



## Wireless Data Transmission Module Design Based on Ultra-Low Power Wireless Transceiver SX1212

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SX1212 is an ultra-low power single-chip wireless transceiver of Semtech that operates in the 300MHz to 510MHz frequency range. SX1212 has a very low receive power consumption and a typical receive current of 2.6mA, which is far below the receive current of similar transceivers. It has a working voltage of 2.1-3.6V and the maximum transmit power of +12.5dBm. SX1212 is a highly integrated transceiver that contains the integrated circuits of RF and logical control functions and internally integrates voltage-controlled oscillator, phase-locked loop circuit, power amplifier circuit, low-noise amplification circuit, modulation/demodulation circuit, frequency converter and intermediate frequency amplifier circuit. In addition, it incorporates a baseband modem with data rates up to 150 150Kbps. Data handling features include a 64-byte FIFO, packet handling, automatic CRC generation and data whitening. The highly integrated architecture of SX1212 allows for minimum amount of external components while maintaining maximum design flexibility. All major RF communication parameters are programmable and most of them may be dynamically set. SX1212 complies with European (ETSI EN 300-220 V2.1.1) and North American (FCC part 15.247 and 15.249) regulatory standards

The purpose of this document is to introduce the wireless chip SX1212-based wireless module design characterized by the distinctive features of long transmission distance, high receive sensitivity and low working power consumption. Therefore, it is suitable for use in wireless water and gas meter reading, wireless remote control system, wireless sensor network, wireless temperature pressure data collection and robot control areas where batteries are required to work for a long time.

### System Circuit Design

The system is mainly composed of an MCU and the SX1212 (see Figure 1). The MCU is the low power single-chip microcontroller STM8L101F3 of STMicroelectronics. SX1212 communicates with the single-chip microcontroller through the SPI interface and communicates with external terminals through the UART interface. SX1212 has reduced peripheral parts through high integration. Therefore, the critical part of design is how to design the matching circuits at the RF front end. In addition, the wiring in the high-frequency part shall be as short and thick as possible. The component parameters shall be regulated according to the actual circuit board situations to cancel the impact of distribution parameters. The impedance of RF chip transmit and receive ports is usually not the standard impedance of 50Ω. To reach the optimal receive effect, it is required to compensate for input impedance through peripheral components in order to match the input impedance with the 50Ω antenna, as shown in the circuit in Figure 1. As shown in Figure 1, Y2 is a SAW filter used to attenuate signals outside of the prescribed frequency bands; L2, C3 and C22 are impedance matching networks; L4 and L5 are voltage-controlled oscillator inductors used to regulate voltage-controlled oscillator inductance and enable the module to work in different frequencies; C7, R3 and C8 are phase-locked loop circuits.

