SILICON LABS

AN747

Si4313 to Si4355 Transition Document

1. Introduction

This document provides comparison and transition assistance from the Si4313 to the Si4355 EZRadio receiver. The Si4355 represents a new generation of the EZRadio family with improved performance and flexibility combined with simplicity and cost efficiency. This document provides an overview of the main differences between these two receivers. It is highly recommended that customers read the Si4355 data sheet and the Si4355 application notes when converting a design from Si4313 to Si4355.

2. Benefits

The Si4355 offers improved performance, greater ease of use, and a smaller form factor than does the Si4313. Battery life is extended through improved active receive current, lower standby current, and a faster transition time from standby to active receive mode. Range is greater through superior sensitivity, selectivity, and blocking performance. The Si4355 uses the EZConfig Setup in WDS and uses API commands for normal operation rather than register settings, making operation of the device much easier. The Si4355 is packaged in a 3 mm x 3 mm QFN package and so requires less board space than the 4 mm x 4 mm Si4313.

2.1. DC Characteristics Comparison

Table 1. DC Characteristics Comparison

	Si4313	Si4355
Supply Voltage	1.8 to 3.6 V	1.8 to 3.6 V
Ambient Temperature	–40 to 85 °C	–40 to 85 °C
Shutdown mode current cons.	15 nA	30 nA
Standby mode current cons.	450 nA	50 nA
Ready mode current cons.	800 µA	2 µA
Receive mode current cons.	18.5 mA	10 mA
Shutdown to Receive mode time	16.8 ms	30 ms
Standby to Receive mode time	800 µs	250 µs
Ready to Receive mode time	200 µs	130 µs

The Si4313 and Si4355 receivers work in the same temperature and supply voltage range. Due to its different architecture the Si4355 boots from shutdown mode longer than the Si4313 receiver. But the significantly lower Standby mode current allows using only this mode as low power state. The lower receive current and the shorter turnaround times make the Si4355 more valuable in battery-powered applications than the Si4313.

2.2. RF Parameters Comparison

Table 2. RF Parameters Comparison

	Si4313	Si4355
Frequency range	240 to 480 MHz (156.25 Hz. res.) 480 to 960 MHz (312.5 Hz res.)	283 to 350 MHz (38.1 Hz res.) 425 to 525 MHz (57.2 Hz res.) 850 to 960 MHz (114.4 Hz res.)
RX Channel BW	2.6 to 620 kHz	40 to 850 kHz
RX Sensitivity	–105 dBm (40 kbps, GFSK, ±20 kHz dev., BER<0.1%)	–108 dBm (40 kbps, GFSK, ±25 kHz dev., BER <0.1%)
Blocking 1 MHz Offset	–52 dBm	–61 dBm

The Si4355 targets certain applications where the narrow band operation and the full frequency coverage are not requirements. The improved sensitivity provides better range and the significantly better blocking makes it possible to use the Si4355 receiver even in noisy environments.

3. Hardware Recommendations

Due to the different QFN package and RF Receive inputs, the application printed circuit board must be modified when transitioning from Si4313 to Si4355. The following sections summarize the main differences and provide some guidelines for component selection.

3.1. Package and Pinout

The Si4313 receiver is packaged in a 4x4 mm 20-pin QFN package while the Si4355 has a smaller 3x3 mm 20-pin QFN package. There are also differences in the pinouts of the devices as summarized in Table 3.

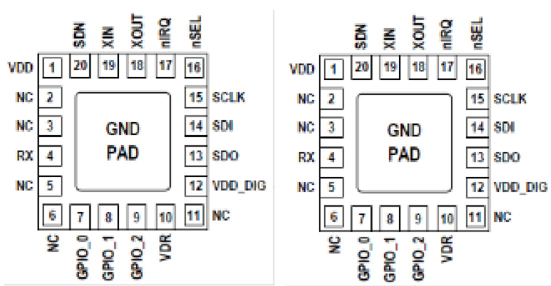

Figure 1. Pin Descriptions

Table 3. Pinout Comparison

	Si4313	Si4355
General purpose IOs	3 GPIOs (digital signals or analog input for the internal ADC)	4 GPIOs (digital signals or analog input for the internal ADC)
RF Receive Input Pins	Single-ended, 50 Ω LNA input	Differential LNA input
Regulated output voltage of the digital LDO	1 µF decoupling capacitor needs to be connected to VDR pin	Internal LDO is not available externally

3.2. Reference Design, Component Selection

The typical application circuit for the Si4313 receiver is shown in (Figure 2). The recommended application circuit for the Si4355 receiver is shown in (Figure 3).

