LoRa® Technology Gateway User's Guide

Note the following details of the code protection feature on Microchip devices:

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as "unbreakable."

Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip's code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

Microchip received ISO/TS-16949:2009 certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona; Gresham, Oregon and design centers in California and India. The Company's quality system processes and procedures are for its PIC® MCUs and dsPIC® DSCs, KEELOQ® code hopping devices, Serial EEPROMs, microperipherals, nonvolatile memory and analog products. In addition, Microchip's quality system for the design and manufacture of development systems is ISO 9001:2000 certified.

QUALITY MANAGEMENT SYSTEM
CERTIFIED BY DNV
═ ISO/TS 16949 ═

Trademarks

ISBN: 978-1-5224-0289-3

Object of Declaration: LoRa® Technology Gateway

EU Declaration of Conformity

Manufacturer: Microchip Technology Inc.
2355 W. Chandler Blvd.
Chandler, Arizona, 85224-6199
USA

This declaration of conformity is issued by the manufacturer.

The development/evaluation tool is designed to be used for research and development in a laboratory environment. This development/evaluation tool is not a Finished Appliance, nor is it intended for incorporation into Finished Appliances that are made commercially available as single functional units to end users under EU EMC Directive 2004/108/EC and as supported by the European Commission's Guide for the EMC Directive 2004/108/EC (8th February 2010).

This development/evaluation tool complies with EU RoHS2 Directive 2011/65/EU.

This development/evaluation tool, when incorporating wireless and radio-telecom functionality, is in compliance with the essential requirement and other relevant provisions of the R&TTE Directive 1999/5/EC and the FCC rules as stated in the declaration of conformity provided in the module datasheet and the module product page available at www.microchip.com.

For information regarding the exclusive, limited warranties applicable to Microchip products, please see Microchip's standard terms and conditions of sale, which are printed on our sales documentation and available at www.microchip.com.

Signed for and on behalf of Microchip Technology Inc. at Chandler, Arizona, USA

Derek Carlson
VP Development Tools

12-Sep-14
Date

NOTES:

Table of Contents

NOTES:

Preface

NOTICE TO CUSTOMERS

All documentation becomes dated, and this manual is no exception. Microchip tools and documentation are constantly evolving to meet customer needs, so some actual dialogs and/or tool descriptions may differ from those in this document. Please refer to our website (www.microchip.com) to obtain the latest documentation available.

Documents are identified with a "DS" number. This number is located on the bottom of each page, in front of the page number. The numbering convention for the DS number is "DSXXXXXXXXA", where "XXXXXXXX" is the document number and "A" is the revision level of the document.

For the most up-to-date information on development tools, see the MPLAB® IDE online help. Select the Help menu, and then Topics to open a list of available online help files.

INTRODUCTION

This chapter contains general information that will be useful to know before using the Microchip LoRa® Technology Gateway. Topics discussed in this chapter include:

- Document Layout
- Conventions Used in this Guide
- Recommended Reading
- The Microchip Website
- Development Systems Customer Change Notification Service
- Customer Support
- Revision History

DOCUMENT LAYOUT

This document describes how to use the LoRa Technology Gateway as a demonstration platform to evaluate how LoRa Technology Gateway packet forwarding, server communication and RN module devices are added to the system. The document is organized as follows:

- **Chapter 1. "Introduction"** – This chapter describes the LoRa Technology Gateway and presents various modes of operation.
- **Chapter 2. "Getting Started"** – This chapter describes the communication methods, setup, configuration and the hardware requirements for getting started with the LoRa Technology infrastructure.
- **Appendix A. "Board Schematics and Bill of Materials"** – This appendix provides the LoRa Gateway schematics and the Bill of Materials (BOM).

