USER MANUAL

Endurosat Telemetry and Telecommand Protocol (ESTTC) for Controlling Sensors and Actuators on the EnduroSat CubeSat

ESTTC PROTOCOL FOR CONTROLLING SENSORS AND ACTUATORS ON THE ENDUROSAT CUBESAT

USER MANUAL

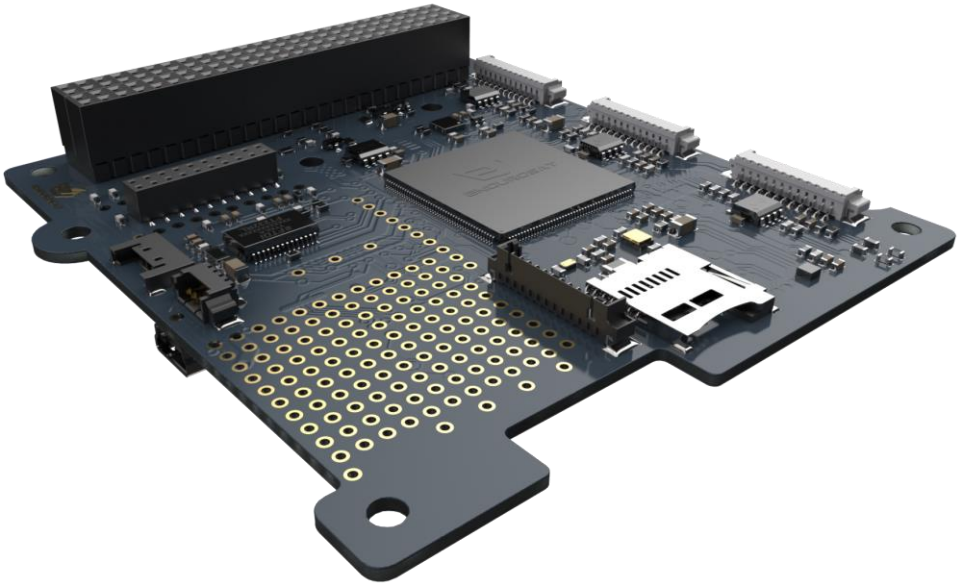

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Figure 1 – EnduroSat OBC

1 CHANGE LOG

Date	Version	Note
22/06/2018	Rev 1	Initial document
14/01/2019	Rev 2	Commands and text modification

2 OBC SENSOR AND ACTUATORS ESTTC PROTOCOL

2.1 Read command format

Byte No	0	1	2	3	4	5	6	7	…		n
	“E”	“S”	“+”	“R”	0x11	0…0xFF	DATA1	DATA2			DATAn
Description	symbol	symbol	Symbol	R- means that command is only for reading	OBC address in I2C bus	Command id					

2.2 Write command format

Byte No	0	1	2	3	4	5	6	7	8	…	n
	“E”	“S”	“+”	“W”	0x11	0…0xFF	0…0xFF	DATA1	DATA2		DATAn
Description	symbol	symbol	Symbol	W- means that command is updating parameters	OBC address in I2C bus	Command id	Number of data bytes				

2.3 Format of the commands

Every command that starts with the “ES+” string means Endurosat plus. The next sign can be R for reading and W (Writing) if command wants to send some data. Be careful, if the command is W (Writing), then there is a byte in the write command format which specifies the number of data bytes which should be sent. Every command string has to end with the CR symbol (0x0D). Please check if your terminal inserts it automatically after the last command byte, otherwise it should be added after each command (it is not present in the command format of the current manual).

Every command has a short and long answer. In case that the on board computer (OBC) is attached to a custom payload via one of the serial interfaces, then the slave device (payload) should ask and require compressed info as an answer, just to collect needed data from the OBC. The Long answer gives more information for the type of the sensor, data format and type etc. It can be useful for a user who has attached an OBC to a host computer and makes a first investigation and diagnostics.

