

1323x Development Hardware

Reference Manual

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About This Book

This manual describes Freescale’s MC1323x development platform hardware. The MC1323x development platform is an IEEE 802.15.4 compliant evaluation environment based on the Freescale MC1323x device. The heart of the MC1323x platform is Freescale’s low cost System-on-Chip (SoC) for the IEEE® 802.15.4 Standard that incorporates a complete, low power, 2.4 GHz radio frequency transceiver with Tx/Rx switch, an 8-bit HCS08 CPU, and a functional set of MCU peripherals into a 48-pin LGA package. This family of products is targeted for wireless RF remote control and other cost-sensitive applications ranging from home TV and entertainment systems such as ZigBee BeeStack Consumer (RF4CE) to low cost, low power, IEEE 802.15.4 and ZigBee end nodes.

Audience

This manual is intended for system designers.

Organization

This document is organized into 6 chapters.

- Chapter 1 Safety Information — Highlights some of the FCC requirements.
- Chapter 2 HCS08 Development Platform Overview and Description — Provides an overview of the three boards that comprise the MC1323x development platform.
- Chapter 3 Modular Reference Board — This chapter details the 1323x-MRB which is an IEEE, 802.15.4 compliant evaluation board based on the Freescale MC1323x device.
- Chapter 4 1323x-Remote Control Module — This chapter details the 1323x-RCM motherboard that accepts the 1323x-Modular Reference Board (1323x-MRB) plug-in module (daughter card) and supplies a power supply and a rich set of interface peripherals.
- Chapter 5 1323x-Remote Extender Board — This chapter details the 1323x REM motherboard that accepts the 1323x-Modular Reference Board (1323x-MRB) plug-in module (daughter card) and supplies a power supply and set of interface peripherals.
- Chapter 6 PCB Manufacturing Specifications — This chapter provides the specifications used to manufacture the various MC1323x printed circuit boards (PCBs).

Revision History

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

Revision History

Location	Revision
Chapter 5	Inserted missing page 2 of REM schematic.

Definitions, Acronyms, and Abbreviations

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

ADC	Analog to Digital Converter
AES	Advanced Encryption Standard
ARM	Advanced RISC Machine
CTS	Clear to Send
DAC	Digital to Analog Converter
DMA	Direct Memory Access
I2C	Inter-Integrated Circuit is a multi-master serial computer bus
ISM	Industrial Scientific Medical 2.4 GHz radio frequency band
JTAG	Joint Test Action Group
LGA	Land Grid Array
MAC	Media Access Controller
MCU	Microcontroller Unit
NEXUS	An embedded processor development tool interface that helps design engineers identify software and hardware-level issues.
PCB	Printed circuit board
PiP	Platform in Package
PWM	Pulse-width modulation
RCM	Remote Control Module
REM	Remote Extender Board
RTS	Request to Send
SMA Connector	SubMiniature version “A” connector
SPI	Serial Peripheral Interface
SSI	Synchronous Serial Interface
TACT Switch	A switch that provides a slight “snap” or “click” to the user to indicate function.
TELCO	Telephone Company
USB	Universal Serial Bus
VCP	Virtual Com Port

Chapter 1

Safety Information

1.1 FCC Guidelines

This equipment is for use by developers for evaluation purposes only and must not be incorporated into any other device or system. This device may not be sold to the general public. Integrators will be responsible for reevaluating the end product (including the transmitter) and obtaining a separate FCC authorization.

FCC approval of this device only covers the original configuration of this device as supplied. Any modifications to this product, including changes shown in this manual, may violate the rules of the Federal Communications Commission and Industry Canada and make operation of the product unlawful.

1.1.1 Labeling

FCC labels are physically located on the back of the board.

1.1.2 Operating Conditions

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions:

- This device may not cause harmful interference.
- This device must accept any interference received, including interference that may cause undesired operation.

1.1.3 Exposure Limits

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.

1.1.4 Antenna Restrictions

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this Section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to carrier current devices or to devices operated under the provisions of Sections 15.211, 15.213, 15.217, 15.219, or 15.221. Further, this requirement does not apply to intentional

radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with Section 15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this Part are not exceeded.

1.2 Regulatory Approval For Canada (IC RSS 210)

This device complies with Industry Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions:

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

1.2.1 26 PART 5 – Appendix

Le présent appareil est conforme aux CNR d'Industrie 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
2. l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

1.3 Electrostatic Discharge Considerations

Although damage from electrostatic discharge (ESD) is much less common on these devices than on early CMOS circuits, normal handling precautions should be used to avoid exposure to static discharge. Qualification tests are performed to ensure that these devices can withstand exposure to reasonable levels of static without suffering any permanent damage.

All ESD testing is in conformity with the JESD22 Stress Test Qualification for Commercial Grade Integrated Circuits. During the device qualification ESD stresses were performed for the human body model (HBM), the machine model (MM) and the charge device model (CDM).

All latch-up test testing is in conformity with the JESD78 IC Latch-Up Test.

When operating or handling the development boards or components, Freescale strongly recommends using at least the grounding wrist straps plus any or all of the following ESD dissipation methods:

- Flexible fabric, solid fixed size, or disposable ESD wrist straps
- Static control workstations, static control monitors and table or floor static control systems
- Static control packaging and transportation materials and environmental systems

1.4 Disposal Instructions

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

Chapter 2

MC1323x Development Platform Overview and Description

2.1 Introduction

The MC1323x development platform is an IEEE 802.15.4 compliant evaluation environment based on the Freescale MC1323x device. The heart of the MC1323x platform is Freescale's low cost System-on-Chip (SoC) for the IEEE[®] 802.15.4 Standard that incorporates a complete, low power, 2.4 GHz radio frequency transceiver with Tx/Rx switch, an 8-bit HCS08 CPU, and a functional set of MCU peripherals into a 48-pin LGA package. This family of products is targeted for wireless RF remote control and other cost-sensitive applications ranging from home TV and entertainment systems such as ZigBee BeeStack Consumer (RF4CE) to low cost, low power, IEEE 802.15.4 and ZigBee end nodes.

The MC1323x development platform is comprised of three boards:

- 1323x-Modular Reference Board (1323x-MRB) - this board contains the MC1323x device with 32 MHz reference oscillator crystal, RF circuitry including antenna, and supporting circuitry. The board can be used as a simple standalone evaluation platform or as a daughter card to the other MC1323x development platform boards or to a custom, application specific motherboard. See [Chapter 3, “1323x-Modular Reference Board”](#) for detailed information.
 - Provides compact reference design for device footprint and RF layout
 - Provides pre-designed MC1323x hardware (device and function)
 - Provides access to the MC1323x full set of GPIO
 - Provides MCU BDM debug port
 - Provides optional local 2 Mbit serial FLASH, 32.768 kHz oscillator crystal, IR “blaster” LED and power management.
- 1323x-Remote Control Motherboard (1323x-RCM) - this board accepts the 1323x-MRB as a plug-in module (daughter card) and supplies a variety of peripheral functions to the MC1323x through the IO connectors. The peripheral functions are targeted primarily to a consumer TV or entertainment remote control application. See [Chapter 4, “1323x Remote Control Motherboard”](#) for detailed information.
 - Provides 36-switch matrix for remote control pushbuttons
 - USB \diamond serial interface for communication to a PC and provides board power
 - Touchpad for user interface
 - Onboard 128 x 32 pixel graphic LCD for menus and host feedback - a unique feature to RF-based remote controls
 - Accelerometer for motion detection and game play
- 1323x-Remote Extender Motherboard (1323x-REM) - this board also accepts the 1323x-MRB plug-in module (daughter card) and supplies a very simple set of peripheral functionality. See

Chapter 5, “1323x Remote Extender Motherboard” for detailed information. A small 8-switch matrix, IR receiver, and USB interface provides means for communication to the MC1323x for:

- Simple keypad-only applications
- Connection to a PC
- Host connection such as for a remote control extender or remote control receiver

Whether the 1323x-MRB is used in a simple standalone application or in combination with another host card, Freescale provides a complete software development environment called the Freescale BeeKit Wireless Connectivity Toolkit (BeeKit). BeeKit is a comprehensive codebase of wireless networking libraries, application templates, and sample applications. The BeeKit Graphical User Interface (GUI) allows users to create, modify, and update various wireless networking implementations. A wide range of software functionality is available to complement the 1323x-MRB and these are provided as codebases within BeeKit.

2.2 Features

The MC1323x development platform is built around the concept of having a single daughter card (1323x-MRB) that contains the MC1323x IC and all necessary I/O connections for use as a self-contained module or for connection to an application motherboard. Figure 2-1 shows a simplified block diagram of the more powerful Freescale configuration of the 1323x-MRB combined with the 1323x-RCM.

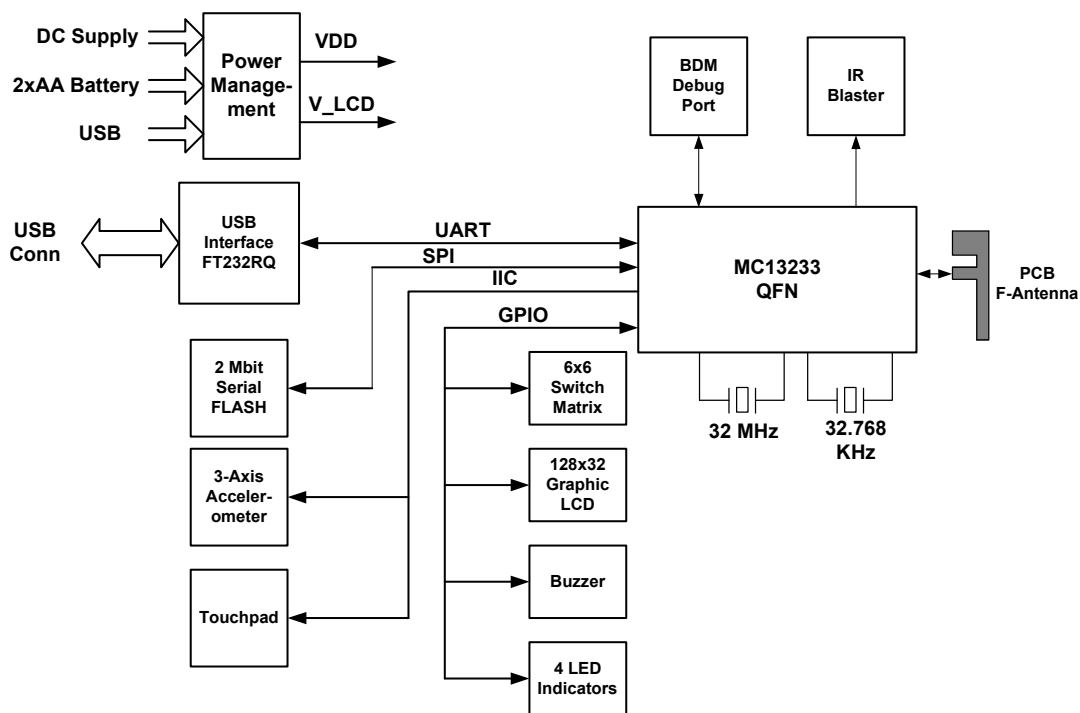


Figure 2-1. Simplified RCM+MRB Block Diagram

Figure 2-2 shows a photo of the combined boards with the 1323x-MRB mounted on the 1323x-RCM.

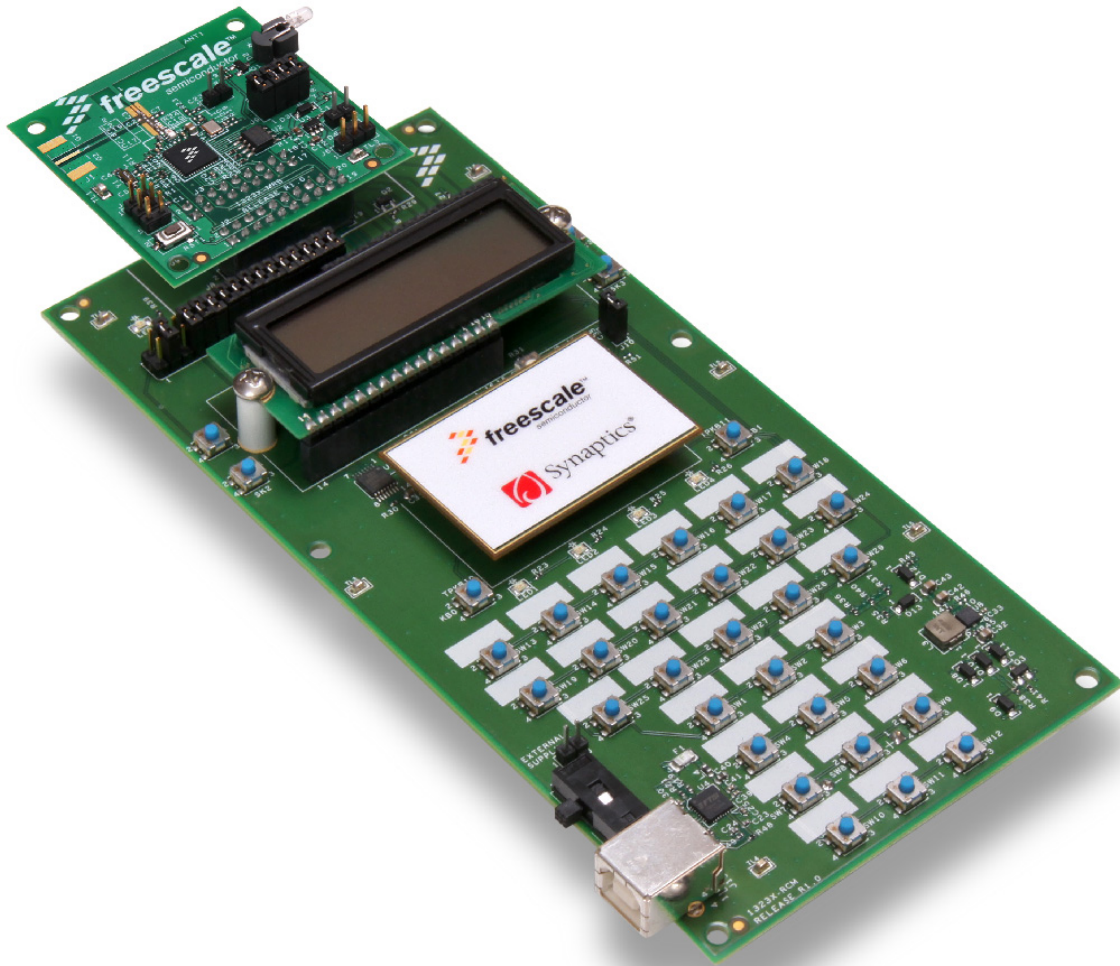


Figure 2-2. 1323x-MRB Mounted on the 1323x-RCM

Features of the MC1323x development platform include:

- Full IEEE 802.15.4 compliant wireless node; ZigBee capable with Freescale's BeeStack software stack
- Based on Freescale's low-cost MC1323x IEEE[®] 802.15.4 SoC platform which incorporates a complete, low power, 2.4 GHz radio frequency transceiver with Tx/Rx switch, an 8-bit HCS08 CPU, and a functional set of MCU peripherals into a 48-pin LGA package
- Reference design area with small footprint, low cost RF node
 - Integrated transmit/receive switch
 - Differential input/output port (typically used with a balun)
 - Low external component count
 - Programmable output power with 0 dBm nominal output power, programmable from -30 dBm to +3 dBm typical
 - Receive sensitivity of -93 dBm (typical) at 1% PER, 20-byte packet, much better than the IEEE 802.15.4 Standard of -85 dBm

- Onboard printed metal F-Antenna
- 32 MHz reference oscillator
- BDM serial MCU debug port
- Optional secondary 32.768 kHz crystal oscillator for accurate low power timing
- IR blaster
- 2 Mbit serial FLASH (uses SPI interface)
- Master reset switch
- Full power regulation and management
- 1323x-MRB board provides
 - Required circuitry for MC13233 - crystals and RF circuitry including F-Antenna and optional SMA connector
 - Local power supply regulation
 - Access to all GPIO
 - Standalone or daughter card use models
 - Serial FLASH, IR blaster, and BDM functions
- 1323x-RCM when used with 1323x-MRB provides
 - USB to UART serial interface that is USB bus-powered and full-speed compatible to the USB 2.0 and 1.1 specifications
 - Power supply source from two AA batteries, USB connector, or DC source
 - 128x32 pixel graphic LCD
 - 3-axis Accelerometer (uses IIC interface)
 - Touch pad interface with interrupt capability (uses IIC interface)
 - 6x6 Switch matrix
 - Single tone buzzer
 - 4 Blue LED indicators
- 1323x-REM when used with 1323x-MRB provides
 - USB to UART serial interface that is USB bus-powered and full-speed compatible to the USB 2.0 and 1.1 specifications
 - Power supply source from two AA batteries, USB connector, or DC source
 - IR receiver
 - 4x2 Switch matrix
 - 4 Blue LED indicators

2.3 Driver Considerations

When users first connect a 1323x-RCM or 1323x-REM based platform to a PC, they may be prompted to install drivers. If BeeKit is installed and this occurs, do not allow Windows to automatically search for and install the drivers. Instead, select manual installation and steer Windows to the following directory:

```
C:\Program Files\Freescale\Drivers
```

If installing the BeeKit software package to another drive or directory, indicate the Drivers directory created by the installer in the custom location where BeeKit was installed.

Follow the instructions as they appear on the screen to complete driver installation.

If BeeKit is not installed, be aware of the following:

- The boards use the FTDI serial to USB converter, Virtual COM Port (VCP) driver for Windows, available at www.ftdichip.com/ftdrivers.htm. (Direct (D2XX) drivers are also available.)
- The FTDI web site offers drivers for other platforms including Windows® (98 through Vista x64 and CE), MAC OS (8 through X) and Linux.
- Download the appropriate driver and follow the instructions to complete driver installation.

2.4 General System Specifications

Table 2-1. MC1323x Platform Specifications

Parameter				Units	Notes/Conditions
	MIN	TYP	MAX		
Power					
Voltage supply (DC)	2.5	5	6	V	When using REM or RCM
Voltage supply (USB)	4.4	5	5.25	V	USB 2.0/1.1 standard specification
Voltage supply (Batteries)		2.8	3.2	V	
Temperature					
Operating temperature; non-battery operation (see note)	-20	+25	+70	°C	Operating temperature is limited to +70 °C due to switches. Basic circuit is good for a maximum temperature of +85 °C.
Operating temperature; battery operation (see note)	0	+25	+50	°C	Operating temperature is limited by battery temperature range
Storage temperature	-30	+25	+70	°C	
USB interface					USB 2.0 and 1.1 full-speed compatible
RF (1323x-MRB)					
802.15.4 Frequency range	2405		2480	MHz	All 16 channels in the 2450 MHz band
Range (outdoor / line of sight)		300		Meter	<1% PER for 20-byte packets (point-to-point in communications with 1322X Sensor Reference Board)

Table 2-1. MC1323x Platform Specifications

Parameter				Units	Notes/Conditions
RF Transmitter					
802.15.4 Output power	-30	0	+3	dBm	Over range of Pout from IC control in 2 dB steps. Note: On channel 26, output power should not exceed -5 dBm (power setting 0x0E) to meet FCC Part 15 requirements.
Harmonics 2 nd harmonics 3 rd harmonics			-30? -30?	dBm dBm	Harmonics are compliant to ETSI and FCC regulatory approval standards
RF Receiver					
802.15.4 sensitivity		-93		dBm	<1% PER for 20-byte packets
Regulatory Approval					
FCC					Not yet certified.
CE (ETSI)					Product is approved accordingly to the EN 300 328 V1.7.1 (2006-10) standard
CE (EMC)					Product is approved accordingly to the EN 301 489-1 V1.6.1 (2005-09) and EN 301 489-17 V1.2.1 (2002-08) standards
Safety					
UL					Product is approved accordingly to the IEC 60950-1 and EN 60950-1, First Edition standards
Environment					
RoHS					Product complies with the EU Directive 2002/95/EC of 27 January 2003
WEEE					Product complies with the EU Directive 2002/95/EC of 27 January 2003

Chapter 3

1323x-Modular Reference Board

3.1 1323x-MRB Overview

The 1323x-Modular Reference Board (1323x-MRB) is an IEEE 802.15.4 compliant evaluation board based on the Freescale MC1323x device. The 1323x-MRB provides a platform to evaluate the MC1323x device, develop software and applications, and demonstrate IEEE 802.15.4 based networking capabilities. The core device is accompanied by the 32 MHz reference oscillator crystal, RF circuitry including antenna, and supporting circuitry.

This basic board is intended as the core module for MC1323x evaluation and application development and can be used in the following modes:

- Simple standalone evaluation platform
- Daughtercard to the other MC1323x Development Platform boards (1323x-RCM or 1323x-REM)
- Daughtercard to an application specific motherboard.

3.1.1 Features

The 1323x-MRB provides the following features:

- Small form factor (2 x 2 inches)
- 4-Layer metal, 0.034 inch thick FR4 board
- MC1323x reference design area
 - LGA footprint and power supply bypass
 - 32 MHz reference oscillator crystal
 - RF components and layout
- Low cost RF node
 - Integrated transmit/receive switch
 - Differential input/output port (typically used with a balun)
 - Programmable output power with 0 dBm nominal output power, programmable from -30 dBm to +3 dBm typical
 - Receive sensitivity of -93 dBm (typical) at 1% PER, 20-byte packet
 - Printed metal F-Antenna
- 32.768 kHz crystal provided for optional timing oscillator
- Two connectors provided daughter card mounting
 - 20-Pin primary connector

- 18-Pin secondary connector
- Provide main supply voltage to board
- Provide access to all MC1323x GPIO
- Flexible board power supply
 - 3.3 V LDO series regulator supplied
 - Regulator bypass jumper option
 - Separate external voltage source option
 - Power-on green LED
 - Jumpers allow various block current measurements
- 6-Pin BDM serial MCU debug port
- MC1323x reset switch
- Onboard peripheral functions
 - IR blaster (The MC1323x CMT port is employed as a GPIO to drive large IR blasters. For IR blasters under 20ma, use the CMT port directly.)
 - 2 Mbit serial FLASH (uses SPI interface)

3.1.2 Form Factor

Figure 3-1 shows the 1323x-MRB connector and header locations.