CONVENTIONS USED IN THIS GUIDE

This manual uses the following documentation conventions:

DOCUMENTATION CONVENTIONS

Description	Represents	Examples
Arial font:		
Italic characters	Referenced books	*MPLAB® IDE User's Guide*
	Emphasized text	...is the *only* compiler...
Initial caps	A window	the Output window
	A dialog	the Settings dialog
	A menu selection	select Enable Programmer
Quotes	A field name in a window or dialog	"Save project before build"
Underlined, italic text with right angle bracket	A menu path	*File>Save*
Bold characters	A dialog button	Click **OK**
	A tab	Click the **Power** tab
N'Rnnnn	A number in verilog format, where N is the total number of digits, R is the radix and n is a digit.	4'b0010, 2'hF1
Text in angle brackets < >	A key on the keyboard	Press <Enter>, <F1>
Courier New font:		
Plain Courier New	Sample source code	`#define START`
	Filenames	`autoexec.bat`
	File paths	`c:\mcc18\h`
	Keywords	`_asm, _endasm, static`
	Command-line options	`-Opa+, -Opa-`
	Bit values	`0, 1`
	Constants	`0xFF, 'A'`
Italic Courier New	A variable argument	*`file`*`.o`, where *`file`* can be any valid filename
Square brackets [ ]	Optional arguments	`mcc18 [options]` *`file`* `[options]`
Curly brackets and pipe character: { | }	Choice of mutually exclusive arguments; an OR selection	`errorlevel {0|1}`
Ellipses...	Replaces repeated text	`var_name [, var_name...]`
	Represents code supplied by user	`void main (void) { ... }`

RECOMMENDED READING

This user's guide describes how to use the LoRa Technology Gateway. Other useful documents are listed below. The following Microchip documents are available and recommended as supplemental reference resources:

RN2483 Low-Power Long-Range LoRa™ Technology Transceiver Module Data Sheet (DS50002346)

This data sheet provides detailed specifications for the RN2483 module.

RN2483 LoRa™ Technology Module Command Reference User's Guide (DS40001784)

This user's guide provides specifications about the commands to be used with the LoRa module.

RN2483 LoRa™ Technology PICtail™/PICtail Plus Daughter Board User's Guide (DS50002366)

This user's guide describes how to configure and use the LoRa Daughter Board.

RN2903 Low-Power Long-Range LoRa™ Technology Transceiver Module Data Sheet (DS50002390)

This data sheet provides detailed specifications for the RN2903 module.

RN2903 LoRa™ Technology Module Command Reference User's Guide (DS40001811)

This user's guide provides specifications about the commands to be used with the LoRa module.

LoRa™ Mote User's Guide (DS40001808)

This user's guide describes how the LoRa Mote demonstration board is used with the LoRa Technology RN modules.

RN2903 LoRa™ Technology PICtail™/PICtail Plus Daughter Board User's Guide (DS50002424)

This user's guide describes how to configure and use the LoRa Daughter Board.

To obtain any of Microchip's documents, visit the Microchip website at www.microchip.com.

THE MICROCHIP WEBSITE

Microchip provides online support via our website at www.microchip.com. This website is used as a means to make files and information easily available to customers. Accessible by using your favorite Internet browser, the website contains the following information:

- **Product Support** – Data sheets and errata, application notes and sample programs, design resources, user's guides and hardware support documents, latest software releases and archived software
- **General Technical Support** – Frequently Asked Questions (FAQs), technical support requests, online discussion groups, Microchip consultant program member listing
- **Business of Microchip** – Product selector and ordering guides, latest Microchip press releases, listing of seminars and events, listings of Microchip sales offices, distributors and factory representatives

DEVELOPMENT SYSTEMS CUSTOMER CHANGE NOTIFICATION SERVICE

Microchip's customer notification service helps keep customers current on Microchip products. Subscribers will receive e-mail notification whenever there are changes, updates, revisions or errata related to a specified product family or development tool of interest.

To register, access the Microchip website at www.microchip.com, click on Customer Change Notification and follow the registration instructions.

The Development Systems product group categories are:

- **Compilers** – The latest information on Microchip C compilers, assemblers, linkers and other language tools. These include all MPLAB® C compilers; all MPLAB assemblers (including MPASM™ assembler); all MPLAB linkers (including MPLINK™ object linker); and all MPLAB librarians (including MPLIB™ object librarian).
- **Emulators** – The latest information on Microchip in-circuit emulators.This includes the MPLAB REAL ICE™ and MPLAB ICE 2000 in-circuit emulators.
- **In-Circuit Debuggers** – The latest information on the Microchip in-circuit debuggers. This includes MPLAB ICD 3 in-circuit debuggers and PICkit™ 3 debug express.
- **MPLAB® X IDE** – The latest information on Microchip MPLAB IDE, the Windows® Integrated Development Environment for development systems tools. This list is focused on the MPLAB IDE, MPLAB IDE Project Manager, MPLAB Editor and MPLAB SIM simulator, as well as general editing and debugging features.
- **Programmers** – The latest information on Microchip programmers. These include production programmers such as MPLAB REAL ICE in-circuit emulator, MPLAB ICD 3 in-circuit debugger and MPLAB PM3 device programmers. Also included are nonproduction development programmers such as PICSTART® Plus and PICkit 2 and 3.

