



**DesignNews**

Getting Started With LoRaWAN and Sensor IoT

# DAY 5: Adding Automation to a LoRAWAN

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## Dr. Don Wilcher

Visit 'Lecturer Profile' in your console for more details.

LinkedIn Page:

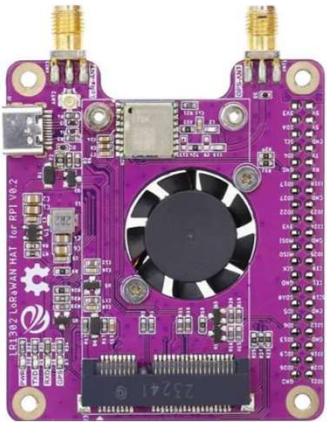
<https://www.linkedin.com/in/dr-don-wilcher-ed-d-mseit-ee-ceta-2735151/>

Patreon Page:

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

## Course Kit and Materials

**Elecrow LR1302 LoRaWAN Pi Hat**



**Raspberry Pi 4 Single Board Computer**



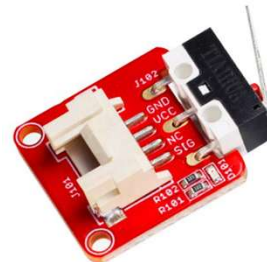
**USB-C Cable**



**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:

- What is Automation in LoRaWAN?
- Developing A LoRaWAN Automation Concept
- Capturing Transmission Data
- The Things Network (TTN)
- Lab: Build and Test An Automation LoRaWAN

## What Is Automation in LoRaWAN?



- Automation in LoRaWAN refers to the automatic control, monitoring, and management of devices, data, and processes over a LoRaWAN (Long Range Wide Area Network) communication system.
- It combines low-power wireless communication with intelligent decision-making to enable systems to operate with minimal human intervention.

## What Is Automation in LoRaWAN?...



### What Is LoRaWAN? (Quick Recap)

LoRaWAN is a wireless protocol designed for

- a) long-range
- b) low-power
- c) low-data-rate communication

between battery-operated IoT (Internet of Things) devices and gateways connected to the internet.

## What Is Automation in LoRaWAN? ...



### What Is Automation in the Context of LoRaWAN?

Automation in LoRaWAN typically involves:

Component	Automation Role
Sensors/Nodes	Collect real-world data (e.g., temperature, motion, water level) automatically.
Gateways	Forward sensor data to the network server without human input.
Network Server	Processes data packets, handles device management, and routes data to apps.
Applications	Use the data to trigger automated decisions (e.g., turn off irrigation system).
Actuators	Automatically perform physical actions based on received commands.

## Question 1

**Which statement is incorrect?**

- a) Automation in LoRaWAN refers to the process control, monitoring, and management of devices and data over a LoRaWAN.**
- b) Automation in LoRaWAN refers to the industrial control, monitoring, and management of devices, data, and processes over a LoRaWAN (Long Range Wide Area Network) communication system.**
- c) Automation in LoRaWAN refers to the automatic control, monitoring, and management of devices, data, and processes over a LoRaWAN (Long Range Wide Area Network) communication system.**
- d) none of the above**



## What Is Automation in LoRaWAN? ...



### What Is Automation in the Context of LoRaWAN?

Automation in LoRaWAN typically involves:

Component	Automation Role
Sensors/Nodes	Collect real-world data (e.g., temperature, motion, water level) automatically.



Opportunity Here!  
An Automation Concept  
will be developed in this discussion.

## What Is Automation in LoRaWAN? ...



### ⚙️ Automation Workflow in LoRaWAN

text

[Sensor/Node]

↓ (sends data)

[LoRaWAN Gateway]

↓

[Network Server]

↓

[Application Server with Automation Logic]

↓

[Actuator or Dashboard Notification]

Automation  
Development  
Concept Opportunity!



## What Is Automation in LoRaWAN? ...



### Example Use Cases of LoRaWAN Automation

#### 1. Smart Agriculture

- Soil moisture sensors automatically trigger irrigation systems only when needed.

#### 2. Smart Cities

- Streetlights automatically adjust brightness based on ambient light or movement.

#### 3. Asset Tracking

- A LoRaWAN GPS tracker updates location automatically and alerts if items leave a defined area.

#### 4. Industrial Monitoring

- Vibration sensors on motors can trigger automated maintenance alerts.

## What Is Automation in LoRaWAN?



### ✓ Benefits of Automation in LoRaWAN

- 🌱 **Energy Efficiency** – Low-power sensors can run for years.
- 📶 **Remote Monitoring** – Devices can operate over kilometers without manual checks.
- 📊 **Real-Time Data** – Enables timely automated decisions.
- 🤖 **Reduced Human Labor** – Systems operate independently.
- 🔒 **Secure and Scalable** – Supports large deployments with encryption.

## Developing A LoRaWAN Automation Concept...



### 1. Define the Use Case (What to Automate?)

Clearly describe the problem or process to be automated.

-  Example: Automatically irrigate crops when soil moisture is low.

Questions to ask:

- What event triggers the automation?
- What outcome or response is required?
- What are the environment and constraints?

