1322x USB Dongle

Reference Manual

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About This Book

This manual describes the Freescale 1322x USB Dongle, which is an IEEE 802.15.4 compliant wireless node based on the Freescale MC1322x device. The 1322x USB Dongle provides a platform to evaluate the MC1322x device, develop software and applications, and demonstrate IEEE 802.15.4 and ZigBee networking capabilities.

Audience

This manual is intended for system designers.

Organization

This document is organized into five chapters.

Chapter 1 Safety Information — Highlights some of the FCC requirements.

Chapter 2 1322x USB Dongle Overview — Introduces the 1322x USB Dongle, which is an IEEE 802.15.4 compliant wireless node based on the Freescale MC1322X device.

Chapter 3 System Overview and Functional Descriptions — Provides an overview of the 1322x USB Dongle and its connections.

Chapter 4 Schematic and Bill of Material — Provides the schematic, board layout, and Bill of Materials.

Chapter 5 PCB Manufacturing Specifications — This chapter provides the specifications used to manufacture the 1322x USB Dongle printed circuit board (PCB).

Revision History

The following table summarizes revisions to this document since the previous release (Rev 1.3).

Revision History

Location	Revision
Chapter 4	Updated schematic and BOM.

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.
SN	Sensor Node
pcb	Printed circuit board
PiP	Platform in Package
PWM	Pulse-width modulation
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.

1.2 FCC Labeling

FCC labels are physically located on the plastic housing.

1.2.1 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.

1.2.2 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.

1.2.3 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.

1.3 Regulatory Approval For Canada

This Class B digital apparatus complies with Canadian ICES-003 and RSS 210, Issue 7.

Cet appareil numérique de la classe B est conforme à la norme NMB-003 du Canada.

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
1322x USB Dongle Overview

2.1 Introduction

The 1322x USB Dongle is an IEEE 802.15.4 compliant wireless node based on the Freescale MC1322x device. The heart of the 1322x USB module is Freescale's MC1322x 99-pin LGA Platform-in-Package (PiP) solution that can be used for wireless applications ranging from simple proprietary point-to-point connectivity to complete ZigBee mesh networking. The MC1322x is designed to provide a highly integrated, total solution, with premier processing capabilities and very low power consumption.

The 1322x USB Dongle provides a platform to evaluate the MC1322x device, develop software and applications, and demonstrate IEEE 802.15.4 and ZigBee networking capabilities. The dongle connects the core device to a personal computer (PC) through a USB port, UART port interface device. The small form factor illustrates an extremely small footprint, 4-layer printed circuit board (PCB) layout with a chip antenna. The MC1322x node typically interfaces to the PC through a virtual COM port (VCM).

As initially provided from Freescale, the dongle is loaded with a software application that implements a wireless "sniffer" to monitor over-the-air IEEE 802.15.4 traffic.

Figure 2-1. 1322x USB Dongle Top View

2.2 Features

The 1322x USB Dongle provides the following features:

- Full IEEE 802.15.4 compliant wireless node; ZigBee capable with Freescale's BeeStack software stack
- Based on Freescale's third-generation MC1322x ZigBee platform which incorporates a complete, low power, 2.4 GHz radio frequency transceiver, 32-bit ARM7 core based MCU, hardware acceleration for both the IEEE 802.15.4 MAC and AES security, and a full set of MCU peripherals into a 99-pin LGA Platform-in-Package (PiP)
- MC1322x provides a highly integrated, low cost RF node
  - On-board balun and antenna switch in package
  - Typical -95 dBm sensitivity
  - Typical 0 dBm output power, with max approximately +4 dBm
  - Chip antenna
- Powered from USB interface with power-on green LED
- USB interface is full-speed compatible to the USB 2.0 and 1.1 specifications
- 20-pin site for standard JTAG debug/development interface connector
- Programmable user red LED for application purposes
- Reset switch
- Default 24 MHz crystal reference oscillator

2.3 Driver Considerations

When users first plug a 1322x USB Dongle into the system, 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 1322x USB Dongle uses 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 Board Level Specifications

Table 2-1. 1322x USB Dongle Specifications

Parameter				Units	Notes/Conditions
	MIN	TYP	MAX		
General					
Size (Enclosure: X, Y, Z)			60x24x12	mm	
Size (PCB: X, Y)			55 x 15 2.165 x 0.590	mm inches	
Layer build (PCB)		0.8 0.032		mm inches	4-Layer
Dielectric material (PCB)					FR4
Power					
Voltage supply (USB)	4.4	5	5.25	V	USB 2.0/1.1 standard specification
Current consumption		35		mA	
Temperature					
Operating temperature (see note)	-30	+25	+70	°C	Operating temperature is limited to +70 °C due to switches. Basic circuit is good for a maximum temperature of +85 °C.
Storage temperature	-30	+25	+70	°C	
USB interface					USB 2.0 and 1.1 full-speed compatible
RF					
802.15.4 Frequency range	2405		2480	MHz	All 16 channels in the 2450 MHz band
Range (outdoor / line of sight)		300		Meters	<1% PER for 20-byte packets (point-to-point in communications with 1322X Sensor Reference Board)
RF Transmitter					
802.15.4 Output power	-30	0	+4	dBm	Over range of Pout from IC control in 2 dB steps. **Note:** On channel 26, output power should not exceed -4 dBm (power setting 0x0E) to meet FCC Part 15 requirements.
Harmonics 2nd harmonics 3rd harmonics			 -38 -35	 dBm dBm	Harmonics are compliant to ETSI and FCC regulatory approval standards
RF Receiver					
802.15.4 sensitivity		-95		dBm	<1% PER for 20-byte packets
Regulatory Approval					
FCC					Product is approved accordingly to the FCC part 15 standard

Table 2-1. 1322x USB Dongle 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

Chapter 3
System Overview and Functional Descriptions

This section provides an overview of the 1322x USB Dongle and its connections.

