# 1320x-QE128EVB

Reference Manual

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## About This Book

This manual describes Freescale's MC1320x and MC9S08QE128 evaluation board (1320x-QE128EVB). The 1320x-QE128EVB contains Freescale's MC13202 QFN-32 package and MC9S08QE128 Daughter card used in the DEMOQE128 Flexis™ QE128 Demonstration Board. The MC13202 is a short range, low power 2.4 GHz Industrial, Scientific, and Medical (ISM) band transceiver. The MC13202 contains a complete 802.15.4 physical layer (PHY) modem designed for the IEEE® 802.15.4 standard which supports peer-to peer, star, and mesh networking. The MC9S08QE128 is a low cost, low power, high-performance HCS08 Family of 8-bit microcontroller units. The MC9S08QE128 use the enhanced HCS08 core with 128 Flash size and 64 pin LQFP package.

## Audience

This manual is intended for system designers.

## Organization

This document is organized into six chapters.

| | |
|---|---|
| Chapter 1 | Safety Information — This chapter highlights Federal Communications Commission operating guidelines. |
| Chapter 2 | MC1320x and QE128 EVB  Module Overview and Description — This chapter introduces MC1320x and QE128 EVB which is an IEEE, 802.15.4 compliant evaluation board based on the Freescale MC1320x and QE128 EVB device. |
| Chapter 3 | System Overview and Functional Block Descriptions — This section provides an overview of the  and system block diagrams. |
| Chapter 4 | Interface Locations and Pinouts — This chapter provides a description of the interface locations and pinout of the 1320x-QE128EVB circuit board. |
| Chapter 5 | Schematic and Bill of Materials — This chapter provides the schematic and Bill of Materials (BOM). |
| Chapter 6 | PCB Manufacturing Specifications — This chapter provides the specifications used to manufacture the 1320x-QE128EVB printed circuit board (PCB). |

## Revision History

The following table summarizes revisions to this document since the previous release (Rev 0.0).

**Revision History**

| Location | Revision |
|---|---|
| Chapter 5 and 6 | Added PCB build information and updated schematic. |

## Definitions, Acronyms, and Abbreviations

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

| | |
|---|---|
| ADC | Analog to Digital Converter |
| CTS | Clear to Send |
| I2C | Inter-Integrated Circuit is a multi-master serial computer bus |
| ISM | Industrial Scientific Medical 2.4 GHz radio frequency band |
| MAC | Media Access Controller |
| MCU | Microcontroller Unit |
| PCB | Printed circuit board |
| RTS | Request to Send |
| SPI | Serial Peripheral Interface |
| SSI | Synchronous Serial Interface |
| USB | Universal Serial Bus |

# Chapter 1
# Safety Information

## 1.1 FCC Guidelines

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

### 1.1.1 47 C.F.R. Sec. 15.21

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

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

### 1.1.2 47 C.F.R. Sec.15.105(b)

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

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

1. This device may not cause harmful interference.
2. This device must accept any interference received, including interference that may cause undesired operation.
3. This device is susceptible to electrostatic discharge (ESD) and surge phenomenon.

### 1.1.3 47 C.F.R. Sec.15.203

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 Disposal Instructions

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

# Chapter 2
# 1320x-QE128EVB Module Overview and Description

## 2.1 Introduction

The 1320x-QE128EVB is an evaluation board for developing IEEE® 802.15.4/ZigBee® software and applications ranging from simple proprietary point-to-point connectivity to complete ZigBee mesh networking on the QE microcontroller platform. The Freescale QE Microcontroller Family is unique in that the user can use an 8-bit CPU or a 32-bit CPU in a pin-compatible package and also retain the exact same peripheral and IO set. The 1320x-QE128EVB uses the MC9S08QE128 Microcontroller unit which is the first device of the pin-compatible 8-bit and 32-bit duo in the Flexis Series family. The Flexis series of controllers is the connection point of the Freescale Controller Continuum, delivering 8- and 32-bit compatibility for migration flexibility.

The 1320x-QE128EVB evaluation board is based on the Freescale MC1320x transceiver and MC9S08QE128 Microcontroller unit (which is supplied as a daughter card). The 1320x-QE128EVB provides a platform to evaluate the MC1320x and MC9S08QE128 devices, develop software and applications, and demonstrate IEEE 802.15.4 and ZigBee networking capabilities. The evaluation board is supported by Freescale's BeeKit software design environment for IEEE 802.15.4/ZigBee applications.

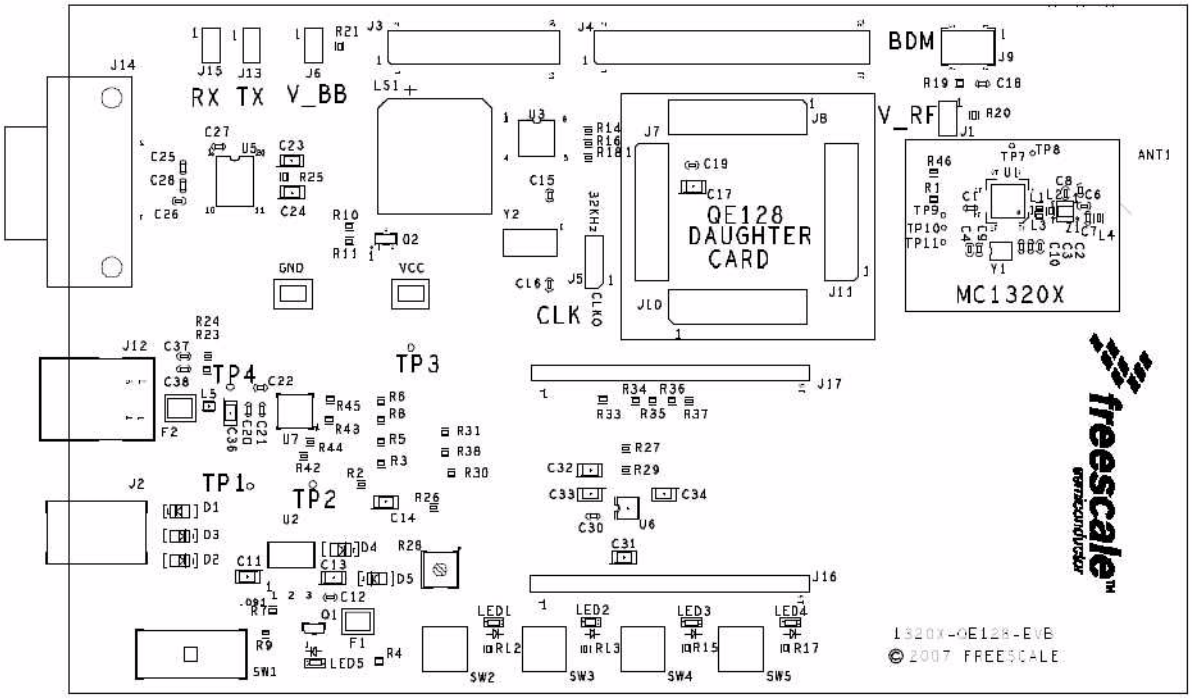


**Figure 2-1. 1320x-QE128EVB**

## 2.2 Features

The 1320x-QE128EVB provides the following features:

- Uses MC9S08QE128 MCU Daughter card - supports the 9S08 based version of the QE128
- Full IEEE 802.15.4 compliant wireless node; ZigBee capable with Freescale's BeeStack software stack
- Based on Freescale's MC13202 transceiver in RF single-port mode
  - Printed F-antenna
  - Typical RX sensitivity of -92 dBm at 1.0% Packet Error Rate
  - Typical 0 dBm up to 3.6 dBm Maximum Output Power
- Based on Freescale's MC9S08QE128 Microcontroller Unit
  - 50 MHz 8-bit 9S08 CPU core / 25 MHz bus speed
  - 128 KB flash memory
  - Up to 8 KB RAM
  - Single-wire background debug interface
  - Device available in 64-pin and 80-pin LQFP packages (evaluation board daughter card uses 80-pin device)
- USB interface is bus-powered and full-speed compatible to the USB 2.0 and 1.1 specifications
- Alternate RS-232/UART (DB-9) serial communication port provided
- User interface switches and LEDs
  - 4 pushbuttons for application purposes
  - 4 processor controlled red LEDs for application purposes
- Supports a 2x16 Character LCD
- Provides an external 1Mbit serial I2C EEPROM
- Audio Resonator
- Uses standard QE128 BDM Development Port
- Supported by Beekit software development environment
- System clock options
  - MCU source derived standard from transceiver CLKO (MC13202 transceiver requires 16 MHz crystal)
  - Optional 32.768 kHz crystal oscillator for accurate real-time delays and low Power Modes
- Power management circuit with on-board regulation for multiple power sources
  - Can be powered from USB interface, DC power jack or two AA batteries
  - On/Off power switch
  - Power-on green LED
- MCU & Transceiver RESET via ON/OFF switch (MCU does not support use of a hardware reset pin when used with the MC13202 transceiver)
- 16-pin and 10-pin user headers for selected General Purpose Input Output signals (GPIO) and data interfaces

