

1.) What is LoRa® Modulation?

LoRa® (Long Range) is a modulation technique that provides significantly longer range than competing technologies. The modulation is based on spread-spectrum techniques and a variation of chirp spread spectrum (CSS) with integrated forward error correction (FEC). LoRa significantly improves the receiver sensitivity and as with other spread-spectrum modulation techniques uses the entire channel bandwidth to broadcast a signal, making it robust to channel noise and insensitive to frequency offsets caused from the use of low cost crystals. LoRa can demodulate signals 19.5dB below the noise floor while most frequency shift keying systems (FSK) need a signal power of 8-10dB above the noise floor to demodulate properly. The LoRa modulation is the PHY layer which can be utilized by many different protocol architectures – Mesh, Star, 6lowPAN, etc.

2.) What is a LoRa® Gateway?

The LoRa gateways are designed to be used in long range star network architectures and are utilized in a LoRaWAN™ system. They are multi-channel, multi-modem transceivers and can demodulate on multiple channels simultaneously and even demodulate multiple signals on the same channel simultaneously due to the properties of LoRa. The gateways use different RF components than the end-point to enable high capacity and serve as a transparent bridge relaying messages between end-devices and a central network server in the backend. Gateways are connected to the network server via standard IP connections while end-devices use single-hop wireless communication to one or many gateways. All end-point communication is generally bidirectional, but also supports operations such as multicast enabling, software upgrade, over the air or other mass distribution messages to reduce the on air communication time. There are different gateway versions depending the desired capacity and installation location (home vs. tower).

3.) What is LoRaWAN™?

The LoRa modulation is the physical layer (PHY), and LoRaWAN is a MAC protocol for a high capacity, long range star network that the LoRa Alliance is standardizing for Low Power Wide Area Networks (LPWAN). The LoRaWAN protocol is optimized for low cost battery operated sensors and includes different classes of nodes to optimize the tradeoff between network latency and battery lifetime. It is fully bi-directional and was architected by security experts to ensure reliability and safety. The architecture of LoRaWAN was also designed to easily locate and track mobile objects for asset tracking, which is one of the fastest growing volume applications for Internet of Things (IoT). LoRaWAN is being deployed for nationwide networks by major telecom operators, and the LoRa Alliance is standardizing LoRaWAN to make sure the different nationwide networks are interoperable.

4.) What is the data rate for LoRaWAN™?

LoRaWAN data rates range for LoRa between 0.3kbps to 22kbps and one GFSK data rate at 100kbps for Europe. In North America the minimum data rate is 0.9kbps due to FCC limitations. To maximize both battery life of the end-devices and overall network capacity, the LoRaWAN network server is managing the data rate and RF output for each end-device individually by means of an adaptive data rate (ADR) algorithm. The ADR is critical for a high performance network and it enables scalability. A network can be deployed with a minimal investment in infrastructure and as capacity is needed, more gateways can be deployed and the ADR will shift the data rates higher which will scale the network capacity by 6-8x.

5.) What is a LoRa® Concentrator?

The term gateway and concentrator are both used, but they are equivalent components in a LoRa system. In other industries the definition of gateway and concentrator imply different components.

6.) How well does LoRa® handle Interference?

The LoRa modem is capable of co-channel GMSK rejection of up to 19.5 dB, or stated differently, it can receive signals 19.5dB below an interfering signal or the noise floor. This immunity to interference permits the simple coexistence of LoRa modulated systems either in bands of heavy spectral usage or in hybrid communication networks that use LoRa to extend range when legacy modulation schemes fail.

7.) What is the data rate for LoRa®?

LoRaWAN defines a specific set of data rates, but the end chip or PHY is possible of more options. The SX1272 supports data rates from 0.3 to 38.4kbps, and the SX1276 0.018 to 38.4kbps.

8.) What is a LoRa® End Node or Point?

The LoRa endpoints are the elements of the LoRa network where the sensing or control is undertaken. They are normally remotely located and battery operated. These endpoints can be setup to communicate with a LoRa Gateway (Concentrator or Base Station) using the LoRaWAN network protocol.

9.) What is Adaptive Data Rate (ADR)?

Adaptive Data Rate is a method where the actual data rate is adjusted to ensure reliable packet delivery, optimal network performance, and scale for capacity. For example, nodes close to the gateway will use a higher data rate (shorter time on air) and a lower output power. Only nodes that are at the very edge of the link budget will use the lowest data rate and highest output power. The ADR method can accommodate changes in the network infrastructure and support varying path loss. To maximize both battery life of end-devices and overall network capacity, the LoRa network infrastructure manages the data rate and RF output for each end-device individually by implementing ADR.

