CEC Continuing Education Center

DesignNews

Getting Started With LoRaWAN and Sensor IoT

DAY 3: Build a LoRaWAN Trainer using an LR1302 Pi Hat and a Raspberry Pi

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Dr. Don Wilcher

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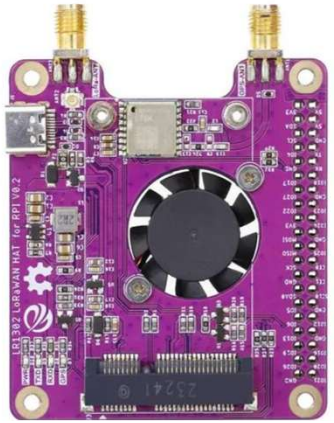
Patreon Page:
https://www.patreon.com/c/DrDon683

Course Kit and Materials

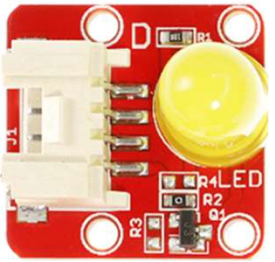
Elecrow LR1302 LoRaWAN Pi Hat



Raspberry Pi 4 Single Board Computer

USB-C Cable

Elecrow Crowtail LED 2.0



LR1302 Gateway Module

Elecrow Crowtail Collision Sensor

Elecrow LR1262 Node Board

Research Perspective

- "LoRaWAN is one of the promising technologies of the Low Power Wide Arena Network (LPWAN) that provides communication with low power, low cost, long-range, and low data rate (Rahman et al., 2020)."

Agenda:

- Exploration of the LR1302 Pi Hat
- Concept System Block Diagram: LoRaWAN Trainer
- Why a LoRaWAN Trainer?
- Lab: Building and Testing the LoRaWAN Trainer

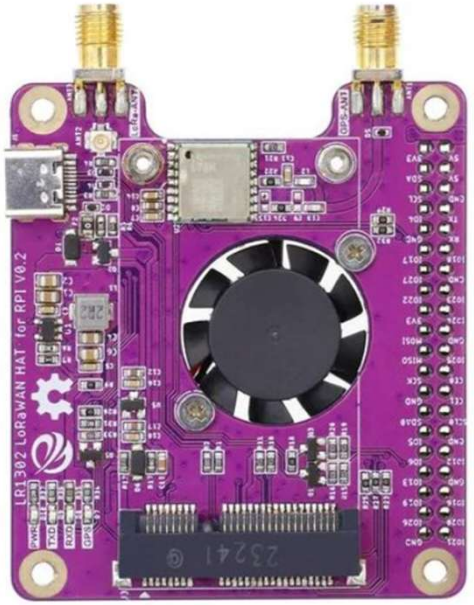
Exploration of the LR1302 LoRaWAN Pi Hat


Elecrow LR1302 LoRaWAN Pi Hat

- The Elecrow LR1302 is a high-performance LoRaWAN gateway module.
- Designed to integrate seamlessly with Raspberry Pi models 3 through 5.
- It features a standard Pi Hat form factor and is powered by the Semtech SX1302 chipset.
    a) Enabling 8-channel LoRaWAN communication.
    b) Makes it suitable for applications requiring long-range, low-power wireless connectivity.

Exploration of the LR1302 LoRaWAN Pi Hat. . .

Elecrow LR1302 LoRaWAN Pi Hat



LR1302Gateway Module

Frequencies:
EU: 868MHz
US-915MHz

Connects Here

Question 1

Which statement is correct?

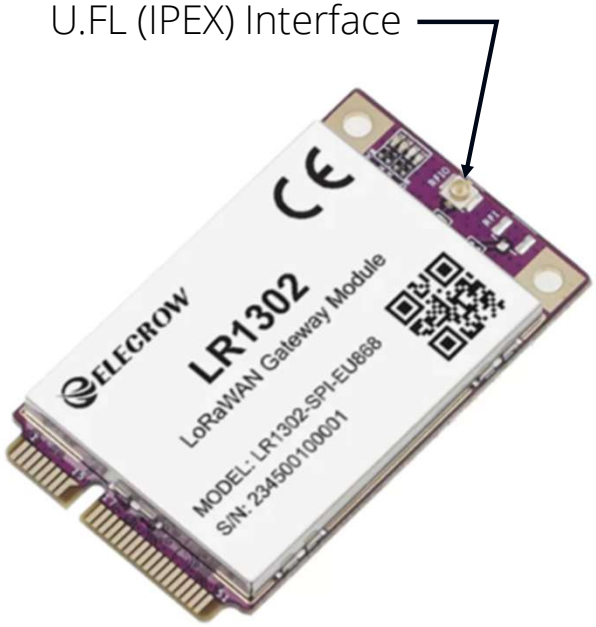
a) The Semtech SB1302 chipset powers the Elecrow LoRaWAN Pi Hat.

b) The Semtech SC1302 chipset powers the Elecrow LoRaWAN Pi Hat.

c) The Semtech SX1302 chipset powers the Elecrow LoRaWAN Pi Hat.

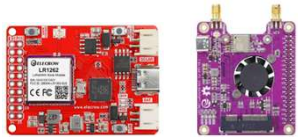
d) none of the above

Exploration of the LR1302 LoRaWAN Pi Hat. . .



- This LR1302 module is a new generation LoRaWAN® gateway module.
- It adopts a mini-PCIe form factor design and features low power consumption and high performance.
- Based on Semtech Network's SX1302 LoRaWAN® baseband chip, the LR1302 gateway module provides gateway products with potential capacity for long-distance wireless transmission.
- It reserves two antenna interfaces,
  a) one for transmitting and receiving LoRa signals
  b) one U.FL (IPEX) interface for independent transmission.
- It has a metal shield to protect against external interference and provide a reliable communications environment.