- All components meet RoHs and WEE requirements

## 2.3 Board Level Specifications

**Table 2-1. MC1320x and QE128 EVB Specifications**

| Parameter | | | | Units | Notes/Conditions |
|---|---|---|---|---|---|
| | MIN | TYP | MAX | | |
| **General** | | | | | |
| Size (PCB: X, Y) | | | 165 x 102/ 6.5 x 4 | mm inches | |
| Layer build (PCB) | | 1.6 / 0.062 | | mm inches | 4-Layer |
| Dielectric material (PCB) | | | | | FR4 |
| **Power** | | | | | |
| Voltage supply (DC) | 4.4 | 5 | 12 | V | |
| Voltage supply (USB) | 4.4 | 5 | 5.25 | V | USB 2.0/1.1 standard specification |
| Voltage supply (Batteries) | | 3 | 3.2 | V | |
| Current consumption | | 70 | | mA | |
| **Temperature** | | | | | |
| Operating temperature (see note) | -20 | +25 | +85 | °C | The operating temperature is limited to +70°C with the monochrome-graphic LCD module applied |
| Storage temperature | -30 | +25 | +85 | °C | |
| **Interfaces** | | | | | |
| USB interface | | | | | USB 2.0 and 1.1 full-speed compatible |
| RS-232 interface | | | | | DE-9 (TIA-574) |
| **Audio** | | | | | |
| Buzzer frequency | | 4 | | kHz | |
| Sound Pressure Level | | 83 | | dB | Buzzer Specification |
| **RF** | | | | | |
| 802.15.4 Frequency range | 2405 | | 2480 | MHz | All 16 channels in the 2450 MHz band |
| Range (outdoor / line of sight) | | 300 | | Meter | |
| **RF Transmitter** | | | | | |
| 802.15.4 Output power | -30 | 0 | +2.5 | dBm | Over range of Pout from IC control in 2 dB steps |
| Harmonics<br>$2^{nd}$ harmonics<br>$3^{rd}$ harmonics | | | <br>-38<br>-35 | <br>dBc<br>dBc | Harmonics are compliant to ETSI and FCC regulatory approval standards |
| **RF Receiver** | | | | | |

**Table 2-1. MC1320x and QE128 EVB Specifications (continued)**

| Parameter | | | | Units | Notes/Conditions |
|---|---|---|---|---|---|
| 802.15.4 sensitivity | | -87 | | dBm | <1% PER |
| **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 |

# Chapter 3
# System Overview and Functional Block Descriptions

This section provides a system overview of the 1320x-QE128EVB module and shows block diagrams.

## 3.1 System Block Diagram

Figure 3-1 shows the 1320x-QE128EVB system level block diagram.

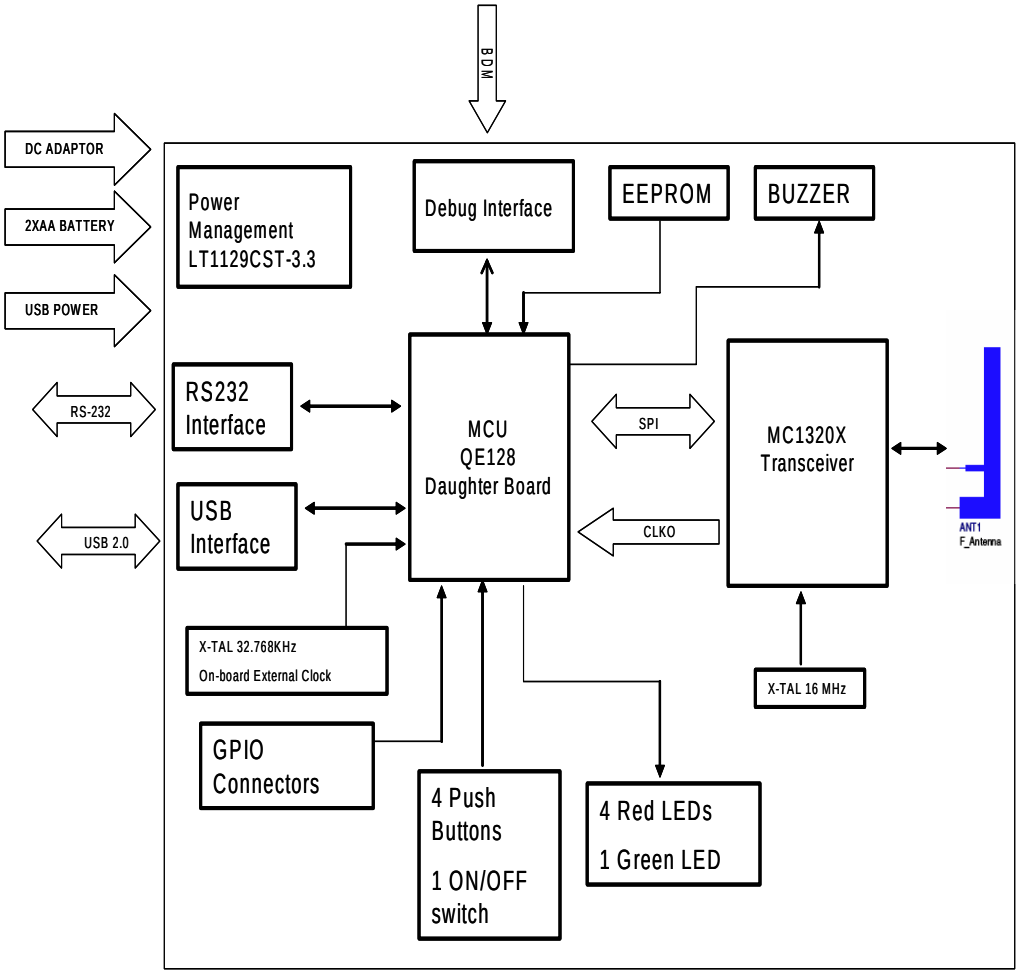


**Figure 3-1. MC1320x and QE128 EVB Block Diagram**

## 3.2 System Overview

The 1320x-QE128EVB combines the Freescale MC1320x Family of IEEE 802.15.4 transceivers to the 9S08 version of QE128 Family of Microcontrollers. The MC9S08QE128 is a natural extension to existing 9S08-based platforms in that it uses the same CPU core, but extends the FLASH memory space to 128 kbytes. The standard 9S08GT/GB maximum FLASH space is 60 kbytes, while the MC9S08QE128 expands the code space to a full 128 kbytes.

The 1320x-QE128EVB provides the MCU as a daughter card and adds the required 802.15.4 transceiver, RF circuitry, and interface elements.

**NOTE**

Although the 1320x-QE128EVB provides the MCU as a pre-fabricated daughter card, the designer must use and reference the MCU by its device designation (MC9S08QE128, MC9S08QE96, and MC9S08QE64). The *MC9S08QE128 Series Data Sheet* (Document number: MC9S08QE128) and *MC9S08QE128 Reference Manual* (Document number: MC9S08QE128RM) are available on the Freescale web site (www.freescale.com) and links are provided on the Freescale ZigBee/IEEE 802.15.4 page (www.freescale.com/zigbee).

### 3.2.1 MC9S08QE128 MCU Module

The 1320x-QE128EVB provides the MC9S08QE128 8-bit HCS08 core microcontroller unit via a 64-pin daughter card, designated as MC9S08QE128_Daughter_card. Figure 3-2 shows the block diagram of the structure of the MC9S08QE128 Series MCU.

The MC9S08QE128 device provides a 50MHz 9S08 CPU core, 8 Kbytes of RAM, 131 Kbytes of on-board ROM, and internal clock source. In addition to the CPU core and memory, on-board peripherals include the following:

- Two dedicated UART modules
- Keyboard interface capability.
- Up to 24 channels of 12-bit analog-to-digital converters (ADCs) with output formatted in 12-, 10- or 8-bit right-justified channels
- General Purpose I/O available ports.
- Two Inter-integrated Circuit Interface (I2C) modules
- Two Synchronous Peripheral Interface (SPI) modules
- Real Time Clock (RTC) counter
- Two analog comparator (ACMP) modules

