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Getting Started With LoRaWAN and Sensor IoT

DAY 1: LoRaWAN Technology Overview

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Dr. Don Wilcher

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LinkedIn Page:

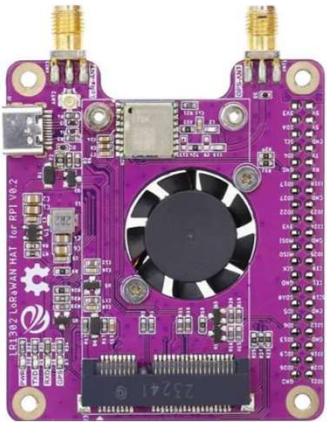
<https://www.linkedin.com/in/dr-don-wilcher-ed-d-mseit-ee-ceta-2735151/>

Patreon Page:

<https://www.patreon.com/c/DrDon683>

Course Kit and Materials

Elecrow LR1302 LoRaWAN Pi Hat



Raspberry Pi 4 Single Board Computer



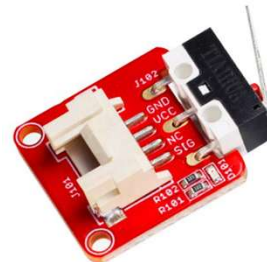
USB-C Cable



Elecrow Crowtail LED 2.0



Elecrow Crowtail Collision Sensor



LR1302 Gateway Module



Elecrow LR1262 Node Board



Research Perspective

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

Agenda:

- Key Terms and Definitions
- Orthogonal Spreading Factor
- LoRaWAN Communication Protocol Stack
- Elecrow LoRaWAN Pi Hat and Node Board Overview
- Lab: Exploring the Elecrow LR1262 Node Board

Key Terms and Definitions



Term	Definition
LoRaWAN	A communication protocol and system architecture for wireless networks that uses LoRa technology at the physical layer. Enables secure, bidirectional communication over long distances with low power.
LoRa	The physical layer modulation technique (based on Chirp Spread Spectrum) used in LoRaWAN. It handles the actual transmission and reception of radio signals.
Chirp Spread Spectrum (CSS)	A modulation technique that spreads the signal over a wider frequency, improving resistance to interference and enabling long-distance communication.
LPWAN (Low Power Wide Area Network)	A wireless network type designed for low power consumption and long-range communication, ideal for IoT devices.
MAC Layer (Medium Access Control)	A network layer responsible for managing how data packets are transmitted and accessed over the medium. In LoRaWAN, this includes device classes and duty cycling rules.

Key Terms and Definitions. . .



Term	Definition
End Device	An IoT device that sends data to a gateway. These are often sensors or actuators using Class A, B, or C configurations.
Gateway	A relay device that forwards messages between end devices and the LoRaWAN network server.
Network Server	Central server that processes data from gateways, manages network functions, and enforces security and routing policies.
Application Server	Processes application-level data and often integrates with cloud platforms or user interfaces.

Question 1

What is LoRa?

- a) The physical layer modulation technique (based on Continuous Spread Spectrum) used in LoRaWAN.**
- b) The physical layer modulation technique (based on Chirp Technology) used in LoRaWAN.**
- c) The physical layer modulation technique (based on Chirp Spread Spectrum).**
- d) none of the above**



Key Terms and Definitions . . .

Chirp Spread Spectrum Signal

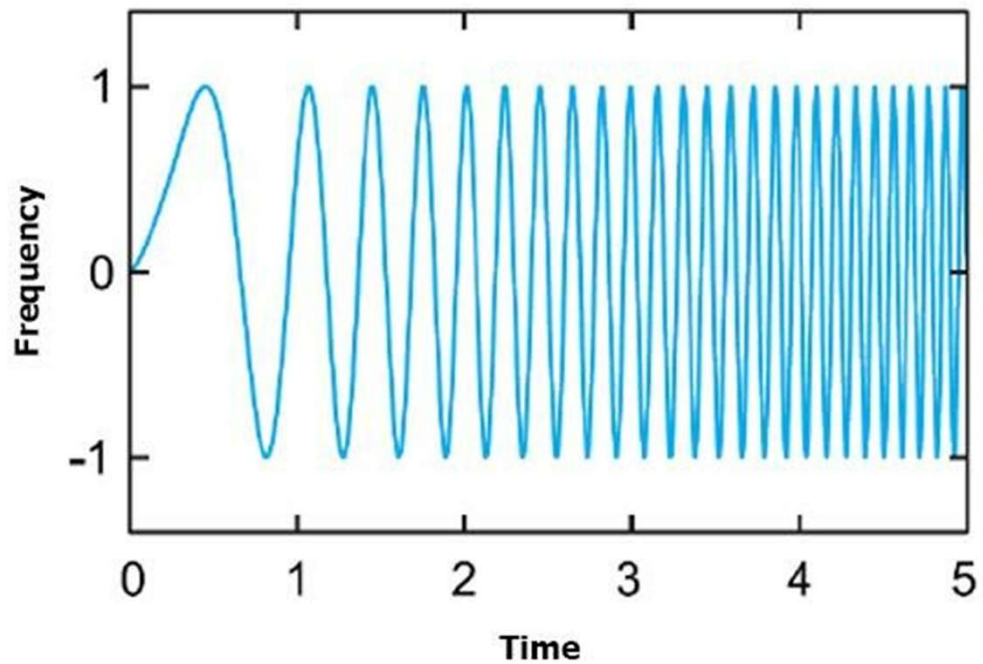


Image: [Research Gate](#)

Key Terms and Definitions . . .

Upchirp and Downchirp in LoRa Communication



In LoRa (Long Range) technology, chirps are the fundamental building blocks of its modulation scheme known as Chirp Spread Spectrum (CSS). These chirps are specialized signals where the frequency changes over time. There are two types:

Upchirp

- An upchirp is a signal whose frequency increases linearly over time.
- It starts at the lowest frequency in the band and ends at the highest.
- Used for data transmission in LoRa because upchirps are the default symbols for representing bits.

Example:

Think of a bird sound that starts low and sweeps up in pitch — that's an upchirp.

Key Terms and Definitions . . .



▼ Downchirp

- A downchirp is a signal whose frequency decreases linearly over time.
- It starts at the highest frequency and sweeps down to the lowest.
- Primarily used for **synchronization, de-spreading, and demodulation** in the receiver.

