Application Note: AN1200.96

One Channel LoRa® Hub

Hardware and Regulatory Aspects

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1 Introduction

The One Channel Hub is a low cost LoRaWAN® Access Point reference design, based on the ESP32-S3 and SX126x shield (also works with LLCC68 and LR1121).

It only supports one channel and one data rate at any moment.

It uses Wi-Fi as backhaul and can be configured from a web UI.

The Hub cannot replace a traditional 8-channel LoRaWAN gateway because of its limited capacity. It can, however, be a good substitute or complement for situations where only a few end-devices are within range of the access point.

This document describes hardware characteristics and regulatory-related aspects of operating a Hub in a LoRaWAN context.

2 Use Cases of the One Channel Hub

A One Channel Hub is typically composed of the following building blocks, with a number of backhaul options available:

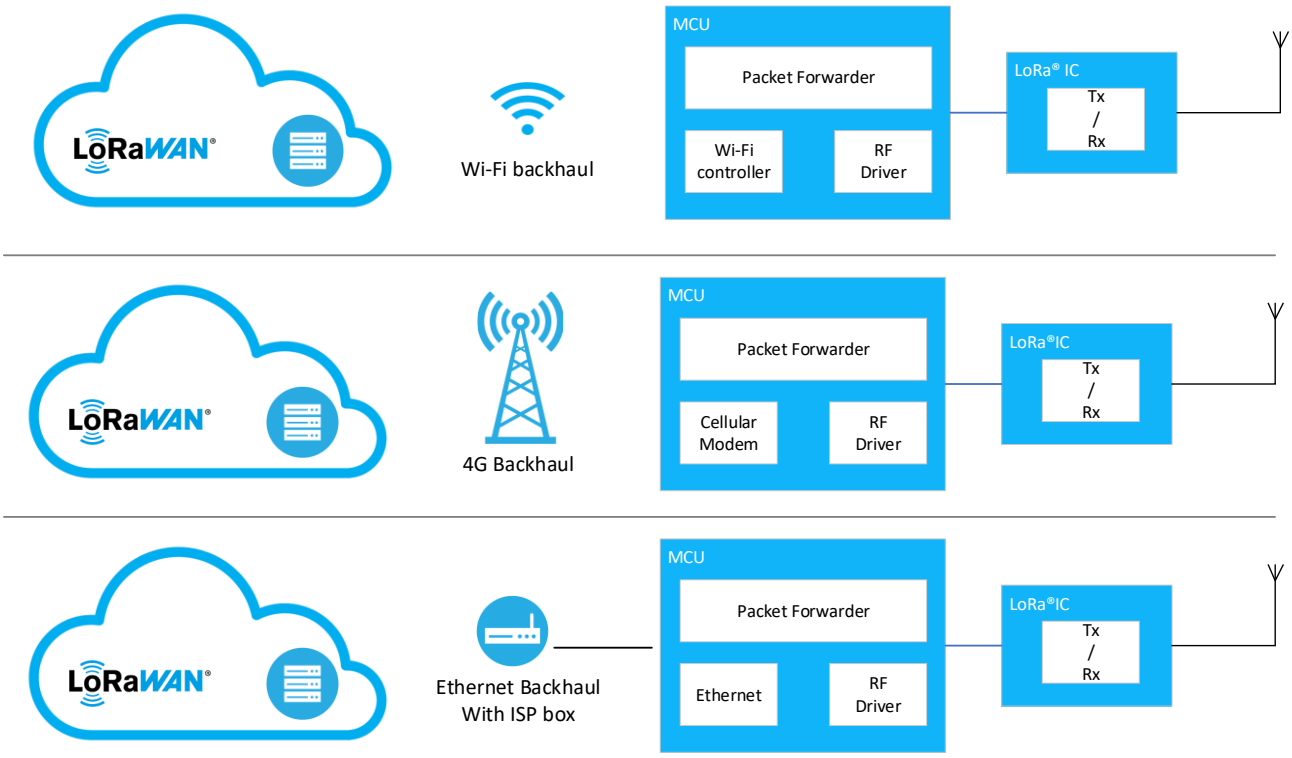

Figure 1: One Channel Hub in Different Contexts

Wi-Fi backhaul is very inexpensive, and may not require a dedicated subscription. That's why it lends itself well for use-cases like multi-dwelling apartment buildings where the network operator can connect their Hubs to a known access point, removing any cost aspect.

4G Backhaul: Another great option is to design a Cellular module and SIM card in the Hub. Cellular networks have a very large footprint, and simplify provisioning by using SIM cards, without having to worry about setting up an access point and security keys for an individual installation.

Ethernet Backhaul: The Hub concept is well adapted for use with Internet Service Provider solutions; the relevant hardware can either be built-in the internet box, or be offered as an add-on card, which can, for instance, be plugged into a free ethernet port of the modem or router.

An example of interconnection between an MCU and a Semtech RF shield is provided with the published ESP32 S3 interface card, offered by Semtech to serve as an evaluation kit for this technology. The schematic of this board is extracted here for reference, and the latest high-resolution update of the schematic can be downloaded from the One Channel Hub web page.