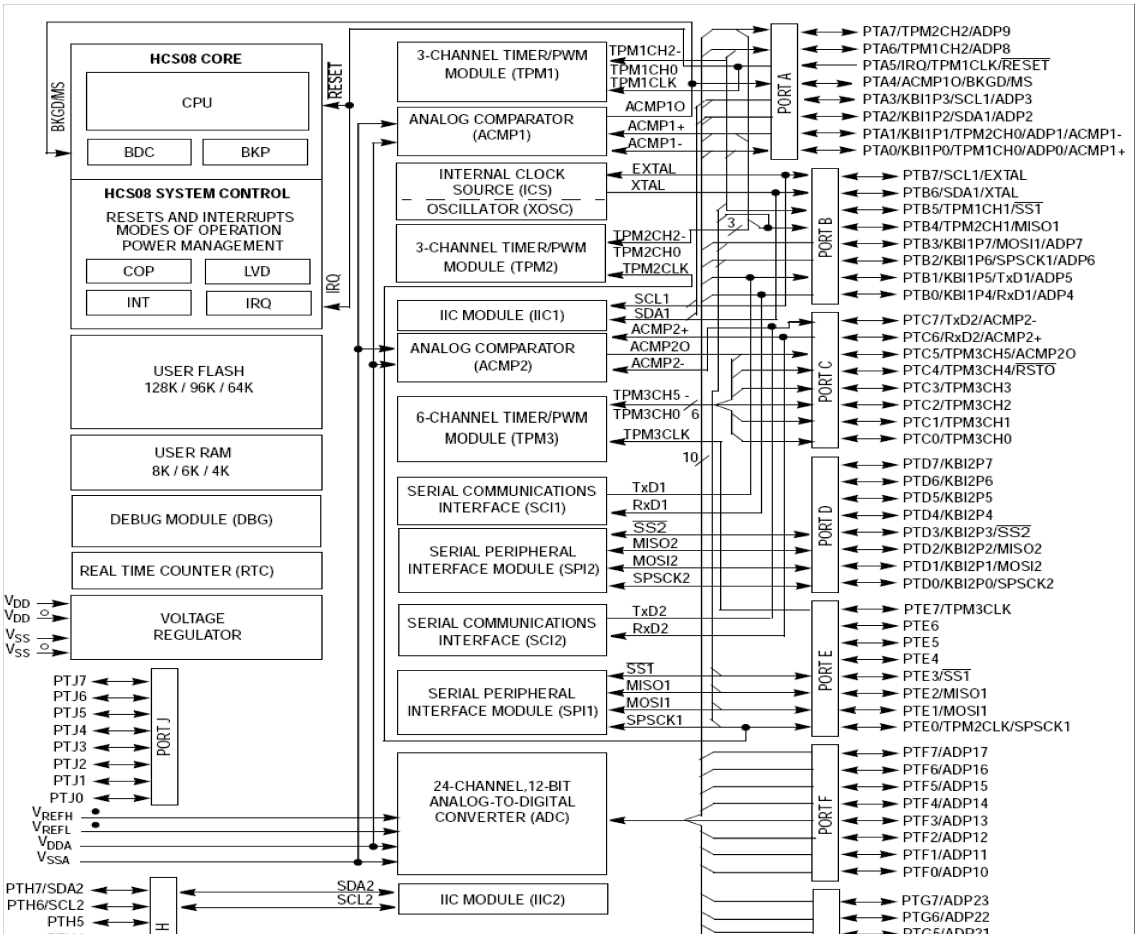


**Figure 3-2. MC9S08QE128 Series Block Diagram**

## 3.2.2 MC1320x IEEE 802.25.4 Transceiver

The MC1320x family is Freescale's second generation of ZigBee / IEEE 802.15.4 compliant integrated circuit transceivers (see Figure 3-3). The MC1320x Family is organized as follows:

- The MC13201 is a short range, low power, IEEE 802.15.4 2.4 GHz ISM band transceiver. The MC13201 contains a complete packet data modem which is compliant with the IEEE 802.15.4 Standard PHY (Physical) layer. It is a low cost device limited to custom applications using the 802.15.4 PHY layer, but cannot support a full 802.15.4 MAC
- The MC13202 is compatible with the MC13201 and extends the IEEE 802.15.4 functionality to support the complete MAC functionality through a streaming data capability. The MC13202 can be used with Freescale's IEEE 802.15.4 MAC and BeeStack, which is Freescale's ZigBee-compliant protocol stack.

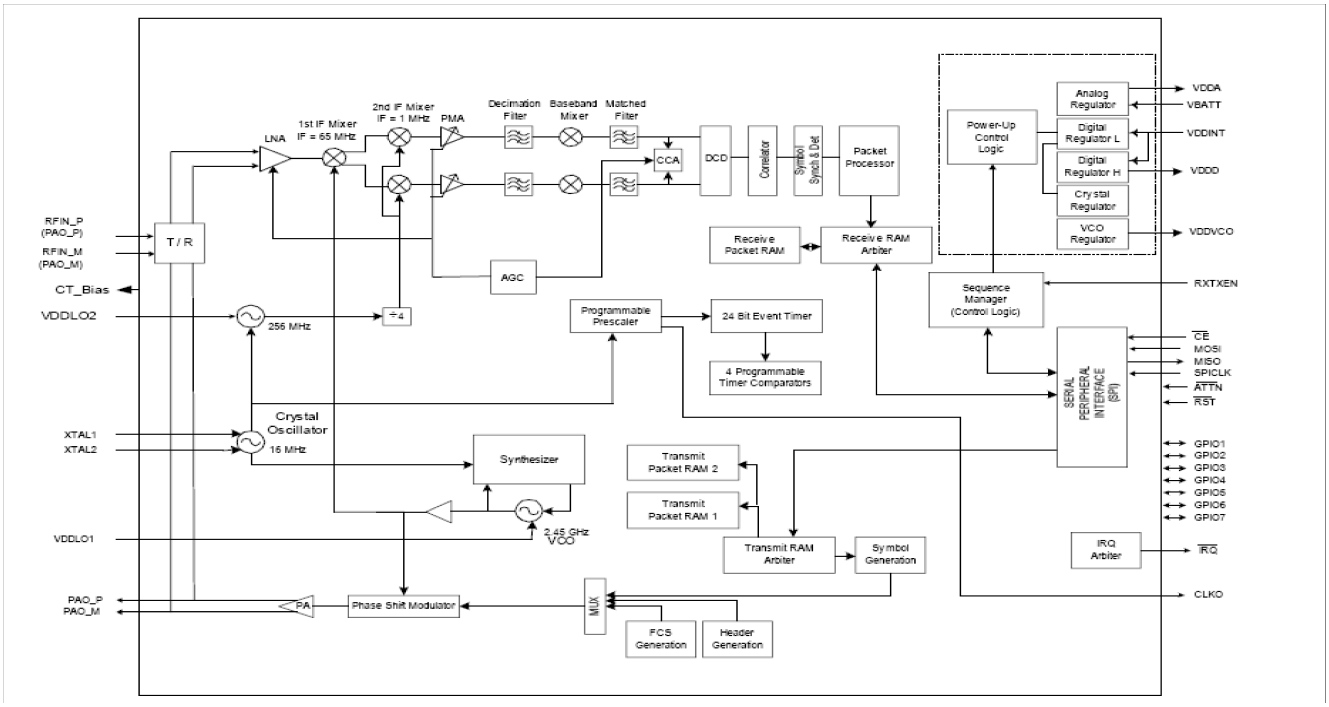


**Figure 3-3. MC1320x Modem Block Diagram**

Features of the MC1320x transceiver include:

- Fully compliant IEEE 802.15.4 Standard transceiver supports 250 kbps O-QPSK data on one of sixteen 5.0 MHz channels and full spread-spectrum encode and decode
- Three power down modes for increased battery life
- Four internal timer comparators available to supplement MCU timer resources
- Supports both Packet Mode and Streaming Mode data transfer
- Buffered transmit and receive data packets

## 3.2.3 1320x-QE128EVB System Functions

The 1320x-QE128EVB is a self-contained wireless node and development module. The module augments the basic MCU and transceiver with the following functionality:

- Complete functional, low-cost 2.4 GHz ISM Band IEEE 802.15.4 radio
- 2.0 USB connection
- User interface with pushbuttons, LEDs, and 16 character x 2 line monochromatic LCD
- Versatile power sources and management
- Debug / development port
- GPIO connectors for system expansion

Users are encouraged to reference the board schematic for the topics covered in the following sections.

## 3.3 Power Management and Measurement

To allow maximum versatility, the 1320x-QE128EVB can be powered via a DC source (typically an AC-DC converter; nominally 5 Vdc), the USB node, or an on-board battery pack with 2 AA alkaline batteries.

- The DC source or USB will automatically shutdown the battery supply
- The DC source and the USB power are regulated to 3.3 V, however, the raw battery pack voltage directly supplies the circuitry
- All sources are isolated via diodes
- An on/off switch and a power-on LED are provided (see Section 4.2.2, “On/Off Switch (Hardware Reset)”)
- Zero-ohm resistors are provided to allow isolation and measurement of various system components (see Section 4.2.4, “Power Measurement”)

## 3.4 Low-cost 2.4 GHz IEEE 802.15.4 ISM Band Radio

The 1320x-QE128EVB provides a complete RF node which only requires a balun and antenna (external to the MC1320x). The  design uses a PCB printed metal F-antenna for an efficient, low cost solution. Figure 3-4 shows the RF network external to the MC1320x.

The RF design provides:

- -1 to 0 dBm nominal output power, programmable from -27 dBm to +3 dBm typical
- Receive sensitivity of <-92 dBm (typical) at 1% PER, 20-byte packet, much better than the 802.15.4 Standard of -85 dBm
- Integrated transmit/receive switch
- Typical range (outdoors, line of sight) of 300 meters
- Optional on-board LC filter for harmonic filtering

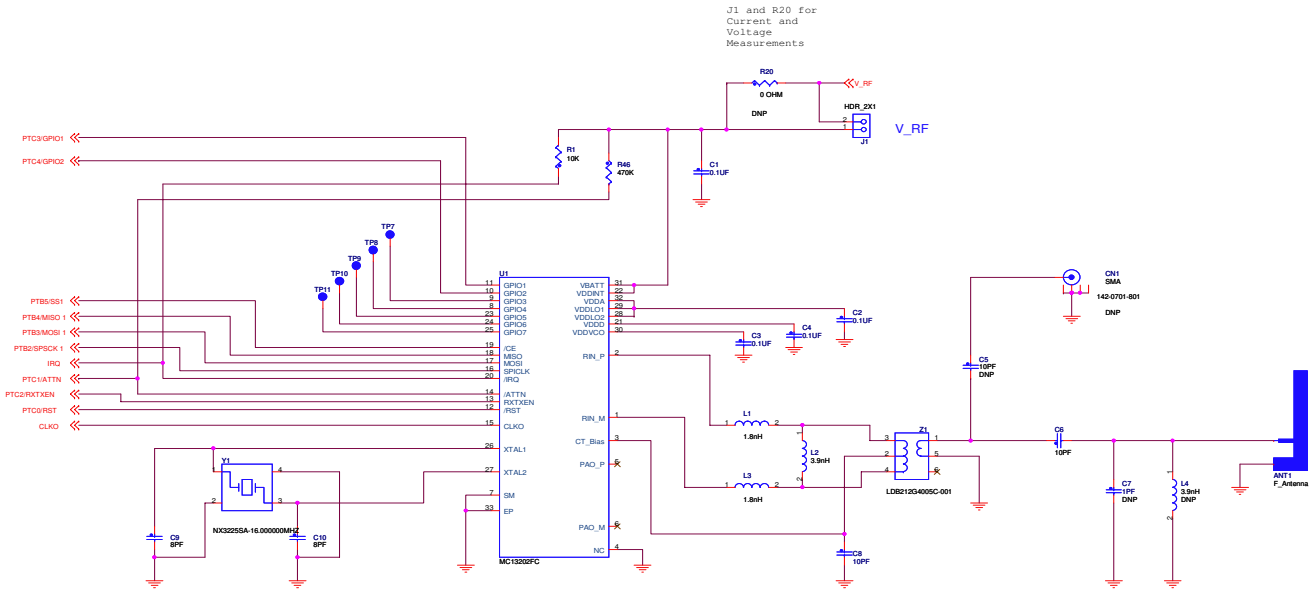


**Figure 3-4. RF Interface Network**

## 3.5 Interfaces

The module provides multiple interfaces for both debug and demonstration.

