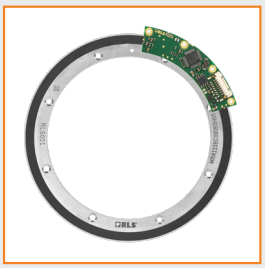
AksIM-4
EncoLink Register Access

EncoLink is a communication protocol that can be implemented on different physical channels, UART and SPI. It is a multilayer communication protocol that provides position, CRC and error/warning bits in the first channel, control position and detailed status in the second channel and register access in the third channel. The user can read all data simultaneously, the first channel with the highest bandwidth and the third channel with the lowest bandwidth.

User implementation: The user can choose one of two options:

- Channel 1 only. Only the encoder position is available, with general Error and Warning bits. For SPI, the MOSI line can be tied to GND (unused) and for UART, an empty request (0x00, 0x00) is sent.
- Full 3-channel access. RLS provides source code of EncoLink master libraries. The end user does not need to write custom code to implement full encoder functionality.

Related products

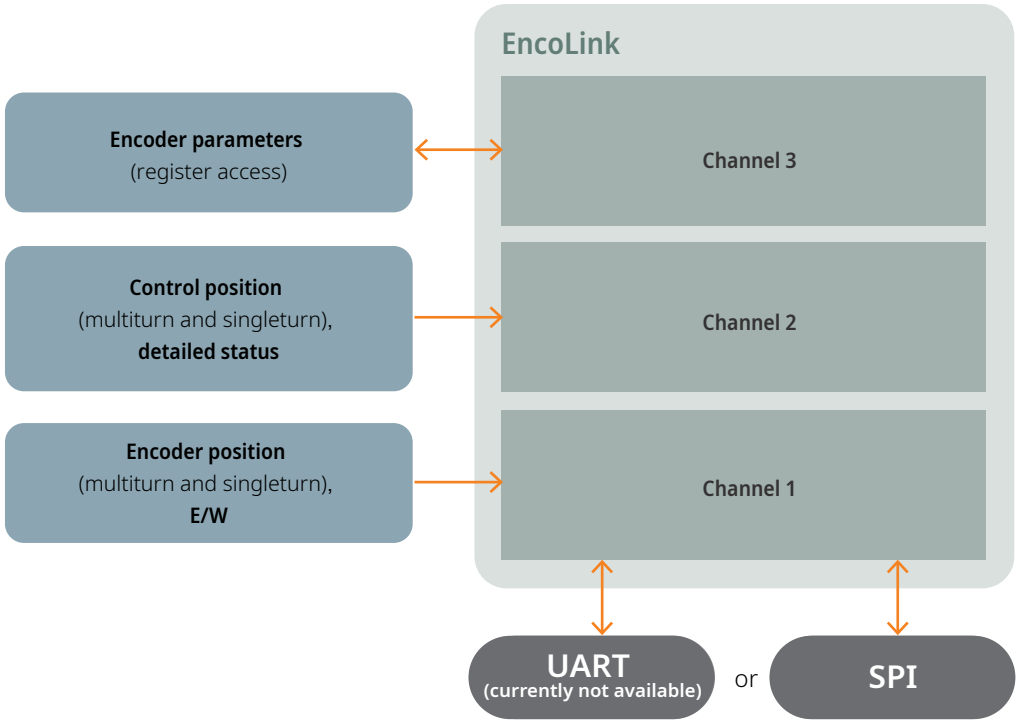


AksIM-4 off-axis absolute magnetic encoder

E201-9P USB interface

EncoLink over SPI bus

EncoLink protocol has three communication channels. Channel 1 provides position and status data. Entire communication frame of first channel is available on every communication request. Channel 2 provides redundant position data along with detailed status data. Communication frame of second channel is available after N communication requests, where N is number of bytes in channel 2. Channel 3 provides register access data. Communication frame of third channel is available after N full frames of channel 2, where N is number of bytes in channel 3.



