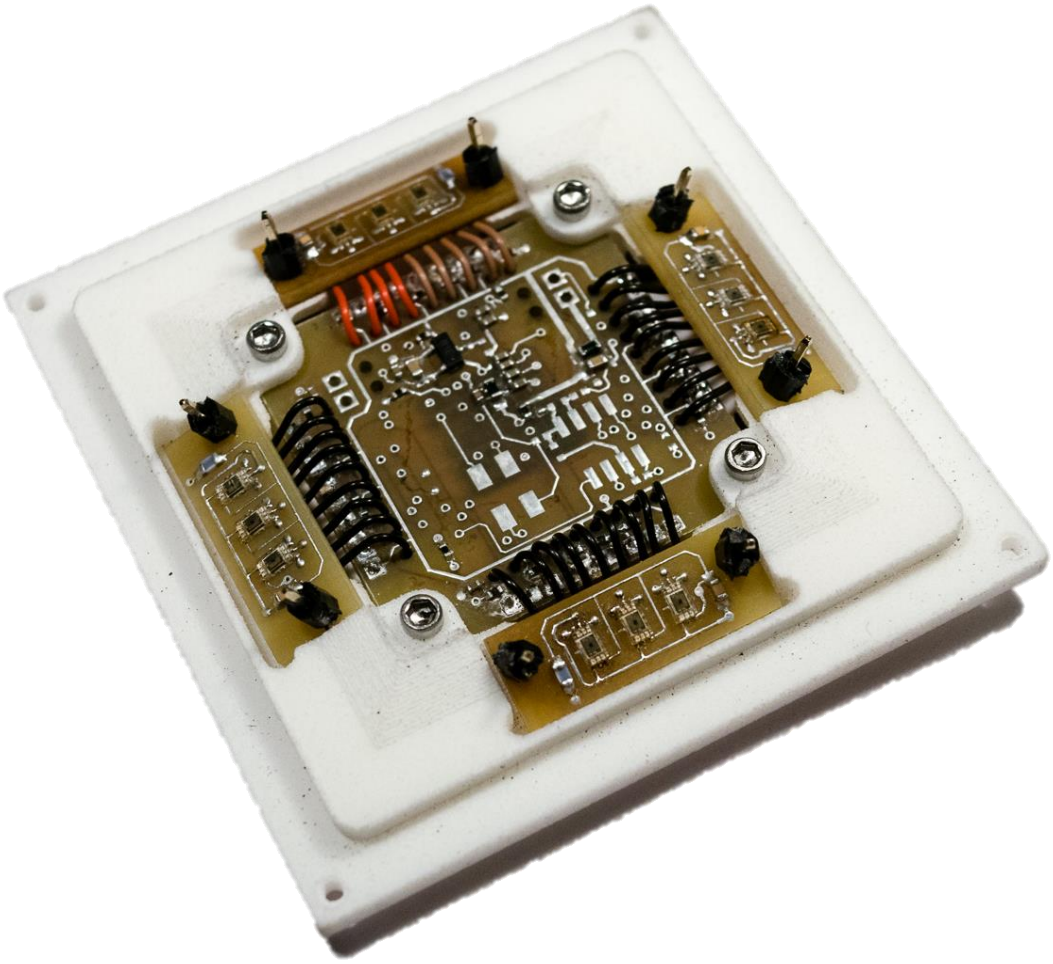
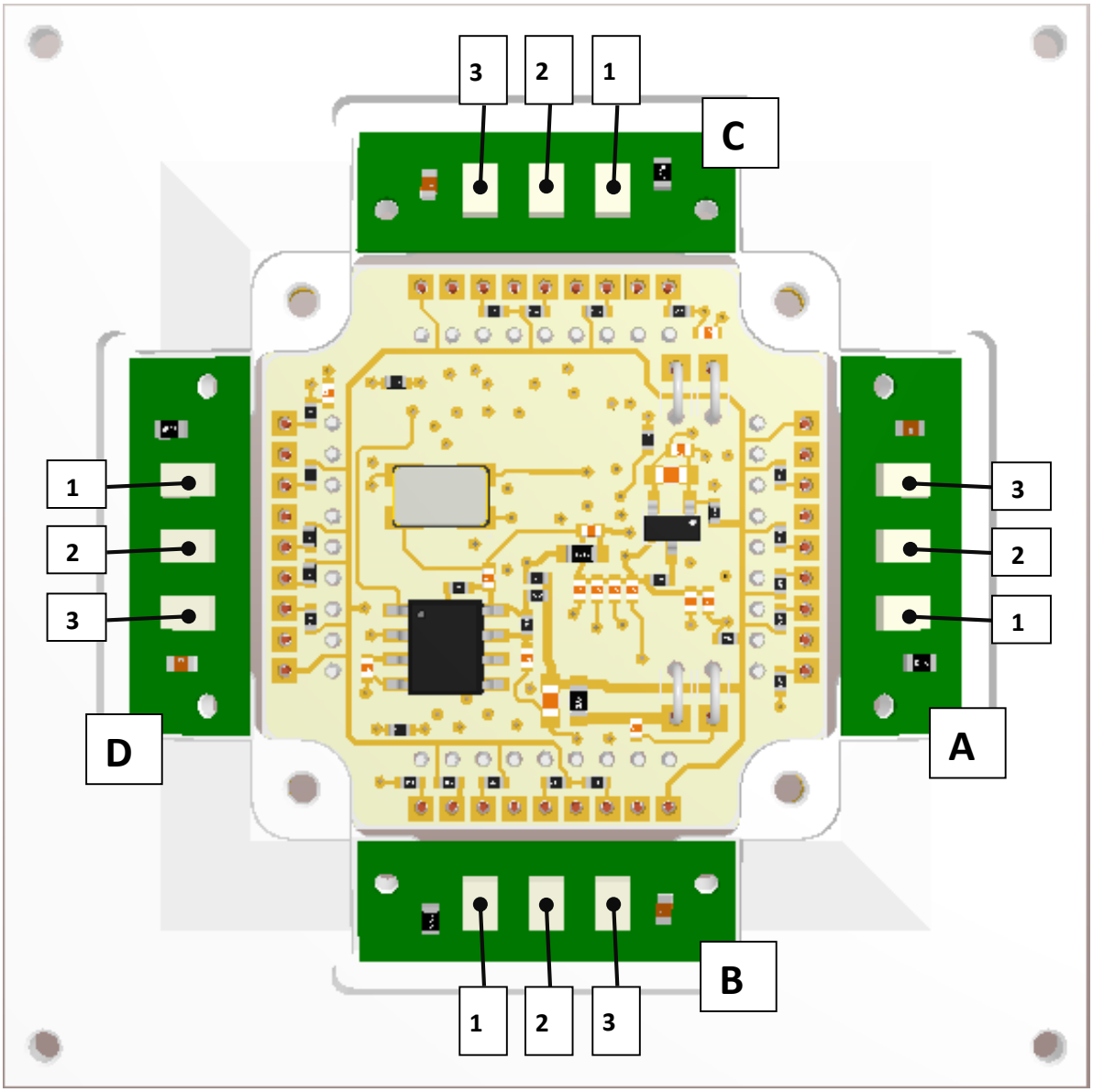
SunS-EM3 Brief Documentation



