SI4455 RF Module User Guide

Pin Description

Pin	Name	I/O	Description
1	SDN	I	Shutdown (0 – V_{DD} V) : SDN=1, part will be in shutdown mode. SDN=0, all other modes
2	nSEL	I	Serial Interface Select Input (0 – V_{DD} V): Provides select/enable function for 4-line serial data bus
3	SDI	I	Serial Data Input (0 – V_{DD} V): Serial data stream input for 4-line serial data bus
4	SDO	O	Serial Data Output (0 – V_{DD} V): Provides serial data readback function of internal control registers
5	SCLK	I	Serial Clock Input (0 – V_{DD} V): Provides serial data clock for 4-line serial data bus
6	nIRQ	O	Interrupt Status Output – nIRQ = 0, interrupt event has occurred. Read interrupt status for event details
7	VDD	VDD	Supply voltage
8	VSS	VSS	Ground
9	VSS	VSS	Ground
10	VSS	VSS	Ground
11	VSS	VSS	Ground
12	VSS	VSS	Ground
A	Ant.	Ant.	Connect to Antenna.

Figure 1. module thickness

Figure 2. PCB Dimension

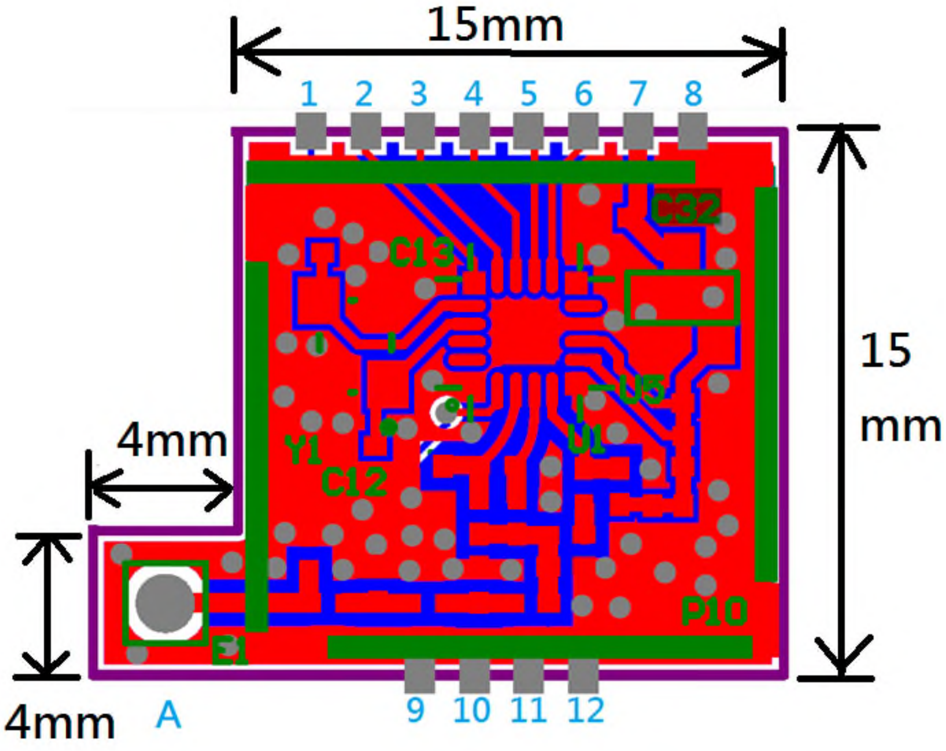
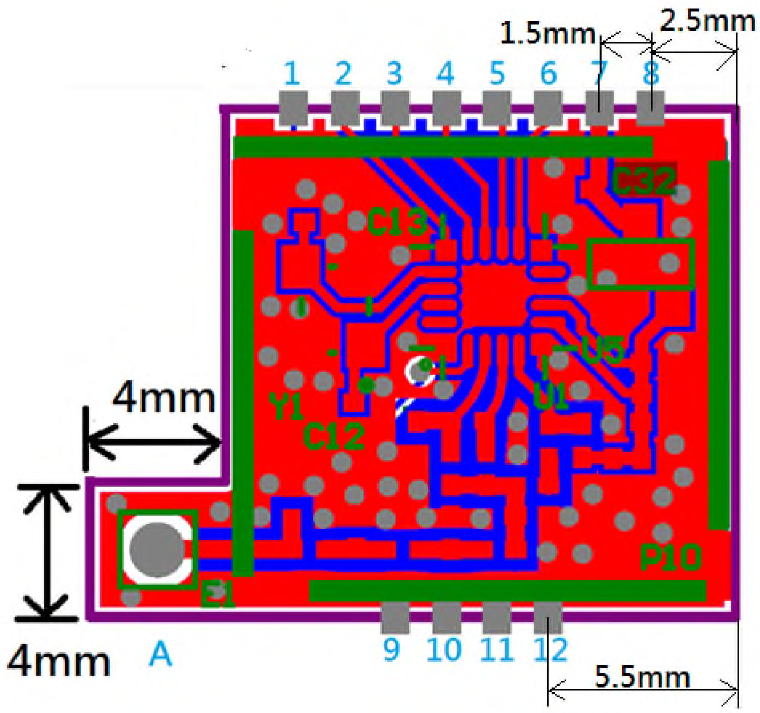