Example:

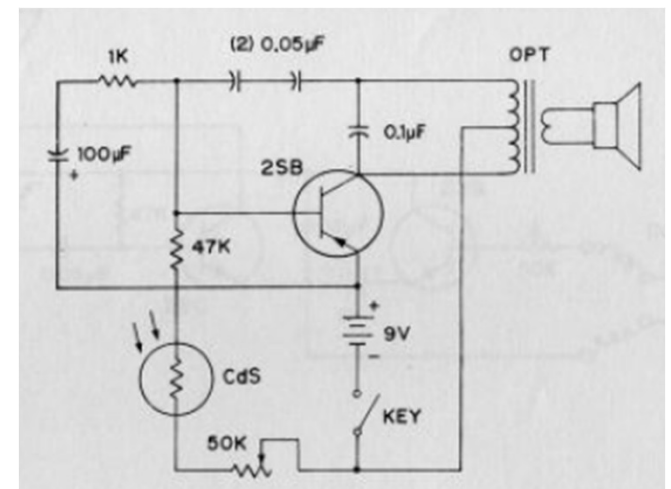
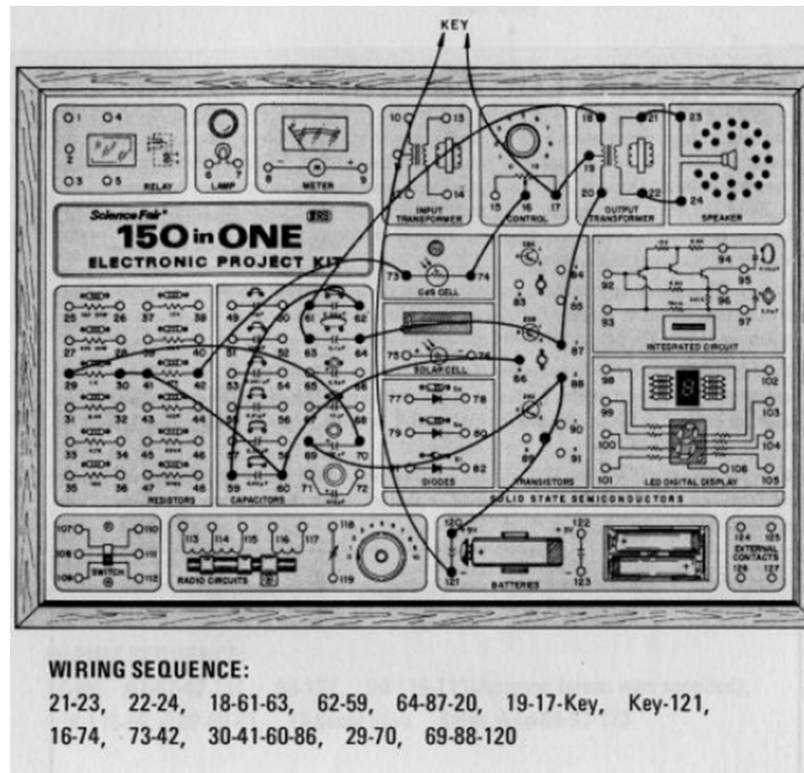
Imagine a siren that starts high and then drops in pitch — that's a downchirp.

Key Terms and Definitions ...

Upchirp and Downchirp Electronic Circuit Example



Daylight Bird or Early Bird:
Radio Shack Science Fair
150-In-1 Electronic Project
Kit



Question 2

What approach is used as the fundamental building blocks for LoRa modulation scheme?

- a) End Device**
- b) Gateway**
- c) MAC Layer**
- d) Chirps**



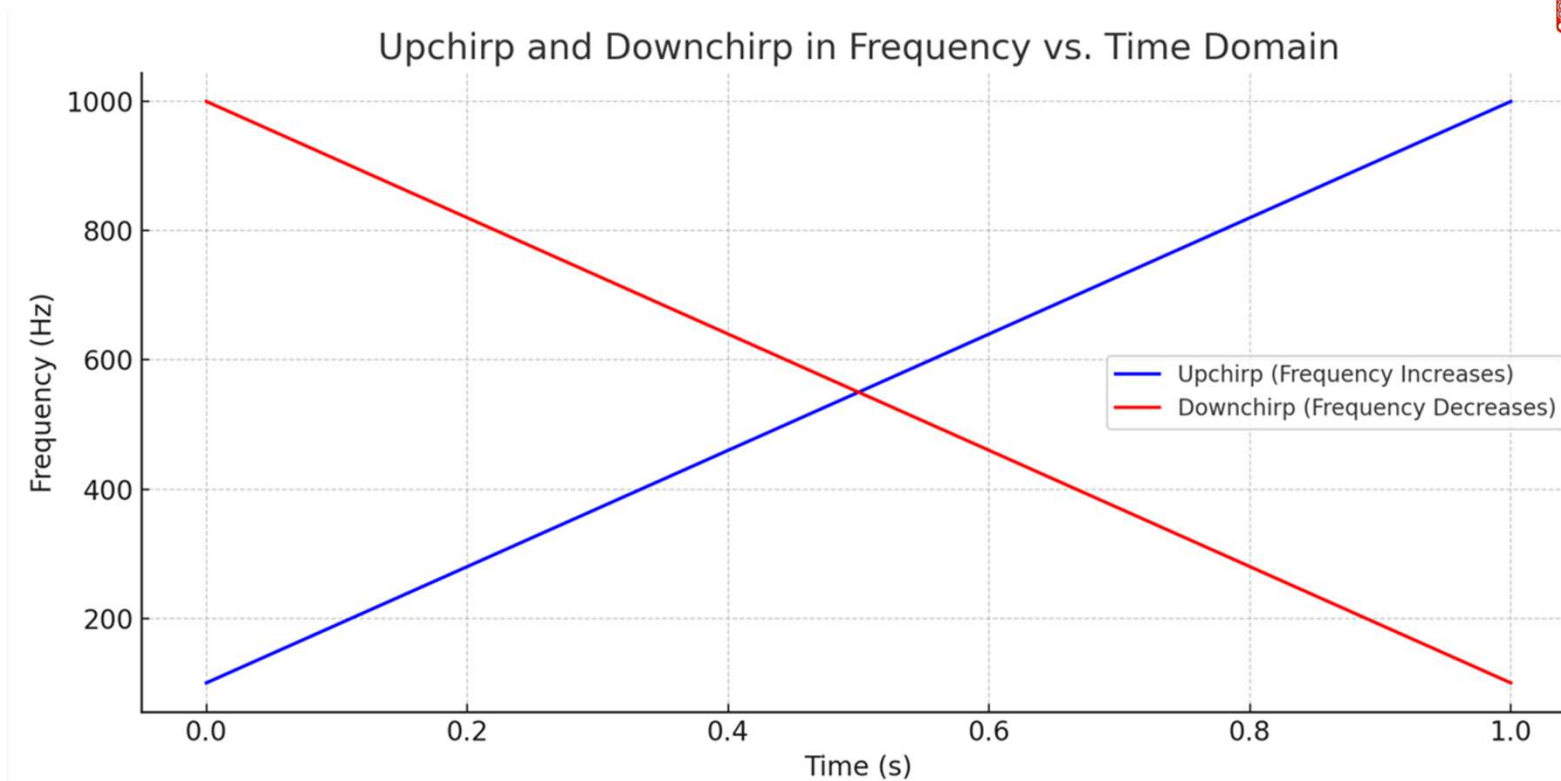
Key Terms and Definitions . . .