User or customer payload can manage sensors immediately after power on and receive all initialization messages as follow:

MAG1_INIT_OK

MAG2_INIT_OK

ACC1_INIT_OK

ACC2_INIT_OK

TRQ1_SET_10%

TRQ2_SET_50%

TRQ3_SET_90%

GYR1_INIT_OK

GYR2_INIT_FAIL

GYR3_INIT_FAIL

Where MAG1 – is magnetometer/compass 1, soldered on the PBC board, MAG2 – second magnetometer/compass (can be used as backup), also on PCB. ACC1 and ACC2 are respectively first and second accelerometer and again can be found on the OBC board. For these sensors, every time initialization should be finished with OK. If the user receives a message different than OK, then he should check the sensor is present on the board and check for possible malfunction.

TRQ are the magnetorquers setting. They are mounted on external panels and can be provided from the EnduroSat web shop. Nevertheless, whether a user has connected a magnetorquer panel or not then this message should be received the same, because the message is not related to feedback from the actuators.

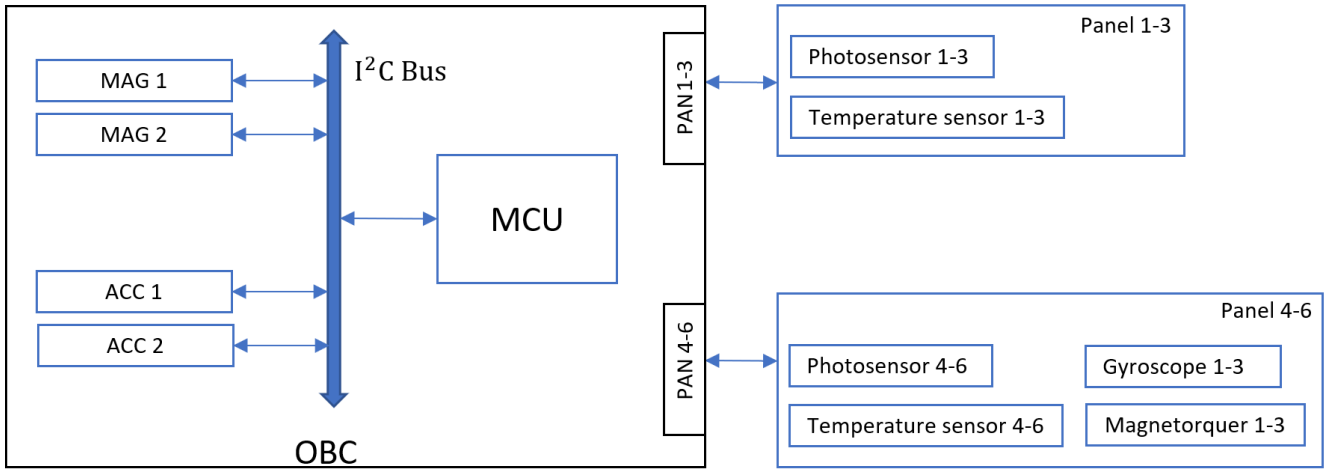
GYR name 1…3 is used for gyroscope sensors, they are not placed on the OBC board and can be connected by wires if the user collects external panels from the EnduroSat web store. It is normal to receive FAIL message for gyroscopes if panels are not attached to the OBC.

The OBC can handle up to three gyroscopes and magnetorquers attached to connectors: PAN4, PAN5 and PAN6. Check OBC manual for reference.

Each panel has a temperature sensor and photosensor. Their values can be read with specific commands and these sensors cannot be configured.

After successful on board computer and sensor initialization, the user can start to work with the system. There are a few types of commands – some are for reading the data (sensors), some are for data setting (actuators – magnetorquers) and there are also specific commands for sensor configuration which can be done by sensor register manipulation. The user should read the data sheet of the sensor to determine the data values for the registers before setting the data.

The picture below explains the place of each sensor/actuator. As can be seen, only the magnetometers and the accelerometers are placed on the OBC board, other sensors can be connected using external panels. These external panels are connected using cables.



