## BOYLE FIRMWARE DOCUMENTATION

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## 1. What does the Firmware do?

# 2. Command sequence for initialization of the PCB hardware and ASIC

## 3. Commands

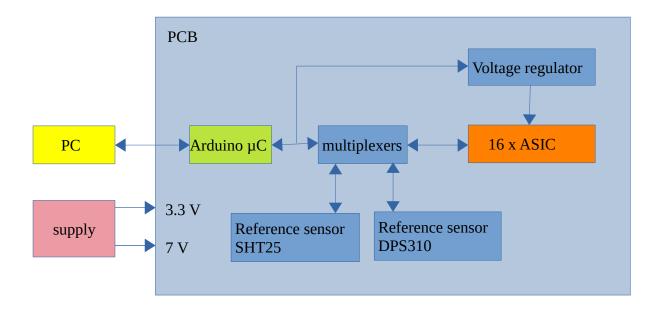
3.1	*IDN?	Ask hardware for identifier
3.2	STOP*	Terminate selftimed mode
3.3	autoscale	Do autoscaling of all internal reference resistors
3.4	measure_pid_t_offset	Calibration of heater PID controller
3.5	read_rref_settings	Read settings of internal reference resistors
3.6	SPS	Delay time between measurements in selftimed mode
3.7	SW	Open/Close hardware switches on the PCB
3.8	GBR	Block read off all ASIC registers
3.9	adc_st_16x	Start ASIC selftimed mode
3.10	r_reg	Read ASIC register
3.11	w_reg_data	Write ASIC registers
3.12	all_heaters_on	Enable all heaters
3.13	all_heaters_off	Disable all heaters
3.14	heater_t_on	On time of heater
3.15	heater_t_off	Off time of heater
3.16	heater_T_high	Heater high temperature
3.17	heater_T_low	Heater low temperature
3.18	heater_toggle_mode	Mode of heater operation
3.19	clean_on	On time of cleaning pulse
3.20	clean_off	Off time of cleaning pulse
3.21	clean_temp	Clean pulse temperature
3.22	clean_shift	Delay of first cleaning pulse to first heater pulse
3.23	dps310_pressure?	Read pressure from reference sensor DPS310
3.24	dps310_temperature?	Read temperature from reference sensor DPS310
3.25	sht25_humidity?	Read humidity from reference sensor SHT25
3.26	sht25_temperature?	Read temperature from reference sensor SHT25
3.27	E6	Set VDD of ASIC
3.28	version?	Read out firmware version
3.29	reference_sensors_enabled	enable reference sensor read out during selftime mode
3.30	reference_sensors_disabled	disable reference sensor read out durin selftime mode
3.31	ref_sens_interval	interval of reference sensor readout
3.32	heater timing recangular	one step between heater T_high and T_low
3.33	heater timing ramp	ramp between heater T_high and T_low
3.34	rising_steps	number of rising steps in heater ramp mode

3.35	falling_steps	number of falling steps in heater ramp mode
3.36	time_per_rising_step	duration of one rising step in heater ramp mode
3.37	time_per_falling_step	duration of one falling step in heater ramp mode

## 1. What does the Firmware do?

The main purpose of the firmware is to communicate with the multigas ASICs and provide an interface via a virtual COM port to the host (PC, raspberry, ...).

### Block diagram of setup:



# 2. Command sequence for initialization of the PCB hardware

Send command	Answer from PCB
SW 1 D	SW 1 13*
E6 00 00	E6*
Wait 100 ms (not a command!)	
E6 0D 00	E6*
con FFFF	connect_to 255 255*

Now send following default values to the ASIC via this command:

```
for (i=0;i<128;i++)
w_reg_data 35 reg value
end
```

i.e.: w\_reg\_data 35  $\frac{19}{80}$   $\rightarrow$  write 0x80 to ASIC register  $\frac{0x19}{80}$ 

