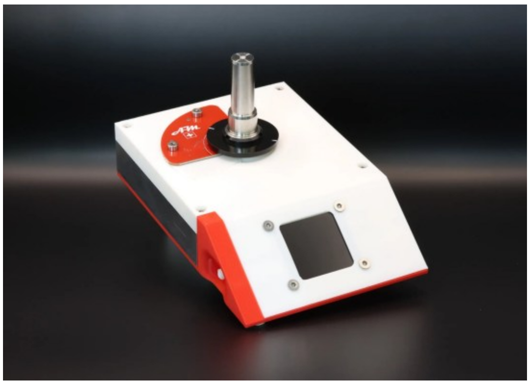
Absolute Magnetics

AM INTEGRATE 37q - Eval Kit

Magnetic Encoder



- ✓ Absolute position encoder
- ✓ No calibration needed
- ✓ Robust against external stray fields
- ✓ Wide mounting tolerances
- ✓ Air gap variation possible
- ✓ 15’000 rpm
- ✓ Typical accuracy ±0.3°

Robust, accurate and stray field immune - innovation for magnetic encoders

Overview

Symbol	Parameter	min.	typ.	max.	Unit
Vcc	Supply voltage	3.1	3.3	3.6	V
Icc	Current consumption	-	60	-	mA
Res_ST_{ABI}	Resolution singleturn ABI interface*	8	12	14	bit
Res_ST_{SPI}	Resolution singleturn SPI interface	-	16	-	bit
Res_MT_{SPI}	Resolution multiturn SPI interface	-	16	32	bit
Acc @1000rpm	Accuracy @ 1’000 rpm	-	± 0.3	-	degree
Acc @7000rpm	Accuracy @ 7’000 rpm	-	± 0.3	-	degree
Acc @15000rpm	Accuracy @ 15’000 rpm	-	± 0.35	-	degree
Rep	Repeatability	-	0.15	-	degree
Speed	Maximum speed	-	15’000	-	rpm
AG	Air gap	0.2	0.7	2.0	mm
Ecc	Eccentricity	-	-	0.5	mm
SF	Stray-field immunity	10	-	-	mT
T_{amb}	Operating temperature	-40	-	+125	°C

*configurable resolution, 8 to 14 bit

Contents

1. Accuracy Measurements

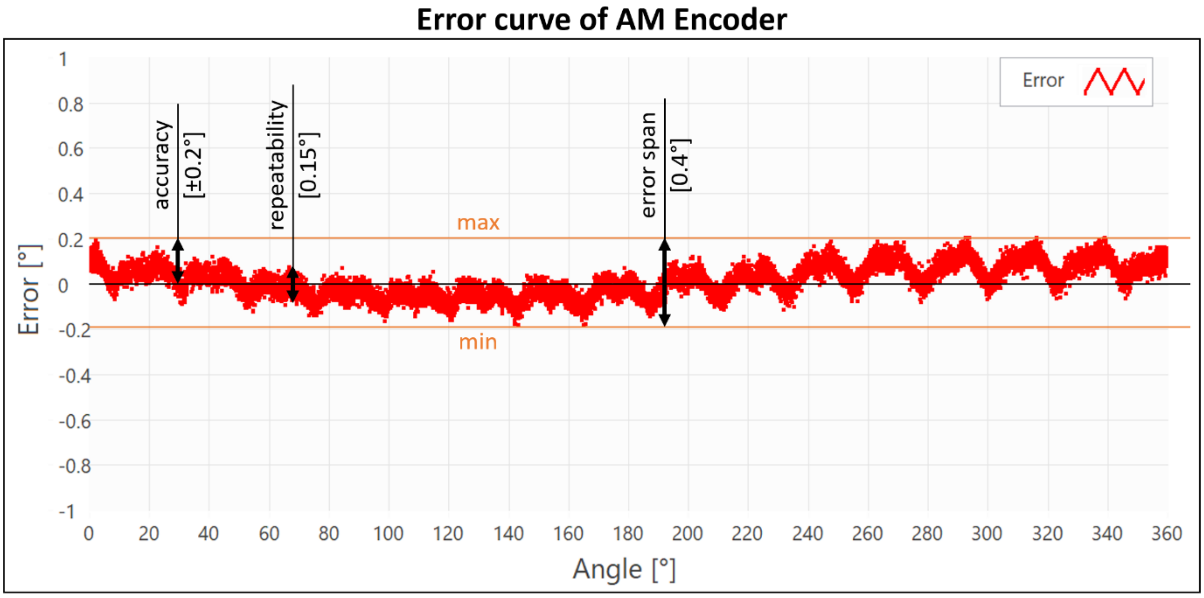


Figure 1: Typical error curve with descriptions, measured at 7'000 rpm at nominal air gap

