AksIM-2
BiSS C Register Access

Abstract: The BiSS C interface implemented in AksIM supports bidirectional communication in register access mode. The readhead is user programmable and has 4 kB of user memory. The implementation is compliant with BiSS (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: The user can implement bidirectional BiSS in their own hardware according to the BiSS documentation provided by iC-Haus. The user can also 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-2 off-axis absolute magnetic encoder

E201-9B USB interface

BiSS memory map for AksIM-2

Bank	Address	Data Type	Access	Description
0	0x00 – 0x03	U32	R/W	Position offset
	0x04 – 0x07	U32	R/W	Position filter value
	0x08 – 0x0B	U32	R/W	Position filter speed
	0x0C – 0x0F	U32	R/W	Velocity filter value
	0x10 – 0x13	U32	R/W	Velocity filter speed
	0x14 – 0x17	U32	R/W	Multiturn counter preset
	0x18	U8	R/W	Multiturn error arc length
	0x19 - 0x1A	U16	R/W	Partial arc length for self-calibration
	0x1B	U16	R	Ring eccentricity shift from rotation axis centre
	0x1D	U16	R	Ring eccentricity angle (phase)
	0x1F	S16	R	Readhead radial shift (positive value – readhead is mounted towards the center of the axis)
	0x20 – 0x2B	U8	R	Reserved
	0x2C – 0x2D	U16	R	Persistent encoder status (see chapter **Encoder operating parameters**)
	0x2E	U8	R/W	Write protect lock
	0x2F – 0x30	U16	R	FW major version
	0x31 – 0x32	U16	R	FW minor version
	0x33 – 0x34	U16	R	Protocol version
	0x35 – 0x36	U16	R	Revision number
	0x37	U8	R	Checksum of bank 8
	0x38	U8	R	Checksum of bank 9
	0x39	U8	R	Checksum of bank 10
	0x3A	U8	R	Checksum of bank 11
	0x3B	U8	R	Checksum of bank 12
	0x3C	U8	R	Checksum of bank 13
	0x3D	U8	R	Checksum of bank 14
	0x3E	U8	R	Checksum of bank 15
	0x3F	U8	R	Checksum of bank 0
1 - 7	0x00 – 0x3F	U8	R	Reserved
8	0x00 – 0x3F	S8	R	Error Map [0 - 63]
9	0x00 – 0x3F	S8	R	Error Map [64 - 127]
10	0x00 – 0x3F	S8	R	Error Map [128 - 191]
11	0x00 – 0x3F	S8	R	Error Map [192 - 255]
12	0x00 – 0x3F	S8	R	Error Map [256 - 319]
13	0x00 – 0x3F	S8	R	Error Map [320 - 383]
14	0x00 – 0x3F	S8	R	Error Map [384 - 447]
15	0x00 – 0x3F	S8	R	Error Map [448 - 511]
16	0x00 – 0x3F	U8	R	BiSS EDS common part
17	0x00 – 0x3F	U8	R	BiSS EDS standard encoder profile
18 - 23	0x00 – 0x3F	U8	R	Reserved
24 - 87	0x00 – 0x3F	U8	R/W	User memory

Bank	Address	Data Type	Access	Description
Direct access	0x40	U8	R/W	Bank select
	0x41	U8	R	EDS bank
	0x42 – 0x43	U16	R	Profile ID
	0x44 – 0x47	U32	R	Serial number (encoded)
	0x48	U8	R/W	Key register
	0x49	U8	R/W	Command register
	0x4A – 0x4B	U16	R	Encoder status (see chapter **Encoder operating parameters**)
	0x4C – 0x4D	S16	R	Sensor temperature in °C
	0x4E – 0x4F	U16	R	Signal level
	0x50 – 0x51	S16	R	Rotational speed in rpm
	0x52	U8	R	Self-calibration status
	0x5C – 0x61	U8	R	RLS serial number
	0x62 – 0x63	U8	R	Reserved
	0x64 – 0x73	U8	R	RLS part number
	0x74 – 0x77	U8	R	Reserved
	0x78 – 0x7D	U48	R	Device ID
	0x7E – 0x7F	U16	R	Manufacturer ID

U16, U32, U48 data is stored in Big Endian format (highest-value byte at the lowest-value address).