reg	value	reg	value	reg	value	reg	value
0	0x00	20	0x00	40	0x03	60	0x00
1	0x00	21	0x60	41	0x00	61	0x00
2	0x00	22	0x80	42	0x00	62	0x00
3	0x00	23	0x00	43	0x00	63	0x00
4	0x00	24	0x25	44	0x00	64	0x00
5	0x00	25	0x05	45	0x00	65	0x00
6	0x00	26	0x00	46	0x00	66	0x00
7	0x00	27	0x00	47	0x00	67	0x00
8	0x00	28	0x64	48	0x00	68	0x00
9	0x00	29	0x00	49	0x00	69	0x80
Α	0x00	2A	0xb8	4A	0x00	6A	0x00
В	0x00	2B	0x0b	4B	0x00	6B	0x00
С	0x00	2C	0x00	4C	0x00	6C	0x00
D	0x00	2D	0x00	4D	0x00	6D	0x00
Ε	0x00	2E	0xd4	4E	0x00	6E	0x00
F	0x00	2F	0xb0	4F	0x00	6F	0x00
10	0x00	30	0xa5	50	0x00	70	0x00
11	0x00	31	0x01	51	0x00	71	0x00
12	0x00	32	0x80	52	0x00	72	0x00
13	0x00	33	0x00	53	0x00	73	0x00
14	0x00	34	0x00	54	0x00	74	0x00
15	0x00	35	0x00	55	0x00	75	0x00
16	0x00	36	0x74	56	0x00	76	0x00
17	0x00	37	0x00	57	0x00	77	0x00
18	0x00	38	0x00	58	0x00	78	0x00
19	0x80	39	0x00	59	0x00	79	0x00
1A	0x02	3A	0x00	5A	0x00	7A	0x00
1B	0x00	3B	0x88	5B	0x00	7B	0x00
1C	0x00	3C	0x7a	5C	0x00	7C	0x00
1D	0x23	3D	0x00	5D	0x00	7D	0x00
1E	0x23	3E	0x00	5E	0x00	7E	0x80
1F	0x09	3F	0x03	5F	0x00	7F	0x00

#### **Description of SW 1:**

It's a I2c controlled switch. U\$8 on the 16x hardware

command	bit	function
SW 1	0	connect multiplexed INT signal to levelshifter for Arduino
SW 1	1	connect multiplexed INT signal to onboard ADC
SW 1	2	not used
SW 1	3	not used
SW 1	4	not used
SW 1	5	not used
SW 1	6	connect multiplexed INT signal to 300k (used for sinking bias current)
SW 1	7	not used

#### 3. Commands

3.1 command: \*IDN? answer: BOYLE\*

Ask hardware for identifier. This command can be used to scan all COM ports for the connected hardware.

3.2 command: **STOP\*** answer: no answer

The stop command is used to terminate the self time mode (adc\_st\_16x)

3.3 command: **autoscale 2000** (2000 = value of external reference resistor) answer: see description below

Do autoscaling of all internal reference resistors

This command will take some seconds to execute! The best internal reference resistors for all channels and all ASICs are chosen automaticly. Also the connected external reference resistor is used to calibrate all the internal reference resistors.

The  $\mu C$  will answer with a string containing all the calibration values for all ASCIs and all internal Rref settings.

A1\_0.5k A1\_1k ... A1\_1024k A2\_0.5k ... A2\_1024k ... A16\_1024k \*\r\n A1\_0.5k  $\rightarrow$  ADC value for Rext\_ref from ASCI1 with an internal Rref of 0.5k A1\_1k  $\rightarrow$  ADC value for Rext\_ref from ASCI1 with an internal Rref of 1k A16\_1024k  $\rightarrow$  ADC value for Rext\_ref from ASCI16 with an internal Rref of 1024k

i.e.: a typical answer will look like this:

32767 32590 16270 8135 4059 2021 1017 507 239 121 56 11 ... \*\r\n

Now the real value of all internal reference resistors can be calculated. With the values, which you get from the "autoscale" command it is possible to calculate the exact resistance of the internal Rrefs (example with Rref\_external = 1k and internal Rref = 2k):

```
int_rref_abs_value_ohm = 32768 / A1_2k * value_of_external_rref;
value of external rref = 2000;
```

A1\_2k is one of the values, which the "autoscale" command is answering.

Absolute value of sensor = ADC\_LSBs / 32768 \* rref\_abs\_value\_ohm

3.4 command: **measure\_pid\_t\_offset** 

answer: 16x value of PID\_T\_OFFSET + ASIC temperature

i.e.: 45056 45056 57344 45056 57344 47104 57344 57344 59392 45056 55296 57344 45056 45056 57344 45056 22.55 \*

This command needs to be executed once to calibrate the heater PID controller. The answer is just for information/debugging. No need for further processing of these values. All necessary stuff is done in the firmware.