2.4 Accelerometer commands

Com ID	Description	Notes
0x00	ACC1 current acceleration data X, Y, Z axis	Local RD only
0x01	ACC1 direct register access (see AIS328dq datasheet)	AIS328dq API RD/WR reg
0x02	ACC2 current acceleration data X, Y, Z axis	Local RD only
0x03	ACC2 direct register access (see AIS328dq datasheet)	AIS328dq API RD/WR reg

Command ID: 0x00

ES+R1100

ACC1 current acceleration data X, Y, Z axis

Short Answer: OK+1-12/48/1035

Where 1 – accelerometer 1, digits for X, Y and Z are separated by /

Long Answer: Accelerometer 1 X=-12 Y=48 Z=1035

Command ID: 0x01

ES+R1101A0

ACC1 direct register access (see AIS328dq)

Read data on reg A0

Short Answer: OK+1A0/2F

Where 1 – accelerometer 1, A0 reg address, 2F register value

Long Answer: Accelerometer 1 register A0 has value 2F

ES+W110102A003

ACC1 direct register access (see AIS328dq)

Write data 03 on reg A0

Short Answer: OK+1A003

Where 1 – accelerometer 1, A0 reg address, 03 register value

Long Answer: Accelerometer 1 register A0 is set with value 3

Command ID: 0x02

ES+R1102

ACC2 current acceleration data X, Y, Z axis

Short Answer: OK+2-8/53/1028

Where 2 – accelerometer 2, digits for X, Y and Z are separated by /

Long Answer: Accelerometer 2 X=-8 Y=53 Z=1028

Command ID: 0x03

ES+R1103A0

ACC2 direct register access (see AIS328dq)

Read data on reg A0

Short Answer: OK+2A0/2F

Where 2 – accelerometer 2, A0 reg address, 2F register value

Long Answer: Accelerometer 2 register A0 has value 2F

ES+W110302A003

ACC2 direct register access (see AIS328dq)

Write data 03 on reg A0

Short Answer: OK+2A0/03

Where 2 – accelerometer 2, A0 reg address, 03 register value

Long Answer: Accelerometer 2 register A0 is set with value 3

2.5 Magnetometer commands

Com ID	Description	Notes
0x04	MAG1 current magnet field data X,Y,Z axis	Local RD only
0x05	MAG1 direct register access (see LIS3MDL datasheet)	LIS3MDL API RD/WR reg
0x06	MAG2 current magnet field data X,Y,Z axis	Local RD only
0x07	MAG2 direct register access (see LIS3MDL datasheet)	LIS3MDL API RD/WR reg

Command ID: 0x04

ES+R1104

MAG1 current magnetic field data X, Y, Z axis

Short Answer: OK+1-712/-1284/2094

Long Answer: Magnetometer 1 – Magnetic field in specific range X=-712 Y=-1284 Z=2094

Command ID: 0x05

ES+R110503

MAG1 direct register access

Read data on reg 03

Short Answer: OK+103/00

Where 1 – magnetometer 1, 03 reg address, 00 register value

Long Answer: Magnetometer 1 reg No 3 has value 0

ES+W11050203AB

MAG1 direct register access

Write data AB on reg 03

Short Answer: OK+103/AB

Long Answer: Magnetometer 1 reg No 03 is set with value 171

Command ID: 0x06

ES+R1106

MAG2 current magnetic field data X, Y, Z axis

Short Answer: OK+2-712/-1284/2094

Long Answer: Magnetometer 2 – Magnetic field in specific range X=-712 Y=-1284 Z=2094

Command ID: 0x07

ES+R110703

MAG2 direct register access

Read data on reg 03

Short Answer: OK+203/00

Where 2 – magnetometer 2, 03 reg address, 00 register value

Long Answer: Magnetometer 2 reg No 3 has value 0

ES+W11070203AB

MAG2 direct register access

Write data AB on reg 03

Short Answer: OK+203/AB

Long Answer: Magnetometer 2 reg No 03 is set with value 171

2.6 Gyroscope commands

Com ID	Description	Notes
0x08	GYR1 current metric data X-axis	Local RD only
0x09	GYR1 current angle data X-axis	Local RD only
0x0A	GYR1 direct register access (see ADIS16265 datasheet)	ADIS16265 API RD/WR reg
0x0B	GYR2 current metric data X-axis	Local RD only
0x0C	GYR2 current angle data X-axis	Local RD only
0x0D	GYR2 direct register access (see ADIS16265 datasheet)	ADIS16265 API RD/WR reg
0x0E	GYR3 current metric data X-axis	Local RD only
0x0F	GYR3 current angle data X-axis	Local RD only
0x10	GYR3 direct register access (see ADIS16265 datasheet)	ADIS16265 API RD/WR reg

