SensMat Particle Sensor

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Chapter 1

SensMat Particle Sensor <!-- omit in toc -->

1.1 Description

This is the documentation for the SensMat Particle Sensor software, which runs on the STM32L476RGT6 microcontroller.

1.1.1 Features

- Particulate matter measurement using the `Sensirion SensorSPS30` sensor
- Ambient temperature, relative humidity and pressure measurement using the `Bosch Sensortec SensorBME280` sensor
- Battery operated (operation time depending on measurement frequency: More than 2 months at a measurement interval of 15 minutes)
- On-board battery charger
- Logging of measurement data to micro SD card
- LoRa module to upload data via Smartmote gateway to SensMat cloud
- USB serial interface for configuration and calibration

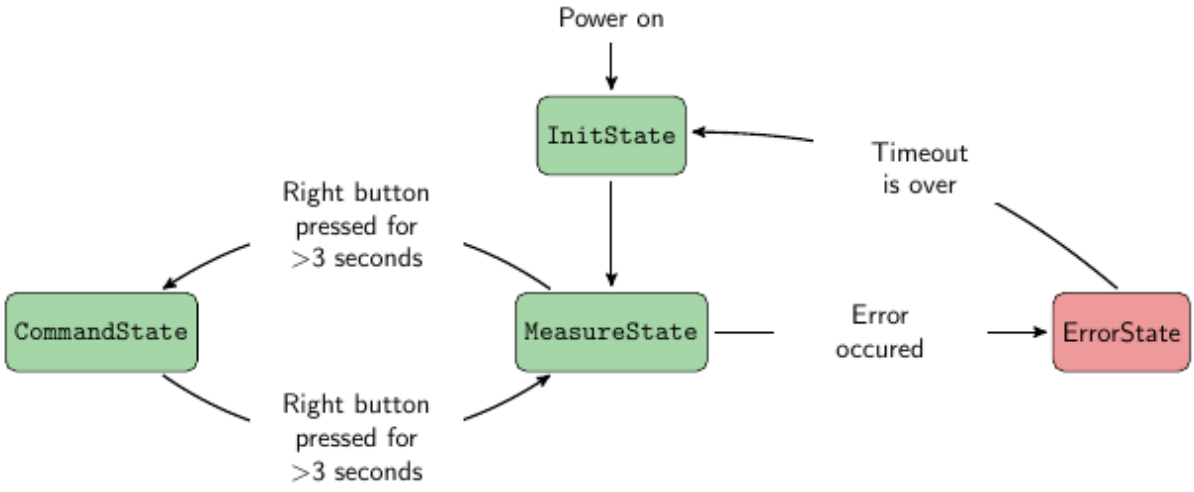
1.1.2 Documentation

The source code documentation can be built with `doxygen` by executing `doxygen Doxyfile` in the folder `SensMat/Software/Particle_Sensor`. This will create the html documentation in the folder `SensMat/Software/Particle_Sensor/doc/html/`.

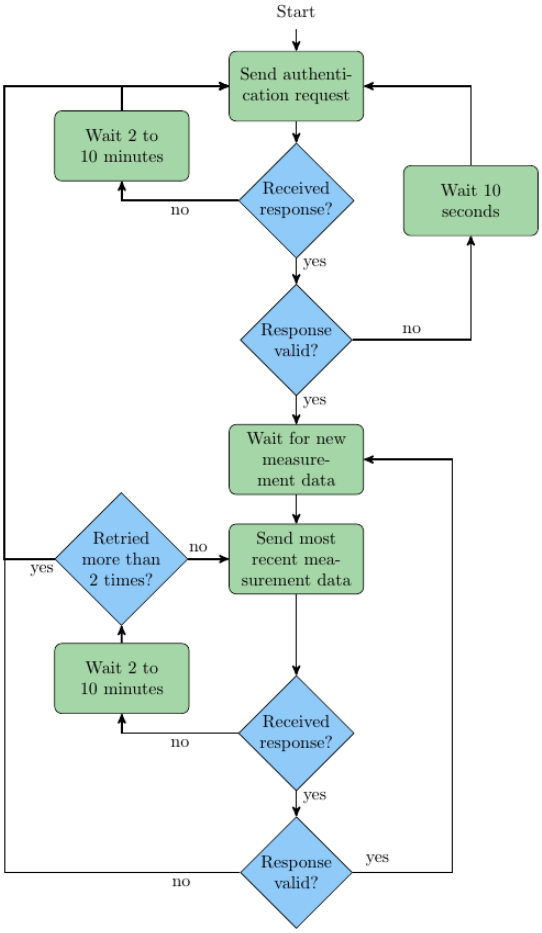
To create a PDF file from the LaTeX sources the program `pdflatex` is needed. Then execute `make` in `SensMat/Software/Particle_Sensor/doc/latex/` which compiles the documentation to a PDF named `refman.pdf`.

1.1.3 Program Flow Chart

The application uses two threads. The main thread implements a simple state machine with four states and the following transitions:



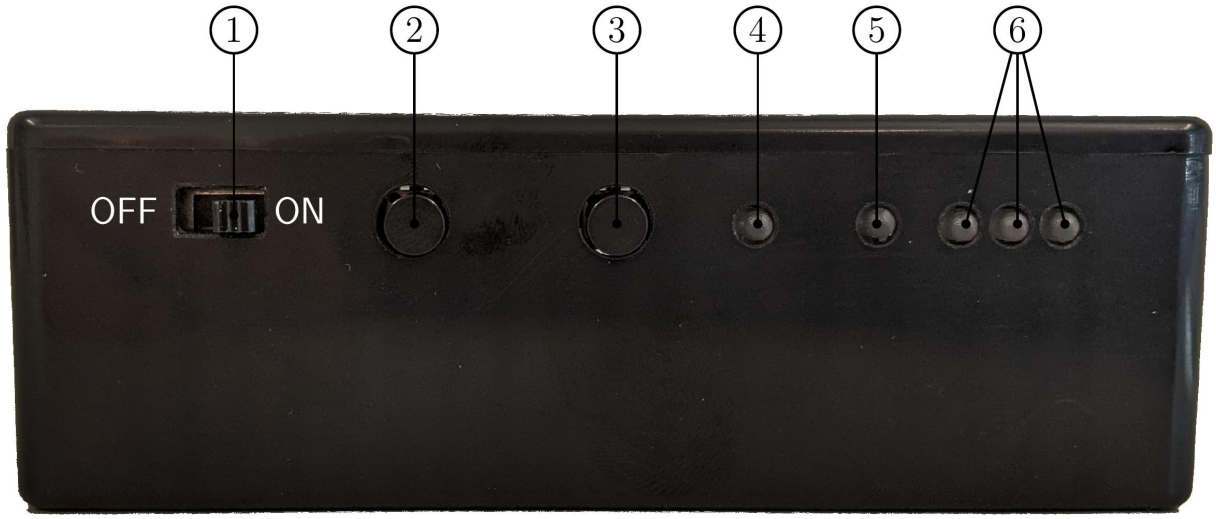
In a second thread, which is started in the InitState of the main thread, the LoRa communication is handled accoring to the protocol specification from SensMat:



1.2 Usage

NOTE:
The device is not waterproof and should therefore only be placed indoors or at a weatherproof location. Placing it in direct sunlight can lead to measurement deviations due to the black enclosure.

1.2.1 Interfaces



1. **Power switch** to turn the power supply on and off
2. **Button** to manually start a single measurement
3. **Button** to display the status and battery charge level for 3 seconds
4. **Status LED** indicating the status of the program (green => no error, red => error)
5. **Charge LED** which indicates if the battery is charging or not
6. **Battery level LEDs** indicating the battery status
7. **SD card slot** for a micro SD card to store measurement data and log data
8. **Micro USB connector** to configure the particle sensor using a PC
9. **Power connector** to connect the power adapter (9-22V) to for battery charging

1.2.2 Starting the sensor

1. Make sure that the gateway is running.
2. Switch on the power supply by setting the power switch to ON (to the right).
3. The status LED lights up orange for a while during the start-up process.
4. As soon as the status LED turns green for 3 seconds, the sensor starts reporting measurement data.
5. Optional: By pressing the right button, the status of the sensor (status LED: green => no error; red => error) and the battery level (all battery LEDs green => full; all LEDs off => low/empty) are shown for 3 seconds.
6. Optional: By pressing the left button, a single measurement can be started.

1.2.3 Charging the sensor

1. Switch off the power by setting the power switch to OFF (to the left).
2. Connect the power adapter to the power connector. The charging process will start immediately.
3. While charging, the charge LED is orange. The charging time is approximately 3 hours.
4. As soon as the charge LED turns off, the battery is fully charged and the power adapter can be unplugged and the sensor can be started again.

1.2.4 SD card logging

If logging of measurment data is enabled in the configuration, the raw measurements are stored as CSV file on the microSD card. Every 24 hours, a new file is created.

At each start of the partcle sensor, a log file is created which logs events from the application according to the configured log level. This file should help to debug the firmware.

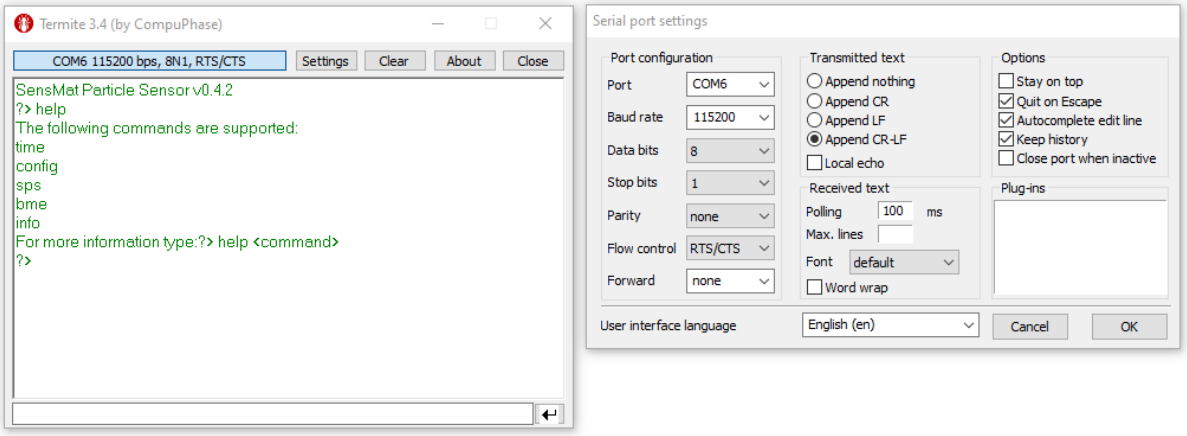
1.2.5 USB serial command interface

The USB interface can be used to configure several parameters of the particle sensor, to set and calibrate the RTC, to read version numbers or to test the sensors.

To access it, the following steps are necessary:

1. Turn on the particle sensor and wait until the status LED is green or off.
2. Press the right button (status button) for more than 3 seconds.
3. After releasing the button, the status LED is orange, indicating that the particle sensor is in the command state.
4. Connect the particle sensor with a micro USB cable to a PC.
5. Open a serial terminal (e.g. `Termite`) at the PC and connect to the right port. The settings for the serial connection are visible in the screenshot below these steps.
6. You should receive something like `SensMat Particle Sensor v0.4.2` and in the following line `?>`, as shown in the figure below.

7. Send `help` to see the supported commands and `help <command name>` to see the usage information for a specific command.
8. To conveniently execute multiple commands in a sequence, the python script `scripts/configure.py` may help.



1.2.5.1 Supported commands

In the following, all supported commands are listed, including a description how to use them.

1.2.5.1.1 help This command prints all supported commands in a list. To view the command description for a specific command, type: `help <command name>`. E.g. for the `time`-command: `help time`

1.2.5.1.2 time `Usage: time [OPTIONS]`

```
Options:
    <none>                      Print current time
    set YYYY-MM-DD HH:MM:SS     Set time in specified format
    tick <num_ticks>            Print for <num_ticks> seconds every time, the RTC second counter toggles,
                                the amount of passed seconds. Used to measure RTC time drift.
    calibrate <milliseconds>    Calibrate the RTC by sending the time drift per day in milliseconds
```

1.2.5.1.3 config `Usage: config [OPTIONS]`

```
Options:
    <none>          Print current configuration
    <name>=<value>  Set the configuration parameter <name> to the given <value>.
                    Multiple parameters can be set in one command by seperating key-value-pairs with spaces.
```

1.2.5.1.4 sps `Usage: sps COMMAND`

```
Commands:
    on          Enable SPS30 power supply
    off         Disable SPS30 power supply
    probe       Perform probe, to check if SPS30 is responding
    serial      Print serial number
    version     Print version numbers for firmware, SHDLC and hardware
    start       Start measurement procedure
    stop        Stop measurement procedure
    read        Read measurement values from sensor
    clean       Start fan cleaning (only works after "sps start")
```

1.2.5.1.5 bme `Usage: bme COMMAND`

```
Commands:
    init    Initialize SensorBME280
    read    Read measurement values from sensor
```

1.2.5.1.6 info `Usage: info`

`Print software version and UUIDs`

1.2.5.2 RTC Calibration and Settings

The time can be set manually via the USB serial interface using the `time` command.
But it is more convenient to do it by using the python script `scripts/rtc_tool.py`, which can set the RTC to the current date and time. `rtc_tool.py` can also calibrate the RTC to be more accurate.

1.3 Development

The software is based on `Arm Mbed OS 6`, which is a RTOS for embedded systems and it includes many drivers and stacks.

For building and configurint this Arm Mbed OS project, the code management tool mbed-cli is used.

1.3.1 Preparations

- For this project, `git` is used as version control system (VCS), which needs to be installed.
- To use the software, clone the SensMat repository from git.tugraz.at:
  `git clone ssh://git@git.tugraz.at/SensMat.git`
- Change into the directory of the Particle Sensor Software:
  `cd SensMat/Software/Particle_Sensor`
- Since mbed-os and other libraries are included as git submodules in the repository, it is necessary to download (update) the submodules:
  `git submodule update --init --recursive`
- Check if the Arm Mbed OS version in the submodule mbed-os is 6.4.0 or higher by typing:
  `git submodule` which will print something like:
  `8ef0a435b2356f8159dea8e427b2935d177309f8 mbed-os (mbed-os-6.4.0)`
- If another version is shown, check out version 6.4.0 with `git checkout mbed-os-6.4.0` in the folder `Software/Framework/mbed-os`
- In the projects root folder, a git patch (`mbed-os.patch`) for the mbed-os submodule is included, which should be applied with `git apply ../../Particle_Sensor/mbed-os.patch` in the folder `Software/Framework/mbed-os`. This patch applies the following changes: 1) It increases the default stack size for the LoRa driver thread from 1024 bytes to 4096 in file SX126X_LoRaRadio.cpp line 111. This is necessary, because 1024 is sometimes too little, leading to a crash of the firmware. 2) Add a `.mbedignore` file to the mbed-os folder to ignore unused modules when compiling with the `mbed` command. This leads to a faster build process.

1.3.2 Toolchain

There are multiple options how to develop build and flash the firmware. In the following two possible toolchain options are explained.

1.3.2.1 Option 1: mbed-cli (tested on Linux)

Needed tools:

- `mbed-cli`: The build system for mbed OS projects.
- `GNU Arm Embedded Toolchain`
- (Optional) `stlink`: Tool to flash ST microcontrollers
- openocd or pyocd (only for debugging)

Setting the toolchain path is done with:
```
mbed config -G GCC_ARM_PATH /usr/bin/arm-none-eabi-gcc
```

1.3.2.1.1 Building To build the project for the particle sensor hardware for PCB version 2 using the release profile, execute:
```
mbed compile --profile release --source .  --source ../Framework/mbed-os
```
It could be necessary to install further python dependencies with:
```
sudo pip3 install -r ../Framework/mbed-os/requirements.txt
```

To change the toolchain, the toolchain path or the target, edit the `.mbed` file.

1.3.2.1.2 Flashing When using a Nucleo board to flash the firmware, just copy the created binary file `BUILD/↩ PART_SENS_V3/GCC_ARM-RELEASE/Particle_Sensor.bin` to the storage device emulated by the Nucleo board.

To flash the binary with stlink use:
```
st-flash write ./BUILD/PART_SENS_V3/GCC_ARM-RELEASE/Particle_Sensor.bin
0x8000000
```

1.3.2.2 Option 2: SW4STM32 (Eclipse with build tools, tested on Windows)

With the mbed-cli tool, a Makefile was exported which allows to compile the project with the `make` tool or with an Eclipse IDE with C/C++ support and the necessary GNU ARM Embedded toolchain installed. System Workbench for STM32 (SW4STM32) is a version of eclipse with all necessary tools included.

> ***NOTE:***
> The Makefile includes the configuration for the release build. For a debug build with debug symbols, the Makefile needs to be adapted.

- Install `SW4STM32`
- Open SW4STM32 and open project folder with `File -> Open Projects from File System...` and select folder `Particle_Sensor` from the SensMat repository.
- Maybe it is necessary to add the locations of the `make` and the GNU ARM Embedded toolchain to the system path.
- To build the project, press the hammer symbol
- To debug the project, press the arrow next to the debug symbol (bug) and select `Debug Configurations...`
- In this window, uncollapse the `Ac STM32 Debugging` configurations and select the configuration `Particle_Sensor Debug`
- Connect the debugger (e.g. the one included on a Nucleo board) to the Particle Sensor 6-pin SWD header. With a USB cable connect the debugger to the PC.
- Then press the `Debug` button. This will build the binary, if not already done, flash the binary, start the debugger and switch eclipse into the debug perspective.

1.3.3 Libraries

For the two sensors, the manufacturers provide drivers, which were included in the `lib` folder of the project. For reference, this are the git repositories, where the libraries are from:

- `Sensirion SensorSPS30 UART driver`
- `Bosch Sensortec SensorBME280 driver`

1.3.4 Stack, Heap and CPU statistics

If `PRINT_STATS` is defined, statistics about stack, heap and CPU usage is printed via the UART interface if the status button is pressed. This can be used to debug power management (deep sleep/sleep/run durations) or memory leakage problems.

> ***NOTE:***
> The microcontroller only goes in deep sleep mode if the firmware is compiled with the **release** profile.