3.5 command: read\_rref\_settings

answer: 16 x 5 bytes

Read settings of internal reference resistors.

```
// 5bytes per ASIC are transmitted

// 0x3B = RF2<7:4), RF1<3:0>

// 0x3C = RF4<7:4), RF3<3:0>

// 0x3D = RF6<7:4), RF5<3:0>

// 0x3E = RF8<7:4), RF7<3:0>
```

```
// 0x3F = RT2<7:4), RT1<3:0>
int k = 0;
for(int i=0;i<16;i++)</pre>
  for(int j=0;j<5;j++)</pre>
      selected_rref_for_all_ascics[i][j] = data[k++];
  rref1_index[i] = selected_rref_for_all_ascics[i][0] & 0x0F;
  rref2_index[i] = (selected_rref_for_all_ascics[i][0] & 0xF0) >> 4;
  rref3_index[i] = selected_rref_for_all_ascics[i][1] & 0x0F;
rref4_index[i] = (selected_rref_for_all_ascics[i][1] & 0xF0) >> 4;
  rref5_index[i] = selected_rref_for_all_ascics[i][2] & 0x0F;
  rref6_index[i] = (selected_rref_for_all_ascics[i][2] & 0xF0) >> 4;
  rref7_index[i] = selected_rref_for_all_ascics[i][3] & 0x0F;
  rref8_index[i] = (selected_rref_for_all_ascics[i][3] & 0xF0) >> 4;
  rrefrt1_index[i] = selected_rref_for_all_ascics[i][4] & 0x0F;
  rrefrt2_index[i] = (selected_rref_for_all_ascics[i][4] & 0xF0) >> 4;
}
3.6
      command: SPS xx
                   SPS yy *
      answer:
      xx ... delay time in ms (in hex)
      vy ... delay time in ms (in dec)
      Sets the delay time between measurements in selftimed mode.
      i.e.: SPS 10 \rightarrow \text{delay } 16\text{ms} between measurements
      answer: SPS16* → answer in decimal
3.7
      command:
                   SW \times y
                   SW 11 v *
      answer:
      x y ... switch number and value in hex
      u v ... answer in decimal
      Open/Close hardware switches on the PCB
      i.e.: SW 1 D
      answer: SW 1 13 *
3.8
      command:
                   GBR 35 00
      answer:
                   128 bytes (binary)
      35 = I2C address of ASIC
```

# 00 = start address

Block read off all ASIC registers.