Memory layout

Encoder status block

Address	Data type	Access	Default value	Description
0x00 – 0x01	S16	R	**	Sensor temperature in °C
0x02 – 0x05	U32	R	< 30000 typ.**	Signal level
0x06 – 0x09	S32	R	**	Measured velocity in 0.1 rpm
0x0A – 0x0D	U32	R	0**	Persistent detailed status
0x0E	U8	R	0**	Parameter access status register – table A
0x0F	U8	/	/	Reserved
0x10	S16	R	**	Min. distance of decoding point from decoding warning threshold (advanced diagnostic parameter)
0x12	S16	RW	**	Min. distance of decoding point from decoding warning threshold - persistent (advanced diagnostic parameter)
0x14 – 0x33	U8	/	/	Reserved
0x34 – 0x37	U32	R	**	Diagnostic data: Number of power cycles (max = 8.388.607)
0x38 – 0x3B	U32	R	**	Diagnostic data: Time of operation in minutes (max = 16.777.215 or ~32 years)
0x3C	S8	R	**	Diagnostic data: Min. measured temperature in °C (limit = –127°C)
0x3D	U8	/	/	Reserved
0x3E – 0x3F	S16	R	**	Diagnostic data: Max. measured temperature in °C (limit = 255°C)

** Parameter value changes during operation.

Encoder identification block

Address	Data type	Access	Default value	Description
0x40 – 0x4F	16 x U8	R	*	RLS serial number (ASCII characters)
0x50 – 0x53	U8	/	/	Reserved
0x54 – 0x67	20 x U8	R	*	RLS part number (ASCII characters)
0x68 – 0x69	U16	R	4	FW major version
0x6A – 0x6B	U16	R	*	FW minor version
0x6C – 0x6D	U16	R	*	FW hotfix version
0x6E – 0x71	U32	R	*	FW build version
0x72 – 0x75	4 x U8	R	*	FW version short hash
0x76 – 0x7F	U8	/	/	Reserved

* Most values of parameters in identification block depend on actual part.

Encoder configuration block

Address	Data type	Access	Value in effect	Default value	Min / max	Description
0x80 – 0x83	U32	RW	Immediate	0	0...RESOL.	Position offset*
0x84 – 0x87	U32	RW	Power-on	150	0...240	Position filter value
0x88 – 0x8B	U32	RW	Power-on	100	0...10000	Position filter speed
0x8C – 0x8F	U32	RW	Power-on	190	0...240	Velocity filter value
0x90 – 0x93	U8	/		/		Reserved
0x94 – 0x97	U32	RW	Immediate	0	0...65535	Multiturn counter preset**
0x98	U8	RW	Immediate	90	2...90	Multiturn error arc length [deg]**
0x99 – 0xBC	U8	/		/		Reserved
0xBD	U8	RW	Immediate	0xFF	0...255	Command register
0xBE	U8	RW	After “c” command	0x5A	0...255	Write protect lock
0xBF	U8	/		/		Reserved

* Max allowed value is determined from encoder resolution.
** Multiturn parameters are set to READ access if encoder has no multiturn support.

Self-calibration block

Address	Data type	Access	Default value	Min / max	Description
0xC0 – 0xC3	U32	R	0		Self-calibration status
0xC4 – 0xC5	U16	RW	360	180...360	Partial arc length [deg]*
0xC6	U8	RW	10	1...40	Calibration timeout [s]
0xC7	U8	/	/		Reserved
0xC8 – 0xC9	U16	R	0		Ring eccentricity shift from rotation axis centre [um]
0xCA – 0xCB	U16	R	0		Ring eccentricity angle (phase) [deg]
0xCC – 0xCD	S16	R	0		Readhead radial shift (positive towards centre of axis) [um]
0xCE – 0xFF	U8	/	/		Reserved

* If partial arc is not supported, this register is read-only.

Some of writable parameters values are taken into account immediately after value gets changed by writing to this register. For these registers it is not needed to save configuraton to non-volatile memory if setting will only be needed in current power cycle.

Error map block

Error map is mapped to address 0x10000 and contains 512 x 16bit error map values.