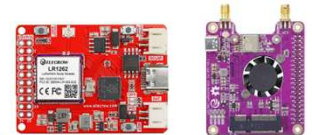
Role in LoRa Modulation and Demodulation

- LoRa encodes data using **variations in the timing (phase offset)** of upchirps.
- The **receiver uses a downchirp** to correlate and decode the upchirps.
- This upchirp/downchirp correlation allows for:
 - **High sensitivity** (below noise floor)
 - **Robustness to interference**
 - **Precise symbol timing**

Key Terms and Definitions ...



Orthogonal Spreading Factor



LoRa uses **Spreading Factors (SFs)** as a way to encode data over a wider bandwidth, allowing it to transmit signals reliably over long distances with low power consumption. These **spreading factors are orthogonal**, which is one of the reasons LoRa can support many devices in the same area without interference.

1 2 **3 4** What is a Spreading Factor (SF)?

A **Spreading Factor** is the ratio between the symbol rate and chip rate in spread spectrum communication. In LoRa, it determines:

- **Duration of each symbol** (time on air)
- **Data rate** (inversely proportional to SF)
- **Sensitivity of the receiver** (higher SF = better sensitivity)

LoRa supports SFs from **SF7** to **SF12**.

Orthogonal Spreading Factor ...



Key Concept: Orthogonality

+ Orthogonal = Independent

- Orthogonal SFs allow multiple signals to coexist on the same frequency and bandwidth **without interfering** with each other.
- A gateway can **simultaneously decode multiple transmissions** using different SFs—even if they overlap in time and frequency.

Orthogonal Spreading Factor ...



Effects of Different SFs

Spreading Factor	Range	Data Rate	Time on Air	Power Use
SF7	Short	High	Low	Low
SF12	Long	Low	High	Higher

- SF7 is used when devices are close to the gateway and can afford higher speeds.
- SF12 is used for distant devices needing better signal sensitivity.

Question 3

What is Spreading Factor?

- a) The ratio between the symbol rate and flop rate in spread spectrum communication.**
- b) The ratio between the modulation rate and chirp rate in spread spectrum communication.**
- c) The ratio between the symbol rate and chirp rate in spread spectrum communication.**
- d) none of the above**



Orthogonal Spreading Factor ...



Why Is Orthogonality Useful in LoRa?

- More devices can share the same frequency.
- Reduced collisions in data transmission.
- Efficient use of spectrum.
- Better network scalability.

Orthogonal Spreading Factor...



Why Orthogonal SFs Matter

- Enables **scalability** in LoRaWAN networks.
- Helps maintain **network reliability** even as more devices are added.
- Supports **adaptive data rate (ADR)**: nodes choose the best SF based on link quality.

LoRaWAN Protocol Stack



LoRaWAN (LoRa Wide Area Network)

While LoRa handles the radio modulation, LoRaWAN is the protocol that defines how devices use LoRa to communicate. It defines the MAC (Medium Access Control) layer.

Protocol Stack:

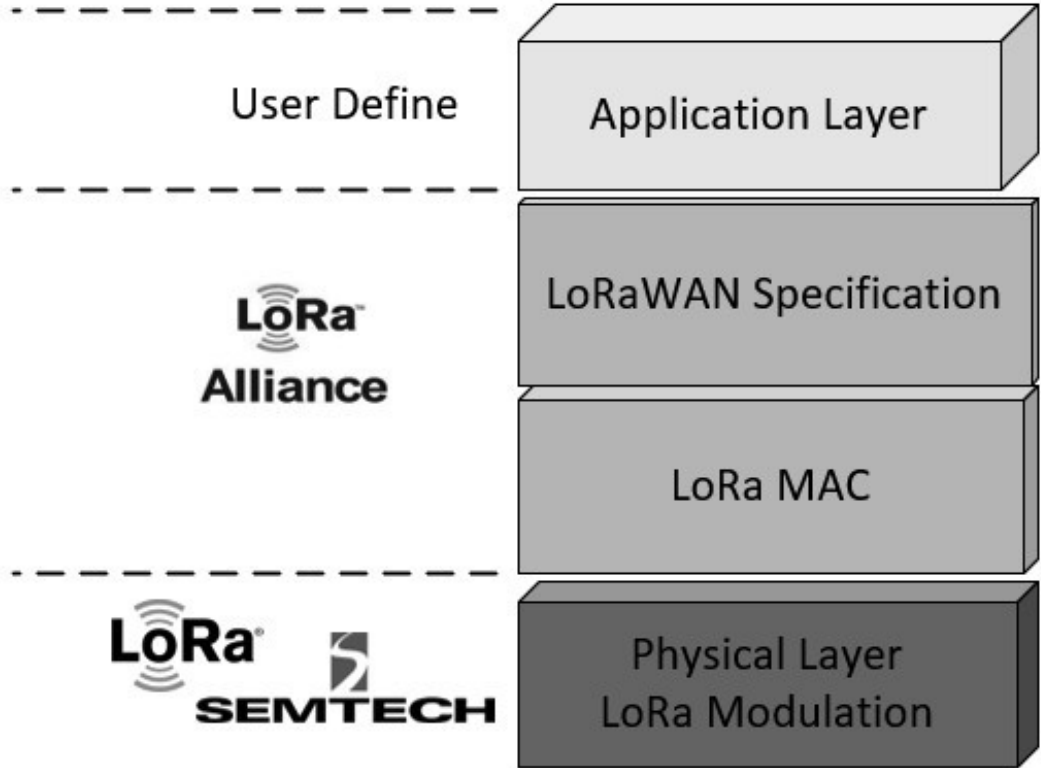
LoRaWAN operates on a **star topology**, where:

- End Devices communicate **only** with gateways.
- Gateways forward the data to a **network server**, which routes it to the appropriate **application server**.