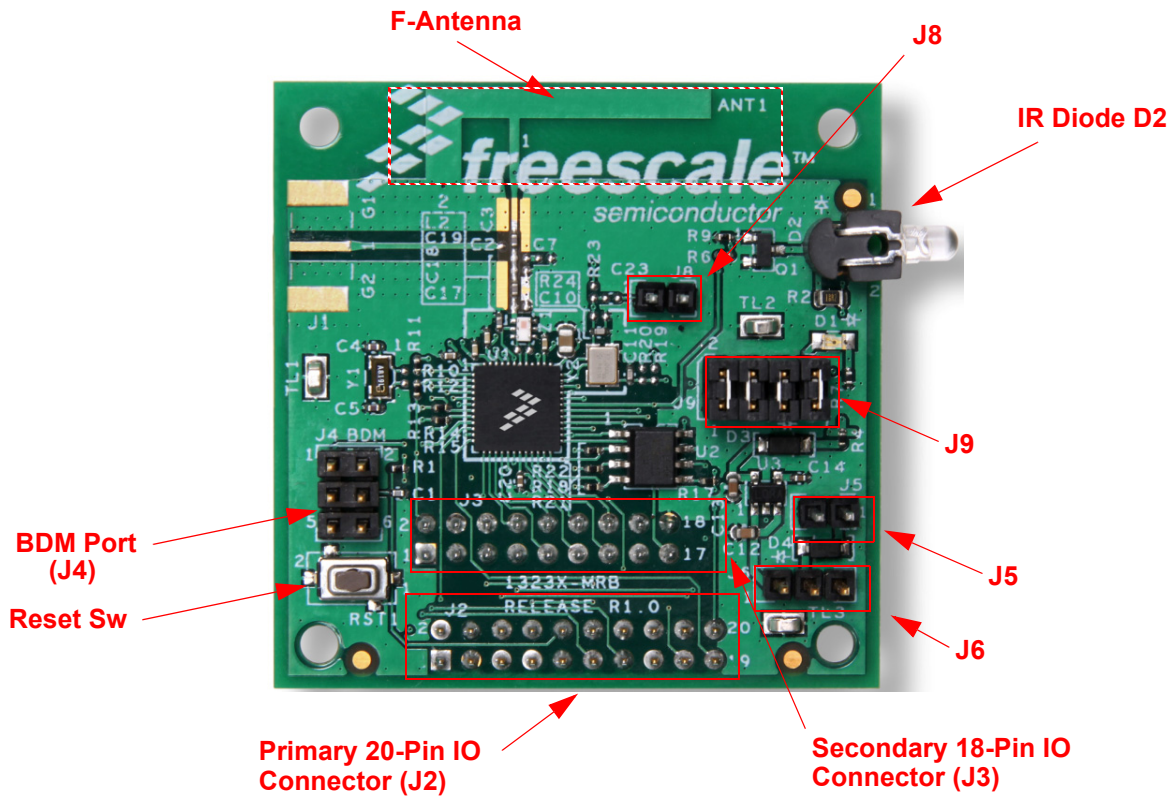


Figure 3-1. 1323x-Modular Reference Board (1323x-MRB)

Figure 3-2 shows a footprint of the 1323x-MRB with the location of the IO Headers J2 and J3. The user may desire to create a motherboard on which the 1323x-MRB would be mounted, and headers J2 and J3 are used for connection to the motherboard:

- Both headers have standard 0.10in / 2.54 mm pin spacing
- J2 is 20-pin and J3 is 18-pin
- Both are pin headers mounted on the bottom side of the 1323x-MRB and are intended to plug into matching receptacles on the motherboard.
- It is recommended that 1323x-MRB be located such that it extends beyond edge of the motherboard (see Figure 3-2) so that the entire F-Antenna is exposed with no motherboard ground or voltage plane beneath it. This is to allow best results transmitting and receiving with the radio.
- With the 1323x-MRB oriented as shown in Figure 3-2, the IR blaster transmits to the right.

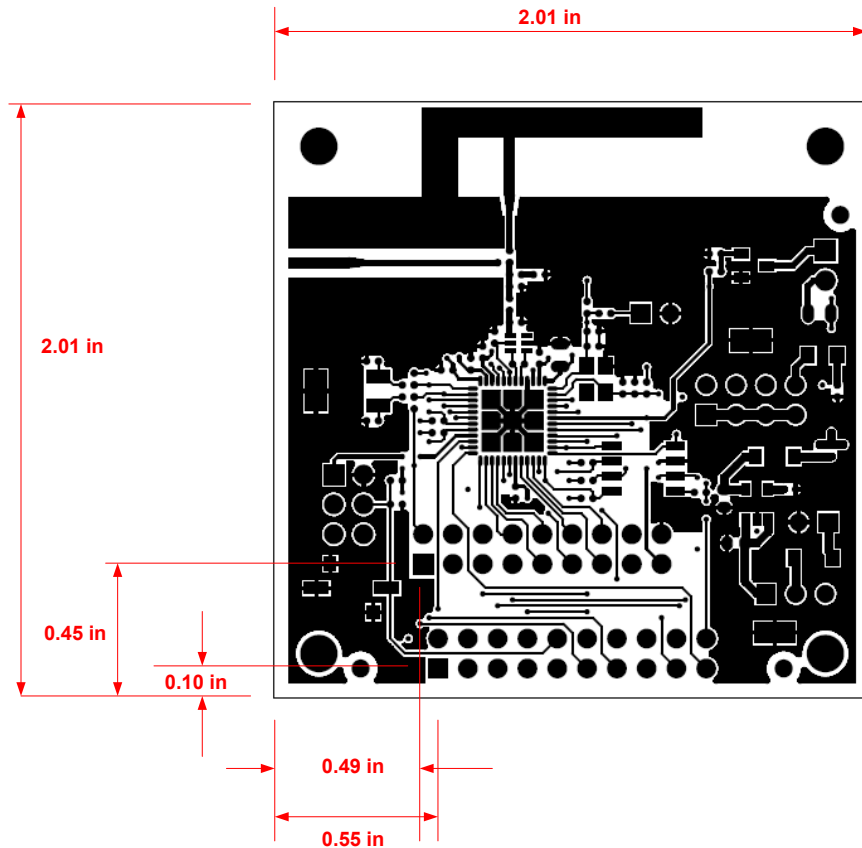


Figure 3-2. 1323x-MRB Top Side (Component Side) Footprint

3.1.3 Board Level Specifications

Table 3-1. 1323x-MRB Specifications

Parameter				Units	Notes/Conditions
	MIN	TYP	MAX		
General					
Size (PCB: X, Y)			51 x 51 2.01 x 2.01	mm inches	
Layer build (PCB)		0.8 0.034		mm inches	4-Layer
Dielectric material (PCB)					FR4
Power					
Voltage supply (DC)					
With 3.3 V regulator in use	3.50		16	V	Full module use
Not using regulator with serial FLASH and IR	2.7		3.6		Not regulated - using all features
Not using regulator with MC1323x only	1.8		3.6		Lower voltage usable only by MC1323x
Current consumption			TBD	mA	
Temperature					
Operating temperature (see note)	-20	+25	+70	°C	<ul style="list-style-type: none"> Operating temperature is limited to +70 °C due to switches. Basic circuit is good for a maximum temperature of +85 °C. Operating temperature may also be further limited when used in conjunction with REM or RCM having a battery supplied voltage source. See Table 4-1 and Table 5-1.
Storage temperature	-30	+25	+70	°C	
IR Transmitter					
Current		63		mA	
Range		10		m	
RF					
802.15.4 Frequency range	2405		2480	MHz	All 16 channels in the 2450 MHz band
Range (outdoor / line of sight)		300		Meter	<1% PER for 20-byte packets (point-to-point in communications with 1323x Sensor Reference Board)
RF Transmitter					
802.15.4 Output power	-30	0	+3	dBm	

Table 3-1. 1323x-MRB Specifications (continued)

Parameter				Units	Notes/Conditions
Harmonics 2 nd harmonics 3 rd harmonics			-38 -35	dBm dBm	Harmonics are compliant to ETSI and FCC regulatory approval standards
RF Receiver					
802.15.4 sensitivity		-93		dBm	<1% PER for 20-byte packets
Regulatory Approval					
FCC					Product is approved accordingly to the FCC part 15 standard
CE (ETSI)					Product is approved accordingly to the EN 300 328 V1.7.1 (2006-10) standard
CE (EMC)					Product is approved accordingly to the EN 301 489-1 V1.6.1 (2005-09) and EN 301 489-17 V1.2.1 (2002-08) standards
Safety					
UL					Product is approved accordingly to the IEC 60950-1 and EN 60950-1, First Edition standards
Environment					
RoHS					Product complies with the EU Directive 2002/95/EC of 27 January 2003
WEEE					Product complies with the EU Directive 2002/95/EC of 27 January 2003

3.2 Functional Description

The 1323x-MRB is built around Freescale's MC1323x 48-pin LGA IEEE 802.15.4 platform. [Figure 3-2](#) shows a simple block diagram. This board is intended as a simple evaluation platform and as a building block for application development. The 4-layer board provides the MC1323x with its required RF circuitry, 32 Mhz reference oscillator crystal, and power supply bypassing. The layout for this base level functionality can be used as a reference layout by the user target board.

In addition to the base MC1323x functionality, the 1323x-MRB provides features to assist in debug, an IR blaster, a 2 Mbit serial FLASH, reset button, simple power manager, and expansion connectors for the GPIO. In the following sections, refer to:

- [Figure 3-1](#) for location of connectors and features
- [Figure 3-3](#) for the functional blocks
- [Figure 3-11](#) for the board schematic

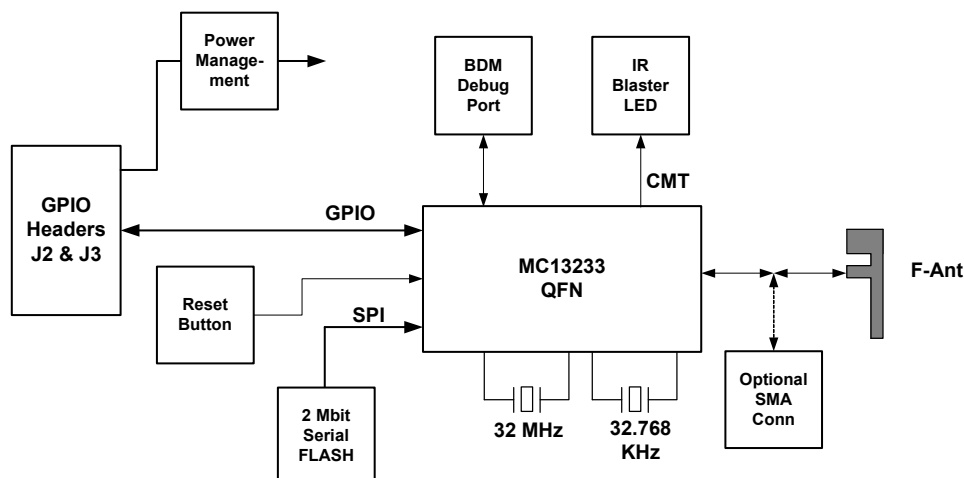


Figure 3-3. 1323x-MRB Block Diagram

3.2.1 RF Performance and Considerations

The MC1323x transceiver includes a low noise amplifier, 1mW nominal output power, PA with internal voltage controlled oscillator (VCO), integrated transmit/receive switch, on-board power supply regulation, and full spread-spectrum encoding and decoding.

- Nominal output power is 0 dBm, with +3 dBm max
- Typical sensitivity is -93 dBm
- Frequency range is 2405 to 2480 MHz
- Typical range (outdoors, line of sight) is 130 meters

The 1323x Modular Reference Board utilizes a minimum number of components while providing good RF performance:

- Uses a minimum number of RF matching components and external 50:100 balun
- “F” printed metal antenna for a small footprint, low cost design

An external 50 (unbal):100 (bal) balun connects a single-ended 50-Ω port to the differential RF port of the MC1323x radio. The layout has provision for out-of-band signal suppression (components L2 and C7) if required. Also note that control pin CT_Bias switches reference voltage to the balun as required for TX (CT_Bias = 1.5V) or RX (CT_Bias = ground).

The default RF mode is use of the “F” antenna coupled through 10 pF C3 to the single-end RF port. An alternative mode is to connect an SMA RF connector (not provided; must be mounted). This is useful for connected measurements to test radio performance.

NOTE

See the MC1323x Data Sheet and Reference Manual for more RF design information.

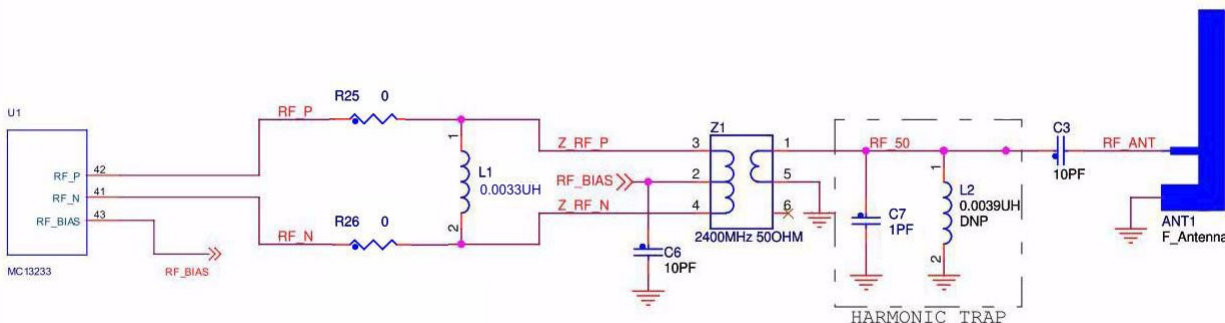


Figure 3-4. 1323x-MRB RF Circuitry

3.2.2 Clocks

The MC1323x provides for two clocks:

- 32 MHz Reference Oscillator - Figure 3-5 shows the external 32 MHz external crystal Y2. This mounted crystal must meet the MC1323x specifications. The IEEE 802.15.4 Standard requires that the frequency be accurate to less than ± 40 ppm.
 - Capacitors C10 and C11 provide the bulk of the crystal load capacitance. Onboard trim capacitors can be programmed to center the frequency. At 25°C, it is desired to have the frequency accurate to ± 10 ppm or less to allow for temperature variation.
 - To measure the 32 MHz oscillator frequency, signal PTD7/XTAL_32MOUT can optionally be programmed to provide a buffered output clock signal
 - The 1323x-MRB has provision for injecting an external 32 MHz clock source as an alternative to use of the onboard crystal:
 - The crystal Y2 should be removed
 - Resistors R23, R24, R19, and R20 must be mounted
 - C23 must be mounted
 - The external 32 MHz source is connected to 2-pin header J8; the frequency accuracy of the external source must meet the ± 40 ppm of the IEEE 802.15.4
- Optional 32.768 kHz Crystal Oscillator - Provision is also made for a secondary 32.768 kHz crystal X2 (see Figure 3-6). This oscillator can be used for a low power accurate time base.
 - The module comes provided with this Y1 crystal and its load capacitors C4 and C15.
 - Load capacitors C4 and C15 provide the entire crystal load capacitance; there is no onboard trim capacitance.
 - The 32 kHz oscillator components are supplied, but un-enabled. Zero-ohm resistors R11 and R13 enable use of IO signals PTA0 and PTA1 via the IO connector and are supplied as mounted. These must be unmounted and moved to resistor sites R10 and R12 to enable the 32.768 kHz crystal and disable PTA0 and PTA1.

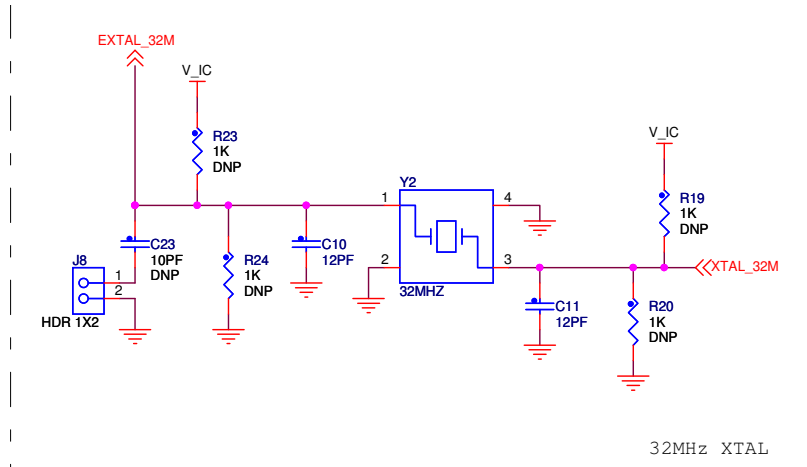


Figure 3-5. 1323x-MRB 32 MHz Reference Oscillator Circuit

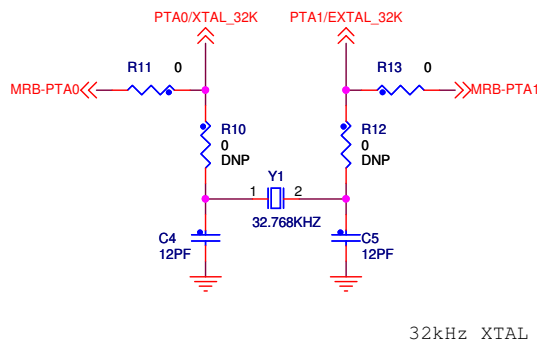


Figure 3-6. 1323x-MRB 32.768 kHz Optional Oscillator Circuit

3.3 Reset and BDM Debug Port

The reset circuit and BDM port connector are shown in Figure 3-7. See Figure 3-1 for switch and header locations.

- Reset switch RST2 is active low and provides a hardware reset to the MC1323x
- The 6-pin BDM 2x3 header J10 is provided to connect the MC1323x serial debug port to a standard HC9S08 debug module.

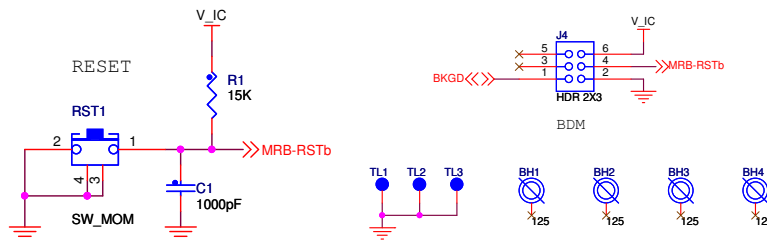


Figure 3-7. 1323x-MRB Reset Switch and BDM Port

3.3.1 Power Management

The 1323x-MRB power management circuit is shown in Figure 3-8.

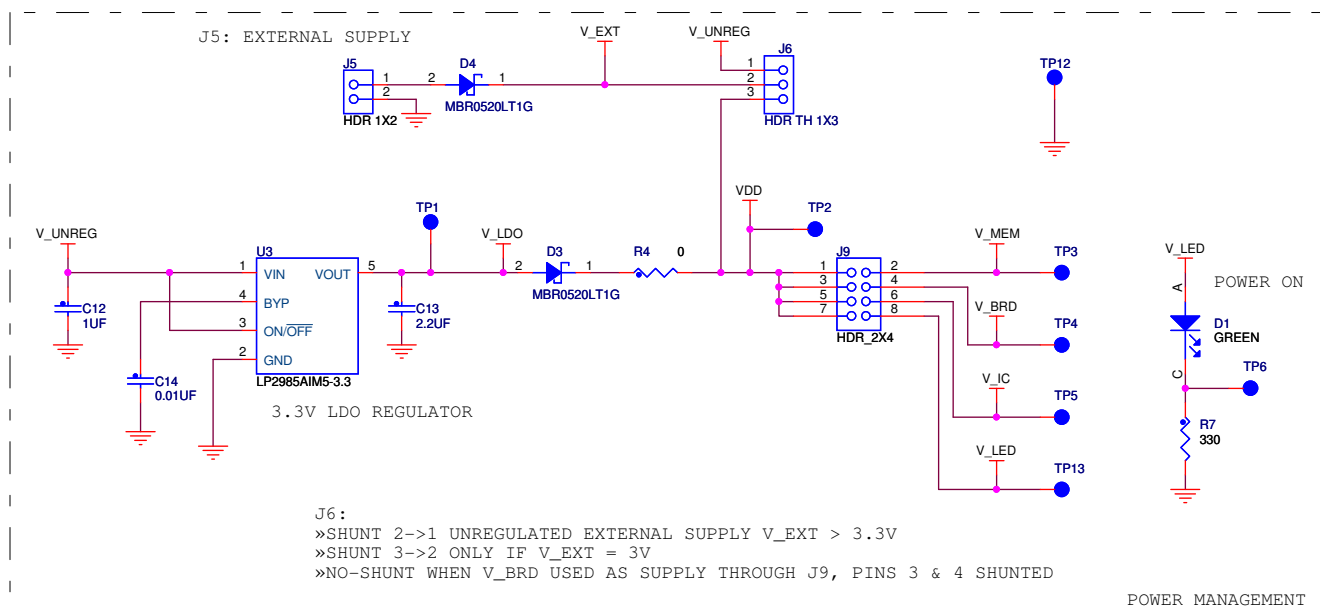


Figure 3-8. 1323x-MRB Power Management Circuit

Power to the 1323x-MRB can be configured in several ways and the circuit has the following features:

- Board can be supplied through the IO headers (V_BRD)
- Board can be supplied from an external DC supply (J5)
 - The external supply can be unregulated (V_UNREG) and make use of the onboard 3.3 V LDO regulator
 - The external supply voltage can be used directly without use of the LDO
- 8-Pin 2x4 header J9 provides means to supply current to various board components and also measure current if desired
- Green LED D1 is available as a power indicator.

Table 3-2 shows the header configuration information for the various power supply modes.

NOTE

- The Freescale 1323x-RCM and 1323x-REM development boards generate the system power supply on the motherboard and supply the voltage to the 1323x-MRB through the V_BRD pin of Headers J2 and J3. In this mode, the current flows to the 1323x-MRB through the pins.
- If an external supply is used via 1323x-MRB header J5, current flows to the motherboard through the V_BRD pin of Headers J2 and J3. THE MOTHERBOARD SUPPLY SHOULD NOT BE USED.
- In all modes, the IO voltage supply of peripherals on a motherboard must be the same voltage as V_BRD, which is also the voltage applied to the IC MC1323x.

Table 3-2. 1323x-MRB Power Configurations

Mode	Voltage Range	External Source J5	Ext Mode Select J6	Current Enable J9	Description
Source V_BRD	2.7 - 3.6 V ¹	Not used	Not used - all pins open	Short Pins 3-4 - short other desired supplies	Normal Operation - <u>The 1323x-MRB main supply is supplied by the motherboard through the J2 and J3 Headers</u>
External Source - Using LDO	3.5 - 16 V	Connected - supplies DC Voltage	Short Pins 1-2	Short pins for all desired supplies	External voltage w/regulation - <ul style="list-style-type: none"> Input range is set by the LDO regulator. 3.3 V is supplied to 1323x-MRB; do not use motherboard supply J2 and J3 Headers supply voltage to V_BRD pins when J9, Pins 3-4 are shorted
External Source - Not Using LDO	2.7 - 3.6 V ¹	Connected - supplies DC Voltage	Short Pins 2-3	Short pins for all desired supplies	External voltage w/o regulation - <ul style="list-style-type: none"> Input range is set by the onboard circuitry 2.7 - 3.3 V is supplied to 1323x-MRB J2 and J3 Headers supply voltage to V_BRD pins

¹ The MC1323x can run as low as 1.8 V, however, the serial FLASH and IR blaster require 2.7 V or greater

Header J9 provides means to disable different sub-circuits or measure current and connections are described in [Table 3-3](#). Current measurements can be made by inserting a current meter in place of a designated jumper.

