# Transitioning From Si4x6x-B1B To Si4x6x-C2A and Si4467/8-A2A

## 1. Introduction

This document provides assistance in transitioning from the Si4x6x-B1B to the Si4x6x-C2A or Si4467/8-A2A EZRadioPRO transceivers, transmitters, and receiver. The new radios and radio revisions represents the newest generation of the EZRadioPRO family with improved performance, new features and flexibility combined with simplicity and cost efficiency. The main differences between these radios are described in this document. It is highly recommended that the customer also read the corresponding data sheets and application notes when converting a design to a new radio.

## 2. Benefits

Various digital and packet handler related enhancements and auxiliary features are introduced in the new radio families that is going to be summarized in later chapters. The Si4x6x-C2A and Si4467/8-A2A improves performance in several key areas compared to the Si4x6x-B1B revision. Key among these are the extended power supply voltage to 3.8 V, overall improved link budget to 153 dB, extended ambient temperature to 125 °C, blocking and adjacent channel rejection improvements.

In order to determine the worst case parameters for the end application, both Si4x6x-C2A and Si4467/8-A2A data sheets specify minimum or maximum limits for the most critical characteristics. Maximum values are guaranteed across the recommended operating conditions of supply voltage and from –40 to +85 °C unless otherwise stated.

### 2.1. Comparison of DC Characteristics

**Table 1. DC Characteristics Comparison**

| Parameter | Si4x6x-B1B | Si4x6x-C2A | Si4467/8-A2A |
|---|---|---|---|
| Supply voltage | 1.8 to 3.6 V | 1.8 to 3.8 V | 1.8 to 3.8 V |
| Ambient Temperature | –40 to 85 °C | –40 to 85 °C | –40 to 125 °C |
| Standby mode current consumption | 50 nA | 40 nA | 40 nA |
| Sleep current consumption (RC oscillator ON) | 900 nA | 740 nA | 740 nA |
| RX Tune mode current consumption | 7.2 mA | 7.6 mA | 7.6 mA |
| TX Tune mode current consumption | 8 mA | 7.8 mA | 7.8 mA |
| Low Power RX Mode current consumption | 10.7 mA | 10.9 mA | 10.9 mA |
| Ready to TX/RX state transition timings | 126 / 122 µs | 100 / 100 µs | 100 / 100 µs |
| RX Tune to RX state transition timing | 74 µs | 60 µs | 60 µs |
| TX State to RX State transition timing | 138 µs | 100 µs | 100 µs |
| RX state to TX state transition timing | 130 µs | 100 µs | 100 µs |
| 30 MHz XTAL Start-up Time | 250 µs | 300 µs | 300 µs |
| POR Reset Time | 5 ms | 6 ms | 6 ms |

Both new radio families support the extended supply voltage that makes them ideal for Automatic Meter Reading applications, where the device is typically supplied from a lithium thionyl chloride battery without voltage conversion. The extended ambient temperature range allows to use the Si4467/8 devices in lighting applications.

Faster turnaround times, lower standby and sleep current consumption make the Si4x6x-C2A and Si4467/8-A2A devices more desirable in battery-powered applications, compared to the previous radio family.

## 2.2. Comparison of RF Parameters

**Table 2. Synthesizer Frequency Range Comparison**

| Parameter | Si4x6x-B1B | Si4x6x-B1B | Si4x6x-C2A<br>Si4467/8-A2A |
|---|---|---|---|
| **Synthesizer Frequency Range** | 850 to 1050 MHz<br>(28.6 Hz res.)<br>420 to 525 MHz<br>(14.3 Hz res.)<br>284 to 350 MHz<br>(9.5 Hz res.)<br>142 to 175 MHz<br>(4.7 Hz res.) | 705 to 960 MHz<br>(28.6 Hz res.)<br>470 to 639 MHz<br>(19.1 Hz res.)<br>353 to 479 MHz<br>(14.3 Hz res.)<br>235 to 319 MHz<br>(9.5 Hz res.)<br>177 to 239 MHz<br>(7.1 Hz res.)<br>119 to 159 MHz<br>(4.7 Hz res.) | 850 to 1050 MHz<br>(28.6 Hz res.)<br>420 to 525 MHz<br>(14.3 Hz res.)<br>350 to 420 MHz<br>(11.4 Hz res.)<br>284 to 350 MHz<br>(9.5 Hz res.)<br>142 to 175 MHz<br>(4.7 Hz res.) |

Both Si4x6x-C2A and Si4467/8-A2A families cover the most common ISM bands, including the 390 MHz frequency band that is useful for remote control applications.