Network Management:

- Managed by the **LoRa Alliance**.
- Supports **secure bi-directional communication** between devices and the cloud.

LoRaWAN Protocol Stack . .

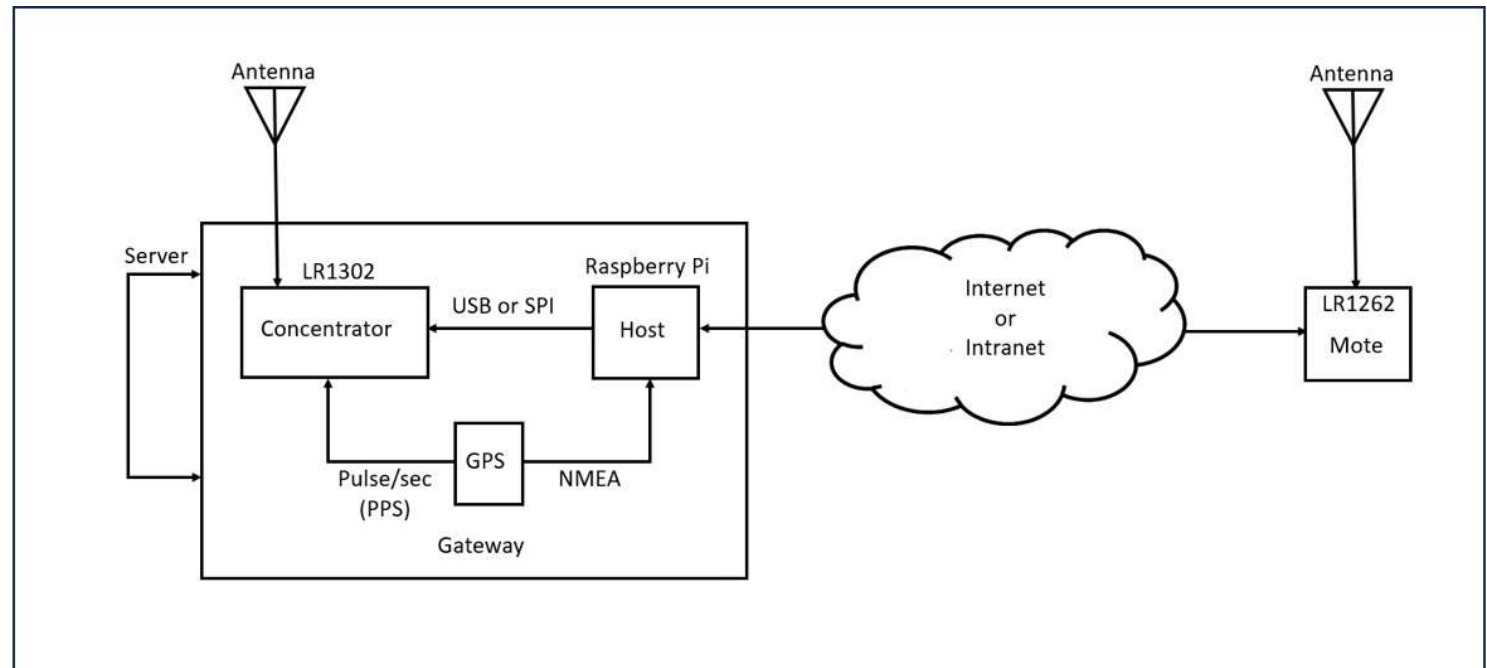


Rahman et al.,2020

LoRaWAN Protocol Stack...



LoRaWAN Network Architecture



LoRaWAN Protocol Stack...

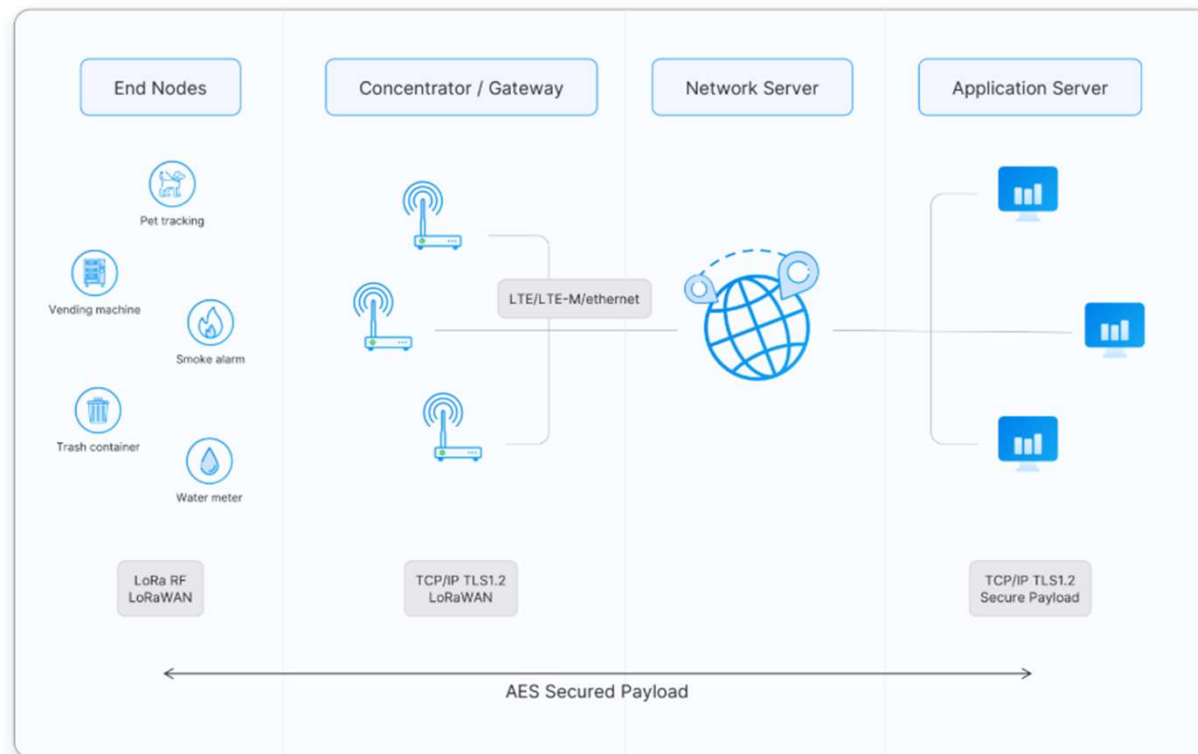


Image: [The Things Network](#)

Question 4

In reviewing slide 24, what level does the LoRaWAN specification align with?