Table 3-3. Power Distribution Header J9

Supply Designation	Header Pins	Description
V_MEM	1 - 2	Supply voltage to serial FLASH memory - <ul style="list-style-type: none"> Jumper pins to supply memory. If memory is not powered, it can load MC1323x SPI port
V_BRD	3 - 4	Supply voltage connected to IO Connectors J2 and J3 - <ul style="list-style-type: none"> This supplies J2 and J3 if an external MRB supply is used This voltage supplies the MRB if the motherboard is the main power This connection is normally always jumpered
V_IC	5 - 6	Supply voltage to MC1323x - <ul style="list-style-type: none"> Normally jumpered Supplies only the MC1323x IC Normally always same voltage as V_BRD
V_LED	7 - 8	Supply voltage to power indicator LED and IR blaster LED - <ul style="list-style-type: none"> Jumper to use indicator or IR blaster Leave open for lowest power

3.3.2 IO Connectors J2 and J3

The two IO connectors J2 and J3 are standard 100 mil pin headers mounted on the back (non-component side) of the 1323x-MRB. The primary header J2 is 20-pin and the secondary header J3 is 18-pin, and they are mounted physically in such a manner as to prevent reverse insertion of the 1323x-MRB into a motherboard receptacle (see [Figure 3-2](#)). When the 1323x-RCM or 1323x-REM or custom motherboard is plugged into these connectors, they allow access to MC1323x MCU GPIO.

- V_BRD is the connector supply voltage.
 - Depending on power supply configuration, this voltage may supply the 1323x-MRB from the motherboard or the 1323x-MRB may supply this voltage to the motherboard. See [Section 3.3.1, “Power Management”](#).
 - Peripherals IO to the MC1323x and the MC1323x supply should use this same voltage

NOTE

The 1323x-RCM and 1323x-REM and 1323x-MRB are supplied configured for the motherboard to supply main power.

- Some of the GPIO are shared with onboard devices. Check for the 1323x-MRB schematic and [Table 3-4](#) and [Table 3-5](#) for any conflict.
- BDM port signal PTA7/BKGD is NOT connected to the IO headers to prevent possible interference with the debug port.

Table 3-4. 20 Pin Connector

Header Pin Number	MC1323x Pin Name	Description
1	V_BRD	VDD supply to module
2	PTC5/SS	SPI Bus Slave Select (SS) - shared with serial FLASH
3	GND	Module ground
4	PTC7/MOSI	SPI Bus MOSI signal - shared with serial FLASH
5	PTD5/RXD	UART RXD input to MCU
6	PTC6/MISO	SPI Bus MISO signal - shared with serial FLASH
7	PTD6/TXD	UART TXD Output from MCU
8	PTC4/SPICLK	SPI Clock (SPISCK) - shared with serial FLASH
9	PTD0/TPM0	GPIO / Timer IO
10	RESET	Reset
11	PTA5/SDA	I2C Bus data signal (SDA)
12	PTB7/KBI1P7	UART flow control RTS input into MCU (implemented in Freescale software)
13	PTA6/SCL	I2C Bus clock signal (SCL)
14	PTD2/TPM2	UART flow control CTS output from MCU (implemented in Freescale software)
15	GND	Module ground
16	PTD7/XTAL_32MOUT	Port D Bit 7

Table 3-4. 20 Pin Connector

Header Pin Number	MC1323x Pin Name	Description
17	PTB0/KBI1P0	Port B Bit 0 / KBI1 Input Bit 0
18	PTB1/KBI1P1	Port B Bit 1 / KBI1 Input Bit 1
19	PTB2/KBI1P2	Port B Bit 2 / KBI1 Input Bit 2
20	PTB3/KBI1P3	Port B Bit 3 / KBI1 Input Bit 3

Table 3-5. 18 Pin Connector

Header Pin Number	MC1323x Pin Name	Description
1	V_BRD	VDD supply to module
2	PTA1/EXTAL_32K	Port A Bit 1 - signal shared with 32.768 kHz oscillator
3	PTA0/XTAL_32K	Port A Bit 0 - signal shared with 32.768 kHz oscillator
4	GND	Module Ground
5	PTA2	Port A Bit 2 - MC1323x test mode enable; SPECIAL SIGNAL REFER TO <i>MC1323x Reference Manual</i>
6	PTA3/IRQ	Port A Bit 3 / IRQ (active low)
7	PTA4/XTAL_32KOUT	Port A Bit 4 / optional buffered 32.768 kHz clock output
8	PTB4/KBI1P4	Port B Bit 4 / KBI1 Input Bit 4
9	PTB5/KBI1P5	Port B Bit 5 / KBI1 Input Bit 5
10	PTB6/KBI1P6	Port B Bit 6 / KBI1 Input Bit 6
11	PTC0/KBI2P0	Port C Bit 0 / KBI2 Input Bit 0
12	PTC1/KBI2P1	Port C Bit 1 / KBI2 Input Bit 1
13	PTC2/KBI2P2	Port C Bit 2 / KBI2 Input Bit 2
14	PTC3/KBI2P3	Port C Bit 3 / KBI2 Input Bit 3
15	PTD1/TPM1	Port D Bit 1/ TPM1
16	PTD3/TPM3	Port D Bit 3/ TPM3
17	PTD4/CMT	Port D Bit 4/ CMT output - signal shared with IR blaster
18	GND	Module ground

3.3.3 1323x-MRB Onboard Peripheral Functions

The 1323x-MRB has two onboard peripheral functions to assist in implementing targeted applications.

NOTE

To use the peripherals, a minimum power supply voltage of 2.7 V must be maintained.

3.3.3.1 2 Mbit Serial FLASH (SPI Interface)

Component U2 is an Atmel AT45DB021D 2 Mbit (256 kbyte) serial FLASH memory with SPI interface. The memory is useful for over-the-air programming (OTAP) and for storage of non-volatile system data or parameters. Figure 3-9 shows the memory circuit.

- Memory power supply is V_MEM (Header J9, Pin 1-2)
- Disabling the memory supply V_MEM may load the MC1323x SPI port through the U2 ESD diodes
- Discrete pullup resistors for the SPI port are provided
- The SPI can be shared with another peripheral - an additional IO signal would be required as a chip enable (CS or SS) for the peripheral. The normal SPI_SS and the second chip select should NOT be active at the same time.

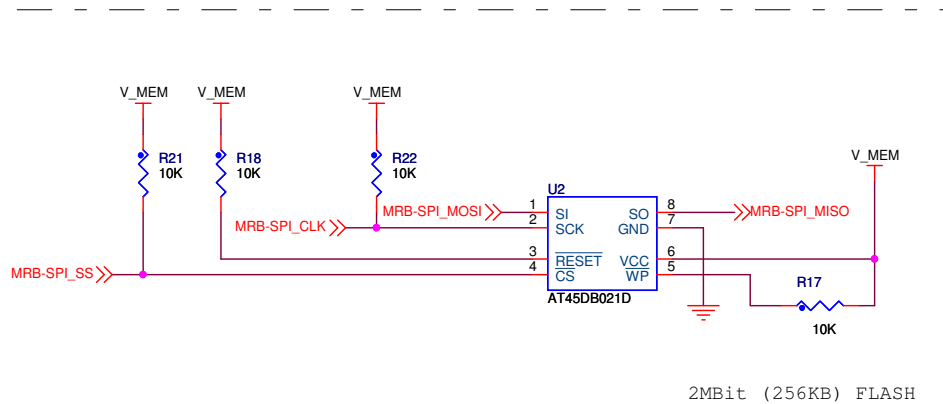


Figure 3-9. AT45DB021D 2 Mbit (256 kbyte) Serial FLASH memory

3.3.3.2 IR Transmitter (Blaster)

An IR transmitter or blaster is provided to control IR legacy components (see [Figure 3-10](#)).

- The IR power supply is V_LED (Header J9, Pin 7-8)
- The IR transmitter has approximately a 10 meter range.
- Current draw is approximately 80 mA when active.
- To reduce the peak current consumption, it is recommended that the IR transmitter only be active when the MC1323x RF transceiver is in-active.
- When using the blaster in an application, observe proper orientation (see [Figure 3-2](#))

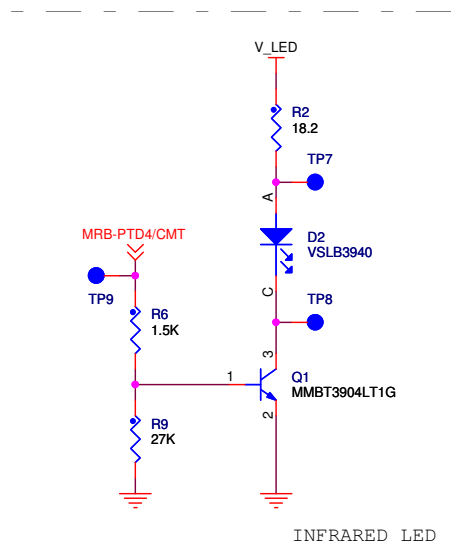


Figure 3-10. IR Transmitter Circuit

3.4 Schematic, Board Layout, and Bill of Material

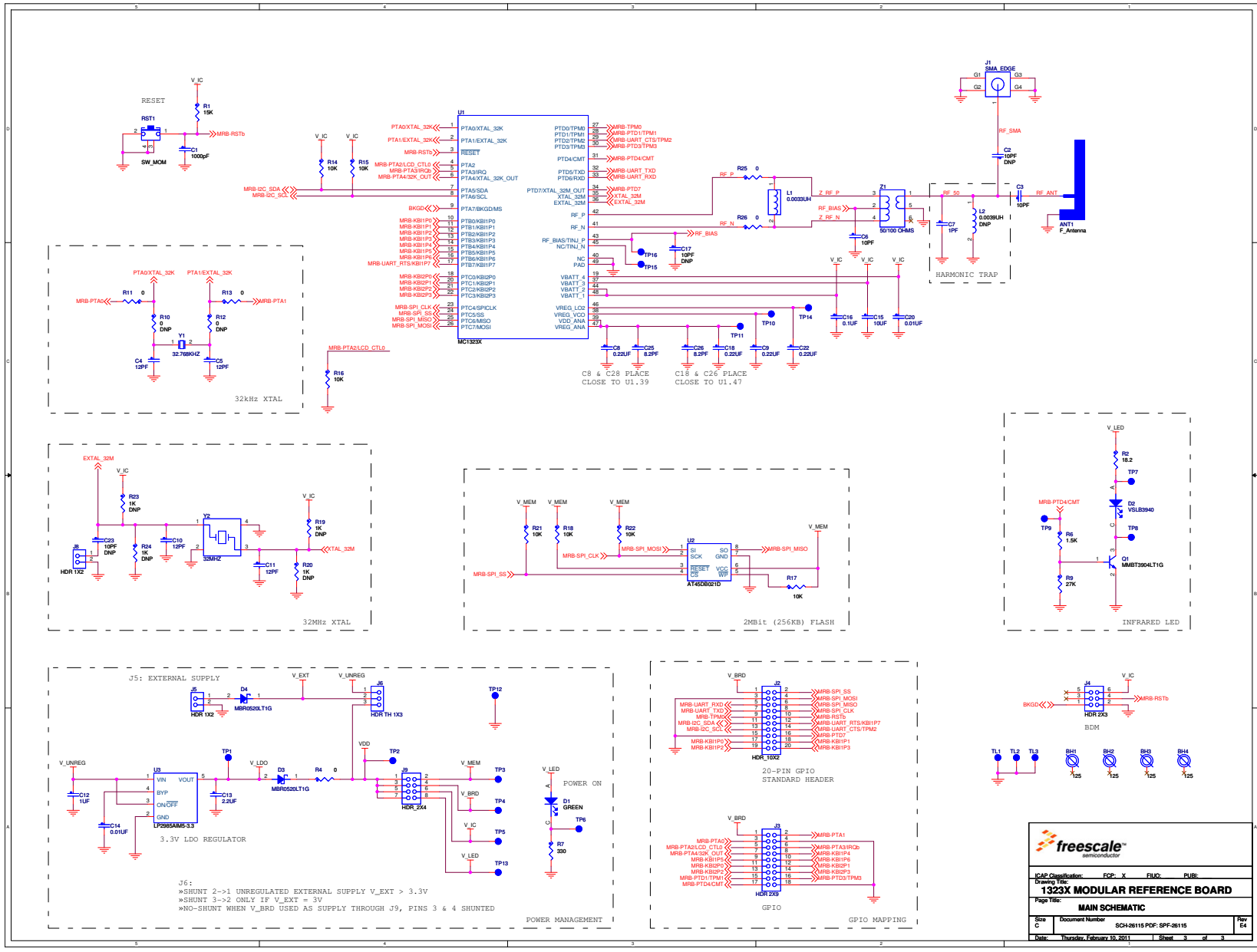


Figure 3-11. 1323x-MRB Schematic

CAD Classification: FCP, X, F100, R10			
Drawing Title: 1323X MODULAR REFERENCE BOARD			
Page Title: MAIN SCHEMATIC			
Size C	Document Number	SCM-26116 PDF: SPF-26116	Rev E4
Date:	Thursday, February 10, 2011	Sheet 3	of 3

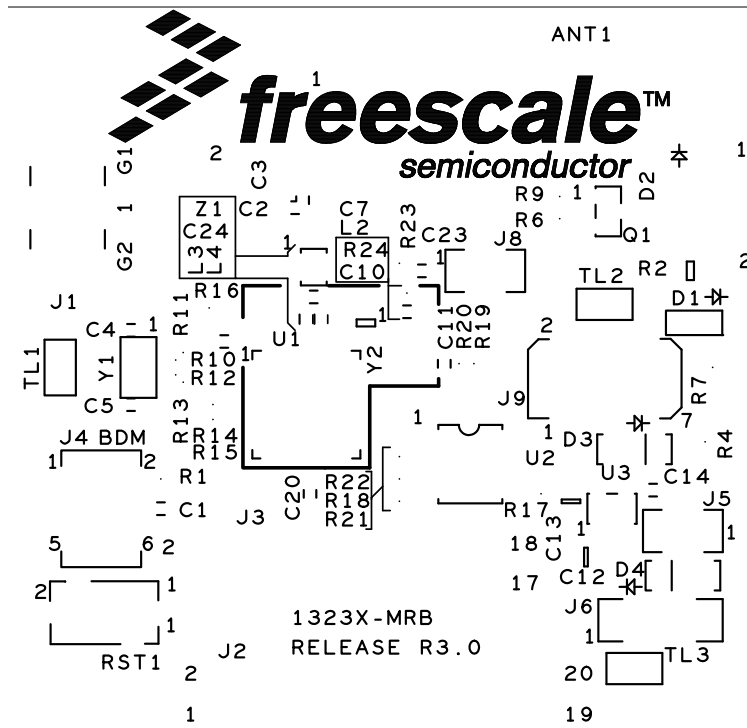


Figure 3-12. Modular Reference Board PCB Component Location (Top View)

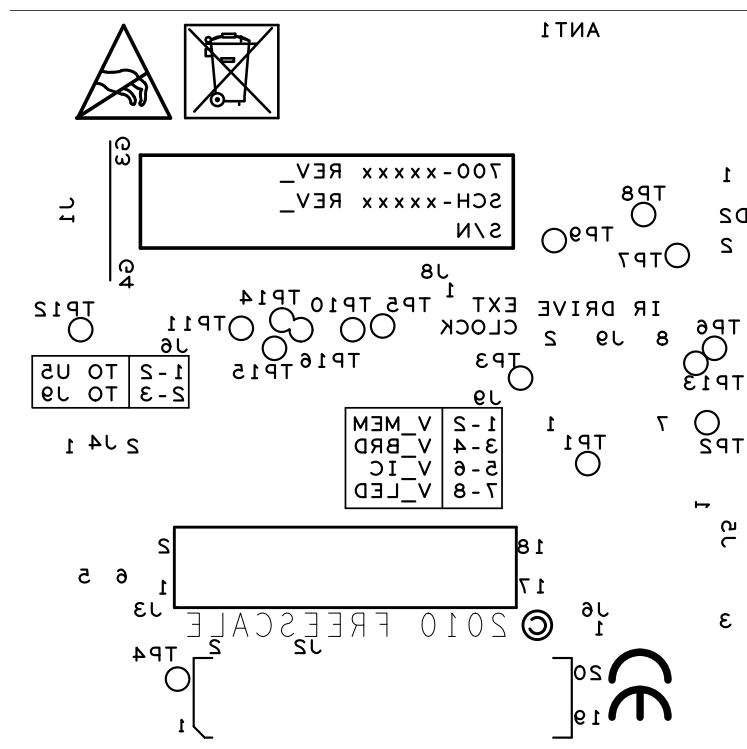


Figure 3-13. Modular Reference Board PCB Test Points

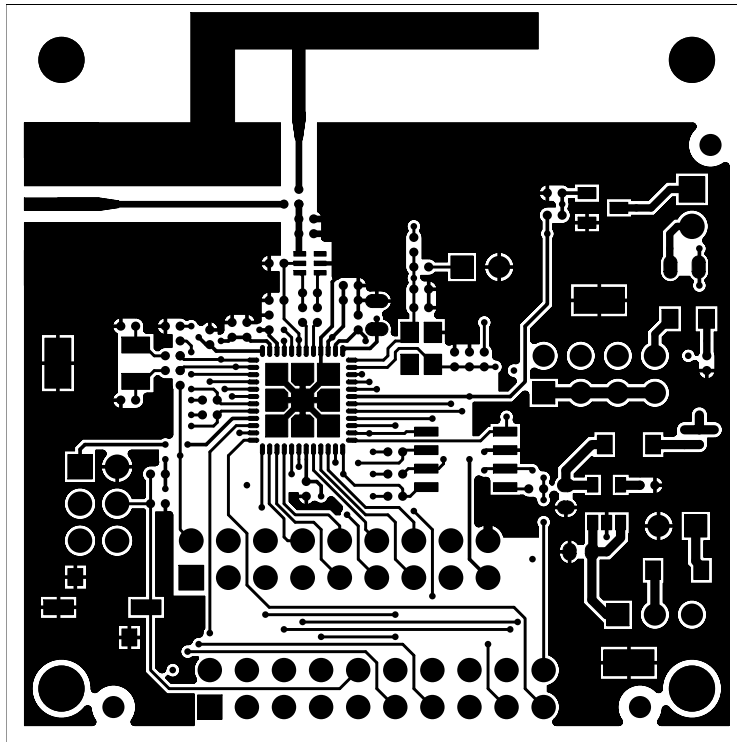


Figure 3-14. Modular Reference Board PCB Layout (Top View)

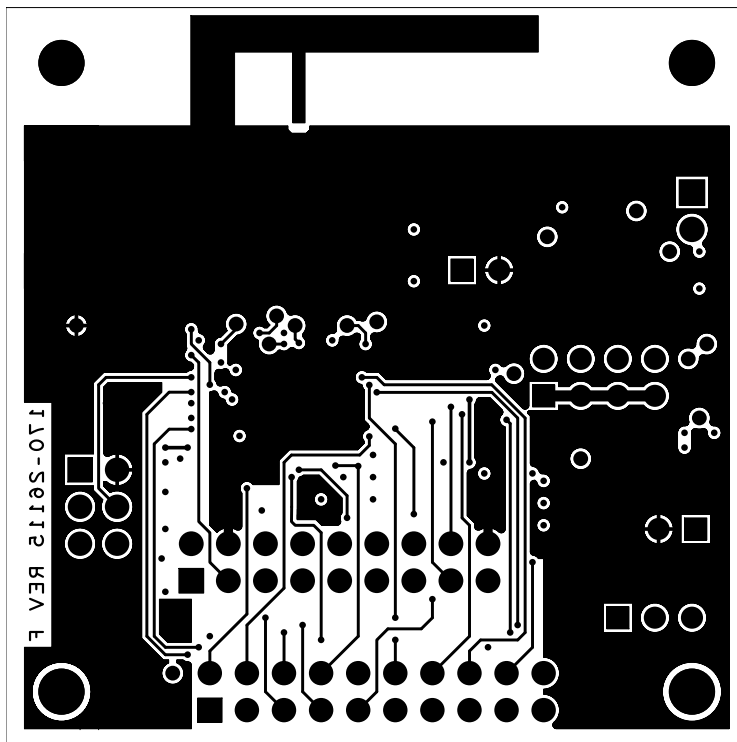


Figure 3-15. Modular Reference Board PCB Layout (Bottom View)

3.4.1 Bill of Materials

Table 3-6. Bill of Materials

Item	Qty	Reference	Value	Description	Mfg Name	Mfg Part Number
1	1	ANT1	F_Antenna	PCB F ANTENNA, NO PART ORDER	Not A Part	NOT A PART
2	4	BH1,BH2,BH3, BH4	125	NON-PLATED MOUNTING HOLE 125 DRILL / 160 KEEPOUT NO PART TO ORDER		
3	1	C1	1000pF	CAP CER 1000PF 50V 5% COG 0402	Murata	GRM1555C1H102JA01 D
4	3	C2,C17,C23 (No Not {Place)	10PF	CAP CER 10PF 50V 5% COG 0402	Murata	GJM1555C1H100JB01
5	2	C3,C6	10PF	CAP CER 10PF 50V 5% COG 0402	Murata	GJM1555C1H100JB01
6	4	C4,C5,C10,C11	12PF	CAP CER 12PF 50V 5% COG 0402	Murata	GRM1555C1H120JZ01 D
7	1	C7	1PF	CAP CER 1.0PF 50V +/-0.25PF COG 0402	Murata	GJM1555C1H1R0CB01 D
8	4	C8,C9,C18,C22	0.22UF	CAP CER 0.22UF 10V 10% X5R 0402	Murata	GRM155R61A224KE19 B
9	1	C12	1UF	CAP CER 1.0UF 10V 10% X7R 0603	Murata	GRM188R71A105KA61 D
10	1	C13	2.2UF	CAP CER 2.2UF 10V 10% X7R 0603	Murata	GRM188R71A225KE15 D
11	2	C14,C20	0.01UF	CAP CER 0.01UF 50V 10% X7R 0402	Murata	GCM155R71H103KA55 D
12	1	C15	10UF	CAP CER 10UF 10V 10% X5R 0805	Murata	GRM21BR61A106KE19 -
13	1	C16	0.1UF	CAP CER 0.1UF 16V 10% X7R 0402	Tdk	C1005X7R1C104KT
14	2	C25,C26	8.2PF	CAP CER 8.2PF 50V 0.25PF COG 0402	Avx	04025A8R2CAT2A
15	1	D1	GREEN	LED GRN SGL 30MA SMT 0805	Lite On	LTST-C171KGKT
16	1	D2	VSLB3940	LED IR SGL 100MA RA TH	Vishay Intertechnology	VSLB3940
17	2	D3,D4	MBR0520LT1G	DIODE SCH 0.5A 20V SOD-123	On Semiconductor	MBR0520LT1G
18	1	J1	SMA_EDGE	CON 1 SKT SMA EDGE 34MIL BOARD SMT 50 OHM -- 171H AU 104L	Johnson Components Inc	142-0701-881

