2019 LoRa and LoRaWAN



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LoRa C - The DNA of IoT

Broadcast

Contact Information

Joe Ward

Director of Sales North Central jward@Semtech.com

Gil Simsic

Sr. FAE North Central gsimsic@Semtech.com



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LoRa Technology & LoRaWAN





Some Trivia Gdynia 702 km Kie Rostock Gdańsk Lübec Hamburg 436 Miles oSzczecin Bydgoszcz Bremen Poland Berlin Poznań erdam Hanover **OWolfsburg** 100 km 200 Rillinswick OMagdeburg etherlands Łódź 300 kr Dortmund Leipzig 0 0 Essen 600 km - Wr Dresden Germany Cologne 702 km Katowiceo Kra COMMUNITIES LABS LOGIN LEARN SUPPORT FORUM MARKETPLACE THE THINGS Ostrava Ground breaking world record! LoRaWAN packet received at 702 km (436 miles) distance Brno Slovak TheThings Network The Things Network Global Team THE THINGS Posted on 08-09-2017



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IoT Technology and LPWAN (Low Power WAN)







IoT Connects the World

LoRa makes it smart!





SMARTER PLANET HIGHER BANDWIDTH GREATER MOBILITY

LoRa Modulation and LoRaWAN





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LoRa[®] Technology Overview



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What is Spread Spectrum?





What is Spread Spectrum?

What can be gained from apparent waste of spectrum?

- Better Noise Immunity
- Minimized multipath distortion
- > Can be used for hiding and encrypting signals
- Several users can use same channel with little interference



What is LoRa? CSS - Chirp Spread Spectrum

LoRa uses CSS Chirp Spread Spectrum



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What is LoRa? CSS - Chirp Spread Spectrum



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Link Budget



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What is LoRa[®] ? Receiver Sensitivity



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LoRa

High Sensitivity Modems







LoRa & FLRC Outdoor Field Test (@ 12.5 dBm)



- LoRa 3.6 km, non Line-of-Sight, 476 bps (SF12)
 *over 4 km in Line-of-Sight
 - FLRC 2.3 km, Line-of-Sight, 260 kbps





LoRa[®] Modulation Parameters

LoRa has four main operational parameters:

#1 Occupied bandwidth

• 500KHz, 250KHz, 125KHz...



#2 Data Rate (DR)

- Expressed as Spreading Factor (SF), inversely logarithmically proportional to SF
 →
- SF12 is slower than SF10

#3 Code Rate (CR)

- · Protection against data corruption at cost of additional data
- Code Rate (CR) vary from 4/5, 4/6, 4/7, 4/8.
- Rate 4/5 means that 5 bits are sent for 4 data bits

#4 Cyclic Redundancy Check (CRC)

• Standard checksum calculation to confirm that data was received correctly



Tools

| 5X1261 C | alculator Tool Ver | sion 0.9 Beta Relea | se | | | | | | | _ | | × |
|--------------------------------|------------------------------|---------------------|----------|---------------------------------------|-------------------------------|---------|-----------|---------------------|------|-----------|-----------------|---|
| Calculator Inputs LoRa GFSK | | | | - Selected Configuation | | | | | | | | |
| LoRa Modem Settings | | | | | Preamble | | | Payload | | | | |
| Sprea | ading Factor | 9 | \sim | | | | | | | | | |
| Bandwidth | | 125 ~ | | kHz | 16,25 Symbols | | | 38 Bytes | | | | |
| Code | e Rate | 4/8 | \sim | | | | | | | | | |
| Low | Datarate Optimize | Disabled | - | | Colordator Octoreta | | | | | | | |
| Packet Configuration | | | | Calculator Outputs Timing Performance | | | | | | | | |
| Prear | mble Length | 12 | - | Symbols | Total length | 80,25 | Symbols | | | | | |
| Paylo | oad Length | β8 | - | Bytes | Symbol time | 4,096 | ms | | | | | |
| Head | der Mode | Disabled | ÷ | | Time on Air | 361,472 | ms | | | | | |
| CRC | : | Disabled | * | | | | | | | | | |
| | | | | | RF Performance Link Budget | 1 | 51 dB F | eceiver Sensitivity | -129 | dBm | | |
| RF Set Trar | ttings nsmit Power | 22,0 | A | dBm | Maximum Frequency | Error ± | 31,25 kHz | | | <i>a</i> | | |
| | | | | | | | | | 5 | SX1261 Da | <u>atasheet</u> | |



LoRa Modulation – Semtech Eval Kit









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LoRaWAN[®] Overview



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LoRa Modulation and LoRaWAN





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LoRaWAN and the LoRa Alliance



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LoRaWAN Operators: Global Adoption



