



BOSCH

Invented for life



CISS - Connected Industrial Sensor Solution

USB Communication Protocol

Table of contents

1. USB SERIAL COMMUNICATION	3
1.1 COMMUNICATION DEVICE CLASS	3
2. NPI PROTOCOL	3
2.1 COMMUNICATION FRAME	3
3. NODE PROTOCOL	3
3.1 SENSOR CONFIGURATION	3
4. SENSORS	4
4.1 ACCELERATION SENSOR	4
4.2 MAGNETOMETER	5
4.3 GYROSCOPE	6
4.4 ENVIRONMENTAL	7
4.5 LIGHT	8
4.6 MICROPHONE - NO SUPPORT FOR USB STREAMING	9
4.7 OTHER COMMANDS	9
4.8 SENSOR DATA STREAMING	10
4.9 ACKNOWLEDGEMENT FRAMES	11
4.9.1 OK Acknowledgment	11
4.9.2 NOK Acknowledgment	12
4.9.3 OK and NOK Acknowledgment in same packet	13
4.10 SPECIAL OPERATION MODES	14
4.10.1 Time Aggregation Mode	14
4.10.1.1 Time Aggregation Mode	14
4.10.1.2 Time Aggregation Mode Data Streaming	15
4.10.2 Event Detection Mode	16
4.10.2.1 Event Detection Mode commands	16
4.10.2.2 Event Detection Mode Data Streaming	16
4.10.2.2.1 Event Detection Mode Data Representation	16
4.10.2.2.1 Sample event detection streaming frame	16
4.10.3 Accelerometer Sensor Streaming at 2 KHz Mode	17
4.10.3.1 2KHz Streaming commands	17
4.10.3.1.1 Starting the 2KHz Streaming	17
4.10.3.1.2 Stopping the 2KHz Streaming	17
4.10.3.2 2KHz Streaming answer payloads construction	17
4.10.3.2.1 2KHz Streaming acknowledgment	17
4.10.3.2.2 2KHz Data payload construction	18

1. USB Serial Communication

1.1 Communication Device Class

The USB interface is based on the USB CDC Definition. On Windows and Linux, you can use generic drivers to have a Virtual Com Port for the interaction with your own Application.
The Data layer is deviated from the Network Processor Interface protocol.

2. NPI Protocol

2.1 Communication Frame

SOF	LENGTH	PAYLOAD*	CRC
1 Byte	1 Byte	0-255 Byte	1 Byte
Start of frame	Length	Data Bytes	Checksum

The CRC checksum will be calculated for the length and the data bytes of the payload. The below described node protocol will be the PDU of the NPI protocol.

The Payload can contain one or more Command blocks. The Ack/Nack will be sent for one Frame, not for each Command.

3. Node Protocol

3.1 Sensor Configuration

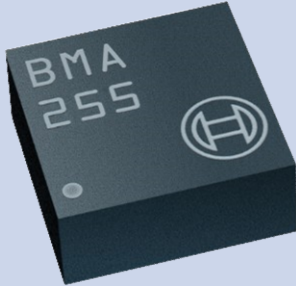
To configure the CISS node following commands are available. Commands will be in the range from 0x80 to 0xFD.



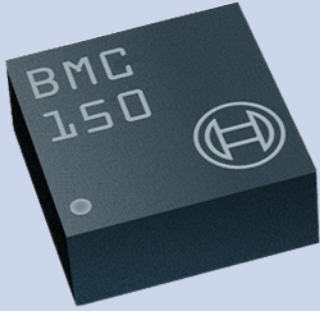
Whenever a sensor gets reconfiguration, sampling will be stopped until the configuration is effective. After the configuration the sensor will automatically restart to send data with the configured sampling rate.