3.1 System Block Diagram

The following is the 1322x USB Dongle system level block diagram.

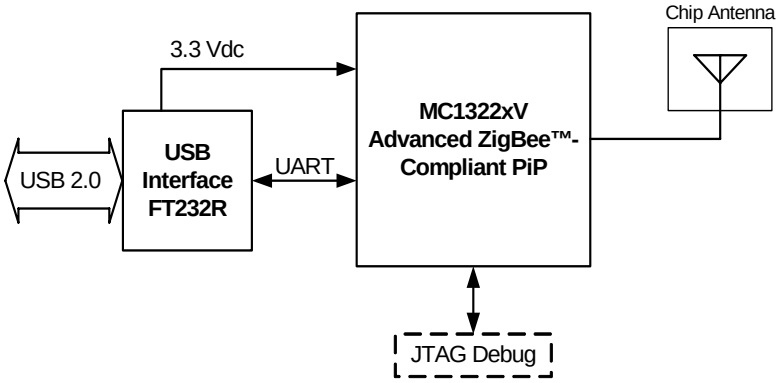


Figure 3-1. 1322x USB Dongle Block Diagram

3.2 System Overview

The heart of the 1322x USB Dongle is Freescale's MC1322x 99-pin LGA Platform-in-Package (PiP) solution that can be used for wireless applications ranging from simple proprietary point-to-point connectivity to complete ZigBee mesh networking. The MC1322x is designed to provide a highly integrated, total solution, with premier processing capabilities and very low power consumption.

The MC1322x MCU resources offer superior processing power for ZigBee and IEEE 802.15.4 applications. A full 32-bit ARM7TDMI-S core operates up to 26 MHz. A 128 Kbyte FLASH memory is mirrored into a 96 Kbyte RAM for upper stack and applications software. In addition, an 80 Kbyte ROM is available for boot software, peripheral device drivers, standardized IEEE 802.15.4 MAC and communications stack software. A full set of peripherals and Direct Memory Access (DMA) capability for transceiver packet data complement the processor core.