Table 3-6. Bill of Materials

19	1	J2	HDR_10X2	HDR 2X10 TH 100MIL CTR 330H AU 100L	Samtec	TSW-110-07-S-D
20	1	J3	HDR 2X9	HDR 2X9 TH 100MIL CTR 330H AU	Samtec	TSW-109-07-S-D
21	1	J4	HDR 2X3	HDR 2X3 TH 100MIL CTR 335H AU 95L	Samtec	TSW-103-07-S-D
22	2	J5,J8	HDR 1X2	HDR 1X2 TH 100MIL SP 330H SN 115L	Samtec	TSW-102-07-T-S
23	1	J6	HDR TH 1X3	HDR 1X3 TH 100MIL SP 339H AU 100L	Samtec	TSW-103-07-G-S
24	1	J9	HDR_2X4	HDR 2X4 TH 100MIL CTR 330H AU 100L	Samtec	TSW-104-07-S-D
25	1	L1	0.0033UH	IND -- 0.0027UH@100MHZ 300MA +/-0.3NH 0402	Murata	LQG15HS2N7S02D
26	1	L2 (No Not {Place})	0.0039UH	IND -- 0.0039UH@100MHZ 300MA +/-0.3NH 0402	Murata	LQG15HN3N9S02D
27	1	Q1	MMBT3904LT1G	TRAN NPN GEN 200MA 40V SOT-23	On Semiconductor	MMBT3904LT1G
28	1	RST1	SW_MOM	SW SPST MOM PB 50MA 12V SMT	Alps Electric (Usa) Inc.	SKQYPDE010
29	1	R1	15K	RES MF 15K 1/16W 5% 0402	Vishay Intertechnology	CRCW040215K0JNED
30	1	R2	18.2	RES MF 18.2 OHM 1/4W 1% 0805	Rohm	ESR10EZPF18R2
31	5	R4,R11,R13,R 25,R26	0	RES MF ZERO OHM 1/16W 5% 0402	Rohm	MCR01MZPJ000
32	1	R6	1.5K	RES MF 1.5K 1/16W 5% 0402	Vishay Intertechnology	CRCW04021K50JNED
33	1	R7	330	RES MF 330 OHM 1/16W 5% 0402	Vishay Intertechnology	CRCW0402330RJNED
34	1	R9	27K	RES MF 27K 1/16W 5% 0402	Vishay Intertechnology	CRCW040227K0JNED
35	2	R10,R12 (No Not {Place})	0	RES MF ZERO OHM 1/16W 5% 0402	Rohm	MCR01MZPJ000
36	7	R14,R15,R16, R17,R18,R21, R22	10K	RES MF 10K 1/16W 5% 0402	Vishay Intertechnology	CRCW040210K0JNED
37	4	R19,R20,R23, R24 (No Not {Place})	1K	RES MF 1.0K 1/16W 5% 0402	Vishay Intertechnology	CRCW04021K00JNED
38	3	TL1,TL2,TL3	TESTLOOP	TEST POINT PAD SIZE 3.4MM X 1.8MM SMT	Keystone Electronics	5015

Table 3-6. Bill of Materials

39	16	TP1,TP2,TP3,TP4,TP5,TP6,TP7,TP8,TP9,TP10,TP11,TP12,TP13,TP14,TP15,TP16	TPAD_040	TEST POINT PAD 40MIL DIA SMT, NO PART TO ORDER	Notacomponent	NOTACOMPONENT
40	1	U1	MC1323X	IC MCU+XCVR 8BITS 2.4GHZ 1.8-3.6V LGA48	Freescale Semiconductor	PC13233C
41	1	U2	AT45DB021D	IC MEM FLASH 256KX8 66MHz 2.7-3.6V 8S1	Atmel	AT45DB021D-SSH-T
42	1	U3	LP2985AIM5-3.3	IC VREG LDO 3.3V 150MA 3.8-16V SOT-23-5	National Semiconductor	LP2985AIM5-3.3/NOPB
43	1	Y1	32.768KHZ	XTAL 32.768KHZ SMT ROHS COMPLIANT	Epson Electronics	FC-135 32.7680KA-A3
44	1	Y2	32MHZ	XTAL 32MHZ 9PF -- SMT 3.2X2.5MM	Ndk	EXS00A-CS02368
45	1	Z1	50/100 OHMS	XFMR BALUN 2.45GHZ +/-50MHZ 50/100OHM 3W SMT	Johanson Technology	2450BL15B100_

Chapter 4

1323x Remote Control Motherboard

4.1 1323x-RCM Overview

The Remote Control Motherboard (1323x-RCM) is a motherboard that accepts the 1323x-Modular Reference Board (1323x-MRB) plug-in module (daughter card) and supplies a power supply and a rich set of interface peripherals. The two boards in combination provide a complete platform to evaluate the MC1323x, write software, and develop a full featured IEEE 802.15.4 based wireless remote control.

4.1.1 Features

The 1323x-RCM provides the following features:

- 4-Layer metal, 0.034 inch thick FR4 board
- Two connectors provide daughter card mounting
 - 20-Pin primary connector
 - 18-Pin secondary connector
 - Provide main supply voltage to board
 - Provide access to all MC13233 GPIO
- Handheld battery operation
- Flexible power supply
 - Sources include USB port, two AA batteries, or DC source
 - Power-On green LED
 - On-Off switch
- Used in conjunction with 1323x-MRB where MRB provides -
 - 2.4 GHz IEEE 802.15.4 wireless node
 - 2 Mbit serial FLASH for over-the-air programming (OTAP)
 - IR blaster
- USB interface is bus-powered and full-speed compatible to the USB 2.0 and 1.1 specifications
- 36 Pushbutton 6x6 switch matrix
- 128x32 pixel monochrome graphic/alphanumeric LCD - uses SPI serial interface
- Synaptics® Touchpad™ - capacitive touch sensor
- 3-Axis accelerometer with IIC serial interface
- Four application-controlled blue indicator LEDs
- Single tone buzzer

4.1.2 Form Factor

Figure 4-1 shows a photo of the 1323x-RCM with the location of connectors and headers designated.

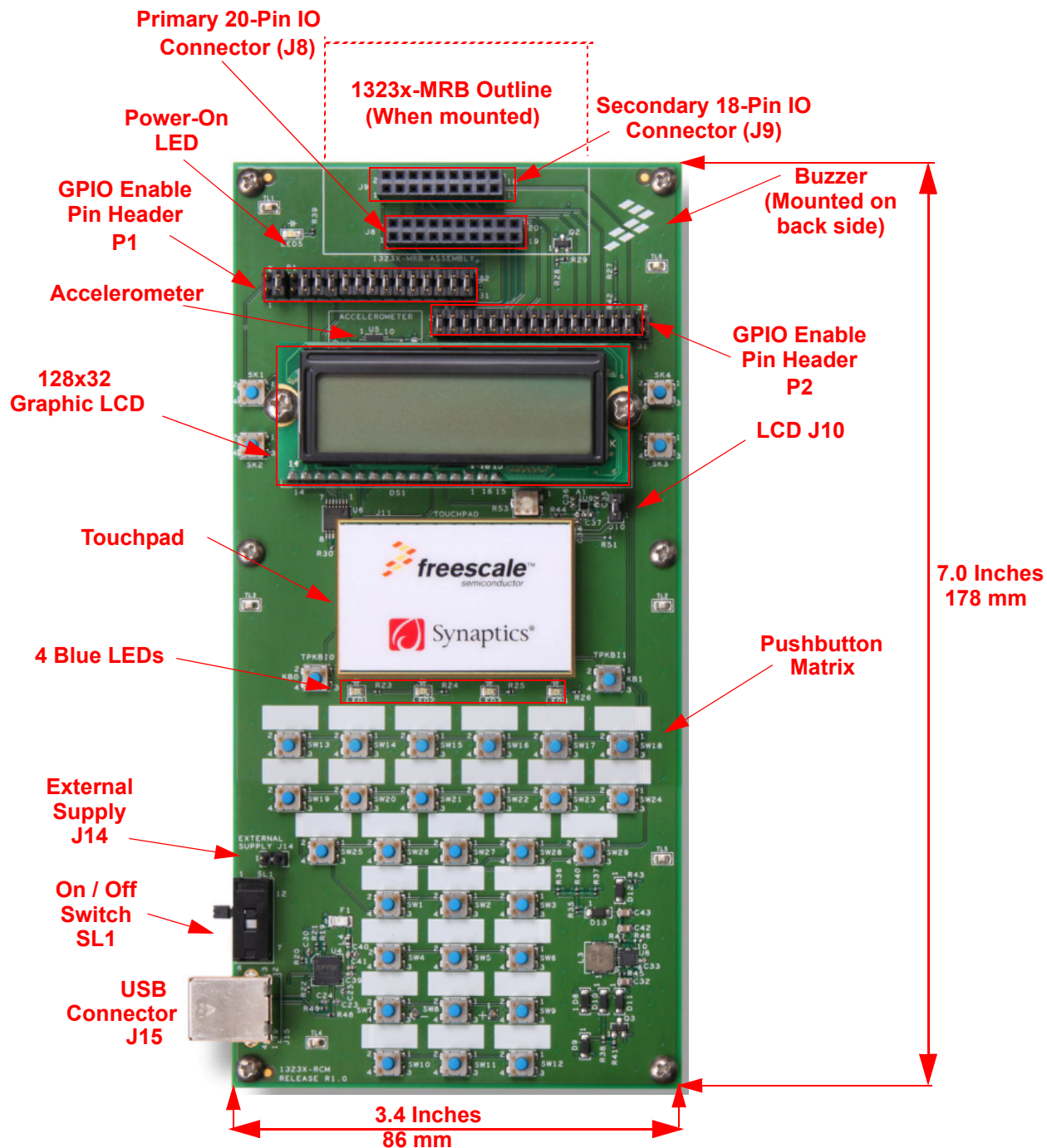


Figure 4-1. 1323x-RCM (1323x-MRB)

The 1323x-Modular Reference Board (1323x-MRB) mounts on the 1323x-RCM via receptacles J8 and J9. Figure 4-1 shows an outline of the 1323x-MRB placement when mounted.

4.1.3 Board Level Specifications

NOTE

Temperature range specifications apply to RCM used in combination with MRB.

Table 4-1. 1323x-RCM Specifications

Parameter				Units	Notes/Conditions
	MIN	TYP	MAX		
General					
Size (PCB: X, Y)			86 x 178 3.40 x 7.00	mm inches	
Layer build (PCB)		0.8 0.034		mm inches	4-Layer
Dielectric material (PCB)					FR4
Power					
Voltage supply (DC)	2.3	5	6	V	
Voltage supply (USB)	4.4	5	5.25	V	USB 2.0/1.1 standard specification
Voltage supply (Batteries)		2.8	3.2	V	
Current consumption			100	mA	
Temperature					
Operating temperature; non-battery operation (see note)	-20	+25	+70	°C	Operating temperature is limited to +70 °C due to switches. Basic circuit is good for a maximum temperature of +85 °C.
Operating temperature; battery operation (see note)	0	+25	+50	°C	Operating temperature is limited by battery temperature range
Storage temperature	-30	+25	+70	°C	
USB interface					USB 2.0 and 1.1 full-speed compatible
Buzzer					
CUI #CMI-1240					See data sheet
Touchpad					
Synaptics					Semi-custom
Tri-axis Low-g Accelerometer					
MMA7660FC (Freescale Semi)					See data sheet
LCD					
CRYSTALFONZ #CFAG12832A-YGH-N					See data sheet
Regulatory Approval					

Table 4-1. 1323x-RCM Specifications (continued)

Parameter				Units	Notes/Conditions
CE (ETSI)					Product is approved accordingly to the EN 300 328 V1.7.1 (2006-10) standard
CE (EMC)					Product is approved accordingly to the EN 301 489-1 V1.6.1 (2005-09) and EN 301 489-17 V1.2.1 (2002-08) standards
Safety					
UL					Product is approved accordingly to the IEC 60950-1 and EN 60950-1, First Edition standards
Environment					
RoHS					Product complies with the EU Directive 2002/95/EC of 27 January 2003
WEEE					Product complies with the EU Directive 2002/95/EC of 27 January 2003

4.2 Functional Description

The 1323x-RCM is a host motherboard for the 1323x-MRB. The two-board combination provides a powerful evaluation and development platform for the MC13233. [Figure 4-2](#) shows a simple block diagram. The 4-layer board provides a flexible power supply, 36 pushbutton matrix, 128x32 LCD, Touchpad sensor, 3-axis accelerometer, four indicator LEDs, buzzer, and a USB ↔ UART serial port.

As the board name implies this platform is useful to develop an RF remote control application for a DTV, entertainment console, or similar function. The 1323x-MRB provides the RF node and an IR transmitter is available to support legacy IR protocol remote controls. The rich set of peripherals of the 1323x-RCM allows a user to develop a remote control ranging from a simple input device to a higher end unit with display.

In the following sections, refer to:

- [Figure 4-1](#) for location of connectors and features
- [Figure 4-2](#) for the functional blocks
- [Figure 4-10](#) for the board schematic

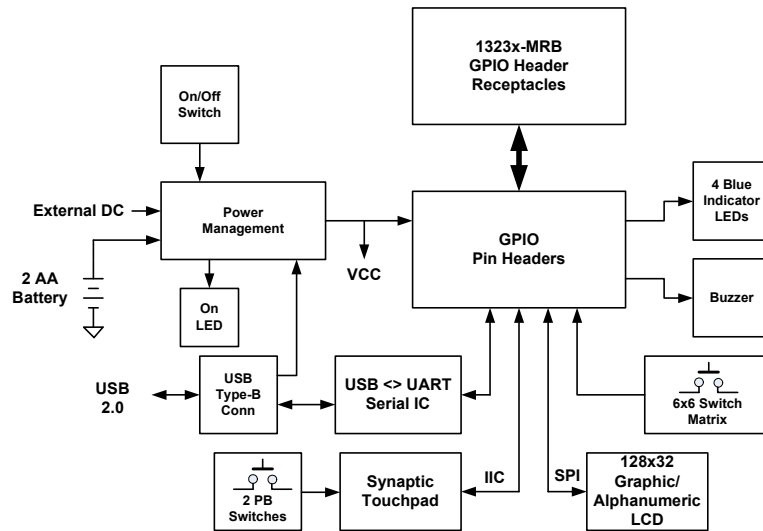


Figure 4-2. 1323x-RCM Block Diagram

4.2.1 Power Management

The 1323x-RCM can be powered from two AA batteries, the USB connector 5 V supply, or an external DC supply and is also intended to power the 1323x-MRB. Figure 4-3 shows the power management circuit.

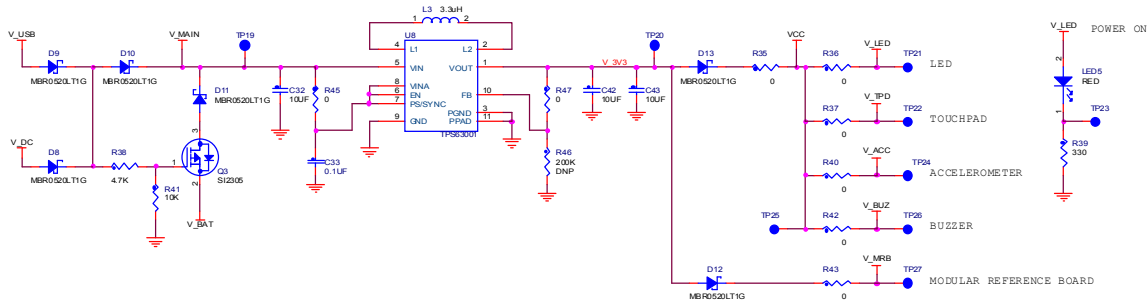


Figure 4-3. 1323x-RCM Power Management Circuit

A boost-buck voltage regulator U8 is used in this design to allow operation over a relatively wide, low voltage input range, i.e., the TPS63001 regulator has an input voltage range from 1.8 V to 5.5V. This allows a broad range of power supply sources. The regulated output voltage of the TPS63001 is 3.3 V which delivers about 3.05 V to the board due to the drop across the isolation Schottky diodes.

Attributes of the power management circuit include:

- Switch SL1 provides an ON/OFF function for all input voltage sources
- Red LED5 provides a POWER-ON indicator for all sources
- The 1323x-RCM can derive power from three different sources -
 1. USB port Type-B connector J15 - power can be supplied from an actual USB port connection or from an AC to DC converter that uses the USB connector to supply power.

2. External DC source via header J14 - a standard 0.1 in. spacing 1x2 pin header allows for connection of an external DC supply.
3. Battery Operation - a battery holder that accommodates two AA batteries is mounted on the non-component (back) side of the board and provides for battery operation.
 - If either the USB or external DC source is present, the battery source is disabled by MOSFET transistor Q3
 - The sources are all isolated and protected by Schottky diodes
 - The minimum effective battery operating voltage is controlled by the use the FTDI FT232RQ USB \leftrightarrow UART device - leakage current back through the FT232RQ UART connections to the MC13233 on the MRB can cause the Q3 MOSFET to partially turnoff at battery voltage below approximately 2.7-2.8 Vdc.

NOTE

To avoid current leakage through the USB device and to have lowest minimum battery operating voltage for battery-only operation, remove the following jumpers:

- P1, Pins 7-8
- P1, Pins 11-12
- P1, Pins 17-18
- P1, Pins 21-22

NOTE

When battery operation is used, the temperature range of the two board system should be limited to within the specified temperature range of the battery technology. [Table 4-1](#) limits temperature range from 0 °C to +50 °C when battery operation is applied.

[Table 4-2](#) lists the voltage source attributes.

Table 4-2. 1323x-RCM Voltage Sources

Source	Connector	Input Voltage Range	Description
USB Port	USB Type-B J15	4.4 V - 5.25 V	<ul style="list-style-type: none"> • The input voltage range is set the USB Spec • The voltage can be supplied by either a standard USB cable connection or an AC to DC power adaptor that uses the USB connector J15 • If a power adaptor is in use, the USB serial port cannot be used

Table 4-2. 1323x-RCM Voltage Sources

Source	Connector	Input Voltage Range	Description
External DC Supply	1x2 Pin Header J14	2.3 V - 6 V	The input voltage range is determined by the U8 regulator and the diode isolation circuit
Two AA Batteries	Battery Holder	2.0 V - 3.1 V ¹	<ul style="list-style-type: none"> The input voltage range reflects the usable range of alkaline cells and the voltage drop incurred by the diode isolation circuit. The battery source is disabled if another source is connected

¹ The minimum operating battery voltage is determined by use model, see Note, [Section 4.2.1, "Power Management"](#)

Again referring to [Figure 4-3](#), a number of zero-ohm resistors are provided to isolate different circuits and to allow current measurement:

- VCC (main 1323x-RCM supply) - resistor R35
- V_LED (all LEDs supply) - resistor R36
- V_TPD (touchpad supply) - resistor R37
- V_ACC (accelerometer supply) - resistor R40
- V_BUZ (buzzer supply) - resistor R42
- V_MRB (1323x-MRB supply) - resistor R43

4.2.2 GPIO Connection to 1323x-MRB

IO Connectors J8 and J9 (see [Figure 4-1](#)) are receptacles that accept the 1323x-MRB pin headers to mount the daughter card. [Figure 2-1](#) shows the 1323x-RCM with the 1323x-MRB mounted. Receptacles J8 and J9 connect to the MC13233 GPIO.

To provide better access and versatility to the GPIO, a secondary set of pin headers P1 and P2 is connected in series with the IO signals:

- Jumpers must be installed on P1 and P2 to connect 1323x-RCM peripherals and functions
- The pin headers provide direct access for connecting custom circuitry to the GPIO
- Power and ground to primary connectors J8 and J9 are not enabled though the pin headers

[Figure 4-4](#) shows IO Header P1 and P2 pin mapping.

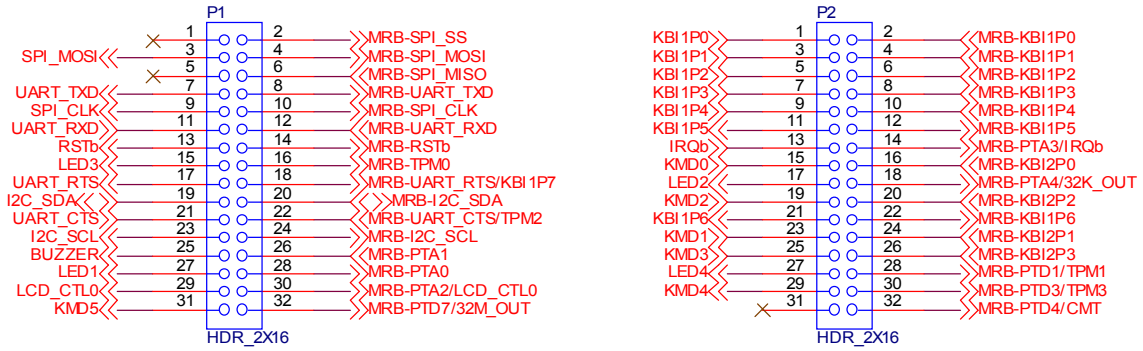


Figure 4-4. 1323x-RCM IO Connector J8 and J9 Pin Mapping

Table 4-3 list the P1 and P2 pin header function as it relates to the MC13233.