Byte #

O sample counter MSB 1 sample counter MSB 1 sample counter LSB 2 RTEMP LSB 3 RTEMP MSB 4 RSENS_1 LSB 5 RSENS_1 MSB 6 RSENS_2 LSB 7 RSENS_2 MSB 8 RSENS_3 LSB 10 RSENS_3 LSB 11 RSENS_4 MSB 10 RSENS_4 MSB 11 RSENS_4 MSB 11 RSENS_4 MSB 12 RTEMP LSB 13 RTEMP MSB 14 RREF_EXT LSB 15 RREF_EXT LSB 16 ASIC TEMP 0 LSB 17 ASIC TEMP 0 LSB 18 ASIC TEMP 0 LSB 19 ASIC TEMP 1 LSB 20 ASIC TEMP 1 LSB 21 ASIC TEMP 1 LSB 22 humidity MSB 23 humidity LSB 24 pressure LSB 25 pressure CSB 26 pressure RSB 27 temperature MSB 28 temperature LSB 400 RSENS_1 MSB 410 RSENS_1 MSB 411 RSENS_2 LSB 410 RSENS_1 LSB 411 RSENS_2 LSB 412 RSENS_2 MSB 414 RSENS_3 MSB 415 RSENS_1 MSB 416 RSENS_3 MSB 417 RTEMP LSB 418 RTEMP MSB 419 RREF_EXT LSB 410 RSENS_1 MSB 411 RSENS_2 LSB 412 RSENS_2 MSB 414 RSENS_3 MSB 415 RSENS_4 MSB 416 RSENS_4 MSB 417 RTEMP LSB 418 RTEMP MSB 419 RREF_EXT LSB 410 RSERS_1 LSB 411 RSENS_2 LSB 412 RSENS_2 MSB 414 RSENS_3 MSB 415 RSENS_4 LSB 416 RSENS_4 MSB 417 RTEMP LSB 418 RTEMP MSB 419 RREF_EXT LSB 420 RREF_EXT LSB 421 ASIC TEMP 0 LSB 422 ASIC TEMP 0 LSB 423 ASIC TEMP 0 LSB 424 ASIC TEMP 0 LSB 425 ASIC TEMP 0 LSB 426 ASIC TEMP 1 LSB 427 humidity LSB 428 humidity LSB 429 pressure LSB 430 pressure LSB 431 pressure MSB 432 temperature MSB 433 temperature MSB 434 end of data *\r\n\r\n\r\n	registers.	d a a a si mati a m	
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ASIC TEMP 0 MSB  19 ASIC TEMP 1 LSB ASIC TEMP 1 CSB ASIC TEMP 1 MSB DESCRIPTION OF THE MODE. THE			Start ASIC
ASIC TEMP 1 LSB ASIC TEMP 1 CSB ASIC TEMP 1 MSB Thumidity MSB ASIC TEMP 1 MSB Thumidity LSB Thumidit			selftimed
ASIC TEMP 1 CSB ASIC TEMP 1 MSB  The mode can be stopped with the "STOP*"  ASIC TEMP 1 MSB  ASIC TEMP 1 MSB  The mode can be stopped with the "STOP*"  The table below is showing the structure and order of the bytes.  The table below is showing the structure and order of the bytes.  The table below is showing the structure and order of the bytes.			
ASIC TEMP 1 MSB  humidity MSB humidity LSB pressure LSB pressure CSB pressure MSB temperature MSB temperature LSB  The total 435 bytes are transmitted for every measurement cycle.  The table  RSENS_1 MSB RSENS_1 LSB RSENS_2 LSB RSENS_3 LSB RSENS_3 LSB RSENS_3 LSB RSENS_3 LSB RSENS_4 MSB RSENS_4 MSB RSENS_4 MSB RSENS_4 MSB RSENS_4 MSB RSENS_4 MSB RSEMP MSB RSENS_4 MSB RSEMP MSB ASIC TEMP LSB RSENS_4 MSB RSEMS_4			
humidity MSB stopped with the "STOP*" pressure LSB pressure CSB pressure MSB temperature MSB temperature LSB  The total 435 bytes are transmitted for every measurement expenses and stopped with the "STOP*"  The table temperature LSB for every measurement expenses are transmitted for every measurement expenses are expenses are transmitted for every measurement expenses are transmitted for every meas			mode can be
humidity LSB pressure LSB pressure CSB pressure CSB pressure MSB pressure MSB pressure MSB Temperature LSB  In total 435 bytes are transmitted for every pressure MSB pressure LSB  In total 435 bytes are transmitted for every pressure LSB  In total 435 bytes are transmitted for every pressure LSB pressure MSB			stopped with
pressure LSB pressure CSB pressure CSB pressure MSB temperature MSB temperature LSB  The total 435 bytes are transmitted for every for e	23	humidity LSB	11
26 pressure MSB 27 temperature MSB 28 temperature LSB  407 RTEMP LSB 408 RTEMP MSB 409 RSENS_1 LSB 410 RSENS_1 LSB 411 RSENS_2 LSB 412 RSENS_2 LSB 413 RSENS_3 LSB 414 RSENS_3 LSB 415 RSENS_4 LSB 416 RSENS_4 LSB 417 RTEMP LSB 418 RTEMP MSB 419 RREF_EXT LSB 420 RREF_EXT LSB 420 RREF_EXT MSB 421 ASIC TEMP 0 LSB 422 ASIC TEMP 0 CSB 423 ASIC TEMP 0 CSB 424 ASIC TEMP 1 LSB 425 ASIC TEMP 1 CSB 426 ASIC TEMP 1 MSB 427 humidity MSB 428 humidity LSB 429 pressure LSB 430 pressure CSB 431 pressure MSB 432 temperature MSB 433 temperature LSB	24	pressure LSB	_