- USB 2.0 full speed compatible interface
- 16 x 2 monochrome character LCD display
- BDM Debug and Development interface
- Four individual pushbuttons can be used as input and have interrupt generation capability
- Four individual LEDs can be used as indicators for debug or status
- A fully buffered RS232 serial interface with RTS/CTS control is supplied as a secondary COM port

### 3.5.1 USB Interface

Primary communication with an application device or platform is provided by a USB port with a USB “B” receptacle plug. USB connectivity is provided by a FTDI FT232R USB < > UART device that appears as a virtual COM port (VCP) to a connected PC. PC drivers are provided with the module. For pinout information, see Section 4.5, “USB Connector (“B” Receptacle)”.

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.

### 3.5.2 16x2 Monochrome Character LCD Display

The 1320x-QE128EVB supports a 16x2 monochrome character LCD that provides for alpha-numeric readout. The LCD module is mounted on top of the main circuit board and connects via a 16 pin header with 0.1in spacing. For pinout information, see Section 4.6, “LCD Connector”.

- The module supports two similar LCD modules, one of which is the CFAH1602NYG-JP STN daughter board from Crystalfontz.
- The LCD operates from 5 Vdc generated from the main operating voltage. The LCD module requires a highly regulated 5V so that the high voltages generated on-board the display are consistent.
- The LCD uses no backlighting
- LCD interface to the MCU is via an 4-bit parallel interface
- The on-board controller is a industry-standard HD44780 compatible controller

### 3.5.3 Debug/Development Interface

The 1320x-QE128EVB contains a standard BDM debug port. For pinout information see Section 4.8, “Debug/Development Connector (BDM Interface)”). A 6-pin connector is provided for the standard BDM debug interface.

### 3.5.4 RS232 Interface

The 1320x-QE128EVB provides a secondary standard RS232-compatible UART serial port with the connection provided by a standard DB9 connector (J14). For pinout information see Section 4.9, “RS232-Compatible UART Connector”.

## 3.6 GPIO Connectors

Two GPIO connectors (J3 and J4) provide connection to data interfaces and GPIO for external system expansion of the MCU resources. For pinout information see Section 4.10, “GPIO Connectors”.

- Some GPIO are shared with on-board devices. The user should be careful to avoid conflict.
- External current draw should be limited to 50 mA maximum.

## 3.7 Clocks

The primary clock source for the 1320x-QE128EVB is supplied by the MC1320x transceiver. The transceiver requires an accurate 16 MHz reference clock that is supplied via an on-board 16 MHz crystal oscillator, and in turn, the transceiver typically supplies the clock for the MCU. However, there are options for the MCU clock usage:

- The default clock source for the QE128 is obtained through MC1320x CLKO programmable frequency clock output. The RF transceiver reference oscillator is 16 MHz and the mounted crystal Y1 is a 16 MHz device that meets MC1320x specifications. In turn, CLKO can be enabled to provide the clock source to the MCU as an external input.
- The QE128 Internal Clock Source (ICS) supplies an optional on-board reference oscillator (32KHz nominal). With use of the on-board Frequency-locked-loop (FLL), CPU frequencies from 2-50 MHz are available. Precision trimming of the internal reference allows for 0.2% resolution and 2% deviation over temperature and voltage.
- The module also supports optional use of an external 32.768KHz crystal for the MCU. The on-board MCU clock amp is used with the 32KHz crystal, and higher CPU and bus clock frequencies are again synthesized through use of the on-board FLL in the ICS.

The external source of clock is selected by Jumper (J5) (See Section 4.11, “Jumper Selection”).

# Chapter 4
# Interface Locations and Pinouts

This chapter provides a description of the interface locations and pinouts of the 1320x-QE128EVB printed circuit board.

## 4.1 Overview

This section details the locations (as shown in Figure 4-1) and descriptions of switches, jumpers, and connectors on the 1320x-QE128EVB main circuit board. The MC9S08QE128 MCU module and the LCD module mount on the main board as daughter cards. Users should refer to the figures in the subsequent sections while moving through this chapter. Users should also reference the main circuit board schematic in Section 5.1, “Schematic” , for additional information.

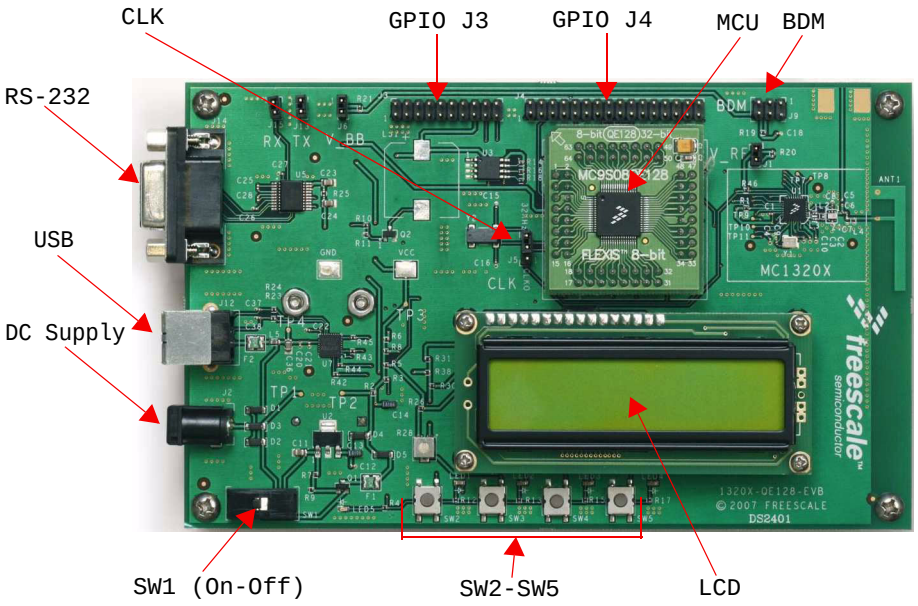


**Figure 4-1. The 1320x-QE128 PCB Top View**

## 4.2 Power Management

The module can be powered from the DC power jack, the USB port, or the battery pack.

### 4.2.1 Supply Sources

Table 4-1 lists the supply sources, connectors, and voltages. Maximum board current draw is rated at 100 mA.

**Table 4-1. Power Supply Sources**

| Source | Connector | Min (Volts) | Typical (Volts) | Max (Volts) | Notes |
|---|---|---|---|---|---|
| DC Source | J2 | 4.4 | 5 | 12 | Use DC only source. The connector is a 2 mm DC power jack; positive center conductor. |
| USB | J12 | 4.4 | 5 | 5.25 | Per USB specification. Power from USB connector. |
| AA Battery Pack | BT1 | ~2.0 | 3 | 3.2 | Two AA cells. Battery pack is automatically disabled by either DC source or USB. |

### 4.2.2 On/Off Switch (Hardware Reset)

The slide switch designated SW1 provides an on/off function and the only hardware reset to the main board and subsystems.

- The hardware reset was implemented through power on/off because of the IO/reset configuration of the MC9S08QE128 MCU. The MCU has a single pin that can be used as an external interrupt request (IRQ) or hardware reset input. In this application the MC1320x transceiver requires use of the external IRQ function, and as a result, the MCU cannot directly use the hardware reset pin. For the module, the only hardware reset is to cycle main power through SW1.
- When the module is powered from the USB connection, the USB interface IC is always powered and SW1 does not disconnect power from it. This has been done such that switching power via SW1 does not disrupt connection with a PC and cause software driver problems with the applications software.

### 4.2.3 Power On Indicator

Green light emitting diode LED5 is the power on indicator for any source. The LED is active anytime a power source is present and SW1 is ON. If the power source is the USB connection, LED5 will be inactive when SW1 is open (off), but the USB interface device will be powered as long as connected to the USB bus.

### 4.2.4 Power Measurement

It is possible to isolate various circuit blocks to measure current draw via 0-ohm resistors. The resistors are all mounted as default.

Below is a list of the supply nodes.

- R8 -> V_RS232 (Supply for RS-232 Transceiver circuit)
- R6 -> V_PERIF (Output from on-board regulator for GPIO customer access)
- R5 -> V_LCD (Supply for LCD Daughter Board)
- R21 -> V_BB (Supply for QE128 EVB)
- R20 -> V_RF (Supply for MC1320x)
- R3 -> V_LED (Supply for LEDs)
- R2 -> VCC (Output from main on-board regulator)

## 4.3 MC9S08QE128 MCU Module

The MC9S08QE128 MCU is provided as a module that mounts as a daughter card on the main PBC. Four 2x8 headers designated J7, J8, J10, and J11 are used to mount the module.

**NOTE**

The MCU is mounted to the module during manufacturing. Freescale recommends that users do not remove and replace this module.

## 4.4 RF Circuitry

The 1320x-QE128EVB RF circuitry contains a printed metal F-antenna (ANT1).

## 4.5 USB Connector (“B” Receptacle)

The USB connector is a “B”-type device and is designated as J12. Figure 4-2 shows the connector pinout. The USB port is connected to MCU port SCI2.

