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CISS - Connected Industrial Sensor Solution

BLE Communication Protocol

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1 Change-log

1. Updated the profile description section
2. Added the details of self test result characteristics 0x7506
3. Modified the security implementation section with "Just works" pairing with bonding
4. Updated the default threshold values for event detection.
5. Removed the AES128 payload encryption for custom characteristics except for FOTA.
6. Extending the Documentation of the Device name change characteristics 0x750b
7. Removed the USB disconnect notify bit from the FOTA characteristics 0x7603
8. Adding the support information for Device information service
9. Adding Battery low Notification and Battery service Documentation
10. Adding the missing documentation describing the bit values and indication information for all the characteristics
11. Default interface selection of event detection in Event detection configuration characteristics 0x7701 has changed to NONE from BOTH.
12. Adding the values that will be streamed when reading the sensor failed
13. Streaming error values for disabled sensors instead of 0's.
14. Changing the unit of Pressure (in 0x7504 payload) from (hPa*100) to Pa
15. Sending Data control characteristics, 0x750A for unsuccessful flash delete operation
16. Error value of light sensor and default threshold of light sensor for Event detection is changed from 200000 to 300000Lux

2 General information & limitations

S. NO	Description
1	Environmental sensors sampling - Minimum supported sampling period is 1 s. Any request for less than 1 s will not be supported and CISS will operate with 1 s sampling.
2	User cannot configure different sampling rates for inertial and environmental sensors since there is only one field to configure the sampling rates. The configuration in "0x750a" characteristics will be applied to both "inertial" and "environmental" sampling rates.
3	When sensors are not selected and the streaming is enabled, the sensor values are still notified but with the error values
4	After the connection, supervision timeout value will be same as that of MASTER within 5 seconds. After that once the MASTER accepts the new parameter update request from CISS the supervision timeout value will be 32 seconds else it will be same as the that of MASTER
5	Change the sampling rate: If the device is streaming data, stop streaming before you change the sample rate. Stop streaming <ol style="list-style-type: none"> 1. Disable read notification of the sensor value characteristic 2. Disable sensor streaming Start streaming <ol style="list-style-type: none"> 1. Check if read notification of the sensor value characteristic is off, if not disable it 2. Check if sensor streaming is off, if not disable it 3. Set streaming on for the dedicated sensors on with a sample rate 4. Enable notification for the sensor values

3 140 Bluetooth Low Energy profile

3.1 Profile description

HANDLE	UUID	DESCRIPTION	VALUE	GATT SERVER PERMISSIONS
1	0x2800	Primary Service	0x1801 (Generic Attribute)	READ
2	0x2803	GATT characteristic declaration	0x2A05	READ
3	0x2A05	GATT service changed		READ
4	0x2902	Client characteristic configuration	0x0000	READ WRITE
5	0x2800	Primary Service	0x1800 (Generic Access)	READ
6	0x2803	GATT characteristic declaration	0x2A00	READ
7	0x2A00	Device Name		READ
8	0x2803	GATT characteristic declaration	0x2A01	READ
9	0x2A01	Appearance	0x0000 ("unknown")	READ
10	0x2803	GATT characteristic declaration	0x2A28	READ
11	0x2A28	Software revision string	"Software revision of alpwis"	READ
12	0x2803	GATT characteristic declaration	0x2A29	READ
13	0x2A29	Manufacturer name string	Ble stack vendor	READ
14	0x2800	Primary Service	0x7500 (I40 service)	READ
15	0x2803	GATT characteristic declaration	0x7502 (Inertial data)	READ
16	0x7502		<i>see payload definition below</i>	READ NOTIFY INDICATE
17	0x2902	Client characteristic configuration		READ WRITE