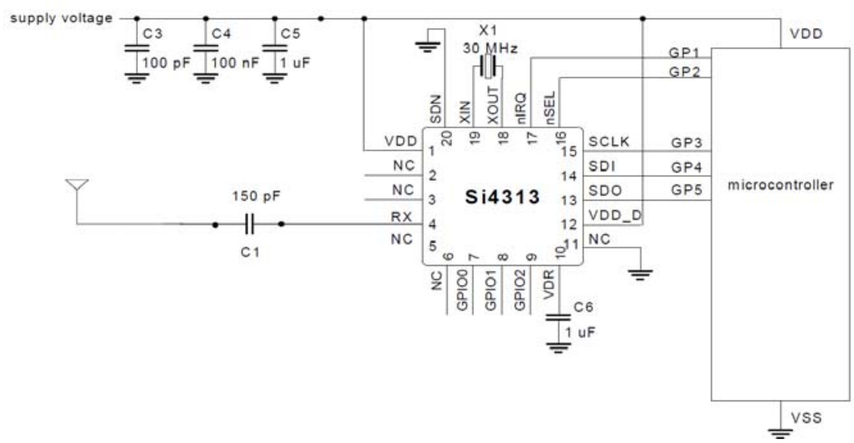

Figure 2. Si4313 Application Example

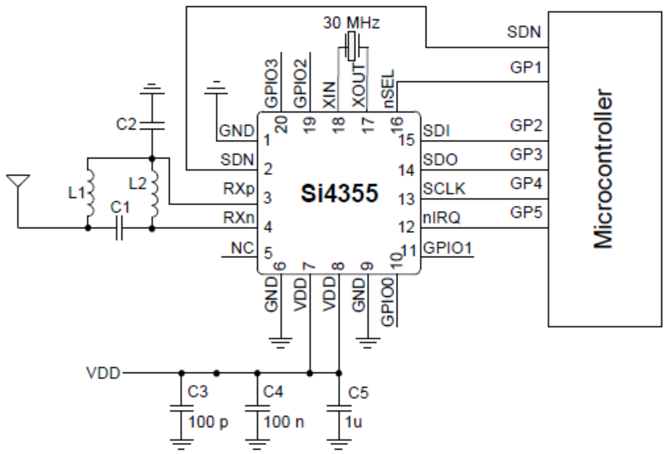

Figure 3. Si4355 Application Example

The main difference between the two application examples is the RF Receive matching circuit. Due to the 50 Ω, single-ended LNA interface the Si4313 requires only a 150 pF decoupling capacitor between the antenna and the RF Receive pin.

Si4355 has a differential LNA interface that requires a matching network if a 50 Ω antenna is used. However the differential LNA makes it possible to connect a PCB antenna directly to the Rx pins of the radio. For more details on the PCB antennas and receiver matching circuit for the Si4355 receiver, please refer to AN686: Antenna for the Si4455/Si4355 RF ICs.

Si4355 can run from the same crystal used for the Si4313. In order to use a lower-cost crystal in the application, the Si4355 is designed to accommodate a wide range of crystal frequencies (25–32 MHz).

4. Firmware Recommendations

4.1. Configuration Interface

Both radios can be configured through a standard SPI interface with up to 10 MHz clock speed. An Application Programming Interface (API) is designed for the Si4355 device over the SPI interface, instead of using the register configuration approach as for the Si4313 receiver. The major benefit of the API is that the radio can execute complex commands, procedures with minimal host MCU interaction. This approach helps to reduce the time taken by critical tasks from the host MCU and allows selecting a simpler MCU for the application. On the other end the API causes the following:

- the command execution time varies from command to command and it may be slower than changing a simple register for very basic commands.
- retrieving status information from the chip requires the following process: issue a command that addresses what information the host MCU is looking for; wait as long as the radio prepares the data (wait for the Clear To Send signal) and read the actual status information.

