V (U_B) → 5 V Sens
0 V (U_N) → 0 V Sens

Connection on encoder side over
12-pin PCB connector,
Manufacturer Berg, Type: Minitek.



2.8 Cable

SSI: max. cable length	100 m (70KHz...2 MHz)
BiSS (CAT5 cable):	Cable capacity ≤ 100 pF/m
max. cable length	100 m (0...10 MHz)

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3 Mechanical Data

3.1 Shaft variants

8 mm – through hollow shaft
8 mm –hub shaft

3.2 Max. shaft load / Bearing life expectancy

axial ≤ 5 N
radial ≤ 10 N
Above values are the max. worst case forces to the encoder bearings through the flexible torque support
(Fixing point of torque support is 10mm towards the encoder referring the diameter 9,25 mm)
Bearing Live at constant speed of 8.000 1/min and above mentioned loads > 20.000 h.

3.3 Max . speed

Continuous 12.000 min^{-1}
Short term 15.000 min^{-1} ST

The peak max. speed considers eventual oscillations in the speed loop and may occur only for a short time (max. 1 second).

3.4 Starting torque

≤ 1 Ncm

3.5 Moment of inertia

2,5 x 10^{-6} kgm^2
Inclusive central shaft screw

3.6 IP - Protection

IP40
Mounted on motor with cable and cover

Test standard: IEC 529, EN 60529 resp. DIN VDE 0470 T1 (11.92) and DIN 40053 T5 (7.80)

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3.7 Operating temperature range

Environmental air of encoder:	-15°C ... +120°C
Motor shaft at encoder connection point:	-15°C ... 160°C
Connection points of torque support and motor:	-15°C ... 140°C

3.8 Storage temperature range

-20°C ... +85°C (due to packaging)

3.9 Humidity

Humidity F (KUF annual average 75% rel. humidity; non condensing)

Test standard: IEC 68 part 2-38 „temperature, humidity, cycle“ (04.79)
Test condition adjusted to humidity F (DIN 4040)

3.10 Vibration resistance

100 m/s^2 (10 ... 2000 Hz)

Test standard: DIN EN 60068-2-6 / 05.96
Test Fc: Vibration, sinusoidal

3.11 Shock resistance

1000 m/s^2 (6 ms)

Test standard: DIN EN 60068-2-27 / 03.95
Test Ea and guideline: shock

3.12 Materials

Flange:	Aluminum
Shaft:	Stainless steel
Cover:	Aluminum
Mass:	Singleturn app. 80 g
	Multiturn app.130 g