## Developing A LoRaWAN Automation Concept...



### 2. Identify Key Components

Break the system into the following parts:

Function	Example Component
Sensing	Soil Moisture Sensor
Communication Node	LR1262 LoRa Node (sensor-side)
Gateway	Elecrow LR1302 with Pi HAT
Network Server	The Things Stack, ChirpStack, or Helium
Application Server	Node-RED, AWS IoT Core, or custom dashboard
Control/Actuator	Relay module to activate irrigation pump

## Developing A LoRaWAN Automation Concept...



### 3. Define Data Flow and Automation Logic

Use a Sensing → Decision → Action flow model:

```
Sensor (moisture level) → LoRaWAN Node → Gateway → Network Server  
→ Automation Rule (IF soil < threshold THEN turn on pump)  
→ Downlink Command → Actuator Node → Irrigation Pump ON
```

## Developing A LoRaWAN Automation Concept...



### 4. Set Communication Parameters

Define the LoRaWAN settings:

- Spreading Factor (SF) – affects range and data rate
- Data Rate – low for infrequent sensor updates
- Uplink/Downlink Frequency
- Device Classes:
  - Class A: Basic, low-power (sensor node)
  - Class C: Always listening (actuator)

## Developing A LoRaWAN Automation Concept...



### 5. Choose Network Architecture

Decide if the network will be:

- Private (e.g., using your own LoRaWAN gateway and server)
- Public (e.g., using Helium, TTN)




Deployment options:

- Edge gateway with local automation
- Cloud-based automation with OTA control

## Developing A LoRaWAN Automation Concept...



6. Implement the Automation Logic  
Use one of the following tools:

-  **Node-RED**: Drag-and-drop logic builder
-  **Custom Python/MQTT Application**
-  **IFTTT / AWS Lambda / Azure Functions**

Example Rule:

```
javascript
```

```
IF moisture_level < 25%  
THEN send downlink command to turn on relay
```

## Developing A LoRaWAN Automation Concept...



### 7. Test and Validate

Simulate or run real-world tests:

- Inject test data from sensors
- Confirm downlink commands reach actuators
- Measure response time, accuracy, and power use

### 8. Refine and Document

- Optimize power consumption
- Tune thresholds and logic
- Document architecture, workflow, and decision logic

# Developing A LoRaWAN Automation Concept...



## Summary: LoRaWAN Automation Blueprint

Stage	Output
1. Define Use Case	Clear objective and automation scenario
2. Identify Devices	Sensors, Nodes, Gateway, Server, Actuator
3. Design Logic	Sensing → Decision Rules → Action
4. Set Parameters	LoRaWAN settings: SF, DR, frequency, class
5. Build Network	Private/public setup with selected tools
6. Deploy Logic	Node-RED, cloud services, or microcontroller logic
7. Test System	Functional validation and performance assessment
8. Finalize Design	Optimized, documented system

## Question 2



**What is the first step in Developing A LoRaWAN Automation Concept?**

- a) Define Data Flow and Automation Logic.**
- b) Identify Key Concepts.**
- c) Define the Use Case (What to Automate?).**
- d) none of the above**

## Capturing Transmission Data



### Objective

To log transmission activities for the following experimental investigations.

- Capturing LoRa parameters like frequency or data rates (DR)
- Capturing login session data
- Evaluating the effectiveness of message transmissions
- Capturing Gateway Extended Unique Identifier (EUI) data.



### Tech Notes

- A Gateway EUI (Extended Unique Identifier) is a 64-bit unique identifier assigned to a LoRaWAN gateway.
- The EUI is used to register the gateway with a LoRaWAN network server (like The Things Network) and allows the server to identify and manage the gateway.

## Capturing Transmission Data...



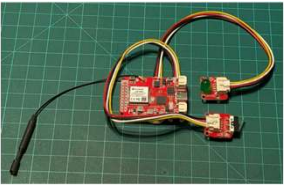
### Method:


- To log transmission data, a software serial monitor terminal tool can be used.
  - a) Tera Term
  - b) Putty
- Transmission data can be logged as a csv file.
- Data can be reviewed and analyzed for effective node data (message) transmission to the LoRaWAN.

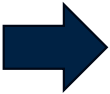
# Capturing Transmission Data...



Process:



Node  Activating Data Transmission Event using a sensor



```

COM5 - Tera Term VT
File Edit Setup Control Window Help
Sent command: AT+ChannlMode=1
Sent command: AT+BAND=8
Sent command: AT+DevEui=70B3057ED0069CE5
OK
JlOnS=0##### OTAA #####7 ABP #####
##### AppSKey: 2B:7E:15:16:2B:AE:D2:A6:AB:F7:15:88:09:CF:4F:3C
##### NwkSKey: 2B:7E:15:16:2B:AE:D2:A6:AB:F7:15:88:09:CF:4F:3C
##### ID: #####
##### DevEui: 00:80:E1:15:05:04:E4:57
##### AppEui: 01:01:01:01:01:01:01:01
##### DevAddr: 05:04:E4:57
OK
OK
Sent command: AT+AppEui=0101010101010101
Sent command: AT+AppKey=2B7E15162BAED2A6ABF7158809CF4F3C
Sent command: AT+JOIN=1,8
OK
OK
Ready to join in
SSIVATION_TYPE_OTAA
OK
531524:MAC txDone
536508:RX_1 on freq 923300000 Hz at DR 10
536557:IRQ_RX_TX_TIMEOUT
536557:MAC rxTimeout
537520:RX_2 on freq 923300000 Hz at DR 8
537585:IRQ_RX_TX_TIMEOUT
537585:MAC rxTimeout
+LR1262: JOIN FAILED
537591:TX on freq 904700000 Hz at DR 0
LmHandlerJoin type :ACTIVATION_TYPE_OTAA5375963:MAC txDone
542548:RX_1 on freq 925700000 Hz at DR 10
542597:IRQ_RX_TX_TIMEOUT
542597:MAC rxTimeout
543559:RX_2 on freq 923300000 Hz at DR 8
544025:IRQ_RX_TX_TIMEOUT
544025:MAC rxTimeout
+LR1262: JOIN FAILED
544031:TX on freq 908200000 Hz at DR 0
    
```