The host MCU can access time-critical information very efficiently through the Fast Response Registers (RSSI, interrupt status, etc) or dedicated HW commands (Transmit FIFO Write, Receive FIFO Read) as well.

The complete list of commands and their descriptions is provided in AN691: EZRadio API Guide.

4.2. Power On Sequence, Radio Configuration

After waiting for the Power On Reset, the Si4313 is ready to receive configuration commands.

There is an additional step for the Si4355 since it needs to boot up before the radio is ready to receive configuration commands. The boot-up process takes about 15 ms.

The Si4313 radio can be initialized by overwriting registers that need to be different from their default value. The value of the registers needs to be defined by the user based on the data sheet; therefore, it is easy to overlook a necessary setting that results in unwanted radio behavior.

The initialization process by the Si4355 radio minimizes the risk of missing configuration: all the configuration settings are organized into an array. The array is generated by a PC GUI (WDS) and the radio configuration is set on a graphical interface, rather than set by the user based on documentation. The GUI provides the possibility to pick up predefined, tested radio settings for customers who are not familiar with RF tradeoffs. However, the GUI also allows the flexibility to configure any desired radio configuration as well. The consistence of the array is protected with CRC and the array is encoded to prevent bit-by-bit changes and possible risk of missing important configuration settings.

The size of the configuration array is 212 bytes that needs to be stored in the host MCU. It could result in an increased code size compared to a Si4313 application code.

The configuration array stores all the settings that are typically set during initialization:

- radio configuration: crystal parameters, frequency band, modulation format, data rate, etc.
- packet content-related settings: preamble, synchron word, CRC, etc.
- the operation mode: packet-based communication or direct data reception on a GPIO

If the application requires changing any of the above settings during runtime, then the radio needs to be reset (toggling the SDN pin) and a new configuration array needs to be sent to the radio.

In addition to the configuration array there are settings that can be changed even after the configuration array is sent to the radio. Those are fine-tuning parameters (for example, crystal frequency fine-tuning registers), center frequency, channel spacing, packet content-related or interrupt-related settings.