1.4 Known Problems

- Communication over the USB serial interface does not work reliably when compiling in debug profile (at least on Linux). This is caused by using a while-loop in the receive interrupt handler instead of an if-statement when polling for available characters. But if an if-statement is used, the USB serial interface does not work on Windows.
- If the microcontroller is in deep sleep mode when it is flashed with a new firmware using st-flash, it only erases the flash memory but writing the new firmware will fail. Just reconnect the debugger from the PC and flash again . Another solution is to switch sensor node into command state, as in this state the microcontroller is not in deep sleep mode.

1.5 Deployed Particle Sensors

PCB #	HWUUID	SPS30 Serial #
1	0x274784d6	15E099066D0D420B
2	0xbe90f3bf	6F5BAC226EB9E8CE
3	0xb2881e43	AFD8C4D630E0E33E
4	0x73eba155	FD1922CB58117D02
5	0xbd69061e	00941E593F1072DE
6	0x7e8af484	FF3297200FEEBA54
7	0x92b16a1b	C498FD7969A0A47B
8	0x95444f80	244063AEB5C5B31E
9	0xbb1a5576	7D6E454FFCFF64BB
10	0x5b392615	C903D98B57446B25
11	0x9442d23b	4484E7F7A263A28F
12	0xe7d0d0f1	AB41F5B2330B0ECB
13	0xb208f50b	BA5D484176C95811
14	0xe6d64d4a	934B87913FD5D3F2
15	0xc09c6a7a	E9DEFAD71B7FAF3F

PCB #	HWUUID	SPS30 Serial #
16	0xc59627fb	9BC4514C922B18F5
17	0xe0da3bb4	98F9290B17B584E9
18	0x9744e944	DE685F7756526A66
19	0x0ee103ef	3D0EBA6AC17D82AF
20	0x7c759c9e	E7D536CB98CF8EA6
21	0x640cfe8a	6077E177E4EB78CC
22	0x2de283d9	07D563C944A1CE29
23	0x35316342	CEDFFF0110924553
24	0xe56c526c	8742721F9C4035F5

Chapter 2

Changelog

All notable changes to this project will be documented in this file.

The format is based on Keep a Changelog, and this project adheres to Semantic Versioning.

The version number of the program is defined in src/defs/defines.h and needs to be adjusted according to the version in this file.

2.1 [Unreleased]

2.2 [0.4.3] - 2021-05-11

2.2.1 Fixed

- Rename class BME280 to SensorBME280 and SPS30 to SensorSPS30 due to name conflicts on Windows

2.2.2 Changed

- Update usage description for USB serial interface commands.

2.3 [0.4.2] - 2021-02-25

2.3.1 Added

- Compute moving average over a configurable number of measurement values

2.3.2 Fixed

- Increase buffer size for measurement values written to SD card.
- Retry reading battery level maximum 5 times if it fails.

2.4 [0.4.1] - 2021-01-07

2.4.1 Changed

- Move StateContext::Result to State::Result to remove circular include dependency

2.4.2 Removed

- Remove unused functions during code cleanup

2.5 [0.4.0] - 2020-12-03

2.5.1 Changed

- Switch off IIR filter on SensorBME280
- Use intf_ptr to pass SPI context to bme280_spi_∗ functions to avoid static objects

2.6 [0.3.1] - 2020-11-30

2.6.1 Changed

- Optimize imports, reformat code and document code

2.6.2 Fixed

- Set time to 2020-01-01T00:00:00 if time is not set, otherwise LoRa communication fails

2.7 [0.3.0] - 2020-11-23

2.7.1 Added

- Configuration option to disable sending status messages

2.7.2 Changed

- Change thing-ID and format for status messages

2.8 [0.2.0] - 2020-11-19

2.8.1 Added

- Configuration of correction offset and factor for every measured property
- Log SensorSPS30 serial numbers and UUIDs to measurement data CSV files
- Battery class with function to read battery voltage
- Send a status message with battery voltage, RSSI and SNR in fixed time intervals via LoRa

2.8.2 Changed

- Wait 2-10min instead of 10-60s before retry to authenticate at gateway
- Reboot again after one hour if an error occured
- Print statistics on status button press if PRINT_STAT is defined

2.9 [0.1.0] - 2020-11-10

2.9.1 Added

- Functions to calibrate RTC
- SpsCommand and BmeCommand to control sensors via USB interface
- InfoCommand to display SWUUID, HWUUID and software version
- Possibility to restore default configuration by pressing both buttons during power on

2.9.2 Changed

- Store and send only latest measurement values instead of maintaining a queue

2.9.3 Fixed

- Fix LoRa module state switch delay bug

2.10 [0.0.1] - 2020-11-02

2.10.1 Added

- All source files with initial implementation

Chapter 3

Namespace Index

3.1 Namespace List

Here is a list of all namespaces with brief descriptions:

Chapter 4

Hierarchical Index

4.1 Class Hierarchy

This inheritance list is sorted roughly, but not completely, alphabetically:

Chapter 5

Class Index

5.1 Class List

Here are the classes, structs, unions and interfaces with brief descriptions:

Chapter 6

File Index

6.1 File List

Here is a list of all files with brief descriptions:

Chapter 7

Namespace Documentation

7.1 utils Namespace Reference

Functions

- void get_formatted_time_string (const char *format_string, std::string &dest, time_t timestamp)
- bool is_number (const std::string &str)
- bool string_to_bool (const std::string &str, bool &dest)
- std::string to_hex_string (uint32_t number)
- std::string app_version ()
- uint16_t calc_crc16 (const void *buf, int size)
- uint32_t calc_crc32 (const void *buf, int size)
- uint32_t get_rand ()

7.1.1 Function Documentation

7.1.1.1 app_version()

```
std::string utils::app_version ( )
```

Return the version as a string. (e.g. "1.3.2")

Returns

the version number string

7.1.1.2 calc_crc16()

```
uint16_t utils::calc_crc16 (
            const void * buf,
            int size )
```

Calculate the 16-bit CRC checksum of `buf`.

Parameters

buf	the data buffer to calculate the CRC from
size	the size of the data buffer

Returns

the 16-bit CRC checksum

7.1.1.3 calc_crc32()

```
uint32_t utils::calc_crc32 (
            const void * buf,
            int size )
```

Calculate the 32-bit CRC checksum of `buf`.

Parameters

buf	the data buffer to calculate the CRC from
size	the size of the data buffer

Returns

the 32-bit CRC checksum

7.1.1.4 get_formatted_time_string()

```
void utils::get_formatted_time_string (
            const char * format_string,
            std::string & dest,
            time_t timestamp = 0 )
```

Get the current time in the format specified by `format_string` and write the result into `dest`.

Parameters

format_string	Format specifier for the strftime() function
dest	The string to write to
timestamp	Optional timestamp. If 0, current time is converted to string.

7.1.1.5 get_rand()

```
uint32_t utils::get_rand ( )
```

Get a random 32-bit number generated by the builtin TRNG.

Returns

a random 32-bit number

7.1.1.6 is_number()

```
bool utils::is_number (
            const std::string & str )
```

Check `str` represents a signed integer.

Parameters

str	The number string

Returns

true if `str` is an integer number, false otherwise

7.1.1.7 string_to_bool()

```
bool utils::string_to_bool (
            const std::string & str,
            bool & dest )
```

Check if `represents` a boolean value.

Parameters

str	The boolean string
dest	The destination to write the result to

Returns

true, if the `str` represents a boolean value, false if parsing failed

7.1.1.8 to_hex_string()

```
std::string utils::to_hex_string (
            uint32_t number )
```

Convert a given `number` into a hex string.

Parameters

number	The number to convert

Returns

the string with the number in hex format

Chapter 8

Class Documentation

8.1 MeasureState::avg_data_s Struct Reference

Public Member Functions

- struct avg_data_s & operator+= (const avg_data_s &rhs)
- struct avg_data_s & operator/= (const size_t rhs)

Public Attributes

- float temp
- float hum
- float press
- float pm2_5
- float particle_size

8.1.1 Detailed Description

Struct used to store the measurement points for the moving average. Overloaded operators are used to calculate the average.

8.1.2 Member Function Documentation

8.1.2.1 operator+=()

```
struct avg_data_s& MeasureState::avg_data_s::operator+= (
            const avg_data_s & rhs )  [inline]
```

8.1.2.2 operator/=()

```
struct avg_data_s& MeasureState::avg_data_s::operator/= (
            const size_t rhs )  [inline]
```

8.1.3 Member Data Documentation

8.1.3.1 hum

```
float MeasureState::avg_data_s::hum
```

8.1.3.2 particle_size

```
float MeasureState::avg_data_s::particle_size
```

8.1.3.3 pm2_5

```
float MeasureState::avg_data_s::pm2_5
```

8.1.3.4 press

```
float MeasureState::avg_data_s::press
```

8.1.3.5 temp

```
float MeasureState::avg_data_s::temp
```

The documentation for this struct was generated from the following file:

- src/state/MeasureState.h

8.2 Battery Class Reference

```
#include <Battery.h>
```

Static Public Member Functions

- static float read_voltage ()

8.2.1 Detailed Description

Static class providing functionality to read battery status

8.2.2 Member Function Documentation

8.2.2.1 read_voltage()

```
float Battery::read_voltage ( )  [static]
```

Read the battery level from the analog input.

Returns

the battery level in volts

The documentation for this class was generated from the following files:

- src/driver/Battery.h
- src/driver/Battery.cpp

8.3 SensorBME280::bme280_handle_t Struct Reference

Public Attributes

- mbed::DigitalOut * bme280_cs
- mbed::SPI * spi

8.3.1 Detailed Description

Structure for the handles which are passed to the bme280_spi_* functions to provide access to the _spi and the _bme280_cs object.

8.3.2 Member Data Documentation

8.3.2.1 bme280_cs

```
mbed::DigitalOut* SensorBME280::bme280_handle_t::bme280_cs
```

8.3.2.2 spi

```
mbed::SPI* SensorBME280::bme280_handle_t::spi
```

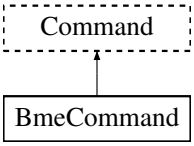
The documentation for this struct was generated from the following file:

- src/driver/SensorBME280.h

8.4 BmeCommand Class Reference

```
#include <BmeCommand.h>
```

Inheritance diagram for BmeCommand:



Public Member Functions

- BmeCommand (USBSerial &usb_serial, SensorBME280 &bme280)
- ~BmeCommand () override=default

Private Member Functions

- void execute_command (std::map< std::string, std::string > &parameter_map, std::vector< std::string > &parameter_vec) override

Private Attributes

- SensorBME280 & _bme280

Additional Inherited Members

8.4.1 Detailed Description

Class handling commands to test and control the on-board BME280 sensor

8.4.2 Constructor & Destructor Documentation

8.4.2.1 BmeCommand()

```
BmeCommand::BmeCommand (
            USBSerial & usb_serial,
            SensorBME280 & bme280 )
```

Create a BmeCommand object

Parameters

usb_serial	reference to an USBSerial object
bme280	reference to the SensorBME280 object which should be controlled

8.4.2.2 ~BmeCommand()

```
BmeCommand::~BmeCommand ( )  [override], [default]
```

Default destructor

8.4.3 Member Function Documentation

8.4.3.1 execute_command()

```
void BmeCommand::execute_command (
            std::map< std::string, std::string > & parameter_map,
            std::vector< std::string > & parameter_vec )  [override], [private], [virtual]
```

Executes the bme command according to the given parameters. The usage of the command is described in the bme_command_description.

Parameters

parameter_map	map holding the parameters that are given as key-value-pairs
parameter_vec	vector holding the option parameters

Implements Command.

8.4.4 Member Data Documentation

8.4.4.1 _bme280

```
SensorBME280& BmeCommand::_bme280  [private]
```

Reference to the SensorBME280 object used to control the sensor by calling its member functions.

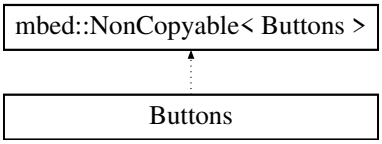
The documentation for this class was generated from the following files:

- src/command/BmeCommand.h
- src/command/BmeCommand.cpp

8.5 Buttons Class Reference

```
#include <Buttons.h>
```

Inheritance diagram for Buttons:



Public Member Functions

- Buttons (rtos::EventFlags &event_flags)
- bool is_left_pressed ()
- bool is_right_pressed ()

Private Member Functions

- void button_left_pressed ()
- void button_right_pressed ()
- void button_left_released ()
- void button_right_released ()

Private Attributes

- rtos::EventFlags & _event_flags
- mbed::InterruptIn _button_left
- mbed::InterruptIn _button_right
- mbed::LowPowerTimer _button_left_timer
- mbed::LowPowerTimer _button_right_timer

8.5.1 Detailed Description

Class handling button input

8.5.2 Constructor & Destructor Documentation

8.5.2.1 Buttons()

```
Buttons::Buttons (
            rtos::EventFlags & event_flags )  [explicit]
```

Create a Buttons object and attach the rise and fall callback functions to the _button_left and the _button_right

Parameters

event_flags	reference to an EventFlags object

8.5.3 Member Function Documentation

8.5.3.1 button_left_pressed()

```
void Buttons::button_left_pressed ( )  [private]
```

Interrupt handler that is called at the falling edge of _button_left.

8.5.3.2 button_left_released()

```
void Buttons::button_left_released ( )  [private]
```

Interrupt handler that is called at the rising edge of _button_left. The FLAG_BUTTON_MEASURE is set in _event_flags.

8.5.3.3 button_right_pressed()

```
void Buttons::button_right_pressed ( )  [private]
```

Interrupt handler that is called at the rising edge of _button_right.

8.5.3.4 button_right_released()

```
void Buttons::button_right_released ( )  [private]
```

Interrupt handler that is called at the rising edge of _button_right. Depending on the time how long the button was pressed, the FLAG_BUTTON_STATUS or the FLAG_BUTTON_COMMAND is set in _event_flags.

8.5.3.5 is_left_pressed()

```
bool Buttons::is_left_pressed ( )
```

Function to check if _button_left is currently pressed

Returns

true if _button_left is pressed, false otherwise

8.5.3.6 is_right_pressed()

```
bool Buttons::is_right_pressed ( )
```

Function to check if _button_right is currently pressed

Returns

true if _button_right is pressed, false otherwise

8.5.4 Member Data Documentation

8.5.4.1 _button_left

```
mbed::InterruptIn Buttons::_button_left  [private]
```

Interrupt input for the left button

8.5.4.2 _button_left_timer

```
mbed::LowPowerTimer Buttons::_button_left_timer  [private]
```

Timer measuring how long the _button_left is pressed

8.5.4.3 _button_right

```
mbed::InterruptIn Buttons::_button_right  [private]
```

Interrupt input for the right button

8.5.4.4 _button_right_timer

```
mbed::LowPowerTimer Buttons::_button_right_timer  [private]
```

Timer measuring how long the _button_right is pressed

8.5.4.5 _event_flags

```
rtos::EventFlags& Buttons::_event_flags  [private]
```

Reference to the EventFlags object, which is used to signal that a button was pressed.

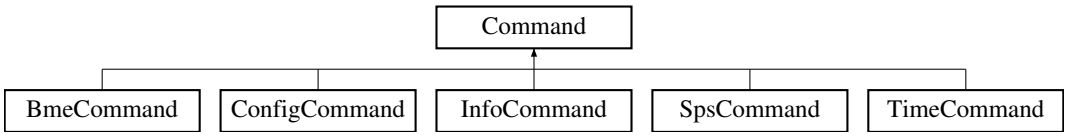
The documentation for this class was generated from the following files:

- src/driver/Buttons.h
- src/driver/Buttons.cpp

8.6 Command Class Reference

```
#include <Command.h>
```

Inheritance diagram for Command:



Public Member Functions

- Command (std::string name, std::string description, USBSerial &serial)
- virtual ~Command ()=default
- void execute (const std::string &parameter_string)
- const std::string & get_name () const
- const std::string & get_description () const

Protected Member Functions

- bool extract_parameters (const std::string &input_string, std::map< std::string, std::string > &parameter_↩ map, std::vector< std::string > &parameter_vec)

Static Protected Member Functions

- static size_t split_string (const std::string &input_string, std::vector< std::string > &split_strings, char delimiter)

Protected Attributes

- USBSerial & _usb_serial

Private Member Functions

- virtual void execute_command (std::map< std::string, std::string > &parameter_map, std::vector< std::string > &parameter_vec)=0

Private Attributes

- const std::string _name
- const std::string _description

8.6.1 Detailed Description

Abstract Command base class

To add a new Command, create a derived class which implements the method execute_command().

8.6.2 Constructor & Destructor Documentation

8.6.2.1 Command()

```
Command::Command (
            std::string name,
            std::string description,
            USBSerial & serial )
```

Basic constructor

Parameters

name	Name of the command, should be defined in defines.h
description	Description and usage info for the command, should be defined in defines.h
serial	Reference to the USBSerial interface object

8.6.2.2 ~Command()

```
virtual Command::~Command ( )  [virtual], [default]
```

Virtual destructor

8.6.3 Member Function Documentation

8.6.3.1 execute()

```
void Command::execute (
            const std::string & parameter_string )
```

Executes extract_parameters() with the `parameter_string` and then the command specific execute_command() is called with the extracted parameters.

Parameters

parameter_string	Command specific parameter string

8.6.3.2 execute_command()

```
virtual void Command::execute_command (
            std::map< std::string, std::string > & parameter_map,
            std::vector< std::string > & parameter_vec )  [private], [pure virtual]
```

Implemented in TimeCommand, SpsCommand, InfoCommand, ConfigCommand, and BmeCommand.

8.6.3.3 extract_parameters()

```
bool Command::extract_parameters (
            const std::string & input_string,
            std::map< std::string, std::string > & parameter_map,
            std::vector< std::string > & parameter_vec )  [protected]
```

Splits the `input_string` into parameters. Parameters are delimited by one or multiple spaces and can be single words, which are stored in the `parameter_vec`. Parameters can be also key-value-pairs (e.g. key=value), which are stored in the `parameter_map`.

Parameters

input_string	The string, including the parameters to be extracted.
parameter_map	Map where key-value-pair parameters are stored to.
parameter_vec	Vector where option parameters are stored to.