Exploration of the LR1302 LoRaWAN Pi Hat. . .



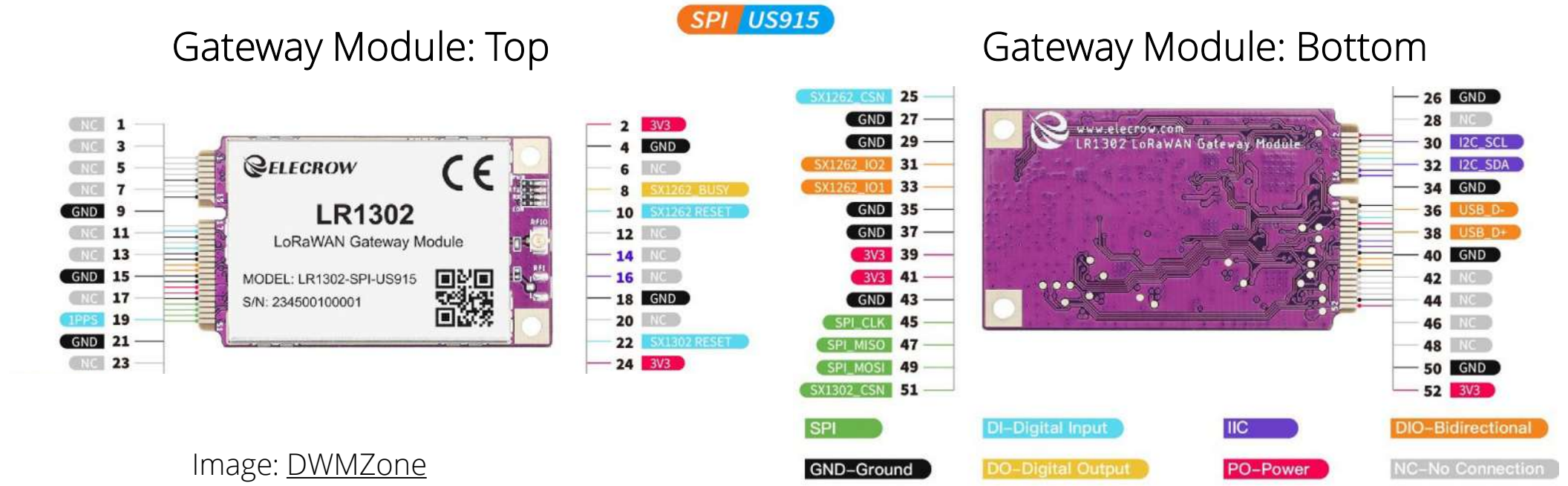


Image: DWMZone

Exploration of the LR1302 LoRaWAN Pi Hat. . .


Tech Note

What is a U.FL IPEX Interface?

- A U.FL (IPEX) interface is an ultra-miniature RF coaxial connector used to connect antennas to small wireless devices like:
  a) laptops.
  b) routers.
  c) GPS modules.
- It's known for its compact size, lightweight design, and ability to handle high-frequency signals.

Ultra-miniature RF Coaxial Connector:
U.Fl (IPEX) Interface

Exploration of the LR1302 LoRaWAN Pi Hat. . .

LR1302 Module:
Hardware Architecture
Block Diagram

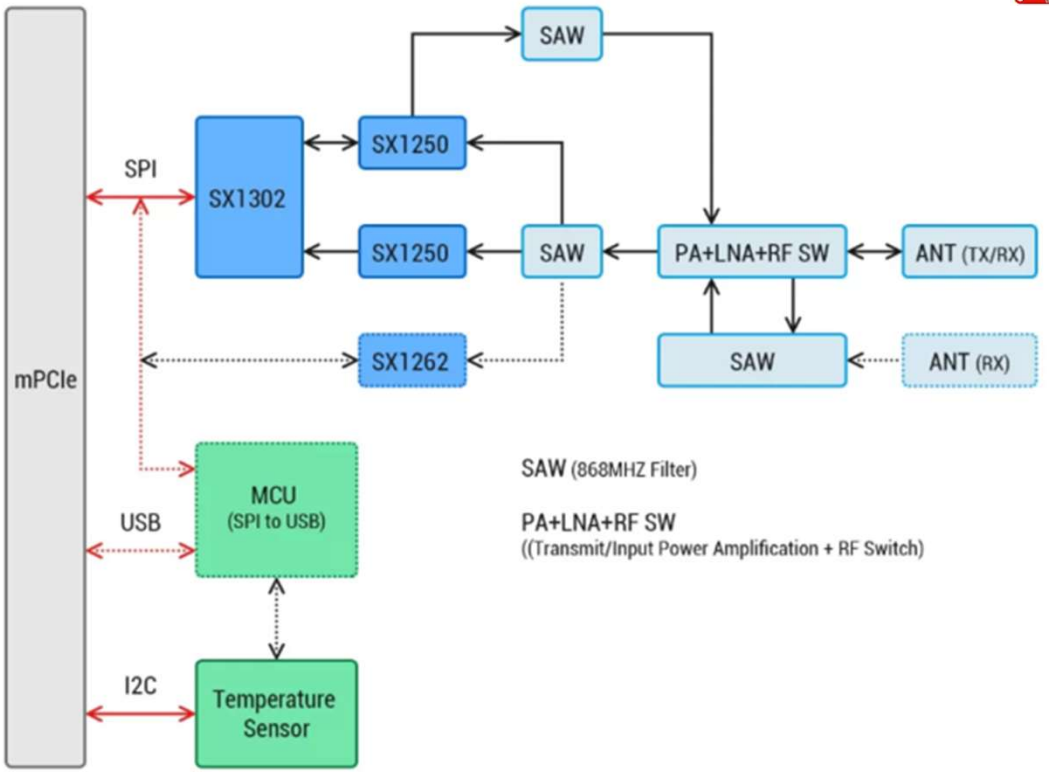


Image: Elecrow

Question 2

What type of connector is used to connect antennas to small wireless devices?

a) Terminal Block
b) Insulated Displaced Connector (IDC)
c) U.FL(IPEX)Interface
d) none of the above

Exploration of the LR1302 LoRaWAN Pi Hat. . .