Figure 3. Pad Spacing



Features

Frequency Range: 433~435 MHz

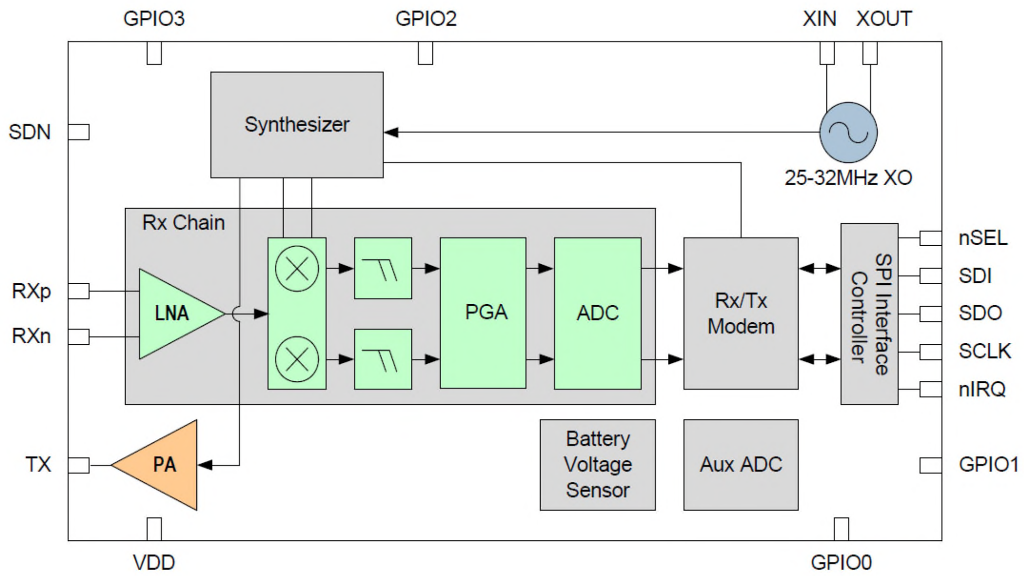
Modulation: FSK

Power Supply = 3.5~6 V

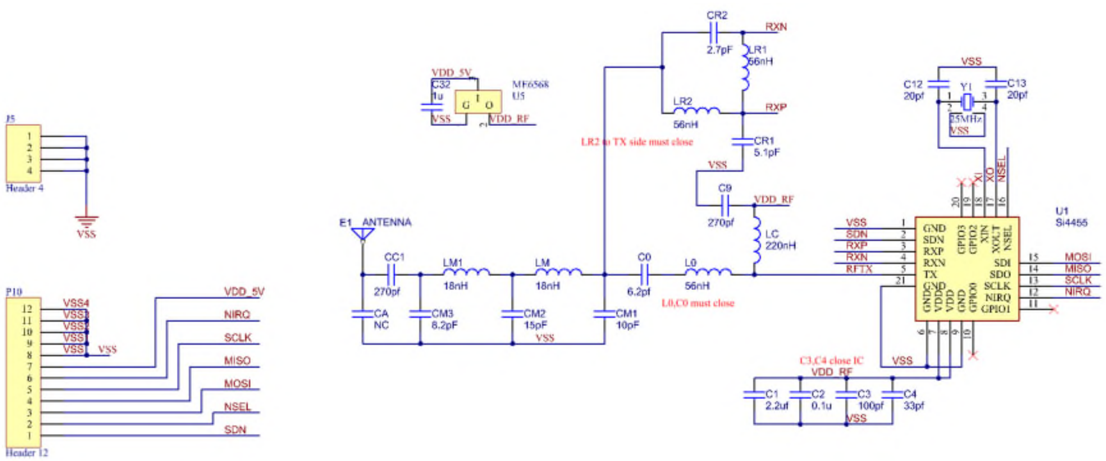
TX and RX 64 byte FIFOs

Operating temperature: -20~85C

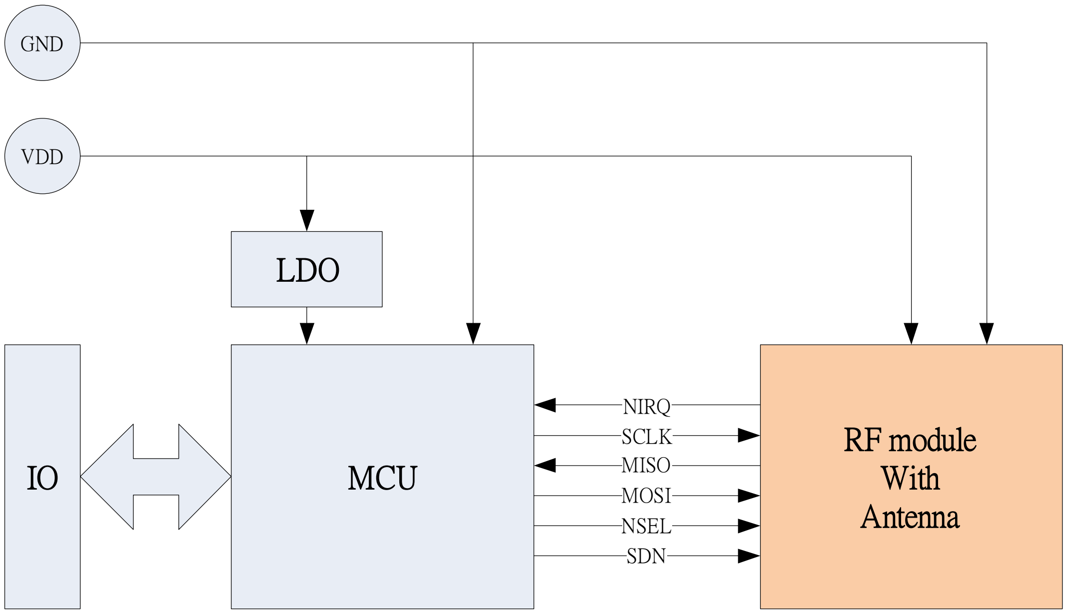
IC Function Block Diagram



Circuit



Typical Application Block Diagram



Serial Peripheral Interface

The Si4455 RF module communicates with the host MCU over a standard 4-wire serial peripheral interface (SPI): SCLK, SDI, SDO, and nSEL. The SPI interface is designed to operate at a maximum of 10 MHz. The SPI timing parameters are listed in Table 1. The host MCU writes data over the SDI pin and can read data from the device on the SDO output pin. Figure 4 shows an SPI write command. The nSEL pin should go low to initiate the SPI command. The first byte of SDI data will be one of the API commands followed by n bytes of parameter data which will be variable depending on the specific command. The rising edges of SCLK should be aligned with the center of the SDI data.