3.13 Spring tether

Tolerance axial	± 0,5 mm
Tolerance radial	± 0,05 mm
Resonance frequency	> 2 kHz

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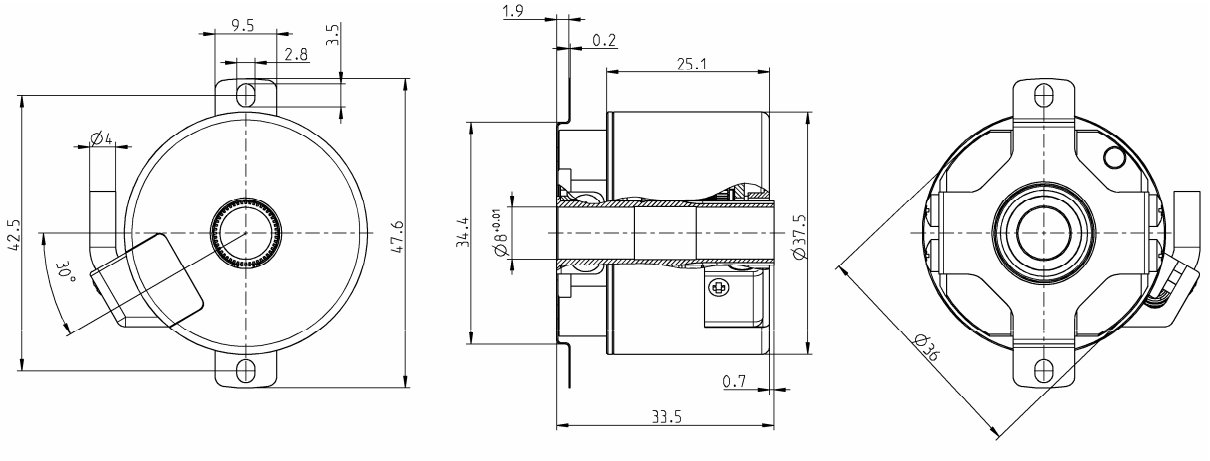
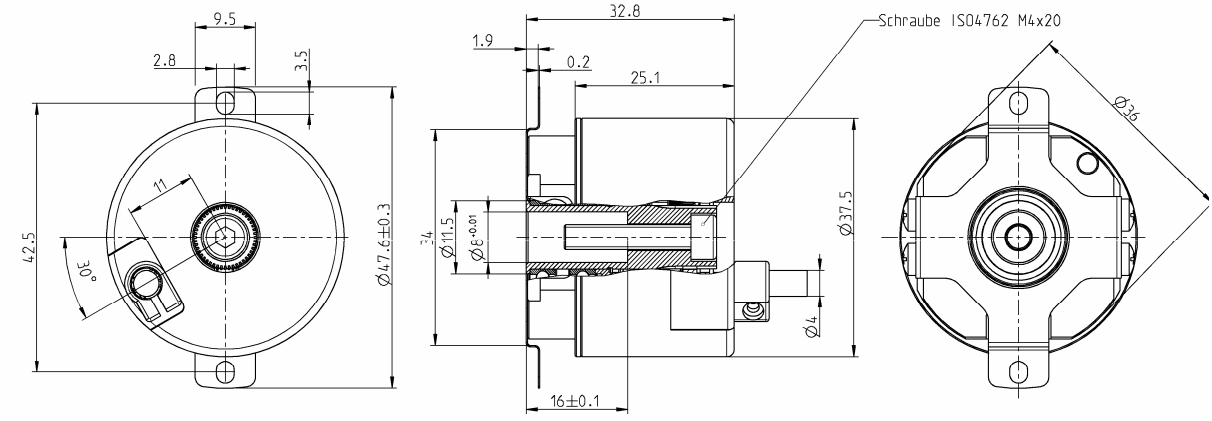
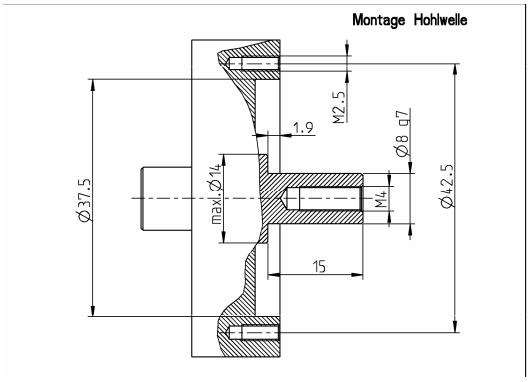
3.14 Dimensioned drawings

3.14.1 Through hollow shaft



3.14.2 Hub shaft





4 Ordering data

Type	Resolution	Supply voltage	Flange, Protection, Shaft	Interface	Connection
AD 36	**0012** 12 Bit ST **0013** 13 Bit ST **0014** 14 Bit ST **0017** 17 Bit ST **0019** 19 Bit ST (BiSS) **1213** 12 Bit MT +13 Bit ST **1217** 12 Bit MT +17 Bit ST **1219** 12 Bit MT +19 Bit ST (BiSS)	**A** DC 5V **E** DC 7-30V	**F.OC** Spring tether, IP40, 8mm through hollow shaft **F.OR** Spring tether, IP40, 8mm hub shaft	**SC** SSI Gray + 1Vss **BI** BiSS (1 Vss redundant optional)	**0** PCB-connector, 12-pin **B** Cable radial, 0,5 m

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