18	0x2803	GATT characteristic declaration	0x7504 (Environmental data)	READ
19	0x7504		<i>see payload definition below</i>	READ NOTIFY INDICATE
20	0x2902	Client characteristic configuration		READ WRITE
21	0x2803	GATT characteristic declaration	0x7506 (Self test result)	READ
22	0x7506		<i>see payload definition below</i>	READ
23	0x2803	GATT characteristic declaration	0x750A (Data control)	READ
24	0x750A		<i>see payload definition below</i>	READ NOTIFY WRITE
25	0x2902	Client characteristic configuration		READ WRITE
26	0x2803	GATT characteristic declaration	0x750B (Device name change)	READ
27	0x750B		<i>see payload definition below</i>	WRITE
28	0x2800	Primary Service	0x7600 (Fota service)	READ
29	0x2803	GATT characteristic declaration	0x7601 (Fota data)	READ
30	0x7601		<i>see payload definition below</i>	WRITE
31	0x2803	GATT characteristic declaration	0x7602 (Fota request)	READ
32	0x7602		<i>see payload definition below</i>	WRITE
33	0x2803	GATT characteristic declaration	0x7603 (Fota notification)	READ
34	0x7603		<i>see payload definition below</i>	READ NOTIFY
35	0x2902	Client characteristic configuration		READ WRITE
36	0x2800	Primary Service	0x7700 (Event detection service)	READ

37	0x2803	GATT characteristic declaration	0x7701 (Event detection configuration)	READ
38	0x7701		<i>see payload definition below</i>	READ WRITE
39	0x2803	GATT characteristic declaration	0x7702 (Event detection notification)	READ
40	0x7702		<i>see payload definition below</i>	READ NOTIFY
41	0x2902	Client characteristic configuration		READ WRITE
42	0x2800	Primary Service	0x180A (Device information service)	READ
43	0x2803	GATT characteristic declaration	0x2A26	READ
44	0x2A26	Firmware revision string	Embedded app version e.g. V02.00.00	READ
45	0x2803	GATT characteristic declaration	0x2A27	READ
46	0x2A27	Hardware revision string	Ciss hardware version e.g. CISS_R2	READ
47	0x2803	GATT characteristic declaration	0x2A28	READ
48	0x2A28	Software revision string	Version of bootloader e.g. V01.00.00	READ
49	0x2800	Primary Service	0x180F (Battery service)	READ
50	0x2803	GATT characteristic declaration	0x2A19	READ

3.2 Custom Services

3.2.1 I40 service 0x7500 (Payload is not encrypted)

3.2.1.1 Inertial data characteristics 0x7502

Payload format: Inertial data notify/read

BYTE	FIELD	BITMAP	DESCRIPTION	UNIT
0-1	int16_t ax	ax(15...0)	Stores accelerometer x-axis value	mg (for ax, ay, az) 16384,16384,16384
2-3	int16_t ay	ay(15...0)	Stores accelerometer y-axis value	
4-5	int16_t az	az(15..0)	Stores accelerometer z-axis value	
6-7	uint16_t gxMsb12_gyMsb4	gx(11...0) gy(11...8)	Packed with 12-bits of gyroscope x-axis and 4-bits of gyroscope y-axis values	°/s (for gx, gy, gz) 2047,2047,2047
8-9	uint16_t gyLsb8_gzMsb8	gy(7...0) gz(11...4)	Packed with 8-bits of gyroscope y-axis and 8-bits of gyroscope z-axis values	
10-11	uint16_t gzLsb4_mxMsb12	gz(3...0) mx(13...2)	Packed with 4-bits of gyroscope z-axis and 12-bits of magnetometer x-axis values	
12-13	uint16_t mxLsb2_myMsb14	mx(1...0) my(13...0)	Packed with 2-bits of magnetometer x-axis and 14-bits of magnetometer y-axis values	uT (for mx, my, mz) / 8191,8191,8191
14-15	int16_t mz	mz(15...0)	Stores magnetometer z-axis value	
16	uint8_t counter		Stores the packet counter value	

3.2.1.2 Environmental data characteristics 0x7504

Payload format: Environmental data notify/ read

BYTE	FIELD	DESCRIPTION	Values when sensor disabled	Values when sensor read fail	UNIT
0-1	int16_t temp_data	Stores temperature value	1000	1000	°C x 10
2-3	uint16_t humidity_data	Stores humidity value	15000	15000	rH * 100
4-7	uint32_t pressure_data	Stores pressure value	12000000	12000000	Pa