Returns

false, if `input_string` has an invalid format, true otherwise

8.6.3.4 get_description()

```
const std::string & Command::get_description ( ) const
```

Returns

reference to _description

8.6.3.5 get_name()

```
const std::string & Command::get_name ( ) const
```

Returns

reference to _name

8.6.3.6 split_string()

```
size_t Command::split_string (
            const std::string & input_string,
            std::vector< std::string > & split_strings,
            char delimiter )  [static], [protected]
```

Splits an `input_string` at a given `delimiter` and pushes the parts to the vector `split_strings`. Empty parts are not added to `split_strings`.

Parameters

input_string	String to be split
split_strings	Vector with the split parts of `input_string`
delimiter	Character on which the `input_string` is split

Returns

final size of `split_strings`

8.6.4 Member Data Documentation

8.6.4.1 _description

```
const std::string Command::_description  [private]
```

Description and usage info for the command

8.6.4.2 _name

```
const std::string Command::_name  [private]
```

Command name

8.6.4.3 _usb_serial

```
USBSerial& Command::_usb_serial  [protected]
```

Reference to the USBSerial object used to read from and write to the USB virtual COM port

The documentation for this class was generated from the following files:

- src/command/Command.h
- src/command/Command.cpp

8.7 CommandHandler Class Reference

```
#include <CommandHandler.h>
```

Public Member Functions

- CommandHandler (USBSerial &usb_serial, mbed::FlashIAP &flash, SensorSPS30 &sps30, SensorBME280 &bme280, rtos::EventFlags &event_flags)
- ~CommandHandler ()
- bool connect ()
- void handle_usb_serial_command ()
- void disconnect ()

Private Member Functions

- void serial_interrupt_handler ()
- void print_help ()
- void print_prompt ()
- void read_line_from_buffer (std::string &line)
- Command * find_command (const std::string &command_name)

Static Private Member Functions

- static void separate_command_name (const std::string &command_string, std::string &command_name, std::string &parameters)

Private Attributes

- USBSerial & _usb_serial
- rtos::EventFlags & _event_flags
- std::vector< Command * > _commands
- mbed::CircularBuffer< char, COMMAND_HANDLER_MAX_BUF_SIZE > _buffer

8.7.1 Detailed Description

Class receiving and handling the commands from the USB virtual COM port interface

8.7.2 Constructor & Destructor Documentation

8.7.2.1 CommandHandler()

```
CommandHandler::CommandHandler (
            USBSerial & usb_serial,
            mbed::FlashIAP & flash,
            SensorSPS30 & sps30,
            SensorBME280 & bme280,
            rtos::EventFlags & event_flags )
```

Create a new CommandHandler and instantiate every command on the heap.

Parameters

usb_serial	reference to an USBSerial object
flash	reference to a FlashIAP object
sps30	reference to a SensorSPS30 object
bme280	reference to a SensorBME280 object
event_flags	reference to an EventFlags object

8.7.2.2 ~CommandHandler()

```
CommandHandler::~CommandHandler ( )
```

The CommandHandler destructor deletes all Command objects from _commands, which are stored on the heap

8.7.3 Member Function Documentation

8.7.3.1 connect()

```
bool CommandHandler::connect ( )
```

Tries to connect (non-blocking) to an USB serial terminal. If connection succeeds, _buffer is cleared and the software version and the command prompt are printed.

Returns

true if connected, false otherwise

8.7.3.2 disconnect()

```
void CommandHandler::disconnect ( )
```

Prints disconnect information and disconnects from the USB serial terminal and calls USBSerial::deinit() to unlock deepsleep again.

8.7.3.3 find_command()

```
Command * CommandHandler::find_command (
            const std::string & command_name )  [private]
```

Searches for a command in _commands with the given `command_name`.

Parameters

command_name	the name of the searched command

Returns

pointer to the Command object if the command exists, nullptr otherwise

8.7.3.4 handle_usb_serial_command()

```
void CommandHandler::handle_usb_serial_command ( )
```

Reads a line from _buffer and executes the given command with the given parameters if the command exists, otherwise a usage information with the supported commands is printed.

8.7.3.5 print_help()

```
void CommandHandler::print_help ( )  [private]
```

Print help message containing a list of all supported commands.

8.7.3.6 print_prompt()

```
void CommandHandler::print_prompt ( )  [private]
```

Prints the command prompt.

8.7.3.7 read_line_from_buffer()

```
void CommandHandler::read_line_from_buffer (
            std::string & line )  [private]
```

Pops one line from _buffer and pushes it to `line`.

Parameters

line	Reference to the string on which the line is pushed

8.7.3.8 separate_command_name()

```
void CommandHandler::separate_command_name (
            const std::string & command_string,
            std::string & command_name,
            std::string & parameters )  [static], [private]
```

Splits the given `command_string` at the first space into the `command_name` and the `parameters`.

Parameters

command_string	whole command string
command_name	name of the command preceding the first space in `command_string`
parameters	parameters succeeding the first space in `command_string`

8.7.3.9 serial_interrupt_handler()

```
void CommandHandler::serial_interrupt_handler ( )  [private]
```

Interrupt handler that receives commands from the USB serial interface and stores them in _buffer. If a newline is received, the FLAG_RECEIVED_COMMAND flag is set in _event_flags.

8.7.4 Member Data Documentation

8.7.4.1 _buffer

```
mbed::CircularBuffer<char, COMMAND_HANDLER_MAX_BUF_SIZE> CommandHandler::_buffer  [private]
```

Buffer used by serial_interrupt_handler() to store received command strings until they are handled by handle_usb_serial_command().

8.7.4.2 _commands

```
std::vector<Command *> CommandHandler::_commands  [private]
```

Vector containing pointers to an instance of every command

8.7.4.3 _event_flags

```
rtos::EventFlags& CommandHandler::_event_flags  [private]
```

Reference to the EventFlags object used to signal the CommandState::handle() that a new command was received.

8.7.4.4 _usb_serial

```
USBSerial& CommandHandler::_usb_serial  [private]
```

Reference to the USBSerial object handling all the low level operations for the connection, the input and the output.

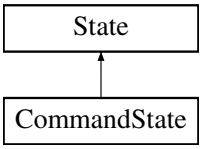
The documentation for this class was generated from the following files:

- src/command/CommandHandler.h
- src/command/CommandHandler.cpp

8.8 CommandState Class Reference

```
#include <CommandState.h>
```

Inheritance diagram for CommandState:



Public Member Functions

- CommandState (LedIndicator &led_indicator, CommandHandler &command_handler, rtos::EventFlags &event_flags)
- ~CommandState () override=default
- State::Result handle () override

Private Member Functions

- State::Result run ()

Private Attributes

- CommandHandler & _command_handler
- rtos::EventFlags & _event_flags

Additional Inherited Members

8.8.1 Detailed Description

State that allows to execute commands received over the USB virtual COM port.

8.8.2 Constructor & Destructor Documentation

8.8.2.1 CommandState()

```
CommandState::CommandState (
            LedIndicator & led_indicator,
            CommandHandler & command_handler,
            rtos::EventFlags & event_flags )
```

Create a CommandState

Parameters

led_indicator	Reference to the LedIndicator to set the LED behavior
command_handler	Reference to the CommandHandler doing the actual command handling
event_flags	Reference to the control event flags to react on button presses and incoming commands.

8.8.2.2 ~CommandState()

```
CommandState::~CommandState ( )  [override], [default]
```

Default destructor

8.8.3 Member Function Documentation

8.8.3.1 handle()

```
State::Result CommandState::handle ( )  [override], [virtual]
```

Set the status LED color to orange and call run() to handle the connection and incoming commands.

Returns

State::Result::COMMAND_PRESSED

Implements State.

8.8.3.2 run()

```
State::Result CommandState::run ( )  [private]
```

Handle connection and incoming commands in the following order: Wait in an endless loop for a serial terminal to connect. If a serial terminal connected, start handling incoming commands by calling CommandHandler::handle_usb_serial_command() if FLAG_RECEIVED_COMMAND is set.

Returns

State::Result::COMMAND_PRESSED if the FLAG_BUTTON_COMMAND was set

8.8.4 Member Data Documentation

8.8.4.1 _command_handler

```
CommandHandler& CommandState::_command_handler  [private]
```

CommandHandler object used to connect and disconnect to the serial terminal and to dispatch the incoming commands.

8.8.4.2 _event_flags

```
rtos::EventFlags& CommandState::_event_flags  [private]
```

Reference to the control event flags object to wait for control events to occur

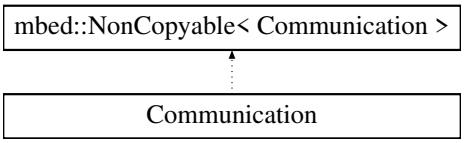
The documentation for this class was generated from the following files:

- src/state/CommandState.h
- src/state/CommandState.cpp

8.9 Communication Class Reference

`#include <Communication.h>`

Inheritance diagram for Communication:



Public Member Functions

- Communication ()
- mbed_error_status_t start ()
- void stop ()
- void send_measured_data (const Protocol::measured_data_t &data)

Private Types

- enum PacketType { MEASURED_DATA , STATUS_DATA }

Private Member Functions

- void run ()
- void authenticate ()
- bool send_data (PacketType packet_type)
- void send_status_data ()

Private Attributes

- Lora _lora
- Protocol _protocol
- rtos::Thread _thread
- PlatformMutex _data_mutex
- Protocol::measured_data_t _measured_data = {}
- rtos::EventFlags _flags
- mbed::LowPowerTicker _status_update_ticker

8.9.1 Detailed Description

Class handling the LoRa communication control flow. The LoRa communication is done in a separate thread, which can be started with start() and stopped with stop().

8.9.2 Member Enumeration Documentation

8.9.2.1 PacketType

`enum Communication::PacketType [private]`

Enum defining the possible data packet types

Enumerator

MEASURED_DATA	
STATUS_DATA	

8.9.3 Constructor & Destructor Documentation

8.9.3.1 Communication()

```
Communication::Communication ( )
```

Creates a Communication object

8.9.4 Member Function Documentation

8.9.4.1 authenticate()

```
void Communication::authenticate ( )  [private]
```

If sensor is not authenticated at the gateway, it will send an authentication request and wait for the gateway authentication response. If no or an invalid response is received, a new authentication message will be sent after a random delay between 2 and 10 minutes. This process will be repeated until a valid response is received.

8.9.4.2 run()

```
void Communication::run ( )  [private]
```

Endless running function executed in _thread handling the LoRa communication by reacting on event _flags.

8.9.4.3 send_data()

```
bool Communication::send_data (
            PacketType packet_type )  [private]
```

Depending on the `packet_type`, a measurement data packet or a status update packet is sent to the gateway. If the gateway does not respond with an acknowledge, the packet will be sent again after a random delay between 2 and 10 minutes. If MAX_SEND_DATA_ATTEMPTS times no or an invalid response is received, the connection will be reset and a new authentication is necessary.

Parameters

packet_type	Type of the packet to send

Returns

true if packet was sent, false otherwise

8.9.4.4 send_measured_data()

```
void Communication::send_measured_data (
            const Protocol::measured_data_t & data )
```

Copies `data` to _measured_data and sets the FLAG_SEND_MEASURED_DATA in _flags.

Parameters

data	measured data to be sent

8.9.4.5 send_status_data()

```
void Communication::send_status_data ( )  [private]
```

Initiates sending a status update packet by setting FLAG_SEND_STATUS_DATA in _flags.

8.9.4.6 start()

```
mbed_error_status_t Communication::start ( )
```

Initialize _lora and start the LoRa communication _thread with the function run(). If "status_enable" is true in Config::global_config, the _status_update_ticker is started to send periodic status updates with an interval defined by "status_interval_sec" in Config::global_config.

Returns

MBED_SUCCESS if thread was started, MBED_ERROR_FAILED_OPERATION otherwise

8.9.4.7 stop()

```
void Communication::stop ( )
```

If the LoRa communication _thread is running, it will be stopped, as well as the _status_update_ticker. The _lora module is set to sleep mode.

8.9.5 Member Data Documentation

8.9.5.1 _data_mutex

```
PlatformMutex Communication::_data_mutex  [private]
```

Mutex to serialize read and write accesses to _measured_data

8.9.5.2 _flags

```
rtos::EventFlags Communication::_flags  [private]
```

EventFlags to signalize _thread, when to send measurement data or a status update

8.9.5.3 _lora

```
Lora Communication::_lora  [private]
```

Lora object used to control the LoRa module

8.9.5.4 _measured_data

```
Protocol::measured_data_t Communication::_measured_data = {}  [private]
```

Buffer for the latest measured data to be sent next

8.9.5.5 _protocol

```
Protocol Communication::_protocol  [private]
```

Protocol object providing functions to communicate with the Smartmote gateway

8.9.5.6 _status_update_ticker

```
mbed::LowPowerTicker Communication::_status_update_ticker  [private]
```

Ticker to periodically initiate sending a status update

8.9.5.7 _thread

```
rtos::Thread Communication::_thread  [private]
```

The communication thread

The documentation for this class was generated from the following files:

- src/communication/Communication.h
- src/communication/Communication.cpp

8.10 Config Class Reference

```
#include <Config.h>
```

Classes

- union config_value_t
- struct entry_t

Public Types

- enum ConfigType { BOOL , UINT32 , FLOAT }

Static Public Member Functions

- static void save_default_config ()
- static void reset_config ()
- template<typename T >
  static T get (const std::string &name)
- static bool get_entry (const std::string &name, entry_t &dest)
- static bool set_value (const std::string &name, const std::string &value_string)
- static mbed_error_status_t write_config_to_flash (mbed::FlashIAP &flash)
- static mbed_error_status_t read_config_from_flash (mbed::FlashIAP &flash)

Static Public Attributes

- static entry_t global_config [NUM_CONFIG_ENTRIES]

Static Private Member Functions

- static mbed_error_status_t write_to_flash (mbed::FlashIAP &flash, uint32_t address, uint8_t *source, size_t size)
- static mbed_error_status_t read_from_flash (mbed::FlashIAP &flash, uint32_t address, uint8_t *destination, size_t size)

Static Private Attributes

- static Config::config_value_t default_config [NUM_CONFIG_ENTRIES] = {0}

8.10.1 Detailed Description

Class holding only static member functions and static variables to provide an easy access to the configuration parameters

8.10.2 Member Enumeration Documentation

8.10.2.1 ConfigType

```
enum Config::ConfigType
```

Enum defining the possible data types for the config entries

Enumerator

BOOL	
UINT32	
FLOAT	

8.10.3 Member Function Documentation

8.10.3.1 get()

```
template<typename T >
T Config::get (
            const std::string & name )  [static]
```

Getter function for configuration parameter values.

Template Parameters

T	Data type of the parameter to be retrieved

Parameters

name	Name of the parameter to be retrieved

Returns

the value of the parameter with the given `name`

8.10.3.2 get_entry()

```
bool Config::get_entry (
            const std::string & name,
            entry_t & dest )  [static]
```

Getter function for a configuration parameter entry

Parameters

name	Name of the parameter to be retrieved
dest	Destination on which the entry is written to

Returns

true if a parameter with the given `name` was found, false otherwise

8.10.3.3 read_config_from_flash()

```
mbed_error_status_t Config::read_config_from_flash (
            mbed::FlashIAP & flash )  [static]
```

Reads all configuration parameter values from the flash memory at address STORAGE_ADDR_CONFIG.

Parameters

flash	

Returns

8.10.3.4 read_from_flash()

```
mbed_error_status_t Config::read_from_flash (
            mbed::FlashIAP & flash,
            uint32_t address,
            uint8_t * destination,
            size_t size )  [static], [private]
```

Parameters

flash	Reference to the FlashIAP object
address	Address within the flash memory to read from
destination	Buffer where the read data is copied to
size	Size of the data to be read

Returns

MBED_SUCCESS if read was successful, an mbed_error_status_t otherwise

8.10.3.5 reset_config()

```
void Config::reset_config ( )  [static]
```

Copies the the values from default_config to global_config.

8.10.3.6 save_default_config()

```
void Config::save_default_config ( )  [static]
```

Copies the parameter values of global_config to default_config. This function is used to store the default configuration before the global_config is overwritten with the values loaded from the flash memory.

8.10.3.7 set_value()

```
bool Config::set_value (
            const std::string & name,
            const std::string & value_string )  [static]
```

Set the parameter with the given `name` to the value of the given `value_string` if the `name` exists and the value is within the range of the parameter.

Parameters

name	Name of the parameter to be set
value_string	The value to be set as string

Returns

true if the parameter was set, false otherwise

8.10.3.8 write_config_to_flash()

```
mbed_error_status_t Config::write_config_to_flash (
            mbed::FlashIAP & flash )  [static]
```

Writes all configuration parameter values to the flash memory at address STORAGE_ADDR_CONFIG.

Parameters

flash	Reference to the FlashIAP object

Returns

MBED_SUCCESS if write operation succeeded, an mbed_error_status_t otherwise

8.10.3.9 write_to_flash()

```
mbed_error_status_t Config::write_to_flash (
            mbed::FlashIAP & flash,
            uint32_t address,
            uint8_t * source,
            size_t size )  [static], [private]
```

Writes data from `source` with the given `size` to the given `address` in the flash memory.

Parameters

flash	Reference to the FlashIAP object
address	Address within the flash memory to write to
source	Data which is written to the flash memory
size	Size of the data to be written

Returns

MBED_SUCCESS if write was successful, an mbed_error_status_t otherwise

8.10.4 Member Data Documentation

8.10.4.1 default_config

```
Config::config_value_t Config::default_config = {0}  [static], [private]
```

Array holding the default configuration parameter values.

8.10.4.2 global_config

```
Config::entry_t Config::global_config  [static]
```

Array holding the configuration parameters including the meta data for every parameter.