1 GENERAL OVERVIEW

Sensors naming convention:

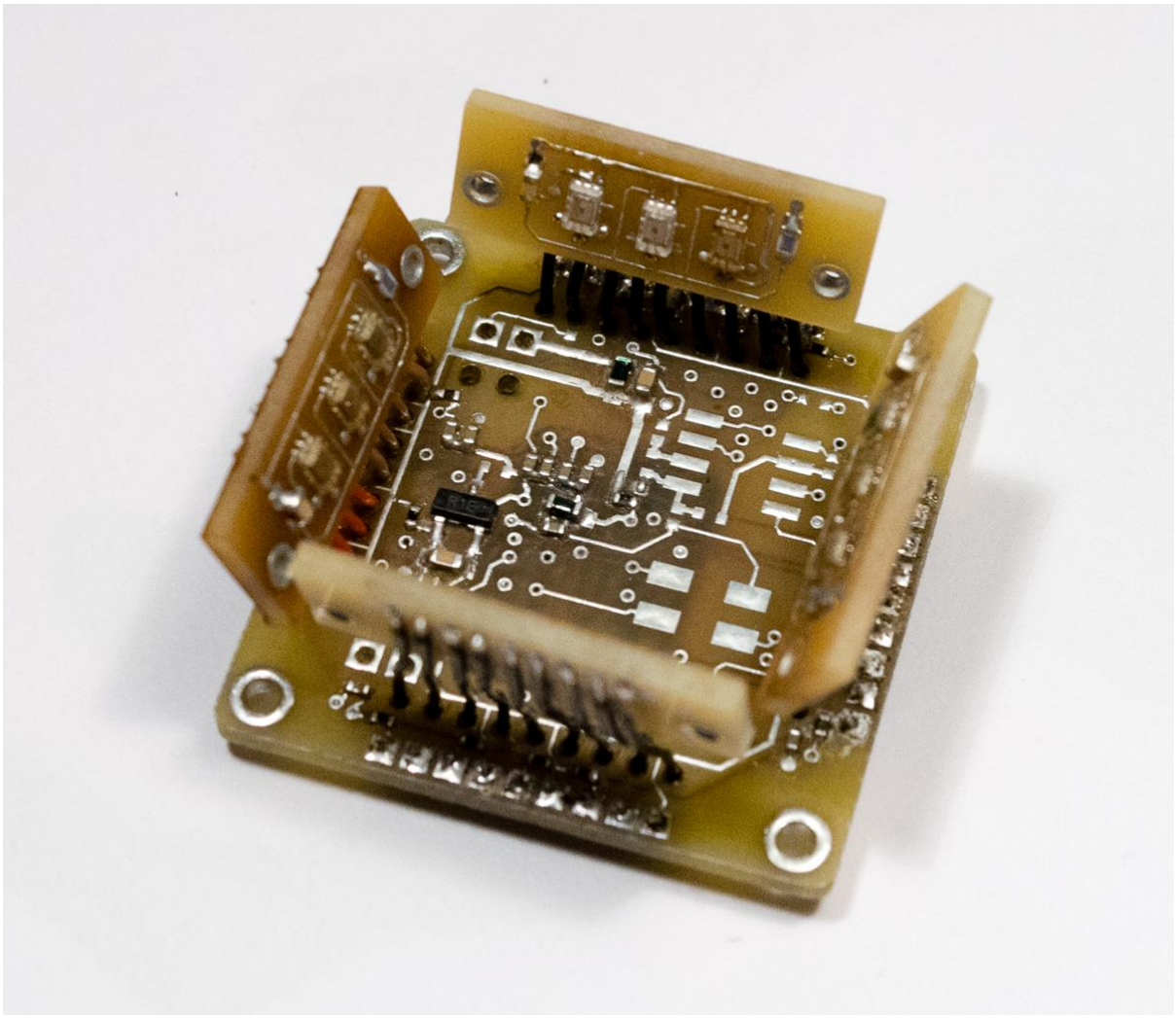


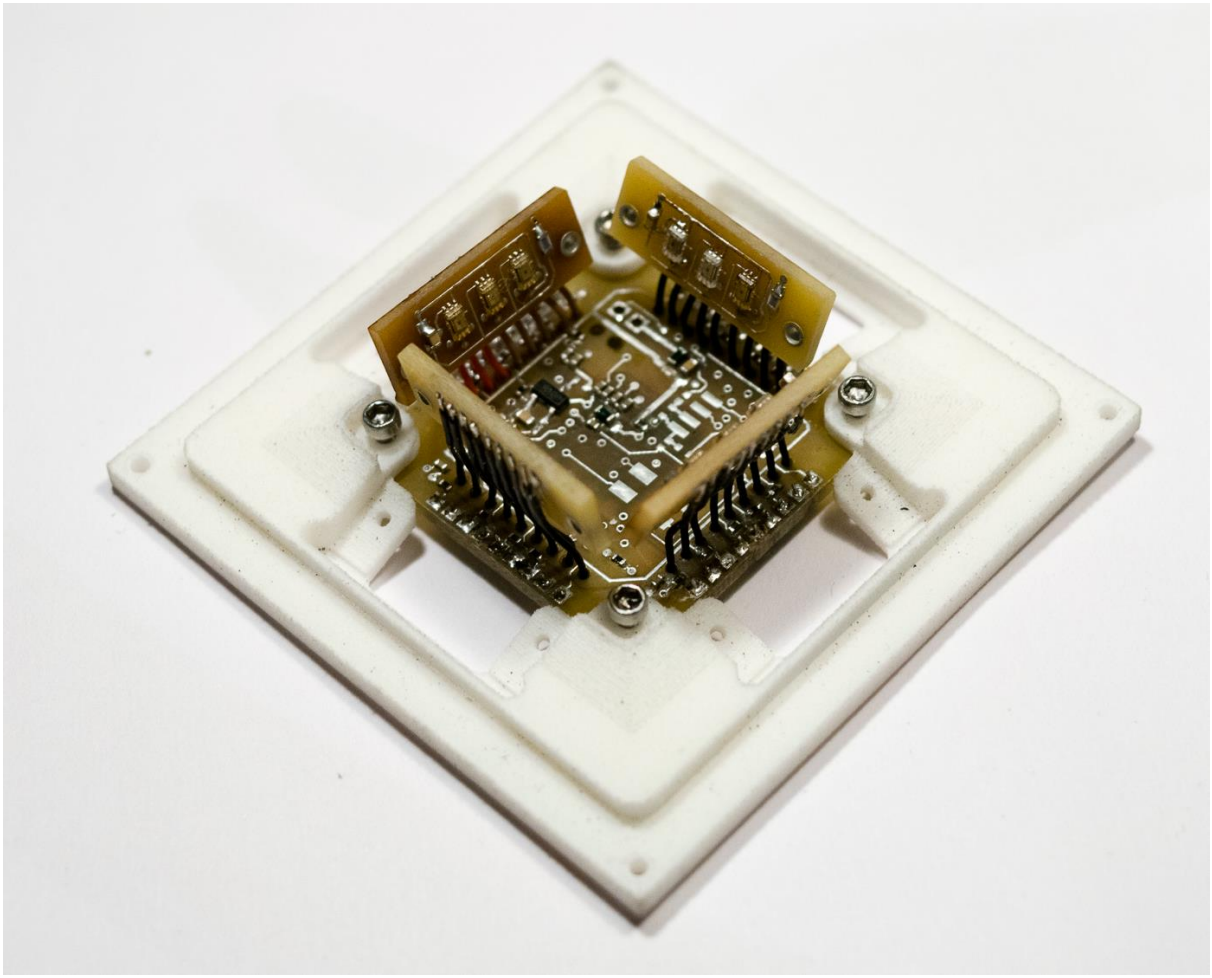
2 ASSEMBLY PROCEDURE