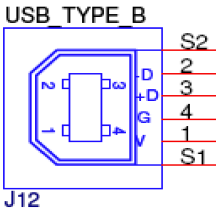


**Figure 4-2. USB Connector Pinout**

## 4.6 LCD Connector

The LCD module is connected to the main circuit board via one of two 16-pin connectors (either J16 or J17). Each connector supports a different LCD module format. The default LCD designated as the CFAH1602B device uses the J17 connector.

## 4.7 LEDs and Switches

The 1321x-QE128EVB contains four red LEDs and one green LED

- The four red LEDs (LED1 through LED4) are intended to be application-based indicators and are driven by the MCU and controlled by the software application.
- As already stated, the green LED is directly connected to the on-board main supply and acts as the “Power On” indication.

There is a slide switch and 4 pushbuttons.

- SW1 is an on/off slide switch that connects the power supplies.
- Four additional pushbuttons (SW2 through SW5) are connected to the MCU GPIO and are intended as application input devices. All four buttons have interrupt generation capability.

**Table 4-2. Switch and LED Summary**

| Item | GPIO Connection | Feature |
|---|---|---|
| PWR LED (green) | VCC | ‘Power On’ indication |
| LED1 (red) | PTE3 | Application specific |
| LED2 (red) | PTE4 | Application specific |
| LED3 (red) | PTE5 | Application specific |
| LED4 (red) | PTE6 | Application specific |
| SW2 (pushbutton) | PTD0 | Interrupt functionality. |
| SW3 (pushbutton) | PTD1 | Interrupt functionality. |
| SW4(pushbutton) | PTD2 | Interrupt functionality. |
| SW5 (pushbutton) | PTD3 | Interrupt functionality. |
| SW1 (ON/OFF) | ON/OFF | HW ON/OFF |

## 4.8 Debug/Development Connector (BDM Interface)

The 1320x-QE128EVB supports connection to a subset of the defined BDM connector. The BDM interface is a standard 2.54mm/0.1inch spacing, 6-pin debug interface (J9). The 6-pin connector is clearly separated from the GPIO pin headers (J3, J4) and located at the upper right corner of top side of the module. The 6-pin connector has Pin 1 marking for correct plug-in of the development cable.

Table 4-3 shows the BDM header pinout.

**Table 4-3. BDM 6-Pin Connector Assignments (J9)**

| Name | Pin # | Pin # | Name |
|---|---|---|---|
| BKGD | 1 | 2 | GND |
| NC[1] | 3 | 4 | Pullup[2] (RESET) |
| NC | 5 | 6 | V_BB |

1 NC = No Connect.

2 Pulled-up to V_BB through 51kohms. Hardware reset not supported on this BDM port.

## 4.9 RS232-Compatible UART Connector

The 1320x-QE128EVB provides a secondary standard RS232-compatible UART serial port. Connection is provided by a standard DB9 connector (J14). The RS232 converter is connected to MCU port SCI1.

## 4.10 GPIO Connectors

The 1320x-QE128EVB contains two GPIO connectors (J3) and (J4). The GPIO connectors are a standard 2.54mm/0.1inch spacing, 20- and 32-pin header, respectively.

These connectors provide access to MCU GPIO, Timer outputs, ADC inputs, the SPI port, the $I^2C$ port, among others. Power is also provided on both connectors.

- V_PERIF is the main supply voltage. Current draw should be limited to 50 mA.
- Some of the GPIO are shared with on-board devices. Check for any conflict.

**Table 4-4. GPIO Connector J3 Pinouts**

| Pin Number | Name | Function | Notes |
|---|---|---|---|
| 1 | PTE2/BUZZER | GPIO | Hardwired to Q2 Base to Turn On/Off on-board Buzzer (LS1) |
| 2 | GND | System ground | |
| 3 | PTF2 | ADC Analog Input Channel or GPIO | |
| 4 | GND | System ground | |
| 5 | PTF3 | ADC Analog Input Channel or GPIO | |
| 6 | GND | System ground | |
| 7 | PTD2 | KBI input or GPIO | Hardwired to Push Button SW4 |
| 8 | GND | System ground | |
| 9 | PTD3 | KBI input or GPIO | Hardwired to Push Button SW5 |
| 10 | GND | System ground | |
| 11 | PTB0/RxD1 | KBI Input or SCI1 or ADC Analog Input Channel or GPIO | Hardwired to J13 and to RS-232 Transceiver |
| 12 | GND | System ground | |
| 13 | PTB1/TxD1 | KBI Input or SCI1 or ADC Analog Input Channel or GPIO | Hardwired to J15 and to RS-232 Transceiver |
| 14 | GND | System ground | |
| 15 | V_PERIF | System Supply | |
| 16 | GND | System ground | |

**Table 4-4. GPIO Connector J3 Pinouts (continued)**

| | | | |
|---|---|---|---|
| 17 | PTH7 | $I^2C$ Port or GPIO | |
| 18 | GND | System ground | |
| 19 | PTH6 | $I^2C$ Port or GPIO | |
| 20 | GND | System ground | |

**Table 4-5. GPIO Connector J4 Pinouts**

| Pin Number | Name | Function |
|---|---|---|
| 1 | V_PERIF | System Supply |
| 2 | GND | System ground |
| 3 | NC | |
| 4 | GND | System ground |
| 5 | PTE7 | Timer/PWM Channel or GPIO |
| 6 | GND | System ground |
| 7 | PTH1 | GPIO |
| 8 | GND | System ground |
| 9 | PTH0 | GPIO |
| 10 | GND | System ground |
| 11 | PTF1 | ADC Analog Input Channel or GPIO |
| 12 | GND | System ground |
| 13 | PTF0 | ADC Analog Input Channel or GPIO |
| 14 | GND | System ground |
| 15 | PTD4 | KBI input or GPIO |
| 16 | GND | System ground |
| 17 | PTG3 | ADC Analog Input Channel or GPIO |
| 18 | GND | System ground |
| 19 | PTG2 | ADC Analog Input Channel or GPIO |
| 20 | GND | System ground |
| 21 | PTG1 | GPIO |
| 22 | GND | System ground |
| 23 | PTG0 | GPIO |
| 24 | GND | System ground |
| 25 | PTE1 | SPI Serial Peripheral Interface MOSI or GPIO |
| 26 | GND | System ground |

**Table 4-5. GPIO Connector J4 Pinouts (continued)**

| Pin Number | Name | Function |
|---|---|---|
| 27 | PTE0 | Timer/PWM Channel or GPIO |
| 28 | GND | System ground |
| 29 | NC | |
| 30 | GND | System ground |
| 31 | NC | |
| 32 | GND | System ground |

## 4.11 Jumper Selection

Table 4-6 lists all the possible jumper selections for the 1320x-QE128EVB. The jumpers available on the board include:

- J1 - used to measure current and voltage on V_RF
- J5 - used to select clock input to the MCU either from the MC1320x CLKO output or from an optional on-board (Y2) 32.768KHz crystal.
- J6 - used to measure current and voltage on V_BB
- J13 - used to connect MCU TxD1 pin to the on-board RS-232 transceiver (U5)
- J15 - used to connect MCU RxD1 pin to the on-board RS-232 transceiver (U5)

**Table 4-6. Jumper Selection**

| Jumper | Pin Number Connection | Description | Default Setting |
|---|---|---|---|
| J1 | 1-2 | Provide the means for voltage and current measurements on the MC1320x Transceiver | Mounted |
| J5 | 1-2 | Connects MCU QE128 XTAL with MC1320x CLKO output | Mounted |
| | 2-3 | Connects MCU QE128 XTAL with on-board 32.768KHz crystal | Not Mounted |
| J6 | 1-2 | Provide the means for voltage and current measurements on the MCU QE128 | Mounted |
| J13 | 1-2 | Provide the means to connect the on-board RS-232 transceiver with MCU TXD1 | Mounted |
| J15 | 1-2 | Provide the means to connect the on-board RS-232 Transceiver with MCU RXD1 | Mounted |

