Programming manual for Serene Innovations CA4 2.4 Ghz Transceiver Module (using nRF24L01+ Transceiver chip):

Operating conditions

Supply voltage: 3 +/-.3 vdc, 30 ma max
Operating Temperature: 0 to 50 ºC

Data and Control Interface

The data and control interface gives you access to all the features in the nRF24L01+. The data and control interface consists of the following six 5-Volt tolerant digital signals:

• **IRQ** (this signal is active low and controlled by three maskable interrupt sources)
• **CE** (this signal is active high and used to activate the chip in RX or TX mode)
• **CSN** (SPI signal)
• **SCK** (SPI signal)
• **MOSI** (SPI signal)
• **MISO** (SPI signal)

Using 1 byte SPI commands, you can activate the nRF24L01+ data FIFOs or the register map during all modes of operation.

The SPI is a standard 4-wire SPI (8-bit command) with a maximum data rate of 10Mbps. Every new command must be started by a high to low transition on **CSN**. The STATUS register is serially shifted out on the **MISO** pin simultaneously to the SPI command word shifting to the **MOSI** pin. The serial shifting SPI commands is in the following format: <**Command word**: MSBit to LSBit (one byte)> <**Data bytes**: LSByte to MSByte, MSBit in each byte first>

RX mode

The RX mode is an active mode where the nRF24L01+ radio is used as a receiver. To enter this mode, the nRF24L01+ must have the PWR_UP bit, PRIM_RX bit and the CE pin set high. In RX mode the receiver demodulates the signals from the RF channel, constantly presenting the demodulated data to the baseband protocol engine. The baseband protocol engine constantly searches for a valid packet. If a valid packet is found (by a matching address and a valid CRC) the payload of the packet is presented in a vacant slot in the RX FIFOs. If the RX FIFOs are full, the received packet is discarded. The nRF24L01+ remains in RX mode until the MCU configures it to standby-I mode or power down mode. However, if the automatic protocol features in the baseband protocol engine are enabled, the nRF24L01+ can enter other modes in order to execute the protocol. In RX mode a Received Power Detector (RPD) signal is available. The RPD is a signal that is set high when a RF signal higher than -64 dBm is detected inside the receiving frequency channel. The internal RPD signal is filtered before presented to the RPD register. The RF signal must be present for at least 40µs before the RPD is set high.

Enhanced ShockBurst receive payload

1. Select RX by setting the PRIM_RX bit in the CONFIG register to high. All data pipes that receive data must be enabled (EN_RXADDR register), enable auto acknowledgement for all pipes running Enhanced ShockBurst™ (EN_AA register), and set the correct payload widths (RX_PW_Px registers). Set up addresses as described in item 2 in the Enhanced ShockBurst transmitting payload above.

2. Start Active RX mode by setting **CE** high.

3. After 130µs nRF24L01+ monitors the air for incoming communication.

4. When a valid packet is received (matching address and correct CRC), the payload is stored in the RX-FIFO, and the RX_DR bit in STATUS register is set high. The **IRQ** pin is active when RX_DR is high. RX_P_NO in STATUS register indicates what data pipe the payload has been received in.
5. If auto acknowledgement is enabled, an ACK packet is transmitted back, unless the NO_ACK bit is set in the received packet. If there is a payload in the TX_PLD FIFO, this payload is added to the ACK packet.

6. MCU sets the **CE** pin low to enter standby-I mode (low current mode).

7. MCU can clock out the payload data at a suitable rate through the SPI.

8. nRF24L01+ is now ready for entering TX or RX mode or power down mode.

TX mode

The TX mode is an active mode for transmitting packets. To enter this mode, the nRF24L01+ must have the PWR_UP bit set high, PRIM_RX bit set low, a payload in the TX FIFO and a high pulse on the CE for more than 10µs. The nRF24L01+ stays in TX mode until it finishes transmitting a packet. If CE = 0, nRF24L01+ returns to standby-I mode. If CE = 1, the status of the TX FIFO determines the next action. If the TX FIFO is not empty the nRF24L01+ remains in TX mode and transmits the next packet. If the TX FIFO is empty the nRF24L01+ goes into standby-II mode. The nRF24L01+ transmitter PLL operates in open loop when in TX mode. It is important never to keep the nRF24L01+ in TX mode for more than 4ms at a time. If the Enhanced ShockBurst features are enabled, nRF24L01+ is never in TX mode longer than 4ms.

