MC1321x Evaluation Kit (EVK)

Reference Manual

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freescale™
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About This Book

This manual provides a detailed hardware description of the MC1321xEVK which consists of a 13213-Network Coordinator Board (13213-NCB) and a 13213-Sensor Reference Board (13213-SRB). The functionality of the 13213-NCB and 13213-SRB boards is very similar. The primary difference between the two boards revolves around the peripheral circuits, not in the reference design itself.

The 13213-NCB and 13213-SRB provide all the necessary components to evaluate and use the MC1321x solution. The 13213-NCB and the 13213-SRB are built around the Freescale MC1321x family. The MC1321x family is Freescale's second-generation ZigBee platform which incorporates a low power 2.4 GHz radio frequency transceiver and an 8-bit microcontroller into a single 9x9x1 mm 71-pin LGA package.

The 13213-NCB and the 13213-SRB are compliant with the following standards:

- FCC standard 47 CFR, part 15, section 15.247
- ETSI EN 300-328-1
- ETSI EN 300-328-2

Audience

This document is intended for software, hardware, and system engineers who are developing their products or software applications making use of the MC1321x to achieve wireless connectivity capability. The MC1321x is compliant with the IEEE 802.15.4 and the ZigBee standards.

Organization

This document is organized into four (4) chapters.

Chapter 1	**Safety Information** — This chapter describes the safety guidelines for the MC1321xEVK.
Chapter 2	**System Overview** — This chapter introduces the basic components, functionality, and power supply options of the MC1321xEVK boards.
Chapter 3	**RF Front End** — This chapter provides a description of the external analog circuitry required to ensure proper MC1321x operation.
Chapter 4	**MC1321xEVK Interfaces and Layout** — This chapter briefly describes the available interfaces between the EVBs and a personal computer (PC) and provides component and board layout information.

Revision History

The following table summarizes revisions to this document since the previous release (Rev. 1.0).

Revision History

Location	Revision
Section 2	Add board pictures
Section 3.1 and 3.2	All new material
Section 4	New drawings and schematics

Definitions, Acronyms, and Abbreviations

The following list defines the acronyms and abbreviations used in this document.

ATD	Analog To Digital
BDM	Background Debug Module
CPU	Central Processing Unit
EEPROM	Electrical Erasable Programmable Read Only Memory
ESD	Electro Static Discharge
EVB	Evaluation Board
EVK	Evaluation Kit
GPIO	General Purpose Input Output
ICG	Internal Clock Generation
LDO	Low Drop Output
LNA	Low Noise Amplifier
MCU	Micro Controller Unit
NCB	Network Coordinator Board
PA	Power Amplifier
PC	Personal Computer
PCB	Printed Circuit Board
QFN	Quad Flat Non-lead package
RAM	Random Access Memory
RF	Radio Frequency
Rx	Receive
SCI	Serial Communication Interface
SMA	SubMiniature version A
SPI	Serial Peripheral Interface
SRB	Sensor Reference Board.
Tx	Transmit

References

The following sources were referenced to produce this book:

[1] MC1321x Data Sheet, MC1321xDS

[2] MC1321x Reference Manual, MC1321xRM

Chapter 1
Safety Information

1.1   FCC Guidelines

Any modifications to this product may violate the rules of the Federal Communications Commission and make operation of the product unlawful.

47 C.F.R. Sec. 15.21

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

47 C.F.R. Sec.15.105(b)

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. The antenna(s) used for this equipment must be installed to provide a separation distance of at least 8 inches (20cm) from all persons.

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.
2. This device must accept any interference received, including interference that may cause undesired operation.
3. This device is susceptible to electrostatic discharge (ESD) and surge phenomenon.

1.2   Disposal Instructions

This product may be subject to special disposal requirements. For product disposal instructions, refer to www.freescale.com/productdisposal.

Chapter 2
System Overview

This chapter introduces the basic components, functionality, and power supply options of the MC1321xEVK boards. The MC1321xEVK consists of the following two boards:

1. 13213-NCB Network Coordinator Board as shown in Figure 2-1.
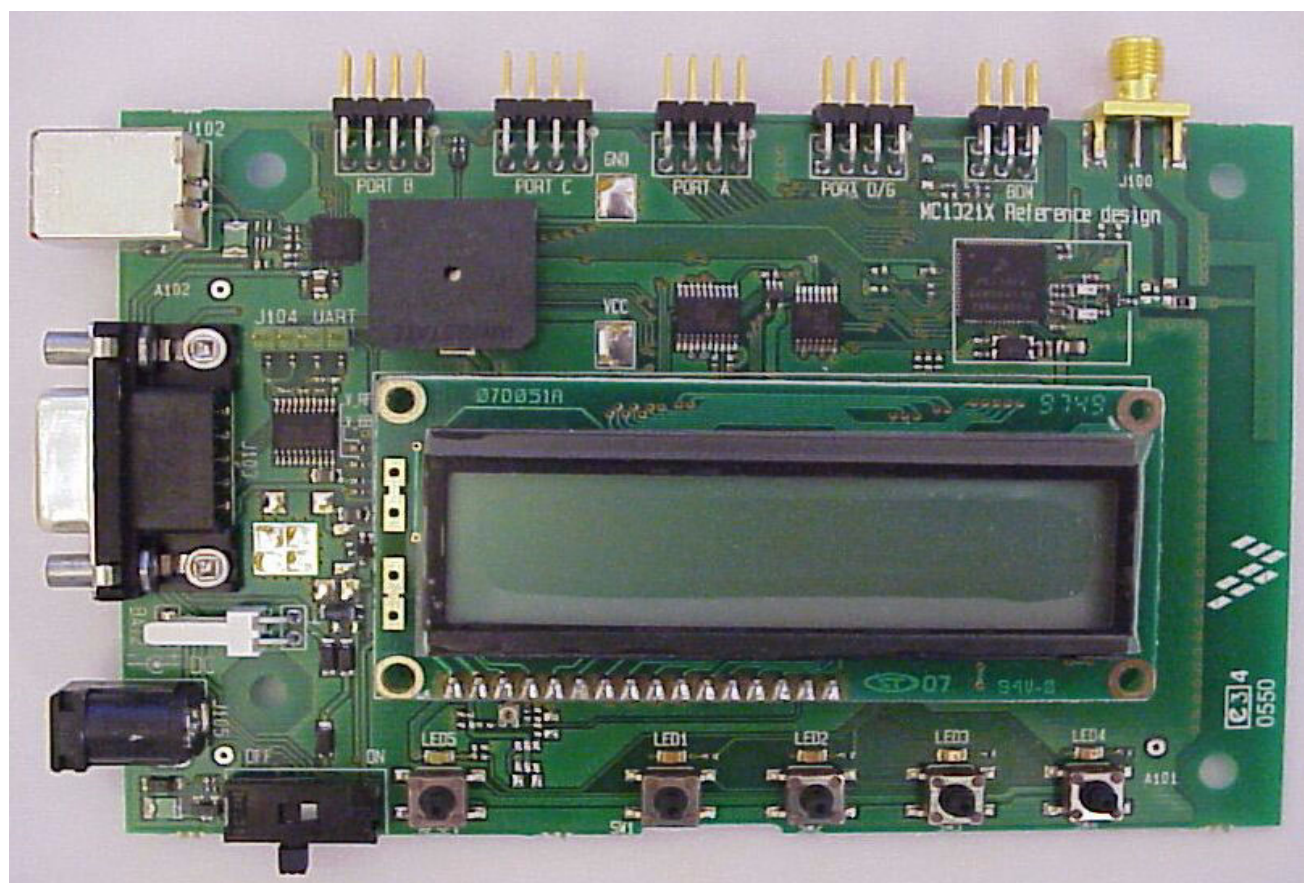
Figure 2-1. 13213-NCB