10.) For the LoRa® devices, what is the actual Tx power that can be achieved on the antenna?

At the chip pin the output power is +20dBm and at the antenna after matching/filtering loss the power is +19dBm +/-0.5dB. Different regions have different regulations for max output power and the LoRaWAN specification defines different output power for the different regions to maximize the link budget.

11.) What is the price of a LoRa® solution?

With a LoRa device (ex: SX1272 or SX1276) a lower cost crystal can be used. In narrow band technology an expensive temperature controlled crystal is needed to minimize frequency drift during RX/TX. A typical bill of materials cost for a complete end-node is between 2-5 dollars depending on volume and features. A long transmit range means simpler network infrastructure and lower cost of deployment as no repeaters are necessary. Lower power consumption means using lower cost batteries and network maintenance.

12.) What is the process of the LoRa® CAD (Channel Activity Detector) mode?

Instead of using a RSSI (Received Signal Strength Indicator) method to identify if a signal is present the channel activity detector (CAD) is used to detect the presence of a LoRa signal. The CAD detection has the advantage of being much faster than a typical RSSI detection and the capability to differentiate between noise and a desired LoRa signal. The CAD process requires two symbols, and if the CAD is detected, the CAD_Detected interrupt will be asserted and the device will stay in RX mode to receive the data payload.

13.) Is it OK to change the mode between FSK and LoRa® modulation frequently?

Yes, it is no problem. The LoRa device can be switched from FSK to LoRa (and vice versa) via simple SPI register write. This has no issue on the performance or reliability of the device. A LoRa device can be configured and reconfigured to any of the parameters as specified in the datasheets.

14.) Why is the output power of my LoRa® device or Module not able to achieve 20dBm?

The +20dBm specification is for the output power at the pin of the chip. The band-pass filter and RF switch have insertion loss characteristics as in any RF system. Achieving +19dBm at the antenna is typical performance after matching and filtering.

15.) How to troubleshoot the output power if it is not able to achieve +20dBm?

- 1.) Please make sure that you connect the right pin (PA_Boost) set for 20dBm output.

 There are two output ports for each band, one is high power port called PA_boost, and another is a high efficiency port called RFO.
- 2.) Then check the configuration in SW. Three registers should be configured correctly: RegPaConfig, RegOcp and RegPaDac. It means that you should select the right pin for proper output in SW, then set the right value refer to power level you need.
- 3.) Confirm the matching per the Semtech reference design to make a good layout, which is important to achieve the maximum output power possible

16.) How to choose a proper crystal for a LoRa® device?

Normally, a +/-10ppm XTAL is good enough for most designs with a bandwidth of 62.5kHz or higher. For BW less than 62.5kHz, a TCXO is strongly suggested to be used. For more details about the specification of the crystal, please refer to the datasheet and LoRa Modem Calculator tool and application note AN1200.14_XO_Guidance_LoRa_Modulation_STD".

17.) How can I implement a mass production test for a LoRa® system?

Three parameters are important to test in mass production: frequency tolerance, output power, and sensitivity. The frequency and output power are easy to test with a spectrum analyzer. If your signal generator can't generate a LoRa signal, testing the sensitivity with FSK mode is strongly suggested. There is only one RF chain in the chip, and the FSK and LoRa demodulation is done in the digital domain. The RF path could potentially be damaged in assembly so this is important to verify. The digital portion of the chip where the LoRa and FSK modulation is done is isolated from the effects of assembly so testing FSK sensitivity is sufficient for verifying the production test performance. The digital and LoRa modulation are tested extensively in the chip production test

18.) For a LoRa® wide band signal, how can you measure the frequency accuracy in LoRa® mode?

If it is just for measurement, you can use the Frequency synthesis TX (FSTX) mode as listed in the LoRa register table to generate a CW tone based on the LoRa configuration.

19.) What is the relationship between Bandwidth (BW), Symbol Rate (Rs) and Data Rate (DR)?

In theory, *Rs=BW/(2^SF)*, *DR=SF*(BW/2^SF)*CR*. But we suggest you use the Semtech LoRa Modem Calculator to evaluate the data rate and time on air for different configuration options.

20.) How do you choose the LoRa® Bandwidth (BW), Spreading factor (SF) and Coding Rate (CR)?

LoRaWAN™ uses primarily the 125kHz BW setting but other proprietary protocols can utilize other BW settings. Changing the BW, SF, and CR changes the link budget and time on air, which results in a battery lifetime vs range tradeoff. Please use the LoRa Modem Calculator to evaluate the tradeoffs.

21.) What are the steps to troubleshoot when two SX127x modules from different manufacturers are not able to communicate with each other?