The documentation for this class was generated from the following files:

- src/config/Config.h
- src/config/Config.cpp

8.11 Config::config_value_t Union Reference

```
#include <Config.h>
```

Public Attributes

- bool bool_v
- uint32_t uint32_v
- float float_v

8.11.1 Detailed Description

Union defining the config value types

8.11.2 Member Data Documentation

8.11.2.1 bool_v

```
bool Config::config_value_t::bool_v
```

8.11.2.2 float_v

```
float Config::config_value_t::float_v
```

8.11.2.3 uint32_v

```
uint32_t Config::config_value_t::uint32_v
```

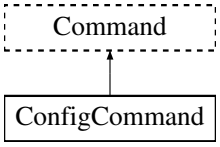
The documentation for this union was generated from the following file:

- src/config/Config.h

8.12 ConfigCommand Class Reference

```
#include <ConfigCommand.h>
```

Inheritance diagram for ConfigCommand:



Public Member Functions

- ConfigCommand (USBSerial &usb_serial, mbed::FlashIAP &flash)
- ~ConfigCommand () override=default

Private Member Functions

- void execute_command (std::map< std::string, std::string > &parameter_map, std::vector< std::string > &parameter_vec) override
- void print_current_config ()
- void handle_parameters (const std::map< std::string, std::string > &parameter_map)

Private Attributes

- mbed::FlashIAP & _flash

Additional Inherited Members

8.12.1 Detailed Description

Class handling commands to change various configuration parameters

8.12.2 Constructor & Destructor Documentation

8.12.2.1 ConfigCommand()

```
ConfigCommand::ConfigCommand (
            USBSerial & usb_serial,
            mbed::FlashIAP & flash )
```

Create a ConfigCommand object

Parameters

usb_serial	reference to an USBSerial object
flash	reference to a FlashIAP object

8.12.2.2 ~ConfigCommand()

```
ConfigCommand::~ConfigCommand ( )  [override], [default]
```

Default destructor

8.12.3 Member Function Documentation

8.12.3.1 execute_command()

```
void ConfigCommand::execute_command (
            std::map< std::string, std::string > & parameter_map,
            std::vector< std::string > & parameter_vec )  [override], [private], [virtual]
```

Executes the config command according to the given parameters. The usage of the command is described in the config_command_description.

Parameters

parameter_map	map holding the parameters that are given as key-value-pairs
parameter_vec	vector holding the option parameters

Implements Command.

8.12.3.2 handle_parameters()

```
void ConfigCommand::handle_parameters (
            const std::map< std::string, std::string > & parameter_map )  [private]
```

Sets the configuration parameters in Config::global_config according to the given parameters. The configuration is then written to the flash memory at address STORAGE_ADDR_CONFIG to store the configuration persistently.

Parameters

parameter_map	Map with parameters as key-value pairs

8.12.3.3 print_current_config()

```
void ConfigCommand::print_current_config ( )  [private]
```

Prints the current configuration

8.12.4 Member Data Documentation

8.12.4.1 _flash

```
mbed::FlashIAP& ConfigCommand::_flash  [private]
```

Referece to the FlashIAP object which handles the low level operations to store the configuration in the flash memory.

The documentation for this class was generated from the following files:

- src/command/ConfigCommand.h
- src/command/ConfigCommand.cpp

8.13 Config::entry_t Struct Reference

```
#include <Config.h>
```

Public Attributes

- std::string name
- ConfigType type
- config_value_t value
- config_value_t min
- config_value_t max
- std::string description

8.13.1 Detailed Description

Defines the format of a config parameter entry

8.13.2 Member Data Documentation

8.13.2.1 description

```
std::string Config::entry_t::description
```

8.13.2.2 max

```
config_value_t Config::entry_t::max
```

8.13.2.3 min

```
config_value_t Config::entry_t::min
```

8.13.2.4 name

```
std::string Config::entry_t::name
```

8.13.2.5 type

```
ConfigType Config::entry_t::type
```

8.13.2.6 value

```
config_value_t Config::entry_t::value
```

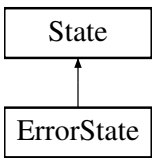
The documentation for this struct was generated from the following file:

- src/config/Config.h

8.14 ErrorState Class Reference

```
#include <ErrorState.h>
```

Inheritance diagram for ErrorState:



Public Member Functions

- ErrorState (LedIndicator &led_indicator, rtos::EventFlags &control_event_flags)
- State::Result handle () override

Private Attributes

- rtos::EventFlags & _control_event_flags

Additional Inherited Members

8.14.1 Detailed Description

Error state that is entered if any other state returned with an error.

8.14.2 Constructor & Destructor Documentation

8.14.2.1 ErrorState()

```
ErrorState::ErrorState (
            LedIndicator & led_indicator,
            rtos::EventFlags & control_event_flags )
```

Create an ErrorState

Parameters

led_indicator	Reference to the LedIndicator to control the status LED
control_event_flags	Reference to the control event flags to react on button presses

8.14.3 Member Function Documentation

8.14.3.1 handle()

```
State::Result ErrorState::handle ( )  [override], [virtual]
```

Set the status LED to red for 3 seconds and start reboot. If an error occurs for MBED_CONF_PLATFORM_↩ ERROR_REBOOT_MAX times, the system will wait for one hour and then reboot again.

Returns

Function never returns, only calls MBED_ERROR(), which results in a reboot

Implements State.

8.14.4 Member Data Documentation

8.14.4.1 _control_event_flags

```
rtos::EventFlags& ErrorState::_control_event_flags  [private]
```

Reference to the control event flags object to wait for control events to occur

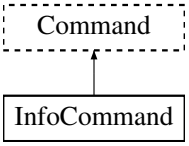
The documentation for this class was generated from the following files:

- src/state/ErrorState.h
- src/state/ErrorState.cpp

8.15 InfoCommand Class Reference

```
#include <InfoCommand.h>
```

Inheritance diagram for InfoCommand:



Public Member Functions

- InfoCommand (USBSerial &usb_serial)
- ~InfoCommand () override=default

Private Member Functions

- void execute_command (std::map< std::string, std::string > &parameter_map, std::vector< std::string > &parameter_vec) override

Additional Inherited Members

8.15.1 Detailed Description

Class handling commands to print version and UUID information about the sensor system.

8.15.2 Constructor & Destructor Documentation

8.15.2.1 InfoCommand()

```
InfoCommand::InfoCommand (
            USBSerial & usb_serial )  [explicit]
```

Create a InfoCommand object

Parameters

usb_serial	reference to an USBSerial object

8.15.2.2 ~InfoCommand()

```
InfoCommand::~InfoCommand ( )  [override], [default]
```

Default destructor

8.15.3 Member Function Documentation

8.15.3.1 execute_command()

```
void InfoCommand::execute_command (
            std::map< std::string, std::string > & parameter_map,
            std::vector< std::string > & parameter_vec )  [override], [private], [virtual]
```

Executes the info command and prints the versions and UUIDs. The usage of the command is described in the info_command_description.

Parameters

parameter_map	map holding the parameters that are given as key-value-pairs
parameter_vec	vector holding the option parameters

Implements Command.

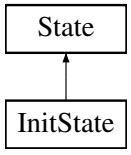
The documentation for this class was generated from the following files:

- src/command/InfoCommand.h
- src/command/InfoCommand.cpp

8.16 InitState Class Reference

```
#include <InitState.h>
```

Inheritance diagram for InitState:



Public Member Functions

- InitState (LedIndicator &led_indicator, SDCard &sd_card, Communication &communication, mbed::FlashIAP &flash, SensorSPS30 &sps30, SensorBME280 &bme280, Buttons &buttons)
- ~InitState () override=default
- State::Result handle () override

Private Member Functions

- State::Result init ()
- mbed_error_status_t sps30_test ()
- mbed_error_status_t bme280_test ()
- void init_rtc ()

Private Attributes

- SDCard & _sd_card
- Communication & _communication
- mbed::FlashIAP & _flash
- SensorSPS30 & _sps30
- SensorBME280 & _bme280
- Buttons & _buttons

Additional Inherited Members

8.16.1 Detailed Description

State initializing all objects which need explicit initialization. Also test if connected sensors are working.

8.16.2 Constructor & Destructor Documentation

8.16.2.1 InitState()

```
InitState::InitState (
            LedIndicator & led_indicator,
            SDCard & sd_card,
            Communication & communication,
            mbed::FlashIAP & flash,
            SensorSPS30 & sps30,
            SensorBME280 & bme280,
            Buttons & buttons )
```

Create an Initstate

Parameters

led_indicator	Reference to the LedIndicator to control the status LED
sd_card	Reference to the SDCard to initialize it and also the Logger
communication	Reference to the Communication object to start the LoRa communication thread
flash	Reference to the FlashIAP to load config from flash
sps30	Reference to the SensorSPS30 to perform a start up test
bme280	Reference to the SensorBME280 to perform a start up test
buttons	Reference to the Buttons, to check if default config should be loaded

8.16.2.2 ~InitState()

```
InitState::~InitState ( )  [override], [default]
```

Default destructor

8.16.3 Member Function Documentation

8.16.3.1 bme280_test()

```
mbed_error_status_t InitState::bme280_test ( )  [private]
```

Initialize the SensorBME280 and test if the BME280 is working by reading measurement values and checking if they are in range.

Returns

MBED_SUCCESS if SPS30 works, an mbed_error_status_t otherwise

8.16.3.2 handle()

```
State::Result InitState::handle ( )  [override], [virtual]
```

Set status LED to orange, execute init() and depending on the return value, set status LED to green or red for 3 seconds.

Returns

the return value of init()

Implements State.

8.16.3.3 init()

```
State::Result InitState::init ( )  [private]
```

Initialize the _sd_card, RTC, Logger, SensorSPS30 and SensorBME280 and the _flash. If the two buttons are pressed, the Config::global_config is set to its default values. Otherwise, the stored config is loaded from flash memory and written to Config::global_config.

Returns

State::Result::SUCCESS on success, an State::Result

8.16.3.4 init_rtc()

```
void InitState::init_rtc ( )  [private]
```

If the RTC time is not set, i.e. it is set to a date earlier than TIMESTAMP_20200101, it will be set to TIMESTAMP_20200101. Note: This is necessary, otherwise odd timing problems occur.

8.16.3.5 sps30_test()

```
mbed_error_status_t InitState::sps30_test ( )  [private]
```

Test if the SPS30 is working by executing the SensorSPS30::probe() function.

Returns

MBED_SUCCESS if SPS30 works, an mbed_error_status_t otherwise

8.16.4 Member Data Documentation

8.16.4.1 _bme280

```
SensorBME280& InitState::_bme280  [private]
```

Reference to SensorBME280 to test if BME280 is working

8.16.4.2 _buttons

```
Buttons& InitState::_buttons  [private]
```

Reference to Buttons. If both buttons are pressed, the default configuration is used for Config::default_config, otherwise the configuration is loaded from _flash.

8.16.4.3 _communication

```
Communication& InitState::_communication  [private]
```

Reference to the Communication object to start the LoRa communication thread.

8.16.4.4 _flash

```
mbed::FlashIAP& InitState::_flash  [private]
```

Reference to the FlashIAP to initialize it and load stored configurations to Config::global_config.

8.16.4.5 _sd_card

```
SDCard& InitState::_sd_card  [private]
```

Reference to the SDCard to initialize it and the Logger

8.16.4.6 _sps30

```
SensorSPS30& InitState::_sps30  [private]
```

Reference to SensorSPS30 to test if SPS30 is working

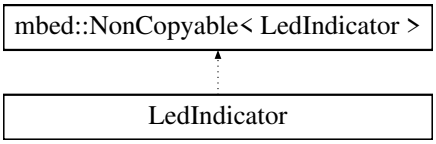
The documentation for this class was generated from the following files:

- src/state/InitState.h
- src/state/InitState.cpp

8.17 LedIndicator Class Reference

```
#include <LedIndicator.h>
```

Inheritance diagram for LedIndicator:



Public Types

- enum class Color { OFF , GREEN , RED , ORANGE }

Public Member Functions

- LedIndicator ()
- ~LedIndicator ()=default
- void display_battery_level_for (uint32_t duration_ms)
- void display_status_for (Color color, uint32_t duration_ms=0)

Private Member Functions

- void switch_battery_leds (float level)
- void turn_off_battery_leds ()
- void switch_status_leds (Color color)
- void turn_off_status_leds ()

Private Attributes

- mbed::DigitalOut _bat_led_1
- mbed::DigitalOut _bat_led_2
- mbed::DigitalOut _bat_led_3
- mbed::DigitalOut _status_led_green
- mbed::DigitalOut _status_led_red
- mbed::LowPowerTimeout _bat_led_timeout
- mbed::LowPowerTimeout _status_led_timeout

8.17.1 Detailed Description

Class handling the behaviour ot the battery LEDs and the status LED.

8.17.2 Member Enumeration Documentation

8.17.2.1 Color

```
enum LedIndicator::Color  [strong]
```

Enum defining the possible states for the bicolor status LED.

Enumerator

OFF	
GREEN	
RED	
ORANGE	

8.17.3 Constructor & Destructor Documentation

8.17.3.1 LedIndicator()

```
LedIndicator::LedIndicator ( )
```

Creates a new LedIndicator object

8.17.3.2 ~LedIndicator()

```
LedIndicator::~LedIndicator ( )  [default]
```

Default destructor

8.17.4 Member Function Documentation

8.17.4.1 display_battery_level_for()

```
void LedIndicator::display_battery_level_for (
            uint32_t duration_ms )
```

Displays the battery level on the battery LEDs for the given time.

Parameters

duration_ms	Time in milliseconds for how long the battery level is displayed

8.17.4.2 display_status_for()

```
void LedIndicator::display_status_for (
            Color color,
            uint32_t duration_ms = 0 )
```

Displays the given `color` on the status LEDs for the given time.

Parameters

color	The color to be displayed
duration_ms	Time in milliseconds for how long the status is displayed

8.17.4.3 switch_battery_leds()

```
void LedIndicator::switch_battery_leds (
            float level )  [private]
```

Switch the battery LEDs according to the given battery level using the defined battery thresholds from LedIndicator.cpp.

Parameters

level	The battery level in volts to be displayed

8.17.4.4 switch_status_leds()

```
void LedIndicator::switch_status_leds (
            Color color )  [private]
```

Switch the status LED to the given `color`

Parameters

color	The color to be displayed

8.17.4.5 turn_off_battery_leds()

```
void LedIndicator::turn_off_battery_leds ( )  [private]
```

Turn off all battery LEDs.

8.17.4.6 turn_off_status_leds()

```
void LedIndicator::turn_off_status_leds ( )  [private]
```

Turn off the status LED

8.17.5 Member Data Documentation

8.17.5.1 _bat_led_1

```
mbed::DigitalOut LedIndicator::_bat_led_1  [private]
```

The digital output for the left most battery LED

8.17.5.2 _bat_led_2

```
mbed::DigitalOut LedIndicator::_bat_led_2  [private]
```

The digital output for the middle battery LED

8.17.5.3 _bat_led_3

```
mbed::DigitalOut LedIndicator::_bat_led_3  [private]
```

The digital output for the right most battery LED

8.17.5.4 _bat_led_timeout

```
mbed::LowPowerTimeout LedIndicator::_bat_led_timeout  [private]
```

Timeout for the battery LEDs used to switch them off after a specified timeout.

8.17.5.5 _status_led_green

```
mbed::DigitalOut LedIndicator::_status_led_green  [private]
```

The digital output for the green part of the status LED

8.17.5.6 _status_led_red

```
mbed::DigitalOut LedIndicator::_status_led_red  [private]
```

The digital output for the red part of the status LED

8.17.5.7 _status_led_timeout

```
mbed::LowPowerTimeout LedIndicator::_status_led_timeout  [private]
```

Timeout for the status LED used to switch it off after a specified timeout.

The documentation for this class was generated from the following files:

- src/driver/LedIndicator.h
- src/driver/LedIndicator.cpp

8.18 Logger Class Reference

`#include <Logger.h>`

Static Public Member Functions

- static void init (SDCard *sd_card)
- static void log_internal (const char *file_name, LogLevel log_level, const char *format_string,...)

Private Member Functions

- Logger ()=default
- ~Logger ()=default
- Logger (const Logger &)
- Logger & operator= (const Logger &)

Static Private Member Functions

- static void compose_log_line (std::string &log_line, const char *file_name, LogLevel log_level, const std::string &message)

Static Private Attributes

- static bool _initialized = false
- static SDCard * _sd_card = nullptr
- static std::string _file_name = "log.txt"

8.18.1 Detailed Description

Class providing logging functionality. This class does not need to and can not be instantiated, because all members and member functions are static and the constructor is private. Instead it is necessary to initialize the Logger once with init()

8.18.2 Constructor & Destructor Documentation

8.18.2.1 Logger() [1/2]

`Logger::Logger ( ) [private], [default]`

Private constructor

8.18.2.2 ~Logger()

```
Logger::~Logger ( )  [private], [default]
```

Private destructor

8.18.2.3 Logger() [2/2]

```
Logger::Logger (
            const Logger &  )  [private]
```

Private copy constructor

8.18.3 Member Function Documentation

8.18.3.1 compose_log_line()

```
void Logger::compose_log_line (
            std::string & log_line,
            const char * file_name,
            LogLevel log_level,
            const std::string & message )  [static], [private]
```

Composes a log entry out of the `file_name`, the `log_level` name and the log `message` and writes it to `log_line`.

Parameters

log_line	The destination where the composed log line is written to
file_name	The file name where the LOG was called from
log_level	The log level
message	The message to be logged

8.18.3.2 init()

```
void Logger::init (
            SDCard * sd_card )  [static]
```

Initialize the Logger. Create a new log file on the SD card.

Parameters

sd_card	Pointer to the SD card object

8.18.3.3 log_internal()

```
void Logger::log_internal (
            const char * file_name,
            LogLevel log_level,
            const char * format_string,
             ... ) [static]
```

Add a log line to the log file if given `log_level` is lower than the one in the Config::global_config.

Parameters

file_name	File name where the function is called from
log_level	Log level
format_string	Format string for sprintf()
...	Argument list for sprintf()

8.18.3.4 operator=()

```
Logger& Logger::operator= (
            const Logger & ) [private]
```

Private assignment operator

8.18.4 Member Data Documentation

8.18.4.1 _file_name

```
std::string Logger::_file_name = "log.txt" [static], [private]
```

File name of the currently used log file

8.18.4.2 _initialized

```
bool Logger::_initialized = false [static], [private]
```

Flag to keep track if the Logger is already initialized or not. Is set to true in the init() function

8.18.4.3 _sd_card

```
SDCard * Logger::_sd_card = nullptr  [static], [private]
```

Pointer to the SD card object

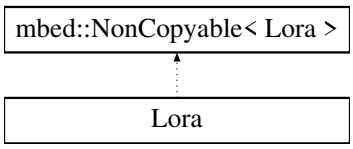
The documentation for this class was generated from the following files:

- src/logging/Logger.h
- src/logging/Logger.cpp

8.19 Lora Class Reference

```
#include <Lora.h>
```

Inheritance diagram for Lora:



Public Member Functions

- Lora ()
- void init ()
- void sleep ()
- void send (uint8_t *data, uint8_t size)
- mbed_error_status_t receive ()
- void set_tx_config ()
- void set_rx_config ()

Public Attributes

- uint8_t rx_payload [MAX_DATA_BUFFER_SIZE_SX126X]
- uint16_t rx_payload_len = 0
- int8_t rx_rssi = 0
- int8_t rx_snr = 0

Private Member Functions

- void tx_done_cb ()
- void rx_error_cb ()
- void tx_timeout_cb ()
- void rx_timeout_cb ()
- void cad_done_cb (bool arg)
- void rx_done_cb (const uint8_t *payload, uint16_t size, int16_t rssi, int8_t snr)
- void fhss_change_channel_cb (uint8_t channel)

Private Attributes

- SX126X_LoRaRadio _radio
- radio_events_t _radio_callbacks
- rtos::EventFlags _event_flags
- mbed::LowPowerTimeout _rx_timeout

8.19.1 Detailed Description

Class acting as an adapter to provide simple functions to control the LoRa module.

