Absolute Magnetics

Smart Sensor Systems

AM INTEGRATE 37s

Magnetic Encoder – Art. No. 100146



- ✓ **Absolute position encoder**
- ✓ **No calibration needed**
- ✓ **Robust against external stray fields**
- ✓ **Wide mounting tolerances**
- ✓ **Air gap variation possible**
- ✓ **30’000 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 single-turn ABI interface	-	12	-	bit
Res_ST$_{SPI}$	Resolution single-turn SPI interface	-	16	-	bit
Res_MT$_{SPI}$	Resolution multi-turn SPI interface	-	32	-	bit
Acc	Accuracy	-	±0.3	-	degree
Rep	Repeatability	-	0.15	-	degree
Speed	Maximum speed	15’000	-	30’000	rpm
AG	Air gap	0.2	0.7	1.5	mm
Ecc	Eccentricity	-	-	±0.5	mm
Tilt	Tilt of Electronics Board	-	-	±1.0	°
SF	Stray-field immunity	10	-	-	mT
T$_{amb}$	Operating temperature	-40	-	+105*	°C

* +125°C with small hardware changes

Contents

Overview *1*
1. Description *3*
2. Accuracy Measurements *4*
3. Absolute Maximum Ratings *6*
4. Electrical Data *6*
5. SPI Interface *7*
5.1 SPI description 8
5.1.1 SPI Frame 8
5.1.2 Value freeze 8
5.1.3 Single-turn position fast readout 8
5.1.4 Read only mode 8
5.1.5 Requesting register value 8
5.1.6 Sending a command 8
5.2 Registers 9
5.2.1 Register 0x01: Single-Turn Position 9
5.2.2 Register 0x02 & 0x03: Multi-Turn Position 9
5.2.3 Register 0x04: Status 10
5.2.4 Register 0x05: Error flags 10
5.2.5 Register 0x07 & 0x08: Timestamp 10
5.2.6 Register 0x40 & 0x41: Serial number 10
5.2.7 Register 0x42: Production date 10
5.2.8 Register 0x44, 0x45 & 0x46: Firmware version 11
5.2.9 Register 0x80: Position Offset 11
5.3 Commands 12
5.3.1 Command: Save & Reset 12
5.3.2 Command: Zero Position 12
5.4 SPI communication examples 13
5.4.1 Example data sequence 13
5.4.2 Set Zero command 13
6. ABI / UVW Interface *14*
6.1 Timing diagram 14
6.2 Output signals 15
6.3 Minimal pulse width 15
6.4 Deviation of pulse width / deviation of phase shift 16
7. Digital I/Os *17*
7.1 Start-up 17
8. Mechanical Data *18*
8.1 Tilt 19
9. Pinout *20*
10. Contact *21*

1. Description

The AM Integrate 37s is a complete magnetic encoder consisting of a patented magnetic disc, hall sensors and a microcontroller. The sensor is single-turn true power on and can be configured with a SPI interface. It outputs the absolute position through an ABI/UVW interface and a SPI interface simultaneously.