temperature MSB temperature LSB  temperature LSB  temperature LSB  bytes are transmitted  for every  for every  for every  for every  for every  measurement  cycle.  The table  below is  showing the  structure and  order of the  bytes.  for every  measurement  cycle.  The table  below is  showing the  structure and  order of the  bytes.	25	pressure CSB	command
bytes are transmitted for every for evere for evere for every fore			
bytes are transmitted for every measurement self-self-self-self-self-self-self-self-			In total 435
407 RTEMP LSB 408 RTEMP MSB 409 RSENS_1 LSB 410 RSENS_1 MSB 411 RSENS_2 LSB 412 RSENS_2 MSB 413 RSENS_3 LSB 414 RSENS_3 MSB 415 RSENS_4 LSB 416 RSENS_4 MSB 417 RTEMP LSB 418 RTEMP MSB 419 RREF_EXT LSB 420 RREF_EXT LSB 420 RREF_EXT MSB 421 ASIC TEMP 0 LSB 422 ASIC TEMP 0 CSB 423 ASIC TEMP 0 CSB 424 ASIC TEMP 1 LSB 425 ASIC TEMP 1 LSB 426 ASIC TEMP 1 MSB 427 humidity MSB 428 humidity LSB 429 pressure LSB 430 pressure CSB 431 pressure MSB 432 temperature MSB 433 temperature LSB	28	temperature LSB	
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408 RTEMP MSB 409 RSENS_1 LSB 410 RSENS_1 MSB 411 RSENS_2 LSB 412 RSENS_2 MSB 413 RSENS_3 LSB 414 RSENS_3 MSB 415 RSENS_4 LSB 416 RSENS_4 MSB 417 RTEMP LSB 418 RTEMP MSB 419 RREF_EXT LSB 420 RREF_EXT LSB 420 RREF_EXT MSB 421 ASIC TEMP 0 LSB 422 ASIC TEMP 0 CSB 423 ASIC TEMP 0 CSB 424 ASIC TEMP 1 LSB 425 ASIC TEMP 1 LSB 426 ASIC TEMP 1 MSB 427 humidity MSB 428 humidity LSB 429 pressure LSB 430 pressure CSB 431 pressure MSB 432 temperature LSB	407	DTEMPICE	transmitted
409 RSENS_1 LSB 410 RSENS_1 MSB 411 RSENS_2 LSB 412 RSENS_2 MSB 413 RSENS_3 LSB 414 RSENS_3 MSB 415 RSENS_4 LSB 416 RSENS_4 MSB 417 RTEMP LSB 418 RTEMP MSB 419 RREF_EXT LSB 420 RREF_EXT LSB 420 RREF_EXT MSB 421 ASIC TEMP 0 LSB 422 ASIC TEMP 0 CSB 423 ASIC TEMP 0 CSB 424 ASIC TEMP 1 LSB 425 ASIC TEMP 1 LSB 426 ASIC TEMP 1 MSB 427 humidity MSB 428 humidity LSB 429 pressure LSB 430 pressure CSB 431 pressure MSB 432 temperature LSB			for every
410 RSENS_1 MSB 411 RSENS_2 LSB 412 RSENS_2 MSB 413 RSENS_3 LSB 414 RSENS_3 LSB 415 RSENS_4 LSB 416 RSENS_4 LSB 417 RTEMP LSB 418 RTEMP MSB 419 RREF_EXT LSB 420 RREF_EXT LSB 420 RREF_EXT MSB 421 ASIC TEMP 0 LSB 422 ASIC TEMP 0 CSB 423 ASIC TEMP 1 LSB 424 ASIC TEMP 1 CSB 425 ASIC TEMP 1 CSB 426 ASIC TEMP 1 MSB 427 humidity MSB 428 humidity LSB 429 pressure LSB 430 pressure CSB 431 pressure MSB 432 temperature MSB 433 temperature LSB			<del>-</del>
411 RSENS_2 LSB  412 RSENS_2 MSB  413 RSENS_3 LSB  414 RSENS_3 MSB  415 RSENS_4 LSB  416 RSENS_4 MSB  417 RTEMP LSB  418 RTEMP MSB  420 RREF_EXT LSB  420 RREF_EXT MSB  421 ASIC TEMP 0 LSB  422 ASIC TEMP 0 CSB  423 ASIC TEMP 1 LSB  424 ASIC TEMP 1 CSB  425 ASIC TEMP 1 CSB  426 ASIC TEMP 1 MSB  427 humidity MSB  428 humidity LSB  429 pressure LSB  430 pressure CSB  431 pressure MSB  432 temperature MSB  433 temperature LSB			
### RSENS_2 MSB ### RSENS_3 LSB ### RSENS_3 LSB ### RSENS_3 LSB ### Below is ### be			cycle.
413 414 RSENS_3 MSB 414 RSENS_4 LSB 415 RSENS_4 LSB 416 RSENS_4 MSB 417 RTEMP LSB 418 RTEMP MSB 419 RREF_EXT LSB 420 RREF_EXT MSB 421 ASIC TEMP 0 LSB 422 ASIC TEMP 0 CSB 423 ASIC TEMP 1 LSB 424 ASIC TEMP 1 CSB 425 ASIC TEMP 1 CSB 426 ASIC TEMP 1 MSB 427 humidity MSB 428 humidity LSB 429 pressure LSB 430 pressure CSB 431 pressure MSB 432 temperature MSB 433 temperature LSB			The table
415  RSENS_4 LSB  416  RSENS_4 MSB  417  RTEMP LSB  418  RTEMP MSB  419  RREF_EXT LSB  420  RREF_EXT MSB  421  ASIC TEMP 0 LSB  422  ASIC TEMP 1 LSB  425  ASIC TEMP 1 CSB  426  ASIC TEMP 1 MSB  427  humidity MSB  428  humidity LSB  429  pressure LSB  430  pressure CSB  431  pressure MSB  432  temperature MSB  433  temperature LSB	413	_	
416 RSENS_4 MSB 417 RTEMP LSB 418 RTEMP MSB ATTEMP OF LSB ATTEMP	414	RSEN\$_3 MSB	
