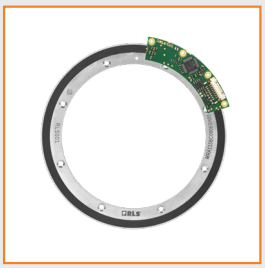
AksIM-4
BiSS C Register Access

Abstract: The BiSS C interface implemented in AksIM supports bidirectional communication in register access mode. The readhead is user configurable. Implementation is compliant with BiSS C (also Standard Encoder Profile known as “BP3”), which is used to group linear and rotary encoders. Details on BiSS register access and BP3 can be found on the **BiSS website**.

User implementation: User can implement bidirectional BiSS in their own hardware according to the BiSS documentation provided by iC-Haus. As an alternative it is also possible to use the iC-Haus chip iC-MB4, which translates the high-level commands on the SPI bus into BiSS. The easiest way is to use the interface E201-9B from RLS including the corresponding software.

Related products



AksIM-4 off-axis absolute magnetic encoder

E201-9B USB interface

General information

BiSS EDS banks

Bank	Address	Symbol	Description	Data type	Unit	Value
0	0x00	EDS_VER	EDS version	U8	-	1
	0x01	EDS_LEN	EDS length	U8	Banks	2
	0x02	USR_STA	Bank address USER start	U8	-	255
	0x03	USR_END	Bank address USER end	U8	-	1
	0x04	TMA	Min. permited clock periond	U8	1 ns	200
	0x05	TO_MIN	Min. BiSS timeout	U8	250 ns	52
	0x06	TO_MAX	Max. BiSS timeout	U8	250 ns	60
	0x07	TOS_MIN	Min. BiSS timeout_S	U8	25 ns	0
	0x08	TOS_MAX	Max. BiSS timeout_S	U8	25 ns	0
	0x09	TCLK_MIN	Min. sampling period adaptive timeout	U8	25 ns	0
	0x0A	TCLK_MAX	Max. sampling period adaptive timeout	U8	25 ns	0
	0x0B	TCYC	Min. cycle time	U8	250 ns	table A
	0x0C	TBUSY_S	Max. Processing time SCD	U8	250 ns	0
	0x0D	BUSY_S	Max. Processing time SCD in clocks	U8	TMA	13
	0x0E – 0x0F	PON_DLY	Max. »power on delay« until control communication is available	U16	1 ms	200
	0x10	DC_NUM	Number of channels in this device	U8	-	1
	0x11	SL_NUM	Area of validity for this EDS (number of slave addresses)	U8	-	1
	0x12	SL_OFF	Memory location for this EDS (slave ID within this device)	U8	-	0
	0x13		Reserved	U8		0
	0x14	BANK1	Bank address for content description of data channel 1 (Profile EDS)	U8	-	1
	0x15	DLEN1	Data length for data channel 1	U8	Bit	table A
	0x16	FORMAT1	Data format for data channel 1	U8	Bit	2
	0x17	CPOLY1	CRC polynomial (8:1) for data channel 1	U8	-	0x21
	0x18 – 0x33		Reserved	U8		0
	0x34	BC_OFF	Bus coupler control location for this device (slave ID within this device)	U8	-	0
	0x35 – 0x3E		Reserved	U8		0
	0x3F	CHKSUM	Checksum (sum of all bytes within this bank)	U8	-	xx