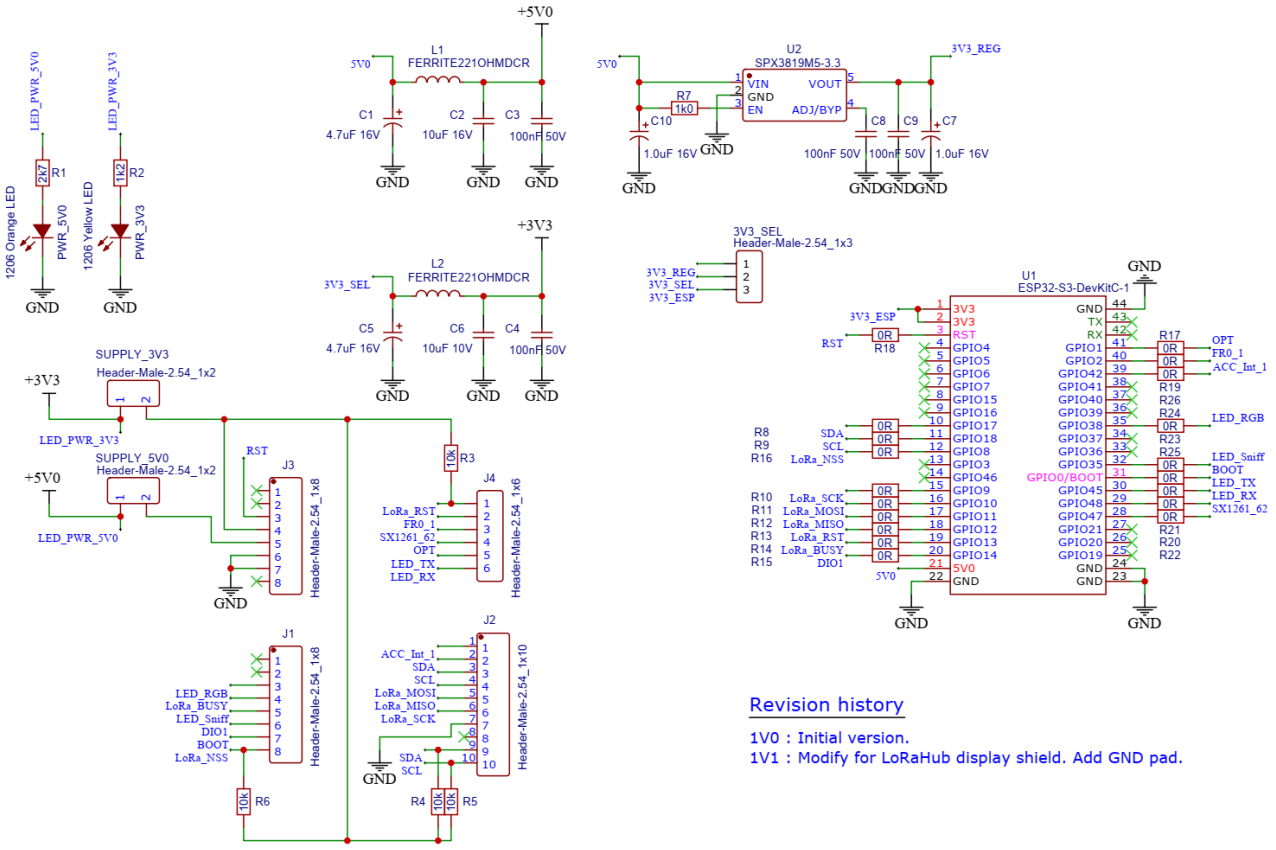

Figure 2: ESP32 Shield Adapter Unit Schematic

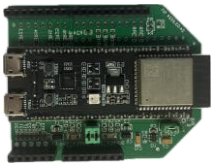

Figure 3: ESP32 Shield Adapter Unit

Off-the-shelf devices can also be used to prototype One Channel Hubs. Some of them embed a Semtech LoRa® transceiver, along with an MCU capable of supporting Wi-Fi backhaul.

Here is a non-exhaustive list of available options:

- From Heltec, ESP32 S3 with a screen, SX1262 and TCXO:

  https://heltec.org/project/wifi-lora-32-v3/

- From Lilygo, ESP32 with an oled screen, SX1262 and TCXO

  https://www.lilygo.cc/products/lora3?srsltid=AfmBOookcVcBqZvdUCUeQkwfqnXGGJPaMjykvSvAttVCF8nR1XgbhDFt

3 Regional Requirements for Hub

Because of its specific characteristics, the One Channel Hub may behave differently in different regions.

3.1 FCC and FCC-Like Regions

3.1.1 Regulatory Regime

In FCC-like regions, the Hub will operate in 500 kHz LoRa channels, as it will work on a single channel with no ability to hop during operation. It uses Channels 64 to 71 for Uplink (in blue on the figure below), and 0 to 7 for downlink (in yellow), with any data rate in the range DR8 to DR13 conforming with the FCC regime described in section 3.1.2.