4. Sensors

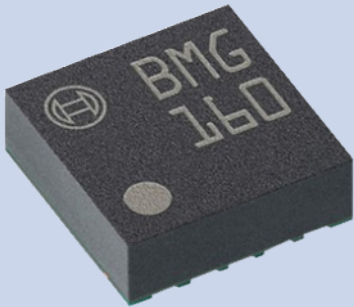
4.1 Acceleration sensor

	Sensor	Command	Data	Description	Example	Remarks
	0x80	0x00	-	Disable acceleration sensor. Power off the sensor	0x8000	Disables sensor by putting it to suspend mode.
		0x01	-	Enable acceleration sensor. In this case enable means power (VCC) on.	0x8001	Enables sensor by putting it to normal mode.
		0x02	4 Bytes - Sampling Rate	Set sampling rate for the acceleration sensor. Range: 1,67 mHz to 2 kHz (maximum sampling period is 10 minutes and minimum sampling periods support up to 10 mSec. 2KHz is separate mode	0x8002yyyyyyyy	The new sampling time should be provided in mS. The data part must be in LSB first order. e.g.: 0x 8002 A08601 for 100mS sampling. This sampling time is common for Accelerometer, Gyro and magnetometer.
				Disable sampling. A value of 0 Hz for the sampling rate will disable sampling of the sensor. This means it will disable the transmission of data.	0x800200000000	
		0x03	2 Bytes - Threshold	Threshold for the special operation mode "event detection"	0x8003yyyy	Threshold for acceleration sensor
		0x04	1 Byte - Range	Set resolution +- 2g, +-4g, +-8g, +-16g default: +- 16g	0x8004yy	Resolution range for acceleration sensor


4.2 Magnetometer

	Sensor	Command	Data	Description	Example	Remarks
	0x81	0x00	-	Disable magnetometer sensor	0x8100	Disables sensor by putting it to suspend mode.
		0x01	-	Enable magnetometer sensor	0x8101	Disables sensor by putting it to active mode.
		0x02	4 Bytes	Set sampling rate	0x8102yyyy	<p>The new sampling time should be provided in mS.</p> <p>The data part must be in lsb first order.</p> <p>e.g.: 0x 8102 A08601 for 100mS sampling</p> <p>This sampling time is common for Accelerometer, Gyro- and magnetometer.</p>
		0x03	2 Bytes - Threshold	Threshold for special operation mode "event detection"	0x8103yyyy	Threshold for magnetometer sensor

4.3 Gyroscope

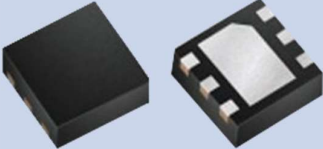
	Sensor	Command	Data	Description	Example	Remarks
	0x82	0x00	-	Disable gyroscope	0x8200	Disables sensor by powering off the sensor
		0x01	-	Enable gyroscope	0x8201	Enables sensor by powering on the sensor and applying the default sensor configurations to it.
		0x02	4 Bytes	Set sampling rate	0x8202yyyy	The new sampling time should be provided in mS. The data part must be in lsb first order. e.g.: 0x 8202 A08601 for 100mS sampling This sampling time is common for Accelerometer, Gyro- and magnetometer.
		0x03	2 Bytes - Threshold	Threshold for special operation mode "event detection"	0x8203yyyy	Threshold for gyroscope sensor

4.4 Environmental


	Sensor	Command	Data	Description	Example	Remarks
	0x83	0x00	-	Disable environmental sensor. This means disabling the complete BME280.	0x8300	Disables the sensor by putting it to sleep mode
		0x01	-	Enable environmental sensor. Power on.	0x8301	Enables the sensor by putting it to normal mode Enables normal USB streaming
		0x03	-	Set to sleep mode	0x8303	Not supported
		0x02	2 Bytes	Set sampling rate for temperature	0x8302yyy	The new sampling time should be provided in mS. The data part must be in LSB first order. e.g.: 0x 8302 0100 for 1000mS or 1S sampling. This sampling time is common for temperature, Pressure, Humidity and light A value of 0x8304 FFFF will be interpreted as infinite. In this case the value of this sensor will not be sampled at all.
		0x05	2 Bytes	Set sampling rate for humidity	0x8305yyyy	As above
		0x06	2 Bytes	Set sampling rate for pressure	0x8306yyyy	As above
		0x07	1 Byte (int8_t) - Threshold (temperature)	Threshold for special operation mode "event detection"	0x8307yy	Threshold for temperature sensor in degree C