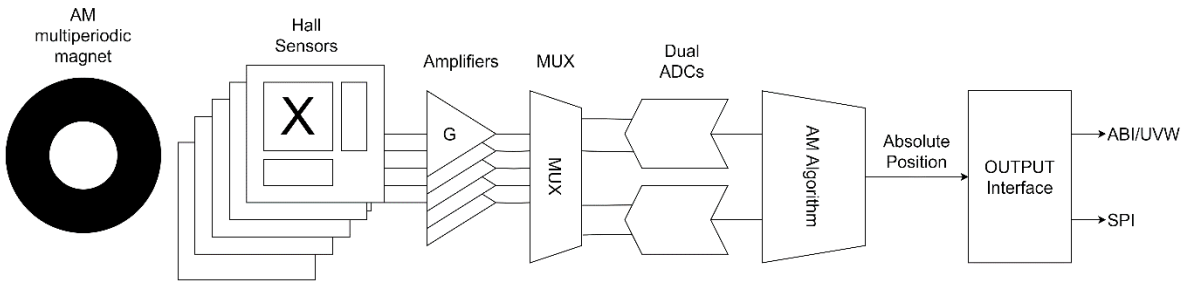


Figure 1: System block diagram

2. Accuracy Measurements

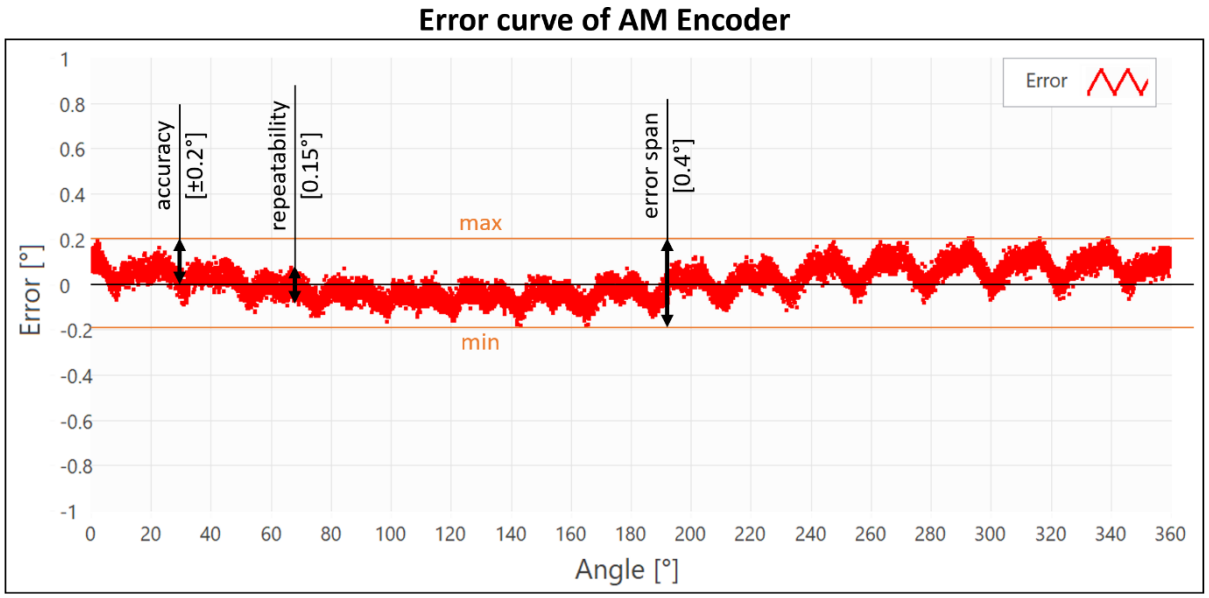


Figure 2: Typical error curve with descriptions, measured at 7'000 rpm at nominal air gap and 25°C

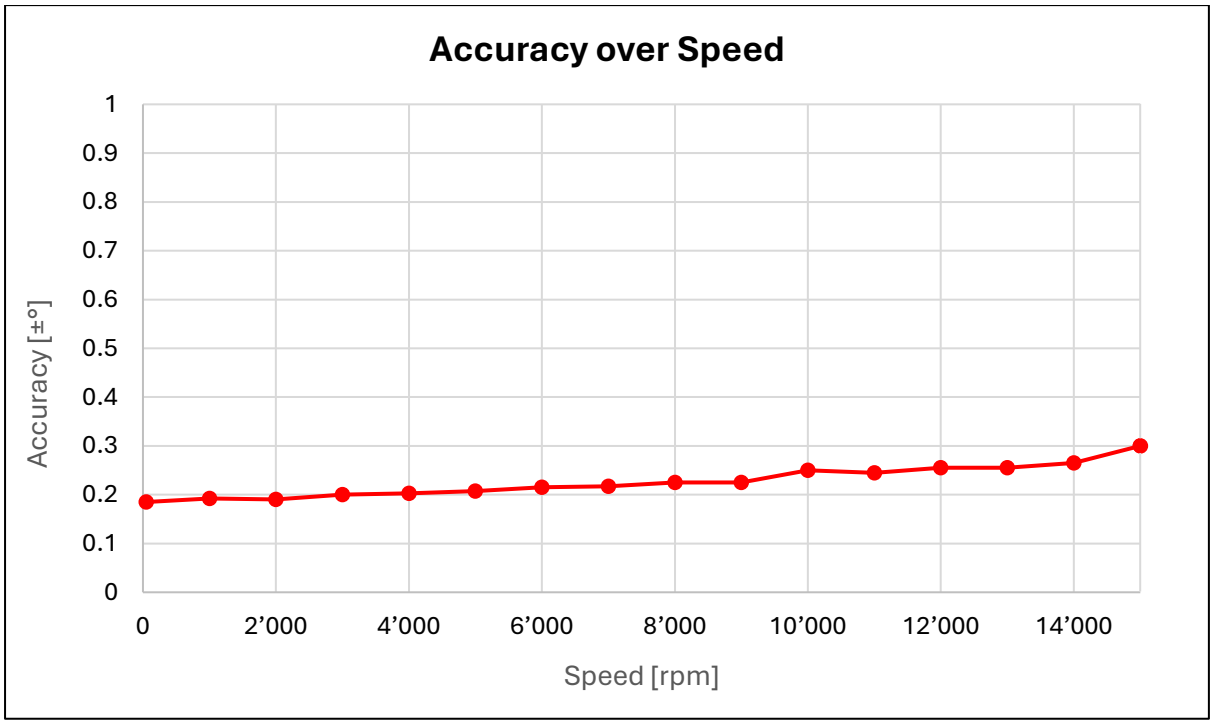


Figure 3: Measurement of accuracy at speeds up to 15'000 rpm, at nominal air gap and 25°C