417 RTEMP LSB 418 RTEMP MSB order of the 419 RREF_EXT LSB bytes. 420 RREF_EXT MSB 421 ASIC TEMP 0 LSB 422 ASIC TEMP 0 CSB 423 ASIC TEMP 1 LSB 424 ASIC TEMP 1 LSB 425 ASIC TEMP 1 LSB 426 ASIC TEMP 1 MSB 427 humidity MSB 428 humidity LSB 429 pressure LSB 430 pressure CSB 431 pressure MSB 432 temperature MSB 433 temperature LSB	415	RSENS_4 LSB	showing the
417 418 RTEMP LSB ATEMP MSB Order of the bytes.  419 RREF_EXT LSB Bytes.  420 RREF_EXT MSB ASIC TEMP 0 LSB ASIC TEMP 0 CSB ASIC TEMP 0 MSB ASIC TEMP 1 LSB ASIC TEMP 1 LSB ASIC TEMP 1 LSB ASIC TEMP 1 MSB ASI	416	RSENS_4 MSB	structure and
419 RREF_EXT LSB bytes.  420 RREF_EXT MSB  421 ASIC TEMP 0 LSB  422 ASIC TEMP 0 MSB  423 ASIC TEMP 1 LSB  424 ASIC TEMP 1 LSB  425 ASIC TEMP 1 MSB  426 ASIC TEMP 1 MSB  427 humidity MSB  428 humidity LSB  429 pressure LSB  430 pressure CSB  431 pressure MSB  432 temperature MSB  433 temperature LSB			
420 RREF_EXT MSB 421 ASIC TEMP 0 LSB 422 ASIC TEMP 0 CSB 423 ASIC TEMP 0 MSB 424 ASIC TEMP 1 LSB 425 ASIC TEMP 1 CSB 426 ASIC TEMP 1 MSB 427 humidity MSB 428 humidity LSB 429 pressure LSB 430 pressure CSB 431 pressure MSB 432 temperature MSB 433 temperature LSB			
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422 ASIC TEMP 0 CSB 423 ASIC TEMP 0 MSB 424 ASIC TEMP 1 LSB 425 ASIC TEMP 1 CSB 426 ASIC TEMP 1 MSB 427 humidity MSB 428 humidity LSB 429 pressure LSB 430 pressure CSB 431 pressure MSB 432 temperature MSB 433 temperature LSB		<del>-</del>	
ASIC TEMP 0 MSB  ASIC TEMP 1 LSB  ASIC TEMP 1 CSB  ASIC TEMP 1 MSB  ASIC TEMP 1 LSB  ASIC TEMP 0 MSB  ASIC TEMP 0 MSB  ASIC TEMP 0 MSB  ASIC TEMP 1 LSB			
424 ASIC TEMP 1 LSB 425 ASIC TEMP 1 CSB 426 ASIC TEMP 1 MSB 427 humidity MSB 428 humidity LSB 429 pressure LSB 430 pressure CSB 431 pressure MSB 432 temperature MSB 433 temperature LSB			
425 ASIC TEMP 1 CSB 426 ASIC TEMP 1 MSB 427 humidity MSB 428 humidity LSB 429 pressure LSB 430 pressure CSB 431 pressure MSB 432 temperature MSB 433 temperature LSB			
426 ASIC TEMP 1 MSB 427 humidity MSB 428 humidity LSB 429 pressure LSB 430 pressure CSB 431 pressure MSB 432 temperature MSB 433 temperature LSB			
<ul> <li>427 humidity MSB</li> <li>428 humidity LSB</li> <li>429 pressure LSB</li> <li>430 pressure CSB</li> <li>431 pressure MSB</li> <li>432 temperature MSB</li> <li>433 temperature LSB</li> </ul>			
<ul> <li>429 pressure LSB</li> <li>430 pressure CSB</li> <li>431 pressure MSB</li> <li>432 temperature MSB</li> <li>433 temperature LSB</li> </ul>			
<ul> <li>430 pressure CSB</li> <li>431 pressure MSB</li> <li>432 temperature MSB</li> <li>433 temperature LSB</li> </ul>	428	humidity LSB	
<ul> <li>431 pressure MSB</li> <li>432 temperature MSB</li> <li>433 temperature LSB</li> </ul>	429	•	
432 temperature MSB 433 temperature LSB		-	
433 temperature LSB			
434 end of data *\r\n\r\n			
	434	end of data *\r\n\r\n	

```
yy *
      answer:
      xx ... register address (in hex)
      35 ... I2C address of ASIC
      Read ASIC register content.
                   r_reg 35 18 \rightarrow read register 0x18
      i.e.:
                   10 *
      answer:
3.11 command: w_reg_data 35 xx yy
                  w reg data 35 uu vv *
      answer:
      xx ... register address (in hex)
      yy ... register value (in hex)
      uu ... register address (in dec)
      vv ... register value (in dec)
      35 ... I2C address of ASIC
      Write ASIC registers.
      i.e.:
                   w reg data 35 18 0A
                                                  write 0x0A to register 0x18
                   w reg data 53 24 10 *
      answer:
3.12 command: all_heaters_on
                   all heaters on *
      answer:
      Enable all heaters in self timed mode.
                   all_heaters_off
3.13 command:
                   all_heaters_off *
      answer:
      Disable all heaters during self timed mode.
                   heater t on xx
      command:
                   heater t on yy *
      answer:
      xx ... heater on time in units of 100ms (in hex)
```