Command ID: 0x08

ES+R1108

GYR1 read current radiometric data X-axis

Short Answer: OK+11427

Where 1 – gyroscope 1, 1427 data for current axis

Long Answer: Gyroscope 1 Data X=1427

Command ID: 0x09

ES+R1109

GYR1 read current angle data X-axis

Short Answer: OK+113

Long Answer: Gyroscope 1 Angle X=13

Command ID: 0x0A

ES+R110A40

GYR1 read data on reg AB data X-axis

Short Answer: OK+140/00

Where 1 – gyroscope 1, 0x40 is register address, 0 – register value

Long Answer: Gyroscope 1 reg No 64 has value 0

ES+W110A0301ABCD

GYR1 write 16 bit data ABCD (43981 dec) on reg 01 data X-axis

Answer: Gyroscope 1 set reg No 1 with value 43981

Command ID: 0x0B

ES+R110B

GYR2 read current radiometric data Y-axis

Short Answer: OK+21427

Where 2 – gyroscope 2, 1427 data for current axis

Long Answer: Gyroscope 2 Data Y=1427

Command ID: 0x0C

ES+R110C

GYR2 read current angle data Y-axis

Short Answer: OK+2244

Long Answer: Gyroscope 2 Angle Y=244

Command ID: 0x0D

ES+R110D40

GYR2 read data on reg AB data Y-axis

Short Answer: OK+240/00

Where 2 – gyroscope 2, 0x40 is register address, 0 – register value

Long Answer: Gyroscope 2 reg No 64 has value 0

ES+W110D0301ABCD

GYR2 write 16 bit data ABCD (43981 dec) on reg 01 data Y-axis

Answer: Gyroscope 2 set reg No 1 with value 43981

Command ID: 0x0E

ES+R110E

GYR3 read current radiometric data Z-axis

Short Answer: OK+31427

Where 3 – gyroscope 3, 1427 data for current axis

Long Answer: Gyroscope 3 Data Z=1427

Command ID: 0x0F

ES+R110F

GYR3 read current angle data Z-axis

Short Answer: OK+3134

Long Answer: Gyroscope 3 Angle Z=134

Command ID: 0x10

ES+R111040

GYR3 read data on reg AB data Z-axis

Short Answer: OK+340/00

Where 3 – gyroscope 3, 0x40 is register address, 0 – register value

Long Answer: Gyroscope 3 reg No 64 has value 0

ES+W11100301ABCD

GYR3 write 16 bit data ABCD (43981 dec) on reg 01 data Z-axis

Answer: Gyroscope 3 set reg No 1 with value 43981

2.7 Magnetorquer commands

Com ID	Description	Notes
0x11	Magnetorq1 Field Setup level and direction	PWM WR only
0x12	Magnetorq2 Field Setup level and direction	PWM WR only
0x13	Magnetorq3 Field Setup level and direction	PWM WR only

Command ID: 0x11

Set Magnetorquer 1 with desired power 100 in positive direction

ES+W1111026401

Power 0…100 (64 hex), direction X: 00 for negative, 01 for positive (greater value is allowed as well)

Short Answer: OK+164/X+

Where 1 - magnetorquer 1, 0x64 is 100 for power, X+ is positive direction

Long Answer: Set Magnetorquer 1 (TRQ1) on PAN 2 with power 100 and direction X+

Command ID: 0x12

Set Magnetorquer 2 with desired power 100 in negative direction

ES+W1112026400

Power 0…100 (64 hex), direction Y: 00 for negative, 01 for positive (greater value is allowed as well)

Short Answer: OK+264/Y-

Where 2 - magnetorquer 2, 0x64 is 100 for power, Y- is negative direction

Long Answer: Set Magnetorquer 2 (TRQ2) on PAN 5 with power 100 and direction Y-

Command ID: 0x13

Set Magnetorquer 3 with desired power 100 in positive direction

ES+W1113026402

Power 0...100 (64 hex), direction Z: 00 for negative, 01 for positive (greater value is allowed as well)