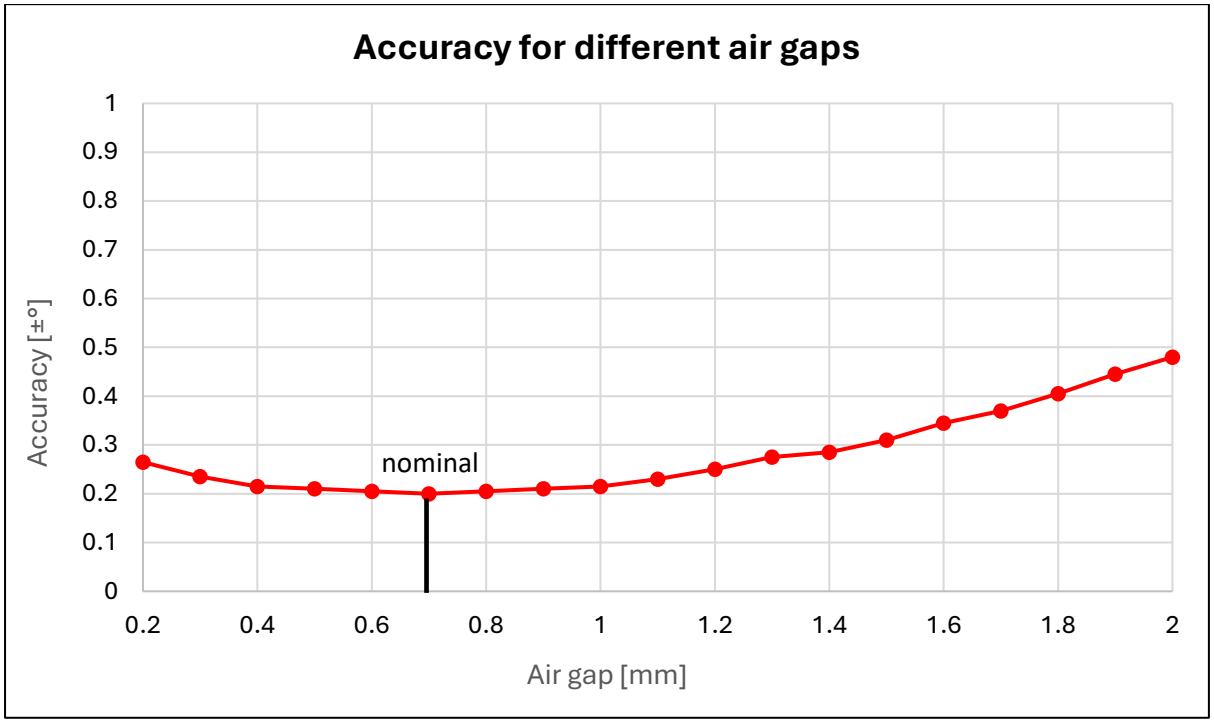


Figure 4: Accuracy for different air gaps, measured at 7'000 rpm and 25°C

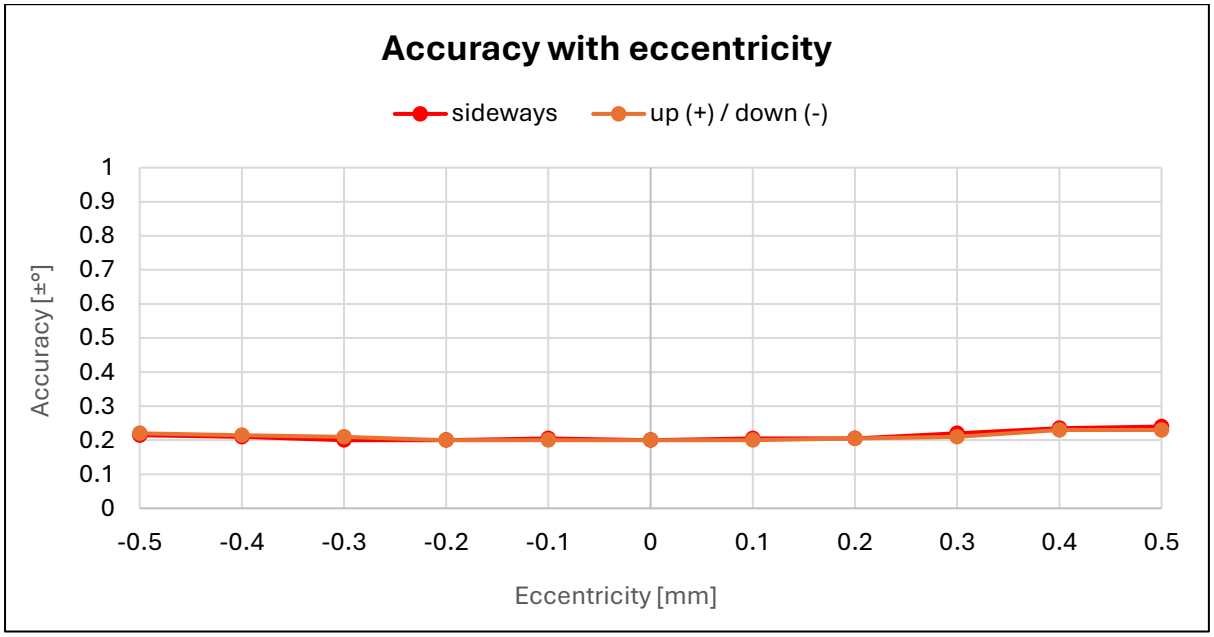


Figure 5: Accuracy with eccentric alignment, measured at nominal air gap with 7'000 rpm and 25°C

3. Absolute Maximum Ratings

Symbol	Parameter	min.	max.	Unit
Vcc	Supply voltage	-0.3	4.0	V
V_{ESD_HBM}	Electrostatic discharge voltage (human body model) per ANSI/ESDA/JEDEC JS-001	-	2000	V
V_{ESD_CDM}	Electrostatic discharge voltage (charge device model) per ANSI/ESDA/JEDEC JS-002	-	250	V
T_{store}	Storage temperature	-55	+125	°C