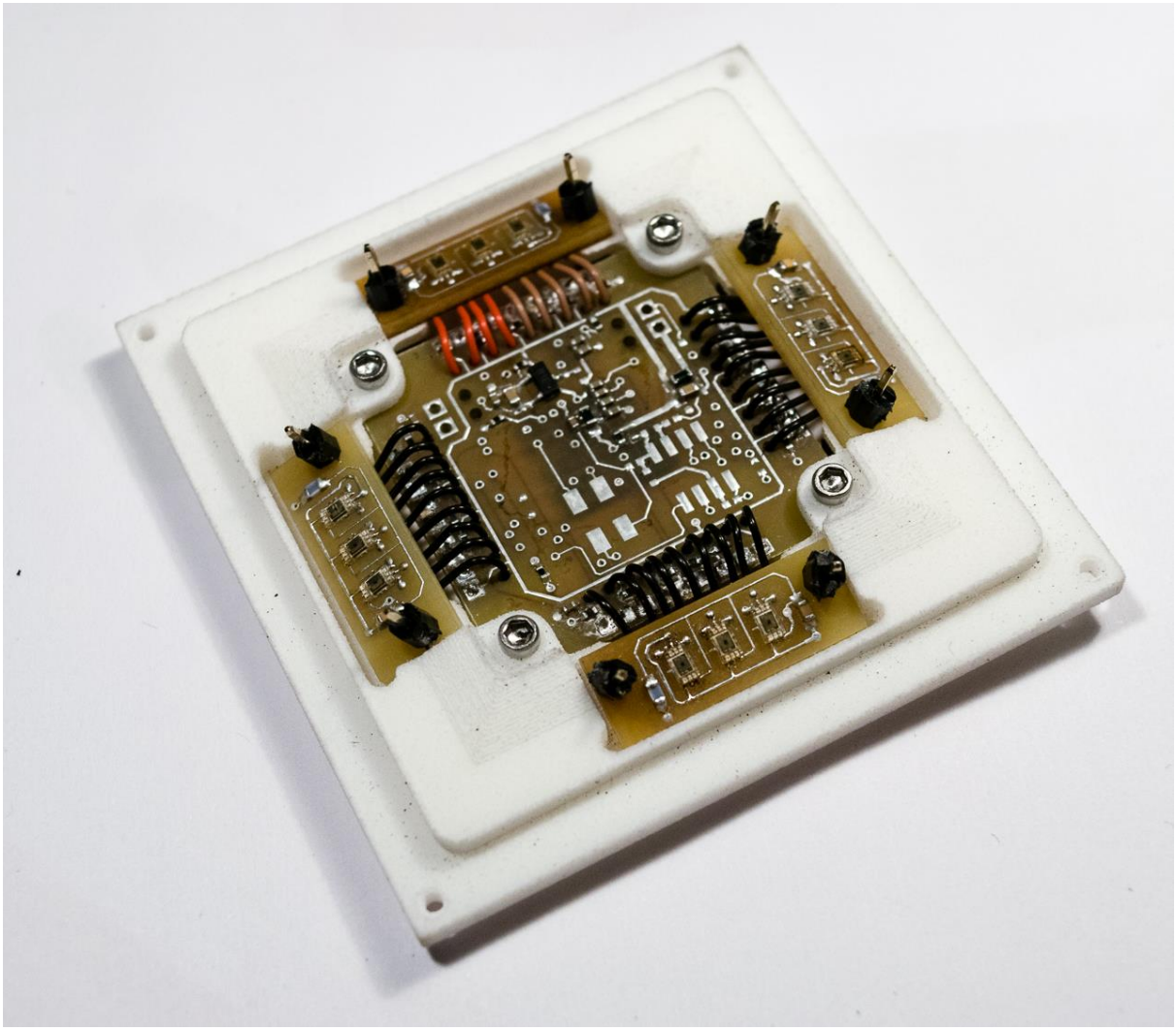
There are several steps involved in assembly procedure of the SunS. They are listed and described below:

1. Assembly (soldering) of the main board and the ALS boards.

2. Electrical tests of the main board and ALS boards
3. Bootloader burn on AVR microcontroller via JTAG interface available on pins dedicated for communication with ALS sensors
4. Tests in uploading a firmware via UART
5. JTAG should be turned off in fuse bits configuration to allow for proper operation of ALS sensors
6. Wires connecting ALS boards and main board should be soldered to the main board
7. At this step wires should be soldered to the ALS boards, resulting device so far is presented in fig.
8. The boards should be put into the case, resulting in a complete device – fig.







3 CHANGES IN ELEMENTS VALUES

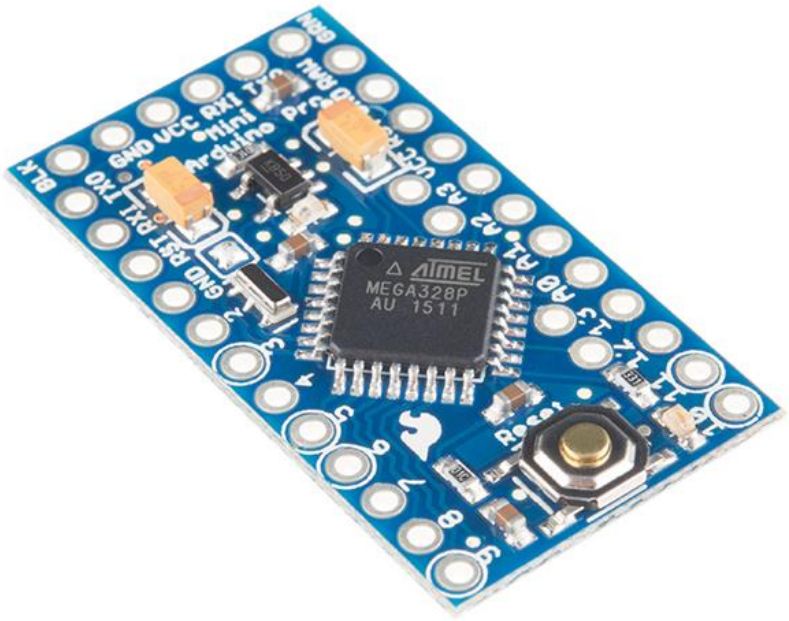
All values in the table refer to the schematic "2016-09-05_manufactured_EM.3.03" put in "PW-Sat2-SVN\suns\pcb\tags".

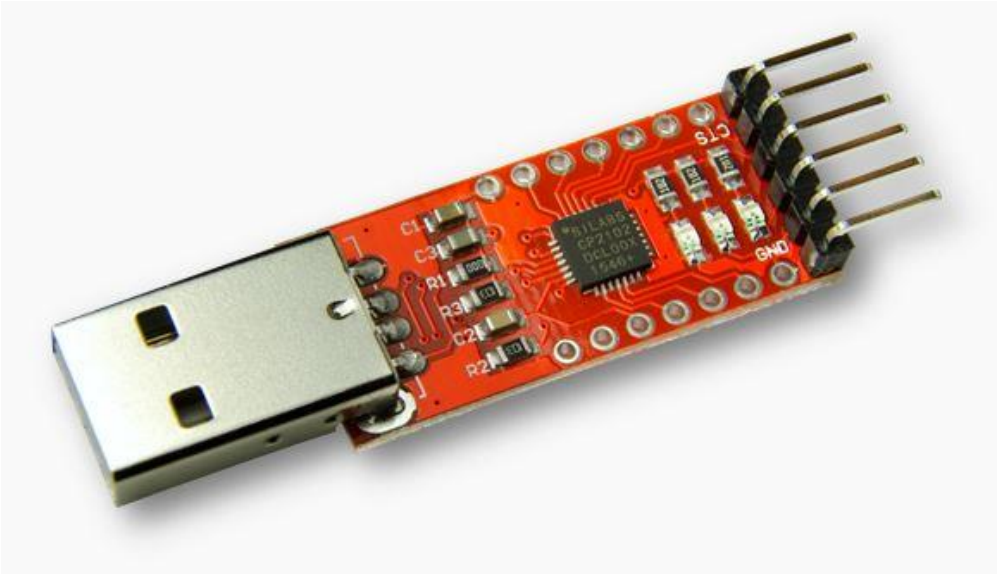
#	Part ID on schematic	Value on the schematic	Actual value	Justification
1	REF1	LM4040-3V 1%	LM4041-N-1.2	Smaller reference voltage to increase resoultion of temperature measurement by LM60
2	R26	1k/1%	470R/1%	To increase output current fo the reference voltage source REF1

3	U2	FM25W256	NC	Not soldered, considered as no longer needed
4	R2, R21, R24, R32, C19, C18, R23, R22, C17, R20, C4, C5	multiple values	NC	Not soldered, considered as no longer needed
5	XT1	8 MHz	NC	Not soldered, considered as no longer needed

4 SUNS-EM3 EGSE

The EGSE for the SunS-EM3 is based on Arduino Pro Mini board with ATMega328p and UART-USB converter. The devices can provide power supply for the SunS, as well as they are used to communicate with the SunS via I2C interface.





A description of communication interface with EGSE via UART is provided below.