Table 1. Serial Interface Timing Parameters

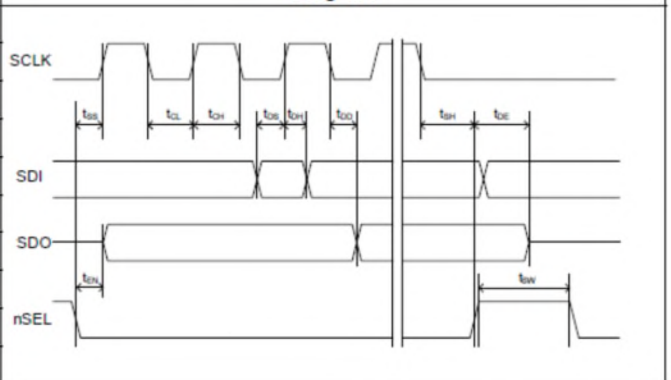
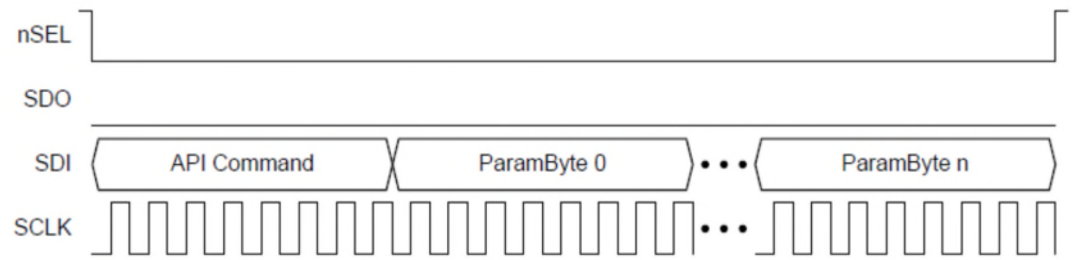
Symbol	Parameter	Min (ns)	Diagram
t_{CH}	Clock high time	40	
t_{CL}	Clock low time	40	
t_{DS}	Data setup time	20	
t_{DH}	Data hold time	20	
t_{DD}	Output data delay time	20	
t_{EN}	Output enable time	20	
t_{DE}	Output disable time	50	
t_{SS}	Select setup time	20	
t_{SH}	Select hold time	50	
t_{SW}	Select high period	80	

Figure 4. SPI Write Command



The Si4455 contains an internal MCU which controls all the internal functions of the radio. For SPI read commands, a typical communication flow of checking clear-to-send (CTS) is used to make sure the internal MCU has executed the command and prepared the data to be output over the SDO pin. Figure 5 demonstrates the general flow of an SPI read command. Once the CTS value reads FFh, then the read data is ready to be clocked out to the host MCU. The typical time for a valid FFh CTS reading is 20 μs. Figure 6 demonstrates the remaining read cycle after CTS is set to FFh. The internal MCU will clock out the SDO data on the negative edge so the host MCU should process the SDO data on the rising edge of SCLK.