8.19.2 Constructor & Destructor Documentation

8.19.2.1 Lora()

```
Lora::Lora ( )
```

Create a new Lora object

8.19.3 Member Function Documentation

8.19.3.1 cad_done_cb()

```
void Lora::cad_done_cb (
            bool arg )  [private]
```

Callback function which is called as soon as the channel activity detection is done.(not used)

Parameters

arg	true, if channel activity detected

8.19.3.2 fhss_change_channel_cb()

```
void Lora::fhss_change_channel_cb (
            uint8_t channel )  [private]
```

FHSS Change Channel callback (not used)

Parameters

channel	The index number of the current channel

8.19.3.3 init()

```
void Lora::init ( )
```

Initialize Lora object by setting the _radio_callbacks initializing the _radio and setting radio specific parameters.

8.19.3.4 receive()

```
mbed_error_status_t Lora::receive ( )
```

Wait to receive a LoRa packet for a maximum time of LORA_RX_TIMEOUT_MS.

Returns

MBED_SUCCESS if a packet was received, MBED_ERROR_TIME_OUT on timeout

8.19.3.5 rx_done_cb()

```
void Lora::rx_done_cb (
            const uint8_t * payload,
            uint16_t size,
            int16_t rssi,
            int8_t snr )  [private]
```

Callback function which is called if a LoRa packet was received.

Parameters

payload	The received payload
size	Size of the received payload
rssi	RSSI of the received packet
snr	SNR of the received packet

8.19.3.6 rx_error_cb()

```
void Lora::rx_error_cb ( )  [private]
```

Callback function which is called on a receive error

8.19.3.7 rx_timeout_cb()

```
void Lora::rx_timeout_cb ( )  [private]
```

Callback function which is called if a receive timeout occurs

8.19.3.8 send()

```
void Lora::send (
            uint8_t * data,
            uint8_t size )
```

Set LoRa module into standby mode, send `data` of the given `size` via the LoRa module and wait until the transmission is done.

Parameters

data	Data to be sent
size	Size of the data

8.19.3.9 set_rx_config()

```
void Lora::set_rx_config ( )
```

Set the RX parameters of _radio to the values defined in the Config::global_config

8.19.3.10 set_tx_config()

```
void Lora::set_tx_config ( )
```

Set the TX parameters of _radio to the values defined in the Config::global_config

8.19.3.11 sleep()

```
void Lora::sleep ( )
```

Set the LoRa module to sleep mode

8.19.3.12 tx_done_cb()

```
void Lora::tx_done_cb ( )  [private]
```

Callback function which is called as soon as a LoRa packet is fully transmitted

8.19.3.13 tx_timeout_cb()

```
void Lora::tx_timeout_cb ( )  [private]
```

Callback function which is called if a transmit timeout occurs

8.19.4 Member Data Documentation

8.19.4.1 _event_flags

```
rtos::EventFlags Lora::_event_flags  [private]
```

Event flags used for event handling within this Lora class

8.19.4.2 _radio

```
SX126X_LoRaRadio Lora::_radio  [private]
```

Radio object to control the LoRa module via the lower level driver from mbed OS.

8.19.4.3 _radio_callbacks

```
radio_events_t Lora::_radio_callbacks  [private]
```

Struct holding the callbacks for the _radio

8.19.4.4 _rx_timeout

```
mbed::LowPowerTimeout Lora::_rx_timeout  [private]
```

Receive timout object used in the receive() function

8.19.4.5 rx_payload

```
uint8_t Lora::rx_payload[MAX_DATA_BUFFER_SIZE_SX126X]
```

Data buffer for the last packet received

8.19.4.6 rx_payload_len

```
uint16_t Lora::rx_payload_len = 0
```

Size of the last packet received

8.19.4.7 rx_rssi

```
int8_t Lora::rx_rssi = 0
```

Received Signal Strength Indicator (RSSI) for the last packet received

8.19.4.8 rx_snr

```
int8_t Lora::rx_snr = 0
```

Signal to Noise Ratio (SNR) for the last packet received

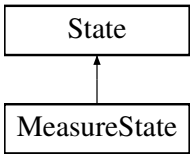
The documentation for this class was generated from the following files:

- src/driver/Lora.h
- src/driver/Lora.cpp

8.20 MeasureState Class Reference

```
#include <MeasureState.h>
```

Inheritance diagram for MeasureState:



Classes

- struct avg_data_s

Public Member Functions

- MeasureState (LedIndicator &led_indicator, SDCard &sd_card, Communication &communication, SensorSPS30 &sps30, SensorBME280 &bme280, rtos::EventFlags &event_flags)
- ~MeasureState () override=default
- State::Result handle () override

Private Types

- enum class SPS30State { OFF , STARTING , RUNNING }
- typedef struct MeasureState::avg_data_s avg_data_t

Private Member Functions

- mbed_error_status_t init_measurement_file ()
- void set_do_measurement_flag ()
- void set_create_new_file_flag ()
- void set_sps30_startup_done_flag ()
- State::Result run ()
- void send_measurement_data (const SensorSPS30::measurement_t &sps30_measurement, const SensorBME280::measurement_t &bme280_measurement)
- mbed_error_status_t store_measurement_data (const SensorSPS30::measurement_t &sps30_measurement, const SensorBME280::measurement_t &bme280_measurement)
- mbed_error_status_t get_sps30_info ()

Private Attributes

- SDCard & _sd_card
- Communication & _communication
- SensorSPS30 & _sps30
- SPS30State _sps30_state
- SensorBME280 & _bme280
- rtos::EventFlags & _event_flags
- std::string _data_file_name
- std::string _sps30_info
- mbed::LowPowerTicker _measurement_ticker
- mbed::LowPowerTicker _new_file_ticker
- mbed::LowPowerTimeout _sps30_startup_timeout
- std::vector< SensorSPS30::measurement_t > _sps30_data_buffer
- std::vector< avg_data_t > _avg_data

Additional Inherited Members

8.20.1 Detailed Description

State handling the measurement process

8.20.2 Member Typedef Documentation

8.20.2.1 avg_data_t

```
typedef struct MeasureState::avg_data_s MeasureState::avg_data_t  [private]
```

Struct used to store the measurement points for the moving average. Overloaded operators are used to calculate the average.

8.20.3 Member Enumeration Documentation

8.20.3.1 SPS30State

```
enum MeasureState::SPS30State  [strong], [private]
```

Enum defining the SPS30 states

Enumerator

OFF	
STARTING	
RUNNING	

8.20.4 Constructor & Destructor Documentation

8.20.4.1 MeasureState()

```
MeasureState::MeasureState (
            LedIndicator & led_indicator,
            SDCard & sd_card,
            Communication & communication,
            SensorSPS30 & sps30,
            SensorBME280 & bme280,
            rtos::EventFlags & event_flags )
```

Create a MeasureState

Parameters

led_indicator	Reference to the LedIndicator to set the LED behavior
sd_card	Reference to the SDCard to write the measurement files to
communication	Reference to the Communication object to send measurement data via LoRa
sps30	Reference to the SensorSPS30
bme280	Reference to the SensorBME280
event_flags	Reference to the control event flags to react on occurring control events.

8.20.4.2 ~MeasureState()

```
MeasureState::~MeasureState ( )  [override], [default]
```

Default destructor

8.20.5 Member Function Documentation

8.20.5.1 get_sps30_info()

```
mbed_error_status_t MeasureState::get_sps30_info ( )  [private]
```

Retrieve the version and serial number from the SPS30 sensor and store it to _sps30_info.

Returns

MBED_SUCCESS on success, an mbed_error_status_t otherwise

8.20.5.2 handle()

```
State::Result MeasureState::handle ( )  [override], [virtual]
```

Start _measurement_ticker and _new_file_ticker to signalize when a measurement needs to be done or a new measurement file needs to be created. Init measurement file and the _sps30_state and clear the _event_flags. Call run() to execute the measurement process.

Returns

the returned value of run()

Implements State.

8.20.5.3 init_measurement_file()

```
mbed_error_status_t MeasureState::init_measurement_file ( )  [private]
```

Create a new measurement file and add the file header to the newly created file.

Returns

MBED_SUCCESS on success, otherwise an mbed_error_status_t

8.20.5.4 run()

```
State::Result MeasureState::run ( )  [private]
```

Handle the measurement process by reacting on set _event_flags.
Depending on the flag, which is set, execute one of the following paths:
1) FLAG_BUTTON_MEASURE: Call set_do_measurement_flag()
2) FLAG_BUTTON_COMMAND: Return with State::Result::COMMAND_PRESSED
3) FLAG_BUTTON_STATUS: Show the program status and battery level with _led_indicator
4) FLAG_DO_MEASUREMENT: Start SPS30 if it is not already starting or running and set FLAG_SPS30_STARTUP_DONE after a given start up timeout. If the SPS30 is already running, set FLAG_SPS30_STARTUP_DONE immediately.
5) FLAG_SPS30_STARTUP_DONE: Read the measurement data from the BME280 and the SPS30. Stop the SPS30 if the next measurement does not start within the next 5 seconds, otherwise keep the SPS30 running. Then write the measurement data to the SD card and send it via LoRa.
6) FLAG_CREATE_NEW_FILE: Create a new measurment file with init_measurement_file()

Returns

a State::Result depending on the return reason

8.20.5.5 send_measurement_data()

```
void MeasureState::send_measurement_data (
            const SensorSPS30::measurement_t & sps30_measurement,
            const SensorBME280::measurement_t & bme280_measurement )  [private]
```

Scale `sps30_measurement` values and `bme280_measurement` values to match the protocol. Send them to the LoRa communication thread, which will send the data to the gateway via LoRa.

Parameters

sps30_measurement	Measurement data of the SPS30 sensor
bme280_measurement	Measurement data of the BME280 sensor

8.20.5.6 set_create_new_file_flag()

```
void MeasureState::set_create_new_file_flag ( )  [private]
```

Set FLAG_CREATE_NEW_FILE in _event_flags

8.20.5.7 set_do_measurement_flag()

```
void MeasureState::set_do_measurement_flag ( )  [private]
```

Set FLAG_DO_MEASUREMENT in _event_flags

8.20.5.8 set_sps30_startup_done_flag()

```
void MeasureState::set_sps30_startup_done_flag ( )  [private]
```

Set FLAG_SPS30_STARTUP_DONE in _event_flags

8.20.5.9 store_measurement_data()

```
mbed_error_status_t MeasureState::store_measurement_data (
            const SensorSPS30::measurement_t & sps30_measurement,
            const SensorBME280::measurement_t & bme280_measurement )  [private]
```

Store the `sps30_measurement` data and `bme280_measurement` data on the SD card.

Parameters

sps30_measurement	Measurement data of the SPS30 sensor
bme280_measurement	Measurement data of the BME280 sensor

Returns

MBED_SUCCESS if write succeeded or SD card logging is turned off, an mbed_error_status_t otherwise.

8.20.6 Member Data Documentation

8.20.6.1 _avg_data

```
std::vector<avg_data_t> MeasureState::_avg_data  [private]
```

Vector storing the latest measurement values for the moving average computation.

8.20.6.2 _bme280

```
SensorBME280& MeasureState::_bme280  [private]
```

Reference to the SensorBME280 object

8.20.6.3 _communication

```
Communication& MeasureState::_communication  [private]
```

Reference to the Communication handling the LoRa communication.

8.20.6.4 _data_file_name

```
std::string MeasureState::_data_file_name  [private]
```

Timestamp when the currently used measurement file was created

8.20.6.5 _event_flags

```
rtos::EventFlags& MeasureState::_event_flags  [private]
```

Reference to the control event flags used to control the measurement process

8.20.6.6 _measurement_ticker

```
mbed::LowPowerTicker MeasureState::_measurement_ticker  [private]
```

Ticker signalizing when it is time to do a measurement

8.20.6.7 _new_file_ticker

```
mbed::LowPowerTicker MeasureState::_new_file_ticker  [private]
```

Ticker signalizing when it is time to create a new measurement file

8.20.6.8 _sd_card

```
SDCard& MeasureState::_sd_card  [private]
```

Reference to the SDCard to write the measurement files to

8.20.6.9 _sps30

```
SensorSPS30& MeasureState::_sps30  [private]
```

Reference to the SensorSPS30 object

8.20.6.10 _sps30_data_buffer

```
std::vector<SensorSPS30::measurement_t> MeasureState::_sps30_data_buffer  [private]
```

Vector storing the latest SPS30 measurement values for the moving average computation.

8.20.6.11 _sps30_info

```
std::string MeasureState::_sps30_info  [private]
```

Version and serial numbers of the SPS30

8.20.6.12 _sps30_startup_timeout

```
mbed::LowPowerTimeout MeasureState::_sps30_startup_timeout  [private]
```

Timeout used to wait for the SPS30 to start up

8.20.6.13 _sps30_state

```
SPS30State MeasureState::_sps30_state  [private]
```

The current state of _sps30

The documentation for this class was generated from the following files:

- src/state/MeasureState.h
- src/state/MeasureState.cpp

8.21 Protocol Class Reference

`#include <Protocol.h>`

Public Member Functions

- struct __attribute__ ((__packed__))
- struct __attribute__ ((__packed__))
- Protocol (Lora &lora)
- void send_auth ()
- bool is_auth_done ()
- void auth_reset ()
- void send_measured_data (const measured_data_t &data)
- void send_status_data (const status_data_t &data)
- mbed_error_status_t read_received ()

Static Public Member Functions

- static uint32_t get_sw_uuid ()
- static uint32_t get_hw_uuid ()

Public Attributes

- measured_data_t
- status_data_t

Private Member Functions

- struct __attribute__ ((__packed__))
- struct __attribute__ ((__packed__))
- struct __attribute__ ((__packed__))
- struct __attribute__ ((__packed__))
- struct __attribute__ ((__packed__)) base_ack_s
- mbed_error_status_t crc_check (const uint8_t *buf, uint16_t size)
- mbed_error_status_t check_auth (const uint8_t *buf, uint16_t size)
- mbed_error_status_t check_ack (const uint8_t *buf, uint16_t size)

Private Attributes

- node_auth_t
- base_auth_t
- node_measured_data_t
- node_status_data_t
- base_ack_t
- Lora & _lora
- uint16_t _node_crc = 0
- uint16_t _base_crc = 0
- uint8_t _node_id = 0
- bool _client_auth_done = false

8.21.1 Detailed Description

Implements the communication protocol between a sensor node and a smartmote gateway.

8.21.2 Constructor & Destructor Documentation

8.21.2.1 Protocol()

```
Protocol::Protocol (
            Lora & lora )  [explicit]
```

Creates a Protocol object which uses `lora` to exchange packets with the gateway.

Parameters

lora	Reference to the Lora object acting as a driver for the LoRa module

8.21.3 Member Function Documentation

8.21.3.1 __attribute__() [1/7]

```
struct Protocol::__attribute__ (
            (__packed__)  )  [inline]
```

Struct defining the format for the measurement data within a Protocol::node_measured_data_t packet

8.21.3.2 __attribute__() [2/7]

```
struct Protocol::__attribute__ (
            (__packed__)  )  [inline]
```

Struct defining the format for the status data within a Protocol::node_status_data_t packet

8.21.3.3 __attribute__() [3/7]

```
struct Protocol::__attribute__ (
            (__packed__)  )  [inline], [private]
```

Struct defining the format for a node authentication request packet

8.21.3.4 __attribute__() [4/7]

```
struct Protocol::__attribute__ (
            (__packed__)  )  [inline], [private]
```

Struct defining the format for the base station authentication response packet

8.21.3.5 __attribute__() [5/7]

```
struct Protocol::__attribute__ (
            (__packed__)  )  [inline], [private]
```

Struct defining the format for the measurement data packet sent by the node

8.21.3.6 __attribute__() [6/7]

```
struct Protocol::__attribute__ (
            (__packed__)  )  [inline], [private]
```

Struct defining the format for the status data packet sent by the node

8.21.3.7 __attribute__() [7/7]

```
struct Protocol::__attribute__ (
            (__packed__)  )  [inline], [private]
```

Struct defining the format for the base station acknowledge response on a data packet

8.21.3.8 auth_reset()

```
void Protocol::auth_reset ( )
```

Resets the connection by setting _client_auth_done to false.

8.21.3.9 check_ack()

```
mbed_error_status_t Protocol::check_ack (
            const uint8_t * buf,
            uint16_t size )  [private]
```

Checks the response from the gateway on a sent data packet. After checking the length, the CRC checksum, the _node_id and the acknowledge byte are checked.

Parameters

buf	The buffer with the acknowledge packet
size	The size of the buffer

Returns

MBED_SUCCESS if the a valid acknowledge was received, an mbed_error_status_t otherwise

8.21.3.10 check_auth()

```
mbed_error_status_t Protocol::check_auth (
            const uint8_t * buf,
            uint16_t size )  [private]
```

Checks the authentication response from the gateway. First, the length is checked, then the _base_crc is extracted and if the crc_check() was sucessful, the _node_id is extracted and _client_auth_done is set to true.

Parameters

buf	The buffer with the received authentication response
size	The size of the buffer

Returns

MBED_SUCCESS if the authentication succeeded, MBED_ERROR_INVALID_SIZE or MBED_ERROR_↩ CRC_ERROR otherwise

8.21.3.11 crc_check()

```
mbed_error_status_t Protocol::crc_check (
            const uint8_t * buf,
            uint16_t size )  [private]
```

Check if the CRC checksum at the end of `buf` is correct.