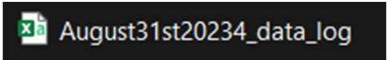
Software Serial Monitor Terminal



COM5 - Tera Term VT

File	Edit	Setup	Control	Window	I
New connection...		Alt+N			
Duplicate session		Alt+D			
Cygwin connection		Alt+G			
Log...					
Pause Logging					
Comment to Log...					
View Log					
Show Log dialog...					
Stop Logging (Q)					
Send file...					
Transfer >					
SSH SCP...					
Change directory...					
Replay Log...					
TTY Record					
TTY Replay					
Print...		Alt+P			
Disconnect		Alt+I			
Exit		Alt+Q			
Exit All					

Data Logging Session



CSV captured data

## Question 3

**Which type of software serial can be used to log transmission data?**

- a) Terror Term**
- b) Puttied**
- c) Tera Term**
- d) none of the above**



## The Things Network (TTN)

The Things Network (TTN) is a global, open-source LoRaWAN network that allows individuals, companies, and communities to connect Internet of Things (IoT) devices using LoRaWAN gateways and infrastructure without building their network from scratch.

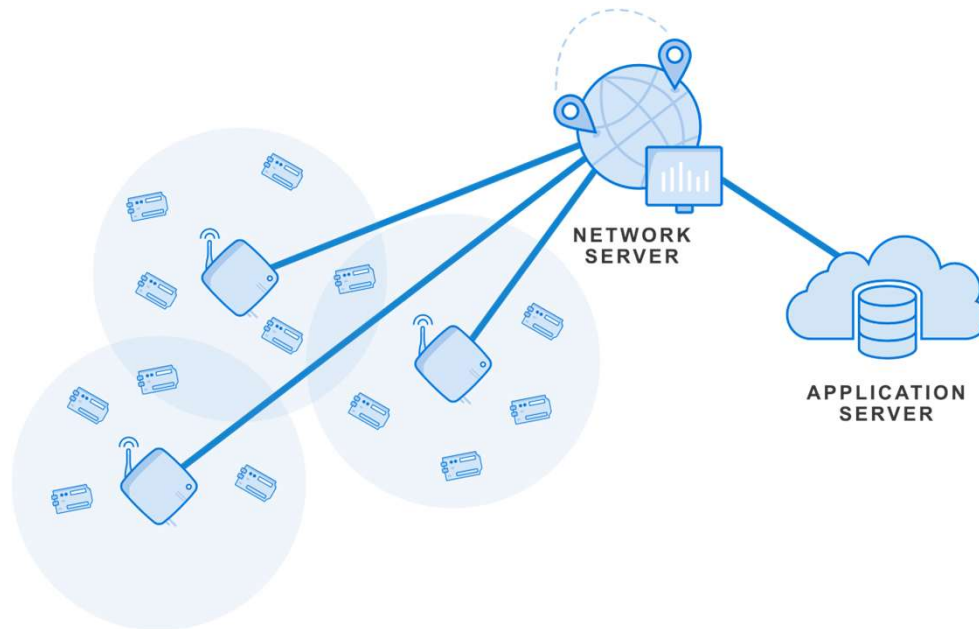


Image: TTN

# The Things Network (TTN)...



## Overview of The Things Network (TTN)

Feature	Description
Type	Public LoRaWAN Network
Access	Free and Open (Community Edition)
Purpose	To provide decentralized LoRaWAN infrastructure for connecting IoT devices
Managed By	<a href="#">The Things Industries</a>
Supports	LoRaWAN 1.0.x and 1.1 device classes (A, B, C)
Regions	Global – EU, US, Asia-Pacific, and others

# The Things Network (TTN)...

## Core Components of TTN

### 1. End Devices

- LoRaWAN-enabled sensors (e.g., temperature, soil moisture)
- Use LoRa modules like LR1262 for communication

### 2. Gateways

- Devices like the Elecrow LR1302 with Raspberry Pi Hat
- Bridge between LoRa end devices and the internet

### 3. Network Server (TTN Backend)

- Routes data from the gateway to your application
- Handles device registration, message integrity, and security

### 4. Application

- Your logic, dashboard, or cloud service that receives device data
- Can use integrations like MQTT, Webhooks, AWS, or Node-RED