Operator Diversity - Strengthens LoRaWAN Ecosystem

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LoRaWAN Network Elements (Per LoRaWAN 1.0.3)







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LoRaWAN Network Elements – End Node





LoRaWAN Network Elements – End Node



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LoRaWAN Network Elements – End Node



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Semtech Wireless Chipsets Enable LoRa Technology

| | LoRa Products | | | | | | | | | | | |
|-----|----------------|--------------------------|---------------------|-------------------|----------------------|-------------------|--------------------------|-------------------|--|--|--|--|
| | Part Number | Frequency Range (MHz) | Link Budget (dB) | RXCurrent (mA) | FSK Max DR (kbps) | LoRa DR (kbps) | Max Sensitivity (dBm) | TX Power (dBm) | | | | |
| | SX1261 | 150–960 | 163 | 4.6 | 300 | 0.018-62.5 | -148 | +15 | | | | |
| NEW | SX1262 | 150–960 | 170 | 4.6 | 300 | 0.018-62.5 | -148 | +22 | | | | |
| | SX1268 | 410-810 | 170 | 4.6 | 300 | 0.018-62.5 | -148 | +22 | | | | |
| | SX1272 | 862-1020 | 158 | 10 | 300 | 0.3–40 | -138 | + 20 | | | | |
| | SX1273 | 862-1020 | 150 | 10 | 300 | 1.7–40 | -130 | + 20 | | | | |
| | SX1276 | 137–1020 | 168 | 11 | 300 | 0.018–40 | -148 | + 20 | | | | |
| | SX1277 | 137–1020 | 158 | 11 | 300 | 1.7–40 | -138 | + 20 | | | | |
| | SX1278 | 137–525 | 168 | 11 | 300 | 0.018–40 | -148 | + 20 | | | | |
| _ | SX1279 | 137–960 | 168 | 11 | 300 | 0.018-40 | -148 | +20 | | | | |





LoRaWAN Network Elements





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LoRaWAN Network Elements – Gateway





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LoRaWAN Network Elements – Gateway



LoRaWAN Network Elements – Gateway





LoRaWAN Network Elements












What is LoRa? Security



LoRaWAN – Pre Defined Data Rates

| Data Rate (DR) | Spreading Factor | Channel Frequency | Up or Down Link | Bit Rate [bits/sec] | Maximum Packet Size [Bytes] |
|----------------------|---------------------|----------------------|--------------------|------------------------|-----------------------------------|
| 0 | SF10 | 125Khz | uplink | 980 | 11 |
| 1 | SF9 | 125Khz | uplink | 1760 | 53 |
| 2 | SF8 | 125Khz | uplink | 3125 | 125 |
| 3 | SF7 | 125Khz | uplink | 5470 | 242 |
| 4 | SF8 | 500Khz | uplink | 12500 | 242 |
| 5-7 | | | | | |
| 8 | SF12 | 500Khz | downlink | 980 | 53 |
| 9 | SF11 | 500Khz | downlink | 1760 | 129 |
| 10 | SF10 | 500Khz | downlink | 3900 | 242 |
| 11 | SF9 | 500Khz | downlink | 7000 | 242 |
| 12 | SF8 | 500Khz | downlink | 12500 | 242 |
| 13 | SF7 | 500Khz | downlink | 21900 | 242 |
| 14-15 | | | | | |



Multiple Sources – End to End Ecosystem





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LoRaWAN Device Classes and Examples





Class A: Event Driven Example - Smart City



Class B: Synchronized Example - Irrigation



Battery Life

Class C: Constantly on Example - Smart Lighting

Downlink Network Latency

| Application | | | | | | | | |
|------------------------------|----------|--------------------|-------------------------|---|--|--|--|--|
| LoRa [®] MAC | | | | | | | | |
| MAC options | | | | | | | | |
| Class A (Baseline) | C (Ba | lass B aseline) | Class C (Continuous) | | | | | |
| LoRa [®] Modulation | | | | | | | | |
| Regional ISM band | | | | | | | | |
| EU 868 | EU 433 | US 915 | AS 430 | - | | | | |

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LoRa, LoRaWAN and IoT







LoRaWAN As a Service - Public Network



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LoRaWAN As a Technology/Service - Private Network





LoRa As a Technology







LoRaWAN Kits



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Smart Building Demo Kit

Smart building solution kit

- 5 Desk occupancy
- 2 Conf room utilization (Grid-eye)
- 2 Temp / humidity
- 2 IR blaster (controller)
- 5 Door / Window security
- 5 Room occupancy security
- 2 Mini-Hub
- 1 Leak detection (TBD)
- 1 Mi-Fi (cellular Wi-Fi hotspot)





Reference Demo User Interface

For demo and reference usage only







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LoRaWAN - Key vertical segments







LoRaWAN in Smart Home (Smart Building)









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LoRaWAN in AG











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LoRaWAN in Smart City









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LoRaWAN[®] and IoT – What is next?