2. 13213-SRB Sensor Reference Board as shown in Figure 2-2.
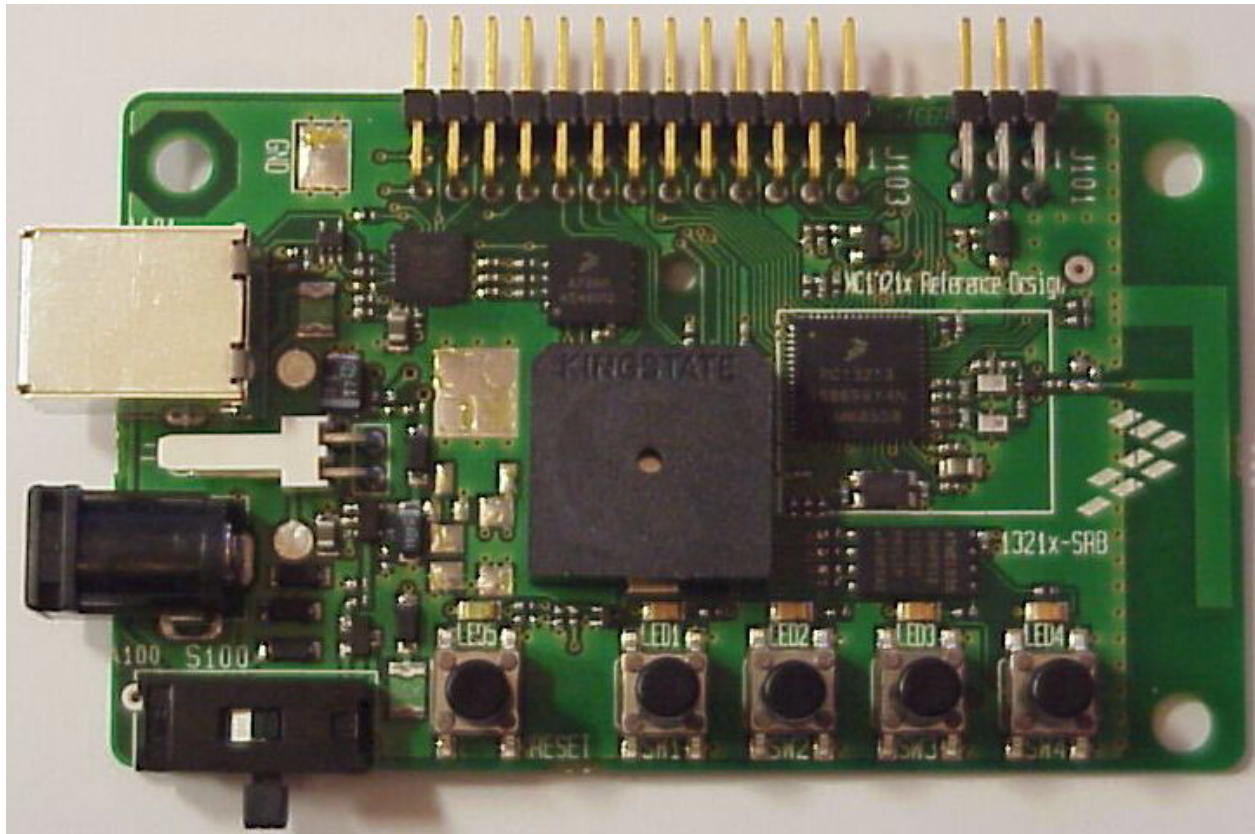
Figure 2-2. 13213-SRB

For information on how to setup the Freescale Zigbee/802.15.4 MAC primitives and the development environment, refer to the *802.15.4 MAC/PHY Software Reference Manual*, (802154MPSRM).

2.1 MC1321x Solution

The MC1321x series RF transceiver is an IEEE® 802.15.4-compliant radio that operates in the 2.4 GHz ISM frequency band. The transceiver includes a low noise amplifier, 1mW nominal output power, voltage controlled oscillator (VCO), integrated transmit/receive switch, on-board power supply regulation, and full spread-spectrum encoding and decoding.

The MC1321x series microcontroller unit is based on the HCS08 Family of Microcontroller Units (MCU) and can provide up to 60KB of flash memory and 4KB of RAM. The onboard MCU allows the communications stack and also the application to reside on the same system-in-package (SiP). The MC1321x family is organized as follows:

- The MC13211 has 16KB of flash and 1KB of RAM and is an ideal solution for low cost, proprietary applications that require wireless point-to-point or star network connectivity. The MC13211 combined with the Freescale Simple MAC (SMAC) provides the foundation for proprietary applications by supplying the necessary source code and application examples to get users started on implementing wireless connectivity.

- The MC13212 contains 32K of flash and 2KB of RAM and is intended for use with the Freescale fully compliant 802.15.4 MAC. Custom networks based on the 802.15.4 standard MAC can be implemented to fit user needs. The 802.15.4 standard supports star, mesh and cluster tree topologies as well as beaconed networks.

- The MC13213 contains 60K of flash and 4KB of RAM and is also intended for use with the Freescale fully compliant 802.15.4 MAC where larger memory is required.

- The MC13214 is a fully compliant ZigBee platform. The MC13214 contains 60K of flash and 4KB of RAM and uses the Figure 8 Wireless ZigBee Stack (Z-stack) software. Applications can be added to develop fully certified ZigBee products.

The MC1321x includes two independent serial communications interface (SCI) modules. These serial communications interfaces are connected to an RS-232 interface and a USB interface.

The MCU contains an analog to digital (ATD) converter module with 8 ports. A serial peripheral interface (SPI) module handles the data communication between the MCU and the transceiver.

The MC1321x is housed in a 71-pin quad flat non-lead package (QFN). 9x9mm and is 1mm in height.

2.2 General-Purpose I/O and Peripheral Ports

Thirty eight pins are shared among general-purpose I/O (GPIO) and on-chip peripheral functions. The MC1321x has six I/O ports, which include a total of up to 38 GPIO pins (one pin, PTG0, is output only). Six of those pins are used internally on the IC, but it is available for debugging and monitoring.

The MCU provides control for the 802.15.4 modem. The required interconnects between the devices are routed onboard the MC1321x SiP. In addition, the signals are brought out to external pads primarily for use as test points. These signals can be useful when writing and debugging software.

