What's Inside

Smart Spot Hardware: Specifications

The present document provides the Smart Spot device hardware specification informing about the development status of the different parts such as the main board, the expansion boards and the sensor probes. Although hardware is not finished, the main board is on a prototyping stage which allow integrate, test and develop over the device. The main board will be expandable with specific boards to provide new functionalities in the Smart Spot, such as the Air quality analysis, the measure of AC current, the detection of noise, ... Additionally, to the main board and expansion boards we are also researching about create new probes in order to provide new functionalities.

Key Benefits

Through the document, users can be aware about the development state of the Smart Spot hardware, follow its evolution and know about specific details, useful for the integration of this device in deployments.

1. Smart Spot

The Smart Spot is a device which can be used in different use cases, most of these use cases matches in a set of features found in the main board:

- Global connectivity via GSM or WiFi
- Device location using GPS
- Interaction with the users via Bluetooth Low Energy.
- Able to integrate any sensor or actuator

To achieve these goals, the device is composed by a main board with the possibility of connect expansion boards, each one specialized on its own business. The main board is composed by several chipsets such as the main processor, the GSM/GPS, ... which provides the basic functionalities. Table 1 shows the final main board features.
Next sections will introduce the available and in development expansion boards, which covers several use cases such as air quality monitoring, AC current measurement, noise sensing, ...

Smart Spot Specification	
MCU Core / Clock Speed	• Tensilica Xtensa dual-core 32-bit LX6 / 240MHz
Internal Memory	• ROM: 448 KiB (For booting and core functions) • SRAM: 520 KiB (For data and instruction) • RTC Slow SRAM: 8 KiB (For co-processor accessing during deep-sleep mode.) • RTC Fast SRAM: 8 KiB (For data storage and main CPU during RTC Boot from the deep-sleep mode.)
External Flash	• 16MiB (Up to 4x16MiB QSPI Flash)
External SRAM	• 8MiB SRAM (with AES hardware encryption)
Hardware accelerated encryption	• AES / SHA2 / Elliptical Curve Cryptography / RSA-4096
WiFi	• Wi-Fi: 802.11 b/g/n/e/i (802.11n @ 2.4 GHz up to 150 Mbit/s)
Bluetooth	• Main Chipset: ○ Bluetooth Classic BR/EDR ○ Bluetooth Low Energy 4.2 (BLE) • Extra integrated Texas Instruments CC2541 Bluetooth Low Energy 4.0 (BLE)
GSM (SIMCom 868)	• Quad-band 850/900/1800/1900MHz • GPRS multi-slot class 12/10 • GPRS mobile station class B • Compliant to GSM phase 2/2+ ○ Class 4 (2 W @ 850/900MHz) ○ Class 1 (1 W @ 1800/1900MHz) • GPRS class 12: max. 85.6 kbps (downlink/uplink) • Coding schemes CS 1, 2, 3, 4 • Micro-SIM card slot (15mm x 12mm – 3FF)

GPS (SIMCom 868)	• Receiver type ○ 22 tracking /66 acquisition -channel ○ GPS L1 C/A code • Sensitivity ○ Tracking: -166 dBm ○ Cold starts: -148 dBm • Time-To-First-Fix ○ Cold starts: 29s (typ.) ○ Hot starts: <1s ○ Warm starts: 22s • Accuracy • Horizontal position: <2.5m CEP
Dimensions	• 105mm x 83mm x 0.8mm
Temperature Range	• -20ºC to 80ºC operating temperature
Power Supply	• 5V (Micro-B USB Connector)
Antennas	• External Bluetooth Low Energy (Texas Instruments CC2541) Antenna • External WiFi 802.11 b/g/n/e/i (STA-AP) / Bluetooth Low Energy Antenna • External GSM/GPRS Antenna (Cellular) • GPS Antenna
On board sensors	• BME280: Temperature/Humidity/Pressure • MPU6050: Accelerometer/Gyroscope

Table 1. Main board hardware specifications

1.1 Hardware configurations

Not all the SmartSpot are equals. Some devices sent by HOPU have specific customizations to demonstrate the device features in different use cases such as Smart Cities, transportation, backend integration demonstrations, etc. This means that some of the information present on this document could not match with the received device. These customizations reside at several levels introduced below which will be called 'configurations' from now (hardware configurations). To identify each device a full name with the following nomenclature is defined: 'SmartSpot <hwcfg>-<backendcfg>