- a) User Define**
- b) LoRa Alliance**
- c) LoRa-Semtech**
- d) none of the above**



LoRaWAN Protocol Stack. . .

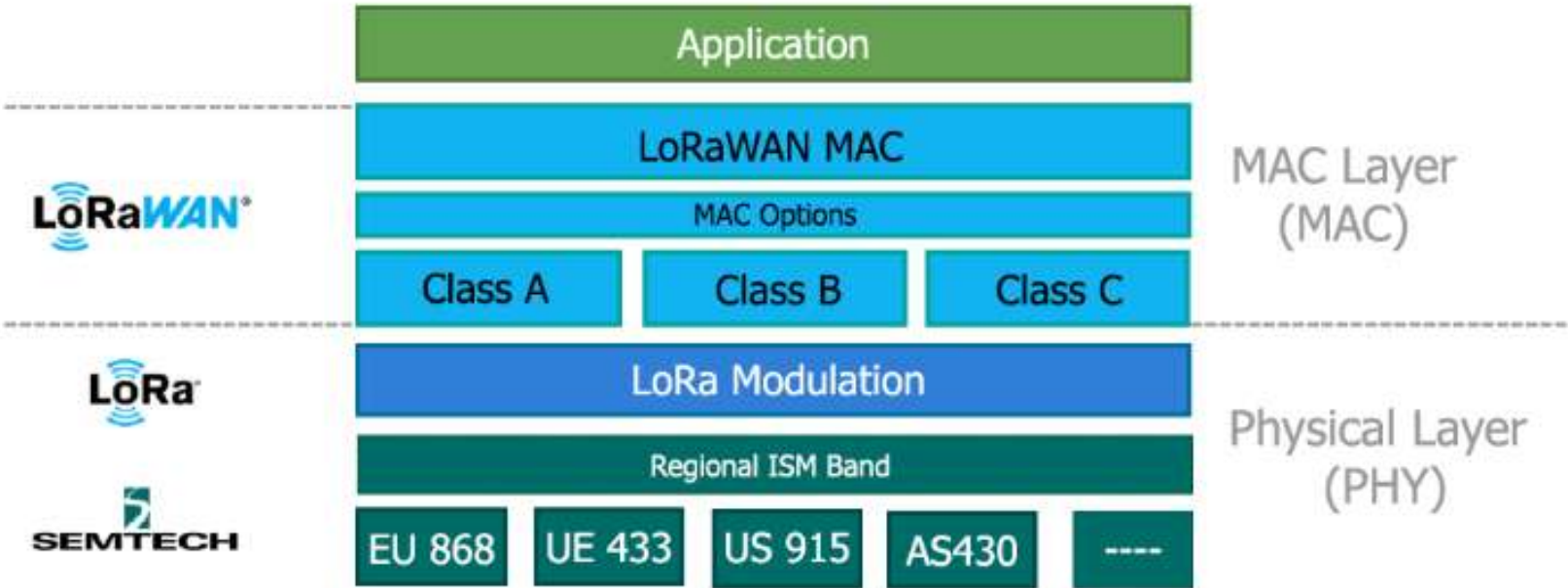


🔌 Device Classes in LoRaWAN

There are three classes of end devices, optimized for different use cases:

Class	Description	Power Use	Use Case
Class A	Most energy-efficient. Devices sleep and wake only to send data (uplink). A short window follows to receive downlink.	Very low	Battery-powered sensors
Class B	Allows scheduled receive windows in addition to Class A behavior. Syncs to beacon signals for downlink scheduling.	Moderate	Semi-frequent control applications
Class C	Always listening (except when transmitting), enabling immediate downlink.	High	Mains-powered actuators or controllers

LoRaWAN Protocol Stack . .



Elecrow LoRaWAN Pi Hat and Node Board Overview



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.

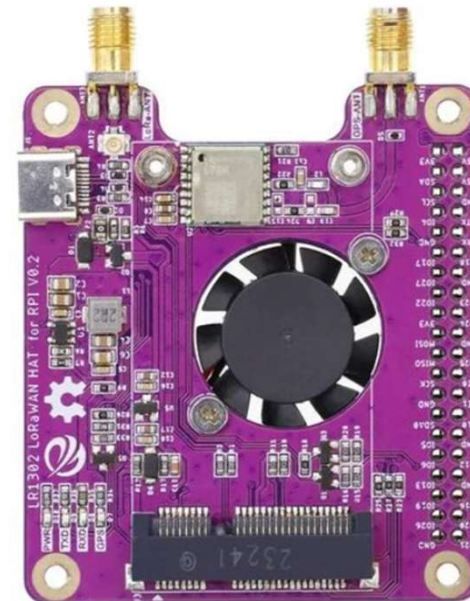
Elecrow LoRaWAN Pi Hat and Node Board Overview...



Elecrow LR1302 LoRaWAN Pi Hat

LR1302 Gateway Module

Frequencies:
EU: 868MHz
US: 915MHz



Connects Here



Elecrow LoRaWAN Pi Hat and Node Board Overview...



Elecrow LR1262 Node Board

- The Elecrow LR1262 Node Board is a compact and efficient LoRaWAN node module designed for long-range communication in IoT applications.
- It combines the Raspberry Pi RP2040 microcontroller with the LR1262 LoRa module, supporting both point-to-point and LoRaWAN network communications.

Elecrow LoRaWAN Pi Hat and Node Board Overview...



Key Features:

- **Microcontroller:** Raspberry Pi RP2040 dual-core ARM Cortex-M0+ processor running at 133 MHz, with 264KB SRAM and 4MB onboard flash memory.
- **LoRa Module:** Integrates the LR1262 module, supporting frequency bands from 803 MHz to 930 MHz, covering regions like IN865, EU868, AU915, US915, KR920, RU864, and AS923.