BiSS EDS common part

Address	Symbol	Description	Data type	Unit	Value
0x00	EDS_VER	EDS version	U8	-	1
0x01	EDS_LEN	EDS length	U8	banks	2
0x02	USR_STA	Bank address USER start	U8	-	24
0x03	USR_END	Bank address USER end	U8	-	87
0x04	TMA	Min. permitted clock period	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	60
0x10	DC_NUM	Number of data channel 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	-	17
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

U16 data is saved as a Big Endian (highest-value byte at the lowest-value address).

Table A

	Type of encoder							
EDS parameter	17 bit ST	17 bit MT	18 bit ST	18 bit MT	19 bit ST	19 bit MT	20 bit ST	20 bit MT
DLEN1	19	35	20	36	21	37	22	38
TCYC	104	116	104	120	108	120	108	120

ST - Singleturn
MT - Multiturn

BiSS EDS standard encoder profile

Address	Symbol	Description	Data type	Unit	Value
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	FB1	Feedback bit 1 (nError = 1)	U8	-	1
0x05	FB2	Feedback bit 2 (nWarning = 2)	U8	-	2
0x06	PON_PDL	Max. “power on delay” until position data is available	U8	ms	60
0x07		Reserved	U8	-	0
0x08	EN_TYP	Encoder type (rotary = 0)	U8	-	0
0x09	POS_NUM	Position value (1 position)	U8	-	1
0x0A	MT_LEN	Data length MULTITURN	U8	bit	table B
0x0B	MT_FMT	Data format MULTITURN	U8	-	table B
0x0C	CO_LEN	Data length COARSE	U8	bit	0
0x0D	CO_FMT	Data format COARSE	U8	-	0
0x0E	FI_LEN	Data length FINE	U8	bit	table B
0x0F	FI_FMT	Data format FINE	U8	-	0
0x10 – 0x13	MT_CNT	Number of distinguishable revolutions	U32	count	table B
0x14 – 0x17	SIP_CNT	Number of signal periods per revolution	U32	PPR	1
0x18 – 0x1B	SIP_RES	Resolution factor per signal period (LSB of interpolation)	U32	count	table B
0x1C – 0x1F	CPOLY	CRC polynomial (32:1 of 0x43)	U32	-	0x21
0x20 – 0x23	CSTART	CRC start value	U32	-	0
0x24 – 0x25	ABS_ACU	Absolute accuracy	U16	LSB/2	table C
0x26 – 0x27	REL_ACU	Relative accuracy	U16	LSB/2	0
0x28 – 0x29	SPD_ACU	Angular speed depending accuracy	U16	LSB/2	0
0x2A – 0x2B	HYST	Hysteresis	U16	LSB/2	0
0x2C – 0x2D	SPD_MAX	Max. revolution speed	U16	1/min	10000
0x2E – 0x2F	ACC_MAX	Max. revolution acceleration	U16	1/min2	0
0x30 – 0x31	TMP_MIN	Min. operating temperature	U16	K	243 (233)
0x32 – 0x33	TMP_MAX	Max. operating temperature	U16	K	358 (378)
0x34 – 0x35	VLT_MIN	Min. operating voltage	U16	mV	4500
0x36 – 0x37	VLT_MAX	Max. operating voltage	U16	mV	5500
0x38 – 0x39	CUR_MAX	Max. current consumption	U16	mA	150
0x3A – 0x3E		Reserved	U8		0
0x3F	CHKSUM	Checksum (sum of all bytes within this bank)	U8	-	xx

U16, U32 data is stored in Big Endian format (highest-value byte at the lowest-value address).

Table B

	EDS BP3 parameter					
Encoder type	BP_ID	MT_LEN	MT_FMT	FI_LEN	MT_CNT	SIP_RES
17 bit ST	0x6213	0	0	17	0	131072
17 bit MT	0x6223	16	1	17	65536	131072
18 bit ST	0x6214	0	0	18	0	262144
18 bit MT	0x6224	16	1	18	65536	262144
19 bit ST	0x6215	0	0	19	0	524288
19 bit MT	0x6225	16	1	19	65536	524288
20 bit ST	0x6216	0	0	20	0	1048576
20 bit MT	0x6226	16	1	20	65536	1048576

Table C

	Singleturn resolution (bits)			
Encoder size	17	18	19	20
080	34	67	135	270
064	37	73	146	293
053	42	83	167	334
049	41	81	163	X
039	53	107	214	X
029	55	110	X	X

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, including “user memory” can be write protected if write access is locked by the user, except of Bank select register. Sequential write access is only available in User memory banks, elsewhere it will be refused. For detailed description on sequential write access refer to documentation provided by iC-Haus.