# The Things Network (TTN)...



## Actual LoRaWAN Trainer – LR1262 Node TTN Session

TIME	TYPE	DATA PREVIEW	Verbose stream	Export as JSON	Clear
↑ 16:42:00	Receive uplink message	JoinEUI: 01 01 01 01 01 01 01 01 DevEUI: 70 B3 D5 7E D0 06 9C E5 Data rate: SF10BW125 SNR: 13 RSSI: -21	<input type="checkbox"/>	<input type="button" value="Export as JSON"/>	<input type="button" value="Clear"/>
↑ 16:41:58	Receive uplink message	JoinEUI: 01 01 01 01 01 01 01 01 DevEUI: 70 B3 D5 7E D0 06 9C E5 Data rate: SF10BW125 SNR: 12.8 RSSI: -20	<input type="checkbox"/>	<input type="button" value="Export as JSON"/>	<input type="button" value="Clear"/>
↑ 16:41:54	Receive uplink message	JoinEUI: 01 01 01 01 01 01 01 01 DevEUI: 70 B3 D5 7E D0 06 9C E5 Data rate: SF10BW125 SNR: 11.8 RSSI: -20	<input type="checkbox"/>	<input type="button" value="Export as JSON"/>	<input type="button" value="Clear"/>
↑ 16:41:54	Receive uplink message	JoinEUI: 01 01 01 01 01 01 01 01 DevEUI: 70 B3 D5 7E D0 06 9C E5 Data rate: SF10BW125 SNR: 12.2 RSSI: -21	<input type="checkbox"/>	<input type="button" value="Export as JSON"/>	<input type="button" value="Clear"/>
↑ 16:41:53	Receive uplink message	JoinEUI: 01 01 01 01 01 01 01 01 DevEUI: 70 B3 D5 7E D0 06 9C E5 Data rate: SF10BW125 SNR: 12 RSSI: -21	<input type="checkbox"/>	<input type="button" value="Export as JSON"/>	<input type="button" value="Clear"/>






**Note:** The Configuring TTN-related content provides setup steps for displaying data on the website. were Elecrow's Wiki Case 3:

[https://www.elecrow.com/wiki/Case3\\_Single-channel\\_Application\\_Routines\\_for\\_Raspberry\\_Pi\\_Gateways\\_and\\_Nodes.html#frequency-selection](https://www.elecrow.com/wiki/Case3_Single-channel_Application_Routines_for_Raspberry_Pi_Gateways_and_Nodes.html#frequency-selection)

# The Things Network (TTN)...



## Why Use The Things Network?

Advantage	Benefit
 Global Infrastructure	Use public gateways or add your own to extend coverage
 Developer Friendly	Web-based console, REST APIs, MQTT, and open-source tooling
 Secure	Uses LoRaWAN's built-in AES-128 encryption
 Low Cost	Free access via Community Edition
 Integration-Ready	Supports integrations with AWS, Azure, Google Cloud, Ubidots, etc.

## The Things Network (TTN)...



### Popular Use Cases with TTN

- Smart Agriculture (soil, water, weather)
- Smart Cities (trash bins, parking, streetlights)
- Environmental Monitoring (air, water quality)
- Asset Tracking (logistics, livestock, vehicles)
- Industrial Automation (remote sensing & alerts)

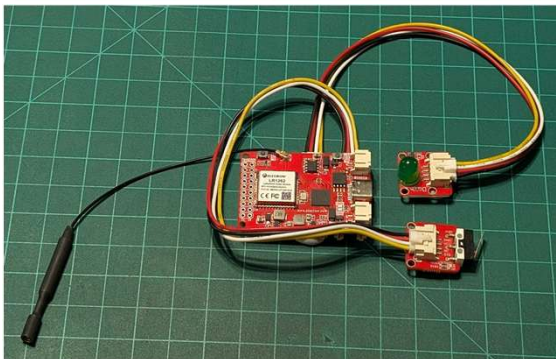
## Question 4

**What component is not core to TTN?**

- a) Gateways**
- b) Filter**
- c) Application**
- d) none of the above**



# Lab: Build and Test An Automation LoRaWAN



```

COM5 - Tera Term VT
File Edit Setup Control Window Help
oSent command: AT+AppEui=0101010101010101
iSent command: AT+AppKey=2B7E151628AED2A6ABF7158809CF4F3C
jSent command: AT+JOIN=1,0
oSent command: AT+SEND=1:1:HELLO
iSent command: AT
nSent command: AT+ChannelMode=1
in
tXRnF 7:
OK
17481s197:MAC txDone
17486s181:RX_1 on freq 923900000 Hz at DR 10
17486s230:IRQ_RX_TX_TIMEOUT
17486s230:MAC rxTimeOut
17487s193:RX_2 on freq 923300000 Hz at DR 8
17487s258:IRQ_RX_TX_TIMEOUT
17487s258:MAC rxTimeOut
+LR1262: JOIN FAILED
17487s264:TX on freq 904700000 Hz at DR 0
LmHandlerJoin type :ACTIVATION_TYPE_OTAA17487s636:MAC txDone
17492s621:RX_1 on freq 925700000 Hz at DR 10
17492s669:IRQ_RX_TX_TIMEOUT
17492s669:MAC rxTimeOut
17493s632:RX_2 on freq 923300000 Hz at DR 8
17493s698:IRQ_RX_TX_TIMEOUT
17493s698:MAC rxTimeOut
+LR1262: JOIN FAILED
17493s704:TX on freq 903900000 Hz at DR 0
LmHandlerJoin type :ACTIVATION_TYPE_OTAA17494s076:MAC txDone
17494s060:RX_1 on freq 923300000 Hz at DR 10
17494s109:IRQ_RX_TX_TIMEOUT
17494s109:MAC rxTimeOut
17500s072:RX_2 on freq 923300000 Hz at DR 8
17500s137:IRQ_RX_TX_TIMEOUT
17500s137:MAC rxTimeOut
+LR1262: JOIN FAILED
17500s143:TX on freq 904300000 Hz at DR 0
LmHandlerJoin type :ACTIVATION_TYPE_OTAA17500s515:MAC txDone
17500s500:RX_1 on freq 924500000 Hz at DR 10
17500s548:IRQ_RX_TX_TIMEOUT
17500s548:MAC rxTimeOut
17500s511:RX_2 on freq 923300000 Hz at DR 8
17500s577:IRQ_RX_TX_TIMEOUT
17500s577:MAC rxTimeOut
+LR1262: JOIN FAILED
17506s583:TX on freq 904900000 Hz at DR 0
LmHandlerJoin type :ACTIVATION_TYPE_OTAA17506s955:MAC txDone
17511s939:RX_1 on freq 926300000 Hz at DR 10
  