Many of these pins are shared with on-chip peripherals such as timer systems, external interrupts, or keyboard interrupts. When these other modules are not controlling the port pins, they revert to GPIO control.

Immediately after reset, all 38 of these pins are configured as high-impedance general-purpose inputs with internal pull-up devices disabled. The port allocation of the general-purpose I/O and on-chip peripheral functions on the EVB are listed in Table 2-1.

Table 2-1. GPIO Port Allocation

Port	13213-NCB Functionality	13213-SRB Functionality
PTA0/KBD0	(UART) (MC1321x CTS)	
PTA1/KBD1	(UART) (MC1321x RTS)	
PTA2/KBD2	(Switch 1)	(Switch 1)
PTA3/KBD3	(Switch 2)	(Switch 2)
PTA4/KBD4	(Switch 3)	(Switch 3)
PTA5/KBD5	(Switch 4)	(Switch 4)
PTA6/KBD6	(USB to UART) (CP2102 CTS)	(USB to UART) (CP2102 CTS)

Table 2-1. GPIO Port Allocation

Port	13213-NCB Functionality	13213-SRB Functionality
PTA7/KBD7	(USB to UART) (CP2102 RTS)	(USB to UART) (CP2102 RTS)
PTB0/AD0	LCD (LCD Enable)	X-Y-Z Axis Accelerometer (G - Select 1)
PTB1/AD1	LCD (Register Select)	X-Y-Z Axis Accelerometer (G - Select 2)
PTB2/AD2	LCD (Enable)	X-Y-Z Axis Accelerometer (X-OUT)
PTB3/AD3	LCD (Data Read/Write)	X-Y-Z Axis Accelerometer (Y-OUT)
PTB4/AD4	Data Line 4	X-Y-Z Axis Accelerometer (Z-OUT)
PTB5/AD5	Data Line 5	X-Y-Z Axis Accelerometer (Power Save)
PTB6/AD6	Data Line 6	Vout (Temperature Sensor)
PTB7/AD7	Data Line 7	VCC (Temperature Sensor)
PTC0/TxD2	(USB to UART) (CP2102 RXD)	(USB to UART) (CP2102 RXD)
PTC1/RxD2	(USB to UART) (CP2102 TXD)	(USB to UART) (CP2102 TXD)
PTC2/SDA	CS (EEPROM)	CS (EEPROM)
PTC3/SCL	Data (EEPROM)	Data (EEPROM)
PTC4	(LED5) Green	(LED5) Green
PTC5	CLK (EEPROM)	CLK (EEPROM)
PTC6	Data (EEPROM)	Data (EEPROM)
PTC7	(USB Suspend)	(USB Suspend)
PTD0	ATTNB	ATTNB
PTD1/RXTXEN	RXTXEN	RXTXEN
PTD2	(Buzzer)	(Buzzer)
PTD3/RSTB	RSTB	RSTB
PTD4	(LED1) Red	(LED1) Red
PTD5	(LED2) Red	(LED2) Red
PTD6	(LED3) Red	(LED3) Red
PTD7	(LED4) Red	(LED4) Red
PTE0/TxD1	(UART) (MC1321x Tx)	
PTE1/RxD1	(UART) (MC1321x Rx)	

Table 2-1. GPIO Port Allocation

Port	13213-NCB Functionality	13213-SRB Functionality
PTE2/CEB	CEB	CEB
PTE3/MISO	MISO	MISO
PTE4/MOSI	MOSI	MOSI
PTE5/SPICLK	SPICLK	SPICLK
PTE6	GPIO2	GPIO2
PTE7	GPIO1	GPIO1
PTG0/BKGD/MS	(BDM)	(BDM)
PTG1/XTAL		
PTG2/EXTAL	(CLKO)	(CLKO)

Table 2-2. Pin Number to Signal Cross Reference

Pin Number	MCU Signal	Transceiver Signal
43	PTE6	GPIO2
44	PTE7	GPIO1
46	PTD0	ATTNB
65	PTE5_SPSCK	SPICLK
66	PTE4_MOSI	MOSI
67	PTE3_MISO	MISO
68	PTE2_SS	CEB
69	IRQ	IRQB
70	PTD1	RXTXEN
71	PTD3	M_RSTB

For more details, see the *MC1321x Datasheet*, MC1321xDS.

2.3 Power-Saving Modes

The transceiver portion of the MC1321x uses the DOZE Mode as a power-saving mode. This mode greatly reduces current consumption and has a typical current consumption of 40 µA. The SPI controls when the transceiver enters and leaves DOZE mode on the MC1321x

The MCU portion of the MC1321x uses the STOP3 power-saving mode. The CPU, FLASH, and RAM are in standby in the STOP3 mode. Also, all of the clocks in the MCU, including the oscillator itself, are halted. Exiting the STOP3 mode is accomplished by the following:

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- Asserting RESET
- An asynchronous interrupt pin (IRQ or KBI)
- Through the real-time interrupt

2.4 Clock

The MC1321x MCU contains an internal clock generation (ICG) module. An internal square wave clock is fed from the MC1321x modem portion into the ICG module at the EXTAL pin on Port G. The clock frequency is 62.5 KHz.

The MC1321x provides several options for the system clock configuration. The modem requires a 16MHz crystal for its source oscillator and can also supply a selectable frequency clock out (CLKO). The CLKO frequency can be programmed for the following:

- 16 MHz
- 8 MHz
- 4 MHz
- 2 MHz
- 1 MHz
- 62.5 kHz
- 32.786+ kHz (default)
- 16.393+ kHz

The MCU also has an internal clock generator that can be used for start-up and when the modem is shutdown (for lowest power). The MCU internal reference is approximately 243 kHz.

2.5 Background Debug Module (BDM) Interface

A Background Debug Module (BDM) interface is available on the 13213-NCB and 13213-SRB. The BDM interfaces to the MCU provide an interface for programming the on-chip FLASH. The BDM connector provides the ability to connect a debug interface for development and for accessing different memory data.

The BDM interface can also be used for traditional debugging. Debugging is accomplished using the CodeWarrior IDE for HCS08.

2.6 Reset

The RESET is a dedicated pin with a built-in pull-up device. This pin is connected to the 6-pin BDM connector to allow a development system to directly reset the MCU. The MCU resets the 13213-NCB and 13213-SRB as part of its startup sequence when power is applied and the On/Off switch is turned on. If required, a manual external reset can be executed by pressing the reset switch. In all cases, the reset sequence resets the MCU, which in turn, resets the transceiver.

Chapter 3
RF Front End

This chapter provides a description of the external analog circuitry required to ensure correct operation of the MC1321x solution. This section primarily refers to the RF section of the MC1321x solution.

3.1   3.1 Transceiver Front-end

The MC1321x RF transceiver has an RF front-end which can be configured in two ways:

1. Single-port I/O with integral RX/TX switch — Allows for very few external components.
2. Dual port with separate RX input/TX output and external switch — Allows for an external LNA and/or PA. (Also allows for an external low-loss RX/TX switch.). This solution is employed on the 13213-NCB for performance reasons (without LNA/PA).