	Sensor	Command	Data	Description	Example	Remarks
		0x08	1 Byte (uint8_t) - Threshold (humidity)	Threshold for special operation mode "event detection"	0x8308yy	Threshold for humidity sensor in %Rh
		0x09	3 Bytes - Threshold (pressure)	Threshold for special operation mode "event detection"	0x8309yyyyyy	Threshold for pressure sensor in Pascal

4.5 Light

	Sensor	Command	Data	Description	Example	Remarks
	0x84	0x00	-	Disable light sensor	0x8400	stops transmission of light values
		0x01	-	Enable light sensor	0x8401	starts transmission of light values
			0x02	Set operation mode to continuous mode	0x840202	Currently not supported
		0x02	2 Bytes			The new sampling time should be provided in mS. The data part must be in lsb first order. e.g.: 0x 8402 0100 for 1000mS or 1S sampling. This sampling time is common for temperature, Pressure, Humidity and light
		0x03	3 Bytes - Threshold	Threshold for special operation mode "event detection"		Threshold for light sensor in lux
		0x04	0x01	Set operation mode to default mode	0x840201	Enabling the light in default mode. The sampling of light is done only once every 800 msec
			0x02	Set operation mode to continuous mode	0x840202	Enabling the light in continuous mode. The samples are taken every 6.25 msec

4.6 Microphone - No support for USB streaming

	Sensor	Command	Data	Description	Example
	0x85	0x00	-	Disable microphone	Disable the MIC sensor by switching VDD pin off
		0x01	-	Enable microphone	Enable the MIC sensor Streaming is not started by sending this command since it is not supported over USB
		0x03	2 Bytes - Threshold	Threshold for special operation mode "event detection"	Threshold for noise sensor in var (statistical variance).

4.7 Other Commands

Name	Command	Data	Description	Example	Comment
BLE Module*	0x90	0x00	Disable BLE Chip	0x9000	Disable the BLE chip by putting it into sleep mode
		0x01	Enable BLE Chip	0x9001	Enable the BLE chip by putting it into active mode
Time Stamp	0x91	4 Bytes	Set the UNIX time stamp	0x91xxxxxxxxxxxxxx	Setting Unix time stamp in seconds

*Note: There should be a minimum delay of 1 sec between two consecutive Enable BLE/Disable BLE commands

Type	Data	Description	Unit	Value when sensor read failed	Example
0x02	6 Bytes	<div>Acceleration</div> <div> <div>16 Bit</div> <div>16 Bit</div> <div>16 Bit</div> </div> <div> <div>ax</div> <div>ay</div> <div>az</div> </div>	x mg	16384, 16384, 16384	-183, 85, 1013
0x03	6 Bytes	<div>Magnetometer</div> <div> <div>16 Bit</div> <div>16 Bit</div> <div>16 Bit</div> </div> <div> <div>mx</div> <div>my</div> <div>mz</div> </div>	x μ T	8191, 8191, 8191	2, -12, 0
0x04	6 Bytes	<div>Gyro</div> <div> <div>16 Bit</div> <div>16 Bit</div> <div>16 Bit</div> </div> <div> <div>gx</div> <div>gy</div> <div>gz</div> </div>	x °/s	2047, 2047, 2047	-22, 28, 238
0x05	2 Bytes	<div>Temperature</div> <div> <div>16 Bit</div> <div>t</div> </div>	x.x °C	1000	283 / 10 = 28.3°C
0x06	4 bytes	<div>Pressure</div> <div> <div>32 Bit</div> <div>p</div> </div>	x hPas	120000	97073 Pa / 100 = 971.63 hPa
0x07	1bytes	<div>Humidity</div> <div> <div>16 Bit</div> <div>h</div> </div>	x %rH	15000	4501 / 100 = 45.01%
0x08	4Bytes	<div>Light</div> <div> <div>32 Bit</div> <div>lx</div> </div>	x lx	3000000	400 lux
0x09	2 bytes	<div>Noise</div> <div> <div>16 Bit</div> <div>n</div> </div>	x Var (statistical variance) Reserved 1	Reserved 1	Reserved 1

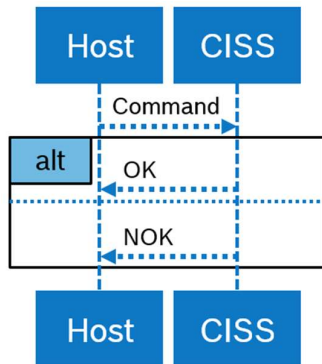
4.8 Sensor Data Streaming

Because of the special frame for OK, data types will have an ID between 0x02 and 0x7F.

