BAHRS serial protocol
Version 1.0

Table of contents

1 General information

1.1 About format

The protocol is used by the Baro-Inertial Attitude and Heading Reference System to communicate on RS232 interface.

1.2 License and copyright

1.3 List of modifications

Date	Author	Change summary
08.04.2022	Fedor Baklanov	Initial version of the document
05.06.2022	Fedor Baklanov	Fletchers's checksum replaced by 32-bit CRC-32/MPEG-2
07.06.2022	Fedor Baklanov	Add padding to frames.
15.06.2022	Fedor Baklanov	Added 2 debug messages
21.06.2022	Fedor Baklanov	Fix byte positions in the message 0x01, 0x02, 0x03. Fixed an inconsistency in the explanation of CRC computation. Added 1 field to the accuracy data message. Changed angle scale factor in the messages 0x02 and 0x03.
16.05.2023	Fedor Baklanov	Document service messages 0xF0 to 0xF3, 0xFF
24.07.2023	Fedor Baklanov	Modified the message "BAHRS accuracy information (0x03)": attitude standard deviation D replaced by magnetic heading standard deviation. Modified the message "BAHRS navigation output data (0x02)": magnetic heading range 0 to 2 pi, type uint16_t. Rolled integer version ID.
09.09.2023	Fedor Baklanov	Cosmetic changes

2 Protocol description

2.1 Byte order (endianness)

Least significant byte first, i. e. little-endian.

2.2 Frame format

Byte position	Data type	Description
1	uint8	Message marker 1, value 0x4E (ASCII 'N')

2	uint8	Message marker 2, value 0x45 (ASCII 'E')
3	uint16	Protocol version
4	uint8	Message type
5 to (4 + LEN)	uint8[LEN]	Payload
(5 + LEN) to (4 + LEN + PAD_LEN)	uint8[PAD_LEN]	Padding to multiple of 32-bit words, PAD_LEN = 4 – (5 + LEN) % 4
(5 + LEN + PAD_LEN) to (8 + LEN + PAD_LEN)	uint32	32-bit CRC, polynomial 0x04C11DB7, initial value 0xFFFFFFFF, input reflection = false, output reflection = false, output XOR = 0x00000000, check = 0x0376E6E7 (CRC of the char array “123456789”), name = “CRC-32/MPEG-2”

2.3 CRC/checksum computation

Bytes 1 to (4 + LEN + PAD_LEN) shall be used in cyclic redundancy check.

3 Description of messages

3.1 BAHRS inertial data output (0x01)

Byte position	Data type	Description
1	uint8	Sequence counter
2 to 3	int16	Specific force body X component
4 to 5	int16	Specific force body Y component
6 to 7	int16	Specific force body Z component
8 to 9	int16	Angular rate body X component
10 to 11	int16	Angular rate body Y component
12 to 13	int16	Angular rate body Z component
14	uint8	Validity flags (0 - invalid, 1 - valid): Bit 0: specific force X Bit 1: specific force Y Bit 2: specific force Z Bit 3: angular rate X Bit 4: angular rate Y Bit 5: angular rate Z Bits 6 to 7: reserved

Specific force in [m/s^2] = 1.495384e-3 * (integer value).

Angular rate in [rad/s] = 1.597921e-4 * (integer value).

3.2 BAHRS navigation output data (0x02)

Byte position	Data type	Description
1	uint8	Sequence counter
2 to 3	int16	Pressure height
4 to 5	int16	Velocity downwards
6 to 7	int16	Roll angle
8 to 9	int16	Pitch angle
10 to 11	uint16	Magnetic heading
12	uint8	Validity flags (0 - invalid, 1 - valid):

	Bit 0: pressure height Bit 1: velocity downwards Bit 2: roll angle Bit 3: pitch angle Bit 4: magnetic heading Bits 5 to 7: reserved

Hejght in meters = (0.16784924 * (integer value) – 1000).

Velocity in meters per second = 9.155413e-3 * (integer value).

Angle in radians = 9.587526e-5 * (integer value).

3.3 BAHRS accuracy information (0x03)

Byte position	Data type	Description
1	uint8	Sequence counter
2 to 3	uint16	Attitude standard deviation N, 0x0000 - invalid
4 to 5	uint16	Attitude standard deviation E, 0x0000 - invalid
6 to 7	uint16	Magnetic heading standard deviation, 0x0000 - invalid
8 to 15	uint64	Microcontroller time, [us]

Angle in radians = 9.587526e-5 * (integer value).

3.4 Time of navigation data (0x04)

Byte position	Data type	Description
1	uint8	Sequence counter
2	uint8	Sequence counter of the navigation data message
3 to 10	uint64	Microcontroller time, [us], that corresponds to navigation data package with the given sequence number

When the second and the third fields contain zeros simultaneously, the data is invalid.

3.5 Time of inertial data (0x05)

Byte position	Data type	Description
1	uint8	Sequence counter
2	uint8	Sequence counter of the inertial data message
3 to 10	uint64	Microcontroller time, [us], that corresponds to inertial data package with the given sequence number

When the second and the third fields contain zeros simultaneously, the data is invalid.

3.6 Time of the latest synchronization pulse (0x06)

Byte position	Data type	Description
1	uint8	Sequence counter
2 to 9	uint64	Microcontroller time, [us]

4 Description of debug messages

4.1 Reserved (0xC0)

4.2 Reserved (0xC1)

5 Service messages

5.1 Request to enter diagnostics mode (0xF0)

The payload is empty.

5.2 Request to exit diagnostics mode (0xF1)

The payload is empty.

5.3 Request to read NVM page (0xF2)

Byte position	Data type	Description
1	uint8	The number of the NVM page to read, from 0 to 249

Remark: as of 16.05.2023 this message type is not padded!

5.4 NVM page data (0xF3)

Byte position	Data type	Description
1	uint8	Page number, from 0 to 249
2	uint8[32]	Page data

Remark: as of 16.05.2023 this message type is not padded!

5.5 Acknowledgement of diagnostics message reception (0xFF)

Byte position	Data type	Description
1	uint8	Message type to acknowledge
2	uint8	Status: 0 – OK, error codes otherwise

Remark: as of 16.05.2023 this message type is not padded!

6 Protocol versions

Document version	16-bit integer protocol version identifier
Version 0.1, 0.2, 0.3, 0.4	0x0001
Version 0.5, 1.0	0x0002