Changing between single-port and dual-port modes is software controlled.
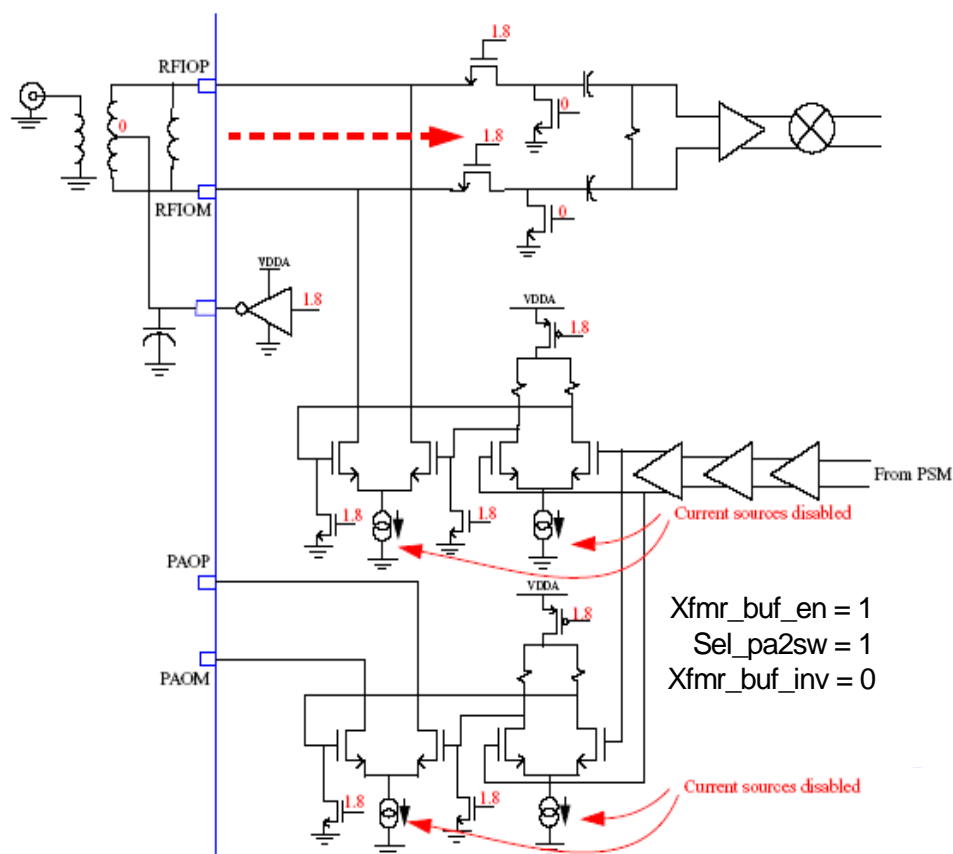
Figure 3-1. Single-port, internal RF Switch

To enable the internal RX/TX switch and single-port mode, enable PA2 and disable PA1. This is accomplished by setting the `Sel_pa2sw` parameter to 1.

```
Xfmr_buf_en = 1
Sel_pa2sw = 1
Xfmr_buf_inv = 0
```

The common input and output pins should also be biased to 0V in RX mode and VDDA (1.8V) in TX mode. This allows correct operation of the switch and PA2. A built-in buffer/inverter is used and is set as follows:

```
Xfmr_buf_en = 1
Xfmr_buf_inv = 0
```

In dual-port mode, this buffer may be used to control an external switch.

Figure 3-2. Dual-port, external RF Switch

In dual-port mode, PA1 should be enabled and PA2 disabled. This is accomplished by setting the `Sel_pa2sw` parameter to 0.

The buffer can be either disabled, or used to control external circuitry. If disabled, set Xfmr_buf_en = 0

```
Xfmr_buf_en = 0
Sel_pa2sw = 0
Xfmr_buf_inv = 0
```
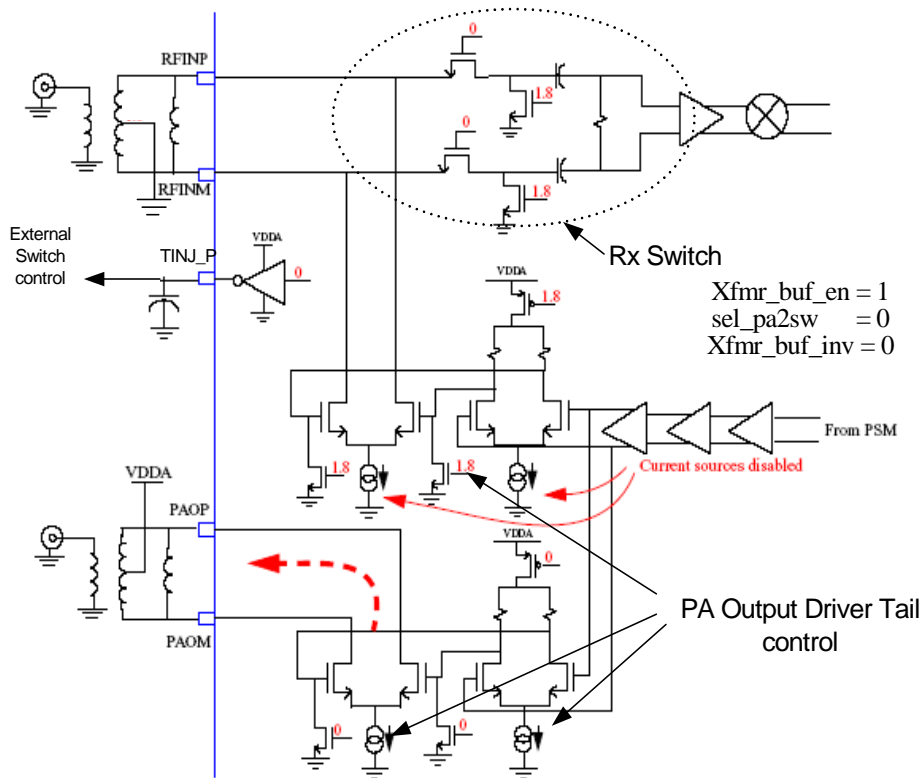
3.1.1   DC Biasing

To ensure correct operation, the inputs and outputs should have the following bias:

   •   RX inputs: Grounded.
   •   TX outputs: Connected to VDDA

The DC bias path is through the baluns and matching network. The external switch is supplied from GPIO1, which is high in RF active mode. The Xfmr_buffer output switches between RX and TX. This output is 1.8V only.

NOTE

> If the full - 40 to 85° C temperature range is required, a buffer should be inserted to raise this control pin to the battery supply. At -40° C, 1.8 V may not be enough to correctly toggle the switch.

3.2   RF Matching

The differential output impedance of the MC1321x is approximately 300-450 ohms and 0.6 pF in parallel. The impedance is slightly different between RX and TX.

An LC-matching network steps the impedance down to 50 Ohms balanced and a small ceramic balun allows the differential to single-ended transformation. A 50:50 ohm balun is used.