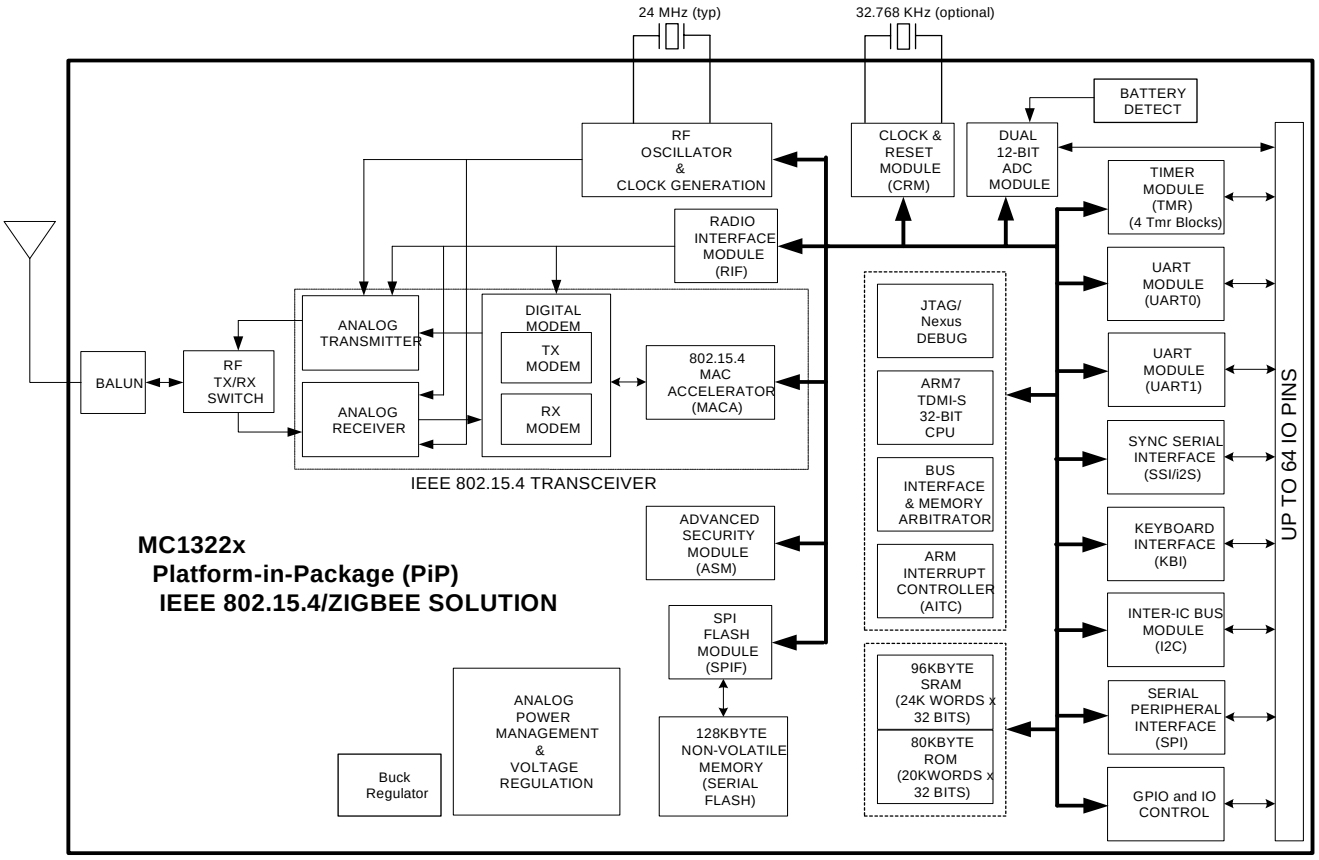


Figure 3-2. MC1322x Block Diagram

The RF radio interface provides for low cost and high density as shown in Figure 3-3. An onboard balun along with a TX/RX switch allows direct connection to a single-ended 50-Ω antenna. The integrated PA provides programmable output power typically from -30 dBm to +4 dBm, and the RX LNA provides -95 dBm sensitivity. This solution also has onboard bypass capacitors and crystal load capacitors for the smallest footprint in the industry. All components are integrated into the package except the crystal and antenna.

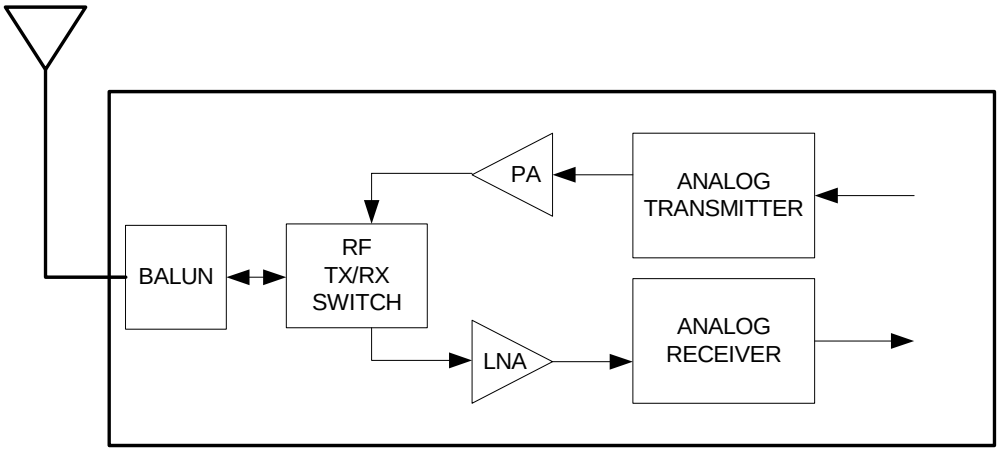
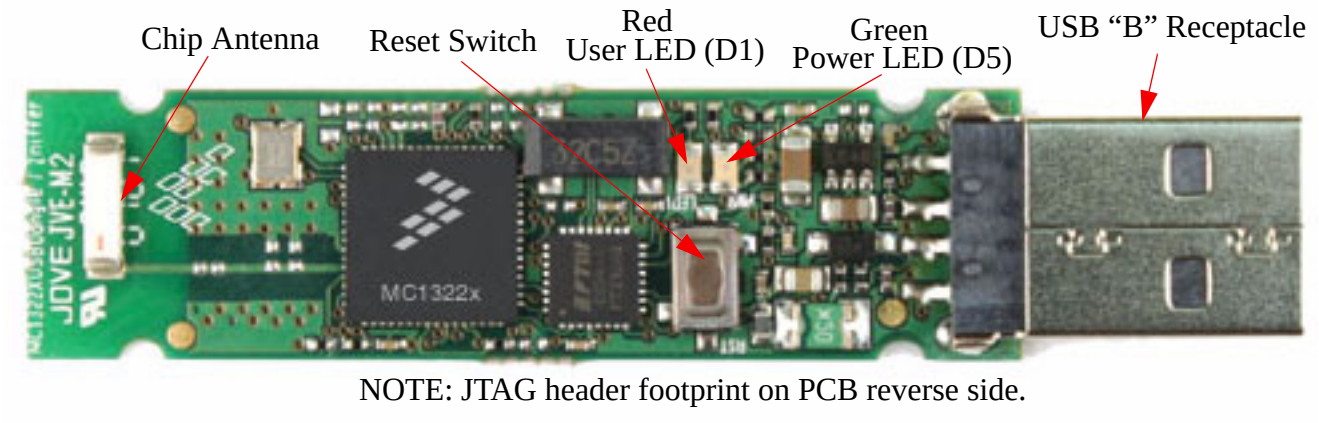


Figure 3-3. MC1322x RF Interface

Augmenting the core device on the 1322x USB Dongle are:

- Low-cost 2.4 GHz ISM Band radio
- 2.0 USB connection
- User interface LED
- Optional debug / development port
- Reset switch

Users are encouraged to reference the board schematic for the topics covered in the following sections. Figure 3-4 and Figure 3-5 shows the 1322x USB Dongle PCB top and bottom view with interface designations.