8-9	int16_t mic_data	Stores noise values	-1	Not Applicable	standard deviation
10-13	uint32_t light_data	Stores light value	3000000	3000000	lux
14-15	uint16_t reserved	Dummy bytes to make the AES plain payload rounded to 16 bytes	-		-
16	uint8_t counter	Stores the packet counter value	-		-

3.2.1.3 Data control characteristics 0x750a

Payload format: Data control read/ notify/ write

BYTE	FIELD	DESCRIPTION	UNIT
0	0	1 / 0(default)	en-/disable send data via ble
	1	1 / 0(default)	en-/disable log data at ext. flash
	2	1 / 0(default)	1 - Delete the files present in external flash 0 - Do not delete the files present in the external flash
	3	1 / 0(default)	1 - Set frequency 0 - Ignore setting the frequency
	4	1 / 0(default)	1 - Set BLE transmission power level # 0 - Ignore setting the transmission power level
	5	1 / 0(default)	1 - Set UNIX timestamp for logging 0 - Ignore updating the UNIX timestamp
	6	1 / 0(default)	1 - set to disable the BLE(EM9301) completely 0 - Ignore
	7		reserved
1*	0	1 / 0(default)	en-/disable log acceleration data (BMA280)
	1	1 / 0(default)	en-/disable log gyro data (BMG160)
	2	1 / 0(default)	en-/disable log magnet data (BMC150)
	3	1 / 0(default)	en-/disable log environmental data (BME280,MAX44009 and AKU340)

	4	-	reserved
	5		reserved
	6	-	reserved
	7		reserved
2			frequency byte 0x01 - 10 ms 0x02 - 100 ms 0x03 - 1 s 0x04 - 10 s 0x05 - 30 s 0x06 - 1 min 0x07 - 10 min
3#	0~2		BLE transmission power level value [refer table below
	3	1 / 0 (default)	1 - Indicates user that maximum files to log in external flash is reached 0 - Capable of creating new log files in the external flash
	4	1 / 0 (default)	1 - Indicate user that the external flash memory is full 0 - Indicates the external flash has memory available
	5	1 / 0 (default)	1 - Indicate user that the Node is connected to PC while logging is in progress 0 - Indicate that the Node is not connected to PC
	6	1 / 0 (default)	1 - Indicate the user that file deletion is successful 0 - Indicate the user that file deletion is unsuccessful
	7	1 / 0 (default)	1 - Indicates battery is low 0 - Indicates battery is not low The Battery Low Notification will be sent out from the node between 0 to 10 seconds after the battery becomes low
4~7			UNIX timestamp value

*byte1 will be considered only if the 'log data at ext. flash' feature is enabled. The bit value in byte1 makes sense only if the sensor sampling is activated in certain application

#byte3 will be considered only if the 'set BLE transmission power level' bit is enabled

byte4~7 will be considered only if the 'Set UNIX timestamp for logging' bit (Byte 0, bit 5) is set

BLE transmission power level table:

BYTE 3	BLE Tx POWER LEVEL	POWER LEVEL VALUES (DBM)
0000	Level 0	-18
0001	Level 1	-15

0010	Level 2	-12
0011	Level 3	-9
0100	Level 4	-6
0101	Level 5	-3
0110	Level 6	0 [default level]
0111	Level 7	+3

3.2.1.4 Device name change characteristics 0x750b

Payload format: for write

Maximum 20bytes are used for device name transmission. User can enter the device name to be updated.

- IF NAME IS GIVEN MORE THAT 20 BYTES ONLY THE FIRST 20 BYTES ARE USED AS THE DEVICE NAME.
- The name that is written will be appended with "CISS-". Example: Name written is "I4.0" will be displayed as "CISS-I4.0"
- If the Name is empty and write operation is performed, then the Device name will be "CISS-"

3.2.1.5 Self test result characteristics 0x7506

This Characteristic will have only read access.