UART settings:

baud rate: 19200 bps / data bits: 8 / parity bit: none / stop: one bit / no HW flow control

Command send to the EGSE:

```
measure <ALS_ITIME> <ALS_GAIN>\r
```

Where:

ALS_ITIME – ALS integration time in range 1 – 255 (time in ms = value * 2.7 ms)

ALS_GAIN – ALS gain in range 0 – 3 (0 = gain 1, 1 = gain 2, 2 = gain 64, 3 = gain 128)

Reply:

Semicolon-separated values:

```
uint8_t STATUS;
uint8_t WHO_AM_I;
uint16_t AZIMUTH_ANGLE;
uint16_t ELEVATION_ANGLE;
int16_t TEMPERATURE_A;
int16_t TEMPERATURE_B;
int16_t TEMPERATURE_C;
int16_t TEMPERATURE_D;
int16_t TEMPERATURE_STRUCT;
uint16_t ALS_1A_VL_RAW;
uint16_t ALS_1B_VL_RAW;
```

```
uint16_t ALS_1C_VL_RAW;
uint16_t ALS_1D_VL_RAW;
uint16_t ALS_2A_VL_RAW;
uint16_t ALS_2B_VL_RAW;
uint16_t ALS_2C_VL_RAW;
uint16_t ALS_2D_VL_RAW;
uint16_t ALS_3A_VL_RAW;
uint16_t ALS_3B_VL_RAW;
uint16_t ALS_3C_VL_RAW;
uint16_t ALS_3D_VL_RAW;
uint16_t ALS_1A_IR_RAW;
uint16_t ALS_1B_IR_RAW;
uint16_t ALS_1C_IR_RAW;
uint16_t ALS_1D_IR_RAW;
uint16_t ALS_2A_IR_RAW;
uint16_t ALS_2B_IR_RAW;
uint16_t ALS_2C_IR_RAW;
uint16_t ALS_2D_IR_RAW;
uint16_t ALS_3A_IR_RAW;
uint16_t ALS_3B_IR_RAW;
uint16_t ALS_3C_IR_RAW;
uint16_t ALS_3D_IR_RAW;
uint16_t TEMPERATURE_A_RAW;
uint16_t TEMPERATURE_B_RAW;
uint16_t TEMPERATURE_C_RAW;
uint16_t TEMPERATURE_D_RAW;
uint16_t TEMPERATURE_STRUCT_RAW;
uint16_t ALS_STATUS;
uint8_t ALS_1A_ID;
uint8_t ALS_1B_ID;
uint8_t ALS_1C_ID;
uint8_t ALS_1D_ID;
uint8_t ALS_2A_ID;
uint8_t ALS_2B_ID;
uint8_t ALS_2C_ID;
uint8_t ALS_2D_ID;
uint8_t ALS_3A_ID;
uint8_t ALS_3B_ID;
uint8_t ALS_3C_ID;
uint8_t ALS_3D_ID;
```

5 TEMPERATURE COMPENSATION OF THE AMBIENT LIGHT SENSORS

The temperature dependence of ALS output was empirically derived and described by the equation:

$$I(T) = I_0 \cdot (1 + \Delta T \cdot \alpha)$$

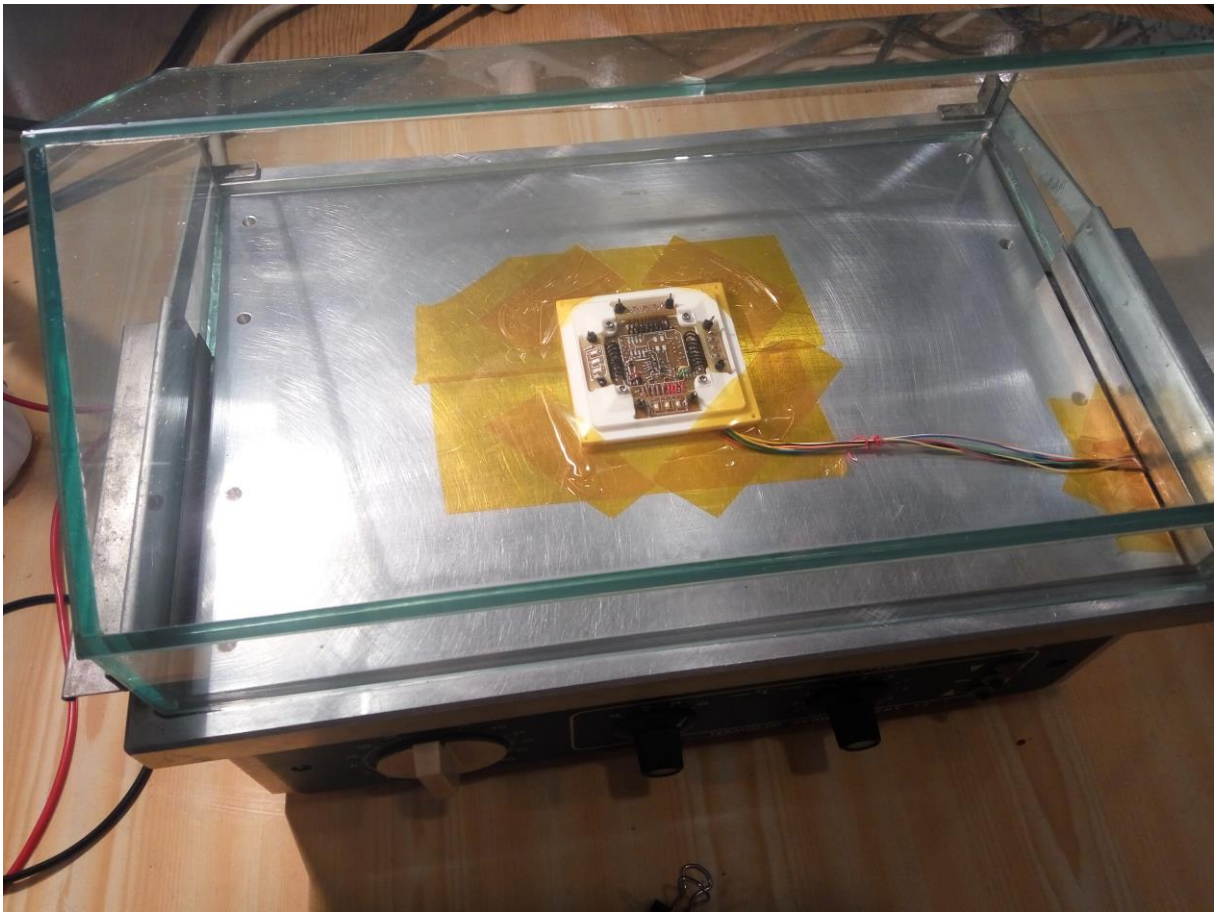
Where:

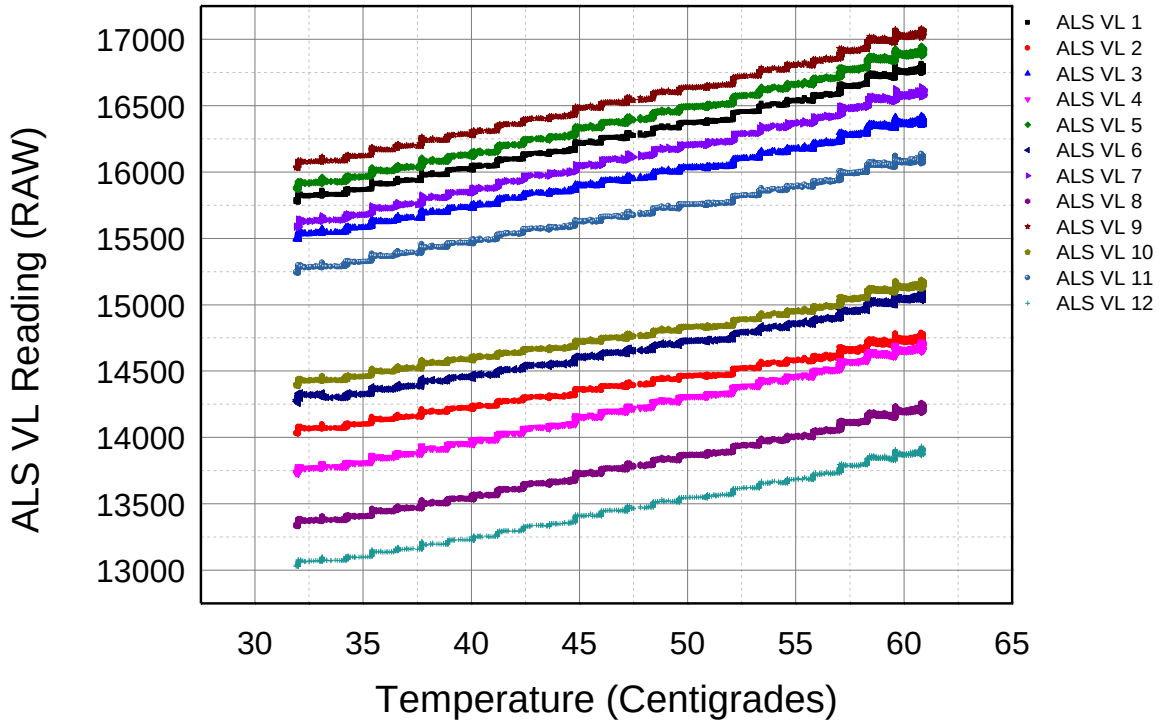
α – empirically measured thermal coefficient

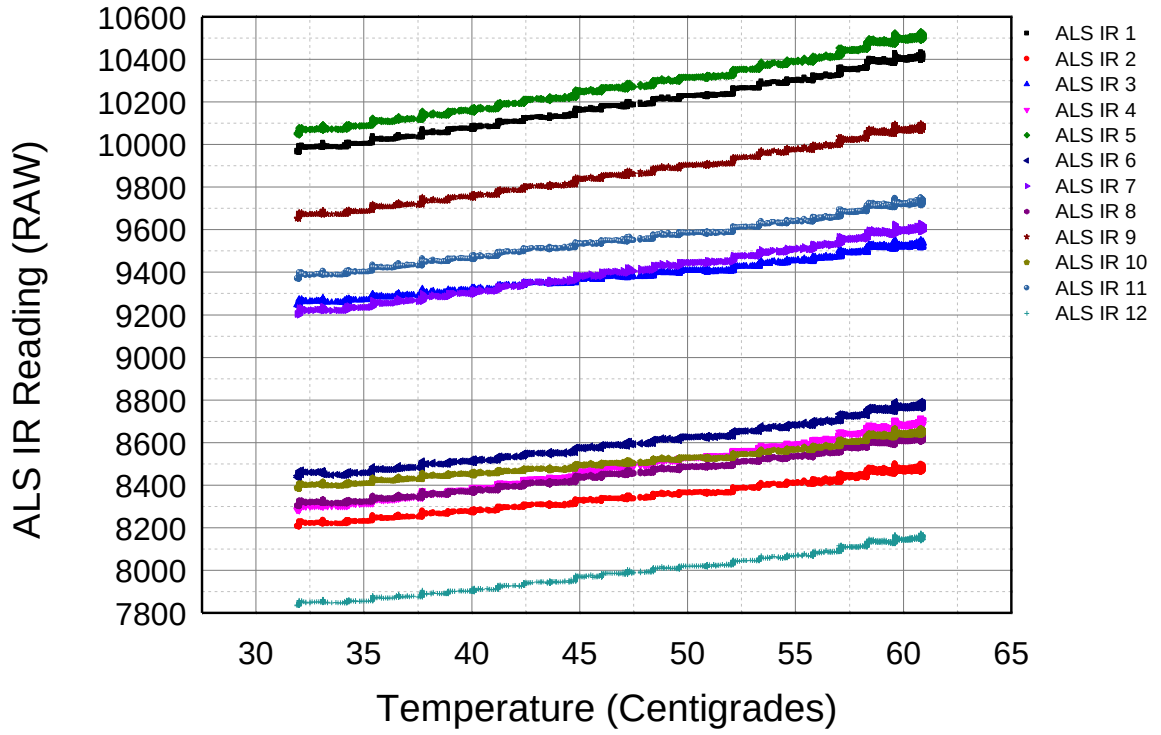
I_0 – light intensity at T_0

$\Delta T = T - T_0$ – temperature difference with reference at T_0

Obtained characteristics and test conditions are presented in figures below:





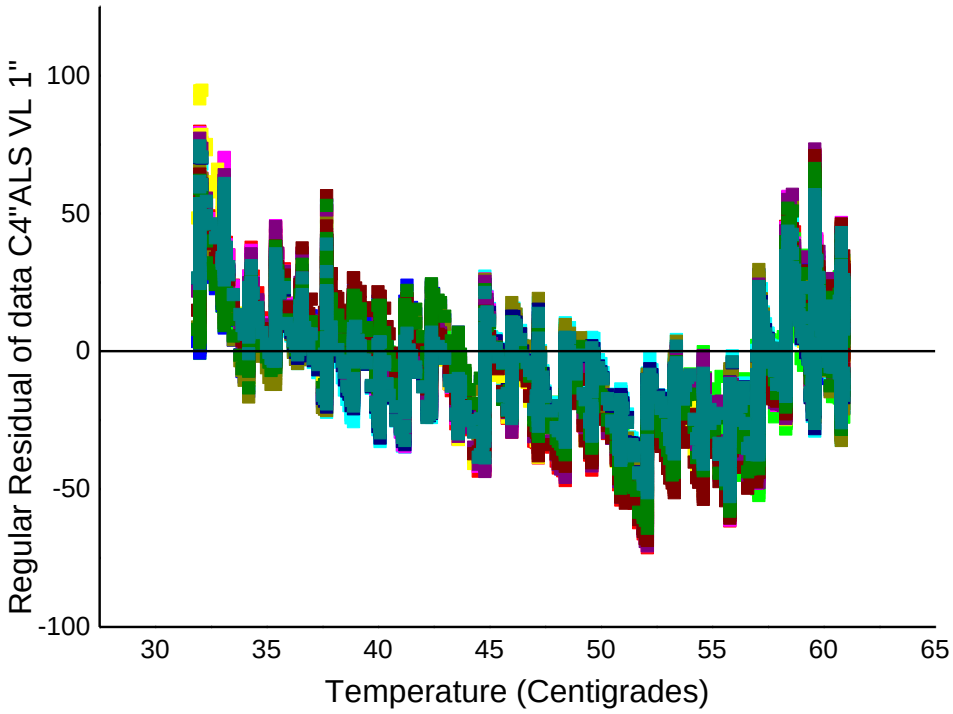


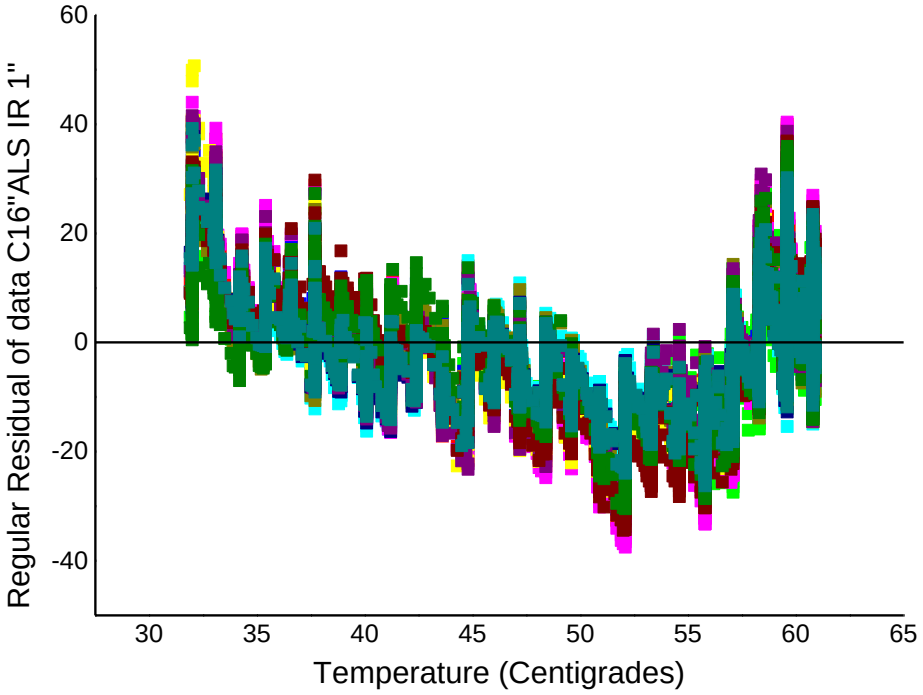
Thremal coefficients for visible light channel.

ALS number	I_0 [LSB]		α [1/°C]		Statistics	
	Value	Std Dev	Value	Std Dev	Reduced Chi.-Square	Adj. R-Square
ALS VL 1	14627.05858	2.25958	0.00241	3.29E-06	751.97567	0.99258
ALS VL 2	13230.6169	1.7563	0.00188	2.75E-06	454.30538	0.99103
ALS VL 3	14503.96614	1.99919	0.00213	2.89E-06	588.64814	0.99245
ALS VL 4	12634.53277	1.81788	0.00266	3.10E-06	486.72037	0.99471
ALS VL 5	14686.61281	2.24088	0.00248	3.26E-06	739.57898	0.99316
ALS VL 6	13339.68567	2.23107	0.00211	3.51E-06	733.12025	0.98871
ALS VL 7	14445.72446	1.94081	0.00245	2.86E-06	554.7737	0.99457
ALS VL 8	12310.72695	1.8332	0.00254	3.19E-06	494.9582	0.99381
ALS VL 9	14873.23785	2.20213	0.00239	3.15E-06	714.22472	0.9931
ALS VL 10	13531.03541	2.23749	0.00196	3.44E-06	737.34457	0.98717
ALS VL 11	14287.82102	1.98062	0.00208	2.90E-06	577.76348	0.99196
ALS VL 12	12024.92428	1.82657	0.00255	3.25E-06	491.38711	0.99358
	AVERAGE		**0.002303**	**0.0002576**		