```

## Lab: Build and Test An Automation LoRaWAN...



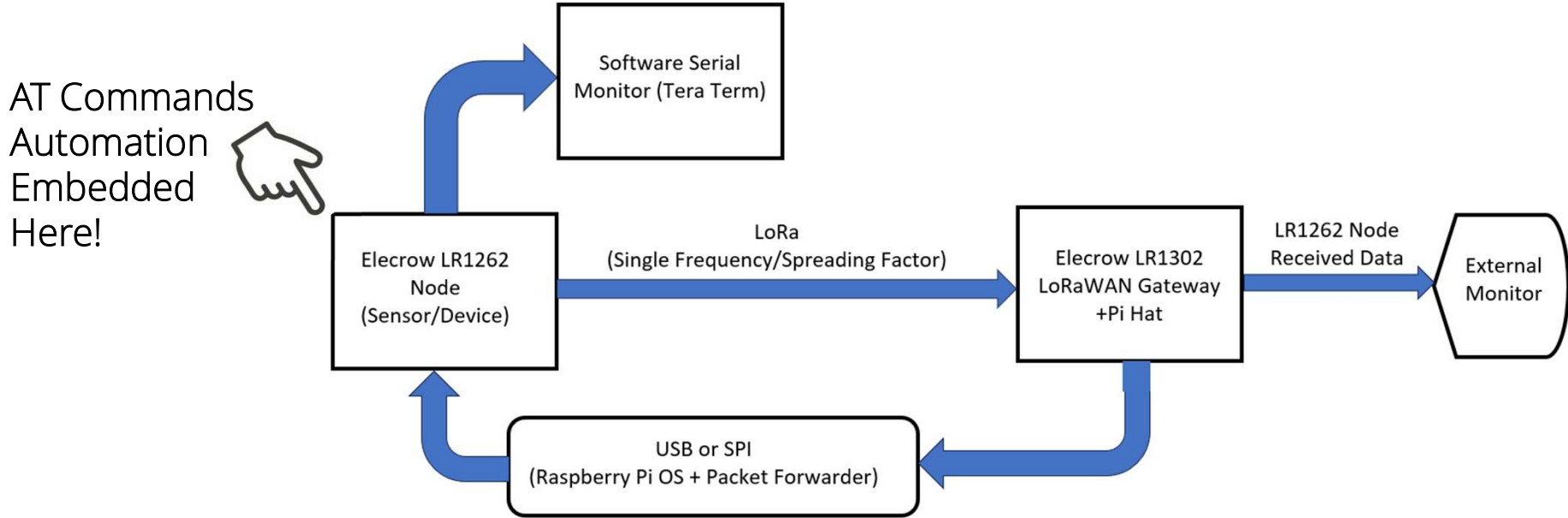
### Participant Learning Objectives:

- Participants will learn to implement the modified LoRa 08H code on the LR1262 Node board to obtain transmission data.
- Participants will learn to set up a software serial monitor to capture LoRaWAN transmission data.

# Lab: Build and Test An Automation LoRaWAN...



## Concept System Diagram



Single-Channel LoRaWAN Network Architecture Diagram

## Lab: Build and Test An Automation LoRaWAN...



These AT Commands provide the automation for joining the LoRaWAN and sending a message!

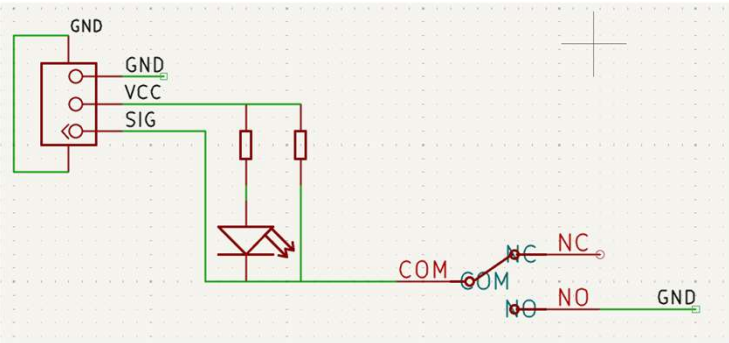
```
1 #define LED_PIN 3
2 #define BUTTON_PIN 2
3 #define BLINK_DURATION 100 // milliseconds
4
5 const char* atCommands[] = {
6     "AT",
7     "AT+ChannelMode=1",
8     "AT+BAND=8",
9     "AT+DevEui=",
10    "AT+AppEui=",
11    "AT+AppKey=",
12    "AT+JOIN=1,8",
13    //"AT+SEND=1:1:7269767679", // HELLO Message
14    "AT+SEND=1:1:HELLO",
15
16 };
17
18 const int numCommands = sizeof(atCommands) / sizeof(atCommands[0]);
19 int currentCommand = 0;
20
21 unsigned long lastDebounceTime = 0;
22 unsigned long debounceDelay = 50;
23 int lastButtonState = HIGH;
```