Figure 5. SPI Read Command - Check CTS Value

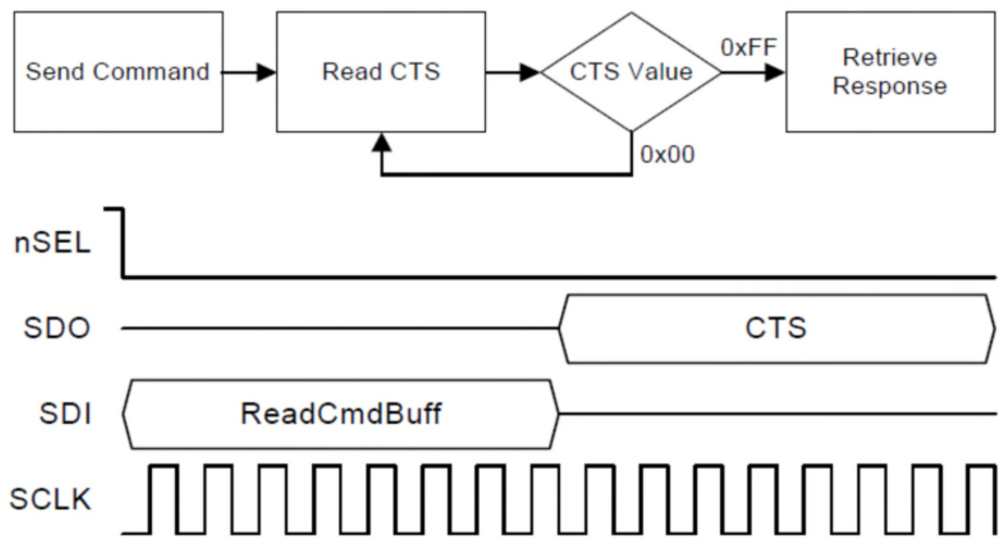
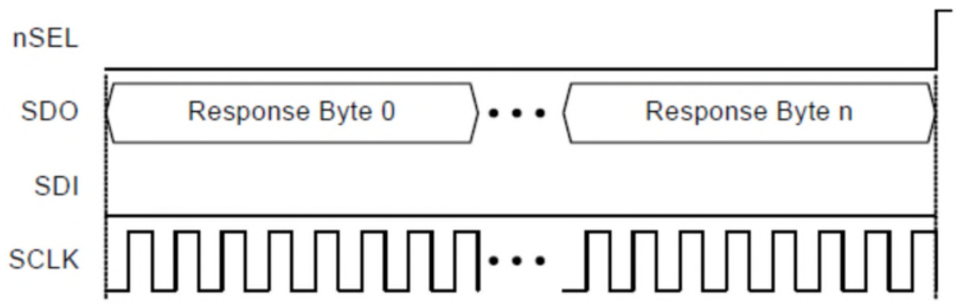


Figure 6. SPI Read Command-Check Out Read Data



Operating Modes and Timing

The primary states of the Si4455 are shown in Figure 7. The shutdown state completely shuts down the radio, minimizing current consumption and is controlled using the SDN . All other states are controlled using the API commands START_RX, START_TX and CHANGE_STATE. Figure 8 shows each of the operating modes with the time required to reach either RX or TX state as well as the current consumption of each state. The times in Figure 8 are measured from the rising edge of nSEL until the chip is in the desired state. This information is included for reference only since an automatic sequencer moves the chip from one state to another and so it is not necessary to manually step through each state. Figure 9 and Figure 10 demonstrate this timing and the current consumption for each radio state as the chip moves from shutdown or standby to TX and back. Most applications will utilize the standby mode since this provides the fastest transition response time, maintains all register values, and results in nearly the same current consumption as shutdown.

Figure 7. State Machine Diagram

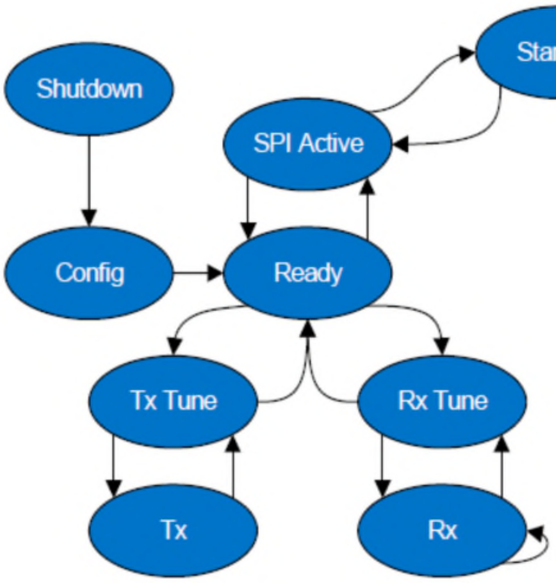


Figure 8. Operating State Response Time and Current Consumption

State / Mode	Response Time to		Current in State / Mode
	Tx	Rx	
Shutdown	30 ms	30 ms	30 nA
Standby	500 µs	460 µs	50 nA
SPI Active	500 µs	330 µs	1.35 mA
Ready	150 µs	130 µs	1.8 mA
Tx Tune	75 µs		6.9 mA
Rx Tune		75 µs	6.5 mA
Tx		150 µs	18 mA @ +10 dBm
Rx	150 µs	150 µs	10 mA