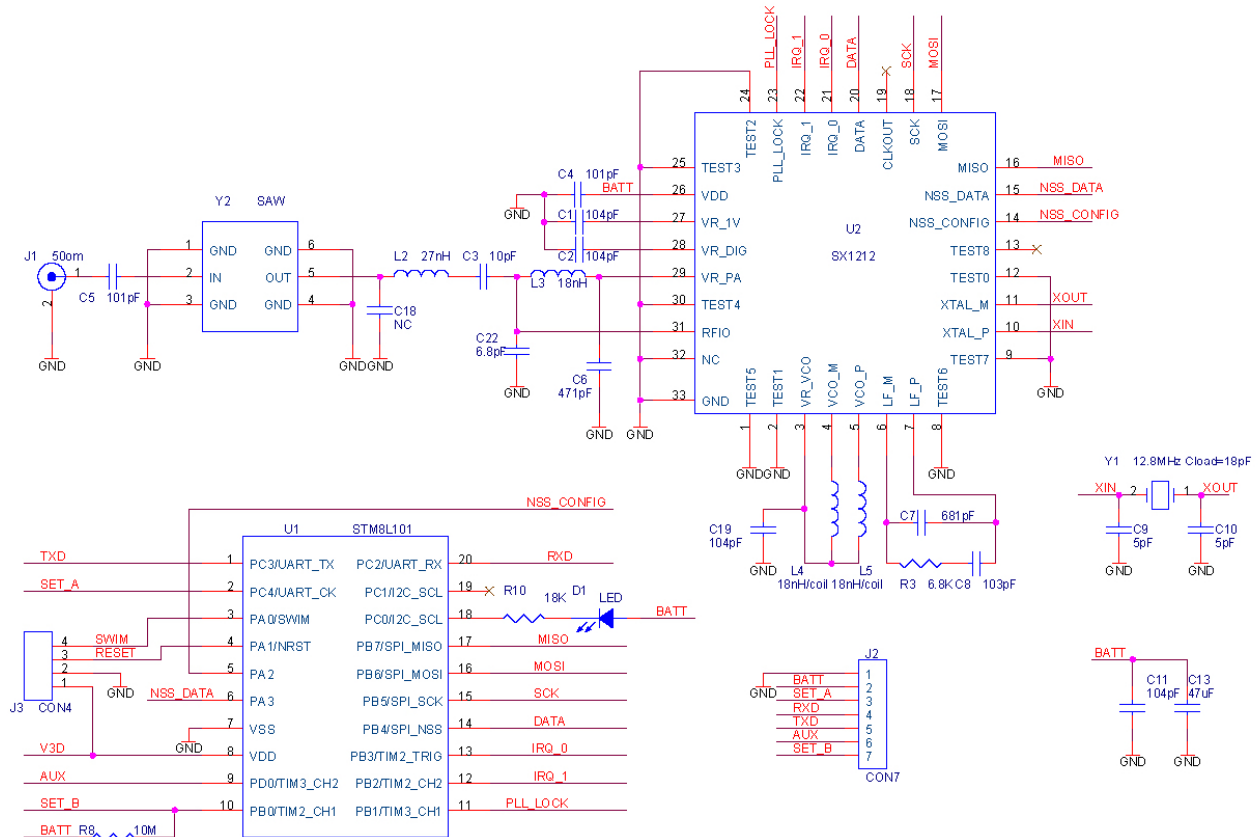


Figure 1. SX1212 System Circuit Design

### Working Mode Design

The typical wireless transceiver code is provided in the following table.

| PREAMBLE | SYNCWORD | ID FIELD (ID)<br>Optional | DATA + FEC +CRC |
|----------|----------|---------------------------|-----------------|
|          |          |                           |                 |

The preamble is the “1010” alternate code used to synchronize destination receiver clock and transmitter. In normal mode, the preamble length is usually 32 bits. In power-saving mode, the preamble also has the receiver wakeup feature. In this case, the transmitter must send a longer preamble to wake up the

receiver in power-saving mode and enable it to enter into normal working status. In the event of setting the receiver wakeup interval to 1s, the receiver will be wakened up once every second to search the preamble (tw) usually with a duration of 16 bits. The transmitter first transmits a preamble (>1s) before transmitting the syncword, meaning that in the event of discovering a preamble in the channel the receiver should be able to successfully detect the preamble and stay awake to receive the data in the wakeup period, as shown in Figure 2.

In this document, we have designed four working modes (see Table 1), which can be interchanged through the SET\_A and SET\_B pins of the MCU.

| SET_A | SET_B | Working Mode            | Working Status  |
|-------|-------|-------------------------|---|
| 0     | 0     | Normal Mode<br>(Mode 1) | <p>The serial port is open and the module is in continuous receive status. When the serial port has data input, set AUX low, switch into the transmit status and send a 32bit long preamble and syncword; after sending the data, reset AUX high and reenter into the continuous receive status.</p> <p>In normal mode, the module does not send a longer preamble when it sends data. Therefore, the receiver must remain in mode 1 or mode 2, namely in continuous receive status.</p> <p>After the module receives data in the current channel, when the data are confirmed through de-interleaved error correction and error check to be error-free, set AUX low and immediately export data from the serial port; after sending the data, reset AUX high.</p>  |
| 0     | 1     | Wakeup Mode<br>(Mode 2) | <p>The serial port is open and the module is in continuous receive status. When the serial port has data input, set AUX low, switch into the transmit status and send a wakeup period+32bit long preamble and syncword; after sending the data, reset AUX high and reenter into the continuous receive status.</p> <p>In this mode, the module sends a longer preamble when it sends data. Therefore, the receiver can receive data in mode 1, mode 2 or mode 3.</p> <p>After the module receives data in the current channel, when the data are confirmed through de-interleaved error correction and error check to be error-free, set AUX low and immediately export data from the serial port; after sending the data, reset AUX high.</p> <p>A schematic diagram of data transmission under mode is shown in Figure 2.</p> |
| 1     | 0     | Power-Saving            | <p>The serial port is in closed status. After the end of the wakeup period (1s), the receiver opens the serial port and searches if there is any preamble in the channel; if there is no preamble, the receiver shall immediately enter into sleep status and wait to be waken up in the next wakeup</p>  |

|   |   |                     |  |
|---|---|---------------------|--|
|   |   | Mode (Mode 3)       | <p>period; if there is a preamble, the receiver shall continue to remain in the receive status, monitor the preamble and wait for the arrival of syncword; upon arrival of the syncword, the receiver shall receive the data. When the data are confirmed through de-interleaved error correction and error check to be error-free, set AUX low and wake up the lower machine; after waiting for 5ms, open the serial port and export data.</p> <p>After the serial has finished exporting data, close the serial port and set AUX high; when the mode setting is not changed, reenter into the immediate sleep status and wait for the next wakeup period.</p> <p>A schematic diagram of data receiving under mode is shown in Figure 2..</p> |
| 1 | 1 | Sleep Mode (Mode 4) | <p>The serial port is in closed status and the module is in sleep status. In this mode, the module's RF circuit, CPU clock and peripherals are closed and the power consumption is only 1.5uA.</p>   |