**Table 3. RX & TX Characteristics Comparison**

| Parameter | Si4x6x-B1B | Si4x6x-C2A | Si4467/8-A2A |
|---|---|---|---|
| RX Channel Bandwidth | 1.1 to 850 kHz | 1.1 to 850 kHz | 0.2 to 850 kHz |
| Best receiver sensitivity using GFSK modulation | –126 dBm[1] | –129 dBm[2] | –133 dBm[3] |
| ±1-Ch Offset Selectivity, 169 MHz band | –60 dB | –69 dB | –69 dB |
| ±1-Ch Offset Selectivity, 450 MHz band | –58 dB | –60 dB | –60 dB |
| ±1-Ch Offset Selectivity, 868/915 MHz band | –53 dB | –55 dB | –55 dB |
| Blocking 1 MHz offset | –75 dB | –79 dB | –79 dB |
| Blocking 8 MHz offset | –84 dB | –86 dB | –86 dB |
| Image Rejection (IF = 468.75 kHz), without image rejection calibration | –35 dB | –40 dB | –40 dB |
| TX RF Output Steps | 0.1 dB | 0.25 dB | 0.25 dB |
| TX RF Output Level Variation vs. Temperature | 1 dB | 2.3 dB[4] | 2.3 dB[4] |
| TX RF Output Level Variation vs. Frequency | 0.5 dB | 0.6 dB[4] | 0.6 dB[4] |

**Notes:**
1. Measured in the 450-470 MHz frequency band, with 500 bps, GFSK, BT = 0.5, Δf=±250 Hz.
2. Measured in the 169 MHz frequency band, with 500 bps, GFSK, BT = 0.5, Δf=±250 Hz.
3. Measured in the 169 MHz frequency band, with 100 bps, GFSK, BT = 0.5, Δf=±100 Hz.
4. Higher variation is caused by differences in the validation process only.

The sensitivity, selectivity, and blocking performance improvements make the Si4x6x-C2A devices more valuable in performance driven applications (FCC Part 90, ETSI Category 1, Wireless MBUS, etc.).

The ultra-narrow RX bandwidth of the Si4467/8-A2A devices results in extremely good sensitivity and improved link budget.

CW "lead-in" time prior to the start of the modulation has been reduced in Si4x6x-C2A and Si4467/8-A2A relative to Si4x6x-B1B.

## 2.3. Wireless M-Bus support

The Si4x6x-C2A and Si4467/8-A2A devices support all Wireless M-Bus modes per the latest specification of the EN13757-4 standard. This includes a much wider deviation error tolerance of ±30% and frequency error tolerance of ±4 kHz, short preamble support (16 bit preamble for 2 and 4 level FSK modes) and 3 of 6 encoding/decoding support. Refer to application note, AN805: "Si446x Wireless MBUS Receiver" for more details of Wireless MBUS compliance and performance.

# 3. Hardware Recommendations

All the Si4x6x-B1B, Si4x6x-C2A and Si4467/8-A2A devices are pin-to-pin compatible and packaged into the same 4x4 mm 20-pin QFN package.

The architecture of the Receiver and Transmitter blocks of all the radios are similar, the matching network topologies are the same for all application examples. The radios can support different TX matching network topologies. Refer to the following application notes for more detail and comparison on the different topologies (these documents contain information for all the Si4x6x-B1B, Si4x6x-C2A, and Si4467/8-A2A devices):

- AN643: “Si446x/Si4362 RX LNA Matching”
- AN627: “Si4060/Si4460/61/67 Low-Power PA Matching”
- AN648: “Si4063/4463/64/68 TX Matching”

All the Si4x6x-B1B, Si4x6x-C2A, and Si4467/8-A2A devices can accommodate a wide range of crystal frequencies (25 to 32 MHz). Refer to the AN785: “Crystal Selection Guide for the Si4x6x RF ICs” for more details on crystal or TCXO selection.