Technical Specifications Chart: Elecrow LR1302 LoRaWAN Module

Category	Specification
LoRa Transceiver	Semtech SX1302 Baseband Processor
Frequency Band	EU868 / US915 / AS923 / AU915 (Region-specific variants)
LoRa Channels	8 x Multi-SF LoRa Channels + 1 x FSK Channel
Spreading Factor	SF5 to SF12 (simultaneous multi-SF support)
Modulation	LoRa, FSK
Data Rate	0.3 kbps to 62.5 kbps (LoRa); up to 300 kbps (FSK)
Max Output Power	+27 dBm (TX) (PA output from external concentrator board)
Receive Sensitivity	Down to -139 dBm (at SF12, 125kHz bandwidth)
Microcontroller	No MCU onboard (acts as concentrator module for host via SPI)

Exploration of the LR1302 LoRaWAN Pi Hat. . .

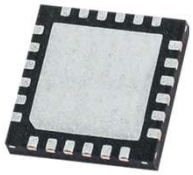

Technical Specifications Chart: Elecrow LR1302 LoRaWAN Module

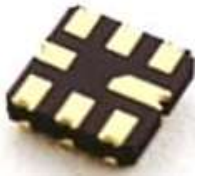
Communication Interface	SPI (to Raspberry Pi, other host SBCs)
Antenna Connector	SMA Connector (external antenna included or optional)
Power Supply	3.3V-5V DC (via GPIO header or separate power input)
Power Consumption	< 800 mW (typical during receive); < 1.5 W (during transmit)
Board Interface	40-pin GPIO Header (compatible with Raspberry Pi)
Form Factor	Raspberry Pi HAT form factor
Operating Temperature	-40 degC to +85 degC
Dimensions	Approx. 65 mm x 56 mm (standard RPi HAT size)
Use Case	LoRaWAN Gateway Concentrator Module
Compatible Software	LoRa Gateway OS, ChirpStack, TTN Gateway Stack
Certifications	CE, FCC (model-dependent)

Exploration of the LR1302 LoRaWAN Pi Hat. . .


Tech Note

SX1250 Front-End Device



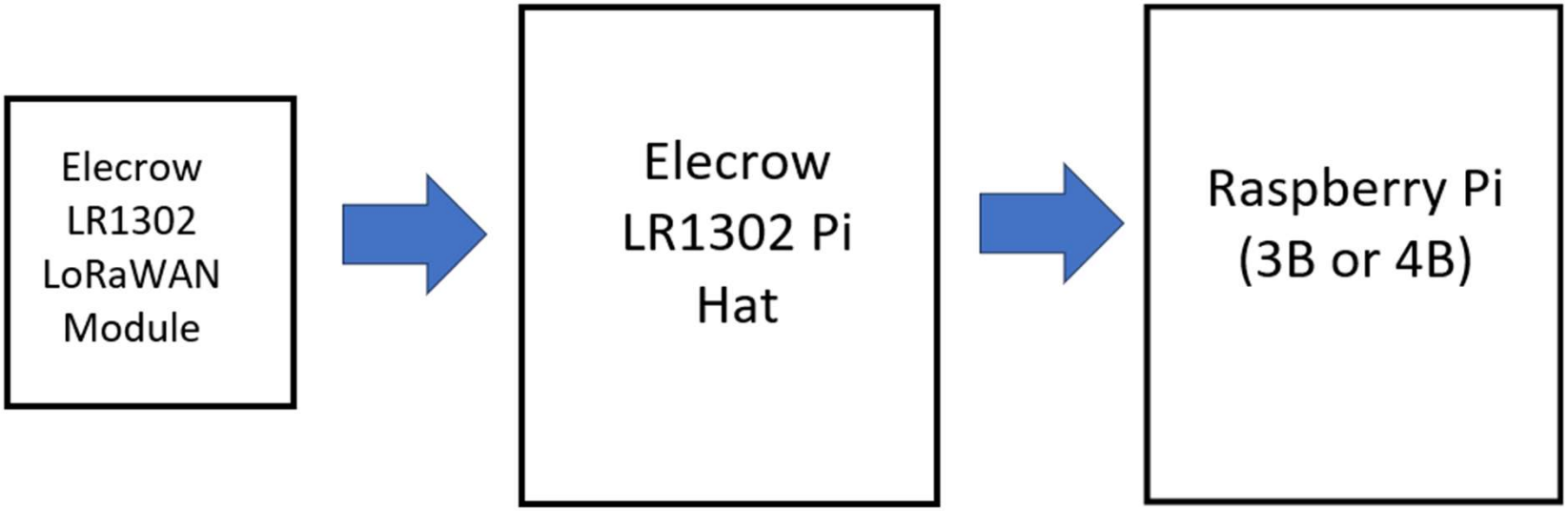


SAW Device

What are SX1250 and SAW Devices?