Parameters

buf	The buffer with a received packet
size	The size of `buf`

Returns

MBED_SUCCESS if the CRC checksum is correct, MBED_ERROR_CRC_ERROR otherwise

8.21.3.12 get_hw_uuid()

```
uint32_t Protocol::get_hw_uuid ( )  [static]
```

Calculate the hardware UUID, which is the 32-bit CRC checksum from the unique identifier of the microcontroller.

Returns

the 32-bit hardware UUID

8.21.3.13 get_sw_uuid()

```
uint32_t Protocol::get_sw_uuid ( )  [static]
```

Calculate the software UUID, which is the 32-bit CRC checksum of the app version string.

Returns

the 32-bit software UUID

8.21.3.14 is_auth_done()

```
bool Protocol::is_auth_done ( )
```

Returns

_client_auth_done, which is true if the node is authenticated and false otherwise

8.21.3.15 read_received()

```
mbed_error_status_t Protocol::read_received ( )
```

Retrieve the received packets from _lora and check the validity of the packet with check_auth() or check_ack()

Returns

MBED_SUCESS if a valid authentication responds or a valid acknowledge was received and a mbed_error↩ _status_t otherwise

8.21.3.16 send_auth()

```
void Protocol::send_auth ( )
```

Send an authentication message to the gateway.

8.21.3.17 send_measured_data()

```
void Protocol::send_measured_data (
            const measured_data_t & data )
```

Send the given measured `data` in format of Protocol::node_measured_data_t via LoRa to the gateway

Parameters

data	measured data to be sent

8.21.3.18 send_status_data()

```
void Protocol::send_status_data (
            const status_data_t & data )
```

Send the given status `data` in format of Protocol::node_status_data_t via LoRa to the gateway

Parameters

data	status data to be sent

8.21.4 Member Data Documentation

8.21.4.1 _base_crc

```
uint16_t Protocol::_base_crc = 0  [private]
```

The base CRC used to ensure message integrity

8.21.4.2 _client_auth_done

```
bool Protocol::_client_auth_done = false  [private]
```

Authentication status

8.21.4.3 _lora

```
Lora& Protocol::_lora  [private]
```

Reference to the Lora object used to control the LoRa module

8.21.4.4 _node_crc

```
uint16_t Protocol::_node_crc = 0  [private]
```

The node CRC used to ensure message integrity

8.21.4.5 _node_id

```
uint8_t Protocol::_node_id = 0  [private]
```

The node ID assigned by the gateway

8.21.4.6 base_ack_t

```
Protocol::base_ack_t  [private]
```

8.21.4.7 base_auth_t

```
Protocol::base_auth_t  [private]
```

8.21.4.8 measured_data_t

```
Protocol::measured_data_t
```

8.21.4.9 node_auth_t

```
Protocol::node_auth_t  [private]
```

8.21.4.10 node_measured_data_t

```
Protocol::node_measured_data_t  [private]
```

8.21.4.11 node_status_data_t

```
Protocol::node_status_data_t  [private]
```

8.21.4.12 status_data_t

`Protocol::status_data_t`

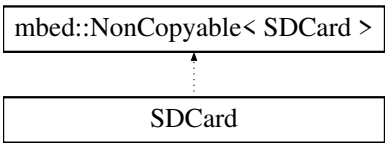
The documentation for this class was generated from the following files:

- src/communication/Protocol.h
- src/communication/Protocol.cpp

8.22 SDCard Class Reference

`#include <SDCard.h>`

Inheritance diagram for SDCard:



Public Member Functions

- SDCard (SDBlockDevice &sd_block_device, FATFileSystem &fat_file_system)
- mbed_error_status_t init ()
- mbed_error_status_t deinit ()
- mbed_error_status_t format ()
- mbed_error_status_t write (const std::string &filename, const std::string &data)
- mbed_error_status_t check_available_memory ()
- bool is_full ()

Private Member Functions

- bool is_inserted ()

Private Attributes

- bool _is_full = false
- mbed::DigitalIn _n_detect
- SDBlockDevice & _sd_block_device
- FATFileSystem & _fat_file_system
- bool _initialized
- PlatformMutex _sd_card_mutex

8.22.1 Detailed Description

Class handling the SD card operations

8.22.2 Constructor & Destructor Documentation

8.22.2.1 SDCard()

```
SDCard::SDCard (
            SDBlockDevice & sd_block_device,
            FATFileSystem & fat_file_system )
```

Create a SDCard object with the given `sd_block_device` and `fat_file_system`. Because the initialization of the SDCard can fail, it is done in the init() function instead of the constructor.

Parameters

sd_block_device	reference to the SDBlockDevice object
fat_file_system	reference to the FATFileSystem object

8.22.3 Member Function Documentation

8.22.3.1 check_available_memory()

```
mbed_error_status_t SDCard::check_available_memory ( )
```

Check the available free memory on the SD card. If the SD card is full, _is_full is set to true.

Returns

MBED_SUCCESS if memory statistics could be read and the available memory is more than 1MB. Otherwise an mbed_error_status_t is returned.

8.22.3.2 deinit()

```
mbed_error_status_t SDCard::deinit ( )
```

Deinitializes the SDCard object by unmounting _fat_file_system and deinitializing _sd_block_device.

Returns

MBED_SUCCESS on success, an mbed_error_status_t otherwise

8.22.3.3 format()

```
mbed_error_status_t SDCard::format ( )
```

Formats the SD card with a cluster size of 4kB

Returns

MBED_SUCCESS on success, an mbed_error_status_t otherwise

8.22.3.4 init()

```
mbed_error_status_t SDCard::init ( )
```

Checks if an SD card is detected, initializes the _sd_block_device, sets its SPI frequency, mounts the _fat_file_system and checks if more than 1MB free memory is available on the SD card.

Returns

MBED_SUCCESS if initialization succeeded or SDCard is already initialized, an mbed_error_status_t otherwise

8.22.3.5 is_full()

```
bool SDCard::is_full ( )
```

Returns

_is_full

8.22.3.6 is_inserted()

```
bool SDCard::is_inserted ( )  [private]
```

Returns

true if an SD card is inserted/detected

8.22.3.7 write()

```
mbed_error_status_t SDCard::write (
            const std::string & filename,
            const std::string & data )
```

Writes the given `data` to the file with the given `filename` in append mode. If the file with the `filename` does not exist, it is created. The file is opened before the write operation and closed afterwards. After closing the file, the available free memory is checked.

Parameters

filename	the name of the file to which the `data` should be appended
data	data string that should be written to the specified file

Returns

MBED_SUCCESS on success, an mbed_error_status_t otherwise

8.22.4 Member Data Documentation

8.22.4.1 _fat_file_system

```
FATFileSystem& SDCard::_fat_file_system  [private]
```

Reference to the FATFileSystem object

8.22.4.2 _initialized

```
bool SDCard::_initialized  [private]
```

Flag which is true if the SDCard object is initialized

8.22.4.3 _is_full

```
bool SDCard::_is_full = false  [private]
```

Flag which is set to true by check_available_memory() as soon as the SD card is full.

8.22.4.4 _n_detect

```
mbed::DigitalIn SDCard::_n_detect  [private]
```

8.22.4.5 _sd_block_device

```
SDBlockDevice& SDCard::_sd_block_device  [private]
```

Reference to the SDBlockDevice object

8.22.4.6 _sd_card_mutex

```
PlatformMutex SDCard::_sd_card_mutex  [private]
```

Mutex to ensure sequential write access to the SD card, because write is called from different threads.

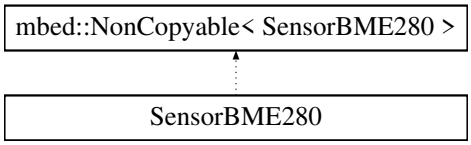
The documentation for this class was generated from the following files:

- src/driver/SDCard.h
- src/driver/SDCard.cpp

8.23 SensorBME280 Class Reference

```
#include <SensorBME280.h>
```

Inheritance diagram for SensorBME280:



Classes

- struct bme280_handle_t

Public Types

- typedef struct bme280_data measurement_t

Public Member Functions

- SensorBME280 ()
- ~SensorBME280 ()=default
- mbed_error_status_t init ()
- mbed_error_status_t read_measurement (measurement_t *data)

Private Member Functions

- void bme280_spi_init ()
- int8_t read_sensor_data (measurement_t *data)
- void correct_data (measurement_t *data)

Static Private Member Functions

- static void bme280_delay_us (uint32_t period, void ∗intf_ptr)
- static int8_t bme280_spi_read (uint8_t reg_addr, uint8_t ∗reg_data, uint32_t len, void ∗intf_ptr)
- static int8_t bme280_spi_write (uint8_t reg_addr, const uint8_t ∗reg_data, uint32_t len, void ∗intf_ptr)

Private Attributes

- mbed::DigitalOut _bme280_cs
- mbed::SPI _spi
- struct bme280_dev _dev
- bme280_handle_t _bme280_handle

8.23.1 Detailed Description

Adapter class providing functions to control the Bosch BME280 environmental sensor

8.23.2 Member Typedef Documentation

8.23.2.1 measurement_t

```
typedef struct bme280_data SensorBME280::measurement_t
```

Data structure for BME280 measurement data

8.23.3 Constructor & Destructor Documentation

8.23.3.1 SensorBME280()

```
SensorBME280::SensorBME280 ( )
```

Creates a SensorBME280 object

8.23.3.2 ∼SensorBME280()

```
SensorBME280::∼SensorBME280 ( )  [default]
```

Default destructor

8.23.4 Member Function Documentation

8.23.4.1 bme280_delay_us()

```
void SensorBME280::bme280_delay_us (
            uint32_t period,
            void * intf_ptr )  [static], [private]
```

Delay function for the BME280 manufacturer driver

Parameters

period	Time to wait in Microseconds
intf_ptr	Pointer to _bme280_handle (not used in this function)

8.23.4.2 bme280_spi_init()

```
void SensorBME280::bme280_spi_init ( )  [private]
```

Initialize the SPI for the BME280

8.23.4.3 bme280_spi_read()

```
int8_t SensorBME280::bme280_spi_read (
            uint8_t reg_addr,
            uint8_t * reg_data,
            uint32_t len,
            void * intf_ptr )  [static], [private]
```

SPI read function for the BME280 manufacturer driver

Parameters

reg_addr	BME280 register address to read from
reg_data	Buffer where the read data is written to
len	Number of bytes to read
intf_ptr	Pointer to _bme280_handle

Returns

always BME280_OK (defined in bme280_defs.h)

8.23.4.4 bme280_spi_write()

```
int8_t SensorBME280::bme280_spi_write (
            uint8_t reg_addr,
            const uint8_t * reg_data,
            uint32_t len,
            void * intf_ptr )  [static], [private]
```

SPI write function for the BME280 manufacturer driver

Parameters

reg_addr	BME280 register address to write to
reg_data	Data which should be written
len	Number of bytes to write
intf_ptr	Pointer to _bme280_handle

Returns

always BME280_OK (defined in bme280_defs.h)

8.23.4.5 correct_data()

```
void SensorBME280::correct_data (
            measurement_t * data )  [private]
```

Apply a correction offset and factor to the measurement `data`. The correction values are defined in Config::global_config.

Parameters

data	the measurement data to be corrected

8.23.4.6 init()

```
mbed_error_status_t SensorBME280::init ( )
```

Initialization function for the BME280 and the SPI bus.

Returns

MBED_SUCCESS if initialization is successful, MBED_ERROR_INITIALIZATION_FAILED otherwise

8.23.4.7 read_measurement()

```
mbed_error_status_t SensorBME280::read_measurement (
            measurement_t * data )
```

Reads measurement data from BME280 and stores it into `data`

Parameters

data	where the measurement data is stored to

Returns

MBED_SUCCESS if read operation succeeded, MBED_ERROR_READ_FAILED otherwise

8.23.4.8 read_sensor_data()

```
int8_t SensorBME280::read_sensor_data (
            measurement_t * data )  [private]
```

Read temperature, pressure and humidity from the sensor in forced mode.

Parameters

data	Buffer to write the measured data to

Returns

BME280_OK on success, a negative error code (see bme280_defs.h) otherwise

8.23.5 Member Data Documentation

8.23.5.1 _bme280_cs

```
mbed::DigitalOut SensorBME280::_bme280_cs  [private]
```

BME280 SPI chip select output

8.23.5.2 _bme280_handle

```
bme280_handle_t SensorBME280::_bme280_handle  [private]
```

Handle for the bme280_spi_* functions

8.23.5.3 _dev

```
struct bme280_dev SensorBME280::_dev  [private]
```

BME280 device structure for the manufacturer driver

8.23.5.4 _spi

```
mbed::SPI SensorBME280::_spi  [private]
```

SPI object for the communication with the BME280 sensor

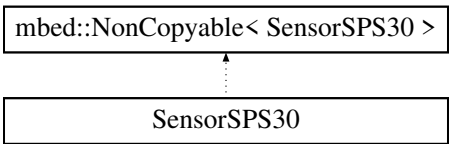
The documentation for this class was generated from the following files:

- src/driver/SensorBME280.h
- src/driver/SensorBME280.cpp

8.24 SensorSPS30 Class Reference

```
#include <SensorSPS30.h>
```

Inheritance diagram for SensorSPS30:



Public Types

- typedef struct sps30_measurement measurement_t

Public Member Functions

- SensorSPS30 ()
- ~SensorSPS30 ()=default
- void power_on ()
- void power_off ()
- mbed_error_status_t probe ()
- mbed_error_status_t get_serial (std::string &serial)
- mbed_error_status_t read_version (sps30_version_information *version)
- mbed_error_status_t start_measurement ()
- void stop_measurement ()
- mbed_error_status_t read_measurement (measurement_t *measurement_data)
- mbed_error_status_t start_manual_fan_cleaning ()

Private Member Functions

- void correct_data (measurement_t *measurement_data)

Private Attributes

- mbed::DigitalOut _supply_enable
- mbed::BufferedSerial _serial

8.24.1 Detailed Description

Adapter class providing functions to control the Sensirion SPS30 particulate matter sensor.

8.24.2 Member Typedef Documentation

8.24.2.1 measurement_t

```
typedef struct sps30_measurement SensorSPS30::measurement_t
```

Data structure for SPS30 measurement data

8.24.3 Constructor & Destructor Documentation

8.24.3.1 SensorSPS30()

```
SensorSPS30::SensorSPS30 ( )
```

Creates a SensorSPS30 object

8.24.3.2 ~SensorSPS30()

```
SensorSPS30::~SensorSPS30 ( )  [default]
```

Default destructor

8.24.4 Member Function Documentation

8.24.4.1 correct_data()

```
void SensorSPS30::correct_data (
            measurement_t * measurement_data )  [private]
```

Correct the `measurement_data` with the correction values defined in Config::global_config

Parameters

measurement_data	the data to be corrected

8.24.4.2 get_serial()

```
mbed_error_status_t SensorSPS30::get_serial (
            std::string & serial )
```

Read serial number string from SPS30

Parameters

serial	string to write the serial number to

Returns

MBED_SUCCESS on success, an mbed_error_status_t otherwise

8.24.4.3 power_off()

```
void SensorSPS30::power_off ( )
```

Turn power supply off for SPS30

8.24.4.4 power_on()

```
void SensorSPS30::power_on ( )
```

Turn power supply on for SPS30

8.24.4.5 probe()

```
mbed_error_status_t SensorSPS30::probe ( )
```

Probe SPS30

Returns

MBED_SUCCESS if probing was successful, MBED_ERROR_FAILED_OPERATION otherwise

8.24.4.6 read_measurement()

```
mbed_error_status_t SensorSPS30::read_measurement (
            measurement_t * measurement_data )
```

Read new measurement data from the SPS30 and correct the data with correct_data().

Parameters

measurement_data	Struct to store the measured data to

Returns

MBED_SUCCESS on success, an mbed_error_status_t otherwise

8.24.4.7 read_version()

```
mbed_error_status_t SensorSPS30::read_version (
            sps30_version_information * version )
```

Read firmware, hardware and shdlc version number from SPS30

Parameters

version	struct to store the version numbers to

Returns

MBED_SUCCESS on success, an mbed_error_status_t otherwise

8.24.4.8 start_manual_fan_cleaning()

```
mbed_error_status_t SensorSPS30::start_manual_fan_cleaning ( )
```

Start a fan cleaning process which lasts about 10 seconds.

Returns

MBED_SUCCESS on success, MBED_ERROR_FAILED_OPERATION otherwise

8.24.4.9 start_measurement()

```
mbed_error_status_t SensorSPS30::start_measurement ( )
```

Set the SPS30 into measurement mode. The SPS30 is then continuously measuring.

Returns

MBED_SUCCESS on success, an mbed_error_status_t otherwise

8.24.4.10 stop_measurement()

```
void SensorSPS30::stop_measurement ( )
```

Let the SPS30 exit the measurement mode and turn off the power supply.

8.24.5 Member Data Documentation

8.24.5.1 _serial

```
mbed::BufferedSerial SensorSPS30::_serial  [private]
```

Serial interface handler

8.24.5.2 _supply_enable

```
mbed::DigitalOut SensorSPS30::_supply_enable  [private]
```

Digital output for the 5V supply enable

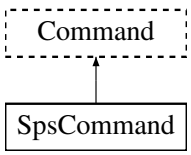
The documentation for this class was generated from the following files:

- src/driver/SensorSPS30.h
- src/driver/SensorSPS30.cpp

8.25 SpsCommand Class Reference

```
#include <SpsCommand.h>
```

Inheritance diagram for SpsCommand:



Public Member Functions

- SpsCommand (USBSerial &usb_serial, SensorSPS30 &sps30)
- ~SpsCommand () override=default

Private Member Functions

- void execute_command (std::map< std::string, std::string > &parameter_map, std::vector< std::string > &parameter_vec) override

Private Attributes

- SensorSPS30 & _sps30

Additional Inherited Members

8.25.1 Detailed Description

Class handling commands to test and control the SPS30 sensor connected via UART serial interface

8.25.2 Constructor & Destructor Documentation

8.25.2.1 SpsCommand()

```
SpsCommand::SpsCommand (
            USBSerial & usb_serial,
            SensorSPS30 & sps30 )
```

Create a SpsCommand object

Parameters

usb_serial	reference to an USBSerial object
sps30	reference to the SensorSPS30 object which should be controlled

8.25.2.2 ~SpsCommand()

```
SpsCommand::~SpsCommand ( )  [override], [default]
```

Default destructor

8.25.3 Member Function Documentation

8.25.3.1 execute_command()

```
void SpsCommand::execute_command (
            std::map< std::string, std::string > & parameter_map,
            std::vector< std::string > & parameter_vec )  [override], [private], [virtual]
```

Executes the sps command according to the given parameters. The usage of the command is described in the sps_command_description.