Address	Data type	Access	Description
0x10000 – 0x103FF	S16	RW	Error Map [0 – 511]

All values written to the error-map are effective immediately.
Values of error map are absolute position correction values for each of 1/512 sector of absolute position. Correction value from error map at index 0 is therefore applied to internal absolute position 0, next index 1 corresponds to position at 1/512 of rotation etc. Correction is applied to internal position which has higher resolution than position which is read out via communication. Internal resolution depend on ring size. Correction value from error map is simply subtracted from current internal position. Corrections within given sector is applied using interpolated value of two adjacent correction values from error map.

Table A (Parameter access status register)

Bit	Description
0	Write access denied
1	Value out of range
2 - 5	Reserved
6	Command fetched and executed
7	Write lock active

* Bits are persistent - they get cleared on register read, except 'Write lock active', which can not be cleared.

Encoder operating parameters

Address	Data Type	Access	Description
EncoLink channel 2	U32	R	Encoder status
0x0A – 0x0D	U32	R	Persistent encoder status
0x00 – 0x01	S16	R	Sensor temperature in °C
0x02 – 0x05	U32	R	Signal level
0x06 – 0x09	S32	R	Rotational speed in 0.1 rpm
0xC0 – 0xC3	U32	R	Self-calibration status

Encoder status

Detailed status bits represent current operational state of the encoder. For more information refer to MCD01 in “Detailed status bits” chapter at **RLS Media center**.

Persistent encoder status

This is similar to “Encoder status”, but with the added functionality that all detailed statuses are accumulated. Any error or warning that appears in Detailed Status during operation of encoder is copied into Persistent detailed status. Even if the value in Detailed Status has very short duration, the past statuses can be read from this Persistent register. It keeps the value as long as the power is present. Clearing is possible either by a power cycle or by writing the command ‘b’ to the Command register.

Sensor temperature

Temperature of the sensor in °C. This value is typically 10 °C to 15 °C higher than ambient. Tolerance of the readout is ±5 °C.

Signal level

The signal level information can be used to calculate the ride height (distance between rubber on the ring and sensor on the readhead).

The value is proportional to the distance between the sensor and the ring. To calculate the real distance, use the following formula:

$$\text{Ride height} = K \times \text{Ln}(\text{SignalLevel}) + N$$

Calculated ride height has tolerance of ±20 µm.
K and N are selected depending on the encoder size.

Encoder size	K	N
MC115	–71.62	760
MC150	–71.62	750

Rotational speed

Encoder rotational speed in 0.1 rpm.

Self-calibration status

See chapter **Self-calibration.**

Position offset (encoder zero position), multiturn counter (optional) and register write protection can be programmed to the AksIM readhead. Additional to this, the readhead can be self-calibrated or reset to the factory defaults.
Values written into registers take effect immediately, with some exceptions - see “value in effect” column in registers description tables.

Command execution

To execute a command, command byte must be written to Command register at address 0xBD.

Command starts executing when master reads out last 2 bytes (CH2, CRC) from channel 1 frame which returns channel 2 byte with “write status” – see Encolink specification document. Consequently master can be sure that command byte was correctly written to command register as it is true for all writable registers.

After each command is fetched by encoder, communication is disabled during command execution.
Communication is enabled only after command has executed which can last up to 100 ms.
During this time encoder will not respond to communication requests.

Master can check if command was executed in “Parameter access status register” – see table A.

Supported commands

Command	Command [hex]	Typ. execution time [ms]	Description
‘A’	0x41	Set with parameter	Self-calibration start
‘b’	0x62	1	Persistent detailed status reset
‘c’	0x63	70	Save current configuration to non-volatile memory
‘m’	0x6D	1	Apply multiturn counter from “multiturn counter preset” parameter value
‘r’	0x72	70	Configuration reset to factory defaults

Position offset (encoder zero position)

Position offset value is substracted from the raw encoder position.
If the absolute applied position offset is greater than the actual encoder resolution, value will not get updated.

After changing zero position for a greater value, acceleration error might appear.
After every setting of a new position offset, verify or adjust multiturn counter value (if present).