First of all, check the frequency offset caused by the crystal between the two devices. The BW, center frequency, and data rate are all derived from the crystal frequency. Second, check the software/firmware settings on both sides for frequency, bandwidth, spreading factor, coding rate and packet structure to ensure they are the same.

22.) How can it be possible to receive a wrong packet when the cyclic redundancy check (CRC) is enabled in LoRa® mode?

In LoRa mode, even if the CRC is wrong, the payload will be filled into the FIFO. We suggest checking header and see if it is valid data or not. This is due to the CRC ON/OFF information included in the header. Discard the packet when the header is invalid. In addition, there is a bit in Reg0x1C named CrcOnPayload(bit6), read this bit before checking CRC, if CRC is turned OFF by mistake then discard this packet.

23.) Can I send or receive an unlimited length payload packet with a LoRa® device?

No, the maximum packet length is 256 bytes in LoRa mode.

24.) How can you use the DIOx pins in LoRa® mode? Should all DIOx pins be connected to the MCU?

When you start your design, check the DIO Mapping in both the LoRa mode and FSK mode. You can find the DIO Mapping information in SX127x LoRa datasheets. The DIOs do not function as normal (typical) MCU GPIOs. There are some special interrupt signals (or clock outputs) to indicate the event or status of the chipset, which then make your FW design easier to implement. In theory, you could connect no DIOs and then read the related register to know the status result. However, we suggest that you connect the DIO as much as possible for external interrupt functionality which saves on the resource loading of the MCU.

25.) Why are there two RSSI registers in LoRa® mode? What is the difference?

The RegPktRssiValue and RegRssiValue are both useful in LoRa mode. RegPktRssiValue refers to the packet RSSI level, and the RegRssiValue is similar to the RSSI that can be found in (non LoRa) FSK mode.

As you know, LoRa could demodulate the packet below the noise floor (PktRssi result) then CurrentRssi would then be equal to or more than the noise floor. For more details about how to calculate these two RSSI Values, please refer to the Semtech API or latest LoRa datasheets.

26.) How can you calculate the actually bit rate and time on air for a LoRa® system?

Follow the steps (i - V) listed below:

(i) symbol rate:
$$Rs = \frac{BW}{2^{SF}}$$

(ii) time of 1 symbol:
$$Ts = \frac{1}{Rs}$$

(iii) preamble duration:
$$T_{preamble} = (n_{preamble} + 4.25)T_{sym}$$

where npreamble is the programmed preamble length, taken from the registers RegPreambleMsb and RegPreambleLsb

(iV) number of payload
$$payloadSymbNb = 8 + max \left(ceil\left(\frac{8PL - 4SF + 28 + 16 - 20H}{4(SF - 2DE)}\right)(CR + 4), 0\right)$$
 symbols:

$$T_{payload} = payloadSymNbTsym$$

(V) duration of packet:
$$T_{packet} = T_{preamble} + T_{payload}$$

This is easy to calculate by using LoRa calculator, which can be downloaded on Semtech website (link below). http://www.semtech.com/apps/filedown/down.php?file=SX1272LoRaCalculatorSetup1%271.zip

27.) Can the payload length of a LoRa mode configuration be set to 256bytes with any data-rate?

The SX127x LoRa device has a FIFO of 256bytes in LoRa mode. In theory, all the 256Bytes could be used for TX or RX. However, with a low data-rate configuration the time on air with a 256byte payload will be very long (this could be several seconds or even longer), which is not good for resisting fading and high interference environments. This is not a robust configuration in most environments so it is suggested if a long payload is desired with a low data-rate that the packet be split into a few shorter packets.

28.) Is LoRa® a mesh network, point to point, or a star network?

The LoRa modulation itself is a physical layer (PHY layer) that can be used in all most network topologies or configurations. A mesh network extends the range of the network but comes at the cost of reduced network capacity, synchronization overhead, and reduced battery lifetime due to synchronization and hops. With the increased link budget and range capability of LoRa there is no need for a mesh network architecture to extend the range so a star architecture was chosen for LoRaWAN to optimize the network capacity, battery lifetime and installation ease.

29.) Is LoRa® IPv6 or 6LoWPAN enabled?

Yes, LoRa is IPv6 and 6LoWPAN compatible. Actility (a LoRa partner) and other partners enabled 6LoWPAN on top of LoRaWAN.

30.) What is the capacity of LoRa® gateway? How many nodes can be connected to a single gateway?

Capacity is, first and foremost, a consequence of the number of packets that can be received in a given time. A single SX1301 with 8 channels can receive approximately 1.5 million packets per day using LoRaWAN protocol. So, if your application sends one packet per hour, then a single SX1301 gateway can handle about 62,500 end-devices.