# Chapter 5
# Schematic and Bill of Material

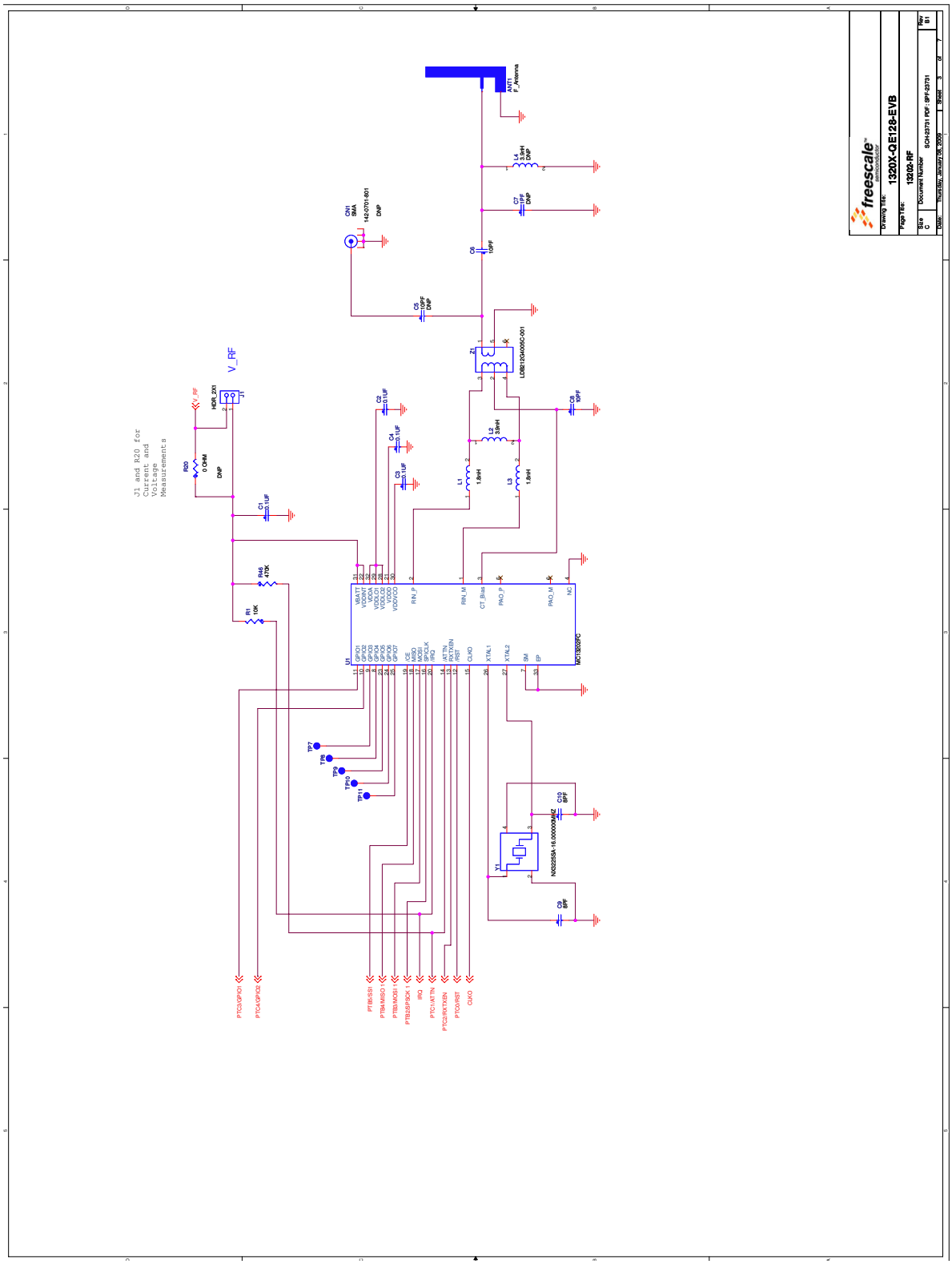


Figure 5-1. Schematic (1 of 5)

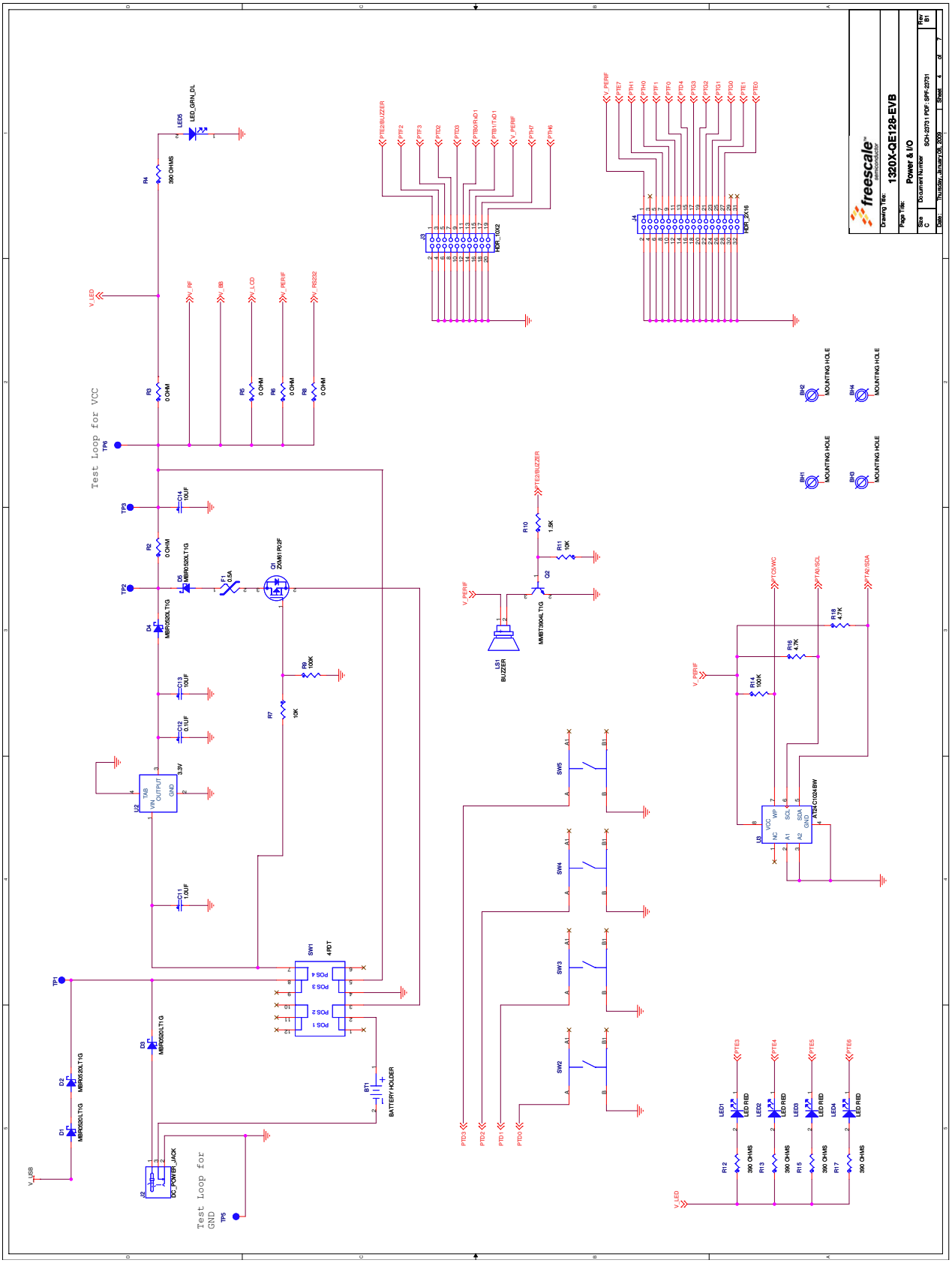


Figure 5-2. Schematic (2 of 5)

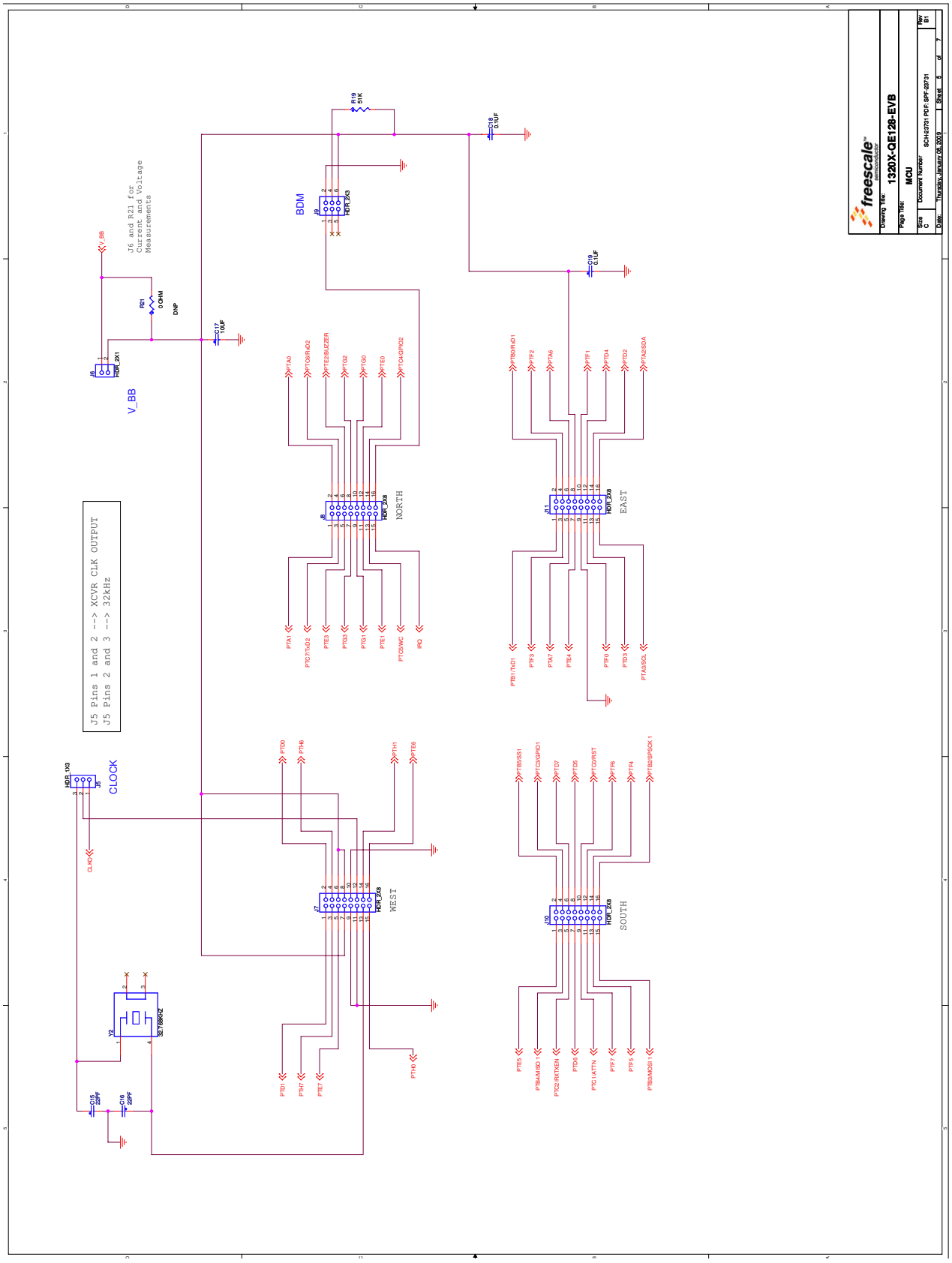


Figure 5-3. Schematic (3 of 5)