To store new value into non-volatile memory use the following command:
Command for saving programmed data to a non-volatile memory: write value 0x63 to address 0xBD

Saving the parameters in the non-volatile memory takes 70 ms. During this time, the encoder position is not calculated. With the multiturn counter option, the counter is only valid if the rotational speed does not exceed ±300 rpm during the saving process.

Multiturn counter

Multiturn counter preset is only available for the multiturn variants of the AksIM encoders.
First, the new multiturn counter value must be written to register 0x94 – 0x97. Programming a multiturn counter greater than 65535 (unsigned) is discarded. At this point, the new multiturn counter is not yet active. To apply it, the user must execute the command to preset the multiturn counter: write value 0x6D to address 0xBD.

Self-calibration

Self-calibration of AksIM is suitable after mounting the readhead. It improves the accuracy of the encoder, which depends on the mounting precision. It can be triggered by sending the Self-calibration start command (0x41) to the Command register (address 0xBD). No communication via the SPI interface is possible during the process; the encoder does not respond to incoming clock cycles. The completion of the process is indicated by the LED flashing rapidly for 3 seconds. If the self-calibration was successful, the LED flashes green, otherwise it flashes red. The SPI interface is then active again. The status of self-calibration can be read from a register 0xC0 – 0xC3. It consists of a two-bit counter. The counter is incremented at the end of each self-calibration. Status bits indicate success or reasons for failure.

Prior to the self-calibration process, the status should be read from register 0xC0 – 0xC3. The controller must remember the current self-calibration counter (bits 1:0). After sending the self-calibration command, LED must be observed for completion. If the LED is not visible, the readhead should be polled via the SPI interface until communication with the readhead is re-established, or wait 10 seconds, which is the default timeout for completion. The self-calibration status register should then be read out again. When the self-calibration counter has increased by 1 (compared to the previously read value), the self-calibration function has been completed. Additional data from the self-calibration is available in the Self-calibration block and includes the measurement of the ring eccentricity and the placement of the readhead.

Speed and direction of rotation during self-calibration are not important and may be inconsistent. The only requirement is that the shaft makes at least one complete revolution within 10 seconds of the command being sent. If the default setting of 10 seconds is not sufficient, this period can be extended to up to 40 seconds using register 0xC6. If the mechanics do not allow 360° rotation, the length of the calibration arc can be reduced to at least 180° and written into the register 0xC4 – 0xC5. The new arc length must be set before the self-calibration function is executed. The performance of the self-calibration procedure is optimal at 360° rotation and is reduced if the arc length is reduced.

Address	Type	Range	Units	Meaning / usage
INPUT				
0xC4 – 0xC5	U16	180 - 360	degrees	Partial arc length
0xC6	U8	1 – 40	s	Calibration timeout
0xBD	U8	0x41	-	Command
OUTPUT				
0xC8 - 0xC9	U16	0 – 400	µm	Ring eccentricity shift from rotation axis centre
0xCA - 0xCB	U16	0 – 360	degrees	Ring eccentricity angle (phase)
0xCC - 0xCD	S16	-1000 – 1000	µm	Readhead radial shift (positive value – readhead is mounted towards the center of the axis)
0xC0 - 0xC3	U32		bit	Status - see table below

Self-calibration status register:

Bit	Meaning
b21	Error - Parameters could not be saved to non-volatile memory (system fault).
b20	Indication - Error map table is not default (self-calibration was successfully performed). Comparison is executed at power-up and at every command “Save current configuration to non-volatile memory”.
b19	Reserved
b18	Reserved
b17	Reserved
b16	Reserved
b15	Error - Radial displacement is very high.
b14	Indication - Eccentricity is already low (no correction is needed).
b13	Error - Eccentricity is very high.
b12	Error - Numerical error during data processing.
b11	Reserved
b10	Reserved
b9	Error - Encoder is in error state while calibration is started - aborted.
b8	Timeout - Encoder did not complete full revolution (or partial arc) in preset time.
b7	Reserved
b6	Error
b5	Ring positioning is already perfect - correction was not performed.
b4	Confirmation - Self calibration successfully completed.
b3	Reserved
b2	Reserved
b1:b0	Counter is incremented at the end of self-calibration procedure.