Modified LoRa 08H  
Partial Code

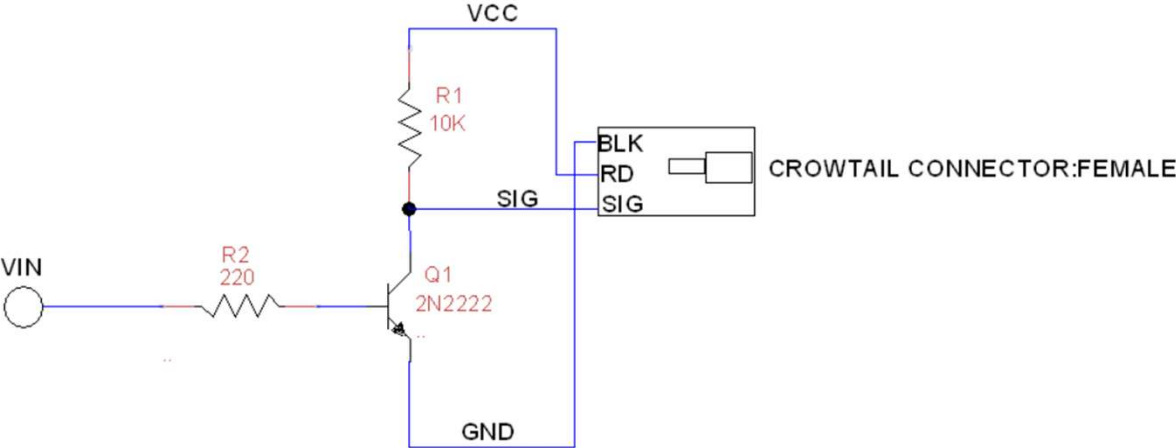
# Lab: Build and Test An Automation LoRaWAN...



Replacing the Collision Sensor with External Control-Sensor Devices



Collision Sensor Electronic Circuit Schematic Diagram:  
Voltage Applied to the "SIG" Input is 0V!



An Electronic Switch Circuit:  
When "VIN" is applied to the circuit, 0V will be applied to the "SIG" Input pin of the Crowtail Connector.

## Lab: Build and Test An Automation LoRaWAN...



**Tera Term Home Page** <https://teratermproject.github.io/index.html>

### Software Download and Installation Steps:

1. Download Tera Term Software to your LR1262 Node development machine.
2. Install the software onto your LR1262 Node development machine.
3. Open the software.
4. Attach to the correct Communication (COM) port.



### Tech Note

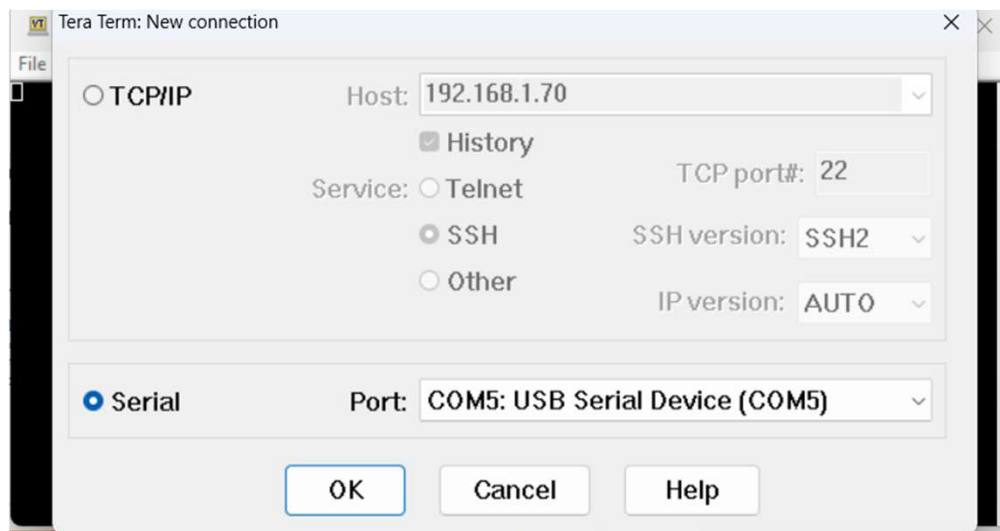
Attach the LR1262 node board to your development machine to ensure the COM port is available in Step 3.

## Lab: Build and Test An Automation LoRaWAN...



### Step 4

Attach to the correct Communication (COM) port.



Selection of  
the correct  
COM port!