Figure 9. Start-Up Timing and Current Consumption using Shutdown State

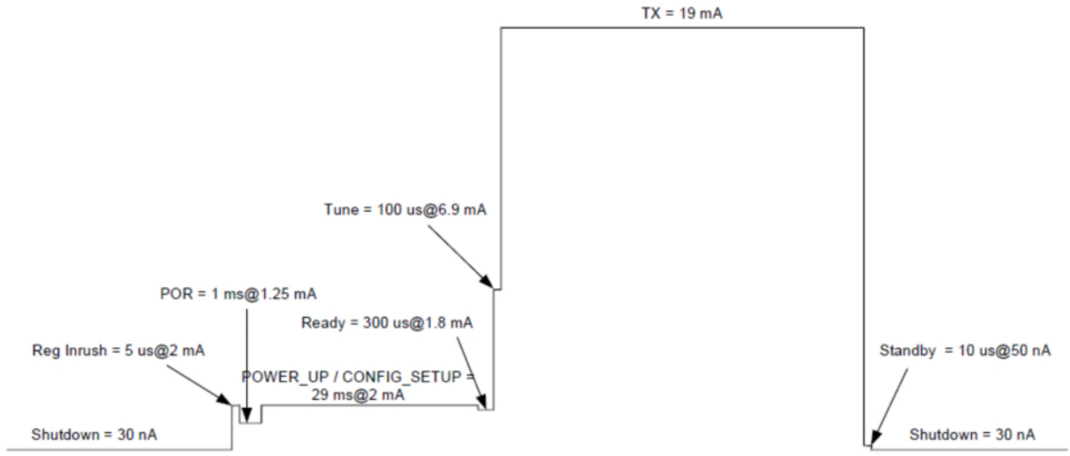
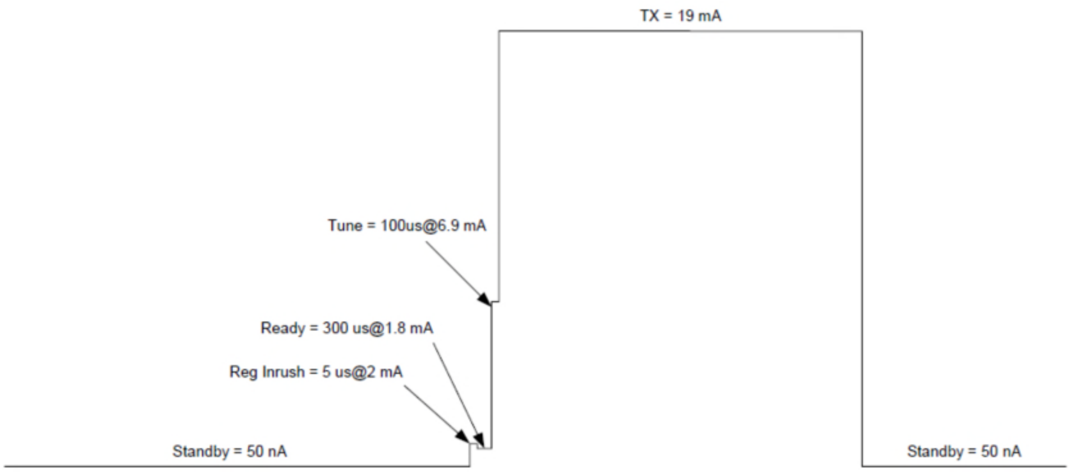