NOTE: JTAG header footprint on PCB reverse side.

Figure 3-4. 1322x USB Dongle PCB Top View

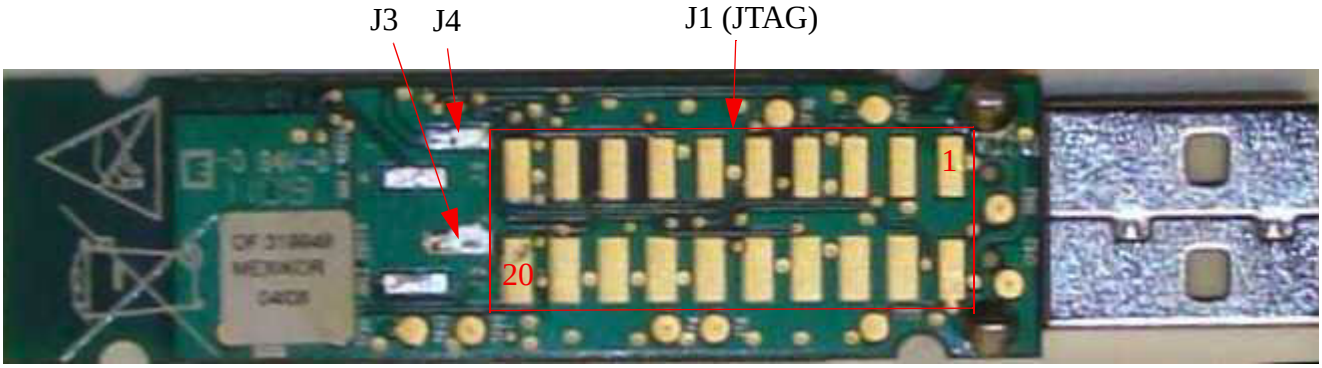


Figure 3-5. 1322x USB Dongle PCB Bottom View

3.3 Power Source

The device is powered directly from the USB connection

- The main source is the USB “B” Receptacle
- The USB connection powers the FTDI FT232R USB<>UART interface device. In turn, the FT232R has an onboard 3.3 V output series regulator that powers the rest of the module.
- A green power-on LED (D5) is provided

3.4 Low-cost 2.4 GHz ISM Band radio

The MC1322x provides an onboard balun, antenna switch, and LNA. The only external component required for the radio is an antenna. The USB dongle uses a PCB-mounted chip antenna. Figure 3-6 shows the RF network external to the MC1322x.

- Typical nominal output power is 0 dBm, with +4 dBm max
- Typical sensitivity is -95 dBm.
- Frequency range is 2405 to 2480 MHz
- Typical range (outdoors, line of sight) is 300 meters

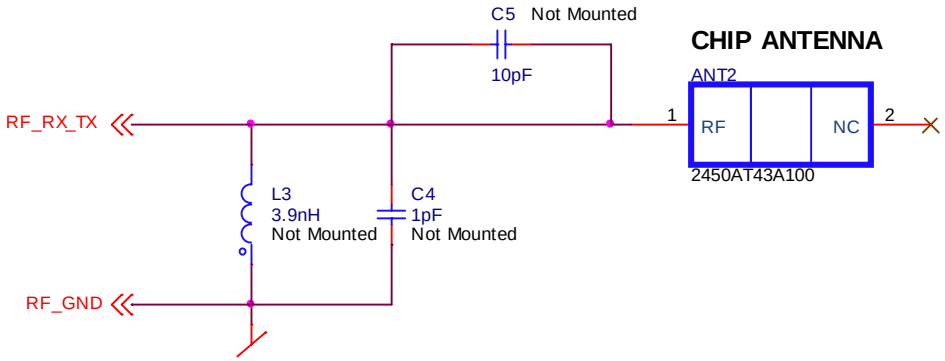


Figure 3-6. 1322x USB Dongle RF Network

3.5 USB Interface

Primary connection to the wireless node is the USB port that is provided via a USB “B” receptacle designated as J2. Figure 3-7 shows the connector pinout.

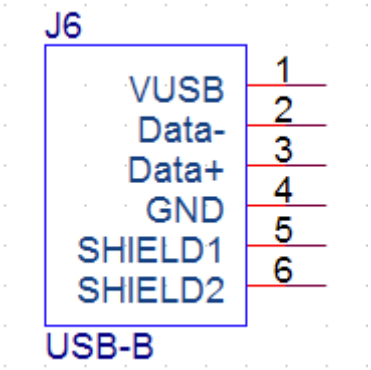


Figure 3-7. USB Connector Pinout

The port is connected to a FTDI FT232R USB <> 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 draws all required power from the USB interface. The device is USB 2.0, full speed compatible.

3.6 Clock

The MC1322x device has a primary reference oscillator of 24 MHz. Crystal X1 is used with the MC1322x for the reference oscillator.

3.7 Reset Switch and LEDs

The USB dongle provides the following

- One green Power-On LED (D5)
- One red LED (D1) is driven by the MCU and controlled by the software application.
- Reset switch to the wireless node; does not reset the USB interface device.