4. Electrical Data

Symbol	Parameter	min.	typ.	max.	Unit
Vcc	Supply voltage	3.1	3.3	3.6	V
Icc	Current consumption	-	60	-	mA
t_{rr}	Position refresh rate	-	15	-	µs
$\tau_{const.\ Speed}$	Latency at constant speed (compensated)	-	< 1	-	µs
err_{accel_SPI}	Calculated additional error on SPI output while accelerating	-	$0.0001 * \frac{a}{rpm/ms}$	-	°
err_{accel_ABI}	Simulated additional error on ABI/UVW output while accelerating > 10 rpm/ms	-	$0.0023 * \frac{a}{rpm/ms} + 0.17$	-	°
t_{start}	Start-up time	-	25		ms

a: acceleration [rpm/ms]

5. SPI Interface

Symbol	Parameter	min.	typ.	max.	Unit
V_{IT-_SPI}	SPI pins input low level Schmitt-Trigger threshold voltage	-	-	0.39*Vcc -0.06	V
V_{IT+_SPI}	SPI pins input high level Schmitt-Trigger threshold voltage	0.49*Vcc +0.26	-	-	V
V_{HYS_SPI}	Input hysteresis voltage	-	0.2	-	V
V_{OL_SPI}	SPI pin output low level voltage	-	-	0.4	V
V_{OH_SPI}	SPI pin output high level voltage	Vcc-0.4	-	-	V
I_{O_SPI}	SPI pin output current	-	-	±2	mA
C_{I/O_SPI}	SPI I/O pin capacitance	-	5	-	pF
Tr_{out_SPI} / Tf_{out_SPI}	SPI pin output rise and fall times @50pF load	-	-	170	ns
f_{SPI}	SPI clock (SCK) frequency	-	1	2*	MHz
t_{setup}(!CS)	!CS setup time	3.6	-	-	µs
t_{hold}(!CS)	!CS hold time	-	50	-	ns
t_{whigh}(SCK)	SCK high time	-	25	-	ns
t_{setup}(MOSI)	MOSI setup time	3.6	-	-	ns
t_{hold}(MOSI)	MOSI hold time	1	-	-	ns
t_{enable}(MISO)	MISO enable time	-	-	3.6	µs
$t_{disable}$(MISO)	MISO disable time	-	-	3.6	µs
t_{setup}(MISO)	MISO valid time	9	-	12	ns
t_{whigh}(!CS)	Time between two transfers	3.6	-	-	µs

*up to 10 MHz possible with small firmware change

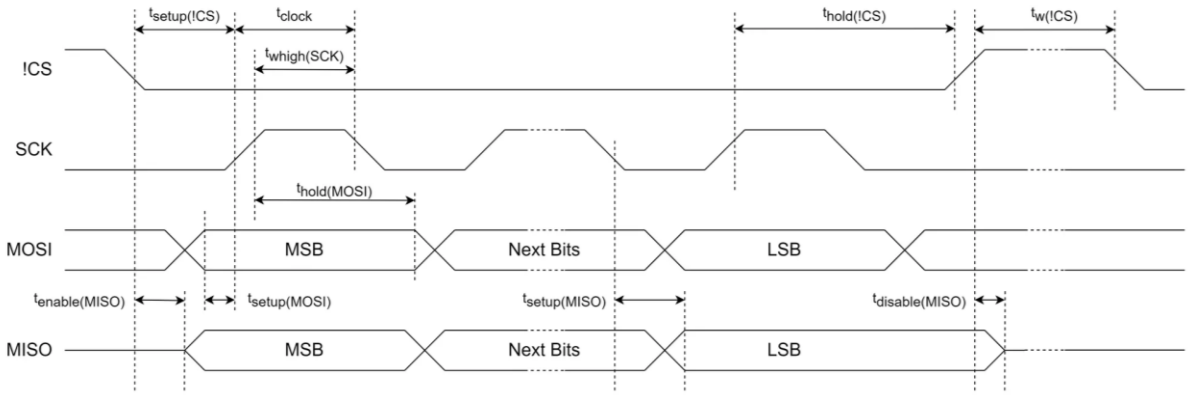


Figure 6: SPI timing diagram

5.1 SPI description

5.1.1 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.

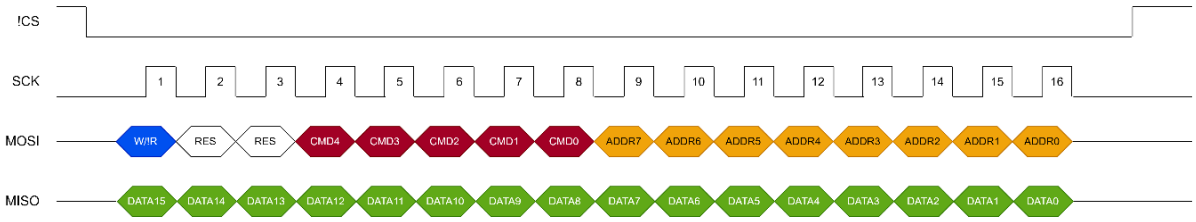


Figure 7: SPI frame

5.1.2 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.

5.1.3 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.

5.1.4 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.

5.1.5 Requesting register value

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

5.1.6 Sending a command

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

5.2 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	Error flags	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

5.2.1 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. $value_{degree} = value_{16bits} / 65536 * 360°$

5.2.2 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.