Table 1. A description of the Four Working Modes

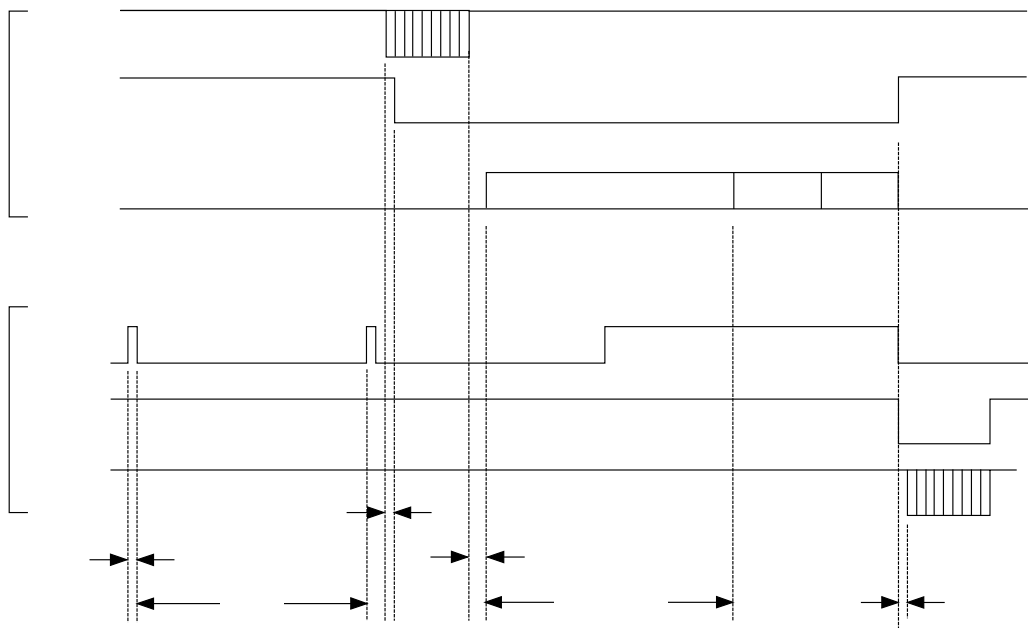


Figure 2: A schematic diagram of transmitting in mode 2 and receiving in mode 3

The sleep mode is realized through software. In sleep mode, all of the system's interfaces shall maintain their respective electrical levels and shall be able to rapidly switch to any status. The main clock of the MCU is generated through the RC oscillator; the oscillation start time is as short as 4uS and it takes only 20uS to conduct measurement from sleep to wakeup as well as going through wakeup initialization. This means that when the module is in sleep status, it takes only 20uS to enter data through the UART interface into the module after setting the SET\_A pin low. The system has been designed to ensure that in the receiving or transmitting process, the module shall carry out the receiving or transmitting process before entering into power-saving mode or sleep mode even if it is set to work in mode 3 or 4. The AUX pin will be set low in the receiving or transmitting process. When the module is in mode 3 or mode 4, after setting the SET\_A pin low and waking up the module and entering data, the lower-level client can immediately set the SET\_A pin high if it needs to go to sleep without waiting until the module has finished sending data wirelessly. After having finished sending the data, the module will automatically detect the SET\_A pin; when the pin is set high, the module will go to sleep. The client/user can inquire into the AUX pin about whether the module has finished sending the data.