If the bit value is 0 – Success; 1 – Failure

BYTE	BIT	VALUE	DESCRIPTION
0	0	0/1	Chip_ID verification of BMA280 sensor
	1	0/1	I2C comm status of BMA280 sensor
	2	0/1	Internal self test result of BMA280 sensor
	3	-	reserved
	4	0/1	Chip_ID verification of BMG160 sensor
	5	0/1	I2C comm status of BMG160 sensor

	6	0/1	Internal self test result of BMG160 sensor
	7	-	reserved
1	0	0/1	Chip_ID verification of BMM050 sensor
	1	0/1	I2C comm status of BMM050 sensor
	2	0/1	Internal self test result of BMM050 sensor
	3	-	reserved
	4	0/1	Chip_ID verification of BME280 sensor
	5	0/1	I2C comm status of BME280 sensor
	6	-	reserved
	7	-	reserved
2	0	0/1	Config Reg verification of MAX44009 sensor
	1	0/1	I2C comm status of MAX44009 sensor
	2	-	reserved
	3	-	reserved

3.2.2 Fota service 0x7600 (Payload is AES-128 encrypted)

3.2.2.1 Fota data characteristics 0x7601 (BLE master to CISS)

BLE master will transmit only 16 bytes of data

NO OF BYTES	DESCRIPTION
(0-14) 15 bytes	DATA
(15th byte) 1 byte	CRC

3.2.2.2 Fota request characteristics 0x7602 (BLE master to CISS)

NO OF BYTES/ BITS	DESCRIPTION
byte 0 (bit 0)	Set bit for fota Init
byte 0 (bit 1)	Reset command (0/1)
byte 0 (bit 2)	Set bit to get the number of bytes written to the hidden file in CISS
byte 0 (bit 3-7)	Reserved
byte 1 - 19	Reserved
byte 0 (bit 0)	FOTA initialization bit sent to CISS node. In CISS embedded side, a firmware file will be created and hidden in external flash.
byte 0 (bit 1)	1 - Reset command from gateway 0 - No reset
byte 0 (bit 2)	In case of interrupt (BLE disconnect) or RESET, send the request command to the sensor node to get the number of bytes written to the hidden file in CISS 1 - Get the number of bytes 0 - Ignore
byte 0 (bit 3-7)	Reserved
byte 1 - 19	Reserved

3.2.2.3 Fota notification characteristics 0x7603 (CISS to BLE master)

Bit value 1 (Set) - Notification received

Bit value 0 (Clear) - No notification

NO OF BYTES/ BITS	DESCRIPTION
byte 0 (bit 0)	Acknowledgement
byte 0 (bit 1)	Reserved
byte 0 (bit 2)	High frequency sampling notification

byte 0 (bit 3)	FOTA update failure notification bit
byte 0 (bit 4-7)	Reserved
byte 1 - 2	Last received packet number
byte 3-6	Number of bytes written to hidden file in CISS
byte 7-19	Reserved
byte 0 - bit 0	Acknowledgement sent from the sensor node. The sensor node receives the packet and calculate the CRC. If CRC is matched it sends the positive acknowledgement. PACK - 1; NACK - 0;
byte 0 - bit 1	Reserved
byte 0 - bit 2	A bit to indicate the gateway that logging/streaming is happening at 10 msec 1 - Indicates user high frequency streaming in progress 0 - Ignore
byte 0 - bit 3	FOTA update failure notification bit. 1 - This bit is set in case of 1) USB connection 2) Battery low 3) Flash full 4) High frequency sampling is in progress 0 - Ignore
byte 0 – bit (4-7)	Reserved
byte 1 - 2	Last received packet number
byte 3 – 6	Number of bytes written to hidden files in CISS
byte 7 - 19	Reserved

3.2.3 Event detection service 0x7700 (Payload is not encrypted)

3.2.3.1 Event detection configuration characteristics 0x7701

Payload format: for read / write 20 byte:

BYTE	BIT	VALUE	DESCRIPTION
0	0	1/0(default)	dis/enable ACC sensor
	1	1/0(default)	dis/enable GYRO sensor