Parameters

parameter_map	map holding the parameters that are given as key-value-pairs
parameter_vec	vector holding the option parameters

Implements Command.

8.25.4 Member Data Documentation

8.25.4.1 _sps30

```
SensorSPS30& SpsCommand::_sps30  [private]
```

Reference to the SensorSPS30 object used to control the sensor by calling its member functions.

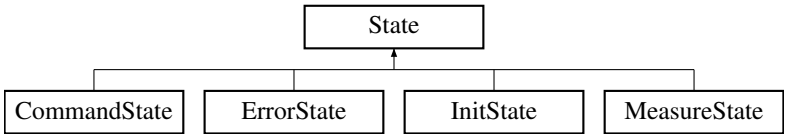
The documentation for this class was generated from the following files:

- src/command/SpsCommand.h
- src/command/SpsCommand.cpp

8.26 State Class Reference

```
#include <State.h>
```

Inheritance diagram for State:



Public Types

- enum class Result {
  SUCCESS , SENSOR_ERROR , SD_CARD_ERROR , FLASH_ERROR ,
  LORA_ERROR , COMMAND_PRESSED }

Public Member Functions

- State (LedIndicator &_led_indicator)
- virtual ~State ()=default
- virtual State::Result handle ()=0

Protected Attributes

- LedIndicator & _led_indicator

8.26.1 Detailed Description

Abstract base class for all states

8.26.2 Member Enumeration Documentation

8.26.2.1 Result

```
enum State::Result  [strong]
```

Enum defining the possible return values for the states

Enumerator

SUCCESS	
SENSOR_ERROR	
SD_CARD_ERROR	
FLASH_ERROR	
LORA_ERROR	
COMMAND_PRESSED	

8.26.3 Constructor & Destructor Documentation

8.26.3.1 State()

```
State::State (
            LedIndicator & _led_indicator )  [explicit]
```

Base constructor

Parameters

_led_indicator	Reference to the LedIndicator object

8.26.3.2 ~State()

```
virtual State::~State ( )  [virtual], [default]
```

Virtual default destructor

8.26.4 Member Function Documentation

8.26.4.1 handle()

```
virtual State::Result State::handle ( )  [pure virtual]
```

Pure virtual method handling the functions of the state. This method is called infinitely as long as the state is active.

Returns

result why the the handle function returned. This return value is used to decide which state is the next one

Implemented in MeasureState, InitState, ErrorState, and CommandState.

8.26.5 Member Data Documentation

8.26.5.1 _led_indicator

```
LedIndicator& State::_led_indicator  [protected]
```

Reference to the LedIndicator object. Used to set the LEDs behavior according to the current state.

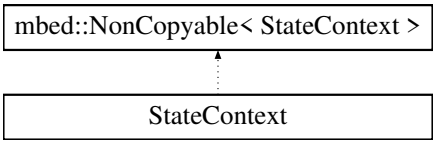
The documentation for this class was generated from the following files:

- src/state/State.h
- src/state/State.cpp

8.27 StateContext Class Reference

`#include <StateContext.h>`

Inheritance diagram for StateContext:



Public Member Functions

- StateContext (SDCard &sd_card, Communication &communication, LedIndicator &led_indicator, CommandHandler &command_handler, mbed::FlashIAP &flash, rtos::EventFlags &event_flags, SensorSPS30 &sps30, SensorBME280 &bme280, Buttons &buttons)
- ~StateContext ()
- void run ()
- void next_state (State::Result result)

Private Attributes

- State * _current_state

- InitState * _init_state
- MeasureState * _measure_state
- CommandState * _command_state
- ErrorState * _error_state

8.27.1 Detailed Description

Class implementing a finite state machine, holding the State objects and handling the state transitions.

8.27.2 Constructor & Destructor Documentation

8.27.2.1 StateContext()

```
StateContext::StateContext (
            SDCard & sd_card,
            Communication & communication,
            LedIndicator & led_indicator,
            CommandHandler & command_handler,
            mbed::FlashIAP & flash,
            rtos::EventFlags & event_flags,
            SensorSPS30 & sps30,
            SensorBME280 & bme280,
            Buttons & buttons )
```

Create a StateContext Create an instance of every State subclass on the heap.

Parameters

sd_card	Reference to the SDCard to perform operations on the SD card
communication	Reference to the Communication object
led_indicator	Reference to the LedIndicator to set the LED behavior
command_handler	Reference to the CommandHandler handling commands over the USB serial COM port
flash	Reference to the FlashIAP to load and store configurations in the flash memory
event_flags	Reference to the event flags used to control the program flow
sps30	Reference to the SensorSPS30 object
bme280	Reference to the BME280 object
buttons	Reference to the Buttons object

8.27.2.2 ~StateContext()

```
StateContext::~StateContext ( )
```

Destructor, delete all State objects from the heap.

8.27.3 Member Function Documentation

8.27.3.1 next_state()

```
void StateContext::next_state (
            State::Result result )
```

Depending `result` the next state is determined and the _current_state pointer is set to the next state.

Parameters

result	The State::Result of the _current_state, used to determine the next state

8.27.3.2 run()

```
void StateContext::run ( )
```

Invoke State::handle() of the _current_state and pass its return value to next_state().

8.27.4 Member Data Documentation

8.27.4.1 _command_state

```
CommandState* StateContext::_command_state  [private]
```

A pointer to the instance of this State.

8.27.4.2 _current_state

```
State* StateContext::_current_state  [private]
```

The current state

8.27.4.3 _error_state

```
ErrorState* StateContext::_error_state  [private]
```

A pointer to the instance of this State.

8.27.4.4 _init_state

```
InitState* StateContext::_init_state  [private]
```

A pointer to the instance of this State.

8.27.4.5 _measure_state

```
MeasureState* StateContext::_measure_state  [private]
```

A pointer to the instance of this State.

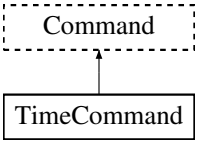
The documentation for this class was generated from the following files:

- src/state/StateContext.h
- src/state/StateContext.cpp

8.28 TimeCommand Class Reference

```
#include <TimeCommand.h>
```

Inheritance diagram for TimeCommand:



Public Member Functions

- TimeCommand (USBSerial &usb_serial)
- ~TimeCommand () override=default

Private Member Functions

- void execute_command (std::map< std::string, std::string > &parameter_map, std::vector< std::string > &parameter_vec) override
- void calibrate ()
- void wait_for_second_toggle ()

Static Private Member Functions

- static time_t parse_datetime (const std::vector< std::string > &parameters)

Private Attributes

- uint32_t _cal_time_sec = 30

Additional Inherited Members

8.28.1 Detailed Description

Class handling commands to set, print and calibrate the time and date

8.28.2 Constructor & Destructor Documentation

8.28.2.1 TimeCommand()

```
TimeCommand::TimeCommand (
            USBSerial & usb_serial )  [explicit]
```

Create a TimeCommand object

Parameters

usb_serial	reference to an USBSerial object

8.28.2.2 ~TimeCommand()

```
TimeCommand::~TimeCommand ( )  [override], [default]
```

Default destructor

8.28.3 Member Function Documentation

8.28.3.1 calibrate()

```
void TimeCommand::calibrate ( )  [private]
```

Emits a 1Hz clock over _usb_serial by printing the number of passed seconds every second. It uses wait_for_second_toggle() to wait until the RTC second counter changes. This function is executed in a separate highest priority thread to maximize the timing accuracy.

8.28.3.2 execute_command()

```
void TimeCommand::execute_command (
            std::map< std::string, std::string > & parameter_map,
            std::vector< std::string > & parameter_vec )  [override], [private], [virtual]
```

Executes the time command according to the given parameters. The usage of the command is described in the time_command_description.

Parameters

parameter_map	map holding the parameters that are given as key-value-pairs
parameter_vec	vector holding the option parameters

Implements Command.

8.28.3.3 parse_datetime()

```
time_t TimeCommand::parse_datetime (
            const std::vector< std::string > & parameters )  [static], [private]
```

Parses the date and time string into a struct tm and returns the corresponding time_t.

Parameters

parameters	vector with two strings, date and time

Returns

timestamp of the parsed time as time_t

8.28.3.4 wait_for_second_toggle()

```
void TimeCommand::wait_for_second_toggle ( )  [private]
```

Repeatedly polls the current RTC time until the RTC time is incremented, which happens every second.

8.28.4 Member Data Documentation

8.28.4.1 _cal_time_sec

```
uint32_t TimeCommand::_cal_time_sec = 30  [private]
```

The calibration time in seconds that indicates how long calibrate() will be executed.

The documentation for this class was generated from the following files:

- src/command/TimeCommand.h
- src/command/TimeCommand.cpp

8.29 version_number_s Struct Reference

```
#include <defines.h>
```

Public Attributes

- uint8_t major
- uint8_t minor
- uint16_t build

8.29.1 Member Data Documentation

8.29.1.1 build

```
uint16_t version_number_s::build
```

8.29.1.2 major

```
uint8_t version_number_s::major
```

8.29.1.3 minor

```
uint8_t version_number_s::minor
```

The documentation for this struct was generated from the following file:

- src/defs/defines.h

Chapter 9

File Documentation

9.1 CHANGELOG.md File Reference

9.2 README.md File Reference

9.3 src/command/BmeCommand.cpp File Reference

```
#include "BmeCommand.h"
#include "defines.h"
```

9.4 src/command/BmeCommand.h File Reference

```
#include "Command.h"
#include "SensorBME280.h"
```

Classes

- class BmeCommand

9.5 src/command/Command.cpp File Reference

```
#include "Command.h"
```

9.6 src/command/Command.h File Reference

```
#include "USBSerial.h"
#include <string>
#include <vector>
#include <map>
```

Classes

- class Command

9.7 src/command/CommandHandler.cpp File Reference

```
#include "CommandHandler.h"
#include "TimeCommand.h"
#include "ConfigCommand.h"
#include "InfoCommand.h"
#include "SpsCommand.h"
#include "BmeCommand.h"
#include "ThisThread.h"
#include "Logger.h"
```

9.8 src/command/CommandHandler.h File Reference

```
#include "Command.h"
#include "CircularBuffer.h"
#include "EventFlags.h"
#include "FlashIAP.h"
#include "SensorSPS30.h"
#include "SensorBME280.h"
#include "defines.h"
```

Classes

- class CommandHandler

9.9 src/command/ConfigCommand.cpp File Reference

```
#include "ConfigCommand.h"
#include "Config.h"
#include "defines.h"
```

9.10 src/command/ConfigCommand.h File Reference

```
#include "Command.h"
#include "FlashIAP.h"
```

Classes

- class ConfigCommand

9.11 src/command/InfoCommand.cpp File Reference

```
#include "InfoCommand.h"
#include "Protocol.h"
#include "defines.h"
#include "utils.h"
```

9.12 src/command/InfoCommand.h File Reference

```
#include "Command.h"
#include <string>
```

Classes

- class InfoCommand

9.13 src/command/SpsCommand.cpp File Reference

```
#include "SpsCommand.h"
#include "defines.h"
```

9.14 src/command/SpsCommand.h File Reference

```
#include "Command.h"
#include "SensorSPS30.h"
```

Classes

- class SpsCommand

9.15 src/command/TimeCommand.cpp File Reference

```
#include "TimeCommand.h"
#include "defines.h"
#include "Logger.h"
#include "utils.h"
#include "Thread.h"
#include "mbed_rtc_time.h"
```

Macros

- #define MS_PER_DAY 86400000.0f

9.15.1 Macro Definition Documentation

9.15.1.1 MS_PER_DAY

```
#define MS_PER_DAY 86400000.0f
```

9.16 src/command/TimeCommand.h File Reference

```
#include "Command.h"
```

Classes

- class TimeCommand

9.17 src/communication/Communication.cpp File Reference

```
#include "Communication.h"
#include "Battery.h"
#include "defines.h"
#include "Logger.h"
```

Macros

- #define FLAG_SEND_MEASURED_DATA (1U << 0U)
- #define FLAG_SEND_STATUS_DATA (1U << 1U)

9.17.1 Macro Definition Documentation

9.17.1.1 FLAG_SEND_MEASURED_DATA

```
#define FLAG_SEND_MEASURED_DATA (1U << 0U)
```

9.17.1.2 FLAG_SEND_STATUS_DATA

```
#define FLAG_SEND_STATUS_DATA (1U << 1U)
```

9.18 src/communication/Communication.h File Reference

```
#include "Lora.h"
#include "Protocol.h"
#include "LowPowerTicker.h"
```

Classes

- class Communication

9.19 src/communication/Protocol.cpp File Reference

```
#include "Protocol.h"
#include "MbedCRC.h"
#include "mbed_error.h"
#include "mbed_debug.h"
#include "utils.h"
#include "Logger.h"
```

Macros

- #define SMARTMOTE_AUTH_ID 0xff
- #define SMARTMOTE_HW_ID 0x4220
- #define SMARTMOTE_ACK 0x5a
- #define MEASURED_DATA_TYPE_ID 32
- #define STATUS_DATA_TYPE_ID 39

9.19.1 Macro Definition Documentation

9.19.1.1 MEASURED_DATA_TYPE_ID

```
#define MEASURED_DATA_TYPE_ID 32
```

9.19.1.2 SMARTMOTE_ACK

```
#define SMARTMOTE_ACK 0x5a
```

9.19.1.3 SMARTMOTE_AUTH_ID

```
#define SMARTMOTE_AUTH_ID 0xff
```

9.19.1.4 SMARTMOTE_HW_ID

```
#define SMARTMOTE_HW_ID 0x4220
```

9.19.1.5 STATUS_DATA_TYPE_ID

```
#define STATUS_DATA_TYPE_ID 39
```

9.20 src/communication/Protocol.h File Reference

```
#include "Lora.h"
```

Classes

- class Protocol

9.21 src/config/Config.cpp File Reference

```
#include "Config.h"
#include <climits>
#include <cstring>
#include "Logger.h"
```

9.22 src/config/Config.h File Reference

```
#include "defines.h"
#include <vector>
#include <map>
#include "utils.h"
#include "mbed_error.h"
#include "FlashIAP.h"
```

Classes

- class Config
- union Config::config_value_t
- struct Config::entry_t

Macros

- #define NUM_CONFIG_ENTRIES 49

9.22.1 Macro Definition Documentation

9.22.1.1 NUM_CONFIG_ENTRIES

```
#define NUM_CONFIG_ENTRIES 49
```

Number of config entries in Config::global_config

9.23 src/defs/defines.h File Reference

```
#include <cstdint>
```

Classes

- struct version_number_s

Macros

- #define VERSION_MAJOR 0U

  Major version.
- #define VERSION_MINOR 4U

  Minor version.
- #define VERSION_BUILD 3U

  Build version.
- #define FLAG_BUTTON_MEASURE (1U << 1U)
- #define FLAG_BUTTON_STATUS (1U << 2U)
- #define FLAG_BUTTON_COMMAND (1U << 3U)
- #define FLAG_RECEIVED_COMMAND (1U << 4U)
- #define FLAG_DO_MEASUREMENT (1U << 5U)
- #define FLAG_SPS30_STARTUP_DONE (1U << 6U)
- #define FLAG_CREATE_NEW_FILE (1U << 7U)
- #define STORAGE_ADDR_CONFIG POST_APPLICATION_ADDR

  Flash address where the values of the Config::global_config are stored. Maximum size is FLASH_PAGE_SIZE (2kB).
- #define BUTTON_DEBOUNCE_TIME 50

  Minimum time in milliseconds a button must be pressed to signal a short button press.
- #define BUTTON_COMMAND_MIN_PRESS_TIME 3000

  Minimum time in milliseconds the command-button must be pressed to signal a long button press.
- #define COMMAND_HANDLER_MAX_BUF_SIZE 1024

  Maximum buffer size for the USB serial interface.
- #define LORA_RESEND_WAIT_MS 10000

  Time to wait before authentication request is sent again after a wrong response was received.
- #define LORA_RX_TIMEOUT_MS 5000

  Maximum time to wait for a response after sending a request or data to the gateway.
- #define MAX_SEND_DATA_ATTEMPTS 3

  Maximum number of attempts to send a data packet until a new authentication message is sent.
- #define FLAG_LORA_TX_DONE (1U << 0U)

  Event flag which is set as soon as transmission is done.
- #define FLAG_LORA_RX_DONE (1U << 1U)

  Event flag which is set as soon as a message is received.
- #define FLAG_LORA_RX_TIMEOUT (1U << 2U)

  Event flag which is set if a receive timeout occurred.
- #define BME280_TEST_STARTUP_TIME_MS 1000
- #define DATA_FILE_CREATION_PERIOD_SEC 86400

  Interval at which a new data file is created (24 hours)

Enumerations

- enum LogLevel {
  LVL_SUPPRESS = 0 , LVL_ERROR , LVL_INFO , LVL_DEBUG ,
  NUM_LOG_LEVELS }

Variables

- const struct version_number_s version = {VERSION_MAJOR, VERSION_MINOR, VERSION_BUILD}
- const char *const time_command_name = "time"
- const char *const time_command_description
- const char *const config_command_name = "config"
- const char *const config_command_description
- const char *const sps_command_name = "sps"
- const char *const sps_command_description
- const char *const bme_command_name = "bme"
- const char *const bme_command_description
- const char *const info_command_name = "info"
- const char *const info_command_description
- const char *const log_level_names [ ]

9.23.1 Macro Definition Documentation

9.23.1.1 BME280_TEST_STARTUP_TIME_MS

```
#define BME280_TEST_STARTUP_TIME_MS 1000
```

9.23.1.2 BUTTON_COMMAND_MIN_PRESS_TIME

```
#define BUTTON_COMMAND_MIN_PRESS_TIME 3000
```

Minimum time in milliseconds the command-button must be pressed to signal a long button press.

9.23.1.3 BUTTON_DEBOUNCE_TIME

```
#define BUTTON_DEBOUNCE_TIME 50
```

Minimum time in milliseconds a button must be pressed to signal a short button press.