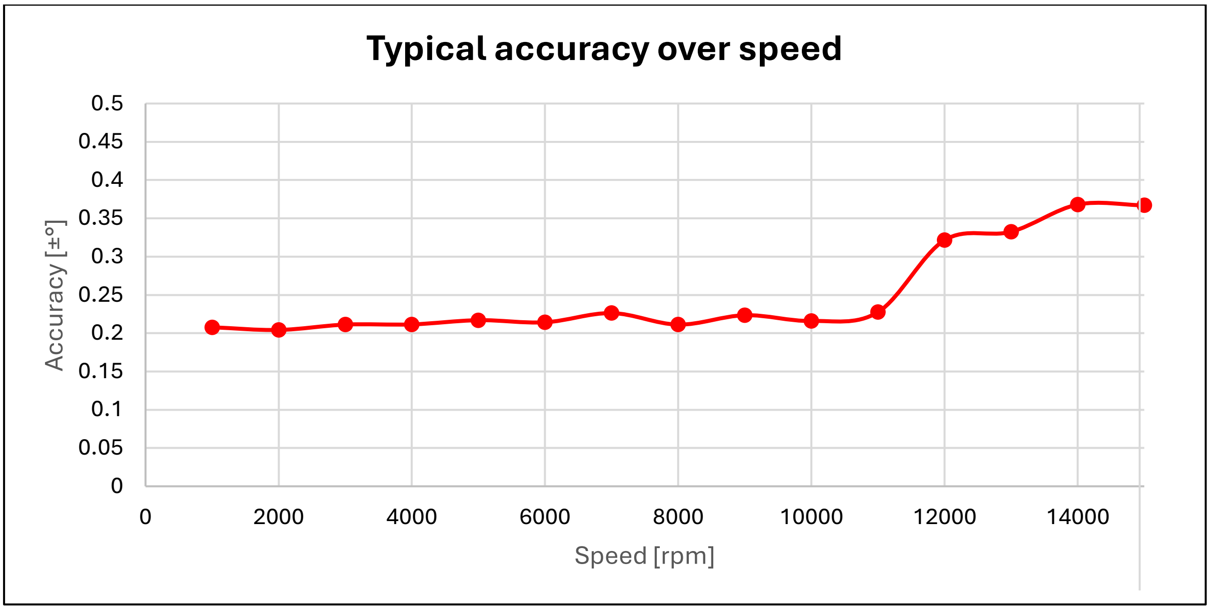


Figure 2: Measurement of typical accuracy at speeds up to 15'000 rpm, at nominal air gap