Table 3-1. Switch and LED Summary

Item	Connection	Feature
PWR (green)	VCC	'Power On' indication
LED1 (red)	KBI_1	Application specific
SW5	$\overline{\text{RESETB}}$	Reset to MC1322x

Refer to Figure 3-4 for location of switches and LEDs.

3.8 FLASH Memory Recovery Jumpers and Erase

The MC1322x has an onboard serial FLASH that stores the memory image that gets loaded into RAM at boot. If it becomes necessary to change or update the image in FLASH, there are two possible means of doing so:

- JTAG Debug Port - if the JTAG connector is mounted and the ARM debug tools are in use, the FLASH image can be changed.
- Load new FLASH image via USB port:
  - The Freescale BeeKit IDE download provides a software tool called Test Tool. This application runs on a PC and can be used with a client running on the MC1322x to test the platform.
  - Test Tool also has the capability to load a new image into the FLASH through the USB port. However, the FLASH must first be cleared.

The 1322x USB Dongle has two jumper sites designated as J3 and J4 (see Figure 3-8) located on the non-component (back) side of the PCB (see Figure 3-5). Use these jumper sites to erase the FLASH.

1. Short Jumper J3 Pin 1 to Pin 2.
2. Short Jumper J4 Pin 1 to Pin 2.

NOTE

For development purposes SMD headers can be soldered to the header sites to make this action easily done with shorting bars.

3. Power on the USB board by plugging it into a USB port.
4. Push the reset button on the USB board.

5. Disconnect the USB board from USB port.
6. Remove the jumpers from both J3 and J4.
7. The board is now ready for boot operation. After the FLASH is erased, plug the module into the USB connection again. The board is now ready to be loaded with a new image using the Freescale Test Tool application.

NOTE

Refer to the Freescale *Test Tool User's Guide* as supplied with Test Tool in the BeeKit Wireless Connectivity Toolkit download.

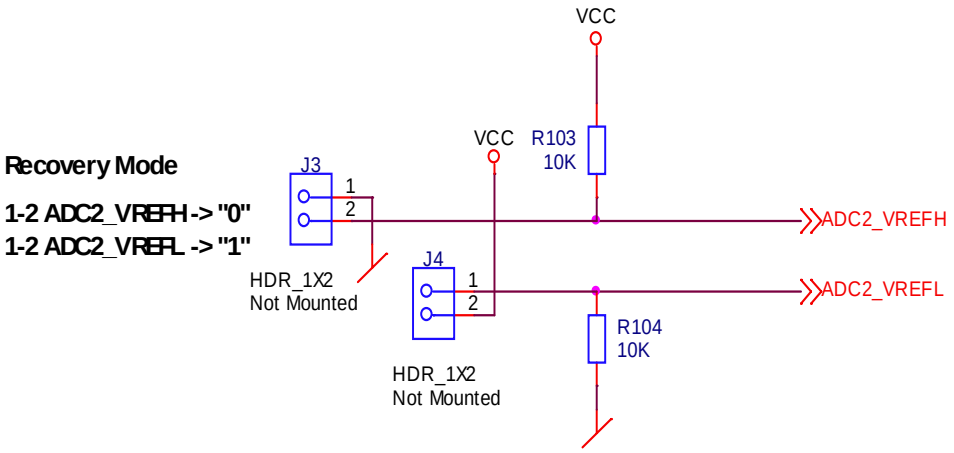


Figure 3-8. FLASH Erase Headers

3.9 Optional Debug/Development Interface (ARM JTAG Interface)

The module optionally supports the standard JTAG debug port. A 20-pin footprint is provided for a standard JTAG debug interface connector. This debug port only requires a simple interface cable to connect to a PC and use standard ARM software development tools.

The MC1322x supports connection to a subset of the defined ARM JTAG connector. The JTAG interface is a standard 2.54mm/0.1inch spacing, 20-pin debug interface (J1). The footprint for the 20-pin connector is located at the rear side of the module. A Pin 1 marking is given for correct plug-in of the development cable.

Table 3-2 shows the device pins that are connected to the associated JTAG header pin outs if the JTAG connector is used.

NOTE

The required header is a 20-position, 0.100" straight SMD connector. Molex/Waldom #15-91-0200 or equivalent.

Table 3-2. ARM JTAG 20-Pin Connector Assignments (J1)

Name[1]	Pin #	Pin #	Name
VCC	1	2	VCC
NC[2]	3	4	GND
TDI	5	6	GND
TMS	7	8	GND
TCK	9	10	GND
RTCK	11	12	GND
TDO	13	14	GND
RESET[3]	15	16	GND
NC	17	18	GND
NC	19	20	GND