Reserved 1 for future use since noise values are not streamed over USB.

4.9 Acknowledgement Frames

A command send by the host to the node must always be acknowledged.



SOF	Length	Data		CRC
0xFE	Length	0x01	optional more data	CRC

4.9.1 OK Acknowledgment

Depending on the command the returned data of the success case may contain additional data. If a sensor configuration command is successful, the same command (2 bytes including the sensor type) are sent back as optional data.

Examples as given below. Packet sent is 0x FE 02 84 00 86.

SOF	Length	Data			CRC
0xFE	Length	0x01	Sensors (1 byte)	Command (1 byte)	CRC
0xFE	0x03	0x01	0x84	0x00	0x86

If multiple commands are sent together, a single ACK will be triggered with the data part containing the response for each command. Example given below. Packet sent is 0 x FE 04 80 00 84 01 01.

SOF	Length	Data						CRC
0xFE	Length	0x01	sensor (1 byte)	Command (1 byte)	0x01	Sensor (1 byte)	command (1 byte)	CRC
0xFE	0x06	0x01	0x80	0x00	0x01	0x84	0x01	0x03

4.9.2 NOK Acknowledgment

SOF	Length	Data		CRC
0xFE	Length	0xFF	optional more data	CRC

If the command/ sensor type used was invalid, the optional data part of the NOK will contain info on the invalid command. The invalid part of the sent command will be replaced by 0x7F. Examples as given below. Packet sent is 0xFE 02 84 0F 89.

SOF	Length	Data			CRC
0xFE	Length	0xFF	Sensor (1 Byte)	Command (1 Byte)	CRC
0xFE	0x03	0xFF	0x84	0x7F	07

The below example is the response for the packet FE 02 8F 00 8D where the sensor type is not valid.

SOF	Length	Data		CRC
0xFE	Length	0xFF	Sensor (1 Byte)	CRC
0xFE	0x02	0xFF	0x7F	82

If the configured sampling rate was invalid, the command part of the sent packet is replaced by 0x8F (Config. not supported). Example as given below. Packet sent is FE 06 82 02 0A 00 00 00 8C.

SOF	Length	Data			CRC
0xFE	Length	0xFF	Sensor (1 Byte)	Command (1 Byte)	CRC
0xFE	0x03	0xFF	0x82	0x8F	0xF1

If the configured Accel range was invalid, the command part of sent packet is replaced by 0x8F (Config not supported). Example as given below. Packet sent is FE 03 80 04 22 A5

SOF	Length	Data		CRC
0xFE	Length	Sensor (1 Byte)	Command (1 Byte)	CRC
0xFE	0x03	0xFF	0x8F	0xF3

If the command is given while any special operation is in progress except disabling particular special operation, the command part of the sent packet is replaced by 0x9F (**Command Not Executed**). Example consider a scenario user given a command FE 02 FD 01 FE (which enables statistical distribution) while event detection is in progress

SOF	Length	Data			CRC
0xFE	Length	0xFF	Sensor / Special-Operation (1 Byte)	Command (1 Byte)	CRC
0xFE	0x03	0xFF	0xFD	0x9F	0x9E

4.9.3 OK and NOK Acknowledgment in same packet

If multiple commands are part of the same packet, and one of the command is invalid, the commands following the invalid one in the same packet will not be processed. OK/NOK is sent until an invalid command is found in the packet. Example as given below, where the second command in the packet is invalid. Packet sent is 0x FE 04 84 01 84 04 01.

SOF	Length	Data						CRC
0xFE	Length		Sensor (1 byte)	Command (1 byte)		Sensor (1 byte)	Command (1 byte)	CRC
0xFE	0x06	0x01	0x84	0x01	0xFF	0x84	0x7F	0x86

The below example is the response of 0x FE 04 84 04 84 01 01, where the first command in the packet is wrong and the second is correct. The second command will not be processed at the node.