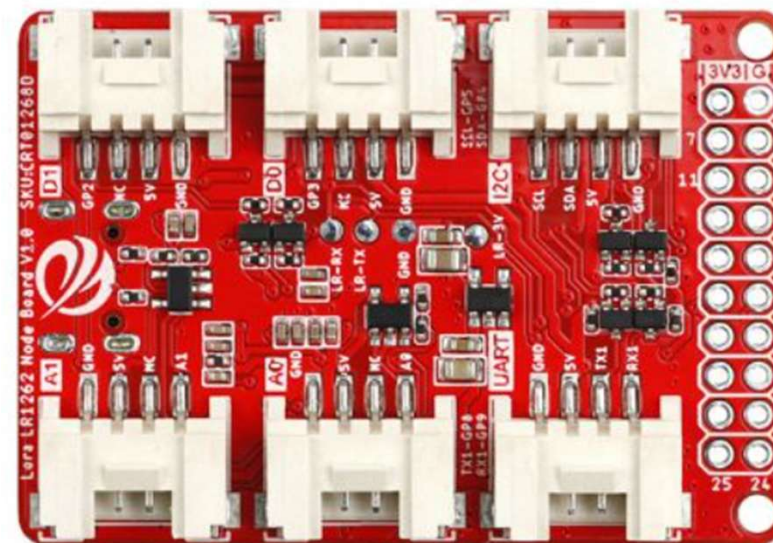
Elecrow LoRaWAN Pi Hat and Node Board Overview...



Top PCB



Bottom PCB



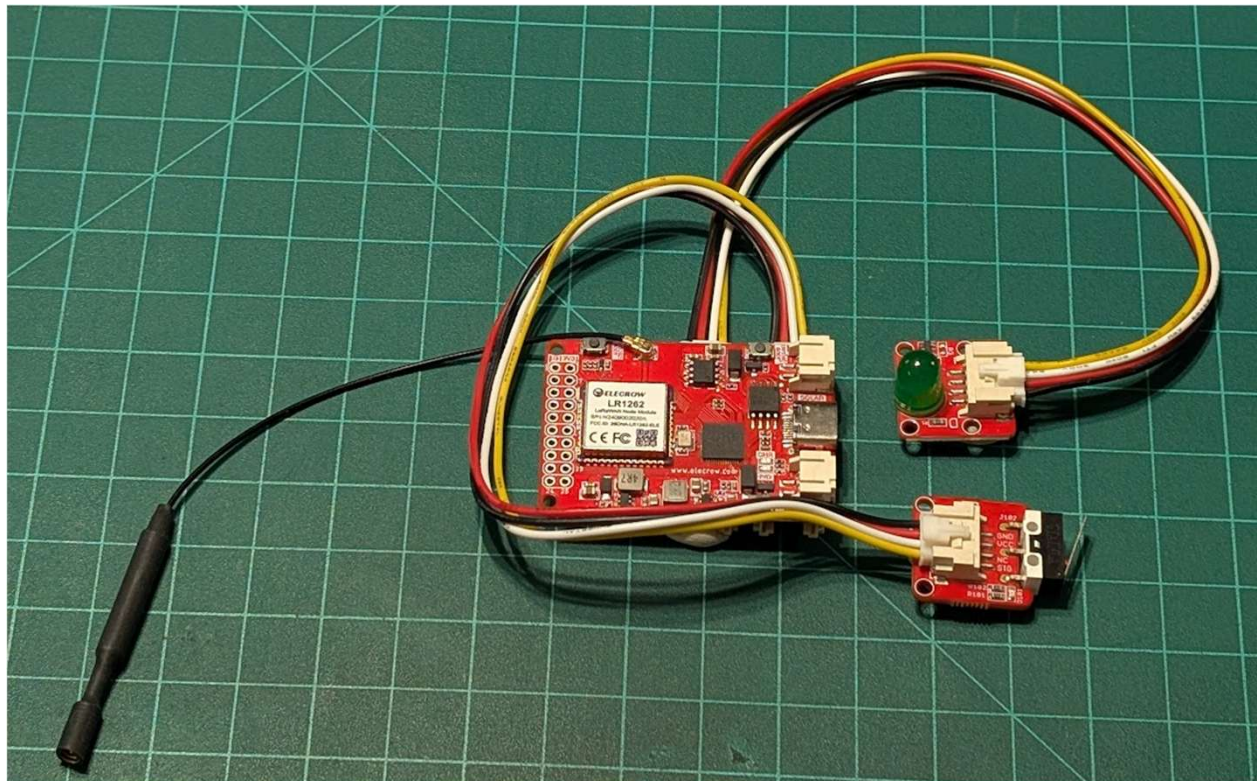
Elecrow LoRaWAN Pi Hat and Node Board Overview...



Interfaces:

- 1x USB-C interface for power and programming.
- 6x 5V Crowtail interfaces: 2x analog, 2x digital, 1x UART, 1x I2C.
- 2x10 universal GPIO interfaces.
- 1x battery interface.
- 1x solar interface for charging.
- Power Supply:** Operates at 5V/1A via USB-C.
- Dimensions:** Compact size of 35mm x 50mm, suitable for embedded applications.
- Development Environment:** Compatible with Arduino and MicroPython, facilitating flexible development options.

Lab: Exploring the Elecrow LR1262 Node Board



Lab: Exploring the Elecrow LR1262 Node Board. . .