5.2.3 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

5.2.4 Register 0x05: Error flags

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

5.2.5 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

5.2.6 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

5.2.7 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

5.2.8 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

5.2.9 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. $value_{degree} = value_{16bits} / 65536 * 360°$

5.3 Commands

Commands can be used to trigger functions inside the sensor. A command is sent 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

5.3.1 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.

5.3.2 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.

5.4 SPI communication examples

5.4.1 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.

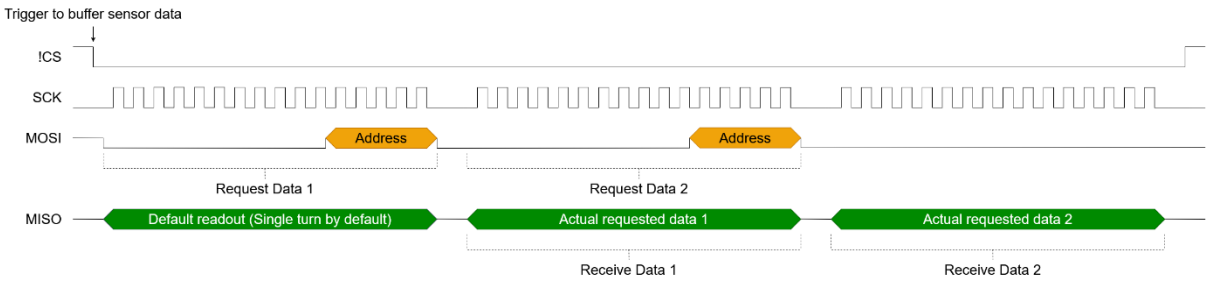


Figure 8: Example SPI data request sequence

5.4.2 Set Zero command

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

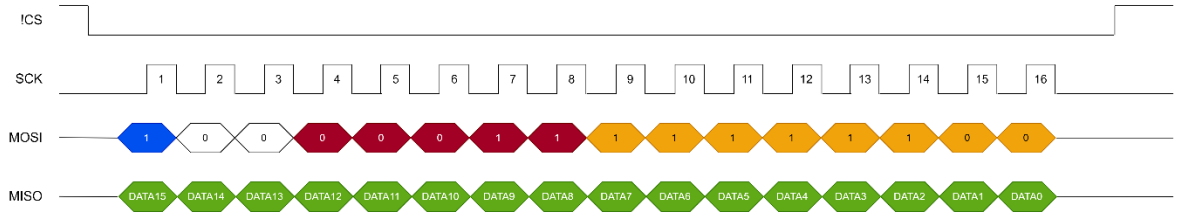


Figure 9: Set Zero Command

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.

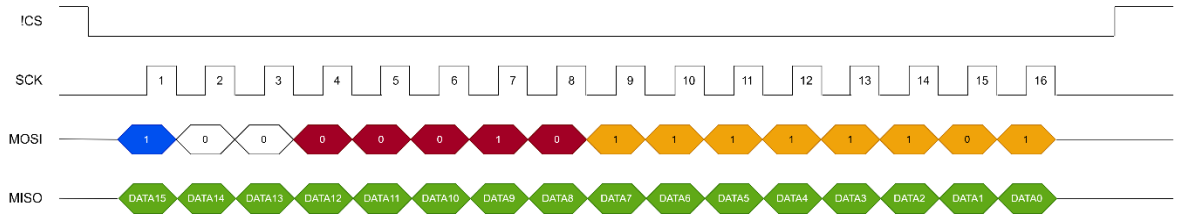


Figure 10: Save new zero position

6. ABI / UVW Interface

Symbol	Parameter	min.	typ.	max.	Unit
$V_{OL_ABI/UVW}$	ABI/UVW pins output low level voltage	-	-	0.4	V
$V_{OH_ABI/UVW}$	ABI/UVW pins output high level voltage	Vcc-0.4	-	-	V
$I_{O_AB/UVW}$	AB/UVW pins output current	-	-	±8	mA
I_{O_I}	I pin output current	-	-	±2	mA
$C_{I/O_ABI/UVW}$	ABI/UVW I/O pins capacitance	-	5	-	pF
$Tr_{out_AB/UVW}$ / $Tf_{out_AB/UVW}$	AB/UVW pins output rise and fall times @50pF load	-	-	25	ns
Tr_{out_I} / Tf_{out_I}	I pin output rise and fall times @50pF load	-	-	170	ns
$t_p_{ABI/UVW}$	Pulse width ABI/UVW output	1	-	-	µs
dev_pw	Deviation of pulse width	-	-	40	deg
dev_ps	Deviation of phase shift	-	-	40	deg