Figure 10. Start-Up Timing and Current Consumption using Standby State

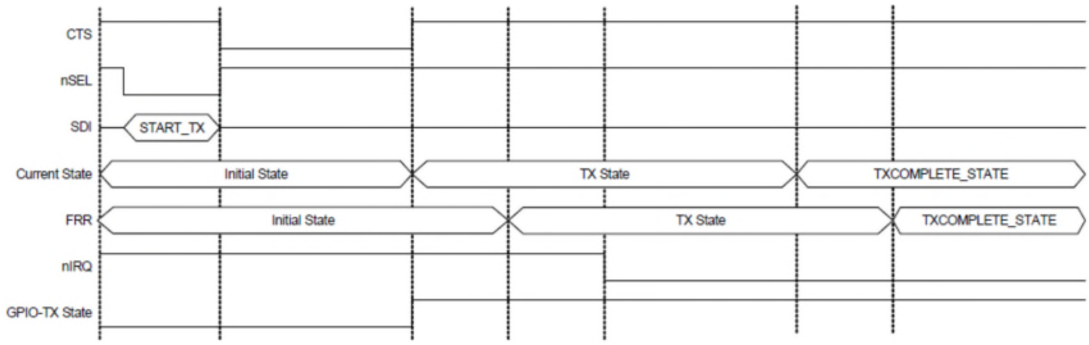


TX State

The TX state is used whenever the device is required to transmit data. It is entered using either the START_TX or CHANGE_STATE command. With the START_TX command, the next state can be defined to insure optimal timing. When either command is sent to enter TX state, an internal sequencer automatically takes care of all actions required to move between states with no additional user commands needed. Examples of the timing of this transition can be seen in Figure 9 and Figure 10. The specific sequencer controlled events that take place during this time can include enable internal LDOs, start up crystal oscillator, enable PLL, calibrate VCO/PLL, active power amplifier, and transmit packet.

Figure 11 shows an example of the commands and timing for the START_TX command. CTS will go high as soon as the sequencer puts the part into TX state. As the sequencer is stepping through the events listed above, CTS will be low and no new commands or property changes are allowed. If the nIRQ is used to monitor the current state, there will be a slight delay caused by the internal hardware from when the event actually occurs to when the transition occurs on the nIRQ. The time from entering TX state to when the nIRQ will transition is 13 µs. If a GPIO is programmed for TX state or used as control for a transmit/receive switch (TR switch), there is no delay.

Figure 11. START_TX commands and Timing



RX State

The RX state is used whenever the device is required to receive data. It is entered using either the START_RX or CHANGE_STATE commands. With the START_RX command, the next state can be defined to insure optimal timing. When either command is sent to enter RX state, an internal sequencer automatically takes care of all actions required to move between states with no additional user commands needed. The sequencer controlled events can include enable the digital and analog LDOs, start up the crystal oscillator, enable PLL, calibrate VCO, enable receiver circuits, and enable receive mode. The device will also automatically set up all receiver features such as packet handling based upon the initial configuration of the device.

RX and TX FIFOs

Two 64-byte FIFOs are integrated into the chip, one for RX and one for TX. Writing to command register 66h loads data into the TX FIFO and reading from command register 77h reads data from the RX FIFO. For packet lengths greater than 64 bytes, RX_FIFO_ALMOST_FULL and TX_FIFO_ALMOST_EMPTY status bits and interrupts can be used to manage the FIFO. The threshold value for these can be configured via the WDS radio configuration application GUI. The maximum payload length supported in packet handler mode is 255 bytes.

Packet Handler

The RF module includes integrated packet handler features such as preamble and sync word detection as well as CRC calculation. This allows the chip to qualify and synchronize with legitimate transmissions independent of the microcontroller. These features can be enabled using the RCA. In this setup, the preamble and sync word length can be modified and the sync word pattern can be selected. If the preamble is greater than or equal to 4 bytes, the device uses the preamble detection circuit with a 2-byte detection threshold. If the preamble is less than 32 bits, then at least two bytes of sync word are required plus at least one byte of 0101 pattern (3 bytes total). In this case, preamble detection is skipped, and only sync word detection is used. For any combination of preamble and sync word less than three bytes, the device will use direct mode. The general packet structure is shown in Figure 12