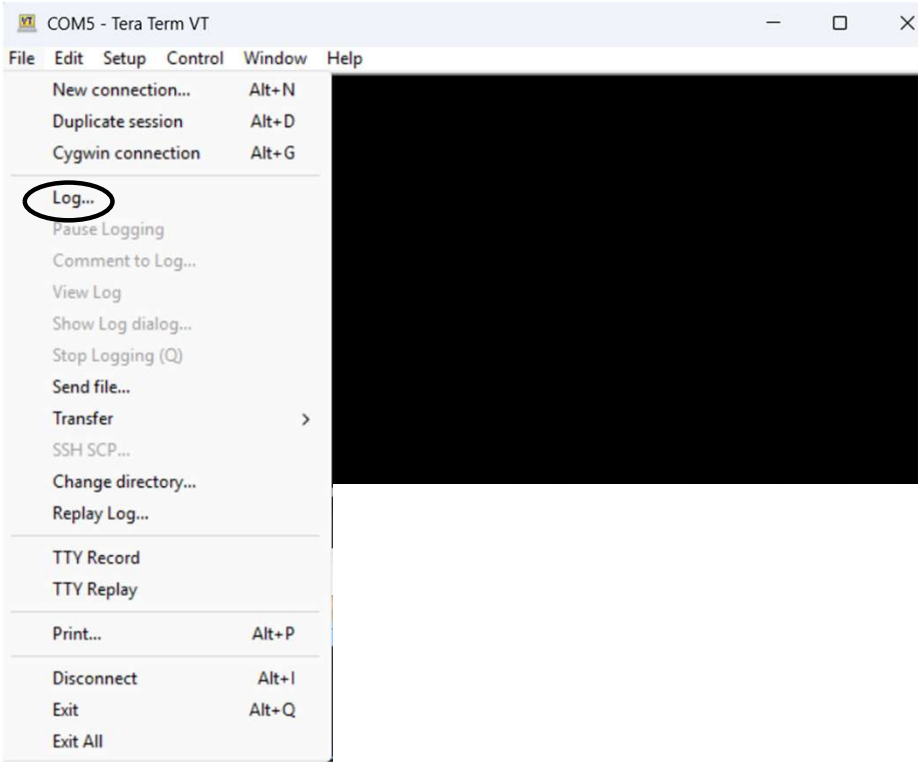


Click the OK  
button!

# Lab: Build and Test An Automation LoRaWAN...



Click on Log



Starting a Data Logging session

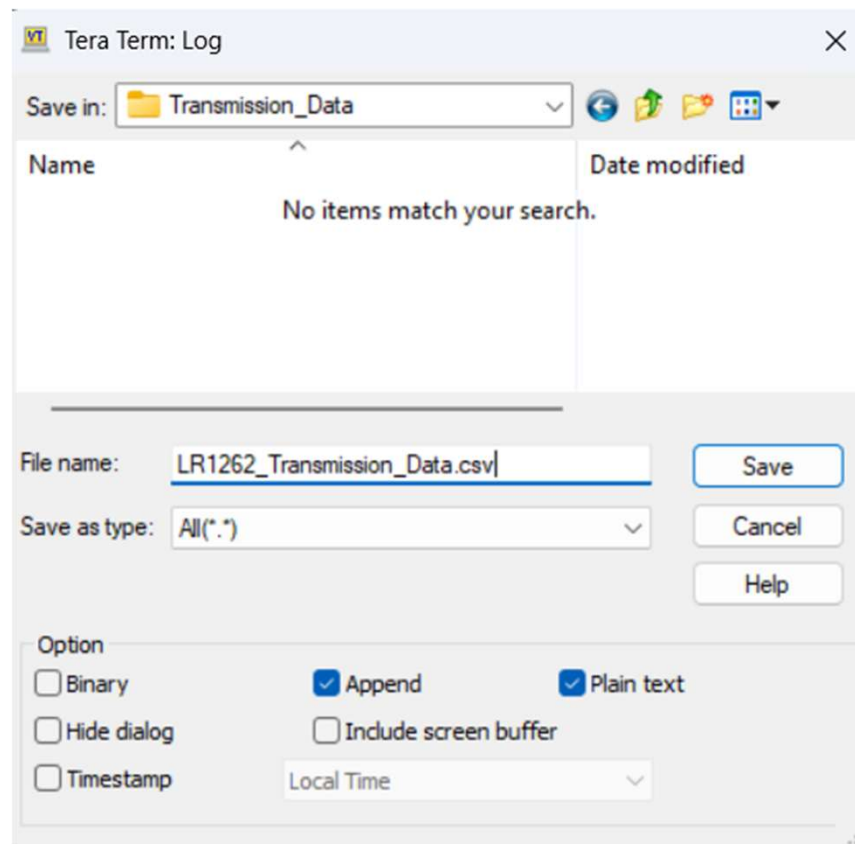
## Lab: Build and Test An Automation LoRaWAN...



### Tech Note

Include ".csv"  
extension after  
the log filename

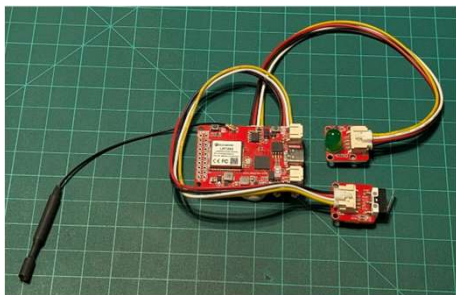
Create Log  
filename 



Creating a Log file

 Click Save button

## Lab: Build and Test An Automation LoRaWAN...



Press lever  
on Collision  
Sensor



### Tech Note

Press the lever several times to allow messaging to occur automatically!

```

COM5 - Tera Term VT
File Edit Setup Control Window Help
Sent command: AT+DevEui=70B3D57ED0069CE5
Sent command: AT+AppEui=0101010101010101
Sent command: AT+AppKey=2B7E151628AED2A6ABF7158809CF4F3C
OK
OK
OK
Sent command: AT+JOIN=1,8
Sent command: AT+SEND=1:1:HELLO
ready to join in
47941s613:TXC47941s985:MAC txDone
47946s969:RX_1 on freq 923900000 Hz at DR 10
47947s018:IRQ_RX_TX_TIMEOUT
47947s018:MAC rxTimeOut
Sent command: AT
Sent command: AT+ChannelMode=1
ready to send data
OK
47947s981:RX_2 on freq 923300000 Hz at DR 8
47948s046:IRQ_RX_TX_TIMEOUT
  