yy ... heater on time in units of 100ms (in dec)

On time of heater. See 3.31 heater timing diagram.

3.14

3.15 command: heater\_t\_off xx answer: heater\_t\_off yy \*

xx ... heater off time in units of 100ms (in hex) yy ... heater off time in units of 100ms (in dec)

Off time of heater. See 3.31 heater timing diagram.

3.16 command: heater\_T\_high xx answer: heater\_T\_high yy \*

```
xx ... heater high temperature in °C (in hex)
yy ... (xx - rtemp_t_offset_calib_temp)/2 (in dec)
```

Heater high temperature. To achieve absolute temperature accuracy, the heater PID loop needs to be calibrated with "measure\_pid\_t\_offset" command before.

**rtemp\_t\_offset\_calib\_temp:** This value is stored by the measure\_pid\_t\_offset routine. The divided by 2 in the return value is needed, because the ASIC register for the target temperature only takes values in units of 2°. The return value is the real value in the ASIC register. See 3.31 heater timing diagram.

3.17 command: heater\_T\_low xx answer: heater T low vy \*

```
xx ... heater low temperature in °C (in hex)
yy ... (xx - rtemp_t_offset_calib_temp)/2 (in dec)
```

Heater low temperature. To achieve absolute temperature accuracy, the heater PID loop needs to be calibrated with "measure\_pid\_t\_offset" command before.

**rtemp\_t\_offset\_calib\_temp:** This value is stored by the measure\_pid\_t\_offset routine. The divided by 2 in the return value is needed, because the ASIC register for the target temperature only takes values in units of 2°. The return value is the real value in the ASIC register. See 3.31 heater timing diagram.

3.18 command: heater\_toggle\_mode xx answer: heater\_toggle\_mode yy \*

xx ... heater toggle mode

### yy ... heater toggle mode

Mode of heater operation.

heater_toggle_mode	description
0	no automatic toggling in self timed mode
1	heater is toggled between T_high and heater off
2	heater is toggled between T_high and T_low

3.19 command: clean\_on xx answer: clean\_on yy \*

xx ... on time of the cleaning pulse in units of 100ms(hex) yy ... on time of the cleaning pulse in units of 100ms(dec)

On time of cleaning pulse. See 3.31 heater timing diagram. If clean\_on time is set to zero, the cleaning pulse feature is disbled.

3.20 command: clean\_off xx answer: clean\_off yy \*

xx ... off time of the cleaning pulse in units of 100ms(hex) yy ... off time of the cleaning pulse in units of 100ms(dec)

Off time of cleaning pulse. See 3.31 heater timing diagram.

3.21 command: clean\_temp xx answer: clean\_temp yy\*

xx ... cleaning pulse temperature (hex)
yy ... (xx - rtemp\_t\_offset\_calib\_temp)/2 (in dec)

Heater cleaning temperature. To achieve absolute temperature accuracy, the heater PID loop needs to be calibrated with "measure\_pid\_t\_offset" command before. See 3.31 heater timing diagram.

**rtemp\_t\_offset\_calib\_temp:** This value is stored by the measure\_pid\_t\_offset routine. The divided by 2 in the return value is needed, because the ASIC register for the target temperature only takes values in units of 2°. The return value is the real value in the ASIC register.

3.22 command: **clean\_shift xx** 

answer: clean\_shift yy \*

xx ... shift of the cleaning pulse to the heater pulse (hex) yy ... shift of the cleaning pulse to the heater pulse (dec)

Delay of first cleaning pulse to first heater pulse. See 3.31 heater timing diagram.