When self-calibration is completed without error, the new parameters are automatically stored in non-volatile memory and no further command is required. All numeric results from the calibration are stored in the volatile memory and are cleared on the power cycle. To verify if encoder was already calibrated, read the Self-calibration status register and verify that bit b6 (0x40) is set.

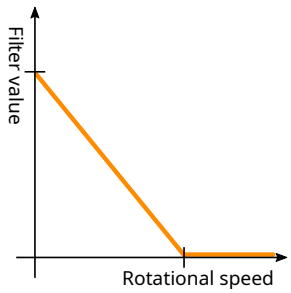
Dynamic filtering

The AksIM-4 encoder uses dynamic low-pass filters to reduce noise in the calculated position value.
The default values are suitable for most applications. However, in some extreme cases, fine tuning is required to achieve optimum performance. For example, in precise applications with low speed and acceleration, the filtering can be increased to increase the resolution.
In contrast, fast and dynamic applications may require a reduction in filtering to reduce delay and increase the bandwidth.

Filter settings
Settings are present in Encoder configuration block.

Address	Name	Default	Range	Description
0x84 – 0x87	Position filter value	150	0 – 240	Maximum value of Position Filter when encoder is standstill. 0 = filter disabled
0x88 – 0x8B	Position filter speed	100	0 – 10,000	Encoder speed when Position Filter is turned off. Below 100: Up to 100 rpm the filter is linearly reduced to 0.
0x8C – 0x8F	Velocity filter value	190	0 – 240	Value of Velocity Filter. 0 = filter disabled

Position filter
Encoder position value, from every internal encoder cycle, is passed through the low-pass filter. This gives smoother position value and increased resolution when encoder speed is low or decelerating.
Increased Value parameter increases filter strength and reduces cut-off frequency. This value is used when encoder is standstill. With increasing rotational speed, filter is linearly reduced. When rotational speed is equal or bigger than Speed parameter, filter is turned off.



Velocity filter
Internally calculated velocity (rotational speed) is passed through the low-pass filter. This gives smoother position value on communication interface. Increased Value parameter increases filter strength and reduces cut-off frequency. Filter is constant and not dependent on the rotational speed.

Changing filter values may cause encoder or closed control loop to become unstable. Use with caution and evaluate all possible situations before keeping the new values.

Saving configuration parameters

Sending a programming command byte ‘c’ triggers the procedure to save all configuration parameters of the encoder in the non-volatile memory. These parameters also include the position offset.
Execute the command to save the data: write value 0x63 to address 0xBD.

Saving the parameters in the non-volatile memory takes 70 ms. During this time, the encoder position is not calculated. With the multiturn counter option, the counter is only valid if the rotational speed does not exceed ±300 rpm during the saving process.

Reset to factory defaults

Resetting to the factory defaults will set all programmed parameters to the default values. This includes the zero position, the calibration results and others.
Execute the command to reset readhead to the factory defaults: write value 0x72 to address 0xBD.

Saving the parameters in the non-volatile memory takes 70 ms. During this time, the encoder position is not calculated. With the multiturn counter option, the counter is only valid if the rotational speed does not exceed ±300 rpm during the saving process.

After locking the write access, the encoder cannot be reset to the factory defaults.

Write protection

Write protection can be used to lock the write access of any writable register in AksIM memory map. It is mapped to the register 0xBE. Its default value is 0x5A. To lock the write access, user should write any value other than 0x5A. After that, the write access of any register will be refused.
All registers will behave as a non writable registers.

Command for saving programmed data to a non-volatile memory: write value 0x63 to address 0xBD.

Saving the parameters in the non-volatile memory takes 70 ms. During this time, the encoder position is not calculated. With the multiturn counter option, the counter is only valid if the rotational speed does not exceed ±300 rpm during the saving process.

After locking the write access, the readhead cannot be programmed anymore. All registers are still readable.

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Document issues

Issue	Date	Page	Description
1	10. 4. 2025	-	New document