	2	1/0(default)	dis/enable MAG sensor
	3	1/0(default)	dis/enable TEMP sensor
	4	1/0(default)	dis/enable HUM sensor
	5	1/0(default)	dis/enable PRES sensor
	6	1/0(default)	dis/enable LIGHT sensor
	7	1/0(default)	dis/enable AKU sensor
1	0~1	00b-NONE(Default) 01b-BLE 10b-USB 11b-BOTH	Select Mode of Notification Interface (NONE/BLE/USB/BOTH)
	2~7	-	reserved
2	0	1/0(default)	en/disable the Event detection Mode
3~4	-	default 65535mg	Accel Threshold Value
5~6		default (65535)	Gyro Threshold Value
7~8		default 65535uT	Mag Threshold Value
9		default +100°C	Temp Threshold Value This is a signed int8_t so that we can give negative values too
10		default 150%	Humidity Threshold Value
11~13		default (120000)	Pressure Threshold Value
14~16		default 3000000lux	Light Threshold Value
17~18		default (65535)	Noise Threshold value
19			Reserved

3.2.3.2 Event detection notification characteristics 0x7702

Payload format: for read / notify

BYTE	BIT	VALUE	DESCRIPTION
0	0~1	00b(default)-Unchanged 01b-Overshoot 11b-Undershoot	For Accel Sensor Notification
	2~3	00b(default)-Unchanged 01b-Overshoot 11b-Undershoot	For Gyro Sensor Notification
	4~5	00b(default)-Unchanged 01b-Overshoot 11b-Undershoot	For Mag Sensor Notification
	6~7	00b(default)-Unchanged 01b-Overshoot 11b-Undershoot	For temperature Sensor Notification
1	0~1	00b(default)-Unchanged 01b-Overshoot 11b-Undershoot	For Humidity Sensor Notification
	2~3	00b(default)-Unchanged 01b-Overshoot 11b-Undershoot	For Pressure Sensor Notification
	4~5	00b(default)-Unchanged 01b-Overshoot 11b-Undershoot	For Light Sensor Notification
	6~7	00b(default)-Unchanged 01b-Overshoot 11b-Undershoot	For Noise Sensor Notification

3.3 Standard services

3.3.1 Battery service

The Battery Service exposes the battery level information of a device. Assigned service number: 0x180F

Characteristics ID: 0x2A19

The battery percentage is updated for every 10 seconds if the Bluetooth is connected to the node.

Presentation Format of the above characteristic is available in this page:

https://developer.bluetooth.org/gatt/descriptors/Pages/DescriptorViewer.aspx?u=org.bluetooth.descriptor.gatt.characteristic_presentation_format.xml

3.3.2 Device information service

S.NO	SERVICE ID	CHARACTERISTICS ID	CHARACTERISTICS NAME	DESCRIPTION	SUPPORT
1	0x180A	0x2A29	Manufacturer Name String	This characteristic represents the name of the manufacturer of the device	Not Supported
		0x2A24	Model Number String	This characteristic represents the model number that is assigned by the device vendor	Not Supported
		0x2A25	Serial Number String	This characteristic represents the serial number for a particular instance of the device	Not Supported
		0x2A27	Hardware Revision String	This characteristic represents the hardware revision for the hardware within the device	Supported
		0x2A26	Firmware Revision String	This characteristic represents the firmware revision for the firmware within the device.(User application version)	Supported
		0x2A28	Software Revision String	This characteristic represents the software revision for the software within the device. (Bootloader version)	Supported
		0x2A23	System ID	This characteristic represents a structure containing an Organizationally Unique Identifier (OUI) followed by a manufacturer-defined identifier and is unique for each individual instance of the product	Not Supported

3.4 BLE security (Just works pairing with bonding)

CISS implements the "Just works" pairing with bonding

3.4.1 "Just works" pairing with Bonding

- Just works: No need to input any pins between master and slave
- Pairing makes the transmission between node and ble master fully encrypted in the link layer, without using a pre-shared key

- Bonded devices can store the keys that were used during pairing and when they connect next time, they can reuse the keys for encryption without generating a new set of keys using the pairing procedure. In other words, the keys are exchanged only once during the first pairing procedure thus making it impossible to find the keys with packet sniffing on further connect disconnect cycles. This makes the system more secure against MITM attacks.