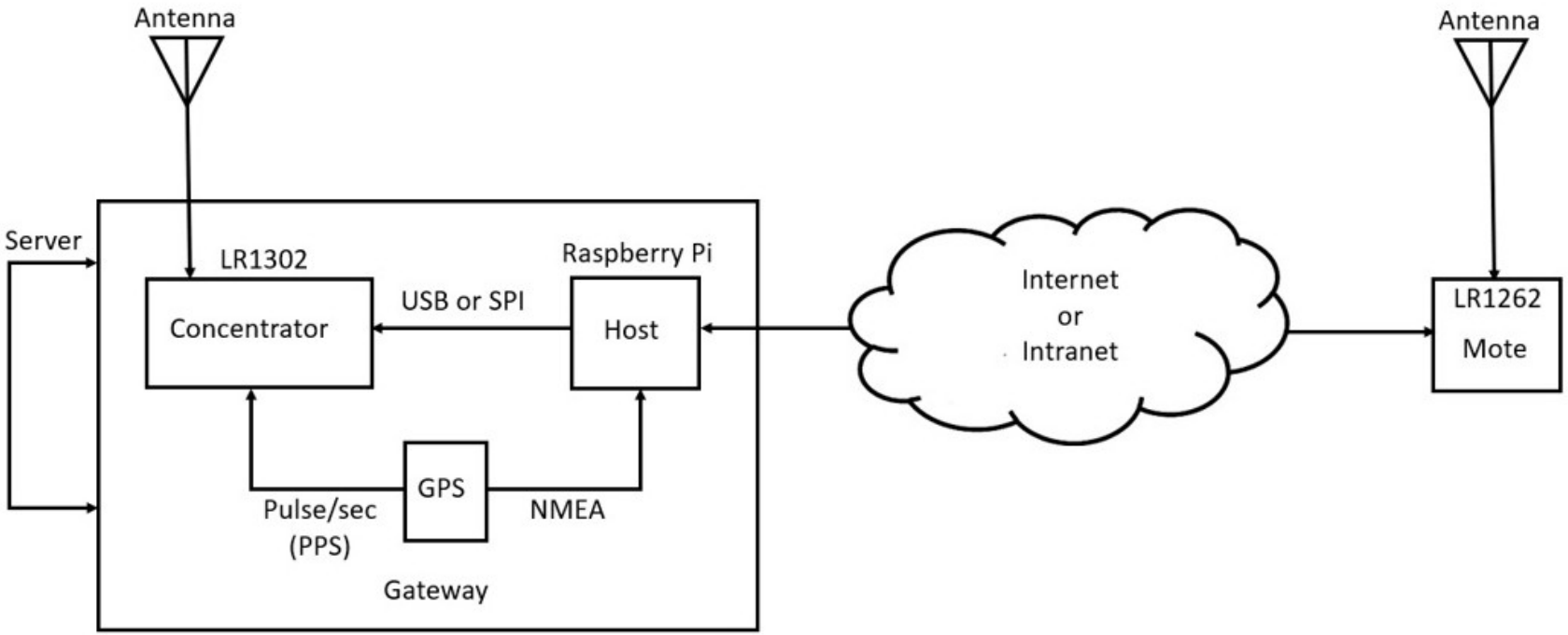
- The SX1250 is a sub-GHz RF front-end device designed to work along with Semtech's SX1302 baseband engine, to design a high-performing gateway leveraging LoRa® or LoRaWAN®
- Surface Acoustic Wave (SAW) devices are electronic components that use acoustic waves traveling along the surface of a material to filter or manipulate signals.

Concept System Diagram: LoRaWAN Trainer



Concept System Diagram: LoRaWAN Trainer. . .

Concept System Diagram: LoRaWAN Trainer. . .



Concept System Diagram: LoRaWAN Trainer. . .


The trainer has three main hardware components:

- A **host computer** (the Raspberry Pi).
- A **concentrator** (the LR1302 Gateway module).
- A **mote** (the LR1262 node module).

It also includes other components that provide supporting features, as we'll discuss at the end of this section. Before we get to those, however, let's go over each of the three pieces of hardware listed above.

Concept System Diagram: LoRaWAN Trainer. . .


Host Computer

- The Raspberry Pi serves as a central processing unit (CPU) and host computer for the trainer.
- It runs software to interface with the gateway and node modules.

Concentrator

- The Elecrow LR1302 gateway module serves as the communication bridge between the LoRaWAN nodes and the internet.
- The most important part of this module is the concentrator, which manages message transmissions to and from the LoRaWAN network.

Concept System Diagram: LoRaWAN Trainer. . .


Tech Note

Concentrator

LR1302 Gateway

What is a Gateway and a Concentrator?

- A ‘gateway’ is a physical device comprising a concentrator and at least one radio.
- Semtech SX1302 LoRaWAN baseband chip, which acts as the concentrator.
- The chip is responsible for managing the LoRaWAN network's message transmissions and receptions.

Concept System Diagram: LoRaWAN Trainer. . .


Mote

- The mote is a LoRaWAN-enabled device used for sending and receiving packet data.
- In this case, it takes the form of the Elecrow LR1262 node module.
- This module supports AT commands for configuring network parameters and transmitting messages to the concentrator.

Question 3

What is the function of a Concentrator?

a) A gateway module that serves as the electrical bridge between the LoRaWAN nodes and the internet.

b) A gateway module that serves as the solid-state bridge between the LoRaWAN nodes and the internet.

c) A gateway module that serves as the communication bridge between the LoRaWAN nodes and the internet.

d) none of the above

Concept System Diagram: LoRaWAN Trainer. . .

Other Components

Some other components of the LoRaWAN Trainer include:

GPS Antenna: The purpose of the antenna module is to allow the transmission and reception of packet data for the trainer by providing global positioning data for the gateway's location.

- If you don't want to use an antenna module, integrating a wireless beacon into the trainer will accomplish the same thing.
- The GPS antenna in the trainer provides a one Pulse-Per-Second (PPS) output signal.
- A serial link to the host computer allows it to send National Marine Electronics Association (NMEA) frames, which contain time and geographical coordinates data.