Although the component values are slightly different for RX and TX to accommodate the different impedances, the overall function is the same. The low-pass LC network configuration reduces TX harmonics.

The center tap on the balun provides DC ground for the RX input pins and biases the TX output pins to VDDA. The TX balun is RF decoupled.

By desolder/solder a 0 ohm resistor to another position, it is possible to select between the on-board F-antenna or the SMA connector (J100). The SMA connector may only be used for conducted RF measurement.

3.3   On-board Antenna

For ease of use, a PCB F-antenna resides on the board. The antenna bandwidth measured an approximate –10 dB return loss point at approximately 350 MHz. The resonant frequency is 2.44 GHz.

Mounting the board in a kit box causes the antenna resonant frequency to shift slightly down in frequency, but due to the high bandwith, this does not have any functional effects.

   •   Return loss across the ISM band is better than –15 dB
   •   The radiation pattern is omnidirectional and is very efficient
   •   The antenna is enabled (default)

3.4 Internal Power Supplies

The MC1321x has built in voltage regulators for the internal RF circuits (1.8V nominal). RF performance is not affected by varying supply voltage and the regulators provide some noise suppression allowing less stringent supply requirements.

3.4.1 RF Section

Input is VBATT and VDDINT. The recommended operating range is 2.0-3.3V (3.6V absolute maximum). This should be decoupled with 1 uF capacitor or more.

The three outputs (VDDA + VDDLO1 + VDDLO2, VDDD and VDDVCO) should each be decoupled with 100 nF capacitor to ensure stability and low noise. The value is not critical.

3.4.2 Digital Section

Input is VDD and VDDAD. Recommended decoupling is 100 nF on each input.

The Operating range is 2.05 –3.3V with 3.6V being the absolute maximum.

3.5 Reference Oscillator

The MC1321x reference oscillator is a very low power oscillator to save battery consumption in Sleep and Doze Modes.

The current consumption is controlled by software. The default value is 12 uA. In Doze Mode, it is possible to lower the current to 6 uA, but this sets tighter requirements on the XTAL to ensure oscillation.

The Reference frequency is 16.000 MHz only. CLK0 supplies the MCU with a clock.

To fulfill the 802.15.4 Standard requirements, the reference frequency must be within $\pm$ 40 ppm of nominal. This includes the following:

- Initial tolerance
- Aging
- Crystal temperature drift
- Spread on the external loading capacitors

The MC1321x has a built-in trimming facility that allows the initial tolerance to be calibrated out during production.

For –10 to 60 °C operation, the following crystal is recommended:

- KDS ZD00882

For –40 to +85 °C operation, the following crystals are recommended:

- NDK (LN-G102-1341)

- Toyocom (OUT1-2B-4395)
- KDS (ZD01812)

NOTE

Some of these crystals require different values of the external loading capacitors to center the frequency.

3.6   RF Performance

The following performance has been measured on the 13213-NCB and 13213-SRB boards as referenced to the SMA connector. Stated typical measured values and spread represents actual measurements on 10 boards, indicating the performance that can be expected. These values does not represent guaranteed performance.

3.6.1   TX Power

The output power is software adjustable with a tuning range of more than 20 dB.

The default power setting (Register 12: BC) is -1 dBm. This is a slight compromise between output power and current consumption. The obtainable maximum output power is 3 dBm. This setting assumes a higher current consumption can be tolerated.

Tolerance: ±1 dBm

The 802.15.4 Standard requirement is greater than -3 dBm.

3.6.2   Harmonics

2nd harmonic is typically -40 dBm or lower.

3rd harmonic is low, but does not exceed -75 dBm.

The 802.15.4 Standard requirement is less than -30 dBm

3.6.3   RX Sensitivity

Sensitivity was measured at -95 dBm, ±2 dBm (1% PER, 20 byte payload).

The 802.15.4 Standard requirement is less than -85 dBm.

Chapter 4
MC1321xEVK Interfaces and Layout

The MC1321xEVK boards can communicate with the Freescale Test Tool (a software tool suite that runs on a PC) either through the USB or RS-232 port.

4.1   Power Supply

The primary voltage supply for the 13213-NCB and 13213-SRB is 3.3V. This voltage is generated by the Low Dropout (LDO) regulators. Several LDO options are available. The board can be supplied from any of the following:

- USB port on a PC
- 9V DC voltage adapter (PHIHONG type PSA-05R-090)
- Two (2) AA (LR6) batteries

NOTE

Do not use a Lithium battery.

The 13123-NCB has an option to supply the display with 5.0V from a specific LDO. Display contrast may need to be adjusted using PT200.

The 3.3 V supply is split into various blocks such as, RF, LNA, BB, and others with 0 ohm resistors. This allows users to measure current consumption of the various 13213-NCB and 13213-SRB blocks.

4.2   USB Interface

The MCU does not contain a dedicated USB port. To support USB, the boards use an all in one IC. This IC interfaces between the UART and the USB port on a personal computer (PC). Silicon Labs manufactures an IC (CP2102) (IC103) on the 13213-NCB and 13213-SRB. IC103 allows USB functionality and requires just a few external components. A simple setup requires only seven (7) components, including the USB-b connector. R120 and R121 act as the driver output impedance of 27 Ohms on the D+ and the D- pins. IC103 is clocked by its own oscillator and it is wired to microcontroller SCI2, with the following four connections:

1. TXD
2. RXD
3. /RTS
4. /CTS

IC103 is supplied from the USB port and has a 3.3V, 100mA, built-in LDO. The USB port from either the PC or the HUB, must be able to supply the 13213-NCB and 13213-SRB including IC103. The CP2102

design supports an internal EEPROM. This supports a chosen vendor ID which can be displayed in the Freescale Test Tool.

4.3   RS-232 Interface

The RS-232 can be used as an alternative interface to the 13213-NCB. A level shifter made by Maxim (MAX3318E) is the interface between the MC1321x and the PC. The Maxim IC only requires four capacitors to generate the RS-232 compliant signal levels. IC102 is wired to the MCU at SCI1, with the following four connections:

1. TXD
2. RXD
3. /RTS
4. /CTS

IC104 is supplied with 3.0 V from the on board LDO.

4.4   Display

The 13213-NCB contains a 2x16 character, 5*7cm matrix display. The display design allows for using multiple display vendors as needed. The display needs a voltage below GND for driving the contrast adjustment. This is accomplished by adding a voltage converter Vin = -Vout. Another option is to use the V- from the RS232 level shifter (IC102). The negative voltage can be chosen by moving zero ohm resistors R211, R210, and R209. Some display vendors offer an onboard negative voltage.

Some displays require 5VDC. If a 3V display is chosen, R126 may be mounted and the 5V LDO can be removed.

IC200 and IC201 are the interface between the display and the MC1321x.

4.5   EEPROM (IC104)

A serial Electrically Erasable Programmable Read-Only Memory (EEPROM) part number AT25HP512, is mounted on the EVBs and connected directly to the MC1321x. The EEPROM provides 524,288 bits of serial EEPROM organized as 65,536 words of 8-bits each, which allows users to store additional software for applications. The EEPROM is optimized for use in many industrial and commercial applications where high-speed, low-power, and low-voltage operation are essential.