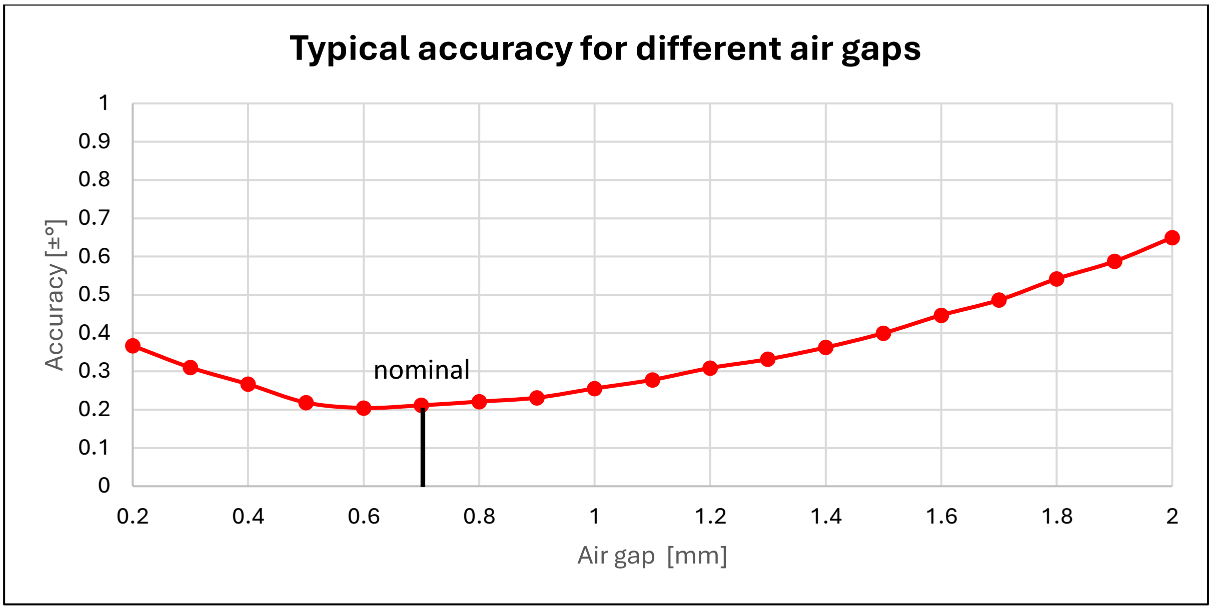


Figure 3:Typical accuracy for different air gaps

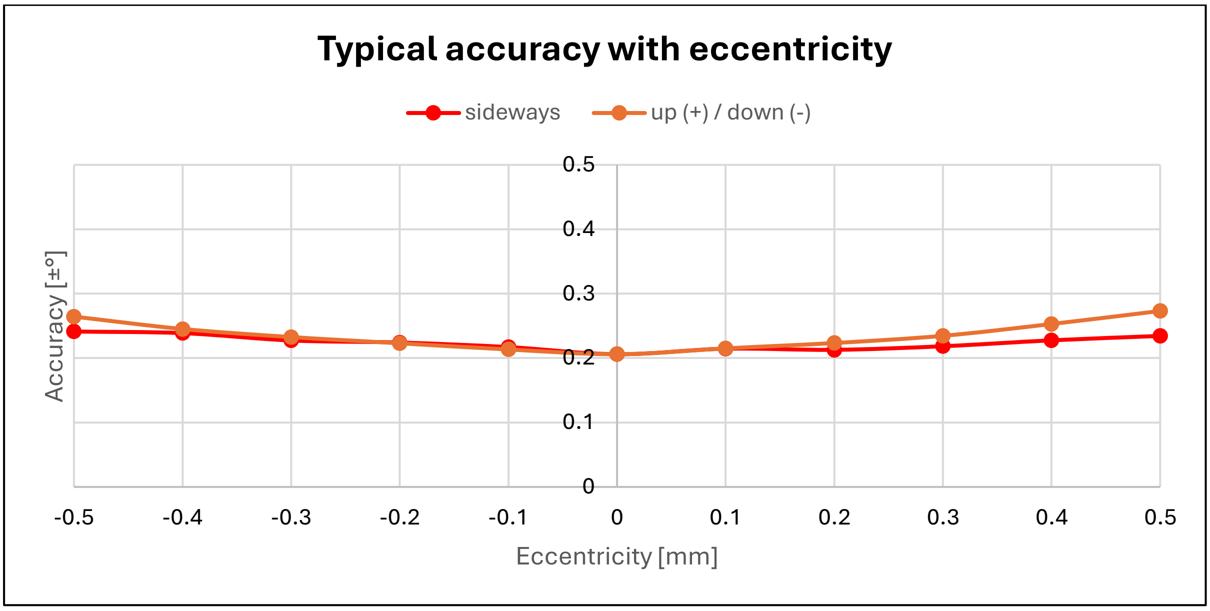


Figure 4: Typical accuracy with eccentric alignment

2. Absolute Maximum Ratings

Symbol	Parameter	min.	max.	Unit
Vcc	Supply voltage	-0.3	4.0	V
ESD_{HBM}	ESD tolerance according to Human Body Model	-	2000	V
ESD_{CDM}	ESD tolerance according to Charge Device Model	-	250	V
T_{store}	Storage temperature	-55	+125	°C

3. Electrical Data

Symbol	Parameter	min.	typ.	max.	Unit	Remark
t_{rr}	Position refresh rate	-	10	-	µs	
τ_{ABI}	Latency ABI interface	-	< 1	-	µs	Internal latency compensation of (3* t_{rr})
t_{start}	Start time	-	-	16	ms	
τ_{SPI}	Latency SPI interface	-	-	t_{rr} + $t_{readout}$	-	Internal latency compensation of (2* t_{rr})

4. SPI Interface

4.1. Timings

Symbol	Parameter	min.	typ.	max.	Unit
f_{SPI} 1 / t_{clock}	SPI clock (SCK) frequency	-	10	-	MHz
t_{setup}(!CS)	!CS setup time	4	-	-	µs
t_{hold}(!CS)	!CS hold time	-	50	-	ns
t_{whigh}(SCK)	SCK high time	-	25	-	ns
t_{setup}(MOSI)	MOSI setup time	3	-	-	ns
t_{hold}(MOSI)	MOSI hold time	1	-	-	ns
t_{enable}(MISO)	MISO enable time	-	-	4	µs
$t_{disable}$(MISO)	MISO disable time	-	-	4	µs
t_{setup}(MISO)	MISO valid time	9	-	12	ns
t_{whigh}(!CS)	Time between two transfers	4	-	-	µs
t_{wframe}	Time between two frames with !CS keeping low	4	-	-	µs