9.23.1.4 COMMAND_HANDLER_MAX_BUF_SIZE

```
#define COMMAND_HANDLER_MAX_BUF_SIZE 1024
```

Maximum buffer size for the USB serial interface.

9.23.1.5 DATA_FILE_CREATION_PERIOD_SEC

```
#define DATA_FILE_CREATION_PERIOD_SEC 86400
```

Interval at which a new data file is created (24 hours)

9.23.1.6 FLAG_BUTTON_COMMAND

```
#define FLAG_BUTTON_COMMAND (1U << 3U)
```

9.23.1.7 FLAG_BUTTON_MEASURE

```
#define FLAG_BUTTON_MEASURE (1U << 1U)
```

9.23.1.8 FLAG_BUTTON_STATUS

```
#define FLAG_BUTTON_STATUS (1U << 2U)
```

9.23.1.9 FLAG_CREATE_NEW_FILE

```
#define FLAG_CREATE_NEW_FILE (1U << 7U)
```

9.23.1.10 FLAG_DO_MEASUREMENT

```
#define FLAG_DO_MEASUREMENT (1U << 5U)
```

9.23.1.11 FLAG_LORA_RX_DONE

```
#define FLAG_LORA_RX_DONE (1U << 1U)
```

Event flag which is set as soon as a message is received.

9.23.1.12 FLAG_LORA_RX_TIMEOUT

```
#define FLAG_LORA_RX_TIMEOUT (1U << 2U)
```

Event flag which is set if a receive timeout occurred.

9.23.1.13 FLAG_LORA_TX_DONE

```
#define FLAG_LORA_TX_DONE (1U << 0U)
```

Event flag which is set as soon as transmission is done.

9.23.1.14 FLAG_RECEIVED_COMMAND

```
#define FLAG_RECEIVED_COMMAND (1U << 4U)
```

9.23.1.15 FLAG_SPS30_STARTUP_DONE

```
#define FLAG_SPS30_STARTUP_DONE (1U << 6U)
```

9.23.1.16 LORA_RESEND_WAIT_MS

```
#define LORA_RESEND_WAIT_MS 10000
```

Time to wait before authentication request is sent again after a wrong response was received.

9.23.1.17 LORA_RX_TIMEOUT_MS

```
#define LORA_RX_TIMEOUT_MS 5000
```

Maximum time to wait for a response after sending a request or data to the gateway.

9.23.1.18 MAX_SEND_DATA_ATTEMPTS

```
#define MAX_SEND_DATA_ATTEMPTS 3
```

Maximum number of attempts to send a data packet until a new authentication message is sent.

9.23.1.19 STORAGE_ADDR_CONFIG

```
#define STORAGE_ADDR_CONFIG POST_APPLICATION_ADDR
```

Flash address where the values of the Config::global_config are stored. Maximum size is FLASH_PAGE_SIZE (2kB).

9.23.1.20 VERSION_BUILD

```
#define VERSION_BUILD 3U
```

Build version.

9.23.1.21 VERSION_MAJOR

```
#define VERSION_MAJOR 0U
```

Major version.

9.23.1.22 VERSION_MINOR

```
#define VERSION_MINOR 4U
```

Minor version.

9.23.2 Enumeration Type Documentation

9.23.2.1 LogLevel

```
enum LogLevel
```

Enum defining the supported log levels.

Enumerator

LVL_SUPPRESS	
LVL_ERROR	
LVL_INFO	
LVL_DEBUG	
NUM_LOG_LEVELS	

9.23.3 Variable Documentation

9.23.3.1 bme_command_description

```
const char* const bme_command_description
```

Initial value:

```
=
    "Usage: bme COMMAND\n"
    "Commands:\n"
    "\tinit\tInitialize BME280\n"
    "\tread\tRead measurement values from sensor (Make sure init is called in advance)\n"
```

9.23.3.2 bme_command_name

```
const char* const bme_command_name = "bme"
```

9.23.3.3 config_command_description

```
const char* const config_command_description
```

Initial value:

```
=
    "Usage: config [OPTIONS]\n"
    "Options:\n"
    "\t<none>\t\t\tPrint current configuration\n"
    "\t<name>=<value>\t\tSet the configuration parameter <name> to the given <value>.\n"
    "\t\t\t\tMultiple parameters can be set in one command by seperating key-value-pairs with spaces.\n"
```

9.23.3.4 config_command_name

```
const char* const config_command_name = "config"
```

9.23.3.5 info_command_description

```
const char* const info_command_description
```

Initial value:

```
=
    "Usage: info\n"
    "Print software version and UUIDs\n"
```

9.23.3.6 info_command_name

```
const char* const info_command_name = "info"
```

9.23.3.7 log_level_names

```
const char* const log_level_names[]
```

Initial value:

```
= {
    "SUPPR",
    "ERROR",
    "INFO ",
    "DEBUG"
}
```

Names of the supported log levels. The order of the names must be the same as in the LogLevel enum from above.

9.23.3.8 sps_command_description

```
const char* const sps_command_description
```

Initial value:

```
=
    "Usage: sps COMMAND\n"
    "Commands:\n"
    "\ton\t\tEnable SPS30 power supply\n"
    "\toff\t\tDisable SPS30 power supply\n"
    "\tprobe\t\tPerform probe, to check if SPS30 is responding\n"
    "\tserial\t\tPrint serial number\n"
    "\tversion\t\tPrint version numbers for firmware, SHDLC and hardware\n"
    "\tstart\t\tStart measurement procedure\n"
    "\tstop\t\tStop measurement procedure\n"
    "\tread\t\tRead measurement values from sensor\n"
    "\tclean\t\tStart fan cleaning (only works after \"sps start\")\n"
```

9.23.3.9 sps_command_name

```
const char* const sps_command_name = "sps"
```

9.23.3.10 time_command_description

```
const char* const time_command_description
```

Initial value:

```
=
    "Usage: time [OPTIONS]\n"
    "Options:\n"
    "\t<none>\t\t\t\tPrint current time\n"
    "\tset YYYY-MM-DD HH:MM:SS\t\tSet time in specified format\n"
    "\ttick <num_ticks>\t\tPrint for <num_ticks> seconds every time, the RTC second counter toggles,\n"
    "\t\t\t\t\tthe amount of passed seconds. Used to measure RTC time drift.\n"
    "\tcalibrate <milliseconds>\tCalibrate the RTC by sending the time drift per day in milliseconds\n"
```

9.23.3.11 time_command_name

```
const char* const time_command_name = "time"
```

9.23.3.12 version

```
const struct version_number_s version = {VERSION_MAJOR, VERSION_MINOR, VERSION_BUILD}
```

9.24 src/driver/Battery.cpp File Reference

```
#include "Battery.h"
#include "Logger.h"
#include "AnalogIn.h"
#include "DigitalOut.h"
#include "analogin_api.h"
#include "mbed_error.h"
#include "ThisThread.h"
```

Functions

- mbed::DigitalOut bat_level_en (MBED_CONF_APP_BATTERY_LEVEL_EN, false)
- mbed::AnalogIn bat_level_input (MBED_CONF_APP_BATTERY_LEVEL)
- void analogin_init_direct (analogin_t *obj, const PinMap *pinmap)

9.24.1 Function Documentation

9.24.1.1 analogin_init_direct()

```
void analogin_init_direct (
            analogin_t * obj,
            const PinMap * pinmap )
```

Overwrite the default ADC configuration to increase oversampling ratio and thus increase the accuracy of the results.

9.24.1.2 bat_level_en()

```
mbed::DigitalOut bat_level_en (
            MBED_CONF_APP_BATTERY_LEVEL_EN ,
            false  )
```

9.24.1.3 bat_level_input()

```
mbed::AnalogIn bat_level_input (
            MBED_CONF_APP_BATTERY_LEVEL  )
```

9.25 src/driver/Battery.h File Reference

Classes

- class Battery

9.26 src/driver/Buttons.cpp File Reference

```
#include "Buttons.h"
#include "defines.h"
```

9.27 src/driver/Buttons.h File Reference

```
#include "EventFlags.h"
#include "InterruptIn.h"
#include "LowPowerTimer.h"
#include "NonCopyable.h"
```

Classes

- class Buttons

9.28 src/driver/LedIndicator.cpp File Reference

```
#include "LedIndicator.h"
#include "Battery.h"
#include "Logger.h"
#include <chrono>
```

Macros

- #define BATTERY_THRESHOLD_LED_1 7.07
- #define BATTERY_THRESHOLD_LED_2 7.24
- #define BATTERY_THRESHOLD_LED_3 7.64

9.28.1 Macro Definition Documentation

9.28.1.1 BATTERY_THRESHOLD_LED_1

```
#define BATTERY_THRESHOLD_LED_1 7.07
```

9.28.1.2 BATTERY_THRESHOLD_LED_2

```
#define BATTERY_THRESHOLD_LED_2 7.24
```

9.28.1.3 BATTERY_THRESHOLD_LED_3

```
#define BATTERY_THRESHOLD_LED_3 7.64
```

9.29 src/driver/LedIndicator.h File Reference

```
#include "DigitalOut.h"
#include "LowPowerTimeout.h"
#include "NonCopyable.h"
```

Classes

- class LedIndicator

9.30 src/driver/Lora.cpp File Reference

```
#include "Lora.h"
#include "defines.h"
#include "Logger.h"
#include "Config.h"
```

9.31 src/driver/Lora.h File Reference

```
#include "SX126X_LoRaRadio.h"
#include "EventFlags.h"
#include "LowPowerTimeout.h"
#include "mbed_error.h"
#include "NonCopyable.h"
```

Classes

- class Lora

Macros

- #define LORA_CFG_MODEM MODEM_LORA
- #define LORA_CFG_TX_FDEV 25000
- #define LORA_CFG_RX_BANDWITH_AFC 0
- #define LORA_CFG_RX_PAYLOAD_LEN 255

9.31.1 Macro Definition Documentation

9.31.1.1 LORA_CFG_MODEM

```
#define LORA_CFG_MODEM MODEM_LORA
```

9.31.1.2 LORA_CFG_RX_BANDWITH_AFC

```
#define LORA_CFG_RX_BANDWITH_AFC 0
```

9.31.1.3 LORA_CFG_RX_PAYLOAD_LEN

```
#define LORA_CFG_RX_PAYLOAD_LEN 255
```

9.31.1.4 LORA_CFG_TX_FDEV

```
#define LORA_CFG_TX_FDEV 25000
```

9.32 src/driver/SDCard.cpp File Reference

```
#include "SDCard.h"
#include "mbed_debug.h"
#include "utils.h"
```

9.33 src/driver/SDCard.h File Reference

```
#include "SDBlockDevice.h"
#include "FATFileSystem.h"
#include "PlatformMutex.h"
#include "mbed_error.h"
#include "DigitalIn.h"
#include <string>
```

Classes

- class SDCard

9.34 src/driver/SensorBME280.cpp File Reference

```
#include "SensorBME280.h"
#include "ThisThread.h"
#include "Logger.h"
#include "bme280.h"
#include "bme280_defs.h"
```

9.35 src/driver/SensorBME280.h File Reference

```
#include "bme280.h"
#include "mbed_error.h"
#include "NonCopyable.h"
#include "DigitalOut.h"
#include "SPI.h"
```

Classes

- class SensorBME280
- struct SensorBME280::bme280_handle_t

9.36 src/driver/SensorSPS30.cpp File Reference

```
#include "SensorSPS30.h"
#include "sensirion_uart.h"
#include "ThisThread.h"
#include "Logger.h"
```

9.37 src/driver/SensorSPS30.h File Reference

```
#include "sps30.h"
#include "NonCopyable.h"
#include "DigitalOut.h"
#include "BufferedSerial.h"
#include "mbed_error.h"
```

Classes

- class SensorSPS30

9.38 src/logging/Logger.cpp File Reference

```
#include "Logger.h"
#include "utils.h"
#include "mbed_debug.h"
```

9.39 src/logging/Logger.h File Reference

```
#include "SDCard.h"
#include "defines.h"
#include "Config.h"
#include <string>
#include <array>
#include <map>
#include <cstring>
```

Classes

- class Logger

Macros

- #define __FILENAME__ (strrchr(__FILE__, '/') ? strrchr(__FILE__, '/') + 1 : __FILE__)
- #define LOG(lvl, fmt, args...) Logger::log_internal(__FILENAME__, lvl, fmt, ## args)

9.39.1 Macro Definition Documentation

9.39.1.1 __FILENAME__

```
#define __FILENAME__ (strrchr(__FILE__, '/') ? strrchr(__FILE__, '/') + 1 : __FILE__)
```

Macro to extract filename without file extension and path from **FILE**

9.39.1.2 LOG

```
#define LOG(
              lvl,
              fmt,
              args...  )   Logger::log_internal(__FILENAME__, lvl, fmt, ## args)
```

Macro to create a log entry. The filename, where the log entry is created is added automatically.

9.40 src/main.cpp File Reference

```
#include "mbed.h"
#include "LedIndicator.h"
#include "SDCard.h"
#include "Logger.h"
#include "SensorSPS30.h"
#include "SensorBME280.h"
#include "Buttons.h"
#include "StateContext.h"
#include "Communication.h"
```

Functions

- int main ()

9.40.1 Function Documentation

9.40.1.1 main()

```
int main ( )
```

9.41 src/state/CommandState.cpp File Reference

```
#include "CommandState.h"
#include "ThisThread.h"
#include "Thread.h"
#include "Logger.h"
```

9.42 src/state/CommandState.h File Reference

```
#include "State.h"
#include "CommandHandler.h"
#include "EventFlags.h"
```

Classes

- class CommandState

9.43 src/state/ErrorState.cpp File Reference

```
#include "ErrorState.h"
#include "Logger.h"
#include "ThisThread.h"
```

Functions

- void mbed_error_reboot_callback (mbed_error_ctx *error_context)

9.43.1 Function Documentation

9.43.1.1 mbed_error_reboot_callback()

```
void mbed_error_reboot_callback (
            mbed_error_ctx * error_context )
```

9.44 src/state/ErrorState.h File Reference

```
#include "State.h"
#include "EventFlags.h"
```

Classes

- class ErrorState

9.45 src/state/InitState.cpp File Reference

```
#include "InitState.h"
#include "Logger.h"
#include "utils.h"
#include "mbed_error.h"
#include "mbed_rtc_time.h"
```

Macros

- #define TIMESTAMP_20200101 1577836800

9.45.1 Macro Definition Documentation

9.45.1.1 TIMESTAMP_20200101

```
#define TIMESTAMP_20200101 1577836800
```

9.46 src/state/InitState.h File Reference

```
#include "State.h"
#include "SDCard.h"
#include "Communication.h"
#include "SensorSPS30.h"
#include "SensorBME280.h"
#include "Buttons.h"
#include "FlashIAP.h"
```

Classes

- class InitState

9.47 src/state/MeasureState.cpp File Reference

```
#include "MeasureState.h"
#include "Communication.h"
#include "Protocol.h"
#include "Logger.h"
#include "utils.h"
#include "Config.h"
```

9.48 src/state/MeasureState.h File Reference

```
#include "State.h"
#include "SDCard.h"
#include "Communication.h"
#include "SensorSPS30.h"
#include "SensorBME280.h"
#include "LowPowerTicker.h"
#include "EventFlags.h"
#include <vector>
```

Classes

- class MeasureState
- struct MeasureState::avg_data_s

9.49 src/state/State.cpp File Reference

```
#include "State.h"
```

9.50 src/state/State.h File Reference

```
#include "LedIndicator.h"
```

Classes

- class State

9.51 src/state/StateContext.cpp File Reference

```
#include "StateContext.h"
#include "CommandHandler.h"
#include "InitState.h"
#include "MeasureState.h"
#include "CommandState.h"
#include "ErrorState.h"
#include "mbed.h"
```

9.52 src/state/StateContext.h File Reference

```
#include "SensorSPS30.h"
#include "SensorBME280.h"
#include "Communication.h"
#include "SDCard.h"
#include "LedIndicator.h"
#include "CommandHandler.h"
#include "Config.h"
#include "USBSerial.h"
#include "EventFlags.h"
#include "NonCopyable.h"
#include "FlashIAP.h"
#include "Buttons.h"
#include "State.h"
#include "InitState.h"
#include "MeasureState.h"
#include "CommandState.h"
#include "ErrorState.h"
```

Classes

- class StateContext

9.53 src/utils/utils.cpp File Reference

```
#include "utils.h"
#include "defines.h"
#include "MbedCRC.h"
#include "trng_api.h"
```

Namespaces

- utils

Functions

- void utils::get_formatted_time_string (const char *format_string, std::string &dest, time_t timestamp)
- bool utils::is_number (const std::string &str)
- bool utils::string_to_bool (const std::string &str, bool &dest)
- std::string utils::to_hex_string (uint32_t number)
- std::string utils::app_version ()
- uint16_t utils::calc_crc16 (const void *buf, int size)
- uint32_t utils::calc_crc32 (const void *buf, int size)
- uint32_t utils::get_rand ()

9.54 src/utils/utils.h File Reference

```
#include <ctime>
#include <string>
```

Namespaces

- utils

Macros

- #define REVERSE_2_BYTE(n) ((((n) & 0x00FFU) << 8U) | (((n) & 0xFF00U) >> 8U))

  Swap least and most significant byte of a uint16_t.
- #define TRY(func)

  Execute func and if it fails return with the return value of func.

Functions

- void utils::get_formatted_time_string (const char *format_string, std::string &dest, time_t timestamp)
- bool utils::is_number (const std::string &str)
- bool utils::string_to_bool (const std::string &str, bool &dest)
- std::string utils::to_hex_string (uint32_t number)
- std::string utils::app_version ()
- uint16_t utils::calc_crc16 (const void *buf, int size)
- uint32_t utils::calc_crc32 (const void *buf, int size)
- uint32_t utils::get_rand ()

9.54.1 Macro Definition Documentation

9.54.1.1 REVERSE_2_BYTE

```
#define REVERSE_2_BYTE(
              n ) ((((n) & 0x00FFU) << 8U) | (((n) & 0xFF00U) >> 8U))
```

Swap least and most significant byte of a uint16_t.

9.54.1.2 TRY

```
#define TRY(
              func )
```

Value:

```
    ({                                          \
      auto err = (func);                        \
      if (0 != err) {                           \
        return err;                             \
      }                                         \
    })
```

Execute func and if it fails return with the return value of func.

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