The EEPROM is enabled through the Chip Select pin (CS) and accessed through a 3-wire interface consisting of the following:

- Serial Data Input (SI)
- Serial Data Output (SO)
- Serial Clock (SCK)

All programming cycles are completely self-timed and no separate erase cycle is required before a write.

4.6   Sensors

4.6.1   XYZ Sensor (IC105)

The XYZ sensor (MMA7260Q) is only available on the 13213-SRB. The MMA7260Q low cost, capacitive, micromachined accelerometer features the following:

- Signal conditioning
- A1-pole low pass filter
- Temperature compensation
- g-Select (which allows for the selection among 4 sensitivities)
- Zero-g offset full scale span (factory set and require no external devices)
- Filter cut-off (factory set and require no external devices)

The sensor is connected directly to the MC1321x with a small RC filter using the ADC port.

4.6.2   Temperature Sensor (IC109)

The temperature sensor is a National Semiconductor device (LM61B) and is only available on the 13213-SRB. The LM61B is a precision integrated-circuit temperature sensor that can sense a -30°C to +100°C temperature range. The LM61B output voltage is linearly proportional to Celsius (Centigrade) temperature (+10 mV/°C) and has a DC offset of +600 mV. The nominal output voltage of the LM61B ranges from +300 mV to +1600 mV for a -30°C to +100°C temperature range. The LM61B is calibrated to provide accuracies of ±2.0°C at room temperature and ±3°C over the full -25°C to +85°C temperature range.

The LM61B linear output, +600 mV offset, and factory calibration simplifies the external circuitry required in a single supply environment where reading negative temperatures is required.

Shutdown capability for the LM61B is intrinsic because its inherent low power consumption allows it to be powered directly from the output of many logic gates.

An option on the 13213-NCB or 13213-SRB can power the LM61B from an MCU port to reduce power consumption.

4.6.3   Audio Indicator (PZ100)

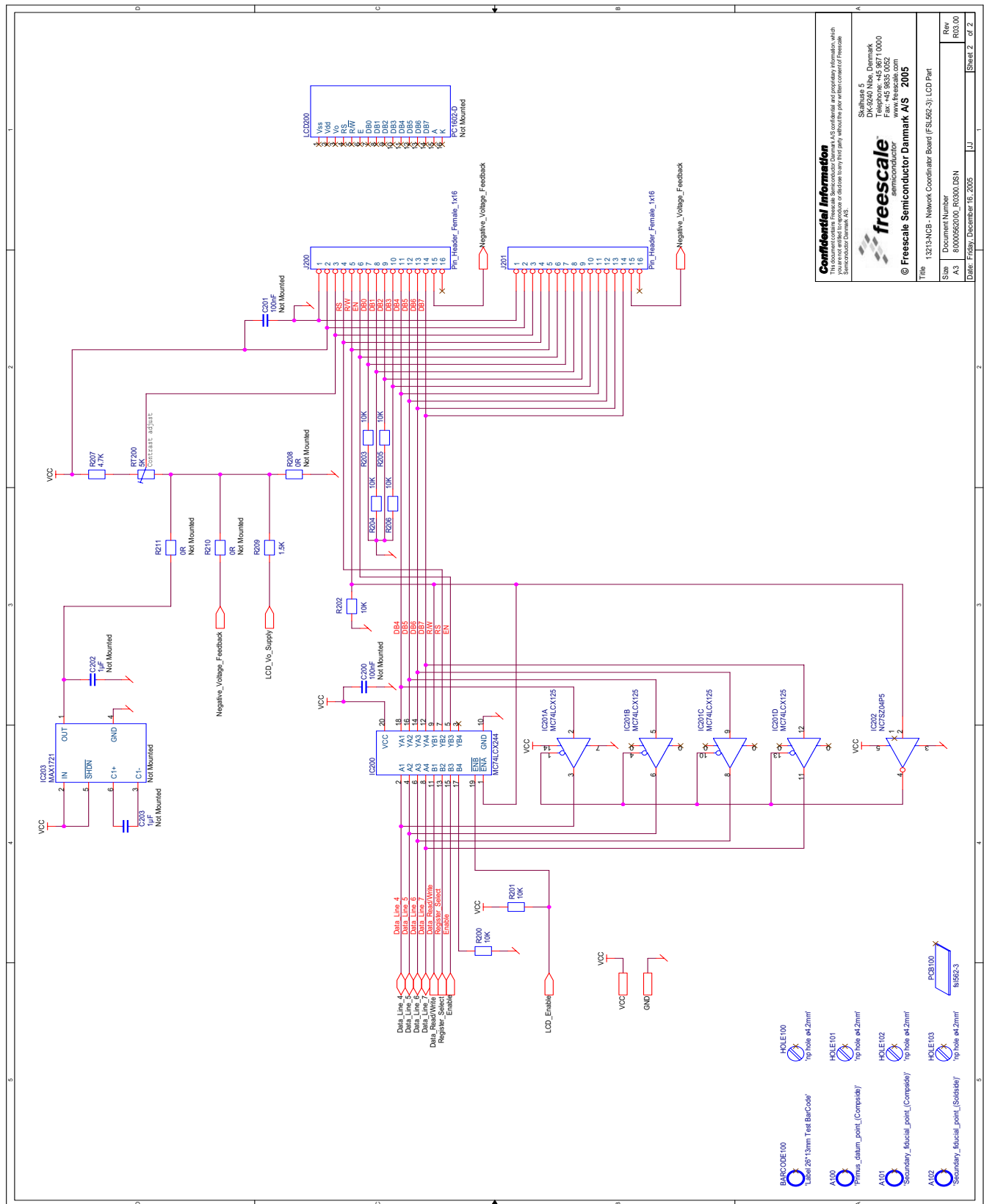A software controlled buzzer is mounted on the EVBs and connected to the MC1321x.

4.7   13213-NCB Schematic

Figure 4-1. 13213-NCB Schematic (1 of 2)

Figure 4-2. 13213-NCB Schematic (2 of 2)