Table 4-3. 1323x-RCM P1 and P2 Pin Header Function Description

1323x-REM Header Pins	MC13233 Signal Name	Description	1323x-REM Application / Notes
P1-27, P1-28	PTA0/XTAL_32K	Port A Bit 2 / 32.768 kHz oscillator output	<ul style="list-style-type: none"> Drives LED1; jumper required 32.768 kHz oscillator can be enabled on MRB
P1-25, P1-26	PTA1/EXTAL_32K	Port A Bit 3 / 32.768 kHz oscillator input	<ul style="list-style-type: none"> Drives Buzzer; jumper required 32.768 kHz oscillator can be enabled on MRB
P1-13, P1-14	RESET	Device asynchronous hardware reset. Active low. Onboard Pullup	<ul style="list-style-type: none"> Drives touchpad reset; jumper required Reset signal driven from MRB
P1-29, P1-30	PTA2	Port A Bit 2. Onboard pull-down for TM	<ul style="list-style-type: none"> Drive LCD_CTL0; jumper required Application is LCD enable clock TM enable
P2-13, P2-14	PTA3/IRQ	Port A Bit 3 / IRQ.	<ul style="list-style-type: none"> Used; jumper required Provides interrupt request input IRQ (active low) from accelerometer and touchpad
P2-17, P2-18	PTA4/XTAL_32KOUT	Port A Bit 4 / Buffered 32.768 kHz clock output	<ul style="list-style-type: none"> Drives LED2; jumper required Optional 32.768 kHz output clock for measuring reference oscillator accuracy (ppm)
P1-19, P1-20	PTA5/SDA	Port A Bit 5 / IIC Bus data	<ul style="list-style-type: none"> Used; jumper required Connects to accelerometer Defaults to open drain for IIC Pullup on MRB
P1-23, P1-24	PTA6/SCL	Port A Bit 6 / IIC Bus clock	<ul style="list-style-type: none"> Used; jumper required Connects to accelerometer Defaults to open drain for IIC Pullup on MRB
P2-1, P2-2	PTB0/KBI1P0	Port B Bit 0 / KBI1 Input Bit 0	RCM switch matrix; jumper required
P2-3, P2-4	PTB1/KBI1P1	Port B Bit 1 / KBI1 Input Bit 1	RCM switch matrix; jumper required

Table 4-3. 1323x-RCM P1 and P2 Pin Header Function Description (continued)

1323x-REM Header Pins	MC13233 Signal Name	Description	1323x-REM Application / Notes
P2-5, P2-6	PTB2//KBI1P2	Port B Bit 2 / KBI1 Input Bit 2	RCM switch matrix; jumper required
P2-7, P2-8	PTB3//KBI1P3	Port B Bit 3 / KBI1 Input Bit 3	RCM switch matrix; jumper required
P2-9, P2-10	PTB4//KBI1P4	Port B Bit 4 / KBI1 Input Bit 4	RCM switch matrix; jumper required
P2-11, P2-12	PTB5//KBI1P5	Port B Bit 5 / KBI1 Input Bit 5	RCM switch matrix; jumper required
P2-21, P2-22	PTB6//KBI1P6	Port B Bit 6 / KBI1 Input Bit 6	RCM switch matrix; jumper required
P1-17, P1-18	PTB7//KBI1P7	Port B Bit 7 / KBI1 Input Bit 7	<ul style="list-style-type: none"> • UART flow control RTS input to MCU; jumper required • Connects to RCM USB <> UART device
P2-15, P2-16	PTC0/KBI2P0	Port C Bit 0 / KBI2 Input Bit 0	RCM switch matrix; jumper required
P2-23, P2-24	PTC1/KBI2P1	Port C Bit 1 / KBI2 Input Bit 1	RCM switch matrix; jumper required
P2-19, P2-20	PTC2/KBI2P2	Port C Bit 2 / KBI2 Input Bit 2	RCM switch matrix; jumper required
P2-25, P2-26	PTC3/KBI2P3	Port C Bit 3 / KBI2 Input Bit 3	RCM switch matrix; jumper required
P1-9, P1-10	PTC4/SPICLK	Port C Bit 4 / SPI clock	<ul style="list-style-type: none"> • Used; jumper required • Connected to serial FLASH on MRB • Connected to serial LCD interface
P1-2	PTC5/SS	Port C Bit 5 / SPI slave select	<ul style="list-style-type: none"> • Unused on RCM • Must be in-active for LCD access • Connected to serial FLASH on MRB
P1-6	PTC6/MISO	Port C Bit 6 / SPI MISO	<ul style="list-style-type: none"> • Unused on RCM • Connected to serial FLASH on MRB
P1-3, P1-4	PTC7/MOSI	Port C Bit 7 / SPI MOSI	<ul style="list-style-type: none"> • Used; jumper required • Connected to serial FLASH on MRB • Connected to serial LCD interface
P1- 15, P1-16	PTD0/TPM0	Port D Bit 0 / TPM0 signal	Drives LED3; jumper required
P2-27, P2-28	PTD1/TPM1	Port D Bit 1/ TPM1 signal	Drives LED4; jumper required
P1-21, P1-22	PTD2/TPM2	Port D Bit 2 / TPM2 signal	<ul style="list-style-type: none"> • UART flow control CTS output from MCU; jumper required • Connects to RCM USB <> UART device
P2-29, P2-30	PTD3/TPM3	Port D Bit 3 / TPM3 signal	RCM switch matrix; jumper required
P2-32	PTD4/CMT	Port D Bit 4/ CMT output	<ul style="list-style-type: none"> • Not used on RCM • Connected to IR blaster on MRB
P1-7, P1-8	PTD6/RXD	Port D Bit 6 / UART RXD input	<ul style="list-style-type: none"> • UART RXD input to MCU; jumper required • Connects to RCM USB <> UART device
P1-11, P1-12	PTD5/TXD	Port D Bit 5 / UART TXD output	<ul style="list-style-type: none"> • UART TXD output from MCU; jumper required • Connects to RCM USB <> UART device
P1-31, P1-32	PTD7/32MOUT	Port D Bit 7	<ul style="list-style-type: none"> • RCM switch matrix; jumper required

4.2.3 1323x-RCM Onboard Peripheral Functions

The 1323x-RCM has a rich set of peripheral functions useful to evaluate the MC13233 and to implement a full featured remote control.

4.2.3.1 USB Interface

For many applications or demonstrations it is desirable to connect the 1323x-RCM to a PC or other device. A USB port is provided with a USB “B” receptacle plug. The port is connected to a FTDI FT232RQ USB \leftrightarrow UART device that appears as a Virtual COM port (VCP) to the PC. PC drivers are available with the module.

The USB interface is configured as a "Bus Powered" device and can draw all required power from the USB interface. The device is USB 2.0 full speed compatible.

The USB connector is designated as J15. [Figure 4-5](#) shows the connector pinout.

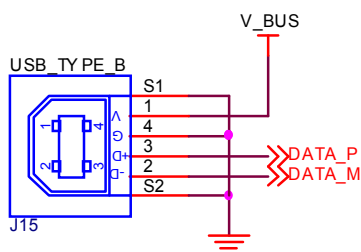


Figure 4-5. USB Connector Pinout

4.2.3.2 128x32 Graphic/Alphanumeric LCD

The 1323x-RCM supports a 128x32 pixel STN passive trans-reflective monochrome graphic LCD that provides for alphanumeric or graphic readout. The LCD module is mounted on top of the main circuit board and connects via a 16-pin connector. [Figure 4-6](#) shows the LCD interface schematic.

- The display is an CRYSTALFONZ #CFAG12832A-YGH-N
- Viewing area is 51.0 (W) × 17.8 (H) mm
- The LCD operates from 5 Vdc generated from the main operating voltage through a boost switching regulator. The LCD module requires a highly regulated 5 V so that the high voltages generated onboard the display are consistent.
- The LCD has optional yellow-green LED backlighting
 - Typical current of 30 mA when full on
 - Enabled via Jumper J10
 - Always on when enabled.
- LCD interface to the MCU is via the SPI port - although the LCD module only supports a parallel interface (8-bit or 4-bit modes), the 1323x-RCM uses a serial interface derived from the SPI port
 - The SPI serial stream is loaded into an 8-bit shift register (74AHCT164) used as a serial-to-parallel converter

- Nibble (4-bit) parallel mode is used on the LCD and the shift register provides the 4 data bits and the RS control signal
- The 4-data and RS control are strobed into the LCD via the LCD_CTL0 control signal derived from MC13233 PTA2 output.
- LCD write mode only is supported; the LCD cannot be read.
- The SPI port is shared with the serial FLASH on the 1323x-MRB. SS must be inactive (high) when writing to the LCD
- The onboard controller is a member of the Sitronix ST7920 Series family with an integrated display data RAM and alphanumeric character set

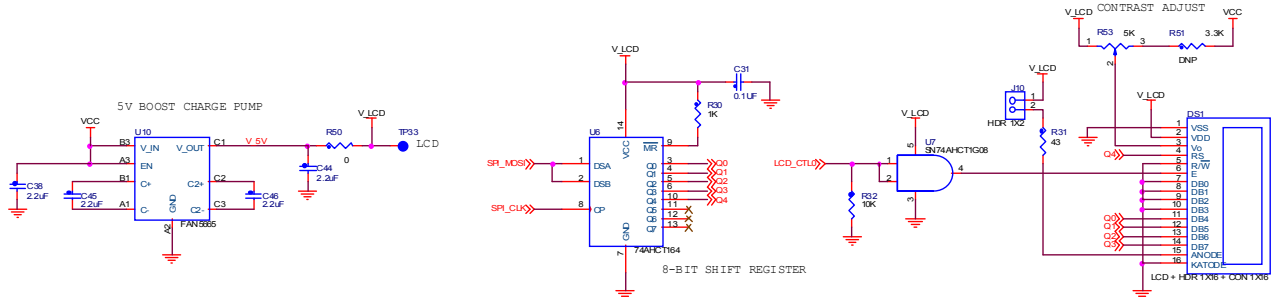


Figure 4-6. 1323x-RCM LCD Interface Circuit

4.2.3.3 36 Pushbutton 6x6 Switch Matrix

The 1323x-RCM provides an 36 pushbutton 6x6 switch matrix for user application input interface.

- The matrix utilizes MC13233 KBI inputs
- All switches have interrupt and device wake up capability
- For these 36 switches
 - Includes the pushbutton array
 - Includes two switches located to the right and two switches to the left of the LCD
 - Includes switches SW31 and SW32 located on the bottom (non-component) side of the board
 - Does not support the two switches (KB0 and KB1) located near the touchpad.

4.2.3.4 Synaptics Touchpad

A Synaptics® Touchpad™ capacitive touch sensor is mounted on the 1323x-RCM for pointing functionality.

- The touchpad is approximately 30mm tall x 45mm wide
- Interface to the MCU uses the IIC interface
- The touchpad has a separate interrupt request line that is tied to the KBI1P6 MCU input
- The MCU reset is tied to the touchpad and resets the touchpad whenever a system reset occurs
- The touchpad support two independent KBI signals that are connected to pushbuttons KB0 and KB1 and used for touchpad select functions
- The touchpad is soldered to the 1323x-RCM using two SMT headers

Figure 4-7 shows the touchpad circuit.

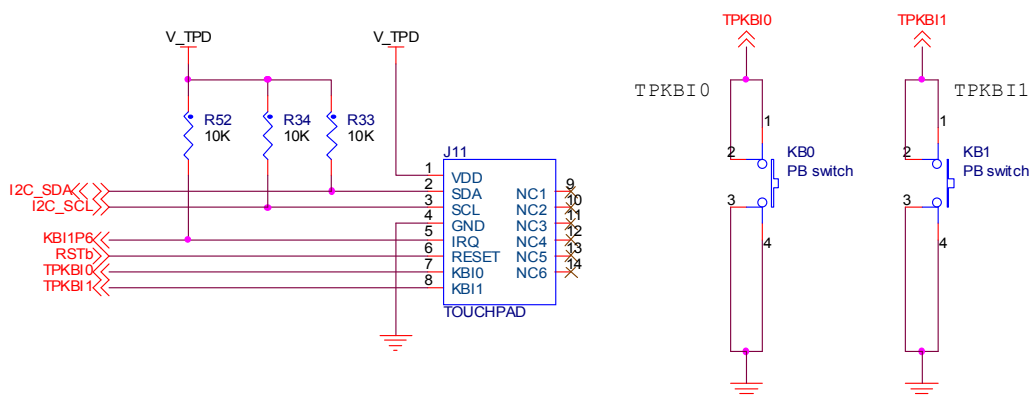


Figure 4-7. 1323x-RCM Touchpad Circuit

4.2.3.5 3-Axis Accelerometer

The 1323x-RCM contains a Freescale MMA7660 3-axis accelerometer with IIC interface.

- Uses a 3mm x 3mm x 0.9mm DFN package
- Device interface supports IIC bus and system reset
- Supports an auto-wake/sleep feature for Low power consumption.
- When the device is in auto-sleep state, if a shake interrupt, tap interrupt, Delta G, or orientation detection interrupt occurs, the device comes out of sleep mode and generates an interrupt request via the IRQ signal

Figure 4-8 shows the accelerometer circuit.

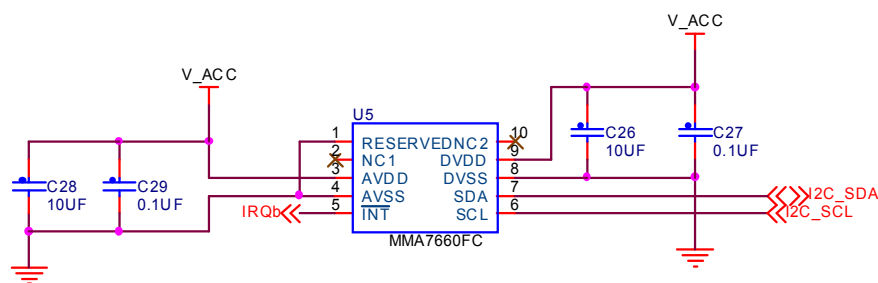


Figure 4-8. 1323x-RCM Accelerometer Circuit

4.2.3.6 Buzzer

The 1323x-RCM provides a single tone audio buzzer.

- Device LS1, CUI Inc., Part No. CMI-1240
- 4.0 kHz resonant frequency
- Device is buffered by Q2 and active when MCU output PTA1 is high (see Table 4-3)

Figure 4-9 shows the buzzer circuit.

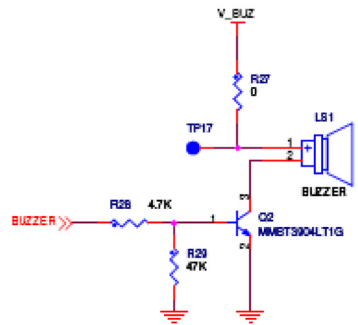


Figure 4-9. 1323x-RCM Buzzer Circuit

4.2.3.7 Blue Indicator LED

The 1323x-RCM provides 4 blue LEDs for user application indicator outputs. Refer to [Table 4-3](#) for listings of the MC13233 outputs that drive the LEDs.

4.3 Schematic, Board Layout, and Bill of Material

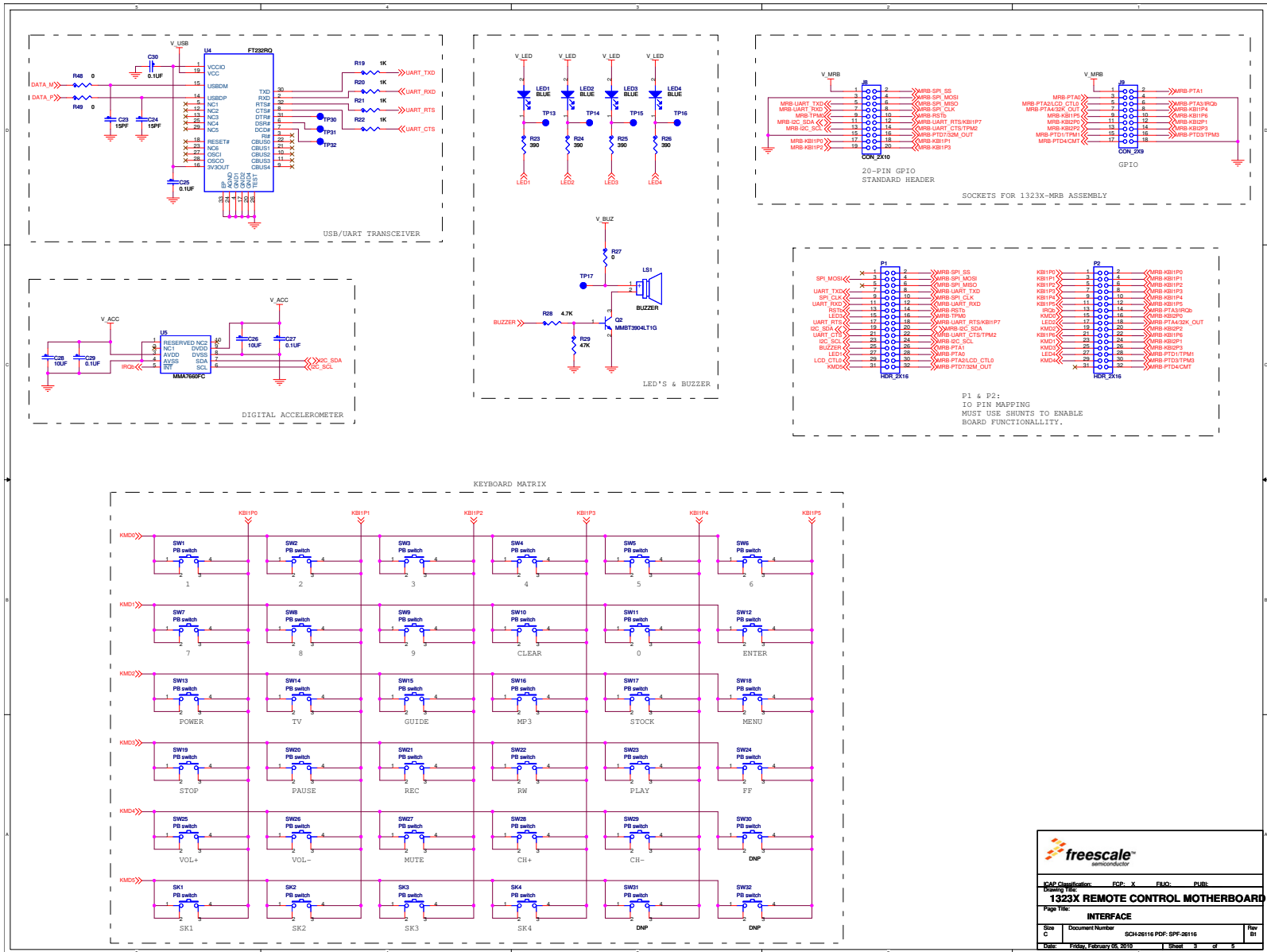
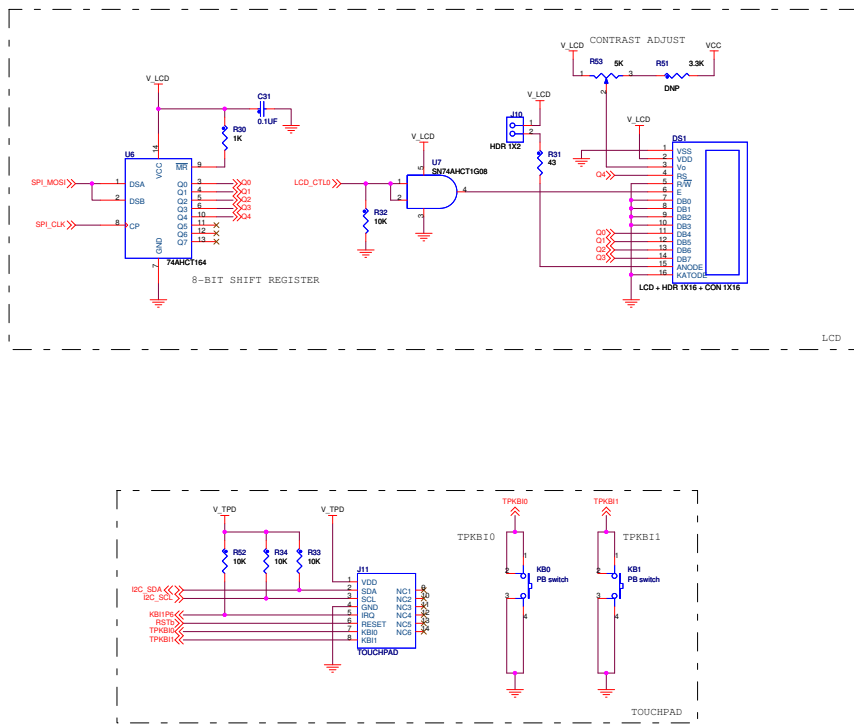


Figure 4-10. 1323x-RCM Schematic (1 of 3)

1323X REMOTE CONTROL MOTHERBOARD			
Page Title:	INTERFACE		
Size C	Document Number	SCM28116 PDF: 8PF-28116	Rev B1
Date:	Friday, February 05, 2010	Sheet 3	of 5



freescale semiconductors	
ICAP Classification:	FCP: X FPU: PUR:
Drawn Title:	1323X REMOTE CONTROL MOTHERBOARD
Page Title:	LCD & TOUCHPAD
Size:	Document Number: SCH-26116 PDF: SPF-26116
Date:	Friday, February 06, 2010 Sheet: 4 of 5

Figure 4-11. 1323x-RCM Schematic (2 of 3)

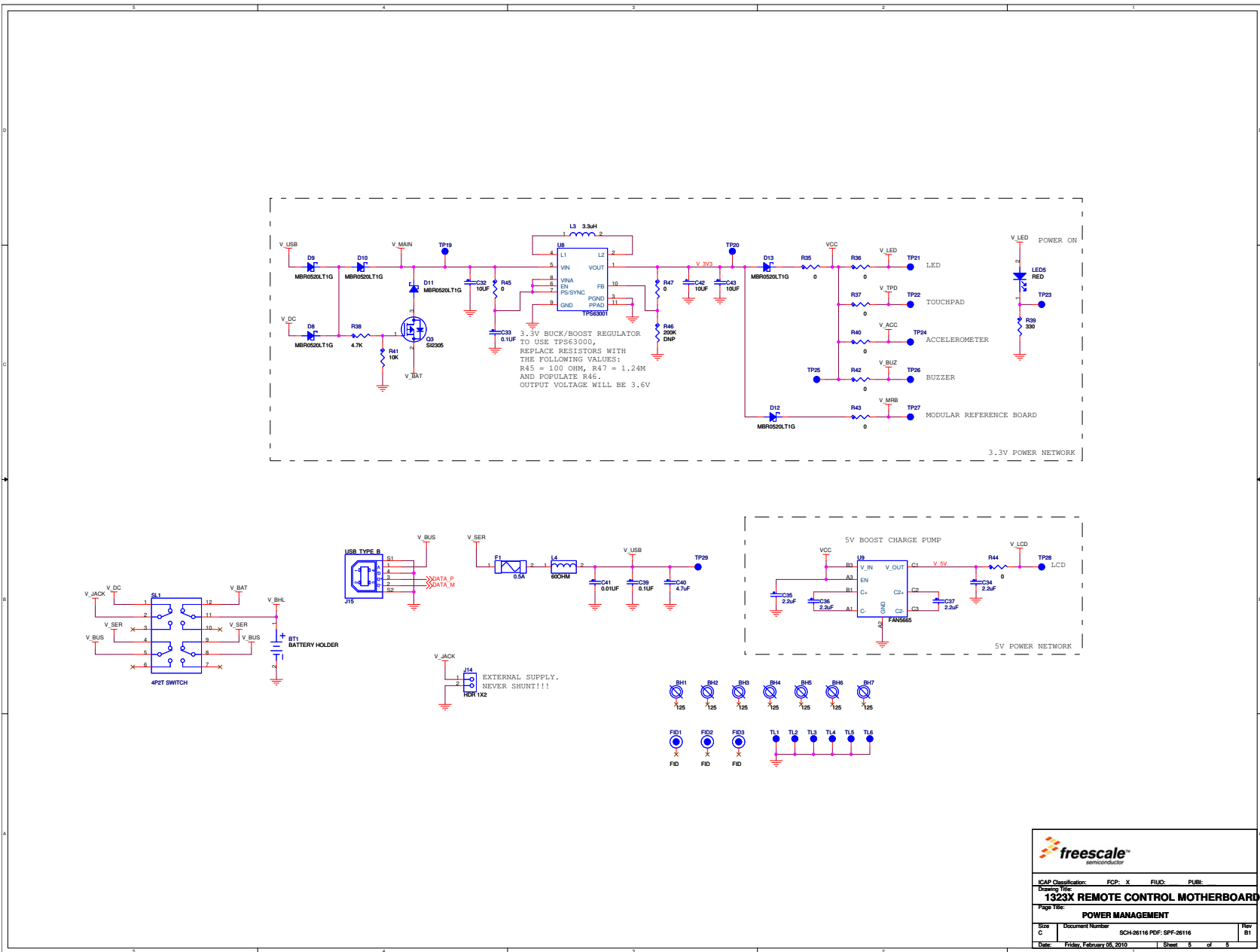


Figure 4-12. 1323x-RCM Schematic (3 of 3)