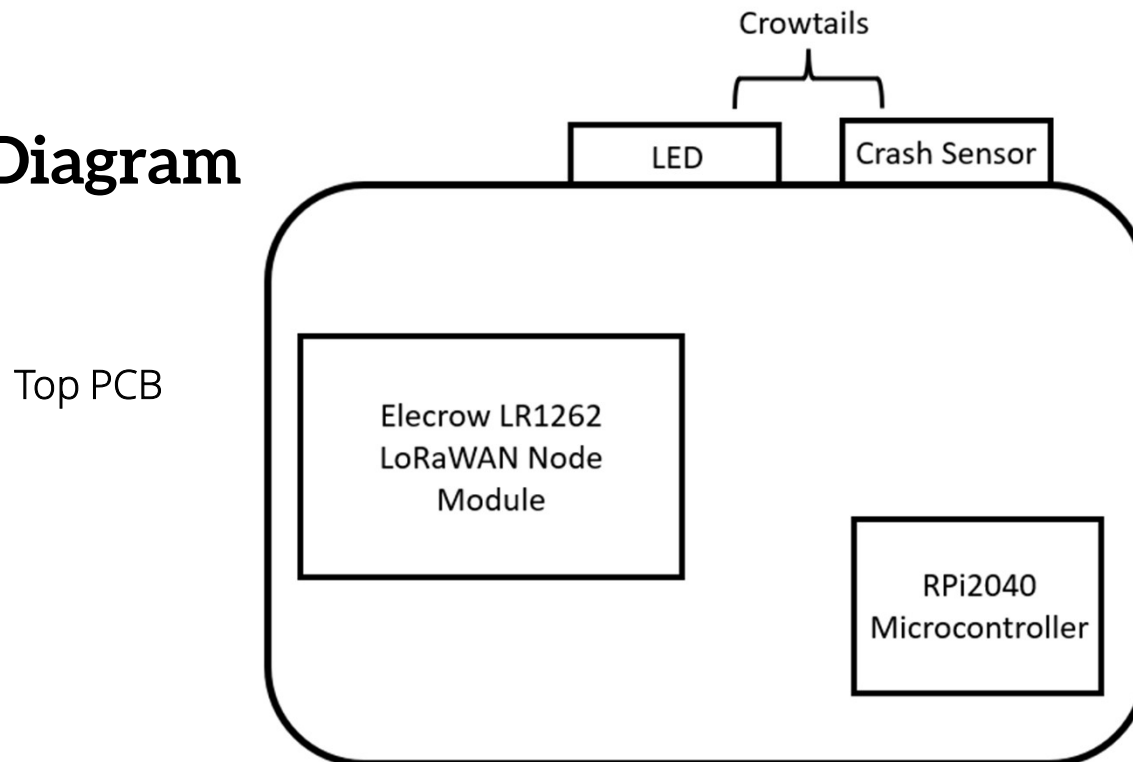
Participant Learning Objectives:

- Participants will learn to set up the LR1262 Node Board.
- Participants will learn to test and program the LR1262 Node Board using the Arduino IDE.
- Participants will learn to verify the operation of the LR1262 Node Board with test code.

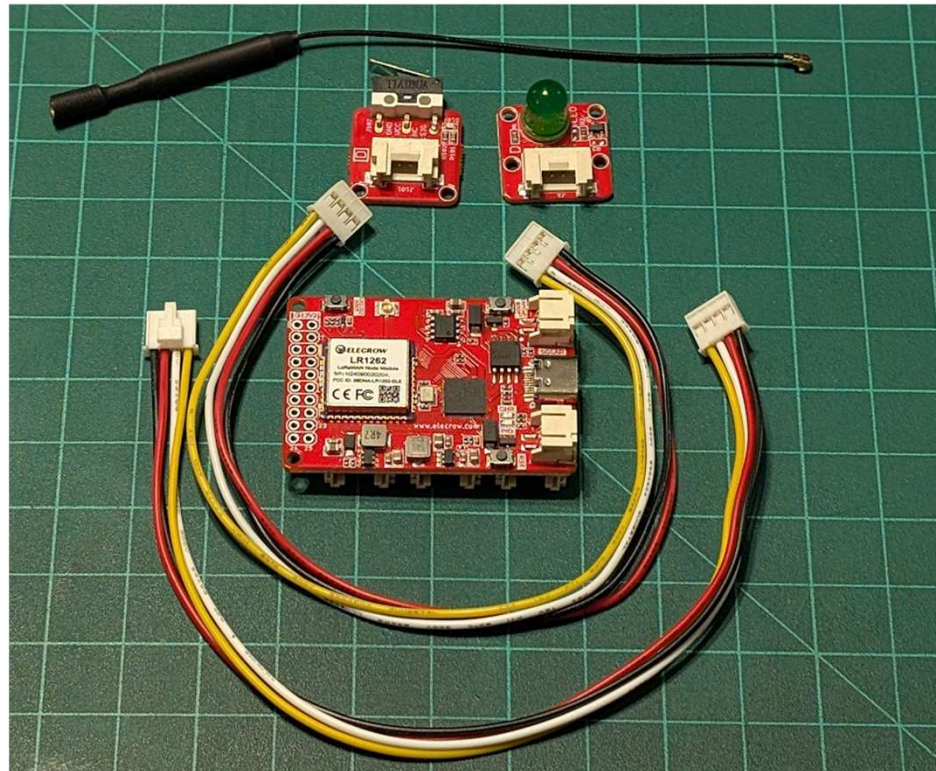
Lab: Exploring the Elecrow LR1262 Node Board



Concept Diagram



Lab: Exploring the Elecrow LR1262 Node Board...

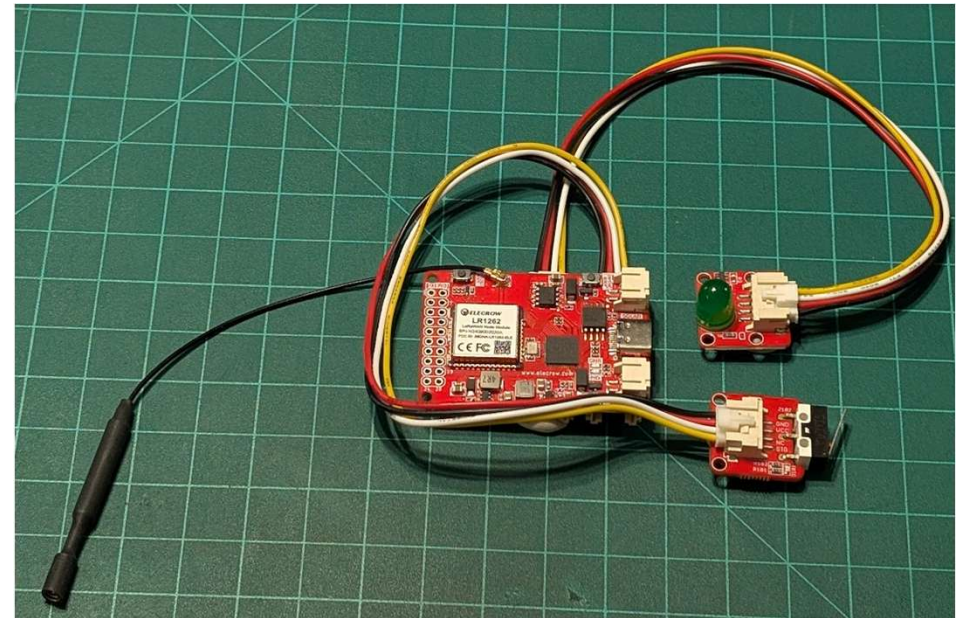
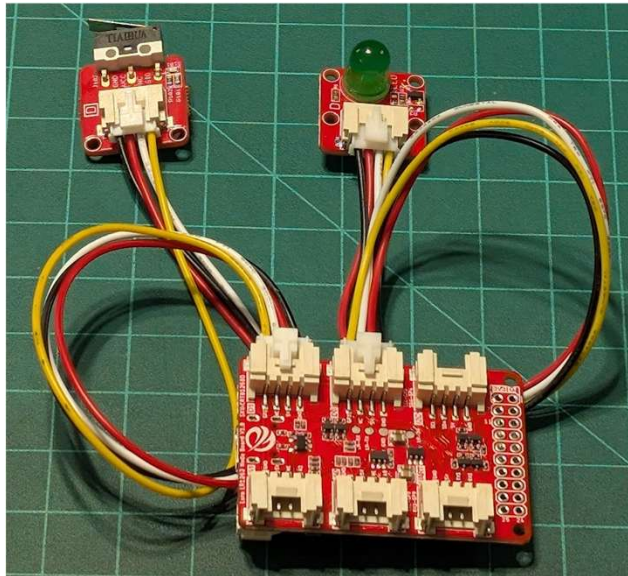