1 NC means No Connect.

2 MC1322x does not support separate JTAG reset TRST.

3 VCC through a 100k-ohm pullup.

Chapter 4
Schematic, Board Layout, and Bill of Materials

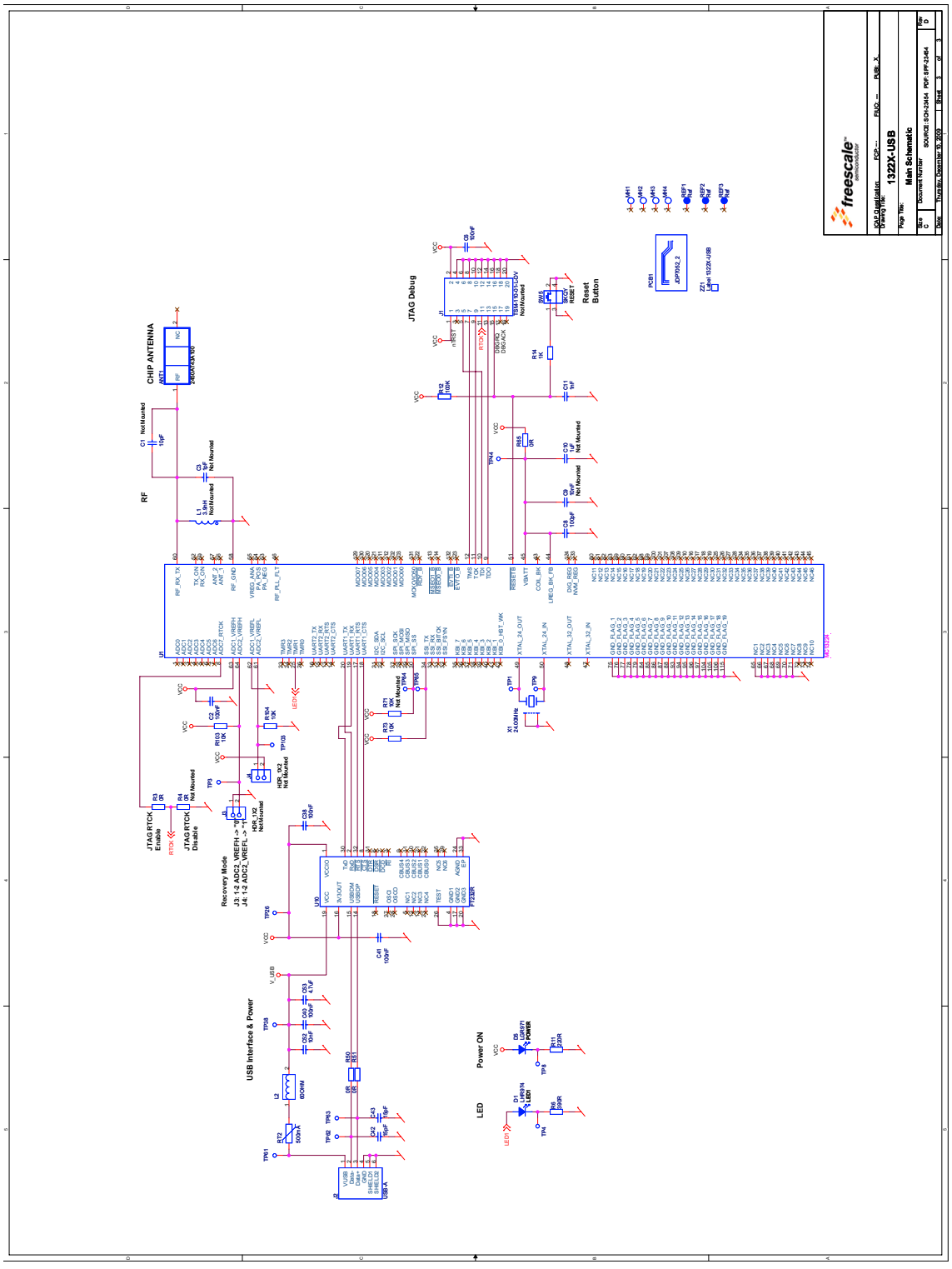


Figure 4-1. 1322x USB Dongle Schematic

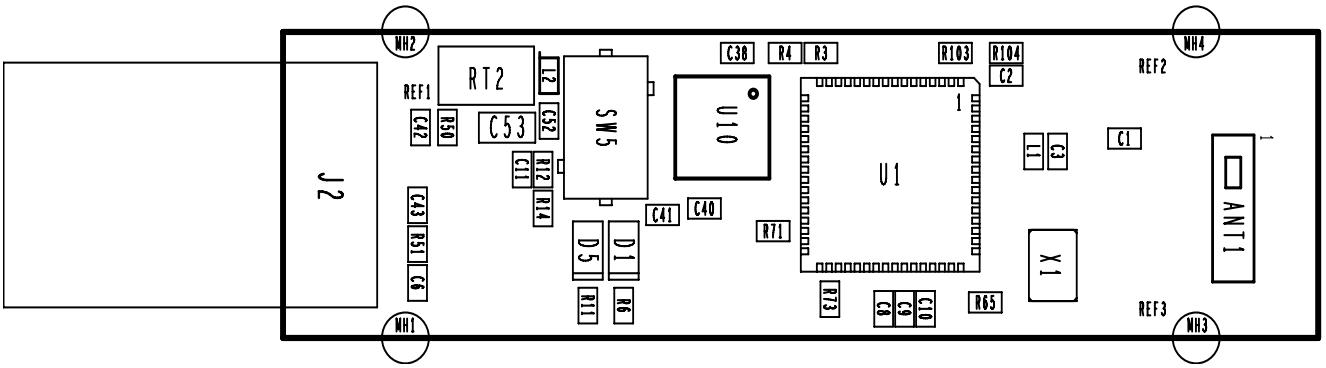


Figure 4-2. 1322x USB Dongle PCB Component Location (Top View)