6.1 Timing diagram

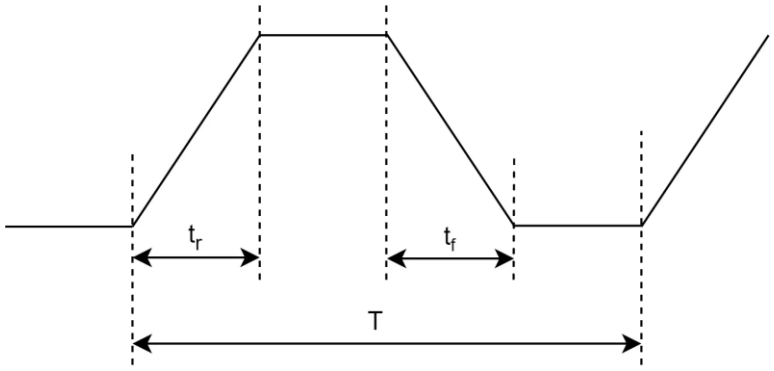


Figure 11: ABI timing diagram

6.2 Output signals

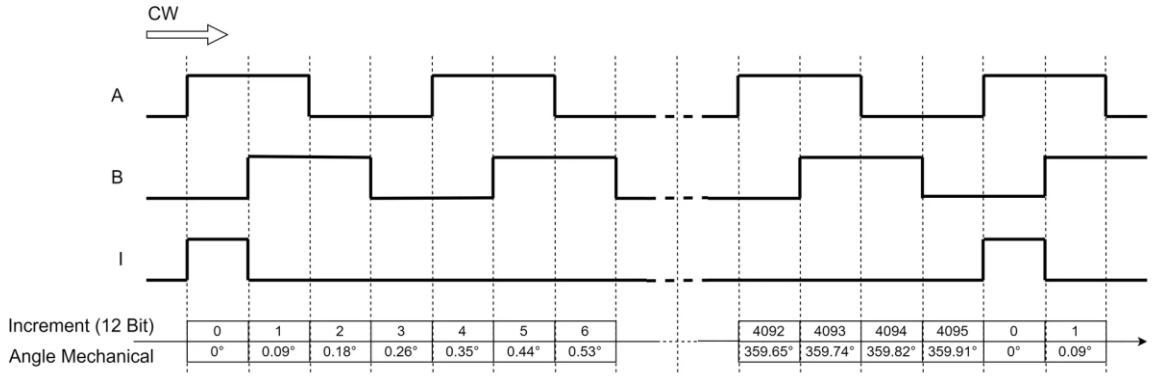


Figure 12: ABI output signal

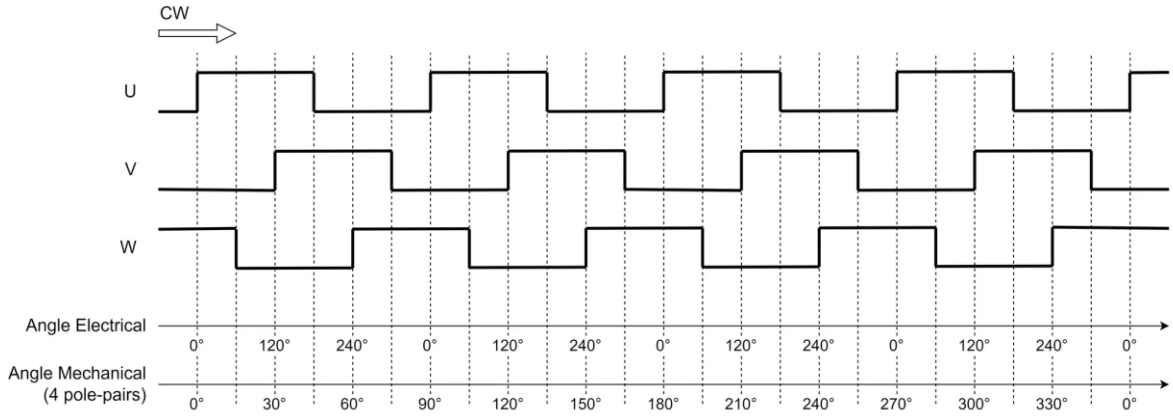


Figure 13: UVW output signal

6.3 Minimal pulse width

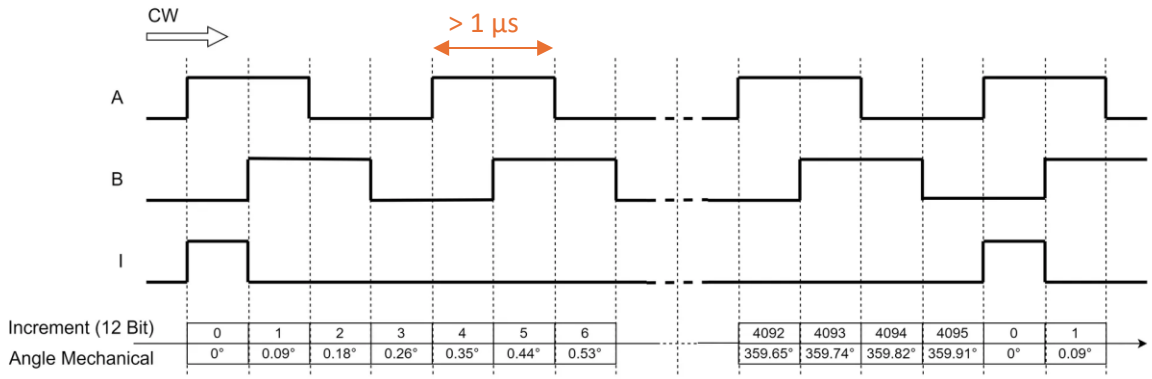


Figure 14: Minimal pulse width > 1 µs

6.4 Deviation of pulse width / deviation of phase shift

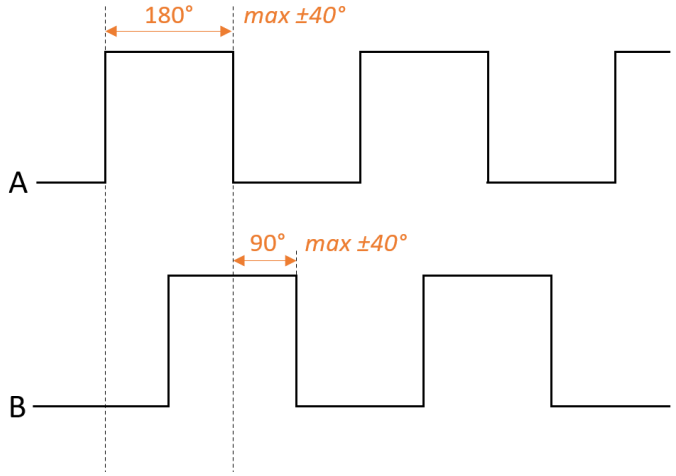


Figure 15: Deviation of pulse width and deviation of phase shift

7. Digital I/Os

Symbol	Parameter	min.	typ.	max.	Unit
$V_{IT-_I/O}$	I/O pins input low level Schmitt-Trigger threshold voltage	-	-	0.39*Vcc -0.06	V
$V_{IT+_I/O}$	I/O pins input high level Schmitt-Trigger threshold voltage	0.49*Vcc +0.26	-	-	V
$V_{IT-_!RST}$	I/O pins input low level Schmitt-Trigger threshold voltage	-	-	0.3*Vcc	V
$V_{IT+_!RST}$	I/O pins input high level Schmitt-Trigger threshold voltage	0.3*Vcc	-	-	V