3.4.2 Payload encryption details

The below table lists the encryption details of various characteristics part of datastreamer custom services.

S.NO	SERVICE	ENCRYPTION INFORMATION
1	I40 service characteristics	Not encrypted
2	Event detection service characteristics	Not encrypted
3	FOTA service characteristics	AES-128 encrypted

3.5 Switch off BLE via BLE

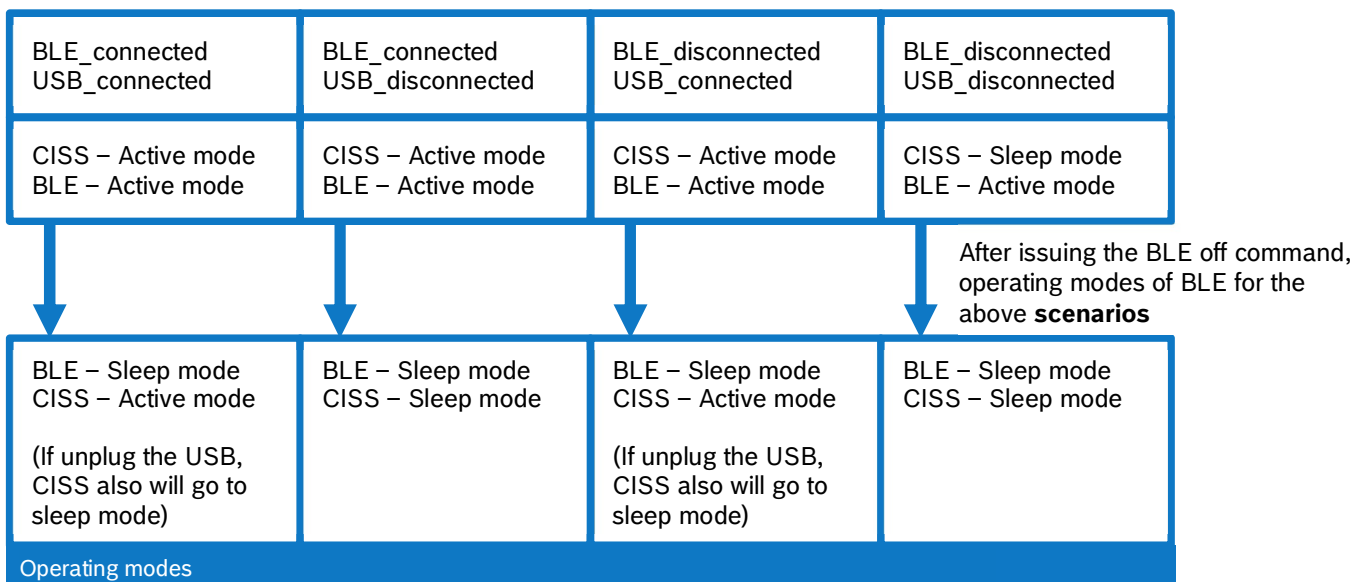
Based on the information transferred via BLE to the node, the software itself disable the BLE and the node will go to sleep mode.

To send the BLE_OFF information from BLE master we can use the existing custom characteristics 0x750A

While disabling the BLE, we will issue the disconnect command from peripheral to the central first and then will switch of the BLE chip. The CISS_BLE_OFF android application can be used to disable the BLE.

3.5.1 Operating modes of BLE and CISS node in different scenarios

If we don't switch off the BLE by our special CISS_BLE_OFF android application:



NOTE:

Once the BLE enters sleep mode, the CISS device cannot be discovered by any BLE scanner. To wake up the BLE, USB has to be connected to PC or Charger. Now the BLE and the CISS will come to active mode.

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