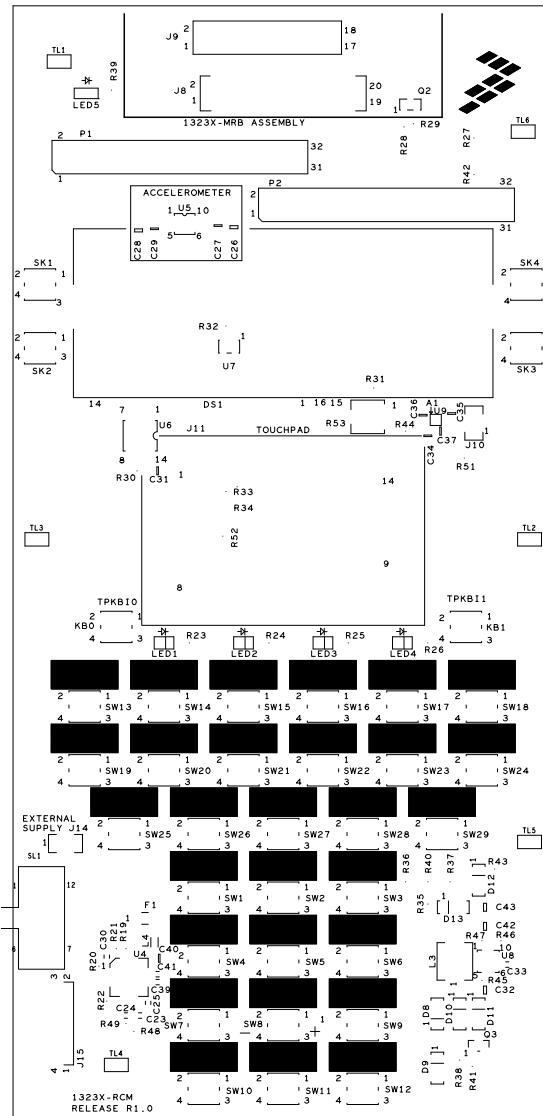


Figure 4-13. 1323x-RCM PCB Component Location (Top View)

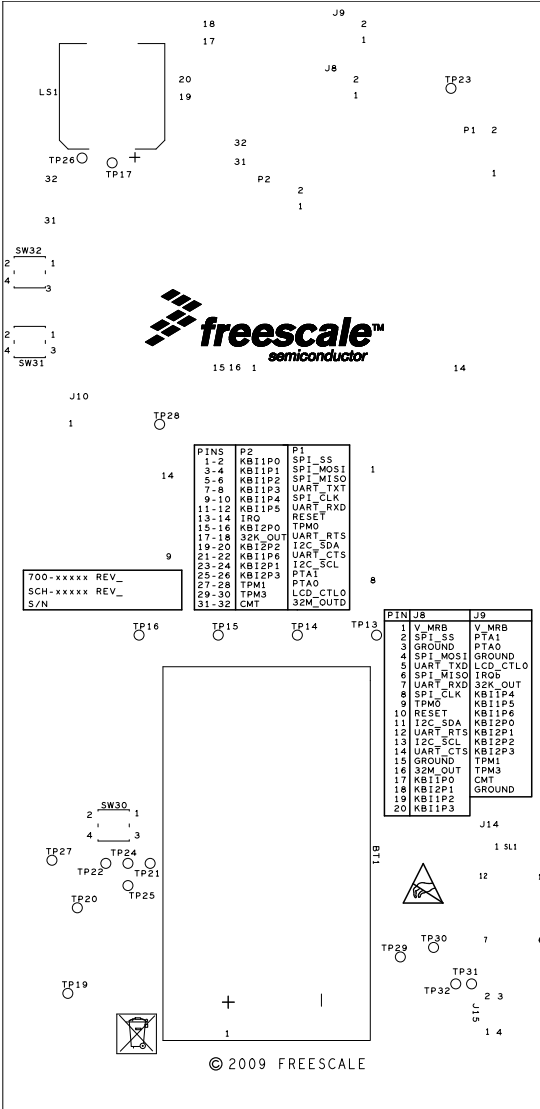


Figure 4-14. 1323x-RCM PCB Test Points

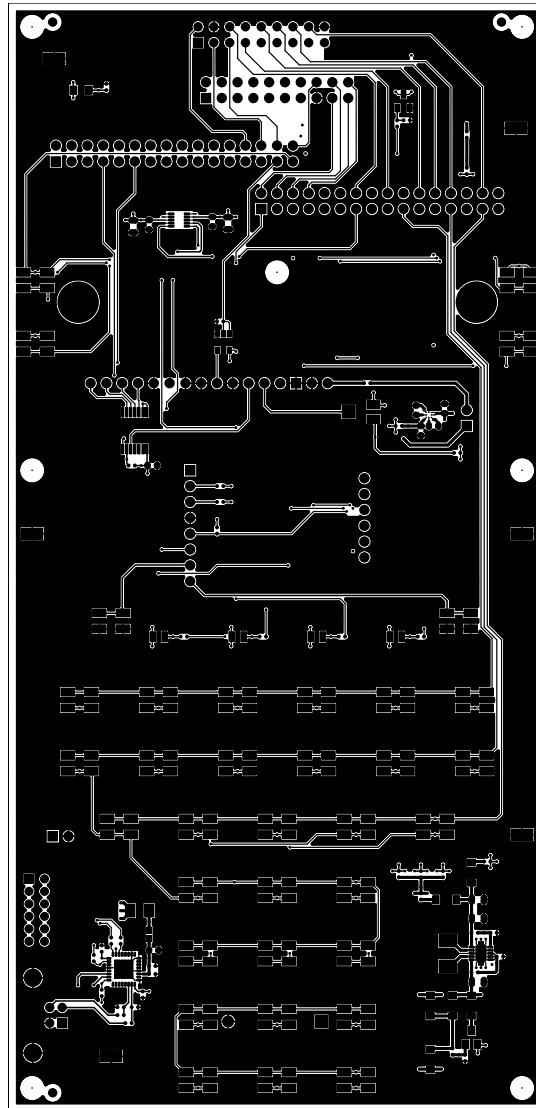


Figure 4-15. 1323x-RCM PCB Layout (Top View)

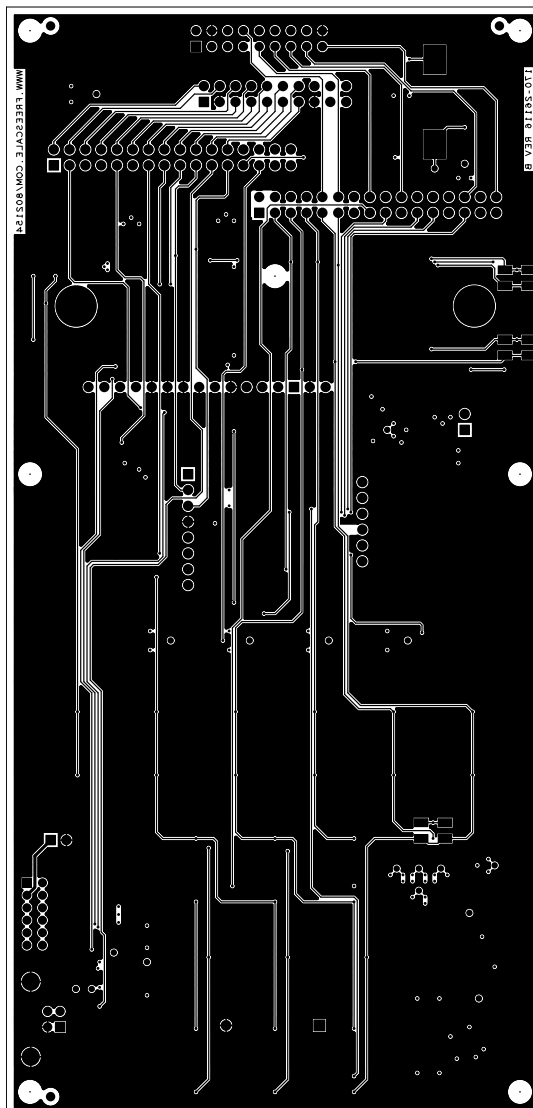


Figure 4-16. 1323x-RCM PCB Layout (Bottom View)

4.3.1 1323x-RCM Bill of Materials

Table 4-4. Bill of Materials

Item	Qty.	Reference	Value	Description	Mfg. Name	Mfg. Part Number
1	8	BH1,BH2,BH3,BH4,BH5,BH6,BH7,BH8	125	NON-PLATED MOUNTING HOLE 125 DRILL / 160 KEEPOUT NO PART TO ORDER		
2	1	BT1	BATTERY HOLDER	BATTERY HOLDER 2XAA TH	Keystone Electronics	2462
3	2	C23,C24	15PF	CAP CER 15PF 50V 5% C0G 0402	Kemet	C0402C150J5GAC
4	4	C25,C30,C33,C39	0.1UF	CAP CER 0.1UF 16V 10% X7R 0402	Murata	GRM155R71C104KA88D
5	5	C26,C28,C32,C42,C43	10UF	CAP CER 10UF 10V 10% X7R 0805	Murata	GRM21BR71A106KE51L
6	3	C27,C29,C31	0.1UF	CAP CER 0.1UF 50V 10% X7R 0603	Murata	GRM188R71H104KA93D
7	4	C34,C35,C36,C37	2.2uF	CAP CER 2.2UF 6.3V 10% X5R 0603	Murata	GRM188R60J225KE19D
8	1	C40	4.7uF	CAP CER 4.7UF 10V 10% X5R 0603	Taiyo Yuden	LMK107BJ475KA-T
9	1	C41	0.01UF	CAP CER 0.01UF 10V 20% X7R 0402	Avx	0402ZC103MAT2A
10	1	DS1	LCD + HDR 1X16 + CON 1X16	SUBASSY LCD 128X32 DOT 4.5-5V TH + HDR 1X16 TH 100MIL SP 330H AU + CON 1X16 SKT TH 100MIL SP 335 AU	Freescale Semiconductor	370-76474, 210-75955, 210-77812
11	6	D8,D9,D10,D11,D12,D13	MBR0520LT 1G	DIODE SCH 0.5A 20V SOD-123	On Semiconductor	MBR0520LT1G
12	3	FID1,FID2,FID3	FID	FIDUCIAL 060 MIL PAD W/120 SOLDERMASK AND 040 MIL PAD W/90 MIL SOLDERMASK NO PART TO ORDER	Generic	FID-040
13	1	F1	0.5A	FUSE FAST 0.5A 63V SMT 1206	Littelfuse	0437.500WR
14	1	J8	CON_2X10	CON 2X10 SKT TH 100MIL CTR 335H AU 104L	Samtec	SSW-110-01-G-D
15	1	J9	CON_2X9	CON 2X9 SKT TH 100MIL SP 335H AU 194L	Samtec	SSW-109-02-G-D
16	2	J10,J14	HDR_1X2	HDR 1X2 TH 100MIL SP 375H AU	Tyco Electronics	826629-2
17	1	J11	TOUCHPAD	TOUCHPAD SERIAL 3V TH	Synaptics, Inc	515-000188-0110

Table 4-4. Bill of Materials

Item	Qty.	Reference	Value	Description	Mfg. Name	Mfg. Part Number
18	1	J15	USB_TYPE_B	CON 2X2 USB_TYPE_B SKT RA SHLD TH 2.5MM SP 453H AU	Tyco Electronics	292304-2
19	35	SW1,SK1,KB1,SW2,SK2,SW3,SK3,SW4,SK4,SW5,SW6,SW7,SW8,SW9,SW10,SW11,SW12,SW13,SW14,SW15,SW16,SW17,SW18,SW19,SW20,SW21,SW22,SW23,SW24,SW25,SW26,SW27,SW28,SW29,KB0	PB switch	SW SMT 4.0MM FMS 0.1A MAX 16V MAX ROHS COMPLIANT	Bourns	7914J-1-000E
20	4	LED1,LED2,LED3,LED4	BLUE	LED BLUE SGL 20MA SMT 0805	Lite On	LTST-C171TBKT-5A
21	1	LED5	RED	LED RED CLEAR SGL 30MA SMT 0805	Lite On	LTST-C171KRKT
22	1	LS1	BUZZER	BUZZER PIEZO AUDIO 83DB 4KHZ 8MA 12V SMT	Cui Stack	CMI-1240
23	1	L3	3.3uH	IND PWR 3.3UH@100KHZ 3.3A 20% SMT	Vishay Intertechnology	IHLP2020BZER3R3M01
24	1	L4	60OHM	IND FER BEAD 60OHM@100MHZ 500MA -- 0603	Murata	BLM18PG600SN1_
25	2	P1,P2	HDR_2X16	HDR 2X16 TH 100MIL CTR 330H AU 100L	Samtec	TSW-116-07-S-D
26	1	Q2	MMBT3904LT1G	TRAN NPN GEN 200MA 40V SOT-23	On Semiconductor	MMBT3904LT1G
27	1	Q3	SI2305	TRAN PMOS PWR 4.1A 8V SOT23	Vishay Intertechnology	SI2305ADS-T1-GE3
28	5	R19,R20,R21,R22,R30	1K	RES MF 1.0K 1/16W 5% 0402	Vishay Intertechnology	CRCW04021K00JNED
29	4	R23,R24,R25,R26	390	RES MF 390 OHM 1/16W 5% 0402	Bourns	CR0402-JW-391GLF
30	2	R27,R45	100	RES MF 100 OHM 1/16W 5% 0402	Vishay Intertechnology	CRCW0402100RJNED
31	10	R28,R35,R36,R37,R40,R42,R43,R44,R48,R49	0	RES TF ZERO OHM 1/16W RC0402	Vishay Intertechnology	CRCW04020000ZS
32	6	R29,R32,R33,R34,R41,R52	10K	RES MF 10K 1/16W 5% 0402	Vishay Intertechnology	CRCW040210K0JNED

Table 4-4. Bill of Materials

Item	Qty.	Reference	Value	Description	Mfg. Name	Mfg. Part Number
33	1	R31	39	RES MF 39 OHM 1/16W 5% 0402	Smec	RC73L2Z390JTF
34	1	R38	4.7K	RES MF 4.7K 1/16W 5% 0402	Smec	RC73L2Z472JTF
35	1	R39	330	RES MF 330 OHM 1/16W 5% 0402	Vishay Intertechnology	CRCW0402330RJNED
36	1	R46	200K	RES MF 200K 1/16W 5% 0402	Yageo America	RC0402JR-07200KL
37	1	R47	1.24M	RES MF 1.24M 1/16W 1% 0402	Vishay Intertechnology	CRCW04021M24FKED
38	1	R50	5K	RES POT 5.0K 1/4W 20% SMT	Bourns	3314J-1-502E
39	1	R51	3.3K	RES MF 3.3K 1/16W 5% 0402	Vishay Intertechnology	CRCW04023K30JNED
40	1	SL1	4PDT SWITCH	SW 4PDT SLD TH RA 30V 100MA --	Tyco Electronics	1-1437575-1
41	3	SW30,SW31,SW32	PB switch	SW SMT 4.0MM FMS 0.1A MAX 16V MAX ROHS COMPLIANT	Bourns	7914J-1-000E
42	19	TP13,TP14,TP15,TP16,TP17,TP19,TP20,TP21,TP22,TP23,TP24,TP25,TP26,TP27,TP28,TP29,TP30,TP31,TP32	TPAD_040	TEST POINT PAD 40MIL DIA SMT, NO PART TO ORDER	Notacomponent	NOTACOMPONENT
43	1	U4	FT232RQ	IC XCVR USB TO UART CTLR 3.3-5.25V QFN32	Future Technology Devices International Ltd.	FT232RQ
44	1	U5	MMA7660FC	IC SENSOR ACCELEROMETER 2.4-3.6V DFN10	Freescale Semiconductor	MMA7660FC
45	1	U6	74AHCT164	IC REG SHIFT SER/PAR 8BIT 4.5-5.5V TSSOP14	Nxp Semiconductors	74AHCT164PW,112
46	1	U7	SN74AHC1G08	IC GATE AND SGL 2-INPUT POSITIVE 4.5-5.5V SOT23-5	Texas Instruments	SN74AHC1G08DBVR
47	1	U8	TPS63001	IC LIN DCDC SYNC 3.3V OUTPUT 1250-1800KHZ 1.8-5.5V QFN-10	Texas Instruments	TPS63001DRCT

Table 4-4. Bill of Materials

Item	Qty.	Reference	Value	Description	Mfg. Name	Mfg. Part Number
48	1	U9	FAN5665	IC LIN DCDC SWT 5V 2.9-5.5V WLCSP-8	Fairchild	FAN5665UCX

Chapter 5

1323x Remote Extender Motherboard

5.1 1323x-REM Overview

The 1323x-Remote Extender Motherboard (1323x-REM) is a motherboard that accepts the 1323x-Modular Reference Board (1323x-MRB) plug-in module (daughtercard) and supplies a power supply and set of interface peripherals. The two boards in combination provide a simple platform to evaluate the MC1323x, develop software, and demonstrate IEEE 802.15.4 based networking capabilities.

5.1.1 Features

The 1323x-REM provides the following features:

- Small form factor (3.1 x 3.1 inches)
- 2-Layer metal, 0.034 inch thick FR4 board
- Two connectors provide daughter card mounting
 - 20-Pin primary connector
 - 18-Pin secondary connector
 - Provide main supply voltage to board
 - Provide access to all MC13233 GPIO
- Flexible power supply
 - Sources include USB port, two AA batteries, or DC source
 - Power-On LED
 - On-Off switch
- USB \leftrightarrow UART serial port
- 2x4 Switch matrix
- IR receiver
- Four application controlled blue indicator LEDs
- Secondary set of pin headers uses jumpers to enable/disable IO connections and allows user application connection to MC13233 GPIO

5.1.2 Form Factor

Figure 5-1 shows a photo of the 1323x-REM showing the locations of connectors and headers.

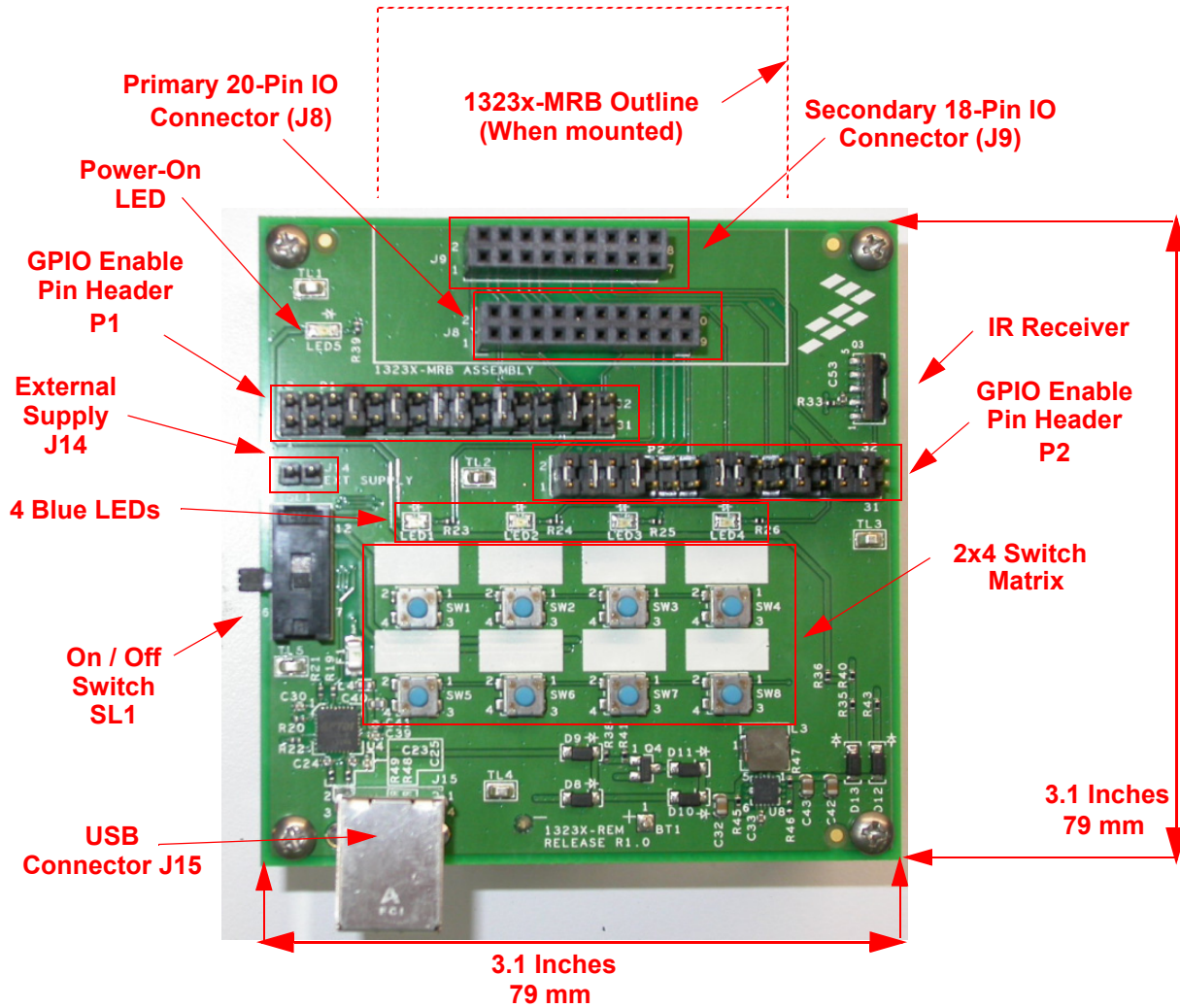


Figure 5-1. 1323x-REM

The 1323x-MRB mounts on the 1323x-REM via receptacles J8 and J9. Figure 5-1 shows an outline of the 1323x-MRB placement when mounted.

5.1.3 Board Level Specifications

NOTE

Temperature range specifications apply to REM used in combination with MRB.

Table 5-1. 1323x-REM Specifications

Parameter				Units	Notes/Conditions
	MIN	TYP	MAX		
General					
Size (PCB: X, Y)			79 x 79 3.1 x 3.1	mm inches	
Layer build (PCB)		0.8 0.034		mm inches	2-Layer
Dielectric material (PCB)					FR4
Power					
Voltage supply (DC)	2.3	5	6	V	
Voltage supply (USB)	4.4	5	5.25	V	USB 2.0/1.1 standard specification
Voltage supply (Batteries)		2.8	3.2	V	
Current consumption			100	mA	
Temperature					
Operating temperature; non-battery operation (see note)	-20	+25	+70	°C	Operating temperature is limited to +70 °C due to switches. Basic circuit is good for a maximum temperature of +85 °C.
Operating temperature; battery operation (see note)	0	+25	+50	°C	Operating temperature is limited by battery temperature range
Storage temperature	-30	+25	+70	°C	
USB interface					USB 2.0 and 1.1 full-speed compatible
IR Receiver					
Carrier frequency		38			kHz
Angle of half transmission distance		+/-50			degrees
Regulatory Approval					
CE (ETSI)					Product is approved accordingly to the EN 300 328 V1.7.1 (2006-10) standard
CE (EMC)					Product is approved accordingly to the EN 301 489-1 V1.6.1 (2005-09) and EN 301 489-17 V1.2.1 (2002-08) standards
Safety					

Table 5-1. 1323x-REM Specifications (continued)

Parameter				Units	Notes/Conditions
UL					Product is approved accordingly to the IEC 60950-1 and EN 60950-1, First Edition standards
Environment					
RoHS					Product complies with the EU Directive 2002/95/EC of 27 January 2003
WEEE					Product complies with the EU Directive 2002/95/EC of 27 January 2003

5.2 Functional Description

The 1323x-REM is a simple host motherboard for the 1323x-MRB. The two-board combination provides a simple evaluation and development platform for the MC13233. [Figure 5-2](#) shows a simple block diagram. The 2-layer board provides a flexible power supply, eight pushbutton matrix, four indicator LEDs, IR receiver, and a USB \leftrightarrow UART serial port.