Encoder operating parameters

Address	Data Type	Access	Description
0x4A – 0x4B	U16	R	Encoder status (see table below)
0x2C – 0x2D (Bank 0)	U16	R	Persistent encoder status (see table below)
0x4C – 0x4D	S16	R	Sensor temperature in °C
0x4E – 0x4F	U16	R	Signal level
0x50 – 0x51	S16	R	Rotational speed in rpm
0x52	U8	R	Self-calibration status

Encoder status (address 0x4A—0x4B)

Detailed status (part 1)	
b15	Error - Multiturn counter mismatch. Encoder was rotated for more than ±90° during power off. Cycle the power to clear this error.
b14	Error - Signal amplitude too high. The readhead is too close to the ring or an external magnetic field is present.
b13	Warning - Signal amplitude too high. The readhead is too close to the ring or an external magnetic field is present.
b12	Error - Magnetic sensor. Cycle power to the encoder.
b11	Error - Sensor reading error, probably caused by electrical interference, ground loop or RFI.
b10	Error - Encoder not configured properly.
General status	
b9	Error. If bit is set, position is not valid.
b8	Warning. If bit is set, encoder is near operational limits. Position is valid. Resolution and / or accuracy might be lower than specified.

Error and Warning bits can be set at the same time; in this case Error bit has priority.
The colour of the LED on the readhead housing indicates the value of the General status bits:
● Red = Error, ● Orange = Warning, ● Green = Normal operation, ○ No light = no power supply.
The warning or error status is more closely defined by the Detailed status bits.

Detailed status (part 2)	
b7	Warning - Signal amplitude too high. The readhead is too close to the ring or an external magnetic field is present.
b6	Warning - Signal amplitude low. The distance between the readhead and the ring is too large.
b5	Error - Signal lost. The readhead is out of alignment with the ring or the ring is damaged.
b4	Warning - Temperature. The readhead temperature is out of specified range.
b3	Error - Power supply error. The readhead power supply voltage is out of specified range.
b2	Error - System error. Malfunction inside the circuitry or 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	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.
b0	Error - Acceleration error. The position data changed too fast. A stray magnetic field is present or metal particles are present between the readhead and the ring.

Persistent encoder status (address 0x2C - 0x2D in Bank 0)

This is similar to “Detailed status”, but with the additional function that all detailed statuses are accumulated. Any error or warning displayed in Detailed Status during operation of encoder is copied into Persistent detailed status. Even if the value in the “Detailed status” only has a very short duration, the past statuses can be read from this Persistent register. The value is retained for as long as the power is present. Clearing is possible either by a power cycle or by sending Key and Command sequence (write 0xCD into register 0x48 and 0x62 into register 0x49).

Sensor temperature (address 0x4C—0x4D)

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 0x4E—0x4F)

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:

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

Calculated ride height has tolerance of ±20 µm.

K and N are selected depending on the encoder size.

Encoder size	K	N
022, 029	–95.49	977
039, 049	–83.56	865
053, 064, 080	–71.62	748

Rotational speed (address 0x50—0x51)

Encoder rotational speed in rpm.

Self-calibration status (address 0x52)

See chapter **Self-calibration** on page 10.

AksIM-2 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 do not take effect until saved to non-volatile memory. Exception is Multiturn counter value which is effective immediately.

Position offset (encoder zero position)

Position offset is mapped to the registers 0x00, 0x01, 0x02, 0x03 of bank 0 in a Big Endian format. User must first write separate bytes of a new position offset in counts to these addresses. Afterwards, they can be read to verify the proper write operation. At this moment, new position offset is not active yet. To validate it, user must first unlock the command register by writing the KEY. Next register access must be a write of the Command for saving programmed data to a non-volatile memory.

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 80 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.

If the applied position offset is larger than the actual encoder resolution or smaller than zero, value 0 is set as a new offset.

The position offset will not change. 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).

Multiturn counter

Multiturn counter preset is available only in multiturn AksIM. It is mapped to the registers 0x14, 0x15, 0x16, 0x17 of bank 0 in a Big Endian format. User must first write separate bytes of a new multiturn counter to these addresses. Afterwards, they can be read to verify the proper write operation. At this moment, new multiturn counter is not active yet. To validate it, user must first unlock the command register by writing the KEY. Next register access must be a write of the Command to validate the multiturn counter value.

KEY: value 0xCD to address 0x48
Command for validation of multiturn counter: ASCII ‘m’ (0x6D) to address 0x49

Programming of multiturn counter larger than 65535 (unsigned) is discarded.