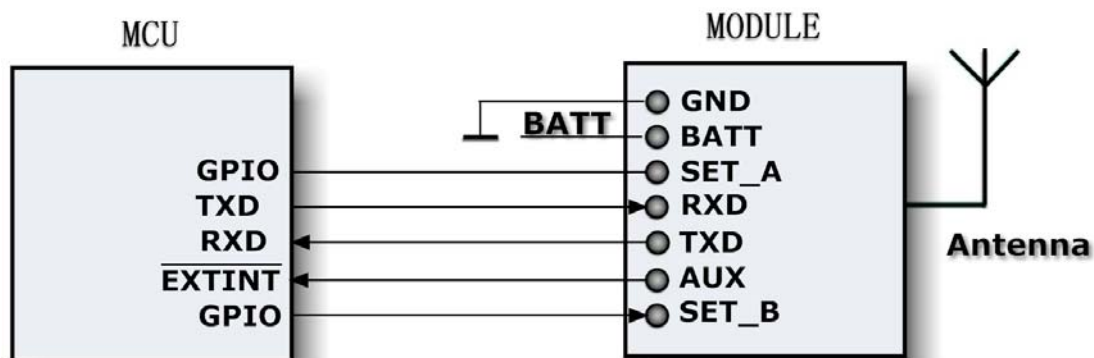


Figure 3. The connection between module and lower-level client

In the battery power supply circuit, the slave modules (such as water and gas meters) can normally be set to mode 3. When the master module (such as collector or meter reading data collector) send data in mode 2, the slave modules will receive data after they are wakened up; after having receiving the data, the slave modules use the AUX pin to wake up the lower-level MCU and then transmit the data; after receiving the data, the MCU can switch slave modules to mode 1 and respond to the master module. After receiving the response, the master module can also be switch to mode 1. All the master and slave modules are then in normal mode, thereby realizing high-speed data transmission. When there is no data exchange after the master module receives the response, the slave modules can be switched into mode 3 (power-saving mode), waiting for the next wakeup. Meanwhile, the master module can be switched into mode 4 (sleep status).

As power-saving is realized through the repetitive wakeup, sleep and wakeup cycle, the power consumption in power-saving mode is thus related to the wakeup period and the wakeup and preamble search time ( $t_w$ ) as well as the static power consumption in sleep mode. The wakeup period/cycle can be set online by users to be 50ms-5s. The preamble search time is related to RF transmission rates, which can be dynamically set. The average wakeup and preamble search time is about 4.5ms when the data rate is 10Kbps.

The useful life of battery in power-saving mode can be calculated per the equation:

Useful life =

Battery Capacity mAH

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((Data Transmission Time before searching/(wake up time + data transmission time before searching))\*receiving current + quassient current)

For example, when the battery is a 3.6V/3.6A ER18505Li-SOCI2 battery, the receive current of the MCU is 3.2mA and the sleep current 1.5uA; the RF transmission rate is 10Kbps and the wakeup period is 1s, the useful life of the battery is:

$$= \frac{3600\text{mAH}}{(4.5\text{ms}/(1000\text{ms}+4.5\text{ms})) * 3.2\text{mA} + 0.0015\text{mA}} \approx 227337\text{H} \approx (25.95 \square)$$

In consideration of the self-discharge nature of batteries, their capacity variation under different currents and their temperature conditions as well as the power consumption of client-side MCU in sleep mode and the times of usage each month, the 3.6V/3.6A ER18505Li-SOCI 2 battery has a normal useful life of more than 10 years.

The power-saving work mode is ideally suitable for use in water/gas/heat meter and container information management scenarios where the data collection system is not used very frequently but the batteries are required to work for a long time.

### Summary

In some wireless transceiving applications in which battery power supply must be used and the transceiver shall remain in the receive status to ensure real-time response, there is no alternative but to activate wakeup signal and receive data at a fixed time interval. When the battery capacity remains unchanged, the battery working time can be extended only by reducing the duty ratio and increasing the wireless transceiving rate. However, reducing the duty ratio will directly affect response real-timeliness; doubling wireless receiving rates will usually cause the sensitivity to fall by 2-3dBm, thus directly affecting the distance of communications. The receive current of the single-chip wireless ICs currently available on the market is usually in the range of 15-20mA. When these ICs are used for wireless water/gas meter reading systems where the battery shall work for 6-10 years, it is very difficult to accept or reject parameters such as distance, working life and response time. By contrast, SEMTECH SX1212 has innovatively reduced the current to 2.6mA and increased receive sensitivity, anti-interference and adjacent channel selectivity to very high levels.

The SX1212-based wireless module has been developed by Shenzhen Appcon Technologies CO., Ltd and successfully applied to wireless water and gas meter collection. Within a distance of about 450m at the data rate of 10Kbps or a distance of about 600m at the data rate of 2Kbps in an open area, it takes less than 2s to manually collect water and gas meter data each time when the module is opened once every second. The collector can be used to realize automatic meter reading, while manual meter readers can be combined with GPS to automatically discover adjacent water and gas meters without manually entering any input command. This has further increased the meter reading speed. Under the traditional manual meter reading method, one person can read 3000-4000 household meters each month. In addition, gas meters are usually read from door to door in the evening. Therefore, the SX1212-based wireless module has significantly boosted meter reading efficiency.