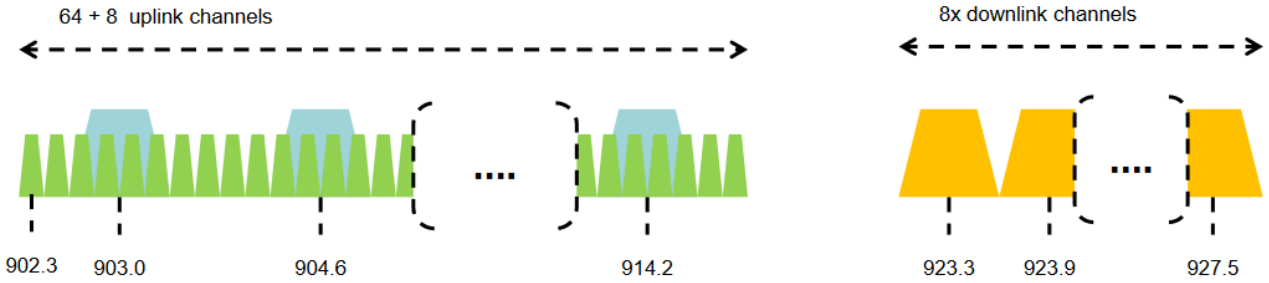

Figure 4: FCC Regional Parameters ; the Hub will use a Blue 500kHz channel

Data Rate	Configuration	Indicative Physical Bit Rate [bit/sec]
0	LoRa: SF10 / 125 kHz	980
1	LoRa: SF9 / 125 kHz	1760
2	LoRa: SF8 / 125 kHz	3125
3	LoRa: SF7 / 125 kHz	5470
4	LoRa: SF8 / 500 kHz	12500
5	LR-FHSS CR1/3: 1.523 MHz BW	162
6	LR-FHSS CR2/3: 1.523 MHz BW	325
7	RFU	
8	LoRa: SF12 / 500 kHz	980
9	LoRa: SF11 / 500 kHz	1760
10	LoRa: SF10 / 500 kHz	3900
11	LoRa: SF9 / 500 kHz	7000
12	LoRa: SF8 / 500 kHz	12500
13	LoRa: SF7 / 500 kHz	21900
14	RFU	
15	Defined in [TS001][18]	

Figure 5: Regional Parameters; DR8-13 can be used

When the Hub is operating in a 500 kHz channel as defined above, it needs to be certified and to operate as a wideband modulator, as defined in FCC CFR part 15.247 “Digitally Modulated Systems”. For additional details, refer to Application Note AN1200.62 “Best Practices for FCC Pre-Compliance testing of LoRaWAN Modules”, specifically section 6 “Measurement Methods for Systems Employing Digital Modulation”.

3.1.2 Required Hardware

When 500 kHz LoRa modulations is used, the frequency alignment between the end-device and the Hub can be as loose as +/-1/4th of the bandwidth, or +/-125 kHz.

This means that in a LoRaWAN context, the One Channel Hub can be built with an inexpensive XTAL reference oscillator, comparable to the ones used on end-devices. Each side of the link will induce at most +/-30 ppm of potential error, which overall would be much less than +/-60 kHz, which is well below the frequency correction capability of LoRa @500 kHz.

3.2 Regions Employing 125 kHz LoRa Modulation

Most regions outside of USA, Canada and Australia employ LoRa 125 kHz, generally with a channel spacing of 200 kHz. This has two implications:

- The regulatory regime is the same as that of the end-device, with the transmitter being limited to about 10-25 mW depending on the region.
- An accurate frequency reference must be used on the One Channel Hub. The frequency offset requirement can be broken down as follows:
    - Accepted frequency error in a 125 kHz LoRa communication: **+/-31.25** kHz (refer to the FERR specification, this is +/-1/4th of the LoRa Bandwidth)
    - Frequency error of the end-devices, including initial error, ageing and temperature dependency: +/-30 ppm
    - Frequency error allowable for the Hub:
        - @ 868 MHz, (31.25 kHz / 0.868) – 30 ppm = 6 ppm → **a TCXO is required**
        - @ 490 MHz, (31.25 kHz / 0.490) – 30 ppm = 34 ppm → a TCXO is NOT required

For proprietary systems where the solution provider controls both the frequency offset of the end-device and that of the Hub, it may be possible to either:

- Calibrate the frequency reference of both devices.
- Or adjust the frequency error as a function of the operating temperature.
- Alternatively, for home use, the temperature range could be restricted, aiding with the overall frequency offset.

Make sure the frequency error between any Tx and any Rx is well understood and controlled, as a function of the LoRa bandwidth that is used, the temperature range, and potential ageing of the system.

4 Glossary

Term	Description
ADR	Adaptive Data Rate
LoRa®	Long Range Communication The LoRa® Mark is a registered trademark of the Semtech Corporation
LoRaWAN®	LoRa® Wide Area Network Standard The LoRaWAN® mark is used under license from the LoRa Alliance®
LNS	LoRa Network Server
SF	LoRa® modulation Spreading Factor

5 Revision History

Version	ECO	Date	Changes and/or Modifications
01.00	072825	Sept 2024	Initial Release

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