- Hardware configuration example: A1EGHK
- Backend configuration example: C

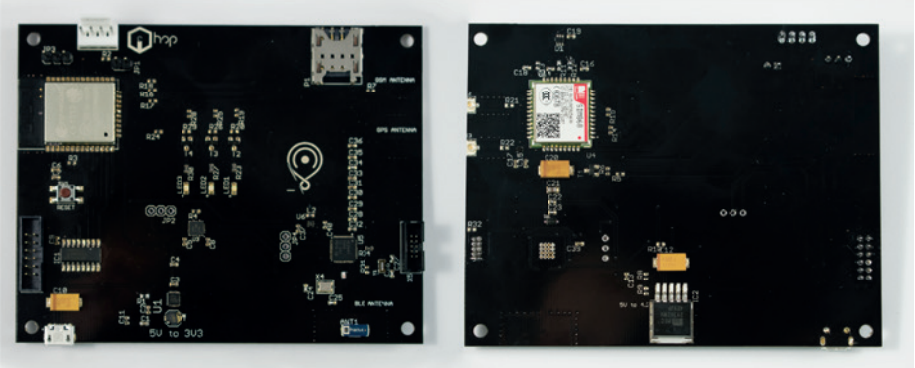

Figure 1. v.1.1 Smart Spot hardware

Customization number	Customization name	Features	Customization state
A1	Smart Spot main board V1.1	• Alphasense Gas Board connector • HOP Expansion Board connector	Obsolete
A2	Smart Spot main board V1.2	• 2x HOP Expansion Board connector • RGB LED • Reset Factory Button • BME280 (temperature/humidity/ pressure) • MPU6050 (Accelerometer/Gyroscope) • External CC2541 BLE Interface	Obsolete
A3	Smart Spot main board V1.3	• Alphasense Gas Board connector • 2x HOP Expansion Board connector • RGB LED • Reset Factory Button • BME280 (temperature/humidity/ pressure) • MPU6050 (Accelerometer/Gyroscope) • External CC2541 BLE Interface	Current
B	Solar Charging Expansion	• Battery included in the Smart Spot encapsulation • External Solar Panel	Under development
C	Active AC Power Measure	• Measure active AC Power consumption	Under development
D	Noise Measure	• Measure Noise in the environment in a unique wide range with high precision	Under development
E	Alphasense Gas Sensors	• Integration of the Alphasense board to allow observe gas concentrations • Requires G to properly work	Current
F	HOPU Gas Sensor Expansion	• Integration of Alphasense/Specsensor gas sensors through HOP Expansion Board Connector to allow observe gas concentrations • Requires G to properly work	Under development
G	Temperature-Humi-dity Probe v1.0	• Measure ambient temperature and humidity	Current
H	Internal GPS	• Internal GPS antenna to provide precise location of the device	Current
I	External GPS	• External GPS antenna to provide precise location of the device	Under development
J	Internal GSM Antenna	• Internal GSM antenna	Under study

K	External GSM Antenna	• External GSM antenna	Current

1.2 Backend Configurations

Customization number	Customization name	Features
A	Extra LwM2M Servers	• Thirds party LwM2M Servers has been added to the LwM2M Bootstrap Server in order to connect the device to other backends (commonly owned by the user).
B	Extra FIWARE Integration	• The device points to IOTAgents deployed by HOPU which will map the device to a third party FIWARE Orion Context Broker (commonly owned by the user).
C	HOP FIWARE Integration	• The device can be easily integrated via FIWARE Data Models using an Orion Context Broker provided by HOPU

2. Expanding functionalities in the Smart Spot

2.1 Expansion boards

Several use cases such as noise sensing, air quality monitoring, … requires the introduction of specific hardware. To achieve device modularity, these components are integrated through specialized boards connected to the main board. Next sub-sections introduce the current available and in development expansion boards.

2.1.1 Air Quality monitoring

To achieve air quality monitoring, the Smart Spot currently integrates the Alphasense sensors (2.1.1.1) but we are also researching about the use of other sensors such as the provided by Specsensors (2.1.1.2). Next sections illustrate the current development state for the integration of Air Quality monitoring in the Smart Spot.

2.1.1.1 Alphasense gas sensors

Alphasense is a well reputed company which offers sensors to measure different gases. Between the available gases, we selected the most important to quantify the air quality (gases required by the OMS), the most interesting depending of the use cases but also interesting gases to carry out corrections in measures such as explained below in this section.

- NO_2: Nitrogen dioxide
- SO_2: Sulfur dioxide
- O_3: Ozone
- H_2S: Hydrogen Sulfide
- CO: Carbon monoxide

The main sensors features are:

- They can measure from 0 to 20 Parts Per Million of analyte.
- Sensors sensibility is greater than most of the manufacturers.
- The response time of the sensors is about 60 seconds, depending on the sensor.
- 2 years of estimated life time.
- Temperature range -20 to 50 °C.
- They include a fourth electrode to improve the temperature correction. The electrode output current doesn't change with the gas concentration.

Despite of the World Health Organization does not have any guidelines about H2S we decided to include a H2S sensor in our product. The reason why we included this sensor is the cross sensitivity. Amperometric electrochemical sensors does not measure only one analyte, every single sensor reacts to various gases. Fortunately, the sensors manufacturers offer approximated cross sensitivity values. With these values we can discard the current from the sensor corresponding to other gas. Most of the sensors has a really high response against H2S, if we include this sensor, we can discard the current and, by this, improve the measurements.
These sensors need to be connected to a board with specialized hardware to translate the electrical values to understandable and standard measures. Next subsections explain the current approximations to carry out this.