**Electronic Components
required for the LR1262
Node Board**

Lab: Exploring the Elecrow LR1262 Node Board...



The attached
components to
the LR1262
Node Board



Lab: Exploring the Elecrow LR1262 Node Board. . .

Programming the LR1262 Node Board



1. Install the Arduino IDE:

If you haven't already, download and install the Arduino IDE from the official Arduino website.

2. Add the LR1262 Board Package:

- Open the Arduino IDE.
- Go to File > Preferences.
- In the "Additional Boards Manager URLs" field, add the following URL: https://github.com/earlephilhower/arduino-pico/releases/download/global/package_rp2040_index.json (This URL is for the RP2040, which is often associated with similar LoRa boards like the LR1262).
- Click "OK."

3. Install the Board Package:

- Go to Tools > Board > Boards Manager.
- Search for "RP2040" or a similar term related to the LR1262 board.
- Install the board package, but avoid the latest version. It is recommended to choose version 2.6.0.

Lab: Exploring the Elecrow LR1262 Node Board. . .

Programming the LR1262 Node Board



4. Select the LR1262 Board:

- After installing the board package, go to Tools > Board > ... (expand the menu) and select the specific LR1262 board from the list (e.g., "RP2040").

5. Connect the Board:

Connect your LR1262 Node board to your computer using a USB cable.

6. Select the Port:

Go to Tools > Port and select the COM port that corresponds to your LR1262 board.

7. Upload Code:

Open or create a sketch in the Arduino IDE.

Click the "Upload" button to compile and upload your code to the LR1262 board.

Lab: Exploring the Elecrow LR1262 Node Board...



```
1 void setup() {  
2   pinMode(2, INPUT_PULLUP);  
3   pinMode(3, OUTPUT);  
4 }  
5  
6 void loop() {  
7   if (digitalRead(2) == LOW) {  
8     digitalWrite(3, HIGH);  
9   }  
10  else {  
11    digitalWrite(3, LOW);  
12  }  
13 }  
14
```

Switch_Light Code

Congratulations: The LED should turn on when the Crash Sensor is pressed.

Question 5

In reviewing slide 43, what type of digital logic switch is being implemented in Line 7?

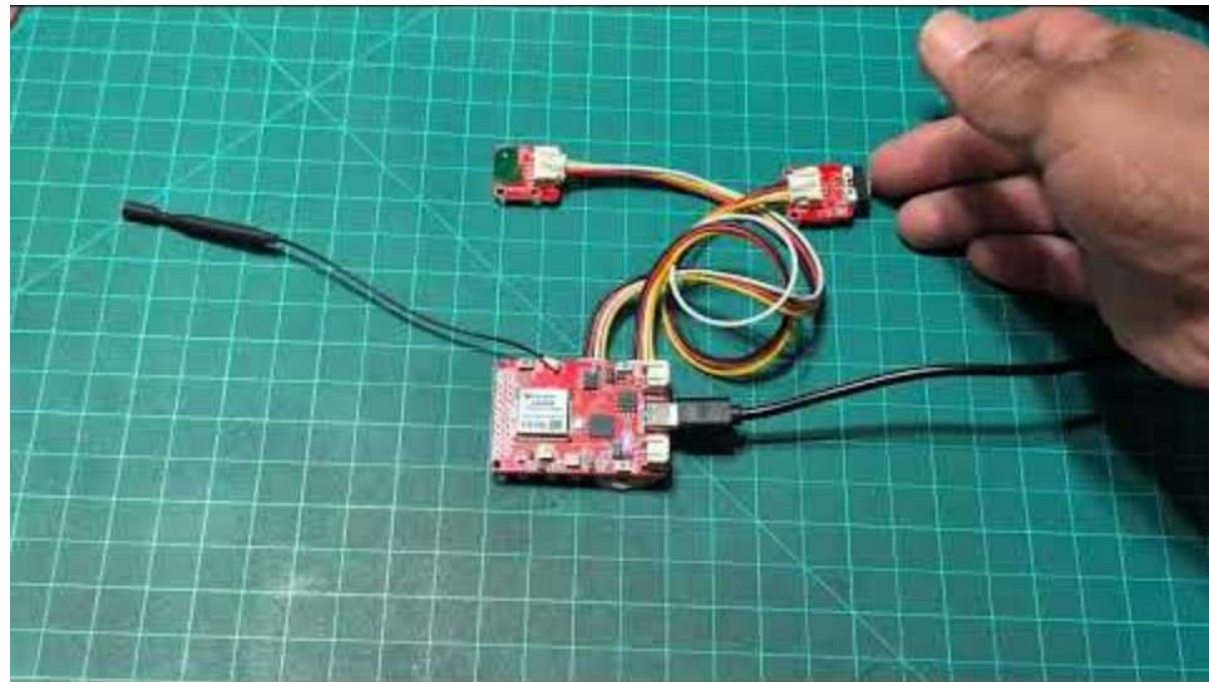
- a) Positive Logic**
- b) Inverted Logic**
- c) Buffer**
- d) none of the above**





Assembled and
Functional Switch-Light
RP2040 Device

Watch the Video Clip!



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

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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