CUSTOMER SUPPORT

Users of Microchip products can receive assistance through several channels:

- Distributor or Representative
- Local Sales Office
- Field Application Engineer (FAE)
- Technical Support

Customers should contact their distributor, representative or field application engineer (FAE) for support. Local sales offices are also available to help customers. A listing of sales offices and locations is included in the back of this document.

Technical support is available through the website at:

http://www.microchip.com/support.

REVISION HISTORY

Revision A (February 2016)

Initial release of the document.

Chapter 1. Introduction

1.1 OVERVIEW

The LoRa® Gateway is a demonstration board intended to be used along with the development of applications and products which utilize one of the LoRa Technology Transceiver RN modules.

The Microchip LoRa Gateway provides communication with the Microchip supported example LoRa network and application server. Uplink packets issued according to the LoRa WAN specification are captured and forwarded by Microchip's Gateway. Microchip supplies multiple Gateway Radio boards, each with its own designated frequency band of operations to support the available Microchip RN modules. Communication with the specified server is achieved through TCP/IP protocol as supported by the demonstration board hardware.

This chapter discusses the following topics:

- Features
  - Radio Board
  - Core Board
- Contents

1.2 FEATURES

1.2.1 LoRa® Radio Board

The LoRa Gateway Radio board has the following features, as represented in Figure 1-1:

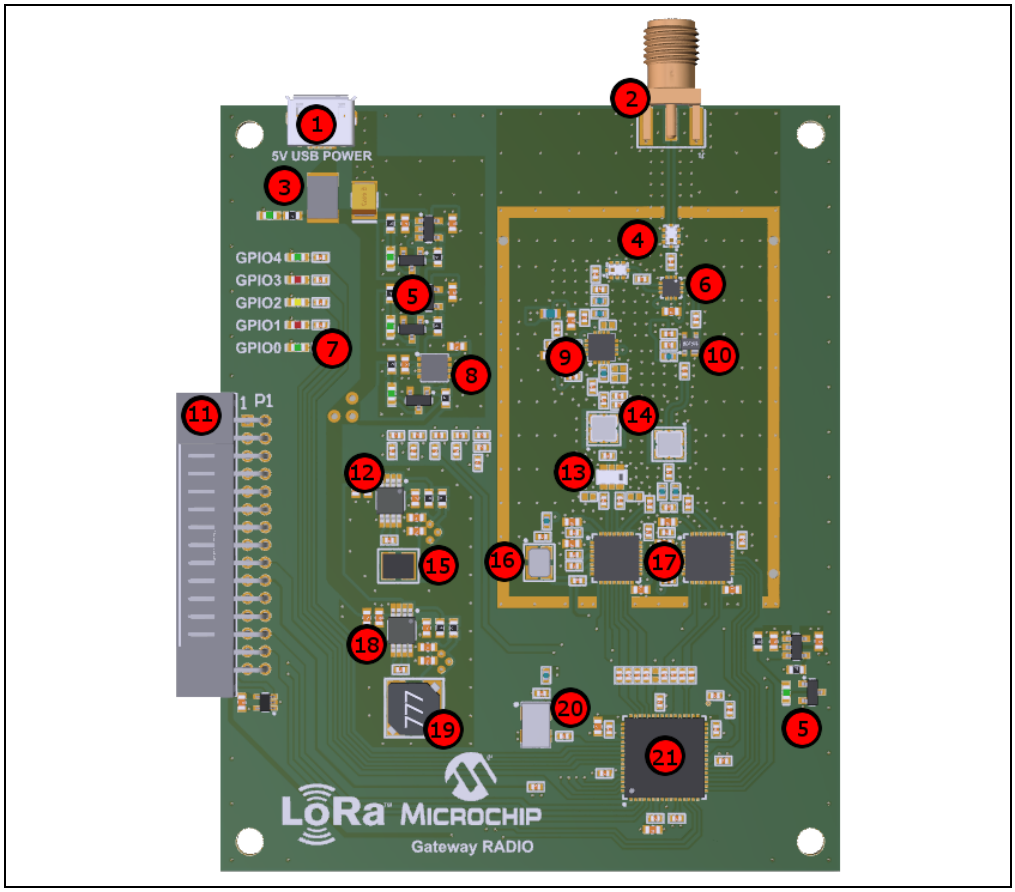
1. Micro-USB, Type-B Receptacle
2. 50Ω SMA Jack; Female Connector
3. MINISMDC150F-2 – PTC Resettable Fuse (1.5A-3A)
4. (2) Low-Pass Filters *(1)
5. MCP1824 – 3.3V 300 mA LDO Regulator circuits and Status G. LEDs
6. RFSW1012 – Broadband SPDT Switch
7. SX1301 GPIO Status LEDs
8. MCP1726 – 3.3V 1A LDO Regulator
9. RFPA0133TR7 – 3-5V Programmable Gain HE Power Amplifier
10. SPF5043Z – 50-4000 MHz Low-Noise MMIC Amplifier