Concept System Diagram: LoRaWAN Trainer. . .


Other Components. . .

- Keyboard and monitor: Like a power supply, these probably go without saying. Still, make sure you have them handy.
- Assorted cables: You will need a jumper wire and a USB-C cable.

Why a LoRaWAN Trainer?


- A LoRaWAN Trainer is an educational or development platform designed to:
  - a) teach.
  - b) demonstrate.
  - c) and prototype the functionality of LoRaWAN (Long Range Wide Area Network) technology.
- Its primary purpose is to help learners, engineers, and developers learn and experiment with wireless IoT communication devices using LoRa/LoRaWAN protocols.

Why a LoRaWAN Trainer?. . .


- The LoRaWAN Trainer will help users gain insights into:
  a) network setup,
  b) data transmission,
  c) and device management.
- Once assembled and programmed, it will provide a practical platform for configuring and testing long-range, wireless systems.

Why a LoRaWAN Trainer?. . .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Why a LoRaWAN Trainer?. . .

🔍 Purpose of a LoRaWAN Trainer:

Purpose	Description
1. Hands-on Learning	Helps learners understand LoRaWAN architecture, including end-nodes, gateways, and network servers through practical experiments.
2. AT Command Practice	Allows users to send AT commands to configure and control LoRa modules, aiding in learning how low-level wireless communication works.
3. Protocol Demonstration	Demonstrates how LoRaWAN handles data transmission, spreading factors, and adaptive data rates.
4. Application Prototyping	Enables quick development and testing of IoT applications such as smart agriculture, environmental monitoring, and asset tracking.

Why a LoRaWAN Trainer?. . .

🔍 Purpose of a LoRaWAN Trainer:

5. Network Integration	Provides experience with integrating nodes to public (e.g., The Things Network) or private LoRaWAN networks.
6. Curriculum Support	Used in IoT or embedded systems courses to support lessons with structured lab activities and tutorials.
7. Debugging & Troubleshooting	Helps users observe real-time communication and learn how to troubleshoot connection and configuration issues.

Why a LoRaWAN Trainer?. . .

Summary Diagram

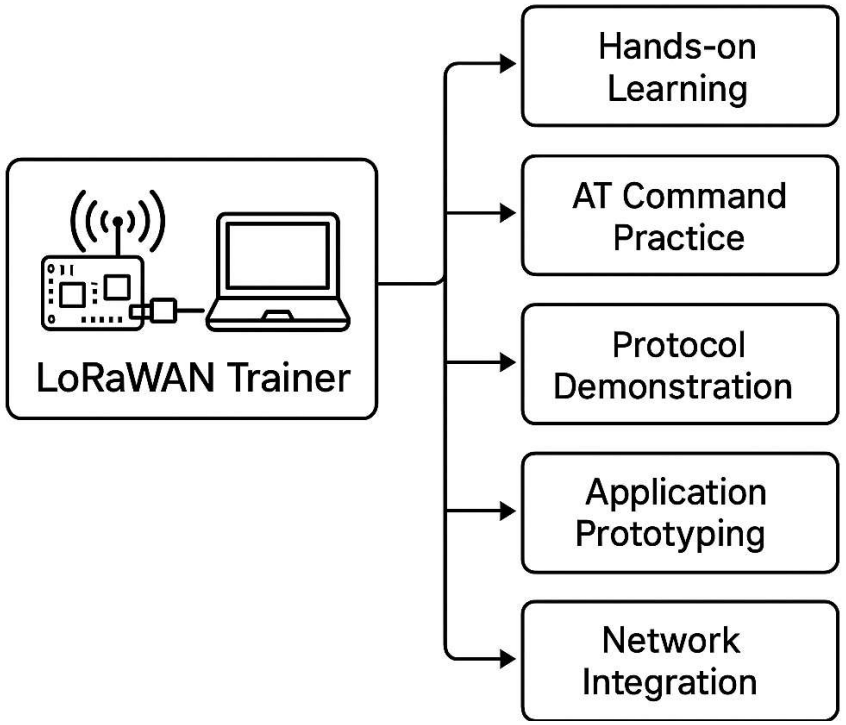


Image Generated: ChatGPT

Question 4

What is a LoRaWAN Trainer?

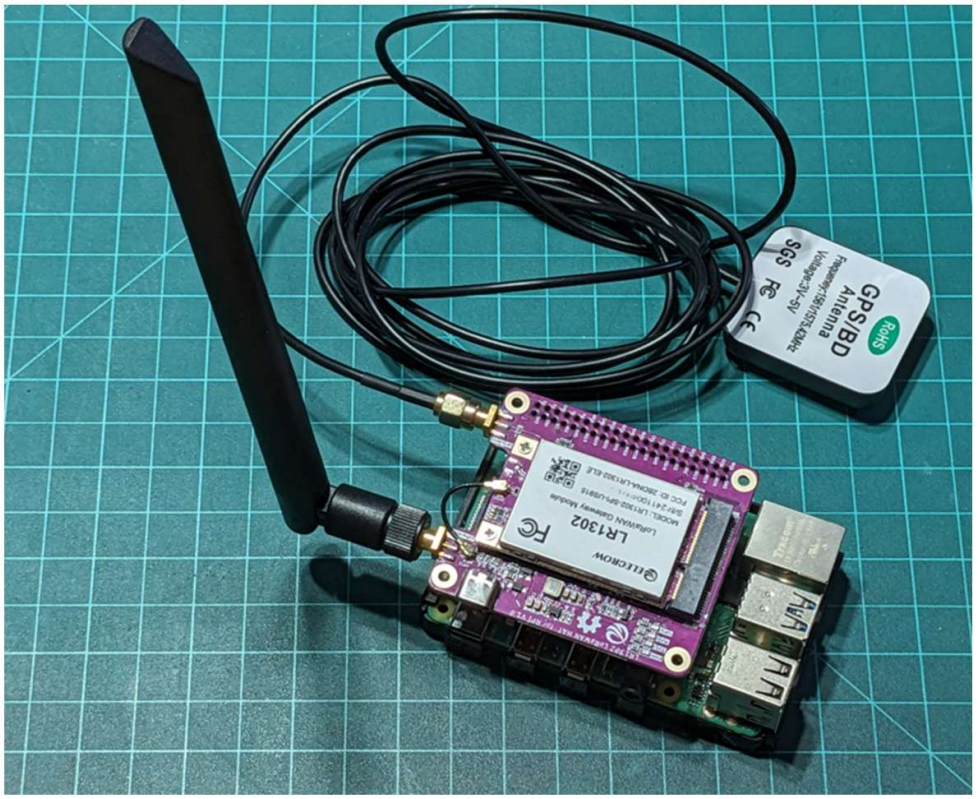
a) An educational or development platform designed to teach, demonstrate, and prototype the LoRaWAN functionality.