$V_{HYS_I/O}$	I/O pins input hysteresis voltage	-	0.2	-	V
$V_{OL_I/O}$	I/O pins output low level voltage	-	-	0.4	V
$V_{OH_I/O}$	I/O pins output high level voltage	Vcc-0.4	-	-	V
$I_{O_I/O}$	I/O pins output current	-	-	±8	mA
$C_{I/O}$	I/O pins capacitance	-	5	-	pF
$Tr_{out_I/O}$ / $Tf_{out_I/O}$	SPI pins output rise and fall times @50pF load	-	-	25	ns

7.1 Start-up

After power on or reset, the encoder initializes itself. The initialization phase is finished after the TICK (CLK) is starting to toggle.

8. Mechanical Data

[This section will be updated when feedback from mechanical team of Dunker is there.]

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	-	40	-	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

*Highest element PCB to magnet surface

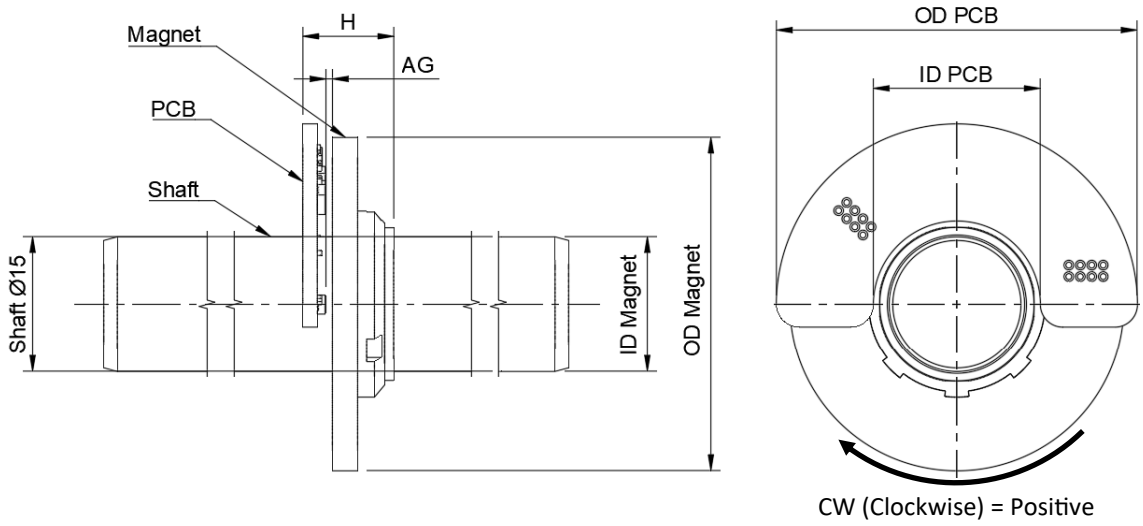


Figure 16: Mechanical dimensions

8.1 Tilt

A maximum tilt of ±1° between the magnet and the electronics board is tolerated in all directions.