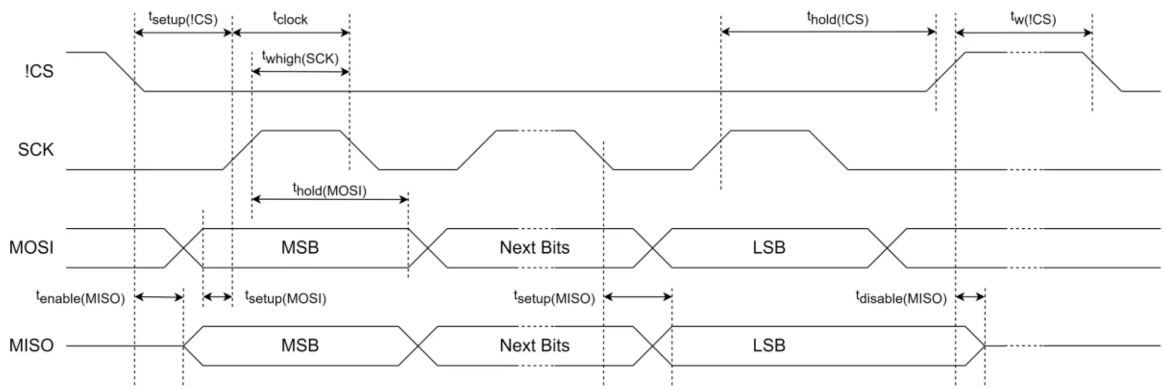


Figure 5: SPI timing diagram

4.2. SPI description

4.2.1. SPI Frame

The SPI frame is 16 bit long, full duplex and MSB first. It consists of 8 address bits (bit 0-7) to access internal registers. The frame consists of five command bits (bit 8-12) to trigger internal functionalities. Bit 13 und 14 are reserved for future use. The W/!R (Write/!Read) bit (bit 15) indicates a read or write action.

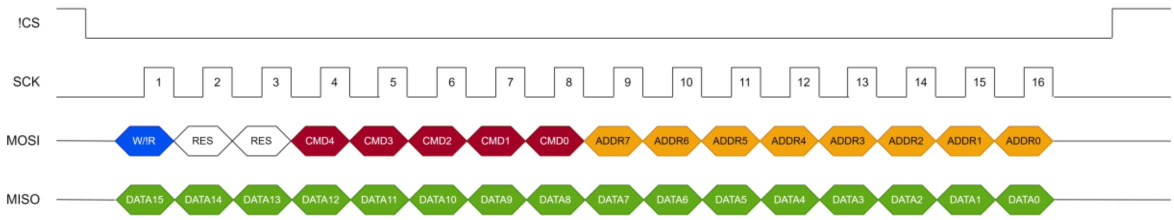


Figure 6: SPI frame

4.2.2. Value freeze

By setting the !CS pin low, the internal SPI values will freeze, allowing to read multiple values at the same timestamp. It is recommended to synchronize the SPI reading with the sensor tick for consistent latency.

4.2.3. Single turn position fast readout

The MISO return value of the first frame after the !CS pin is set low is the single turn position, allowing for fast reading of the single turn position without requesting it first.

4.2.4. Read only mode

The SPI interface can be used in read only mode by setting the MOSI line always to 0. In this mode, the registers will be returned in the read-only mode order without additional request. If the !CS pin is set high and low again. The readout will restart at position 1.

4.2.5. Requesting register value

Sending a read command will return the requested value in the next following frame.

4.2.6. Sending a command

A command can be sent at any time. The MISO value of the following frame will be all 0.

4.3. Registers

Address	Name	SPI value	Read-only mode order
0x01	Single Turn Position	0x0001	1
0x02	Multi turn upper	0x0002	2
0x03	Multi turn lower	0x0003	3
0x04	Status	0x0004	4
0x05	Errorflags	0x0005	5
0x07	Timestamp upper	0x0007	6
0x08	Timestamp lower	0x0008	7
0x40	Serial number upper	0x0040	
0x41	Serial number lower	0x0041	
0x42	Production date	0x0042	
0x44	Firmware version major	0x0044	
0x45	Firmware version minor	0x0045	
0x46	Firmware version patch	0x0046	
0x80	Position Offset	0x0080	8

4.3.1. Register 0x01: Single Turn Position

Bit	Name	Datatype	Description
15-0	Single Turn Position	Int16	The position is displayed in -180..180° in 16 bits. $value_{degree} = value_{16bits} / 65536 * 360°$

4.3.2. Register 0x02 & 0x03: Multi Turn Position

Bit	Name	Datatype	Description
31-0	Multi Turn Position	Int32	After crossing the 0 position, the counter will increase or decrease depending on the direction. The value is 0 after reset.