3.23 command: dps310\_pressure?

answer: xx\*

xx ... pressure in Pascal (dec)

Read pressure from reference sensor DPS310

3.24 command: dps310\_temperature?

answer: xx\*

xx ... temperature in °C (dec)

Read temperature from reference sensor DPS310

3.25 command: sht25\_humidity?

answer: xx\*

xx ... humidity in RH% (dec)

Read humidity from reference sensor SHT25

3.26 command: sht25\_temperature?

answer: xx\*

xx ... temperature in °C (dec)

Read temperature from reference sensor SHT25

3.27 command: **E6** 

answer: E6\*

xx ... ASIC VDD in mV MSB (hex) yy ... ASIC VDD in mV LSB (hex)

Set VDD of ASIC.

i.e.: E6 0D 00  $\rightarrow$  0x0D00 = 3328 mV

3.28 command: **version?** 

Answer: 1.4.2020 \* (i.e.)

Read out firmware version

3.29 command: reference\_sensors\_enabled reference\_sensors\_enabled\*

Enable reference sensor read out during selftime mode.

Since the readout of the reference sensors during self timed mode takes quite some time, the user can choose, if they should be read out or not. This command is enabling it.

3.30 command: **reference\_sensors\_disabled** reference\_sensors\_disabled\*

Disable reference sensor read out durin selftime mode.

Since the readout of the reference sensors during self timed mode takes quite some time, the user can choose, if they should be read out or not. This command is enabling it.

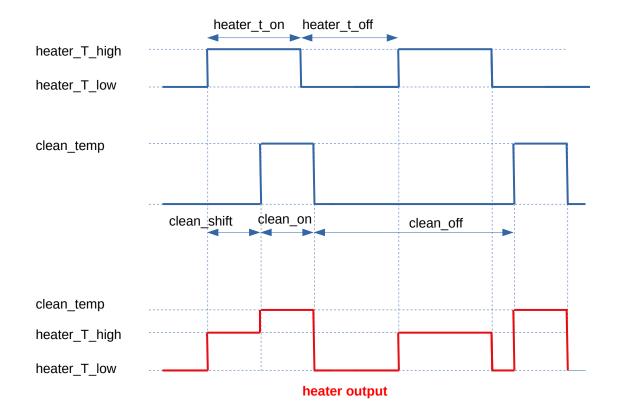
3.31 command: ref\_sens\_interval xx answer: ref\_sens\_interval \*

xx ... interval of reference sensors readout (hex) yy ... interval of reference sensors readout (dec)

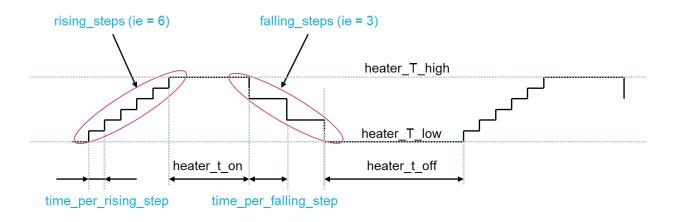
The reference sensors can be read out during selftimed mode if the command **reference\_sensors\_enabled** was sent. The period of the readout can be set by **ref\_sens\_interval**. Unit are samples.

i.e.: ref\_sens\_interval 64 (hex)  $\rightarrow$  measure reference sensor after every 100<sup>th</sup> ASIC sample.

#### 3.32 Heater timing diagram (no ramp)



### 3.33 Heater timing diagram (with additional ramp parameters)



Cleaning pulse can also be added additionaly like in standard rectangular operation (see 3.32)

3.34 command: rising\_steps xx answer: rising\_steps yv \*

xx ... number of rising steps in heater ramp mode (in hex) yy ... number of rising steps in heater ramp mode (in dec)

Number of rising steps in heater ramp mode. If set to zero, ramping for rising edge is disabled.

3.34 command: **falling\_steps xx** answer: falling\_steps yy \*

xx ... number of falling steps in heater ramp mode (in hex) yy ... number of falling steps in heater ramp mode (in dec)

Number of falling steps in heater ramp mode. If set to zero, ramping for falling edge is disabled.

3.35 command: **time\_per\_rising\_step xx** answer: time\_per\_rising\_step yy \*

xx ... time per rising step in units of 100ms (in hex) yy ... time per rising step in units of 100ms (in dec)

Time per rising step in heater ramp mode.

3.36 command: time\_per\_falling\_step xx answer: time\_per\_falling\_step yy \*

xx ... time per falling step in units of 100ms (in hex) yy ... time per falling step in units of 100ms (in dec)

Time per falling step in heater ramp mode.