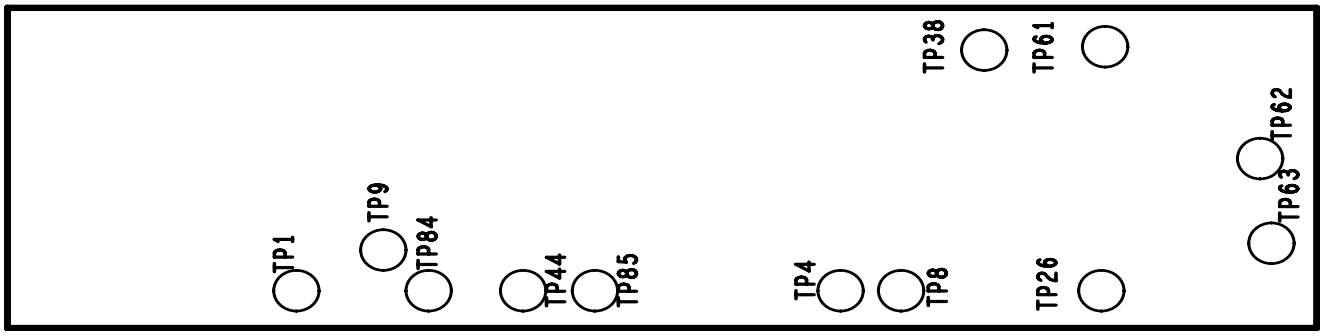


Figure 4-3. 1322x USB Dongle PCB Test Points (Bottom View)

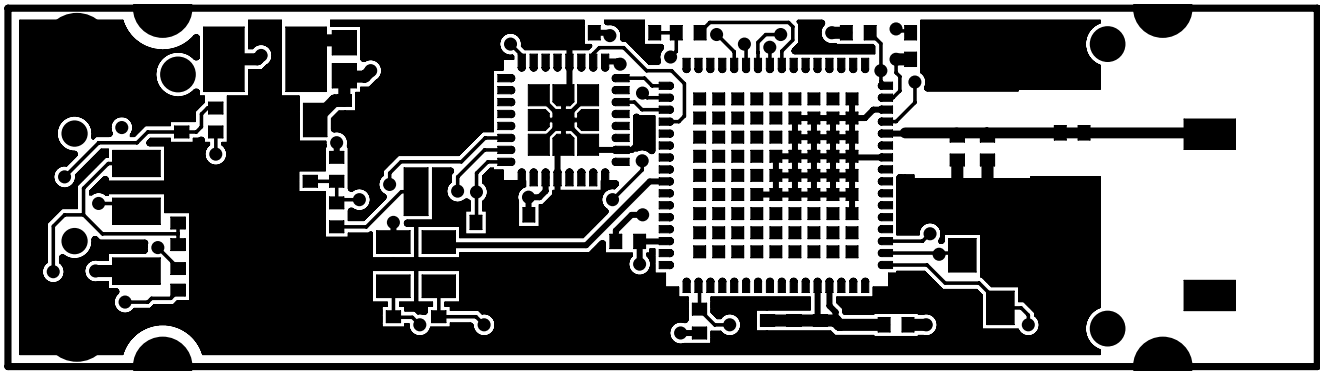


Figure 4-4. 1322x USB Dongle PCB Layout (Top View)

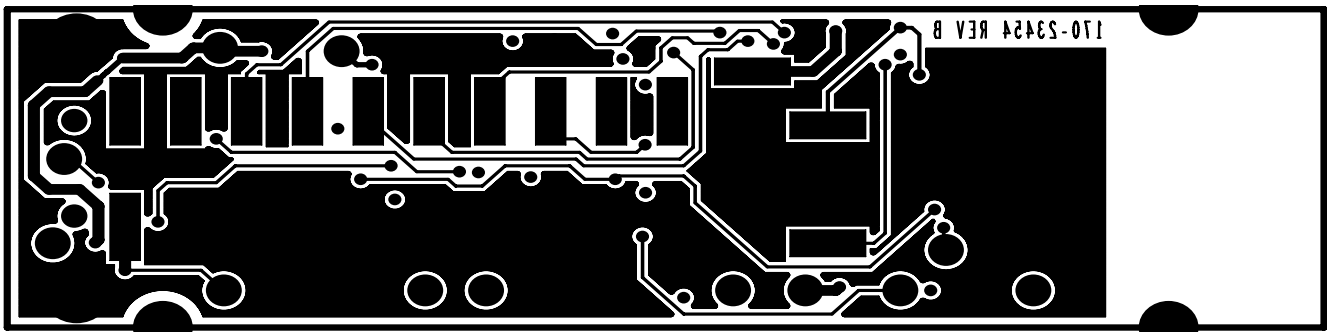


Figure 4-5. 1322x USB Dongle PCB Layout (Bottom View)

Table 4-1. Bill of Materials (BOM)