SOF	Length	Data			CRC
0xFE	Length	0xFF	Sensor (1 Byte)	Command (1 Byte)	CRC
0xFE	0x03	0xFF	0x84	0x7F	07

Note: The exception to this is when the 2K streaming mode is disabled by sending the Accel disable command. Here the node will immediately go to reset and will not send the acknowledgment.

4.10 Special Operation Modes

4.10.1 Time Aggregation Mode

Note: In the Time Aggregation Mode, the CISS does not support Magnetometer, Humidity, Pressure, illumination, noise sensors.

4.10.1.1 Time Aggregation Mode

Mode	Command	Data	Description	Functionality	Example
Time Frame	0xfd	0x00	Disable operation mode	<p>In this operation mode the data will be transmitted via USB only. <u>BLE is switched off</u> (powered down using the VDD pin). If this operation mode gets enabled only the following sensors are active:</p> <ul style="list-style-type: none">• Acceleration sensor• Gyroscope• Environmental sensor <p><u>all other sensors are switched off</u> (powered down using the VDD pin). The node will sample data from the acceleration sensor and the gyroscope with a sampling rate of 100 Hz (10ms) for a fixed duration of 2 seconds. In parallel the node will sample the temperature from the environmental sensor with a sampling rate of 1 Hz (1s) for a fixed duration of 10 seconds.</p> <p>Acceleration sensor and Gyroscope After each time frame (every 2 seconds) the nodes transmits the maximum, minimum, mean value and the standard deviation for each axis of the acceleration sensor and the gyroscope.</p> <p>Environmental sensor After each time frame (every 10 seconds) the node will transmit the maximum, minimum, mean value and the standard deviation for the temperature. Please find additional information related to the data types used for the transmission here.</p>	0xfd00
		0x01	Enable operation mode		0xfd01

4.10.1.2 Time Aggregation Mode Data Streaming

Type	Data	Description	Unit	Example
0x7E	64 Bytes	Acceleration and gyroscope values	Acceleration: x mg Gyroscope: x °/s	
		ax_minax_maxax_meanax_std		
		ax_minax_maxax_meanax_std		
		ax_minax_maxax_meanax_std		
		a_minamax_meana_std		
		gx_mingx_maxgx_meangx_std		
		gy_mingy_maxgy_meangy_std		
		gz_mingz_maxgz_meangz_std		
		g_ming_maxg_meang_std		
		Magnetometer	uT	Not supported in this mode
0x7D	8 Bytes	Temperature	x.x °C	
		t_mint_maxt_meant_std		
0x7C	4 Bytes	Humidity	x% rH	Not supported in this mode
		h_minh_maxh_meanh_std		
0x7B	16 Bytes	Illumination	x lux	Not supported in this mode
		t_mint_maxt_meant_std		
		Pressure	hpa	Not supported in this mode
		Noise	var	Not supported in this mode

4.10.2 Event Detection Mode

4.10.2.1 Event Detection Mode commands

Mode	Command	Data	Description	Functionality	Example
Event detection	0xfc	0x00	Disable operation mode	Switch from "normal" operation to event detection. In this mode, the measured values will be compared against a configured threshold. A threshold violation will be indicated as an over- or an undershoot of the respective threshold. In this mode the node will transmit only a bit coded value representing the threshold violation. The configuration of the sensor (sampling rate, selecting sensors,) has to be done separately before switching to this mode.	0xfc00
		0x01	Enable operation mode		0xfc01

Note: The sensor selection is based on the threshold configuration.

If the user wants to update the sensor selection again for event detection, they need to stop event detection. This will disable all sensors. The user has then to configure thresholds to the respective sensors. The thresholds for previously selected sensors are retained but the sensors themselves are disabled.