b) A dev-kit designed to teach, demonstrate, and prototype the LoRaWAN functionality.

c) A demonstration board designed to illustrate and prototype the LoRaWAN functionality.

d) none of the above

Lab: Building and Testing the LoRaWAN Trainer



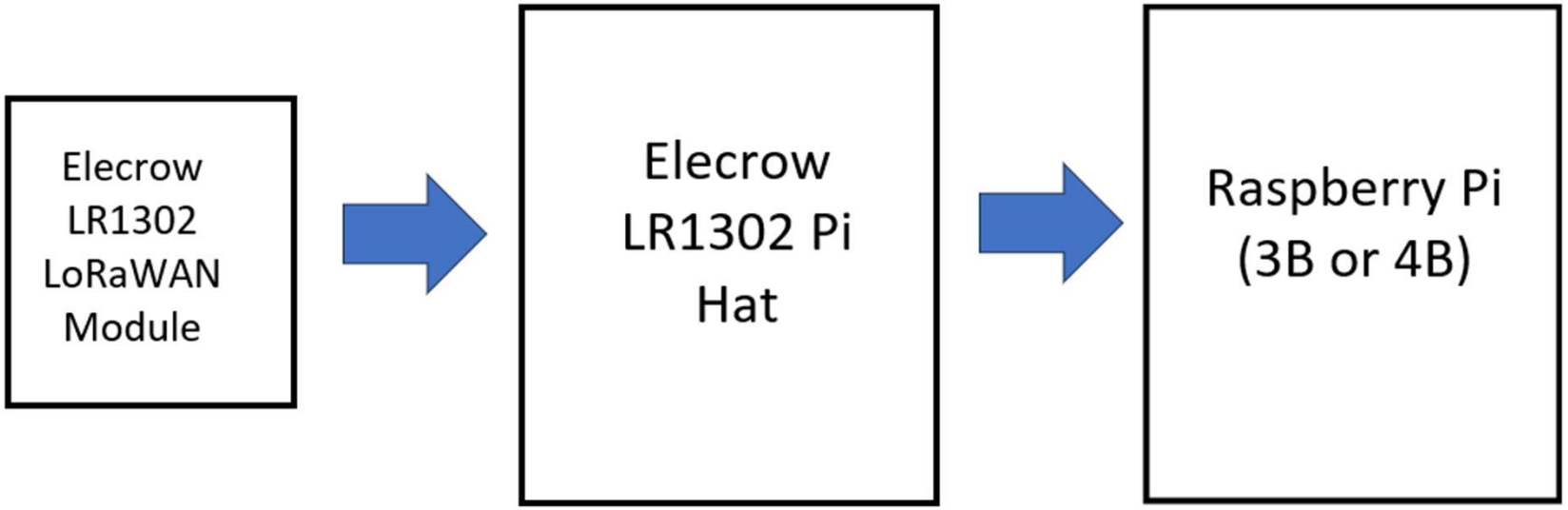
Lab: Building and Testing the LoRaWAN Trainer. . .

Participant Learning Objectives:

- Participants will learn to assemble the LoRaWAN Trainer.
- Participants will learn to download and install the “lora packet forward” software onto the Raspberry Pi.
- Participants will learn to verify the operation of the “lora packet forward” software on the Raspberry Pi.

Lab: Building and Testing the LoRaWAN Trainer. . .

Concept System Diagram



Lab: Building and Testing the LoRaWAN Trainer. . .

Building the LoRaWAN Trainer

The steps to build the LoRaWAN Trainer are listed below.

1. Attach the LR1302 gateway module to the Raspberry Pi Hat.

2. Mate the Gateway/Pi Hat Assembly to the Raspberry Pi.

3. Attach both antennas to the Raspberry Pi Hat.

4. Attach short antenna wire (Jumper wire) between the mini-RF coaxial connectors: U.FL (IPEX) Interface

4. Hook up a keyboard, monitor, and power supply to the Raspberry Pi.

5. Turn on the power supply to the Raspberry Pi.

Lab: Building and Testing the LoRaWAN Trainer. . .