4.3.3. Register 0x04: Status

Bit	Name	Datatype	Description
15-3	Reserved	Enum	Reserved for future use
2	SAVING	Enum	Indicates, that the sensor saves data to the flash
1	Reserved	Enum	Reserved for future use
0	RUNNING	Enum	Indicates, that the sensor is running

4.3.4. Register 0x05: Errorflags

Bit	Name	Datatype	Description
15-0	Reserved	Enum	Reserved for future use

4.3.5. Register 0x07 & 0x08: Timestamp

Bit	Name	Datatype	Description
31-0	Timestamp	Uint32	The timestamp increases each time a new measurement is started. It is synchronized with the Sensor Tick

4.3.6. Register 0x40 & 0x41: Serial number

Bit	Name	Datatype	Description
31-0	Serial number	Uint32	The serial number of the pcb. The serial number is set back every month and must be read in combination with the production date

4.3.7. Register 0x42: Production date

Bit	Name	Datatype	Description
15-12	Production month	Uint4	Month of the year, when the pcb was produced
11-0	Production year	Uint12	Year in which the pcb was produced

4.3.8. Register 0x44, 0x45 & 0x46: Firmware version

Bit	Name	Datatype	Description
47-32	Major version	Uint16	The major version increases if new features are added, that are no longer reverse compatible
31-16	Minor version	Uint16	The minor version increases if new features are added which are reverse compatible within the same major version
15-0	Patch version	Uint16	Patch version increases for minor bugfixes

4.3.9. Register 0x80: Position Offset

Bit	Name	Datatype	Description
15-0	Position Offset	Int16	The position offset is internally added to the absolute position and output on the single turn position. It can be written by using the set zero command. The position offset is displayed in -180..180° in 16 bits. $value_{degree} = value_{16bits} / 65536 * 360°$

4.4. Commands

Commands can be used to trigger functions inside the sensor. A command is send by setting the W/!R bit high (except for read register), writing the command number into the command bits and inverting the command bits and writing them into the address bits. Address bit 5 to 7 must be high.

Only the below descripted commands are valid and must be used. Performing invalid commands may lead to unintended behavior.

Command	Name	SPI value
0x00	Read	0x00XX
0x02	Save & Reset	0x82FD
0x03	Zero Position	0x83FC

4.4.1. Command: Save & Reset

This command will save parameter changes into the flash memory and reset the sensor afterwards. It must be used after the zero position command to save the new position offset into the flash memory.

4.4.2. Command: Zero Position

This command will set the actual position as position zero. The corresponding position offset will be calculated and saved in the position offset register (0x80). After this command the new position offset is only save in the RAM memory and will be lost after a reset or reboot. To save the value into the flash memory, the save & reset command (0x02) must be performed.

4.5. SPI communication examples

4.5.1. Example data sequence

The falling edge of the !CS pin will trigger the buffering of the sensor data. All available data will have the same timestamp and can be read sequentially. To get new actual data, the !CS pin must set high and low again respecting the timings. The first received Data is by default always the single turn position of the sensor.

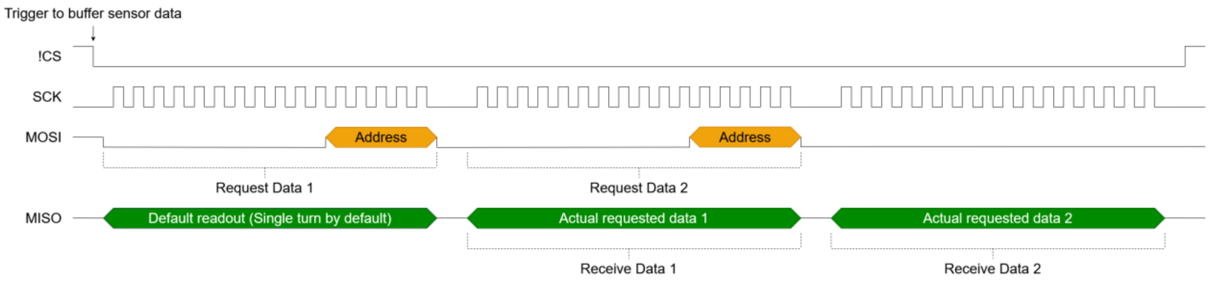


Figure 7: Example SPI data request sequence

4.5.2. Set Zero command

To set the current position of the sensor as the new zero position, send the 16bit command 0x83FC via SPI.

Figure 8: Set Zero Command

The new position can be saved to the flash with the command 0x82FD. The Set Zero Command is volatile by default. If the sensor is power cycled without sending the save command (0x82FD), it will revert to the previous zero position.