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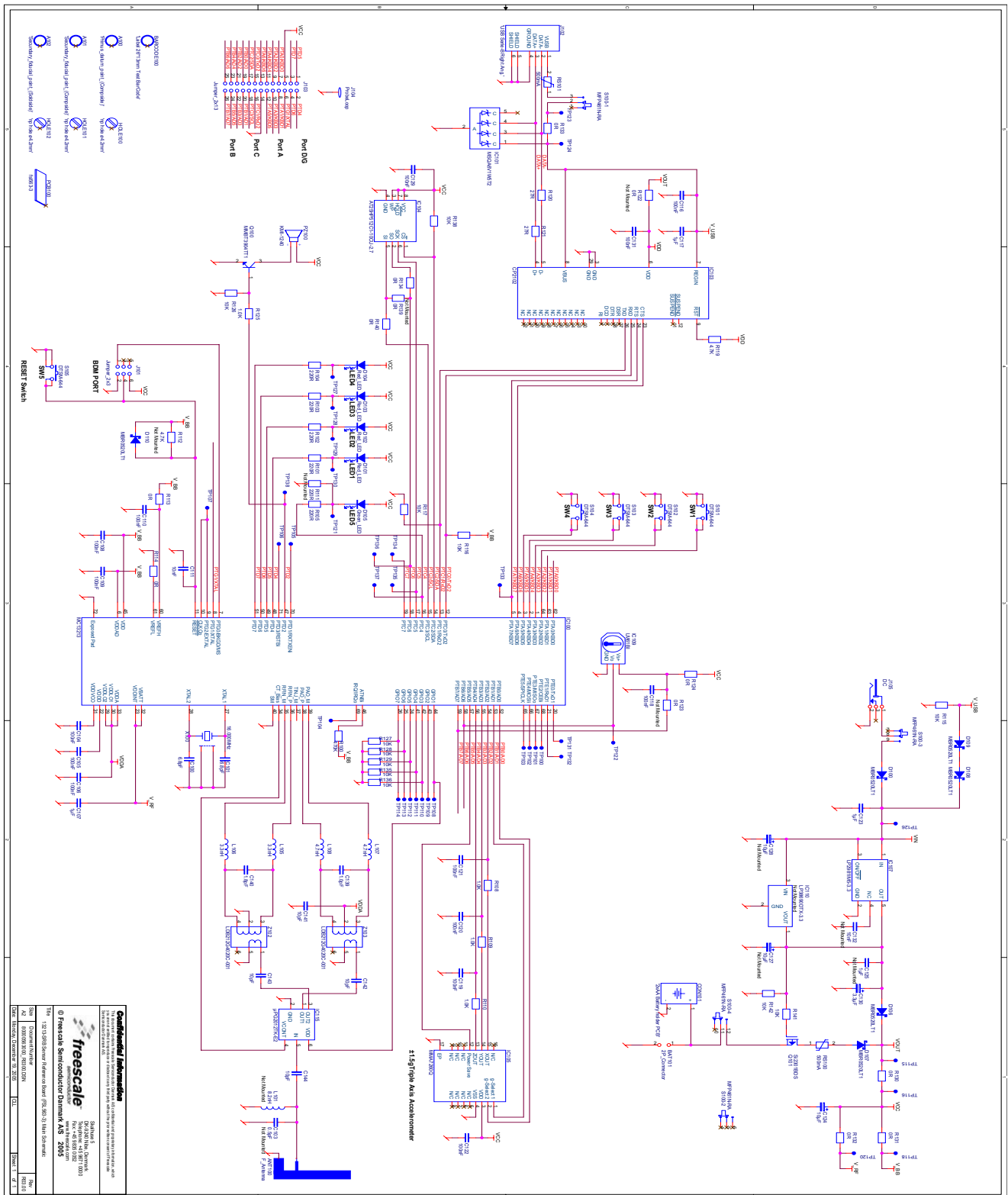
4.8 13213-SRB Schematic

Figure 4-3. 13213-SRB Schematic

4.8.1   PCB build

The PCBs are two layer boards and contain no blind, buried, or micro vias. The PCB is 85 x 125 mm.

The base material (laminate) meets the following requirements:

- Base laminate material: FR4
- Layers 1 and 2: FR4 core = (1000µm)
- The copper foil outer layers 18 µm + plating, approximately 30-35 µm
- All pad plating is lead-free, Hot Air Levelling (HAL).

4.8.2   Component Placement

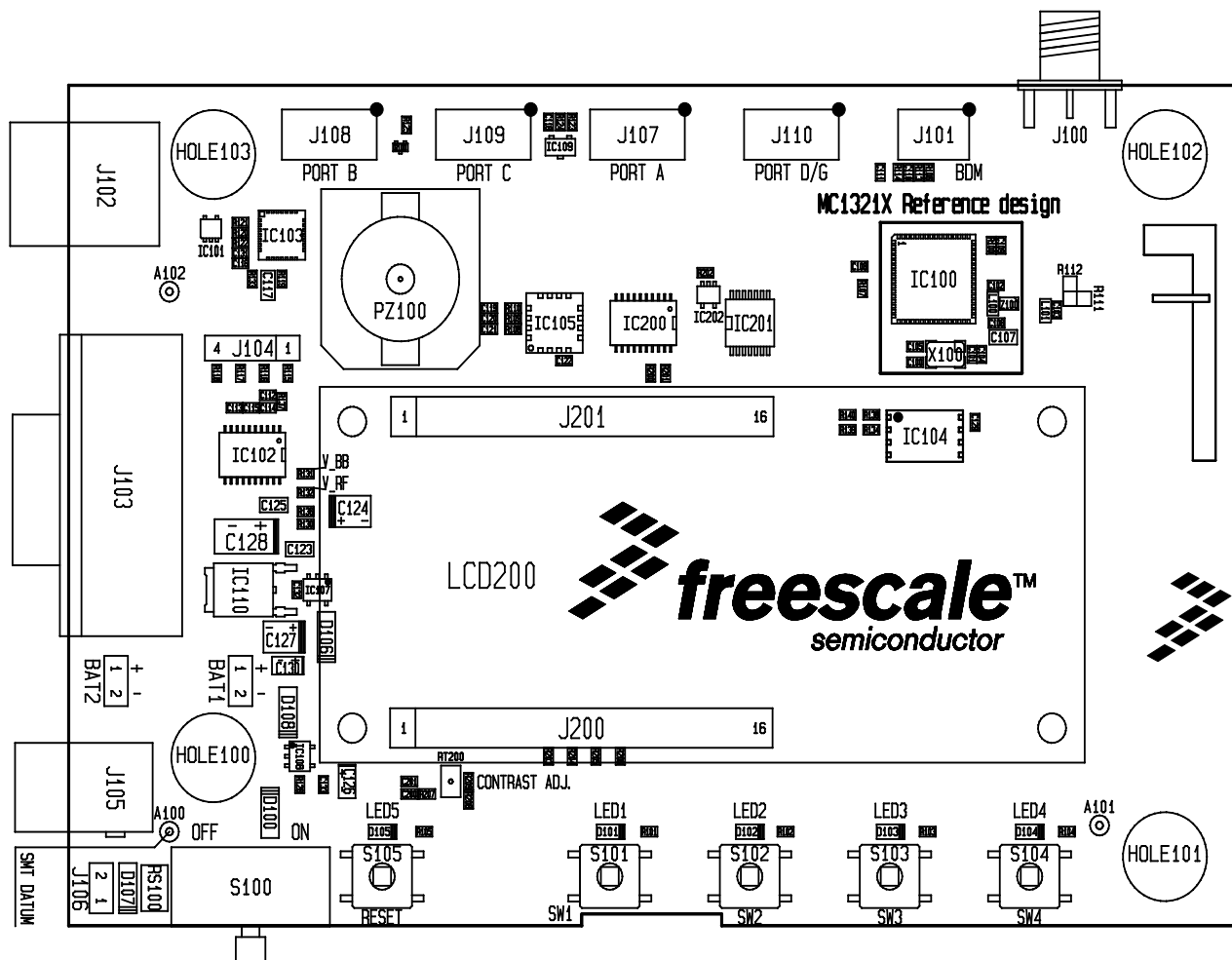The following figures show PCB component placement on the 13123-NCB and 13123-SRB.