11. Radio to Core board Terminal Strip Connector, Shrouded, 15 POS, 2 mm SP; Double Row
12. MCP1612 – 1.4 MHz Synchronous Buck Regulator, 1A
13. Johanson Technology Inc. Balun 900 MHz GSM/DCS/PCS/CDMA
14. Saw Filter *(2)
15. ME3220-103 KLB – Power Inductor 10 µH, 1A
16. 32 MHz Oscillator
17. (2) SX1257 – 862 – 960 MHz RF to Digital FE Transceiver
18. MCP16311 – Integrated Synch Switch Step-Down Regulator, 1A
19. MSS6132 – Power Inductor 15 µH shielded, 1.16A
20. 133 MHz Crystal Clock Oscillator
21. SX1301 – Base Band Processor and Data Concentrator

Note 1: 0868LP15A020E – Low Pass Filter, GSM/CDMA, 868 MHz, SMD (868 Radio)
0915LP15B026E – Low Pass Filter, GSM/CDMA 915 MHz, 0.5dB IL, SMD (915 Radio)

2: TA0547A @ 867.7 Center (15 MHz Bandwidth 860-875 MHz)
TA1561A @ 915 Center (26 MHz Bandwidth 902-928 MHz)

FIGURE 1-1: LoRa® GATEWAY RADIO BOARD



The LoRa Gateway Radio board captures all LoRa uplink packets using the two on-board SX1257 Semtech transceivers, and concentrates them into the SX1301 Base Band Processor. The 5V micro-USB B connector can be used to supply power to the

LoRa Gateway Radio board, but is not necessary when connected to a LoRa Gateway Core board. This allows the LoRa Gateway Radio boards to be used with development platforms besides Microchip's Gateway Core board solution.

The default operation of the SX1301 occurs upon power-on; when connected to a Gateway Core board, the PIC24 modifies firmware behavior through specific transceiver register settings. This configuration is not retained by the SX1301; for custom implementation or configurations of the SX1301, reference to the LoRa Gateway project firmware and SX1301 data sheet is recommended.

All captured uplink messages are automatically received by the SX1257 transceivers and are concentrated into a single SX1301 for communication via SPI to the LoRa Gateway through the jumper connector (J1).

On-board power LEDs are used to indicate functional power rails at a glance. Additionally, GPIO status LEDs are capable of being controlled by the on-board SX1301. Custom setting of the GPIO LEDs is not supported by this development kit, but can be achieved through firmware modification.