Qty	Part Reference	Description	Value	Manufacturer	Manufacturer Part Number
1	ANT1	Antenna 2.45GHZ SMT 50 OHM CASE43-1	Antenna_2.45GHZ	Johanson Technology	2450AT43A100
0	C1	Ceramic Capacitor C0G	10pF	Murata	GRM1555C1H100JZ01
5	C2,C6,C38, C40,C41	Ceramic Capacitor X5R	100nF	Murata	GRM155R61A104KA01D
0	C3	Ceramic Capacitor C0G	1pF	Murata	GRM1555C1H1R0CZ01D
	C8	Ceramic Capacitor C0G	100pF	Murata	GRM1555C1H101JZ01
0	C9	Ceramic Capacitor X7R	10nF	Murata	GRM155R71E103KA01D
0	C10	Ceramic Capacitor X5R	1uF	Murata	GRM155R60J105KE19B
1	C11	Ceramic Capacitor X7R	1nF	Murata	GRM155R71H102KA01D
2	C42,C43	Ceramic Capacitor C0G	15pF	Murata	GRM1555C1H150JZ01J
1	C52	Ceramic Capacitor X7R	10nF	Murata	GRM155R71E103KA01D
1	C53	Ceramic Multilayer Capacitor X5R	4.7uF	Murata	GRM219R61A475KE34D
1	D1	SMD Red topled	LHR974	OSRAM	Q62702P5182
1	D5	SMD Green topled	LGR971	OSRAM	Q65110P5179
0	J1	Dual Row Straight Pin Header SMD	TSM-110-01-L-DV	Samtec	TSM-110-01-L-DV-M
1	J2	USB-series "A" plug	USB-A	Samtec	USB-AM-S-S-B-SM1-R-TR
0	J3,J4	HDR 1X2 SMT 100MIL SP 380H AU	HDR_1X2	SAMTEC	TSM-102-01-SM-SV-P-TR
0	L1	HF Chip coil	3.9nH	Murata	LQG15HS3N9S02D
1	L2	IND FER BEAD 60OHM@100MHZ 500MA -- 0603	60OHM	Murata	BLM18PG600SN1_
1	RT2	Polyswitch Overcurrent Protection Device	500mA	Tyco Electronics	microSMD050F
4	R3,R50,R51,R65	Fixed resistor RC31	0R	Phillips	2322 705 91002
0	R4	Fixed resistor RC31	0R	Phillips	2322 705 91002
1	R6	Fixed resistor RC31	390R	Phillips	2322 705 50391
1	R11	Fixed resistor RC31	220R	Phillips	2322 705 50221
1	R12	Fixed resistor RC31	100K	Phillips	2322 705 50104
1	R14	Fixed resistor RC31	1K	Phillips	2322 705 50102
0	R71	Fixed resistor RC31	10K	Phillips	2322 705 50103
3	R73,R103, R104	Fixed resistor RC31	10K	Phillips	2322 705 50103

Table 4-1. Bill of Materials (BOM) (continued)

1	SW5	SMD Tact Switch 3.14N (2.5mm)	SKQY	ALPS	SKQYPDE010
1	U1	ZigBee Wireless Transceiver and ARM7 processor	MC13224	Freescale	MC13224
1	U10	USB UART, PB-free	FT232R	FTDI	FT232RQ
1	X1	Crystal SMD	24.00MHz	NDK	EXS00A-CS02020 (24MHz NX3225SA)

Chapter 5
PCB Manufacturing Specifications

This chapter provides the specifications used to manufacture the 1322x USB Dongle printed circuit board (PCB).

The 1322x USB Dongle 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 1322x USB Dongle 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.

5.1 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 55 x 15 mm (2.165 x 0.590 inches)
  - Final thickness (Cu/Cu): 0.864 mm (0.034 inches) +/- 10% (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 5-1. Layer by Layer Overview

Layer	Artwork Identification	File Name
1	Solder Resist	MASK1.art
2	Copper Top Layer (component side; layer 1)	LAY1.art
3	Copper 2nd Layer	LAY2.art
4	Copper 3nd Layer	LAY3.art
5	Copper bottom Layer	LAY4.art
6	Solder Resist	MASK2.art

NOTE

The 1322x USB Dongle 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 5-1) information is provided with the reference design.

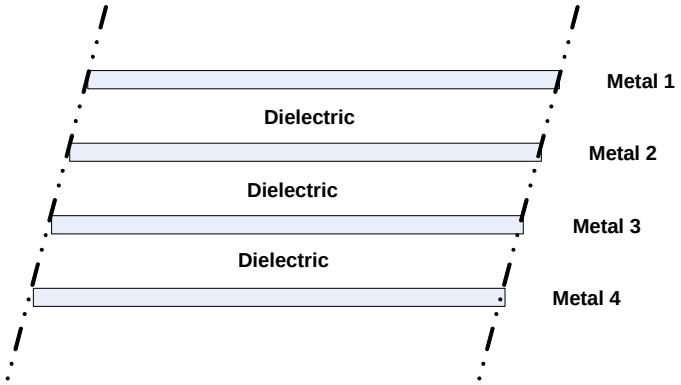


Figure 5-1. PCB Stackup Cross-Section

- Solder mask is required
- Silk screen is required

5.2 Panelization

The panel size can be negotiated depending on production volume.

5.3 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)

5.4 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

5.5 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

5.6 Electrical PCB Testing

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

5.7 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.

5.8 Hole Specification/Tool Table

See the `ncdrill-1-4.tap` file included with the Gerber files.

5.9 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 (ASSY1 and ASSY2), board fabrication drawing (FAB-23454), the four metal layers (LAYx), solder mask (MASKx), solder paste (PASTE1) and silk screen (SILKx). The schematic is SPF-23454_REV_x.

Design files are in Allegro format with OrCAD schematic capture.