2.1.1.1.1 Alphasense AFE Board

Alphasense offers a board which allows to easily integrate the gas sensors on new projects and allow connect up to 4 gas sensors. In order to integrate this board, the Smart Spot main board includes the specific connector used by the Alphasense AFE Board. The I/O pins provided by the connector are managed by a GPIO multiplexer. Figure 2 shows the connection between the Alphasense AFE Board and the Smart Spot main board.

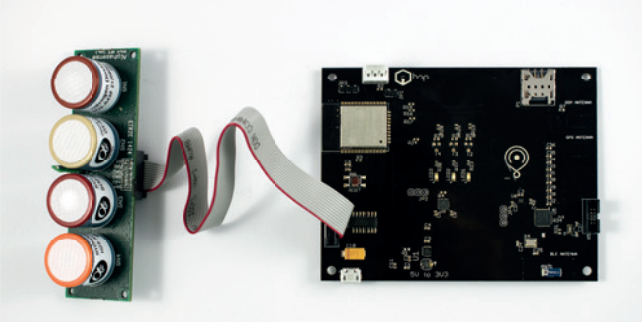

Figure 2. Integration of Alphasense AFE board with Smart Spot main board

2.1.1.1.2 Smart Spot Air Quality Expansion Board

Due to the price scalability problems presented by Alphasense AFE Board in addition to the need of include more sensors in a close future, a research to create our own expansion board has been carried out. This will allow reduce the hardware price, introduce modularity in the sockets where the gas sensor will be connected (sensors doesn't have a fixed socket position) and also facilitate the conversion/communication with the sensors, since it is carried out through I2C protocol instead of read the voltage directly by using an ADC.
Right now, we included just 4 sockets, which seems enough for some use cases but this board can be expanded to manage more gas sensors. This expansion board is currently under development/test phase as can be appreciated on the figure 3 and is expected to be released at the end of September 2017.

2.1.1.2 Spec. sensors gas sensors

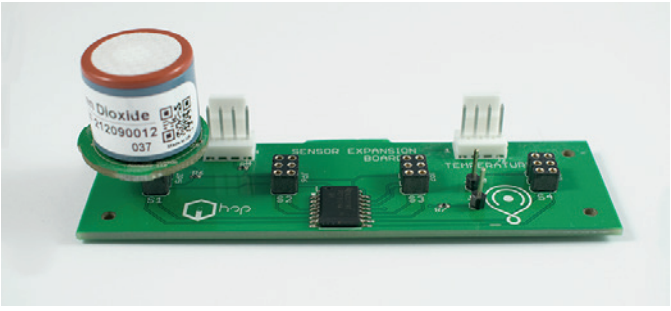

Figure 3. Smart Spot Air Quality Expansion Board

With the aim of improve the performance, durability and price scalability we are also researching about the use of sensors from other manufacturer such as specification sensors. This manufacturer has an innovative way to produce their sensors which provides a greater lifetime and less cross sensitivity than most of the other manufacturers but the use of these sensors is on early research stages. Figure 4 shows a gas sensor from this manufacturer.

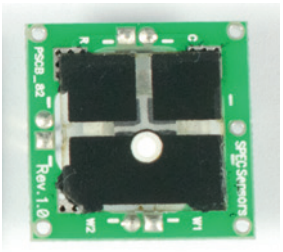

Figure 4. Specsensor gas sensor

2.1.2 AC Current Measurement

Measure the consumption of electric installations is an interesting use case. Non-invasive sensors as show in figure 5 are desired since in most of cases special authorizations or specific protocols are required to manage public installations. The Smart Spot will be able to do this easily by using an expansion board specialized where to connect up to 4 non-invasive sensors to measure the power consumption (up to 100 amperes per sensor). This expansion board is currently under prototyping state and is expected to be ready for deployments in September 2017.

2.1.3 Noise Sensing

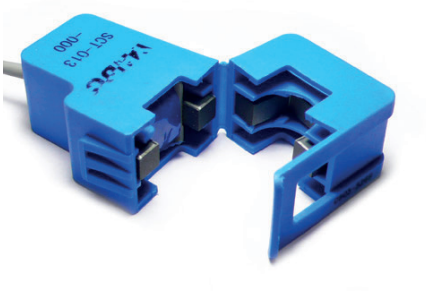

Figure 4. Spec sensor gas sensor

Detect noise in urban areas is a beautiful use cases desired by most of the smart cities. For this reason, we are researching and developing an expansion board dedicated to measure the noise achieving high quality measures. This feature is in research process but the release of this expansion board is expected for December 2017.

2.2 Sensor probes

In addition to expansion boards, the Smart Spot also allow integrate more simplest hardware using probes, allowing measure for example the ambient temperature, ambient humidity, ... Currently we are researching and developing more probes, some of them simplest such as an ambient pressure sensor and other more complex such as measure ambient particles (PM10).

2.2.1 Temperature/Humidity probe

A simple probe which can be currently provided with the Smart Spot is the ambient temperature and humidity probe. It sounds really simply but is the first desired value to measure when a device is deployed in a smart city.