Concept System Diagram

LR1302 Gateway

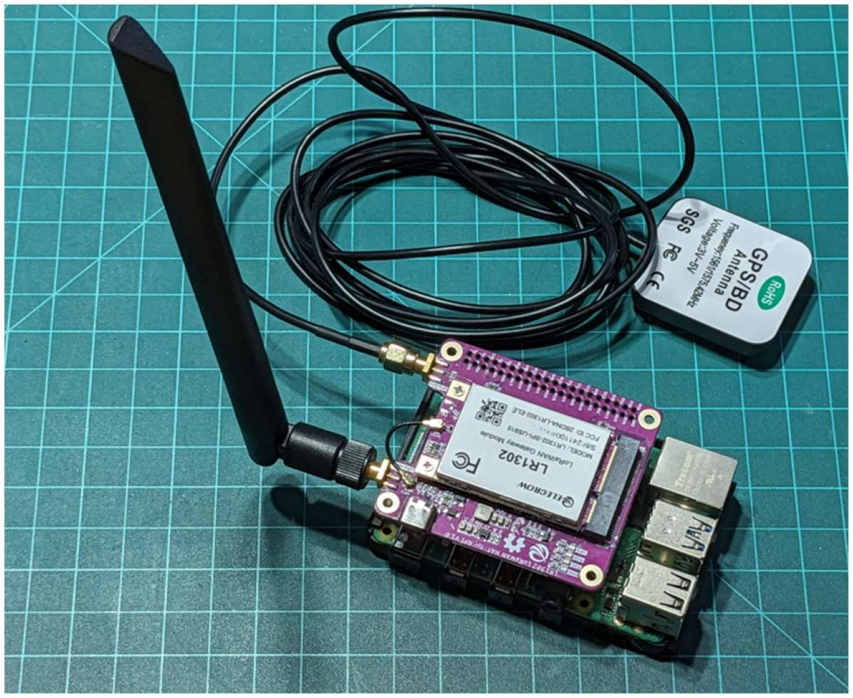
LR1302 Pi Hat

Assembled Gateway to Pi Hat LoRaWAN device

Jumper Wire

Lab: Building and Testing the LoRaWAN Trainer. . .

Complete Assembly of the LoRaWAN Trainer



Lab: Building and Testing the LoRaWAN Trainer. . .


Final Hardware Assembly

With all of the LoRaWAN Trainer's primary components assembled, attach the keyboard and monitor to the Raspberry Pi's available USB ports, plug in the power supply, and turn the Raspberry Pi on. If everything is working properly, the following LEDs should be lit up:

- The green power light.
- The red configuration light.
- The blue receive (RX) light.
- The green transmit (TX) light.

The cooling fan on the bottom of the Pi Hat PCB should be running as well. This completes the hardware build of the LoRaWAN Trainer.

Lab: Building and Testing the LoRaWAN Trainer. . .

Software Installation and Use Cases

- For the software portion of this project, we'll draw on Elecrow's wiki.
- Instructions for installing the packet software and configuring the Raspberry Pi can be found on the LR1302 gateway module's wiki page.
- The AT commands needed for the node module to communicate with the gateway module also have their own wiki page.
- Once the software installation is complete, you might also consider exploring the use cases Elecrow provides for the node module.
- Using the Tera-Term software terminal package, the wiki page examples can be executed and demonstrated quite easily on your LoRaWAN Trainer.

Lab: Building and Testing the LoRaWAN Trainer. . .


Software Installation and Use Cases. . .

Obtaining the SX1302 hal software:

```
sudo apt update
sudo apt install -y git
cd ~
git clone https://github.com/Elecrow-RD/LR1302_loraWAN.git
```

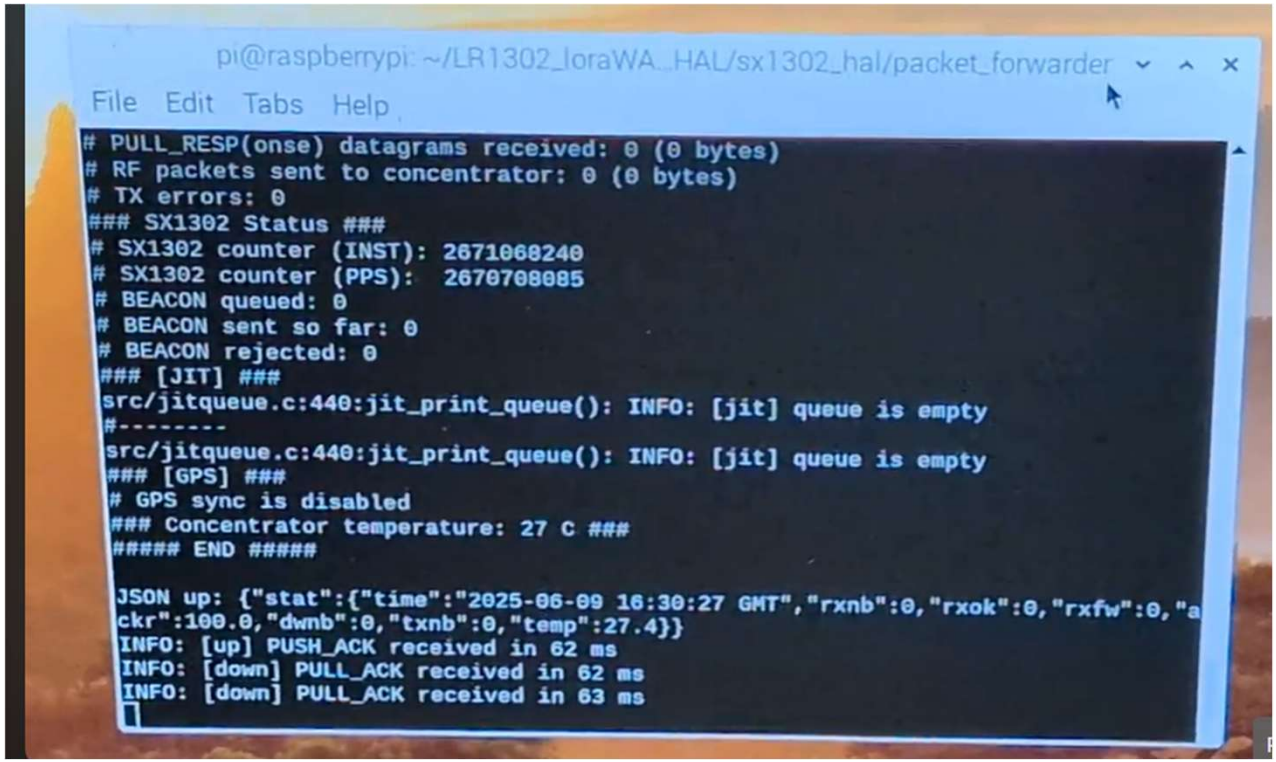
Move to the sx1302_hal folder and compile everything:

```
cd ~/sx1302_hal
make
```

Lab: Building and Testing the LoRaWAN Trainer. . .