```

Transmitting Data-Logging Session

# Lab: Build and Test An Automation LoRaWAN...



To Stop logging data:  
File>Stop Loggin (Q)

<input type="checkbox"/>	Name	Date modified	Type	Size
<input checked="" type="checkbox"/>	Day5	6/13/2025 11:23 PM	Microsoft PowerPo...	9,760 KB
<input type="checkbox"/>	Transmission_Data	6/14/2025 1:02 AM	File folder	
<input type="checkbox"/>	LR1262_Transmission_Data	6/14/2025 1:10 AM	Microsoft Excel Co...	3 KB



Logged data: .csv file format

# Lab: Build and Test An Automation LoRaWAN...



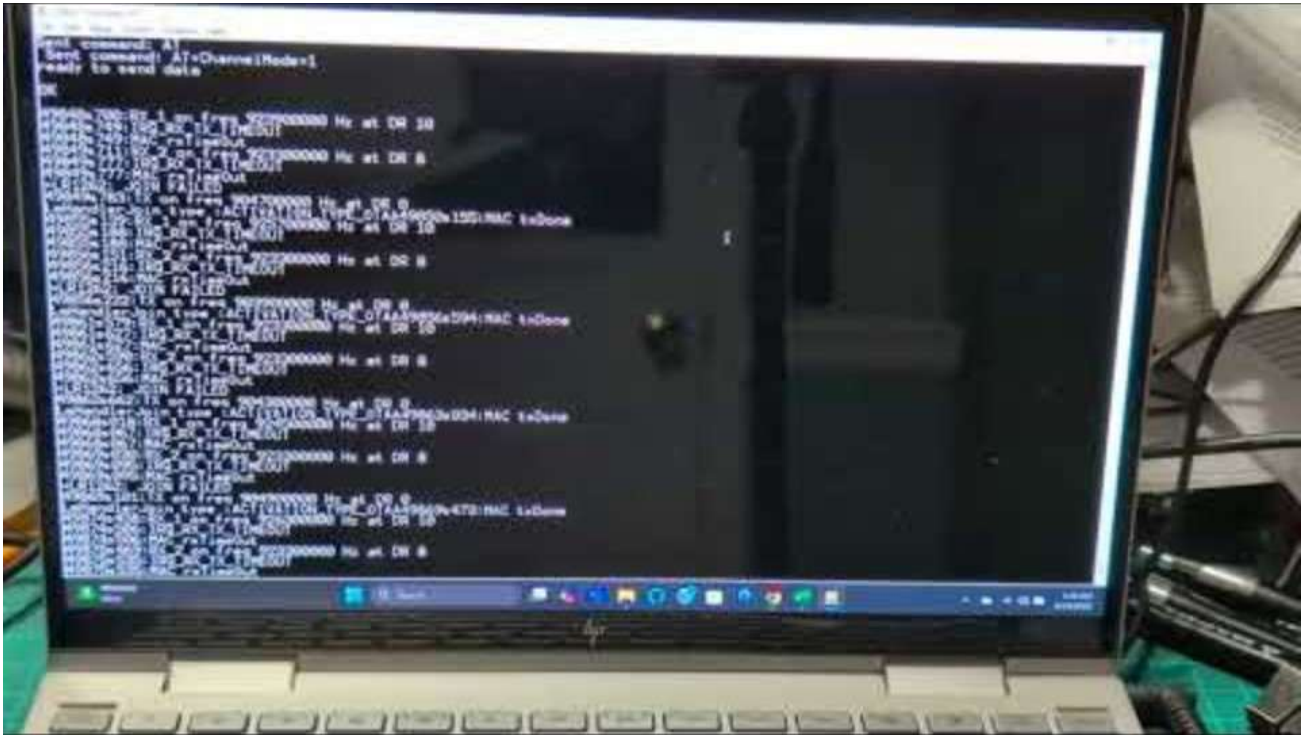
LR1262\_Transmission\_Data file:  
Logged data

	A	B	C	D	E	F	G	H
1	Sent command: AT+DevEui=70B3D57ED0069CE5							
2	Sent command: AT+AppEui=0101010101010101							
3								
4	Sent command: AT+AppKey=2B7E151628AED2A6ABF7158809CF4F3C							
5	OK							
6								
7	OK							
8								
9	OK							
10	Sent command: AT+SEND=1:1:HELLO	8						
11	ready to join in							
12	47941s613:TXC47941s985:MAC txDone							
13	47946s969:RX_1 on freq 923900000 Hz at DR 10							
14	47947s018:IRQ_RX_TX_TIMEOUT							
15	47947s018:MAC rxTimeOut							
16	Sent command: AT							
17	Sent command: AT+ChannelMode=1							
18	ready to send data							
19								
20								
21	OK							
22								
23	OK47947s981:RX_2 on freq 923300000 Hz at DR 8							
24	47948s046:IRQ_RX_TX_TIMEOUT							
25	47948s046:MAC rxTimeOut							

# Lab: Build and Test An Automation LoRaWAN...



Watch the LoRaWAN Automation in Action!



## Question 5

**What extension needs to be added when saving a log file?**

- a) csv**
- b) txt**
- c) pdf**
- d) none of the above**



## 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](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](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-](https://github.com/DWilcher/DesignNews-WebinarCode/blob/main/June_25_Webinar_Code.zip)

[WebinarCode/blob/main/June\\_25\\_Webinar\\_Code.zip](https://github.com/DWilcher/DesignNews-WebinarCode/blob/main/June_25_Webinar_Code.zip)



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