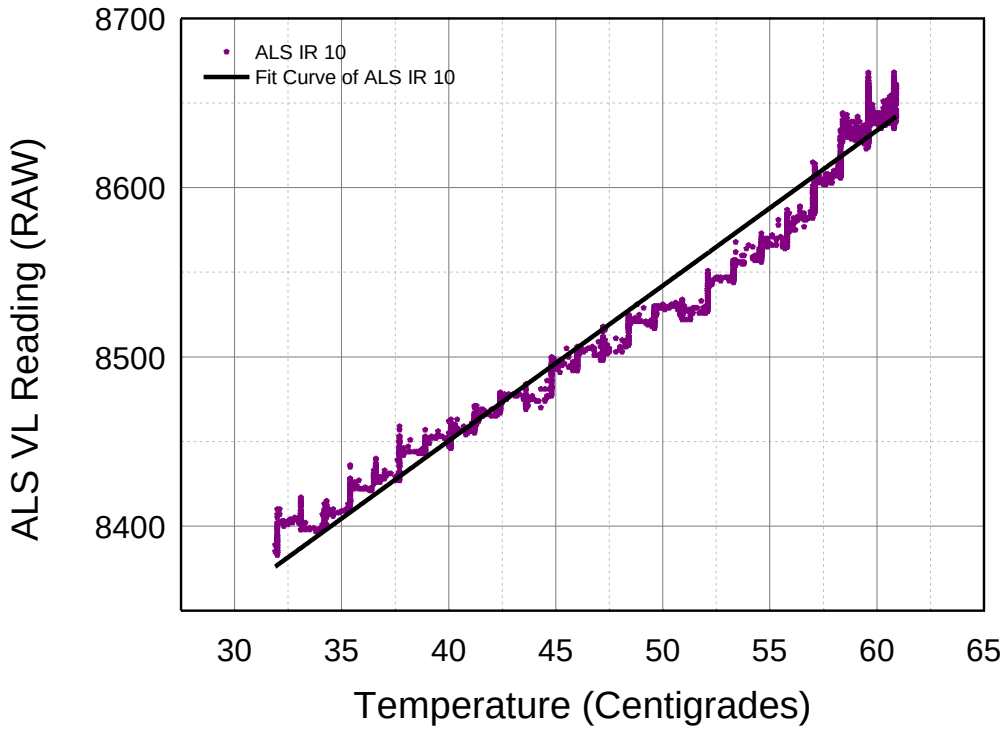
Thremal coefficients for infra-red channel.

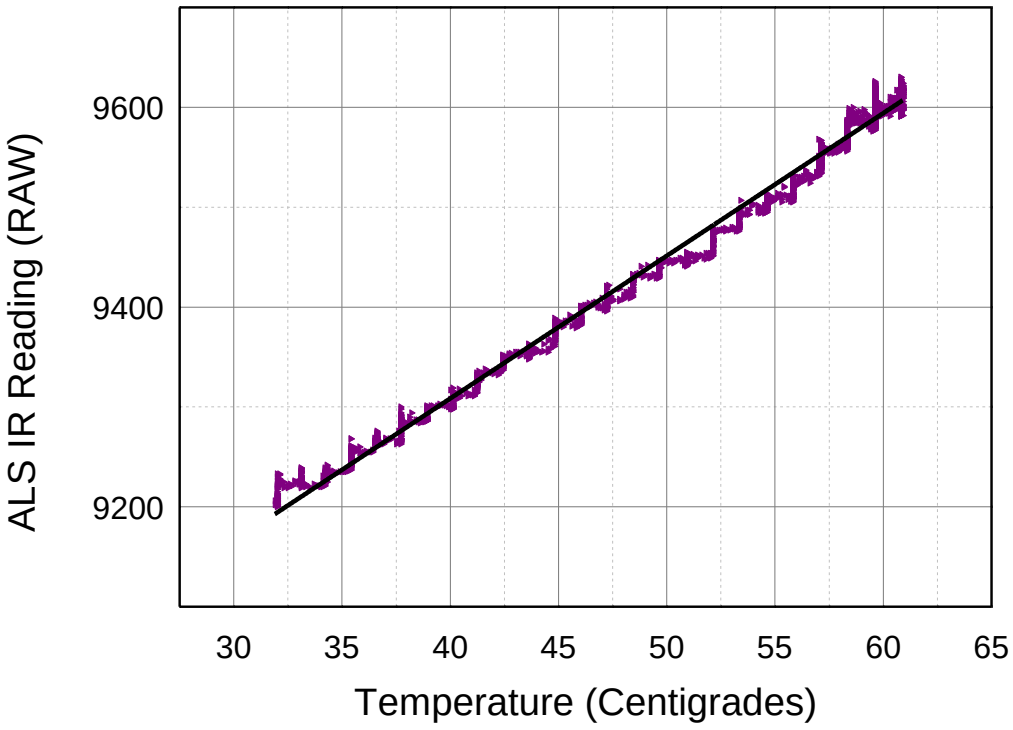
ALS number	I_0 [RAW]		α [1/°C]		Statistics	
	Value	Std Dev	Value	Std Dev	Reduced Chi.-Square	Adj. R-Square
ALS IR 1	9451.43486	1.16153	0.00167	2.52E-06	198.70647	0.99021
ALS IR 2	7898.86001	0.90518	0.0012	2.30E-06	120.67664	0.98372
ALS IR 3	8917.24755	1.04582	0.00113	2.35E-06	161.08656	0.98068
ALS IR 4	7802.85948	0.927	0.00187	2.46E-06	126.56436	0.99275
ALS IR 5	9520.2699	1.23853	0.0017	2.68E-06	225.92438	0.98942
ALS IR 6	8030.158	1.14837	0.00151	2.91E-06	194.22758	0.98404
ALS IR 7	8737.15739	0.98051	0.00163	2.30E-06	141.59805	0.99151
ALS IR 8	7924.3306	0.95685	0.00144	2.45E-06	134.84624	0.98732
ALS IR 9	9155.92778	1.08428	0.00165	2.43E-06	173.15215	0.99077
ALS IR 10	8083.42512	1.173	0.00113	2.90E-06	202.65078	0.97114
ALS IR 11	8969.09842	0.98015	0.00139	2.21E-06	141.49393	0.98892
ALS IR 12	7453.47761	0.92659	0.00154	2.54E-06	126.45029	0.98824
	AVERAGE		**0.001488**	**0.0002383**		





Exemplary characteristics with fitted function:


ALS IR 10
Fit Curve of ALS IR 10
ALS VL Reading (RAW)
8700
8600
8500
8400
30
35
40
45
50
55
60
65
Temperature (Centigrades)


ALS IR Reading (RAW)
9600
9400
9200
30
35
40
45
50
55
60
65
Temperature (Centigrades)