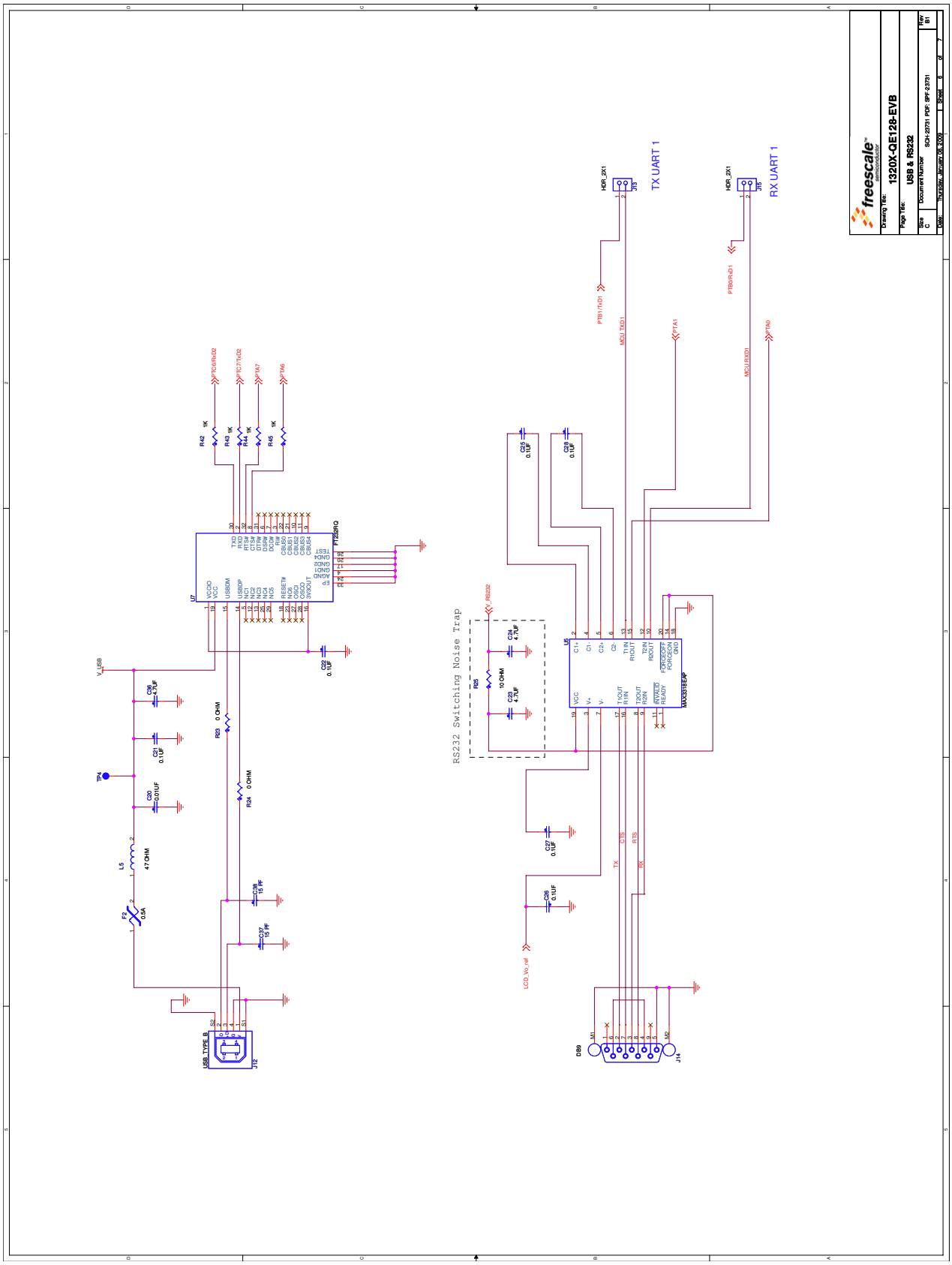


Figure 5-4. Schematic (4 of 5)

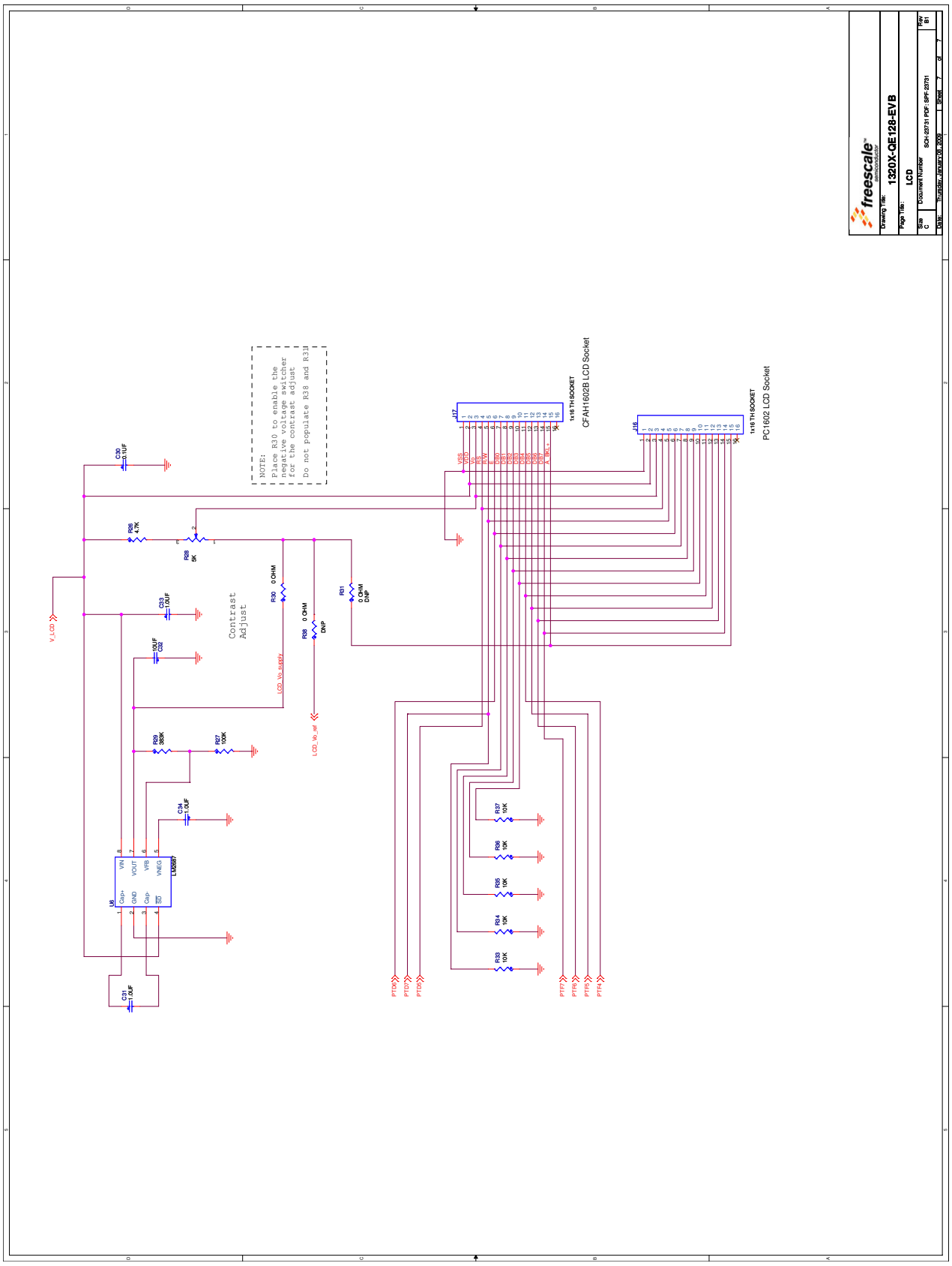


Figure 5-5. Schematic (5 of 5)

# 5.1 Bill of Materials

**Table 5-1. Bill of Materials**

| Qty | Part Reference | Description | Value | Tolerance | Manufacturer | Manufacturer Part Number |
|---|---|---|---|---|---|---|
| 1 | BT1 | PCB Battery Holder 2xAA | 2462 | | Keystone | 2462 |
| 14 | C1 C2 C3 C4 C12 C18 C19 C21 C22 C25 C26 C27 C28 C30 | Ceramic Capacitor X7R | 0.1 µF | 10% | Venkel | C0402X7R160-104KNE |
| 1 | C6 | Ceramic Capacitor COG | 10pF | 0.25pF | Samsung | CL05C100CO5NNNC |
| 1 | C7 | Ceramic Capacitor COG | 1pF | +/- 0.25pF | Yageo America | CC0402CRNPO9BN1R0 |
| 1 | C8 | Ceramic Capacitor COG | 10pF | 5% | Venkel | C0402C0G500-100JNP |
| 2 | C9, C10 | Ceramic Capacitor COG | 8pF | 0.25pF | Murata | GRM1555C1H8R0CB01D |
| 4 | C11 C31 C33 C34 | Ceramic Capacitor X5R | 1uF | 10% | AVX | 0805YD105KAT2A |
| 4 | C13 C14 C17 C32 | Ceramic Capacitor X5R | 10uF | 10% | Venkel | C0805X5R100-106KNE |
| 2 | C15 C16 | Ceramic Capacitor COG | 22pF | 5% | Venkel | C0402C0G250-220JNE |
| 1 | C20 | Ceramic Capacitor X7R | 10nF | 10% | Venkel | C0402X7R500103KNE |
| 3 | C23 C24 C36 | Ceramic Capacitor X5R | 4,7uF | 10% | Panasonic | ECJ2FB1C475K |
| 2 | C37 C38 | Ceramic Capacitor COG | 15pF | 5% | Venkel | C0402C0G250-150JNP |
| 4 | D1 D2 D3 D4 | SMD Power Schottky Rectifier | MBR0520LT1 | | On Semiconductor | MBR0520LT1G |
| 2 | F1 F2 | Polyswitch Overcurrent Protection Device | 500mA | | Raychem | MICROSMD050F-2 |
| 2 | VCC GND | Test Point Pad | TP-107-02-T | | Components Corporation | TP-107-02-T |
| 4 | J1 J6 J13 J15 | Single Row Straight pin Header TH 1X2 | TSW-102-07-S-S | | Samtec | TSW-102-07-S-S |
| 1 | J2 | DC Power Jack PCB, 2mm | PJ-102AH | | CUI Stack | PJ-102AH |