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 0x52. It consists of a two bit counter and two status bits. Counter is incremented at the end of each self-calibration. Error bits indicate success or reasons for failure.

Prior to the self-calibration process, the status should be read from register 0x52. 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 the programmed time for completion (default 10 seconds). 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. If the self-calibration was successful, both status bits (b3, b2) are zero. Additional data from the self-calibration is available with firmware 2.5 and later. This 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 second of sending the command. If default settings of 10 seconds is not enough, this can be extended up to 40 seconds using register 0x21 (available on encoders with firmware 2.9 and later). If the mechanics do not allow 360° rotation, the length of the calibration arc can be reduced to at least 180°. 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				
0x19	U16	180 – 360, default 360	degrees	Partial arc length for calibration
0x21	U8	1 – 40, default 10	seconds	Self-calibration max duration (timeout)
0x48	U8	0xCD	-	Key
0x49	U8	0x41	-	Command
OUTPUT				
0x1B	U16	0 – 500	µm	Ring eccentricity shift from rotation axis centre
0x1D	U16	0 – 360	degrees	Ring eccentricity angle (phase)
0x1F	S16	-500 – 500	µm	Readhead radial shift (positive value - readhead is mounted towards the center of the axis)
0x52	U8		bit	Status - see table below

Self-calibration status register at address 0x52:

Bit	Meaning
b7	Reserved
b6	Calibration was successfully performed, error map is in use.
b5	No correction needed (mechanical installation is perfect).
b4	Arc length parameter (0x19) out of range.
b3	Calculated parameters out of range. Mechanical installation is not inside tolerances.
b2	Timeout. Encoder ring did not make a complete turn during 10 seconds.
b1 : b0	Counter

KEY: value 0xCD to address 0x48
Command for starting self-calibration procedure: ASCII ‘A’ (0x41) to address 0x49.
Once the self-calibration has been successfully completed, the results are automatically saved into the non-volatile memory. All numerical calibration results are stored in the volatile memory and cleared on the power cycle. To verify if encoder has already been calibrated, read the Self-calibration status byte and verify that bit b6 (0x40) is set.

Dynamic filtering

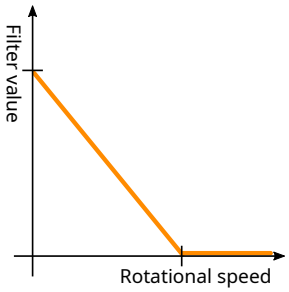
The AksIM-2 encoder uses dynamic low-pass filters to reduce noise in the calculated position value.
The default values are suitable for most applications. However, in some extreme cases, fine tuning is required to achieve optimum performance. For example, in precise applications with low speed and acceleration, 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

Address	Name	Default	Range	Description
0x04 – 0x07	Position filter value	180	0 – 240	Maximum value of Position Filter when encoder is standstill. 0 = filter disabled
0x08 – 0x0B	Position filter speed	100	0 – 99; 100 – 10,000	Encoder speed when Position Filter is turned off. Below 100: filter is constant
0x0C – 0x0F	Velocity filter value	150	0 – 240	Value of Velocity Filter. 0 = filter disabled
0x10 – 0x13	Velocity filter speed	0	0	Not in use.

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 80 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 defaults

Reset to factory defaults will set all programmed parameters to the default values. 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 defaults.

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

Saving parameters to non-volatile memory takes 80ms. 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 defaults.

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 0x2E of bank 0. 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 80 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.

User memory

User memory space comprised of 4 kB of RW registers is mapped between banks 24 and 87. User must first write desired data to these registers. Afterwards, the data has to be stored in a non-volatile memory. To do that, user must first unlock the command register by writing the KEY. Next register access must be a write of the Command to save user data to a non-volatile memory.
User memory banks also supports sequential write access. It is possible to write several consecutive registers in one access.
For detailed description on sequential write access refer to documentation provided by iC-Haus.

KEY: value 0xCD to address 0x48
Command for saving user data to a non-volatile memory: ASCII ‘u’ (0x75) to address 0x49

User memory is no longer writable if write access is locked by the user.

Additional BiSS-C register access documentation can be found on BiSS website.

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Document issues

Issue	Date	Page	Description
5	17. 4. 2024	2	Registers description amended
		7	Encoder operating parameters chapter amended
		10	Self-calibration chapter amended
6	17. 10. 2024	10	Readhead radial shift amended
7	27. 1. 2025	2	Readhead radial shift amended