Enhanced ShockBurst transmitting payload

1. Set the configuration bit PRIM_RX low.

2. When the application MCU has data to transmit, clock the address for the receiving node (TX_ADDR) and payload data (TX_PLD) into nRF24L01+ through the SPI. The width of TX-payload is counted from the number of bytes written into the TX FIFO from the MCU. TX_PLD must be written continuously while holding **CSN** low. TX_ADDR does not have to be rewritten if it is unchanged from last transmit. If the PTX device shall receive acknowledge, configure data pipe 0 to receive the ACK packet. The RX address for data pipe 0 (RX_ADDR_P0) must be equal to the TX address (TX_ADDR) in the PTX device.

3. A high pulse on **CE** starts the transmission. The minimum pulse width on **CE** is 10µs.

4. nRF24L01+ ShockBurst:
- Radio is powered up.

- 16MHz internal clock is started.
- RF packet is completed (see the packet description).
- Data is transmitted at high speed (1Mbps or 2Mbps configured by MCU).

5. If auto acknowledgement is activated (ENAA_P0=1) the radio goes into RX mode immediately, unless the NO_ACK bit is set in the received packet. If a valid packet is received in the valid acknowledgement time window, the transmission is considered a success. The TX_DS bit in the STATUS register is set high and the payload is removed from TX FIFO. If a valid ACK packet is not received in the specified time window, the payload is retransmitted (if auto retransmit is enabled). If the auto retransmit counter (ARC_CNT) exceeds the programmed maximum limit (ARC), the MAX_RT bit in the STATUS register is set high. The payload in TX FIFO is NOT removed. The **IRQ** pin is active when MAX_RT or TX_DS is high. To turn off the **IRQ** pin, reset the interrupt source by writing to the STATUS register (see Interrupt chapter). If no ACK packet is received for a packet after the maximum number of retransmits, no further packets can be transmitted before the MAX_RT interrupt is cleared. The packet loss counter (PLOS_CNT) is incremented at each MAX_RT interrupt. That is, ARC_CNT counts the number of retransmits that were required to get a single packet through. PLOS_CNT counts the number of packets that did not get through after the maximum number of retransmits.

6. nRF24L01+ goes into standby-I mode if **CE** is low. Otherwise, next payload in TX FIFO is transmitted. If TX FIFO is empty and **CE** is still high, nRF24L01+ enters standby-II mode.

7. If nRF24L01+ is in standby-II mode, it goes to standby-I mode immediately if **CE** is set low.

Constant carrier wave output for testing

The output power of a radio is a critical factor for achieving wanted range. Output power is also the first test criteria needed to qualify for all telecommunication regulations.

Configuration

1. Set PWR_UP = 1 and PRIM_RX = 0 in the CONFIG register.
2. Wait 1.5ms PWR_UP->standby.
3. In the RF register set:
   - CONT_WAVE = 1.
   - PLL_LOCK = 1.
   - RF_PWR.
4. Set the wanted RF channel.
5. Set **CE** high.
6. Keep **CE** high as long as the carrier is needed.

Note: Do not use REUSE_TX_PL together with CONT_WAVE=1. When both these registers are set the chip does not react when setting CE low. If however, both registers are set PWR_UP = 0 will turn TX mode off. The nRF24L01+ should now output an unmodulated centered carrier.

REGULATORY INFORMATION

● Compliance Statement

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions:
(1) This device may not cause harmful interference, and
(2) This device must accept any interference received, including interference that may cause undesired operation.

● **Caution**

Any Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

● **Label and manual requirements for the End Product**

For an end product using the CA4 there must be a label containing, at least, the following information.
FCC ID certification number for model CA4
This device contains FCC ID:Z33-CA4
The label must be affixed on an exterior surface of the end product such that it will be visible upon inspection in compliance with the modular approval guidelines developed by the FCC
Where the CA4 will be installed in final products larger than 8cm × 10cm following statements has to be placed ONTO the device
Operation is subject to the following two conditions:
(1) This device may not cause harmful interference, and
(2) This device must accept any interference received, including interference that may cause undesired operation."

This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.
The OEM integrator has to be aware not to provide information to the end user regarding how to install or remove its RF Module in the user manual of the end product which integrates this module.
The end user manual shall include all required regulatory information/warning as show in this use manual.