Bank	Address	Symbol	Description	Data type	Unit	Value
1	0x00	BP_VER	BiSS profile 3 version	U8	-	1
	0x01	BP_LEN	Length of this profile	U8	Banks	1
	0x02 - 0x03	BP_ID	Profile identification BP3 (content also available in addresses 0x42 and 0x43)	U16	-	table B
	0x04	PROFILE_FB1	Feedback bit 1 (nError = 1)	U8	-	1
	0x05	PROFILE_FB2	Feedback bit 2 (nWarning = 2)	U8	-	2
	0x06	PROFILE_PON_PDL	Max. “power on delay” until position data is available	U8	ms	200
	0x07		Reserved	U8		0
	0x08	PROFILE_EN_TYP	Encoder type (rotary = 0)	U8	-	0
	0x09	PROFILE_POS_NUM	Position value (1 position)	U8	-	1
	0x0A	PROFILE_MT_LEN	Data length MULTITURN	U8	Bit	table B
	0x0B	PROFILE_MT_FMT	Data format MULTITURN	U8	-	table B
	0x0C	PROFILE_CO_LEN	Data length COARSE	U8	Bit	0
	0x0D	PROFILE_CO_FMT	Data format COARSE	U8	-	0
	0x0E	PROFILE_FI_LEN	Data length FINE	U8	Bit	table B
	0x0F	PROFILE_FI_FMT	Data format FINE	U8	-	0
	0x10 - 0x13	PROFILE_MT_CNT	Number of distinguishable revolutions	U32	Count	table B
	0x14 – 0x17	PROFILE_SIP_CNT	Number of signal periods per revolution	U32	PPR	1
	0x18 – 0x1B	PROFILE_SIP_RES	Resolution factor per signal period (LSB of interpolation)	U32	Count	table B
	0x1C – 0x1F	PROFILE_CPOLY	CRC polynomial (32:1 of 0x43)	U32	-	0x21
	0x20 – 0x23	PROFILE_CSTART	CRC start value	U32	-	0
	0x24 – 0x25	PROFILE_ABS_ACU	Absolute accuracy	U16	LSB/2	table C
	0x26 – 0x27	PROFILE_REL_ACU	Relative accuracy	U16	LSB/2	0
	0x28 – 0x29	PROFILE_SPD_ACU	Angular speed depending accuracy	U16	LSB/2	0
	0x2A – 0x2B	PROFILE_HYST	Hysteresis	U16	LSB/2	0
	0x2C – 0x2D	PROFILE_SPD_MAX	Max. revolution speed	U16	1/min	**
	0x2E – 0x2F	PROFILE_ACC_MAX	Max. revolution acceleration	U16	1/min2	0
	0x30 – 0x31	PROFILE_TMP_MIN	Min. operating temperature	U16	K	233**
	0x32 – 0x33	PROFILE_TMP_MAX	Max. operating temperature	U16	K	378**
	0x34 – 0x35	PROFILE_VLT_MIN	Min. operating voltage	U16	mV	4500
	0x36 – 0x37	PROFILE_VLT_MAX	Max. operating voltage	U16	mV	5500
	0x38 – 0x39	PROFILE_CUR_MAX	Max. current consumption	U16	mA	160
	0x3A – 0x3E		Reserved	U8		0
	0x3F	CHKSUM	Checksum (sum of all bytes within this bank)	U8	-	xx

* All parameters from EDS banks are read-only.

** Parameter value depends on actual part number.

Encoder identification bank

Bank	Address	Data Type	Access	Default value	Description
2	0x00 – 0x0F	16 x U8	R	*	RLS serial number (ASCII characters)
	0x10 – 0x13	U8	R	0	Reserved
	0x14 – 0x27	20 x U8	R	*	RLS part number (ASCII characters)
	0x28 – 0x29	U16	R	0x04	FW major version
	0x2A – 0x2B	U16	R	0x00	FW minor version
	0x2C – 0x2D	U16	R	0x00	FW hotfix version
	0x2E – 0x31	U32	R	0x00	FW build version
	0x32 – 0x35	4 x U8	R	*	FW version short hash
	0x36 – 0x3E	U8	R	0	Reserved
	0x3F	U8	R	xx	Checksum (sum of all bytes within this bank)

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

Encoder configuration bank

Bank	Address	Data Type	Access	Value in effect	Default value	Description
3	0x00 – 0x03	U32	RW	Immediate	0	Position offset*
	0x04 – 0x07	U32	RW	Power-on	150	Position filter value
	0x08 – 0x0B	U32	RW	Power-on	100	Position filter speed
	0x0C – 0x0F	U32	RW	Power-on	190	Velocity filter value
	0x10 – 0x13	U8	R		0	Reserved
	0x14 – 0x17	U32	RW	Immediate	0	Multiturn counter preset**
	0x18	U8	RW	Immediate	90	Multiturn error arc length**
	0x19 – 0x3D	U8	R		0	Reserved
	0x3E	U8	RW	After “c” command	0x5A	Write protect lock
	0x3F	U8	R		xx	Checksum (sum of all bytes within this bank)

* Max allowed value is determined from encoder resolution: SIP_RES – 1 (see Table B)