As the board name implies this platform is useful to develop the host side (such as a DTV or entertainment console) of an RF remote control application. The MC13233 provides the RF node and an IR receiver is available to support legacy IR protocol remotes. Connection to a host is available through the USB port or any of the other generic MC13233 communications ports.

The 1323x-REM is also recommended for target development of applications where there is little periphery circuitry. There are switches and indicator LEDs onboard for user interface, and if necessary, custom circuitry can be connected via the two pin headers that allow access to the MC13233 GPIO.

In the following sections, refer to:

- [Figure 5-1](#) for location of connectors and features
- [Figure 5-2](#) for the functional blocks
- [Figure 5-8](#) and [Figure 5-9](#) for the board schematic

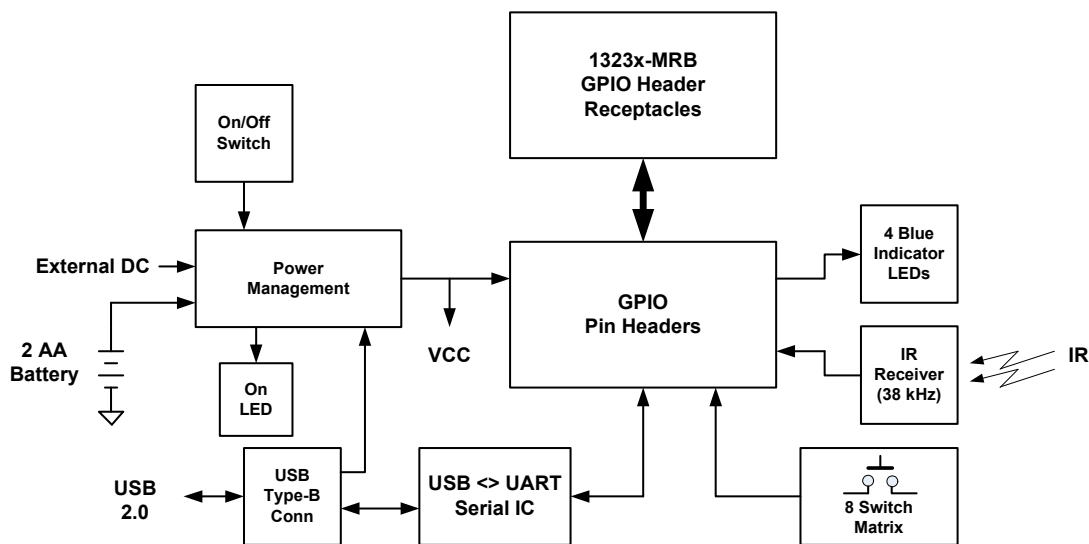


Figure 5-2. 1323x-REM Block Diagram

5.2.1 Power Management

The 1323x-REM can be powered from two AA batteries, the USB connector 5 V supply, or an external DC supply and is also intended to power the 1323x-MRB. Figure 5-3 shows the power management circuit.

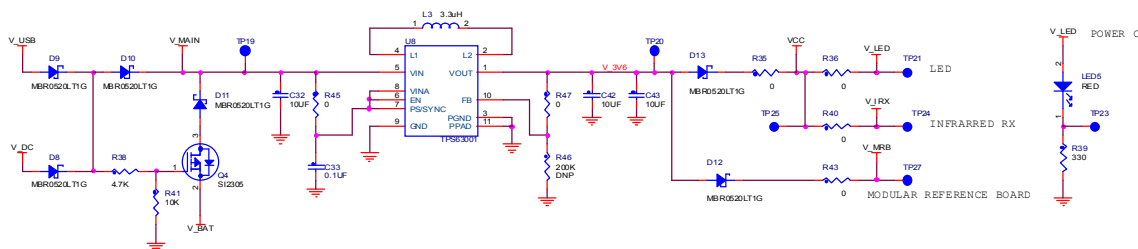


Figure 5-3. 1323x-REM Power Management Circuit

A boost-buck voltage regulator U8 is used in this design to allow operation over a relatively wide, low voltage input range, i.e., the TPS63001 regulator has input voltage range from 1.8 V to 5.5V. This allows a broad range of power supply sources. The regulated output voltage of the TPS63001 is 3.3 V which delivers about 3.05 V to the board due to the drop across the isolation Schottky diodes.

Attributes of the power management circuit include:

- Switch SL1 provides an ON/OFF function for all input voltage sources
- Red LED5 provides a POWER-ON indicator for all sources
- The 1323x-REM can derive power from three different sources -
 1. USB port Type-B connector J15 - power can be supplied from an actual USB port connection or from an AC to DC converter that uses the USB connector to supply power.
 2. External DC source via header J14 - a standard 0.1 in. spacing 1x2 pin header allows for connection of an external DC supply.

3. Battery Operation - a battery holder that accommodates two AA batteries is mounted on the non-component (back) side of the board and provides for battery operation.
 - If either the USB or external DC source is present, the battery source is disabled by MOSFET transistor Q3
 - The sources are all isolated and protected by Schottky diodes
 - The minimum effective battery operating voltage is controlled by the use the FTDI FT232RQ USB \leftrightarrow UART device - leakage current back through the FT232RQ UART connections to the MC13233 on the MRB can cause the Q3 MOSFET to partially turnoff at battery voltage below approximately 2.7-2.8 Vdc.

NOTE

To avoid current leakage through the USB device and lower minimum battery operating voltage for battery-only operation, remove the following jumpers:

- P1, Pins 7-8
- P1, Pins 11-12
- P1, Pins 17-18
- P1, Pins 21-22

NOTE

When battery operation is used, the temperature range of the two board system should be limited to within the specified temperature range of the battery technology. [Table 5-1](#) limits temperature range from 0 °C to +50 °C when battery operation is applied.

[Table 5-2](#) lists the voltage source attributes.

Table 5-2. 1323x-REM Voltage Sources

Source	Connector	Input Voltage Range	Description
USB Port	USB Type-B J15	4.4 V - 5.25 V	<ul style="list-style-type: none"> • The input voltage range is set to the USB specification value • The voltage can be supplied by either a standard USB cable connection or an AC to DC power adaptor that uses the USB connector J15 • If a power adaptor is in use, the USB serial port cannot be used
External DC Supply	1x2 Pin Hdr J14	2.3 V - 6 V	The input voltage range is determined by the U8 regulator and the diode isolation circuit
Two AA Batteries	Battery Holder	2.0 V - 3.1 V ¹	<ul style="list-style-type: none"> • The input voltage range reflects the usable range of alkaline cells and the voltage drop incurred by the diode isolation circuit. • The battery source is disabled if another source is connected

¹ The minimum operating battery voltage is determined by use model, see Note, [Section 5.2.1, "Power Management"](#)

Again referring to [Figure 5-3](#), a number of zero-ohm resistors are provided to isolate different circuits and to allow current measurement:

- VCC (main 1323x-REM supply) - resistor R35
- V_LED (all LEDs supply) - resistor R36
- V_IRX (IR receiver supply) - resistor R40
- V_MRB (1323x-MRB supply) - resistor R43

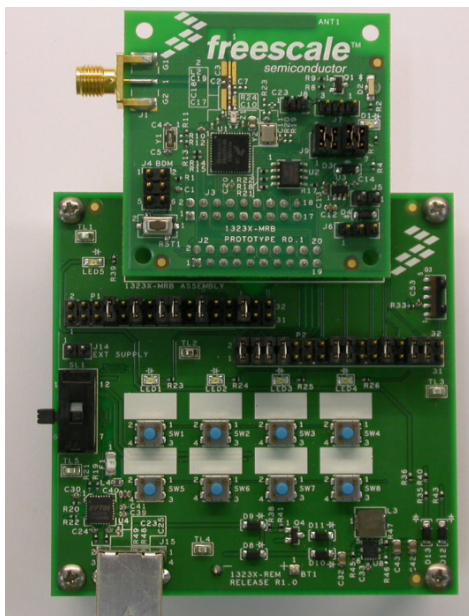


Figure 5-4. 1323x-MRB Mounted on 1323x-REM

5.2.2 GPIO Connection to 1323x-MRB

IO Connectors J8 and J9 (see [Figure 5-1](#)) are receptacles that accept the 1323x-MRB pin headers to mount the daughtercard. [Figure 5-4](#) shows the 1323x-REM with the 1323x-MRB mounted. Receptacles J8 and J9 connect to the MC13233 GPIO.

To provide better access and versatility to the GPIO, a secondary set of pin headers P1 and P2 is connected in series with the IO signals:

- Jumpers must be installed on P1 and P2 to connect 1323x-REM peripherals and functions
- The pin headers provide direct access for connecting custom circuitry to the GPIO
- Power and ground to primary connectors J8 and J9 are not enabled though the pin headers

[Figure 5-5](#) shows IO Header P1 and P2 pin mapping.

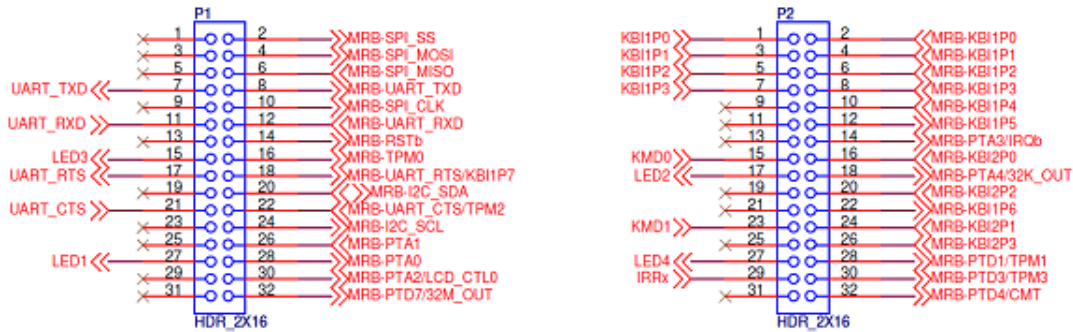


Figure 5-5. 1323x-REM IO Connector J8 and J9 Pin Mapping

Table 5-3 list the P1 and P2 pin header function as it relates to the MC13233.

Table 5-3. 1323x-REM P1 and P2 Pin Header Function Description

1323x-REM Header Pins	MC13233 Signal Name	Description	Comments
P1-27, P1-28	PTA0/XTAL_32K	Port A Bit 2 / 32.768 kHz oscillator output	<ul style="list-style-type: none"> Drives LED1; jumper required 32.768 kHz oscillator can be enabled on MRB
P1-26	PTA1/EXTAL_32K	Port A Bit 3 / 32.768 kHz oscillator input	<ul style="list-style-type: none"> Unused 32.768 kHz oscillator can be enabled on MRB
P1-14	RESET	Device asynchronous hardware reset. Active low. Onboard Pullup	<ul style="list-style-type: none"> Unused Reset signal driven from MRB
P1-30	PTA2	Port A Bit 2. Onboard pullup for TM	<ul style="list-style-type: none"> Unused TM enable; leave unconnected
P2-14	PTA3/IRQ	Port A Bit 3 / IRQ.	<ul style="list-style-type: none"> Unused Provides interrupt request input IRQ (active low)
P2-17, P2-18	PTA4/XTAL_32KOUT	Port A Bit 4 / Buffered 32.768 kHz clock output	<ul style="list-style-type: none"> Drives LED2; jumper required Optional 32.768 kHz output clock for measuring reference oscillator accuracy (ppm)
P1-20	PTA5/SDA	Port A Bit 5 / IIC Bus data	<ul style="list-style-type: none"> Unused Defaults to open drain for IIC Pullup on MRB
P1-24	PTA6/SCL	Port A Bit 6 / IIC Bus clock	<ul style="list-style-type: none"> Unused Defaults to open drain for IIC Pullup on MRB
P2-1, P2-2	PTB0/KBI1P0	Port B Bit 0 / KBI1 Input Bit 0	REM switch matrix; jumper required
P2-3, P2-4	PTB1/KBI1P1	Port B Bit 1 / KBI1 Input Bit 1	REM switch matrix; jumper required
P2-5, P2-6	PTB2//KBI1P2	Port B Bit 2 / KBI1 Input Bit 2	REM switch matrix; jumper required
P2-7, P2-8	PTB3//KBI1P3	Port B Bit 3 / KBI1 Input Bit 3	REM switch matrix; jumper required
P2-10	PTB4//KBI1P4	Port B Bit 4 / KBI1 Input Bit 4	Unused

Table 5-3. 1323x-REM P1 and P2 Pin Header Function Description (continued)

1323x-REM Header Pins	MC13233 Signal Name	Description	Comments
P2-12	PTB5//KBI1P5	Port B Bit 5 / KBI1 Input Bit 5	Unused
P2-22	PTB6//KBI1P6	Port B Bit 6 / KBI1 Input Bit 6	Unused
P1-17, P1-18	PTB7//KBI1P7	Port B Bit 7 / KBI1 Input Bit 7	<ul style="list-style-type: none"> • UART flow control RTS input to MCU; jumper required • Connects to REM USB <> UART device
P2-15, P2-16	PTC0/KBI2P0	Port C Bit 0 / KBI2 Input Bit 0	REM switch matrix; jumper required
P2-23, P2-24	PTC1/KBI2P1	Port C Bit 1 / KBI2 Input Bit 1	REM switch matrix; jumper required
P2-20	PTC2/KBI2P2	Port C Bit 2 / KBI2 Input Bit 2	Unused
P2-26	PTC3/KBI2P3	Port C Bit 3 / KBI2 Input Bit 3	Unused
P1-10	PTC4/SPICLK	Port C Bit 4 / SPI clock	<ul style="list-style-type: none"> • Unused on REM • Connected to serial FLASH on MRB
P1-2	PTC5/SS	Port C Bit 5 / SPI slave select	<ul style="list-style-type: none"> • Unused on REM • Connected to serial FLASH on MRB
P1-6	PTC6/MISO	Port C Bit 6 / SPI MISO	<ul style="list-style-type: none"> • Unused on REM • Connected to serial FLASH on MRB
P1-4	PTC7/MOSI	Port C Bit 7 / SPI MOSI	<ul style="list-style-type: none"> • Unused on REM • Connected to serial FLASH on MRB
P1- 15, P1-16	PTD0/TPM0	Port D Bit 0 / TPM0 signal	Unused
P2-27, P2-28	PTD1/TPM1	Port D Bit 1/ TPM1 signal	Drives LED4; jumper required
P1-21, P1-22	PTD2/TPM2	Port D Bit 2 / TPM2 signal	<ul style="list-style-type: none"> • UART flow control CTS output from MCU; jumper required • Connects to REM USB <> UART device
P2-29, P2-30	PTD3/TPM3	Port D Bit 3 / TPM3 signal	<ul style="list-style-type: none"> • REM IR receiver input; jumper required • Drives timer input
P2-32	PTD4/CMT	Port D Bit 4/ CMT output	<ul style="list-style-type: none"> • Not used on REM • Connected to IR blaster on MRB
P1-7, P1-8	PTD6/RXD	Port D Bit 6 / UART RXD input	<ul style="list-style-type: none"> • UART RXD input to MCU; jumper required • Connects to REM USB <> UART device
P1-11, P1-12	PTD5/TXD	Port D Bit 5 / UART TXD output	<ul style="list-style-type: none"> • UART TXD output from MCU; jumper required • Connects to REM USB <> UART device
P1-32	PTD7/32MOUT	Port D Bit 7	Unused

5.2.3 1323x-REM Onboard Peripheral Functions

The 1323x-REM has a simple set of peripheral functions useful to evaluate the MC13233 and to implement simple node applications, especially a remote control receiver; i.e., interface to host platform.

5.2.4 USB Interface

For many applications or demonstrations it is desirable to connect the 1323x-REM to a PC or other device. A USB port is provided with a USB “B” receptacle plug. The port is connected to a FTDI FT232RQ USB \leftrightarrow UART device that appears as a Virtual COM port (VCP) to the PC. PC drivers are available with the module.

The USB interface is configured as a "Bus Powered" device and can draw all required power from the USB interface. The device is USB 2.0 full speed compatible.

The USB connector is designated as J15. [Figure 5-6](#) shows the connector pinout.

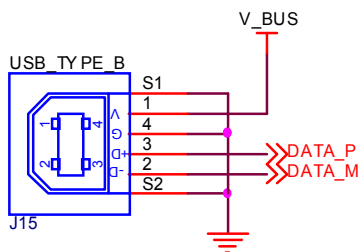


Figure 5-6. USB Connector Pinout

5.2.5 IR Receiver

The 1323x-REM provides an IR receiver that accepts IR signals from the RCM or from any IR based remote control devices.

- The IR receiver is the TSOP85238TR device (Q3)
- 38 kHz carrier frequency
- +/- 50 Degree angle of half transmission distance
- Drives the PTD3/TPM3 signal.

[Figure 5-7](#) shows the IR receiver schematic.

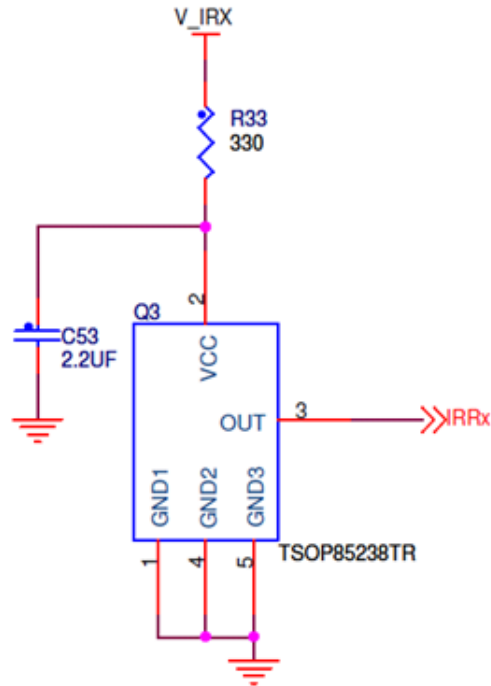


Figure 5-7. IR Receiver Circuit

5.2.6 Pushbutton 2x4 Switch Matrix

The 1323x-REM provides an 8 pushbutton 2x4 switch matrix for user application input interface.

- The matrix utilizes MC13233 KBI inputs
- All switches have interrupt and device wake up capability

5.2.7 Blue Indicator LEDs

The 1323x-REM provides 4 blue LEDs for user application indicator outputs. Refer to [Table 5-3](#) for listings of the MC13233 outputs that drive the LEDs.

5.3 Schematic, Board Layout, and Bill of Material

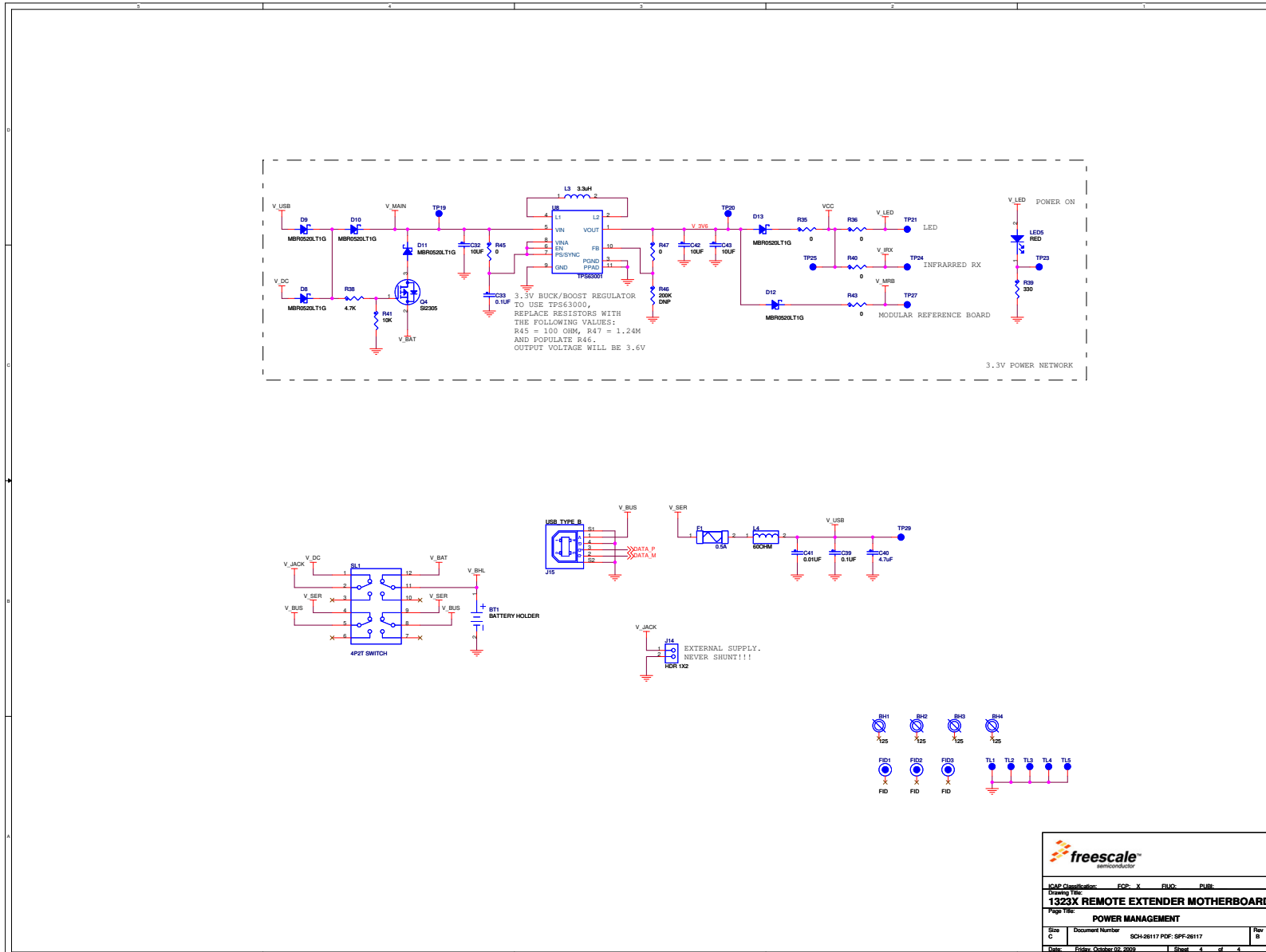


Figure 5-8. 1323x-REM Schematic (1 of 2)

ICAP Classification:	FCP: X FIUC: PURB
1323X REMOTE EXTENDER MOTHERBOARD	
INTERFACE	
Site C	Document Number: SCH-26117 PDF: SPF-26117
Date: Friday, October 29, 2009	Sheet 4 of 4