# 4. Firmware Recommendations

## 4.1. Configuration Interface

All the Si4x6x-B1B, Si4x6x-C2A, and Si4467/8-A2A devices can be configured through a standard SPI interface with up to 10 MHz clock speed, utilizing the Application Programming Interface (API). The complete list of commands and their description are provided as an HTML document (available as the EZRadioPRO API Documentation ZIP file on the Silicon Labs web site).

In general, any API used for the Si4x6x-B1B devices can be used and functional the same way on the Si4x6x-C2A and Si4467/8-A2A devices as well. In this matter the new devices are backward FW compatible with the previous product family, however, there are few additional properties and API commands implemented in the new devices. The following chapters provide a detailed overview of these.

The radios are highly configurable. They have numerous properties that may need to be changed to achieve the desired operation. A PC GUI (WDS) is designed to help determine the necessary property settings. The user needs to set the desired configuration on a graphical user interface, and the tool provides example projects, batch files, or header files with the proper radio configurations. For more information about the WDS and the radio configurations, refer to the following application notes:

- AN632: “WDS User’s Guide for EZRadioPRO Devices”
- AN633: “Programming Guide for EZRadioPRO Si4x6x Devices”

## 4.2. Power On Sequence

### 4.2.1. IEEE 802.15.4 Boot Mode

The Si4467/8-A2A has two boot modes. One boot mode supports 802.15.4 functionality to enable standard-based, sub-GHz mesh networking with support for 802.15.4 MR-FSK PHY (15.4g) and key MAC (15.4) features (like clear channel assessment, CSMA/CA, Auto-acknowledgment, address filtering, etc.). In this mode, the device only processes 802.15.4 / 4g packets and no customization is possible at the packet level. This mode is supported by an 802.15.4 stack running on a Silicon Labs MCU or SoC. In this mode, the device only supports the packet format defined in the 802.15.4 standard.

### 4.2.2. Packet Trace Interface

The Si4467/8-A2A integrates a true PHY-level Packet Trace Interface (PTI) for effective network-level debugging. PTI monitors all the PHY Tx and Rx packets without affecting their normal operation. This asynchronous interface provides a trace of all over-the-air packet data as well as packet status via a single user-selectable GPIO. PTI is supported in the 15.4 boot mode only and is supported by Silicon Labs Development tools.

Please refer to the Si4467/8-A2A data sheet for more details regarding the 802.15.4 boot mode.

### 4.2.3. EZRadioPRO Boot Mode

The second boot mode called EZRadioPRO boot mode supports Si4463/1/0-B1B compatibility and is intended to support proprietary solutions that require additional flexibility in configuring the device. This mode is software- and hardware-compatible with Si4463/1/0-B1B and also supports 802.15.4g PHY and WM-Bus operation. The boot mode selection is done using the POWER_UP command and is described in the API documentation.

The power on sequence of the Si4x6x-B1B, Si4x6x-C2A devices and Si4467/8-A2A in EZRadioPRO boot mode are identical.

## 4.3. Patching the Si4x6x-C2A Devices

For the Si4x6x-C2A devices a software patch has to be used to update the internal FW of the chip for improved operation. The content of the firmware patch has to be downloaded into the radio chip each time after performing a power on reset but before issuing the POWER_UP command. Downloading the patch increases the time of the power-up sequence. For details see paragraph “9.6. Patching the Radio” of AN633:”Programming Guide for EZRadioPRO® Si4x6x Devices”.

## 4.4. Preamble Sense Mode

This mode of operation is suitable for extremely low power applications where power consumption is important. The preamble sense mode (PSM) takes advantage of the Digital Signal Arrival detector (DSA), which can detect a preamble within eight bit times with no sensitivity degradation. In PSM operation this fast detection of an incoming signal is combined with duty cycling of the receiver during the time the device is searching or sniffing for packets over the air. The average receive current is lowered significantly when using this mode. In applications where the timing of the incoming signal is unknown, the amount of power saving is primarily dependent on the data rate and preamble length as the Rx inactive time is determined by these factors. In applications where the timing of the incoming signal is known and the sleep time is fixed, the average current also depends on the signal detection time.

The DSA can be combined with Low Duty Cycle mode, RX Hop and antenna diversity features to further reduce the current consumption in various Receive modes.