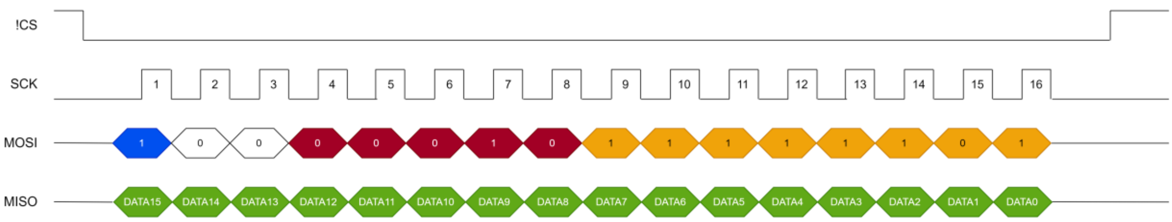


Figure 9: Save new zero position

5. ABI / UVW Interface

Symbol	Parameter	min.	typ.	max.	Unit
t_r_{ABI}	Rise time ABI pulse	-	<25	170	ns
t_f_{ABI}	Fall time ABI pulse	-	<25	170	ns

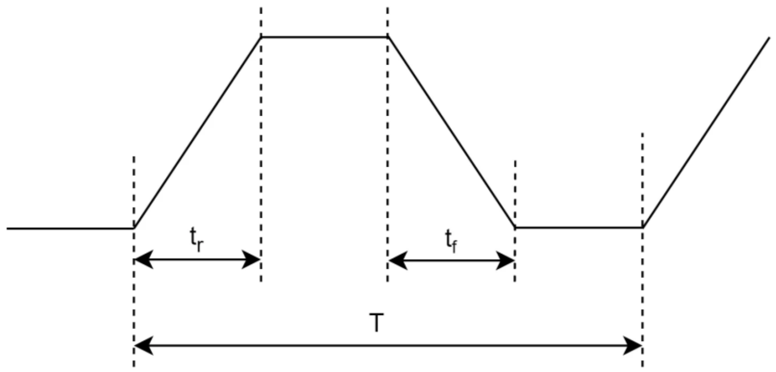


Figure 10: ABI timing diagram

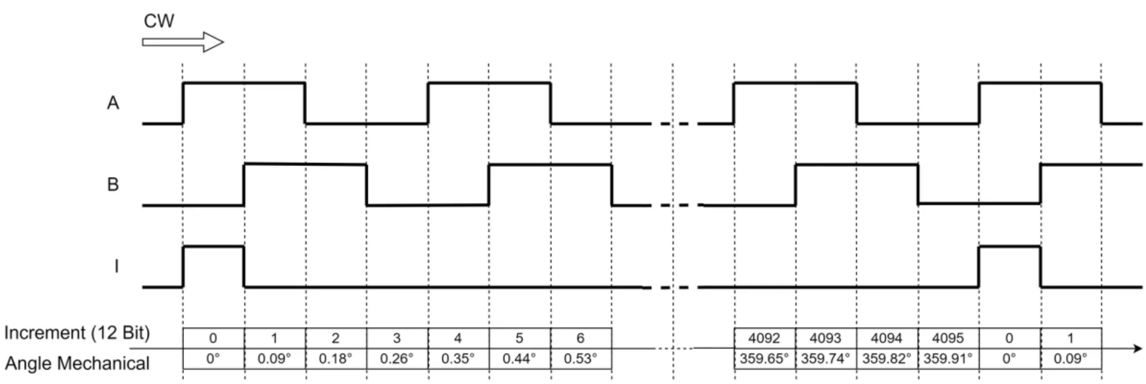


Figure 11: ABI output signal

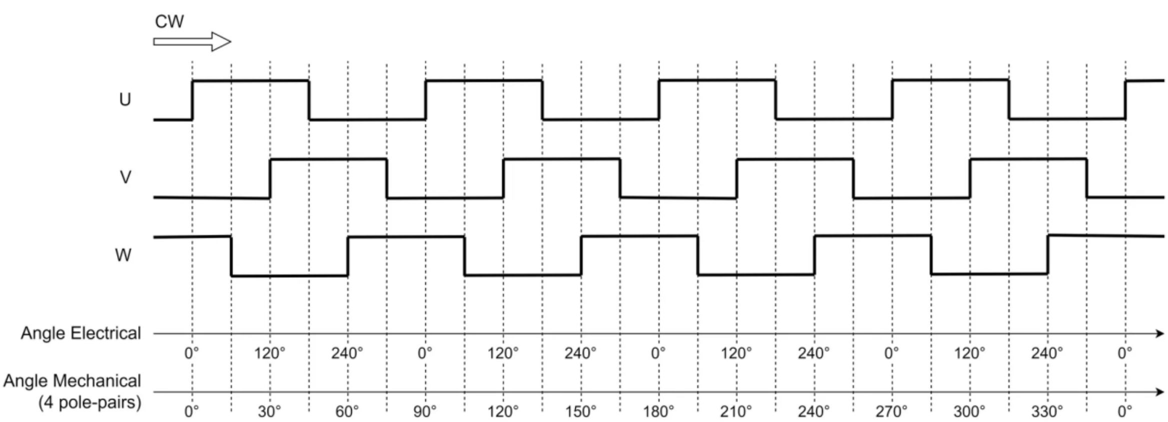


Figure 12: UVW output signal

6. Startup

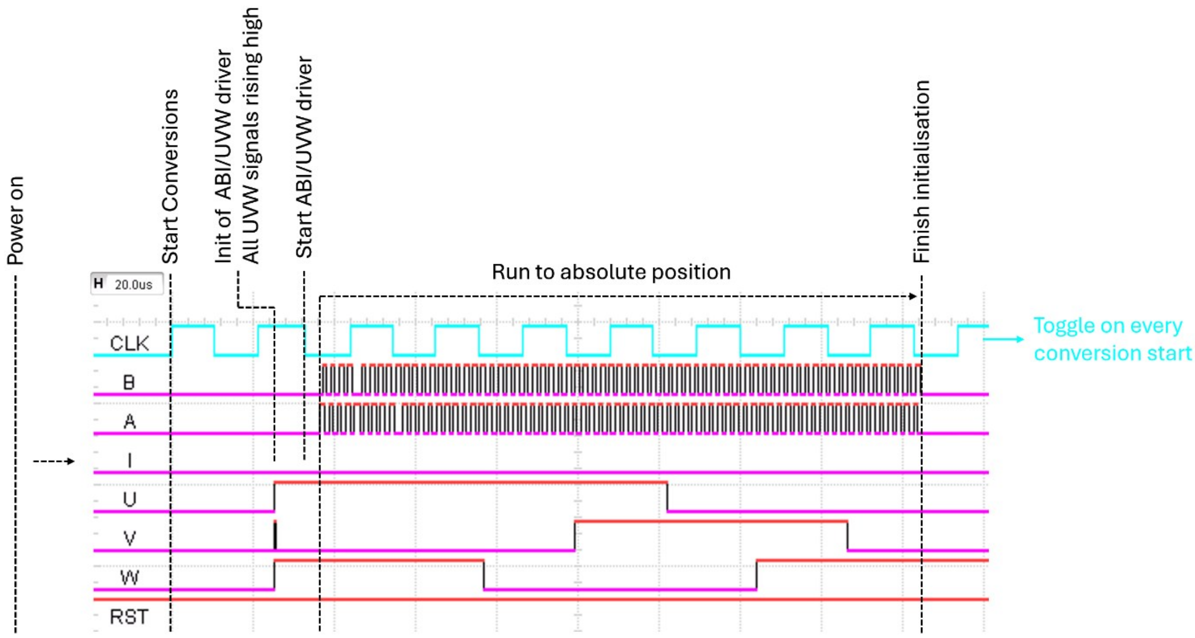


Figure 13: ABI / UVW startup behavior

After power on or reset, the encoder initializes itself. The initialization phase is finished after the TICK (CLK) is starting to toggle. In the first toggle phase, the ABI interface is setting up. The interface starts at position 0 and runs then to the absolute position.

7. Mechanical Data

Symbol	Parameter	min.	typ.	max.	Unit
ID Magnet	Inner diameter magnet	14.983	-	14.994	mm
OD Magnet	Outer diameter magnet	-	37	-	mm
OD PCB	Outer diameter PCB	-	84	-	mm
ID PCB	Inner diameter PCB	-	18.5	-	mm
H	Height of system	-	10	-	mm
AG	Air gap*	0.2	0.7	2.0	mm
Ecc	Eccentricity	-	-	0.5	mm
Mass	Mass magnet assembly	-	16.7	-	g
Shaft	Recommended shaft diameter	15.001	-	15.009	mm