Short Answer: OK+364/Z+

Where 3 - magnetorquer 3, 0x64 is 100 for power, Z+ is positive direction

Long Answer: Set Magnetorquer 3 (TRQ3) on PAN 6 with power 100 and direction Z+

2.8 Temperature sensor commands

Com ID	Description	Notes
0x14	Temperature sensor1 current reading	Local RD only
0x15	Temperature sensor2 current reading	Local RD only
0x16	Temperature sensor3 current reading	Local RD only
0x17	Temperature sensor4 current reading	Local RD only
0x18	Temperature sensor5 current reading	Local RD only
0x19	Temperature sensor6 current reading	Local RD only

Command ID: 0x14

ES+R1114

Read Temperature on Panel 1

Short Answer: OK+10E8F

Where 1 is sensor number on panel 1, 0E8F is hexadecimal value red from ADC

Long Answer: Temperature Panel 1 (PAN1) = 29.0

Command ID: 0x15

ES+R1115

Read Temperature on Panel 2

Short Answer: OK+20EB7

Where 2 is sensor number on panel 2, 0EB7 is hexadecimal value red from ADC

Long Answer: Temperature Panel 2 (PAN2) = 29.3

Command ID: 0x16

ES+R1116

Read Temperature on Panel 3

Short Answer: OK+30EB7

Where 3 is sensor number on panel 3, 0EB7 is hexadecimal value red from ADC

Long Answer: Temperature Panel 3 (PAN3) = 29.3

Command ID: 0x17

ES+R1117

Read Temperature on Panel 4

Short Answer: OK+40E8F

Where 4 is sensor number on panel 4, 0E8F is hexadecimal value red from ADC

Long Answer: Temperature Panel 4 (PAN4) = 29.0

Command ID: 0x18

ES+R1118

Read Temperature on Panel 5

Short Answer: OK+50E8F

Where 5 is sensor number on panel 5, 0E8F is hexadecimal value red from ADC

Long Answer: Temperature Panel 5 (PAN5) = 29.0

Command ID: 0x19

ES+R1119

Read Temperature on Panel 6

Short Answer: OK+60EB7

Where 6 is sensor number on panel 6, 0EB7 is hexadecimal value red from ADC

Long Answer: Temperature Panel 6 (PAN6) = 29.3

2.9 Photosensor commands

Com ID	Description	Notes
0x1A	Photosensor1 current reading	Local RD only
0x1B	Photosensor2 current reading	Local RD only
0x1C	Photosensor3 current reading	Local RD only
0x1D	Photosensor4 current reading	Local RD only
0x1E	Photosensor5 current reading	Local RD only
0x1F	Photosensor6 current reading	Local RD only

Command ID: 0x1A

ES+R111A

Read photosensor value on the panel 1

Short Answer: OK+115

Where 1 is photosensor on panel 1, 0x15 is hexadecimal value red from ADC

Long Answer: Panel Light 1 (PAN1) = 21

Command ID: 0x1B

ES+R111B

Read photosensor value on the panel 2

Short Answer: OK+215

Where 2 is photosensor on panel 2, 0x15 is hexadecimal value red from ADC

Long Answer: Panel Light 2 (PAN2) = 21

Command ID: 0x1C

ES+R111C

Read photosensor value on the panel 3

Short Answer: OK+315

Where 3 is photosensor on panel 3, 0x15 is hexadecimal value red from ADC

Long Answer: Panel Light 3 (PAN3) = 21

Command ID: 0x1D

ES+R111D

Read photosensor value on the panel 4

Short Answer: OK+415

Where 4 is photosensor on panel 4, 0x15 is hexadecimal value red from ADC

Long Answer: Panel Light 4 (PAN4) = 21

Command ID: 0x1E

ES+R111E

Read photosensor value on the panel 5

Short Answer: OK+515

Where 5 is photosensor on panel 5, 0x15 is hexadecimal value red from ADC

Long Answer: Panel Light 5 (PAN5) = 21

Command ID: 0x1F

ES+R111F

Read photosensor value on the panel 6

Short Answer: OK+615

Where 5 is photosensor on panel 6, 0x15 is hexadecimal value red from ADC

Long Answer: Panel Light 6 (PAN6) = 21