4.10.2.2 Event Detection Mode Data Streaming

4.10.2.2.1 Event Detection Mode Data Representation

Type	Lenght	Bit coded valued description																	
0x7A	2 bytes	Bit coded value																	
		Name		Acceleration		Gyroscope		Magnetometer		Temperature		Humidity		Pressure		Light		Noise	
		Bit	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
		Descript.	00b: Unchanged 01b: Overshoot 11b: Undershoot		00b: Unchanged 01b: Overshoot 11b: Undershoot		00b: Unchanged 01b: Overshoot 11b: Undershoot		00b: Unchanged 01b: Overshoot 11b: Undershoot		00b: Unchanged 01b: Overshoot 11b: Undershoot		00b: Unchanged 01b: Overshoot 11b: Undershoot		00b: Unchanged 01b: Overshoot 11b: Undershoot		00b: Unchanged 01b: Overshoot 11b: Undershoot		

4.10.2.2.1 Sample event detection streaming frame

An acceleration sensor overshoot is encoded in the following way:

SOF (1 byte)	Length (1 byte)	Type (1 byte)	Bit coded data (2 bytes)		CRC (1 byte)
0xFE	0x03	0x7A	0x01	0x00	0x78

4.10.3 Accelerometer Sensor Streaming at 2 KHz Mode

4.10.3.1 2 KHz Streaming commands

4.10.3.1.1 Starting the 2 KHz Streaming

The command to start accel 2 KHz Streaming is: 0xFE 0x06 0x80 0x02 0xF4 0x01 0x00 0x00 0x71

This command can be interpreted as illustrated in the following table:

SOF (1 byte)	Length (1 byte)	Sensor Type (1 byte)	Command to set Frequency (1 byte)	Frequency (In microseconds, Little Endian, 4 bytes)	CRC (1 byte)
0xFE	0x06	0x80	0x02	0xF4 0x01 0x00 0x00	0x71

Note: 0xF4 0x01 0x00 0x00 is given to set frequency at 500 microseconds.

4.10.3.1.2 Stopping the 2KHz Streaming

In order to stop 2khz accel sensor streaming we need to send the disable accel sensor command.

The command is 0xFE,0x02,0x80,0x00,0x82. The frame is explained in the following table:

SOF (1 byte)	Length (1 byte)	Sensor Type (1 byte)	Command to disable Accel (1 byte)	CRC
0xFE	0x02	0x80	0x00	0x82

Note: When the CISS receives the disable accel sensor command, it will check if USB 2Khz streaming of accel sensor is in progress. If yes, the node will do a NVIC reset, else if accel 2Khz streaming is not in progress it will just disable the accel sensor.

4.10.3.2 2KHz Streaming answer payloads construction

4.10.3.2.1 2KHz Streaming acknowledgment

Immediately after issuing the 2KHz enable command, an acknowledgment frame is received.

Specifically to the 2Khz accel Streaming, the positive acknowledgement is in the format represented hereafter:

	SOF (1 byte)	Length (1 byte)	Ack (1 byte)	Data	CRC
Positive Acknowledgement	0xFE	0x03	0x01	0x80 0x02	0x80

Note: The data part of the acknowledgement frame contains info on sensor type (0x80) and about the type of command sent (0x02).

4.10.3.2.2 2KHz Data payload construction

If positive Acknowledgement is received then the packets start to be streamed. The packets are in the following format:

SOF	Length	Sampled Accel Data 1	Sampled Accel Data 2	Sampled Accel Data 3	Sampled Accel Data N	CRC
0xFE	X bytes					CRC

All the N Sampled Accel data will have the format illustrated hereafter:

Sensor	Sampled Accel Data N					
Type	ax		ay		az	
0x02	Byte 1	Byte 0	Byte 1	Byte 0	Byte 1	Byte 0

The number of sampled accel Data in each packet = $N = (\text{Length in Bytes}) / (\text{Size of a Sampled Accel Data in Bytes}) = (X \text{ bytes}) / 7 \text{ Bytes}$

In DataStreamer v02.03.00:

Length = 0x70 = 112 bytes (in decimal)

Hence $N = 112 / 7 = 16$

Therefore, each packet contains 16.

For further assistance, please refer to <http://www.bosch-connectivity.com/CISS> or e-mail to: support@bosch-connectivity.com

Bosch Connected Devices and Solutions GmbH

Ludwig-Erhard-Straße 2
72760 Reutlingen
Germany

Postfach 13 42
72703 Reutlingen
Germany

support@bosch-connectivity.com

www.bosch-connectivity.com