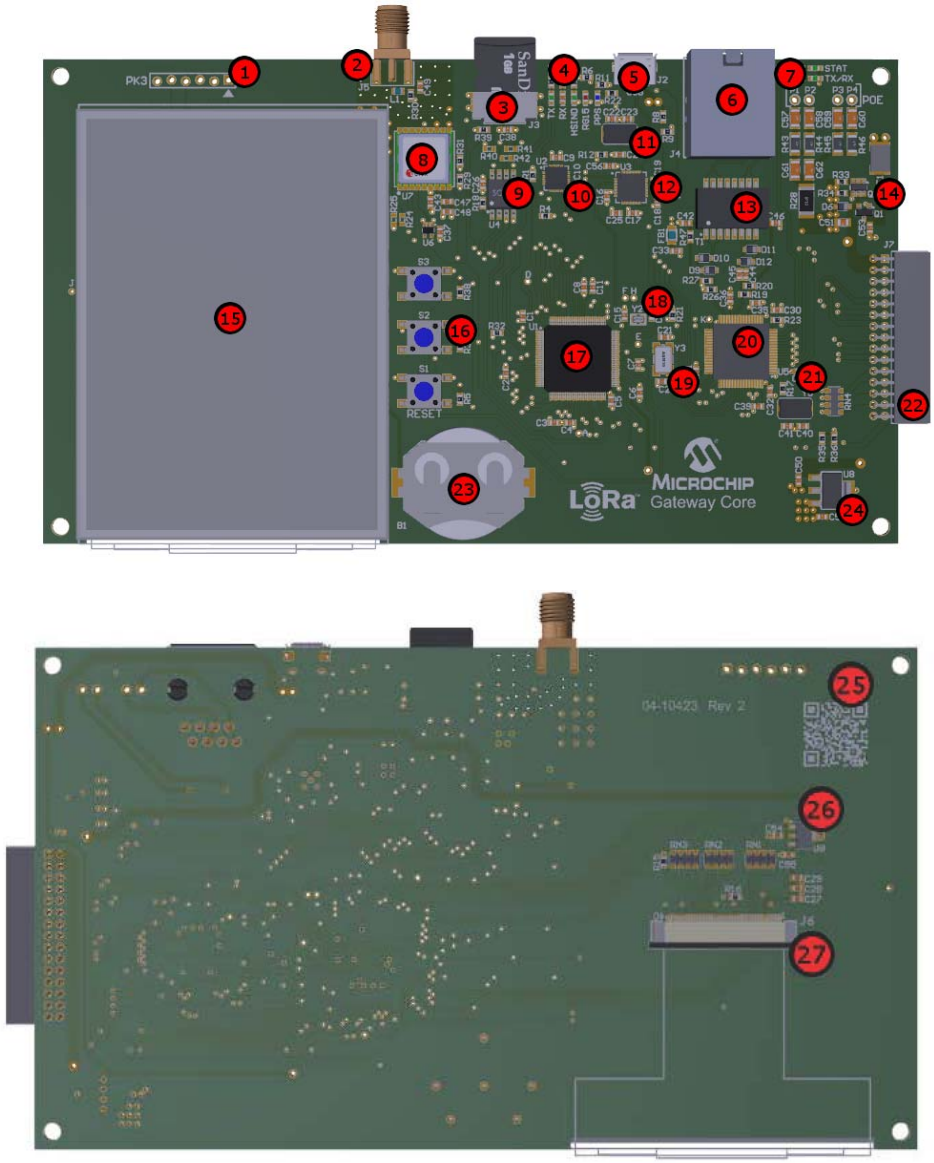
1.2.2 LoRa® Core Board

The LoRa Gateway Core board has the following features, as represented in Figure 1-1:

1. In-Circuit Serial Programmer™ (ICSP™) Programming Header
2. 50Ω SMA Jack; Female Connector
3. Molex microSD, push-pull with Detect pin
4. Status LEDs
5. Micro-USB, Type-B Receptacle
6. RJ45 Connector, Mod Jack, 8P8C
7. TCP/IP Status LEDs
8. Footprint Pads for GPS Device (*)
9. SST25VF080B – 8 Mb SPI Serial Flash Memory
10. MCP2221 – USB 2.0 to UART/I^2C Bridge
11. 24 MHz Crystal 18 pF
12. USB2412 – 2-Port USB 2.0 Hi-Speed Hub
13. Single-Port 10/100 Base-TX PoE Transformer, SMD
14. MINISMDC150F-2 – PTC Resettable Fuse (1.5A-3A)
15. ER-TFT032 – TFT LCD Module, 3.2 inch SPI 8/16-Bit Parallel
16. Push Button Switches
17. PIC24EP512GU810 – 16-Bit Microcontroller with USB, 100-Pin, 512 KB Program Memory, Enhanced Performance Flash Memory
18. 32.768 kHz Crystal, 9 pF
19. 8 MHz Crystal, 18 pF
20. ENC624J600 – 10/100 Ethernet Controller, SPI/Parallel Interface
21. 25 MHz Crystal, 18 pF
22. Two Core-to-Radio board Socket Strip connection, Shrouded, 15 POS 2 mm SP; Double Row
23. CR2032 Coin Cell Battery Holder
24. MCP1825 – 3.3V, 500 mA LDO Regulator
25. QRC Website Code
26. MCP1702T – 2.8V 250 mA LDO Regulator
27. LCD Ribbon FCC Horizontal Connector 40 POS, 0.5 mm - top contacts