LoRa Updates

- LoRaWAN Alliance New
 - Relay
 - FUOTA
- Semtech LoRa New Offerings
 - Localization
 - LoRa Developer Portal
 - LoRa Cloud
 - LoRa Basic



LoRaWAN Relay



LoRa Updates - Alliance

- 1. Use 1.0.3 (and not 1.1) is the version of choice for the year to come
- Stable
- Enables passive roaming
- Has most of the network management commands bugs fixed
- Optimized for NA channel plan
- 2. LoRa Relay for Battery Operated devices





LoRaWAN FUOTA



LoRa Updates - FUOTA

- First draft public.
 - Multicast
 - Sync
 - Fragmentation
- First interop test are on-going
 - Semtech, Kerlink, Senet & Cisco part of the process
- ARM has already an implementation , may be a very good turnkey stack solution. To be checked



LoRa Updates - FUOTA

• ARM has already an implementation , may be a very good turnkey stack solution. To be checked

Example

https://github.com/ARMmbed/mbed-os-example-lorawan-fuota

Presentation

https://www.slideshare.net/janjongboom/firmware-updates-over-lorawan-the-things-conference-2019

Full Video

https://www.youtube.com/watch?v=jGs9WpTTJVs



FUOTA





| 0011 0100 0111 1000 1011 1100 | 100 10 10 10 10 10 10 11 | 00110 01110 01111 10000 101 1 11001 | 00 00 01 .1 |
|--|---|--|----------------------|
| EQL RPL EQL DEL RPL EQL | 8 110 16 1 1 7 | c | ırm |

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Localization



Localization with LoRaWAN (In Development)



Localization with LoRaWAN Network & Location Server

- All base stations share a common timebase
- A LoRaWAN sensor transmits a packet
- Packet received by at least three base stations
- Each base station reports the time of arrival & other meta data such as signal strength, signal to noise ratio

Algorithms compare the time of arrival and other signal parameters. Computes the most likely position of the sensor Differential Time Of Arrival

Accuracy Rural – 20 to 50 meters Urban – 120 to 200 meters



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LoRa Developer Portal



LoRa Developer

Our goal is to enable developers in the Internet of Things (IoT) space to do wonderful things with LoRa Technology. Since this is a Semtech portal, content from all Semtech product groups that support developers and IoT solutions will be added and featured over time.

https://lora-developers.semtech.com/





Semtech LoRa Cloud™



LoRa Updates – LoRa Cloud ©

Coming Soon (through the LoRa Developer Portal)

- LoRa Cloud[™] Geolocation Service
 - TDOA / RSSI / Wi-Fi Lookup (soon).
 - Commercial service with SLA (different tiers, one free tier for developers).
 - Currently in beta testing, Portal scheduled to go live in April.

■ LoRa Cloud[™] Device Management Service

- Device management, telemetric, and data services (e.g., device status, reset, mute / unmute, file upload / download, FUOTA).
- Open protocol.
- Currently in alpha testing, scheduled to go live in June / July.



Semtech LoRa Basic



LoRa Updates - Basics

- •LoRa Basics™
 - Basic code building blocks to assist developers in quickly realizing their ideas.
 - Free, supported, and actively maintained.
 - Released through the forthcoming Semtech Developer Portal:
 - Basic Station,
 - Basic MAC,
 - Basic FUOTA,
 - Basic Analytics, ...

All components are released through the Semtech LoRa Developer Program as open source for easy adoption from Q1/2019 on.


Basic Station (Released)

BASIC STATION (LoRaWAN Packet Forwarder):

- Portable across all Linux-based LoRa gateways on the market (e.g., Kerlink, Multitech, Tektelic, Haxiot, Gemtek);
- Equally suitable for small embedded gateways running, for example, FreeRTOS;
- More robust and secure communication protocol to the LNS; and
- Built-in management protocol for remotely configuring and updating the Basic Station



Basic MAC (To be Released)

- Portable device firmware of LoRaWAN in C, suitable for a broad range of MCUs;
- Focus on functional completeness and best practices, initially LoRaWAN 1.0.3 and kept in sync with future LoRaWAN specifications;
- Event-driven run time with power management, crash reports, timer handling;
- FUOTA based on LoRaWAN specifications;
- Full support of SX1261/2; and
- Fully LoRa Alliance certifiable.



Conclusion







LoRa © - The DNA of IoT

Semantics: LoRa (Modulation) and LoRaWAN (Protocol)



Thank You!



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