** Multiturn parameters are set to READ access if encoder doesn’t have multiturn implemented

Self-calibration bank

Bank	Address	Data Type	Access	Value in effect	Default value	Description
4	0x00 – 0x03	U32	R		0	Self-calibration status
	0x04 – 0x05	U16	RW	Immediate	360	Partial arc length
	0x06 – 0x07	U16	R		0	Ring eccentricity shift from rotation axis centre
	0x08 – 0x09	U16	R		0	Ring eccentricity angle (phase)
	0x0A – 0x0B	S16	R		0	Ring radial shift
	0x0C	U8	RW	Immediate	10	Calibration timeout [s]
	0x0D – 0x3E	U8	R		0	Reserved
	0x3F	U8	R		xx	Checksum (sum of all bytes within this bank)

Error map banks*

Bank	Address	Data Type	Access	Description
8	0x00 – 0x3F	S16	RW	Error Map [0 – 31]
9	0x00 – 0x3F	S16	RW	Error Map [32 – 63]
10	0x00 – 0x3F	S16	RW	Error Map [64 – 95]
11	0x00 – 0x3F	S16	RW	Error Map [96 – 127]
12	0x00 – 0x3F	S16	RW	Error Map [128 – 159]
13	0x00 – 0x3F	S16	RW	Error Map [160 – 191]
14	0x00 – 0x3F	S16	RW	Error Map [192 – 223]
15	0x00 – 0x3F	S16	RW	Error Map [224 – 255]
16	0x00 – 0x3F	S16	RW	Error Map [256 – 287]
17	0x00 – 0x3F	S16	RW	Error Map [288 – 319]
18	0x00 – 0x3F	S16	RW	Error Map [320 – 351]
19	0x00 – 0x3F	S16	RW	Error Map [352 – 383]
20	0x00 – 0x3F	S16	RW	Error Map [384 – 415]
21	0x00 – 0x3F	S16	RW	Error Map [416 – 447]
22	0x00 – 0x3F	S16	RW	Error Map [448– 479]
23	0x00 – 0x3F	S16	RW	Error Map [480 – 511]
24	0x00 – 0x0F	U8	R	Checksums of banks 8-23 on addresses 0-15

* All values written to the error-map are effective immediately.

Direct access registers

Address	Data Type	Access	Value in effect	Default value	Description
0x40	U8	RW	Immediate	0	Bank select
0x41	U8	R		0	EDS bank
0x42 – 0x43	U16	R		*	Profile ID (table B – BP_ID)
0x44 – 0x47	U32	R		*	Serial number (encoded)
0x48	U8	RW	Immediate	255	Key register
0x49	U8	RW	Immediate	255	Command register
0x4A – 0x4D	U32	R		0	Encoder detailed status (see chapter »Encoder operating parameters«)
0x4E – 0x4F	S16	R		**	Sensor temperature in °C
0x50 – 0x53	U32	R		**	Signal level
0x54 – 0x57	S32	R		**	Measured velocity in 0.1 RPM
0x58 – 0x5B	U32	R		0	Persistent detailed status
0x5C	U8	R		0	Parameter access status register – table D
0x5D – 0x73	U8	R		0	Reserved
0x74 – 0x77	U32	R		Same as in Identification bank	Major FW version
0x78 – 0x7D	U8	R		*	Device ID
0x7E – 0x7F	U16	R		0x5253	Manufacturer ID

* Parameter value depends on actual part.
** Parameter value changes during operation.

Table A

EDS parameter	20 bit ST	20 bit MT	21 bit ST	21 bit MT
DLEN	22	38	23	39
TCYC	92	105	93	106

Table B

Encoder type	BP_ID	MT_LEN	MT_FMT	FI_LEN	MT_CNT	SIP_RES
20 bit ST	0x6216	0	0	20	0	1048576
20 bit MT	0x6226	16	1	20	65536	1048576
21 bit ST	0x6217	0	0	21	0	2097152
21 bit MT	0x6227	16	1	21	65536	2097152

Table C

Encoder size	20 bit	21 bit
115	204	/
150	/	292

Table D

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 one time read - they get cleared on register read, except 'Write lock active', which can not be cleared.

Bank switching

BiSS registers are grouped into the banks in size of 64 bytes. Each register in each bank can be accessed with the address from 0x00 to 0x3F. Before access to a certain bank, it has to be selected in the Bank select register, which is mapped to address 0x40. For further information on bank switching refer to documentation provided by iC-Haus.

Read access

All registers in AksIM memory are readable. Read access also supports sequential reading. It is possible to read up to 64 bytes forward from initialized read address. For detailed description on sequential read access refer to documentation provided by iC-Haus.