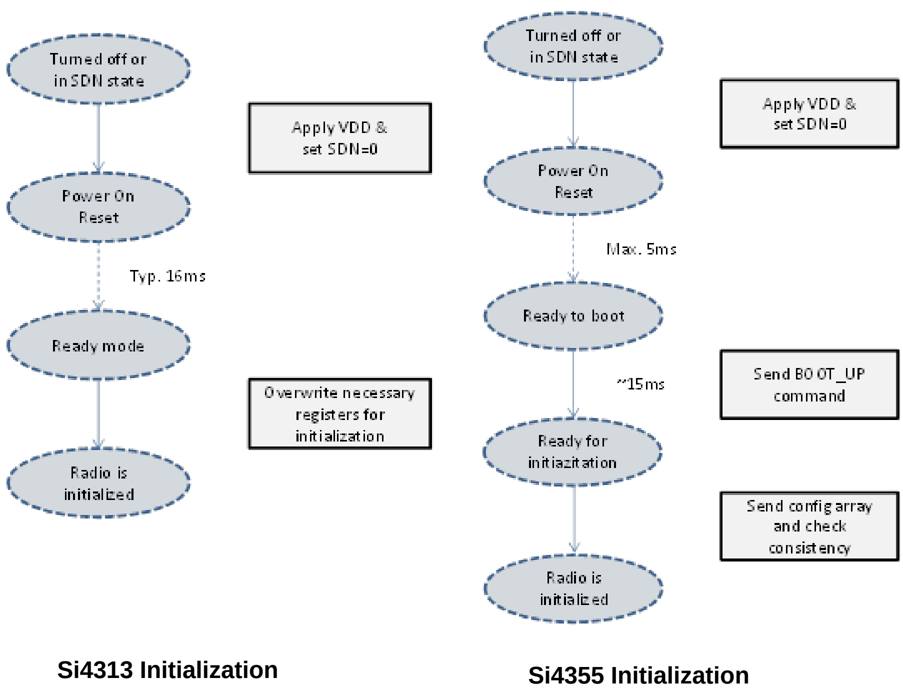

Figure 4. Initialization Process for Si4313 and Si4355

For more information about the WDS and the configuration array, refer to AN692: Si4355/Si4455 Programming Guide and Sample Codes.

4.3. Typical Use Cases

Both radios support the typical use cases: receiving packets or receiving data in direct mode (when the received data is provided through a GPIO instead of through the FIFO).

Due to the API interface of the Si4355 radio, realizing the typical use cases is different than for the Si4313 radio. Other than the SPI low-layer driver and the application code, the rest of the application code needs to be changed.

Both radios have a programming guide with example codes demonstrating how the radio needs to be used. In addition to the radio operation, there are major improvements in the example projects and the support tools of the Si4355:

- The Si4313 example codes are very basic, not partitioned; therefore it is hard to change and port them to another HW platform. The Si4355 example projects are built based on a driver that is well partitioned and in addition to the radio it supports all major peripherals of the evaluation board as well.
- The radio configurations of the Si4313 example codes need to be configured manually. WDS has a new feature for the Si4355 device: it can generate an example project with customized radio settings and packet configuration. The project can be saved or open in the Silicon Laboratories IDE for further FW development. That reduces the possibility of the misconfiguration of the radio and provides a complete, tested C source code for the given use case. It significantly reduces the development time.

Refer to AN692: Si4355/Si4455 Programming Guide and Sample Codes and AN692SW.zip (containing the example project with default radio settings) for more details on the example project.

4.4. Auxiliary Functions

The following table summarizes the auxiliary functions.

Table 4. Auxiliary Functions

	Si4313	Si4355
Power On Reset	Smart Reset	Simple Power On Reset
Low Battery Detect	Battery voltage read possibility Low Battery Threshold Interrupt	Battery voltage read possibility Low Battery Threshold Interrupt
MCU Clock Output	Derived from the XTAL	Derived from the XTAL
RSSI	Actual value during Receive RSSI Threshold Interrupt	Actual value during Receive RSSI Threshold Interrupt
Temperature Sensor	Available through the internal ADC	Not available
Wake Up Timer	Programmable, runs from the 32 kHz RC oscillator	Not available

The Si4355 has a different power on reset circuit for reducing the Standby mode current consumption. It cannot reset the radio upon rising edge on the supply voltage (called smart reset in Si4313). Please refer to the Si4355 data sheet for more details about the power on reset.

Note: To reset the radio from the host MCU, use the SDN pin.

The RSSI can be read through a register for the Si4313 radio while it is in Receive mode. In the Si4355 the RSSI is accessible through the fast response register. Instead of being able to read the RSSI anytime during Receive mode, the Si4355 has a new feature to latch and store the RSSI value based upon certain conditions. This feature helps to offload time-critical tasks from the host MCU:

- If a frequency scan algorithm needs to be designed based on RSSI measurements, then it is recommended to latch the RSSI a few bits after the receiver is settled. That provides a fast way to measure the energy on all frequency channels.
- If the application requires knowing the signal strength of the incoming packet, then it is recommended to latch the RSSI upon preamble or synch word reception.

Both radios can generate an interrupt if the RSSI exceeds a threshold anytime during Receive mode.

The wake up timer (waking up the radio and the host MCU regularly to complete scheduled tasks) and the temperature sensors are not available in the Si4355 receiver; those need to be implemented in the host MCU.

There is a common technique to further reduce the Receive mode current consumption by periodically waking up the radio for a short period of time and checking if there is any transmit activity. It is called Low Duty Cycle (LDC) mode. There is an example project that uses the LDC mode in the host MCU and available in WDS. It is intended for use with the keyfob example project.

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