**Table 5-1. Bill of Materials (continued)**

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | J3 | Double Row Straight pin Header TH 2X10 | TSW-110-07-S-D | | Samtec | TSW-110-07-S-D |
| 1 | J4 | Double Row Straight pin Header TH 2X16 | TSW-116-07-S-D | | Samtec | TSW-116-07-S-D |
| 1 | J5 | Single Row Straight pin Header TH 1X3 | HTSW-103-07-SM-S | | Samtec | HTSW-103-07-SM-S |
| 4 | J7 J8 J10 J11 | Double Row Straight pin Header TH 2X8 | TSW-108-07-G-D | | Samtec | TSW-108-07-G-D |
| 1 | J9 | Double Row Straight pin Header TH 2X3 | TSW-103-07-S-D | | Samtec | TSW-103-07-S-D |
| 1 | J12 | USB-series “B” receptacle | USB-B | | SINGATRON | 2UB1505-000101 |
| 1 | J14 | Connector DB 9 TH | DB 9 | | Tyco Electronics | 5747844-6 |
| 2 | J16 J17 | Socket TH 1X6 | SSW-116-01-G-S | | Samtec | SSW-116-01-G-S |
| 4 | LED1 LED2 LED3 LED4 | SMD Red top led | HSMH-C190 | | Avago Technologies | HSMH-C190 |
| 1 | LED5 | SMD Green top led | 597-5312-407F | | Dialight | 597-5312-407F |
| 1 | LS1 | SMD Speaker | CMI-1240 | | CUI STACK | CMI-1240 |
| 1 | L1 L3 | HF Chip coil | 1,8nH | 0,3nH | TOKO,Inc | LL1005-FHL1N8S |
| 2 | L2 L4 | HF Chip coil | 3,9nH | 0,3nH | TOKO,Inc | LL1005-FHL3N9S |
| 1 | L5 | Chip Ferrite Bead | 500mA | | Steward | LI0603E470R-10 |
| 1 | Q1 | P-channel MOSFET | ZXM61P02F | | Zetex | ZXM61P02F |
| 1 | Q2 | NPN BJT | MMBT3904LT1G | | On Semiconductor | MMBT3904LT1G |
| 8 | R1 R7 R11 R33 R34 R35 R36 R37 | Fixed resistor RC31 | 10K | 5% | SEI Electronics INC | RMCF1/16S10K5%R |
| 8 | R2 R3 R5 R6 R8 R23 R24 R30 | Fixed resistor RC31 | 0R | 5% | ROHM | MCR01MZPJ000 |
| 5 | R4 R12 R13 R15 R17 | Fixed resistor RC31 | 390R | 5% | SMEC | RC73L2Z391JTF |
| 2 | R9 R14 | Fixed resistor RC31 | 100K | 5% | Panasonic | ERJ2GEJ104X |
| 1 | R10 | Fixed resistor RC31 | 1,5K | 5% | Yageo America | RC0402JR-071K5L |
| 3 | R16 R18 R26 | Fixed resistor RC31 | 4,7K | 5% | SMEC | RC73L2Z472JTF |
| 1 | R19 | Fixed resistor RC31 | 51K | 5% | Venkel | CR0402-16W-513JT |
| 4 | R20 R21 R31 R38 | Fixed resistor RC31 | 0R | 5% | ROHM | MCR01MZPJ000 |

**Table 5-1. Bill of Materials (continued)**

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | R25 | Fixed resistor RC31 | 10R | 5% | Venkel Company | CR0402-16W-100JT |
| 1 | R27 | Fixed resistor RC32H | 100K | 1% | Koa Speer | RK73H1ETTP1003F |
| 1 | R28 | SMT Potentiometer Resistor | 5K | 20% | Bourns | 3314J-1-502E |
| 1 | R29 | Fixed resistor RC32H | 383K | 1% | Koa Speer | RK73H1ETTP3833F |
| 4 | R42 R43 R44 R45 | Fixed resistor RC31 | 1K | 5% | Vishay Intertechnology | CRCW04021K00JNED |
| 1 | R46 | Fixed resistor RC31 | 470K | 5% | Venkel | CR0402-16W-474JT |
| 1 | SW1 | Switch 4PDT TH | 1-1437575-0 | | Tyco Electronics | 1-1437575-0 |
| 4 | SW2 SW3 SW4 SW5 | SMD Switch SPST | EVQPHP03T | | Panasonic | EVQPHP03T |
| 1 | U1 | ZigBee Wireless Transceiver | MC13202 | | Freescale | MC13202FC |
| 1 | U2 | Low Dropout Voltage Regulator | LT1129CST-3.3# PBF | | Linear Technology | LT1129CST-3.3#PBF |
| 1 | U3 | EEPROM 128Kx8 | AT24C1024BW | | Atmel | AT24C1024BW |
| 1 | U5 | RS-232 UART Transceiver | MAX3318EAP | | Maxim | MAX3318EAP |
| 1 | U6 | Low Dropout Voltage Regulator | LM2687 | | National Semiconductor | LM2687MMX |
| 1 | U7 | USB UART, PB-free | FT232R | | FTDI | FT232RQ |
| 1 | Y1 | Crystal SMD | 16,00MHz | +-10ppm | NDK | NX3225SA-16.000000MHZ |
| 1 | Y2 | Crystal SMD | 32,768kHz | +-20ppm | Abracon | ABS25-32.768-12.5-2-T |
| 1 | Z1 | Transformer BALUN SMD | 2400MHz 50OHM | | Murata | LDB212G4005C-001 |
| 1 | | P&E MC9S08QE128 Daughter Board | MC9S08QE128_ Daughter_card | | P&E | MC9S08QE128_ Daughter_card |
| 1 | | STN LCD Daughter Board 16x2 | CFAH1602B | | Crystalfontz | CFAH1602NYG-JP |

# Chapter 6
# PCB Manufacturing Specifications

This chapter provides the specifications used to manufacture the 1320x-QE128EVB printed circuit board (PCB).

The 1320x-QE128EVB PCB 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 the 1320x-QE128EVB at he 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*, Document Number: 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 PCB is a four layer, multi-layer design
- The PCB contains no blind, buried, or micro vias
- PCB data:
  - Size: Approximately 165 x 102 mm (6.5 x 4 inches)
  - Final thickness (Cu/Cu): 1.57 mm +/- 10% (0.062 inches) (excluding solder mask)
- The following table defines each layer of the completed PCB. The artwork identification refers to the name of the layer in commonly used terms.

**Table 6-1. Layer by Layer Overview**

| Layer | Artwork Identification | File Name |
|---|---|---|
| 1 | Solder Resist | SMtop.art / SMtop.pdf |
| 2 | Copper Top Layer (component side; layer 1) | TOP.art /TOP.pdf |
| 3 | Copper 2nd Layer | GND.art / GND.pdf |
| 4 | Copper 3nd Layer | INS.art / INS.pdf |
| 5 | Copper bottom Layer | BOT.art /BOT.pdf |
| 6 | Solder Resist | SMbot.art / SMbot.pdf |

**NOTE**

The 1320x-QE128EVB 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.

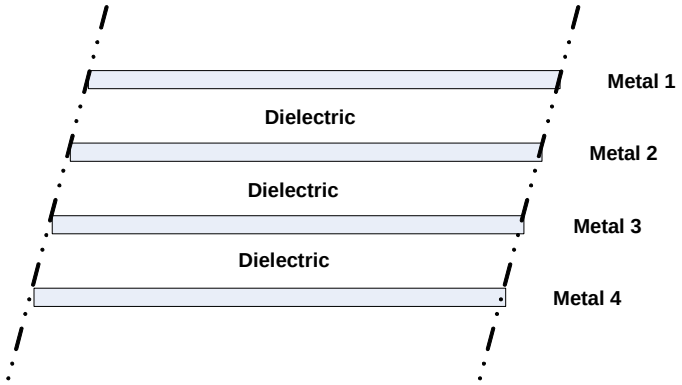


**Figure 6-1. PCB Stackup Cross-Section**

- 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. Interior dielectric thickness is 1.02 mm (40 mils) and the outer dielectric thickness is 0.254 mm (10 mils).
- 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-23731.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 assembly drawings (ASYtop), board fabrication drawing (FAB-23731), the four metal layers (LAYx), solder mask (SMxxx), solder paste (PMxxx) and silk screen (SSxxx). The schematic is SPF-23731.

Design files are in Allegro format with OrCAD schematic capture.