Write access

Writable registers in AksIM memory are presented in table "Memory map". All registers can be write-protected if write access is locked by the user, except of Bank select register. Sequential write access is available in all banks. For detailed description on sequential write access refer to documentation provided by iC-Haus.

Encoder operating parameters

Address	Data Type	Access	Description
0x4A – 0x4D	U32	R	Encoder status (see table below)
0x4E – 0x4F	S16	R	Sensor temperature in °C
0x50 – 0x53	U32	R	Signal level
0x54 – 0x57	S32	R	Rotational speed in 0.1 RPM
0x00 – 0x03	U32	R	Self-calibration status (bank 4)

Encoder status (address 0x4A—0x4D)

Persistent detailed status (address 0x58 – 0x5B)

Detailed status	
b15	Reserved
b14	Warning – Temperature out of range. The readhead temperature is out of specified range.
b13	Warning – Signal amplitude low. The distance between the readhead and the ring is too large.
b12	Warning – Signal amplitude too high. The readhead is too close to the ring or an external magnetic field is present. There is also a possibility that encoder ring is touching encoder head. It is strongly recommended that user checks the encoder mounting immediately after this warning gets set.
b11	Warning - Signal decoding close to treshold. Position readout might fail. Check installation tolerances (radial shift, tilt) and external magnetic field.
b10	Warning - Rotational speed exceeds the limit.
b9	Reserved
b8	Error – Acceleration error. The position data changed unexpectedly or too fast. A stray magnetic field is present or metal particles are present between the readhead and the ring.
b7	Error – Magnetic pattern error. A stray magnetic field is present or metal particles are present between the readhead and the ring or radial positioning between the readhead and the ring is out of tolerances.
b6	Error – Signal lost. The readhead is out of alignment with the ring or the ring is damaged.
b5	Error – Signal amplitude too high. External magnetic field is present.
b4	Error – System error. Malfunction inside the circuitry. To reset the System error bit try to cycle the power supply while the rise time is shorter than 20 ms.
b3	Error – Power supply error. The readhead power supply voltage is out of specified range.
b2	Error – System error. Inconsistent calibration data is detected. To reset the System error bit try to cycle the power supply while the rise time is shorter than 20 ms.
b1	Reserved
b0	Reserved

Register Persistent detailed status (address 0x58 – 0x5B) accumulates all the status bits that were active during encoder operation, in every internal encoder cycle, even if communication is not active.
Format of the data is same as standard Detailed status register.
Clearing the Persistent status register is performed by writing value 0xCD into Key register (0x48), immediately followed by writing value 0x62 into Command register (0x49).

Sensor temperature (address 0x4E – 0x4F)
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 (address 0x50 – 0x53)
Signal level information can be used to calculate encoder ride height.
Value is proportional to the distance between the sensor and the ring. To calculate the actual distance use the following formula:
Ride height = K × Ln (SignalLevel) + N
Calculated ride height has tolerance of ±20 µm.

K and N are selected depending on the encoder size.

Encoder size	K	N
115, 150	–71.62	730

Rotational speed (address 0x54 – 0x57)
Encoder rotational speed in 0.1 RPM.

Self-calibration status (address 0x00 – 0x03)
See chapter Self-calibration on **page 10.**

AksIM-4 programming

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.
Numbers written into registers take effect immediately, with some exceptions - see “value in effect” column in registers description tables.

Command execution

To execute a command following sequence must be used:

- Write value 0xCD to Key register at address 0x48
- Write command byte to Command register at address 0x49

Write to key and command register must be sequential. No other register access should take place in between, otherwise command will not be executed. Any other register access after correct key is entered, invalidates key value and the command write procedure has to be repeated.
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.

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
'r'	0x72	70	Configuration reset to factory defaults

Position offset (encoder zero position)

Position offset is mapped to the registers 0x00, 0x01, 0x02, 0x03 of bank 3 in a big-endian format. User must write separate bytes of a new position offset in counts to these addresses. Afterwards, they can be read to verify the proper write operation.

> If the absolute applied position offset is larger than the actual encoder resolution, value will not get updated.

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

To store new values into non-volatile memory use the following sequence:
KEY: value 0xCD to address 0x48
Command for saving programmed data to a non-volatile memory: ASCII ‘c’ (0x63) to address 0x49

> Saving parameters to non-volatile memory takes 70 ms. During this time position is not valid. In case of multiturn counter option, counter is only valid if rotational speed does not exceed ±300 RPM during save procedure.