*Highest element PCB to magnet surface

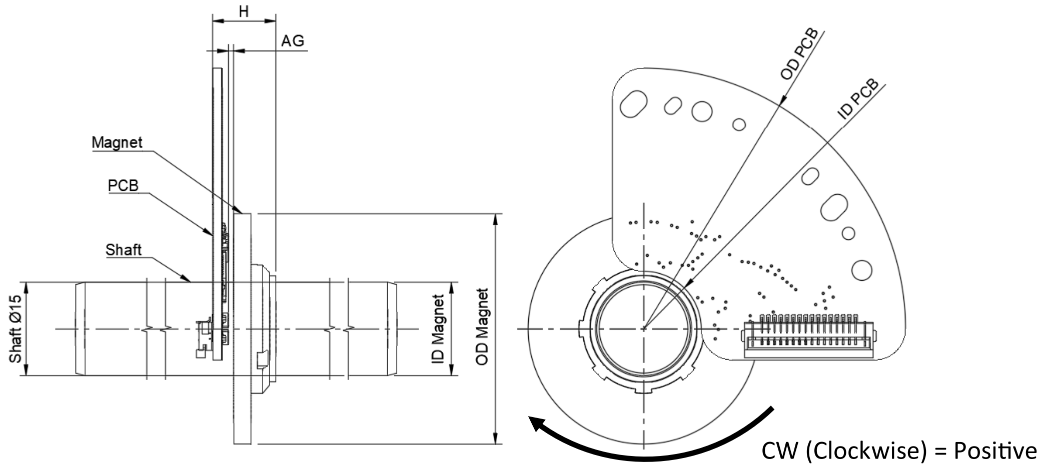


Figure 14: Mechanical dimensions schematic

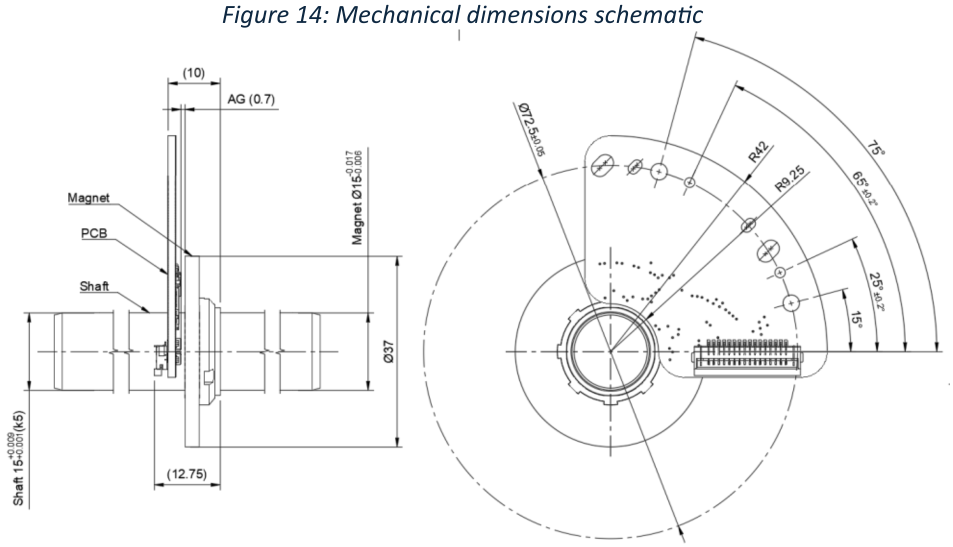


Figure 15: Mechanical dimensions

8. Pinout

Connector: Würth Elektronik – 686116148922

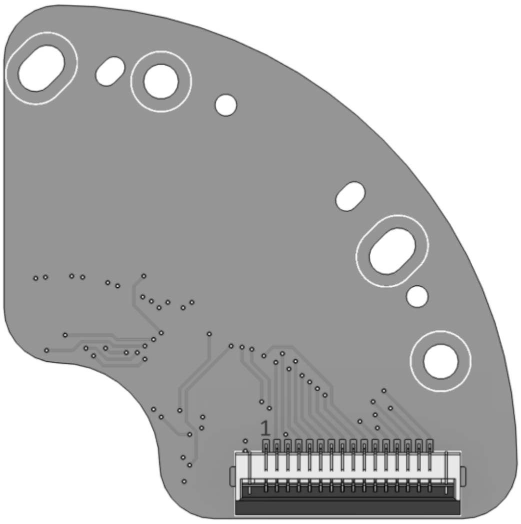


Figure 16: PCB Pinout

Pin	Signal	Description
1	VDD	Power supply 3.3V
2	TICK	Sensor tick (represents t_{rr})
3	!RST	Sensor reset (active low)
4	IO	IO – Reserved for future use
5	TICK	Sensor tick (represents t_{rr})
6	$SPI_{!CS}$	SPI chip select (active low)
7	SPI_{SCK}	SPI clock
8	SPI_{MISO}	SPI MISO signal
9	SPI_{MOSI}	SPI MOSI signal
10	UVW_U	UVW U signal
11	UVW_V	UVW V signal
12	UVW_W	UVW W signal
13	ABI_I	ABI I signal
14	ABI_B	ABI B signal
15	ABI_A	ABI A signal
16	GND	Ground

9. Contact

Absolute Magnetics AG
Auwiesenstrasse 1
8406 Winterthur
Switzerland
www.absolute-magnetics.com

All performance data provided are based on laboratory measurements at 20°C temperature and are for reference only. Actual performance may vary depending on application and conditions.

For additional information, please contact us by e-mail: contact@absolute-magnetics.com

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