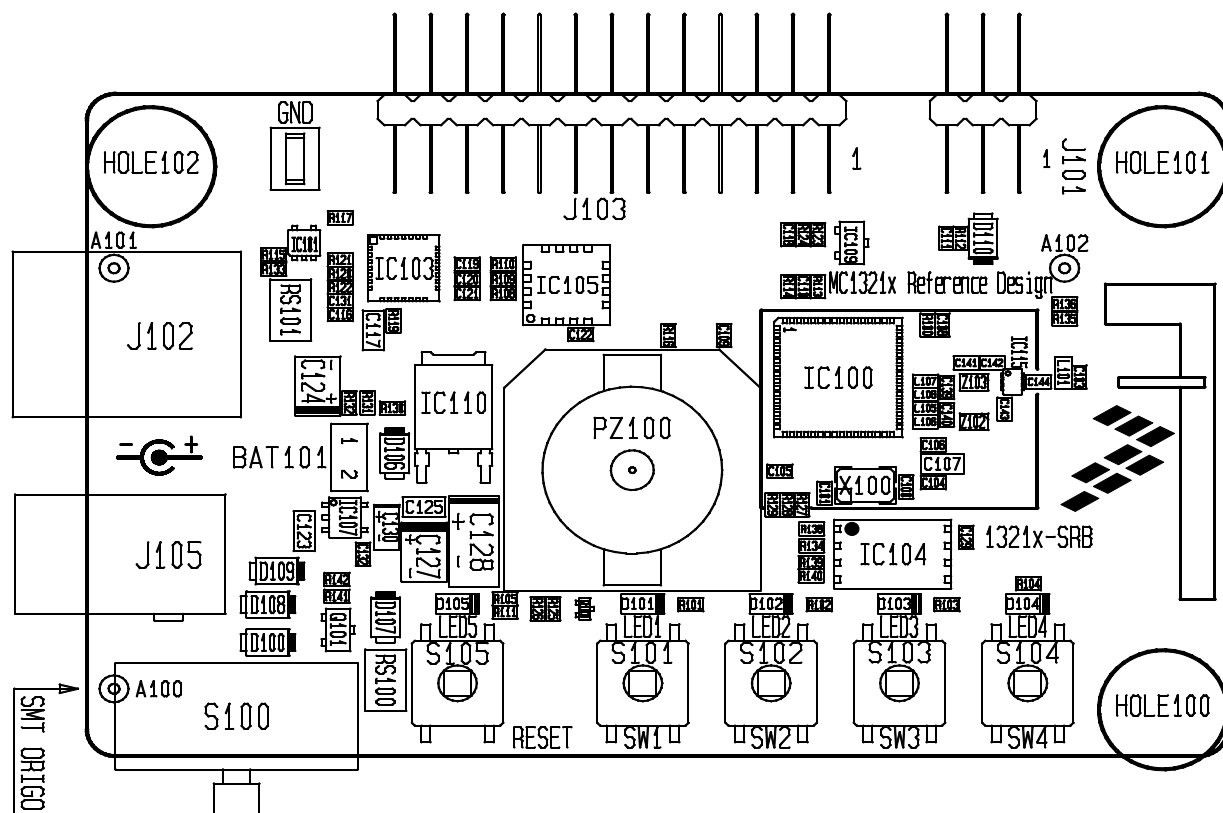

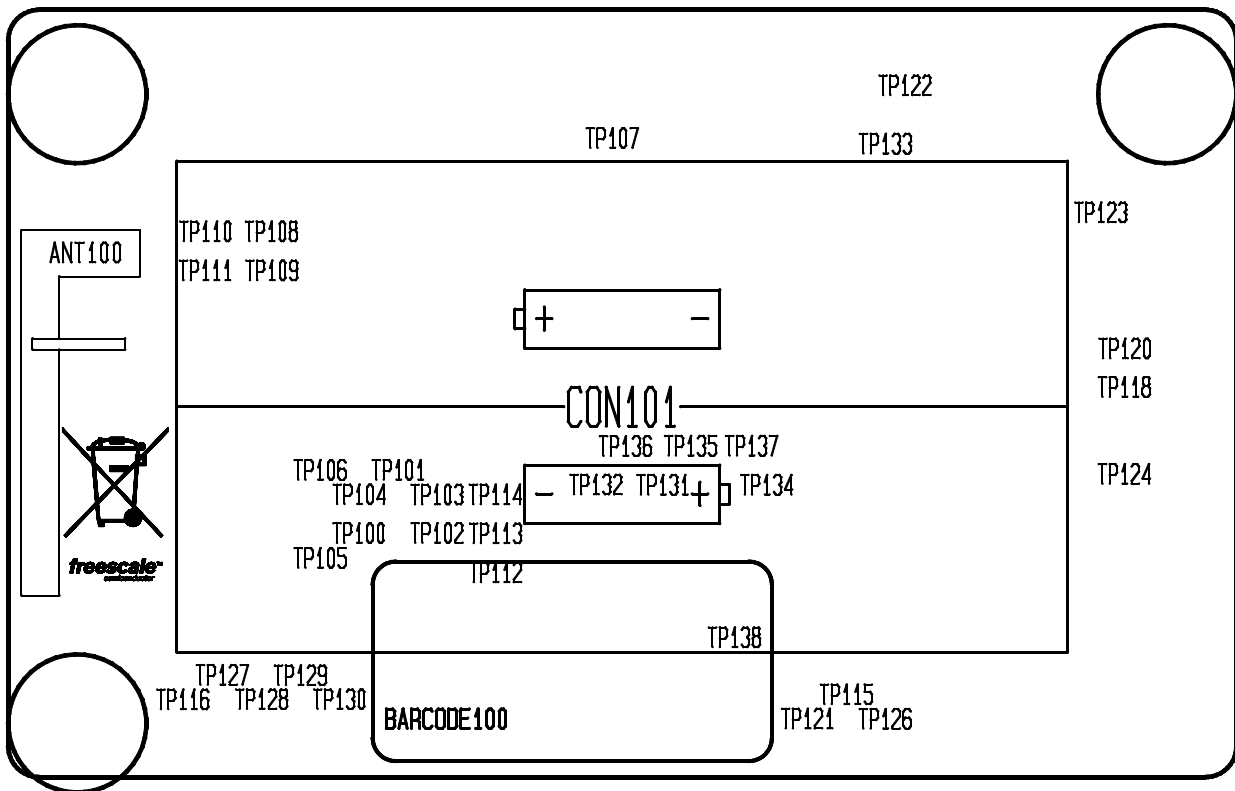**Figure 4-4. 13213-NCB PCB Component Layout (Top View)**

Figure 4-5. 13213-SRB PCB Component Layout (Top View)

Figure 4-6. PCB Test Points