Self-calibration

Self-calibration of the AksIM is suitable after mounting the readhead. It improves the accuracy of the encoder, which depends on the mounting precision. The user must first unlock the command register by writing the KEY (0xCD) to the Key register (address 0x48). The next register access must be a write of the SelfCal command (0x41) to the Command register (address 0x49) to start the self-calibration procedure. During the procedure, no communication is possible via BiSS interface; the encoder does not respond to any incoming clock cycles. Completion of the procedure is indicated by rapid flashing of LED for 3 seconds. If self-calibration was successful, LED flashes green, otherwise it flashes red. The BiSS interface is then active again. The self-calibration status can be read from a register 0x00 in bank 4. It includes two bit counter. 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 0x00 in bank 4. Controller must remember current self-calibration counter (bits 1:0). After sending the self-calibration command, LED must be observed for completion. If LED is not visible, the readhead should be polled via the BiSS interface until communication with the readhead is established again or wait for 10 seconds, which is the default timeout for completion. The self-calibration status register should then be read 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 bank 4 and includes measurement of the ring eccentricity and the placement of the readhead.

Address	Type	Range	Units	Meaning / usage
INPUT				
0x0C, bank 4	U8	1 – 40	s	Calibration timeout
0x48	U8	0xCD	-	Key
0x49	U8	0x41	-	Command
OUTPUT, bank 4				
0x06	U16	0 – 400	µm	Ring eccentricity shift from rotation axis centre
0x08	U16	0 – 360	degrees	Ring eccentricity angle (phase)
0x0A	S16	-1000 – 1000	µm	Readhead radial shift (positive value – readhead is mounted towards the center of the axis)
0x00	U8		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 to NVRAM”.
b19	Reserved
b18	Reserved
b17	Reserved
b16	Reserved
b15	Error - Radial displacement is very high.
b14	Reserved
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	Reserved
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.

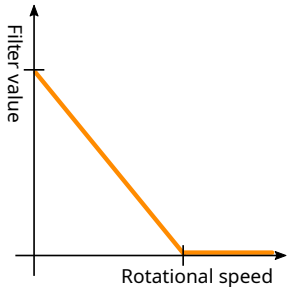
Dynamic filtering

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 bank 3 - Encoder configuration bank.

Address	Name	Default	Range	Description
0x04 – 0x07	Position filter value	150	0 – 240	Maximum value of Position Filter when encoder is standstill. 0 = filter disabled
0x08 – 0x0B	Position filter speed	100	0 – 10,000	Encoder speed when Position Filter is turned off. Below 100: filter is constant
0x0C – 0x0F	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 BiSS and UART interfaces. Increased *Value* parameter increases filter strength and reduces cut-off frequency. Filter is constant and not dependent on the rotational speed. Speed parameter is not used and is set to zero.

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.

To store new values into non-volatile memory use the following sequence:
KEY: value 0xCD to address 0x48
Command for saving programmed data to a non-volatile memory: ASCII ‘c’ (0x63) to address 0x49

Saving parameters to non-volatile memory takes 70 ms. During this time position is not valid. In case of multiturn counter option, counter is only valid if rotational speed does not exceed ±300 RPM during save procedure.

Reset to factory defauls

Reset to factory defauls will set all programmed parameters to the default ones. User must first unlock the command register by writing the KEY. Next register access must be a write of the Command to reset readhead to the factory defauls.

KEY: value 0xCD to address 0x48
Command to reset readhead to the factory defauls: ASCII ‘r’ (0x72) to address 0x49

Saving parameters to non-volatile memory takes 70ms. During this time position is not valid. In case of multiturn counter option, counter is only valid if rotational speed does not exceed ±300 RPM during save procedure.

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

Write protection

Write protection can be used to lock the write access of any writable register in AksIM memory map, except of Bank select register. It is mapped to the register 0x3E of bank 3. 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, except of Bank select, will be refused.
All registers will behave as a non writable registers.

Command for saving programmed data to a non-volatile memory: ASCII ‘c’ (0x63) to address 0x49.

Saving parameters to non-volatile memory takes 70 ms. During this time position is not valid. In case of multiturn counter option counter is only valid if rotational speed does not exceed ±300 RPM.

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	14. 3. 2023	-	New document
2	19. 9. 2023	4, 12	Default value amended
		6	TCYC parameters added
		8	Persistent detailed status amended
		10	Radial shift amended
		11	Self-calibration status register amended