Software Installation and Use Cases...

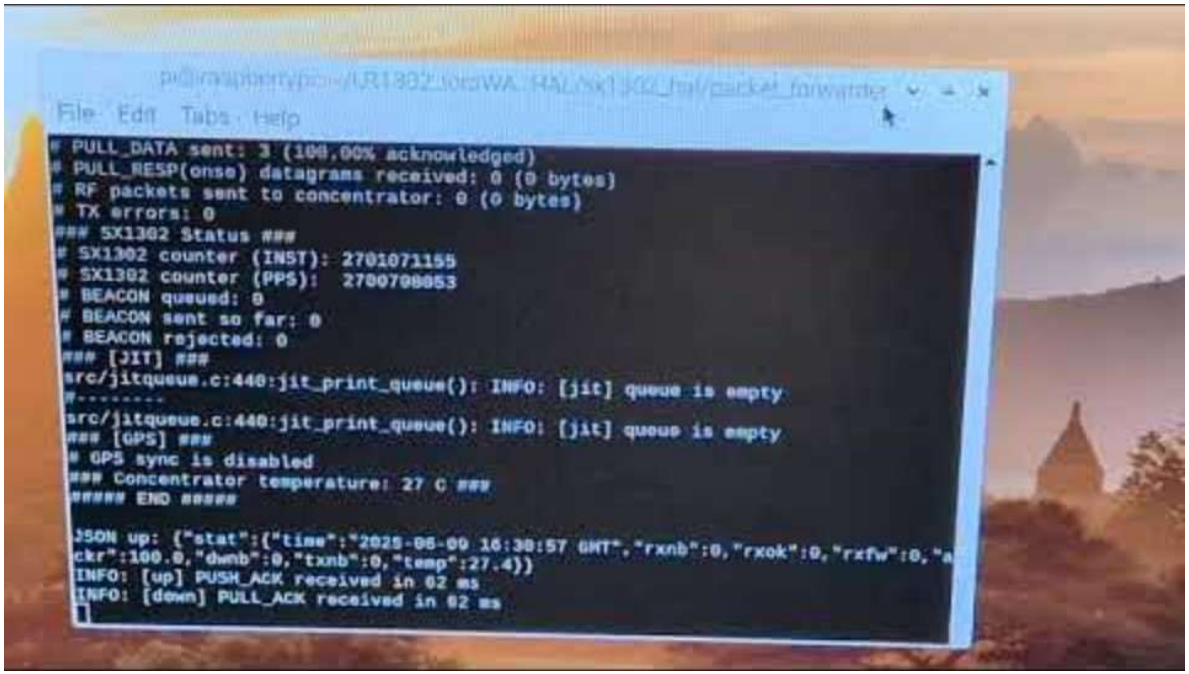
Raspberry Pi
Terminal Session



Lab: Building and Testing the LoRaWAN Trainer. . .

Software Installation and Use Cases...

LoRaWAN Trainer in Operation YouTube Video



Lab: Building and Testing the LoRaWAN Trainer. . .

Software Installation and Use Cases...

Tera Term Session

```
Sent command: AT+AppKey=[redacted]
Sent command: AT+JOIN=1,8

Sent command: AT+SEND=1:1:HELLO
OSent command: AT
KSent command: AT+ChannelMode=1
Sent command: AT+BAND=8

Sent command: AT+DevEui=[redacted]
 Sent command: AT+AppEui=[redacted]
rSent command: AT+AppKey=[redacted]
eady to join in
896s087I A7 y:05:04:E4:57
###### AppEui:  [redacted]
###### DevAddr:  [redacted]

OK
896s528:RX_1 on freq 923300000 Hz at DR 0

OK

OK
```

Question 5

In reviewing slide 41, which color LED is used twice to identify 2 distinct operating modes?

a) Blue
b) Red
c) White
d) Green

Thank you for attending

Please consider the resources below:

Rahman, H.U., Ahmad, H., Ahmad, M., & Asif Habib, M. (2020). *LoRaWAN: State of the art, challenges, protocols, and research issues*. https://www.researchgate.net/publication/348637291_LoRaWAN_State_of_the_Art_Challenges_Protocols_and_Research_Issues.

Sani Danladi, M.& Baykara, M. (2022). Design and implementation of temperature and humidity monitoring system using lpwan technology. *Ingenierie des Systemes d'Information, 27*(4), 521-529. https://www.researchgate.net/publication/363810711_Design_and_Implementation_of_Temperature_and_Humidity_Monitoring_System_Using_LPWAN_Technology

Thank you for attending

Please consider the resources below:

Wilcher, D. (2025). *Hands-on with at commands:The lorawan trainer. Allaboutcircuits.* https://www.allaboutcircuits.com/projects/hands-on-with-at-commands-the-lorawan-trainer/

Wilcher, D. (2025). *Introduction to at commands*. GitHub.https://github.com/DWilcher/DesignNews-WebinarCode/blob/main/June_25_Webinar_Code.zip

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