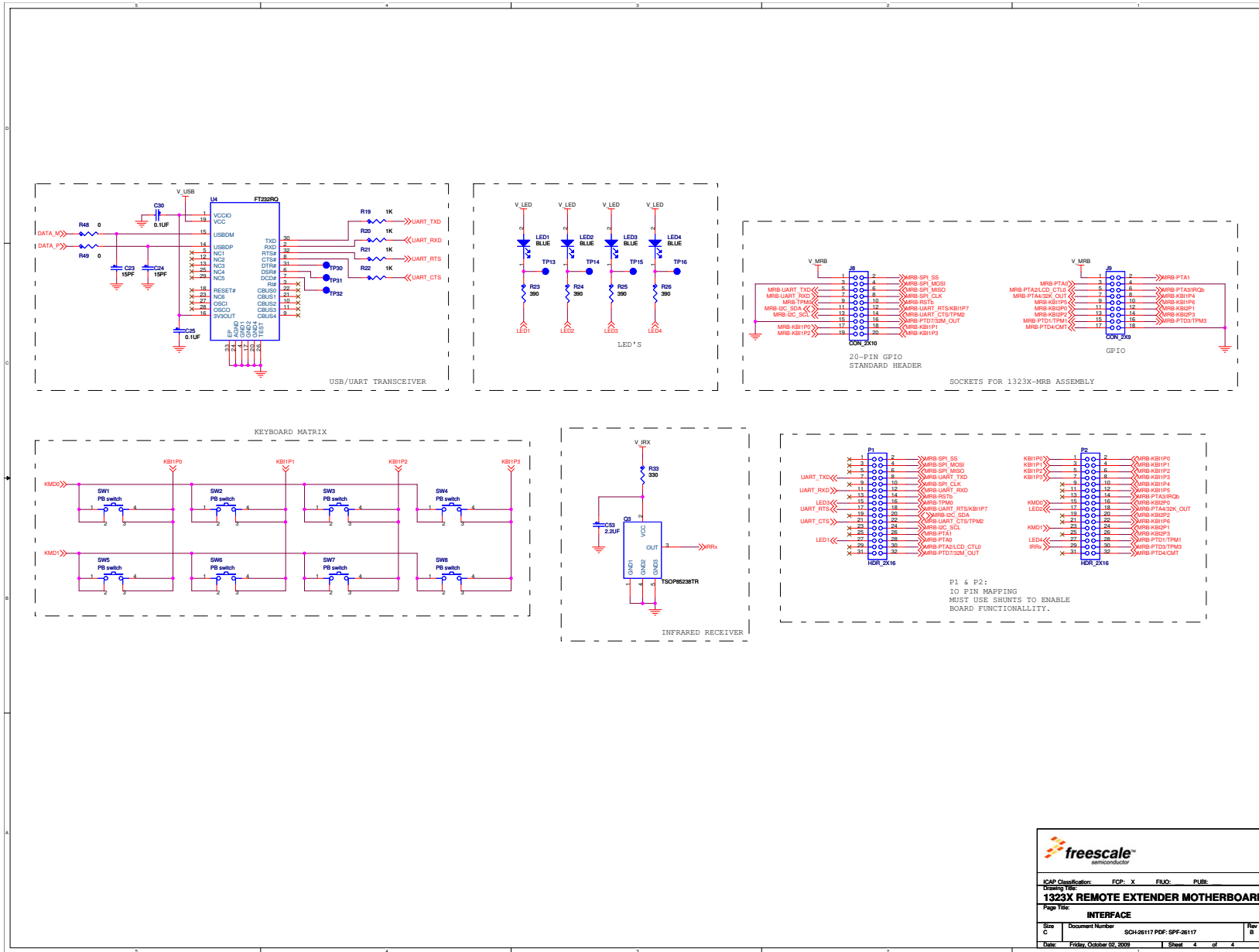


Figure 5-9. 1323x-REM Schematic (2 of 2)

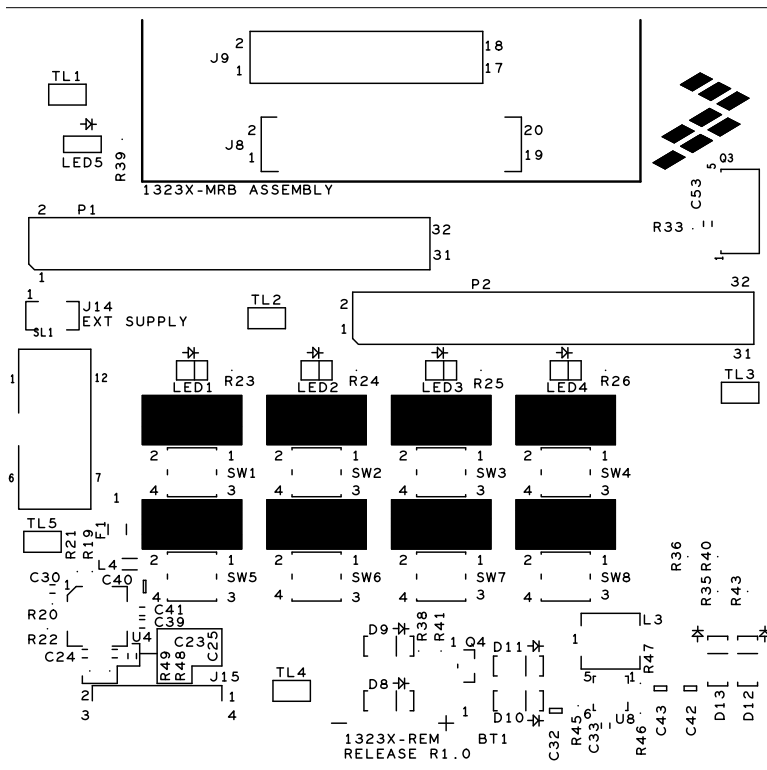


Figure 5-10. 1323x-REM PCB Component Location (Top View)

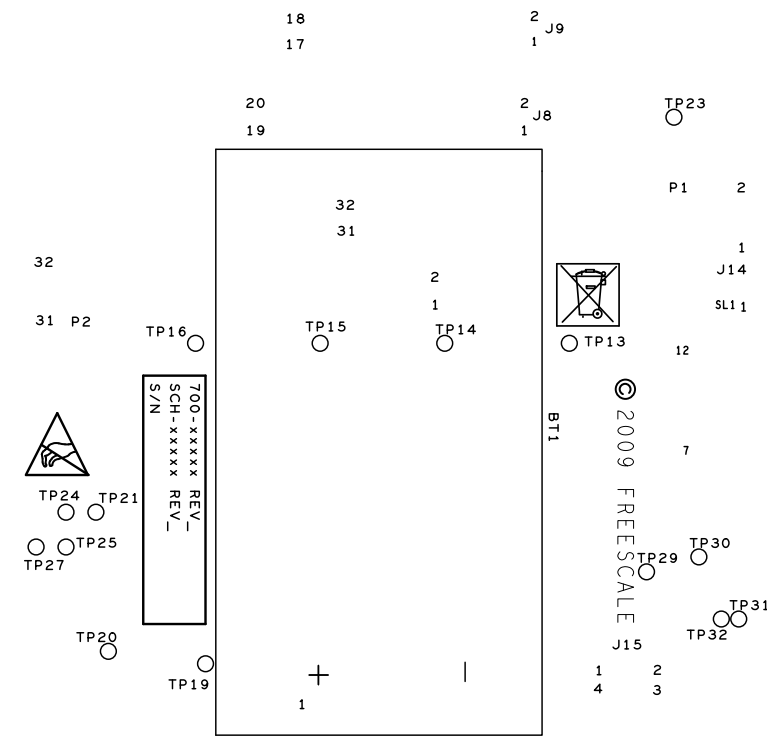


Figure 5-11. 1323x-REM PCB Test Points

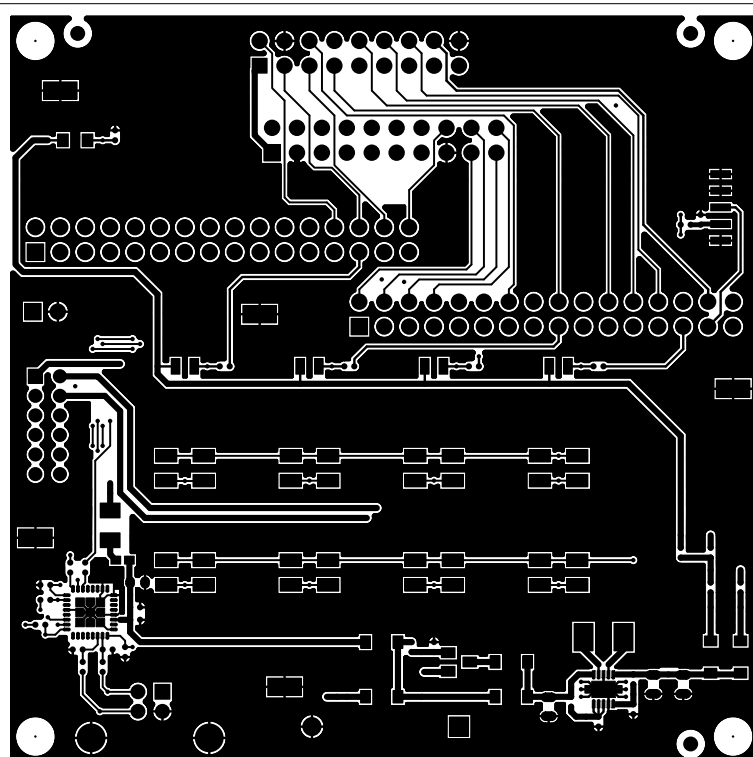


Figure 5-12. 1323x-REM PCB Layout (Top View)

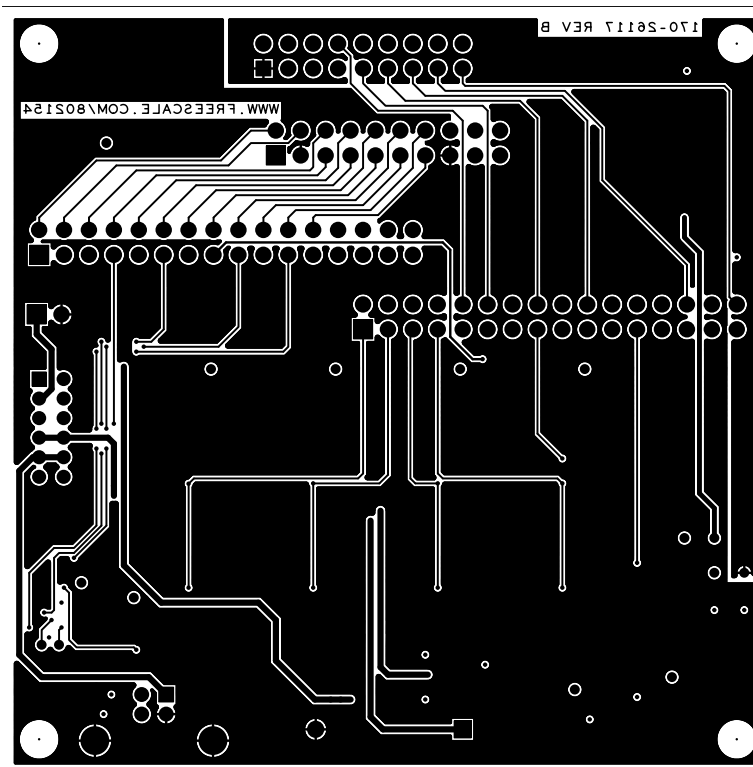


Figure 5-13. 1323x-REM PCB Layout (Bottom View)

5.3.1 1323x-REM Bill of Materials

Table 5-4. Bill of Materials

Item	Qty.	Reference	Value	Description	Mfg. Name	Part Number
1	4	BH1, BH2, BH3, BH4	125	NON-PLATED MOUNTING HOLE 125 DRILL / 160 KEEPOUT NO PART TO ORDER		
2	1	BT1	BATTERY HOLDER	BATTERY HOLDER 2XAA TH	KEystone ELECTRONICS	2462
3	2	C23,C24	15PF	CAP CER 15PF 50V 5% C0G 0402	KEMET	C0402C150J5GAC
4	4	C25,C30,C33, C39	0.1UF	CAP CER 0.1UF 16V 10% X7R 0402	MURATA	GRM155R71C104KA88D
5	3	C32,C42,C43	10UF	CAP CER 10UF 10V 10% X7R 0805	Murata	GRM21BR71A106KE51L
6	1	C40	4.7uF	CAP CER 4.7UF 10V 10% X5R 0603	TAIYO YUDEN	LMK107BJ475KA-T
7	1	C41	0.01UF	CAP CER 0.01UF 10V 20% X7R 0402	AVX	0402ZC103MAT2A
8	1	C53	2.2UF	CAP CER 2.2UF 6.3V 20% X5R 0402	MURATA	GRM155R60J225ME15D
9	6	D8,D9,D10,D11 ,D12,D13	MBR0520L T1G	DIODE SCH 0.5A 20V SOD-123	ON SEMICONDUCTOR	MBR0520LT1G
10	3	FID1,FID2,FID3	FID	FIDUCIAL 060 MIL PAD W/120 SOLDERMASK AND 040 MIL PAD W/90 MIL SOLDERMASK NO PART TO ORDER	GENERIC	FID-040
11	1	F1	0.5A	FUSE FAST 0.5A 63V SMT 1206	LITTELFUSE	0437.500WR
12	1	J8	CON_2X10	CON 2X10 SKT TH 100MIL CTR 335H AU 104L	SAMTEC	SSW-110-01-G-D
13	1	J9	CON_2X9	CON 2X9 SKT TH 100MIL SP 335H AU 194L	SAMTEC	SSW-109-02-G-D
14	1	J14	HDR_1X2	HDR 1X2 TH 100MIL SP 375H AU	TYCO ELECTRONICS	826629-2
15	1	J15	USB_TYP E_B	CON 2X2 USB_TYPE_B SKT RA SHLD TH 2.5MM SP 453H AU	TYCO ELECTRONICS	292304-2
16	4	LED1,LED2,LED3,LED4	BLUE	LED BLUE SGL 20MA SMT 0805	LITE ON	LTST-C171TBKT-5A
17	1	LED5	RED	LED RED CLEAR SGL 30MA SMT 0805	LITE ON	LTST-C171KRKT

Table 5-4. Bill of Materials

Item	Qty.	Reference	Value	Description	Mfg. Name	Part Number
18	1	L3	3.3uH	IND PWR 3.3UH@100KHZ 3.3A 20% SMT	VISHAY INTERTECHNOLO GY	IHLP2020BZER3R3M01
19	1	L4	60OHM	IND FER BEAD 60OHM@100MHZ 500MA -- 0603	MURATA	BLM18PG600SN1_
20	2	P1,P2	HDR_2X1 6	HDR 2X16 TH 100MIL CTR 330H AU 100L	SAMTEC	TSW-116-07-S-D
21	1	Q3	TSOP8523 8TR	TRAN PHOTO 0.45MA 5.5V 950NM SMT	VISHAY INTERTECHNOLO GY	TSOP85238TR
22	1	Q4	SI2305	TRAN PMOS PWR 4.1A 8V SOT23	VISHAY INTERTECHNOLO GY	SI2305ADS-T1-GE3
23	4	R19,R20,R21,R 22	1K	RES MF 1.0K 1/16W 5% 0402	VISHAY INTERTECHNOLO GY	CRCW04021K00JNED
24	4	R23,R24,R25,R 26	390	RES MF 390 OHM 1/16W 5% 0402	BOURNS	CR0402-JW-391GLF
25	2	R33,R39	330	RES MF 330 OHM 1/16W 5% 0402	VISHAY INTERTECHNOLO GY	CRCW0402330RJNED
26	6	R35,R36,R40,R 43,R48,R49	0	RES TF ZERO OHM 1/16W RC0402	VISHAY INTERTECHNOLO GY	CRCW04020000ZS
27	1	R38	4.7K	RES MF 4.7K 1/16W 5% 0402	SMEC	RC73L2Z472JTF
28	1	R41	10K	RES MF 10K 1/16W 5% 0402	VISHAY INTERTECHNOLO GY	CRCW040210K0JNED
29	1	R45	100	RES MF 100 OHM 1/16W 5% 0402	VISHAY INTERTECHNOLO GY	CRCW0402100RJNED
30	1	R46	200K	RES MF 200K 1/16W 5% 0402	YAGEO AMERICA	RC0402JR-07200KL
31	1	R47	1.24M	RES MF 1.24M 1/16W 1% 0402	VISHAY INTERTECHNOLO GY	CRCW04021M24FKED
32	1	SL1	4PDT SWITCH	SW 4PDT SLD TH RA 30V 100MA --	TYCO ELECTRONICS	1-1437575-1
33	8	SW1,SW2,SW3 ,SW4,SW5,SW 6,SW7,SW8	PB switch	SW SMT 4.0MM FMS 0.1A MAX 16V MAX ROHS COMPLIANT	BOURNS	7914J-1-000E

Table 5-4. Bill of Materials

Item	Qty.	Reference	Value	Description	Mfg. Name	Part Number
34	15	TP13,TP14,TP15,TP16,TP19,TP20,TP21,TP23,TP24,TP25,TP27,TP29,TP30,TP31,TP32	TPAD_040	TEST POINT PAD 40MIL DIA SMT, NO PART TO ORDER	NOTACOMPONENT	NOTACOMPONENT
35	1	U4	FT232RQ	IC XCVR USB TO UART CTLR 3.3-5.25V QFN32	FUTURE TECHNOLOGY DEVICES INTERNATIONAL LTD.	FT232RQ
36	1	U8	TPS63001	IC LIN DCDC SYNC 3.3V OUTPUT 1250-1800KHZ 1.8-5.5V QFN-10	TEXAS INSTRUMENTS	TPS63001DRCT

Chapter 6

PCB Manufacturing Specifications

This chapter provides the specifications used to manufacture the 1323x Development hardware printed circuit boards (PCB) described in this manual.

The 1323x Development hardware PCBs must comply with the following:

- The PCB must comply with Perfag10/3C (<http://www.perfag.dk/Uk/ukindex.htm>)
- The PCB manufacturer's logo is required
- The PCB production week and year code is required
 - The manufacturer's logo and week/year code must be stamped on the back of the PCB solder mask
 - The PCB manufacturer can not insert text on the PCB either in copper or in silkscreen without written permission from Freescale Semiconductor, Inc.
- The required Underwriter's Laboratory (UL) Flammability Rating
 - The level is 94V-0 (<http://www.ul.com/plastics/flame.html>)
 - The UL information must be stamped on the back of the PCB solder mask

NOTE

- A complete set of design files is available for the 1323x Development hardware at the Freescale web site (<http://www.freescale.com/802154>) under reference designs. It is recommended that this design or one of a number of other reference designs be used as a starting point for a custom application.
- The *Freescale IEEE 802.15.4 / ZigBee Package and Hardware Layout Considerations Reference Manual*, (ZHDCRM) is also available at the same web site to provide additional design guidance.

6.1 Single PCB Construction

This section describes individual PCB construction details.

- The MRB and RCM PCBs are four-layer, multi layer designs
- The REM PCB is a two layer design
- The PCBs contains no blind, buried, or micro vias
- PCB data:
 - MRB Size: Approximately 51 x 51mm (2.01 x 2.01 inches)
 - RCM Size: Approximately 86 x 178 mm (3.4 x 7.0 inches)
 - REM Size: Approximately 79 x 79 mm (3.1 x 3.1 inches)

- MRB, RCM and REM Final thickness (Cu/Cu): 0.34 mm (0.8 inches) +/- 10% (excluding solder mask)

The following table defines some of the layers of the completed PCB. The artwork identification refers to the name of the layer in commonly used terms.

Table 6-1. MRB Layer by Layer Overview

Layer	Artwork Identification	File Name
1	Silkscreen Top	SILK_TOP.art
2	Top Layer Metal	TOP.art
3	Ground Layer	GND.art
4	Power Layer	PWR.art
5	Bottom Layer Metal	BOTTOM.art
6	Silkscreen Bottom	SILK_BOTTOM.art

Table 6-2. RCM Layer by Layer Overview

Layer	Artwork Identification	File Name
1	Silkscreen Top	SILK_TOP.art
2	Top Layer Metal	TOP.art
3	Ground Layer	GND.art
4	Power Layer	PWR.art
5	Bottom Layer Metal	BOTTOM.art
6	Silkscreen Bottom	SILK_BOTTOM.art

Table 6-3. REM Layer by Layer Overview

Layer	Artwork Identification	File Name
1	Silkscreen Top	SILK_TOP.art
2	Top Layer Metal	TOP.art
3	Bottom Layer Metal	BOTTOM.art
4	Silkscreen Bottom	SILK_BOTTOM.art

The 1323x MRB contains high frequency 2.4 GHz RF circuitry. As a result, RF component placement, line geometries and layout, and spacing to the ground plane are critical parameters. As a result, BOARD STACKUP GEOMETRY IS CRITICAL. Dielectric and copper thicknesses and spacing must not be changed; follow the stackup (see [Figure 6-1](#)) information is provided with the reference design.

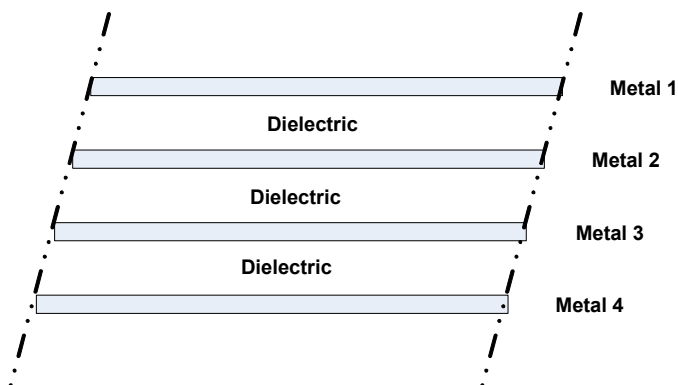


Figure 6-1. MRB PCB Stackup Cross-Section (Four Layer)

- Solder mask is required
- Silk screen is required

6.2 Panelization

The panel size can be negotiated depending on production volume.

6.3 Materials

The PCB composite materials must meet the following requirements:

- Laminate - The base laminate material (laminate) must be FR4. If the laminate material were changed the RF electrical characteristics may change and degrade RF performance.
- Copper Foil -
 - Top and Bottom copper layers must be 1 oz. copper
 - Interior layers must be 1/2 oz. copper
- Plating - All pad plating must be Hot Air Levelling (HAL)

6.4 Solder Mask

The solder mask must meet the following requirements:

- Solder mask type: Liquid Film Electra EMP110 or equivalent
- Solder mask thickness: 10 – 30 μm

6.5 Silk Screen

The silk screen must meet the following requirements:

- Silkscreen color: White
- Silkscreen must be applied after application of solder mask if solder mask is required
- The silkscreen ink must not extend into any plated-thru-holes
- The silk screen must be clipped back to the line of resistance

6.6 Electrical PCB Testing

- All PCBs must be 100 percent tested for opens and shorts
- Impedance Measurement - An impedance measurement report is not mandatory

6.7 Packaging

Packaging for the PCBs must be the following requirements:

- Finished PCBs must remain in panel
- Finished PCBs must be packed in plastic bags that do not contain silicones or sulphur materials. These materials can degrade solderability.

6.8 Hole Specification/Tool Table

See the `ncdrill-1-4.tap` file included with the Gerber files and the `FAB-23451.pdf` file.

6.9 File Description

Files included with the download include Design, Gerber and PDF files.

Gerber files are RS-374x format. Not all files included with the Gerber files are for PCB manufacturing.

PDF files included are:

- FAB-2611x.pdf — Board fabrication drawing
- GRB-2611x.pdf — Metal layers, solder mask, solder paste and silk screen
- SPF-2611x.pdf — Schematic

Design files are in Allegro format with OrCAD schematic capture.