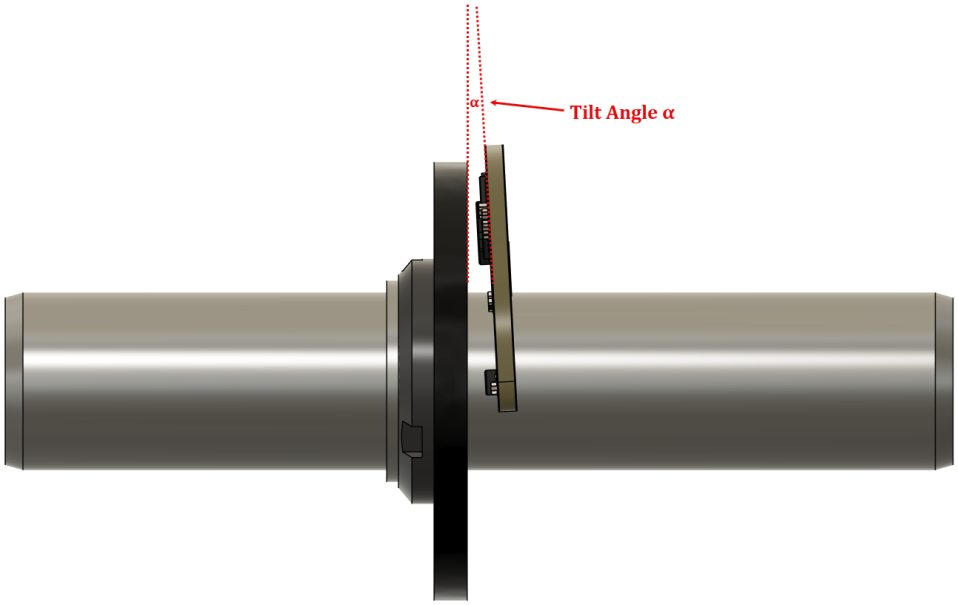
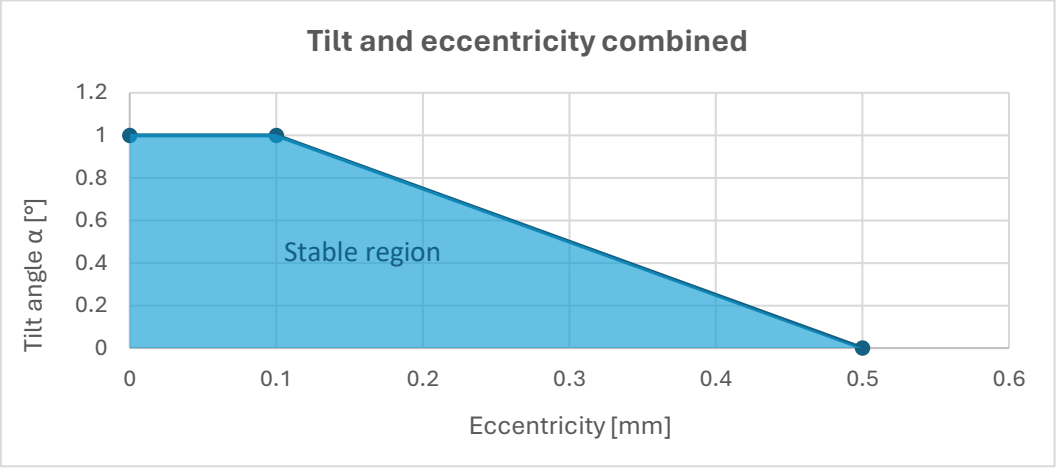


Figure 17: Definition of tilt angle α

When tilt is combined with eccentric alignment, the permissible operating range is defined by the stable region shown in the diagram below.



9. Pinout

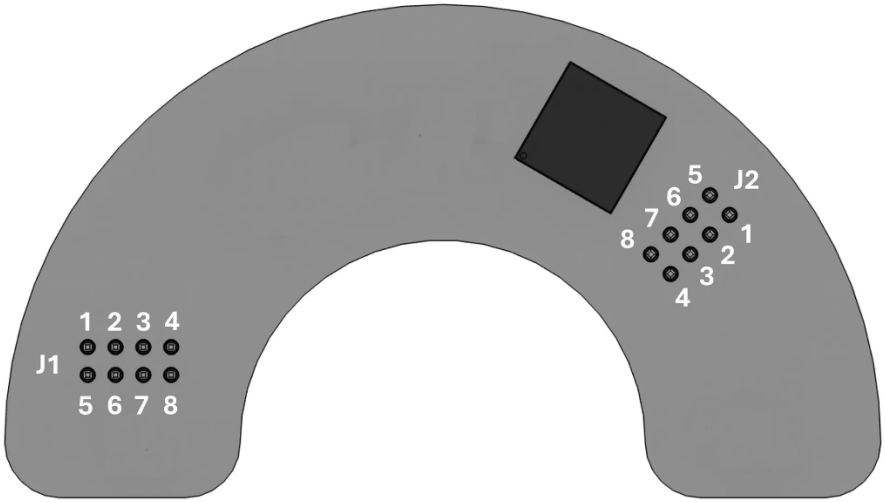


Figure 18: PCB Pinout

Connector	Pin	Signal	Description
J1	1	IO1	IO 1 – Reserved for future use
	2	IO0	IO 0 – Reserved for future use
	3	!RST	Sensor reset (active low)
	4	TICK	Sensor tick (represents t_{rr})
	5	SPI_{MOSI}	SPI MOSI signal
	6	SPI_{MISO}	SPI MISO signal
	7	SPI_{SCK}	SPI clock
	8	SPI_{ICS}	SPI chip select (active low)
J2	1	ABI_A	ABI A signal
	2	ABI_B	ABI B signal
	3	ABI_I	ABI I signal
	4	VDD	Power supply 3.3V
	5	UVW_U	UVW U signal
	6	UVW_V	UVW V signal
	7	UVW_W	UVW W signal
	8	GND	Ground

10. Contact

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All performance data provided are based on laboratory measurements 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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