The following WDS example projects support the PSM or DSA operation:

- Custom packet RX project supports the PSM operation. The user needs to define the length of the transmitted preamble and the data rate only. The WDS will then calculate the corresponding properties and configure the radio duty cycling.
- LDC Rx project can be combined with DSA. Low Duty Cycle mode cycles between sleep and active Receive modes. Even though the active Receive time period is relatively short compare to the sleep time, the DSA can further reduce receive time to further reduce the average current consumption. In order to utilize this feature, the user need to enable the DSA for the LDC Rx project. WDS will configure the radio autonomously.
- Auto RX Hop project can be combined with DSA. Use of the DSA detector will reduce time spent to detect empty channel in order to reduce the average current consumption. In order to utilize this feature, the user need to enable the DSA for the Auto Rx Hop project. WDS will configure the radio accordingly.
- Antenna diversity can be enabled for various example projects. Any cases when the antenna diversity is enabled, the DSA is enabled as well. DSA helps to minimize time and the required preamble bits to evaluate the receive performances of the different antennas.

Refer to the data sheet and the relevant application note for more details of the Preamble Sense Mode and Digital Signal Arrival detector.

## 4.5. IEEE 802.15.4 PHY Support in EZRadioPRO Boot Mode

### 4.5.1. Dual Sync Word Detection

The Si4467/8-A2A devices are capable of simultaneously searching for two sync words with each sync word being user defined and up to four bytes long, in EZRadioPRO boot mode as well. One application of this is to detect packets that use forward error correction (FEC) as defined in IEEE 802.15.4g. The FEC is an optional feature in the standard and is indicated in the sync word. The transceiver does not natively support FEC. It can pass on the information on whether FEC is used or not to the host microcontroller for further processing.

### 4.5.2. Alternative CRC Engine

An alternative CRC engine is introduced that runs in parallel with the primary CRC engine, and can be configured similarly. See ALT_CRC related fields in the API document.

## 4.6. Legacy Packet Format Support

In order to further enhance the flexibility of the Si4x6x-C2A and Si4467/8-A2A devices, the following improvements were made in the packet handler, PA, and modem.

- The devices autonomously handle the error case when a packet is received with packet length of 0.
- New UPDATE argument of START_TX and START_RX commands makes possible to update RX parameters (to be used by a subsequent packet) without entering TX/RX mode.
- Start RX on WUT expiry when LDC mode is not used is now supported. See START field of arguments of the START_TX command.
- Added new command to hop to a new frequency while in TX, called TX_HOP.
- Transmission of content of TX FIFO can be repeated by using NUM_REPEAT argument of START_TX.
- An added property bit (called PN_DIRECTION) can reverse the direction how bits are shifted during whitening operation. This improvement ensures that the radios can handle any kind of data whitening operation up to 16 bits natively by the packet handler. Refer to the API document for more details.
- A new 32 bit property PKT_CRC_SEED allows setting of CRC seed to any value.
- The resolution of the FIFO Almost Full / Empty detection is improved to 4 bytes compared to the previous 7 bytes.
- Sync word length resolution is improved to 2 bits. Relevant API field is LENGTH_SUB of SYNC_CONFIG2.
- SYNC_ERROR_ONLY_BEGIN field of SYNC_CONFIG2 confines allowed sync bit errors to the beginning of the sync.
- CRC bit order can be controlled using CRC_BIT_ENDIAN field of PKT_CONFIG2.
- 3 of 6 encoding/decoding introduced. EN_3_OF_6 bit of PKT_CONFIG2 enables it for all five fields and the CRC.
- New LDC_MAX_PERIODS field of GLOBAL_WUT_R configures how many LDC periods to wait for an incoming packet to be received after preamble or sync has been detected.
- INFINITE_LEN field of PKT_LEN allows for an infinite length packet to be received.
- New property PA_DIG_PWR_SEQ_CONFIG provides for much slower ramp times of the internal PA.
- Ability to generate an interrupt on latched RSSI (RSSI_LATCH_PEND bit of MODEM_PEND) allows autonomous RSSI evaluation in LDC mode.
- New properties MODEM_RSSI_HYSTERESIS, MODEM_RSSI_MUTE and MODEM_FAST_RSSI_DELAY allow improved RSSI operation.

## 4.7. Si4x6x-B1B Errata

All issues listed in the “Si4x6x-B1B and Si4438-B1C Errata” are fixed in the Si4x6x-C2A devices.


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