Figure 12. Packet Structure for Fixed Packet Length

Preamble	Sync Word	Data	CRC
0 – 255 Bytes	1 – 4 Bytes	1 – 255 Bytes	2 Bytes

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Figure 13. Si4455 RF module

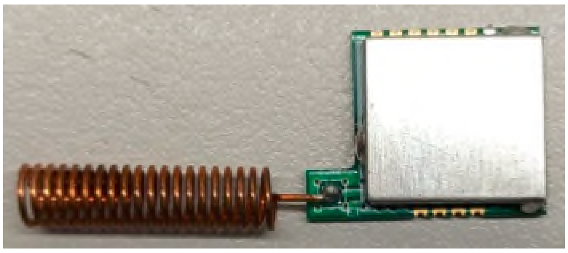

Figure 14. Si4455 RF module + GB300

Agency Certifications

United State (FCC)

This module complies with Part 15 of the FCC rules and regulations. To fulfill FCC Certification requirements, an OEM manufacturer must comply with the following regulations:

The module must be labeled with its own FCC ID (HLZLS1). If the FCC ID is not visible when the module is installed inside another device, then the outside of the device must display FCC information as following:

Contains FCC ID : HLZLS1

a. This device may not cause interference, and
b. This device must accept any interference, including interference that may cause undesired operation of the device.

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

FCC RF Radiation Exposure Statement:

1. This module must not be co-located or operating in conjunction with any other antenna or transmitter.
2. This equipment complies with FCC RF radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with a minimum distance of 20 centimeters between the radiator and all persons.

Canada (IC)

L'émetteur/récepteur exempt de licence contenu dans le présent appareil est conforme aux CNR d'Innovation, Sciences et Développement économique Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes :

1. l'appareil ne doit pas produire de brouillage, et, and
2. l'utilisateur de l'appareil doit accepter tout brouillage radioelectrique subi, meme si le brouillage est susceptible d'en compromettre le fonctionnement.

Attention: exposition au rayonnement radiofréquence

1. Pour se conformer aux exigences de conformité RF canadienne l'exposition, cet appareil et son antenne ne doivent pas être co-localisés ou fonctionnant en conjonction avec une autre antenne ou transmetteur.
2. Pour se conformer aux exigences de conformité CNR 102 RF exposition, une distance de séparation d'au moins 20 cm doit être maintenue entre l'antenne de cet appareil et toutes les personnes

CAUTION: Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment. The OEM integrator is still responsible for testing their end product for any additional compliance requirements required with this module installed (for example, digital device emissions, PC peripheral requirements, etc.).
This Module is labeled with its own IC ID. If the IC ID Certification Number is not visible while installed inside another device, then the device should display the label on it referring the enclosed module. In that case, the final end product must be labeled in a visible area with the following:

Contains IC: 1754F-LS1

a. To comply with the Canadian RF exposure compliance requirements, this device and its antenna must not be co-located or operating in conjunction with any other antenna or transmitter.
b. To comply with RSS 102 RF exposure compliance requirements, a separation distance of at least 20 cm must be maintained between the antenna of this device and all persons.

NCC Warning Statement

根據低功率電波輻射性電機管理辦法 (930322)

第十二條

經型式認證合格之低功率射頻電機，非經許可，公司、商號或使用者均不得擅自變更頻率、加大功率或變更原設計之特性及功能。

第十四條

低功率射頻電機之使用不得影響飛航安全及干擾合法通信；經發現有干擾現象時，應立即停用，並改善至無干擾時方得繼續使用。

前項合法通信，指依電信法規定作業之無線電通信。低功率射頻電機須忍受合法通信或工業、科學及醫療用電波輻射性電機設備之干擾。

本模組於取得認證後，將依規定於模組本體標示審驗合格標籤，並要求平台廠商於平台上標示『內含發射器模組：CCXXxxLPyyyZzW』。

本器材屬於模組認證，可適用於各種平台。