Note: GPS Pad layout supports: MAX-M8Q - GNSS Module, Dual Frequency Front-End.

FIGURE 1-2: LoRa® GATEWAY CORE BOARD



The LoRa Gateway Core board receives data information captured by the Radio board. The on-board PIC24 is then responsible for forwarding that data through the encoder device (ENC624J600) which converts the information into a TCP/IP ready packet structure, then outputs through the (J4) Ethernet connector. Ethernet communication allows exchange of information between the LoRa Gateway and the network server. The network is responsible for forwarding the information to the specified application server.

Through the use of the USB IC (USB2412), debug information and basic commands are communicated through the micro-USB connector between the host PC and PIC® MCU. Board configuration settings can be stored onto a microSD card. Read/write access to the card is granted through I^2C bus communication.

If populated (not included with development board), a GPS unit is capable of supplying an accurate timestamp, along with navigational information related to Gateway world location. The (B1) coin cell connector populated on the board can be used to help aid in retention of satellite information pertaining to the GPS.

1.3 CONTENTS

The LoRa Gateway contains the following tools, as listed in Table 1-1.

TABLE 1-1: LoRa® GATEWAY TOOLS

Description	Part number
LoRa® Gateway Core Board	02-10423
LoRa Gateway Radio Board	02-10424
Radio Board Antenna	RFA-09-C55-U-B70-2
Ethernet Cable	CAB-0025
Micro-USB Cable	CAB-0028

NOTES:

Chapter 2. Getting Started

2.1 INTRODUCTION

This chapter describes the hardware requirements for the LoRa® Gateway board and provides descriptions of the different communication protocols.

The LoRa Gateway Core board is capable of communication with a host computer through usage of the micro-USB connector (J2).

Data exchange with the LoRa server is achieved with TCP/IP communication through the Ethernet connector (J4).

This chapter discusses the following topics:

- Communication Methods
- Gateway Configurations
- Hardware Description
- Gateway Application Description

2.2 COMMUNICATION METHODS

2.2.1 USB

If a micro-USB cable is connected to the LoRa Gateway Core board, it will automatically power-on and enumerate the device as a Serial Communication Port. The COMx port can then be used to issue commands between the core board and the host PC.

The power supply is regulated from 5V, provided via the micro-USB, to the nominal 3.3V for the PIC24 MCU to be used by the LDO (U8). The same 5V micro-USB power supply is regulated from 5V to the nominal 2.8V for the LCD to be used by the LDO (U9).

2.2.2 Ethernet

Connecting a Ethernet cable to the RJ45 Mod Jack (J4) allows for TCP/IP communication between the LoRa Gateway Core board and LoRa network server.

The TCP/IP Communication Protocol is handled by the ENC624J600. The Ethernet controller is connected with the microcontroller through a dedicated Serial Peripheral Interface (SPI).

2.3 GATEWAY CONFIGURATION

The LoRa Gateway Core board requires minor configurations prior to implementation; this setup is required to establish communication with the desired LoRa server. The descriptions of parameters, along with the command syntax can be found in **Section 2.5.4 "Command List and Server Parameters"**.

- Gateway ID
- Gateway Method
- Gateway IP Address
- Gateway Network
- Default Subnet Mask
- Server IP
- Server Up Port
- Server Down Port
- Keep Alive Interval
- Stat Interval
- Forward Status Settings (`CRC_Valid`, `CRC_Error`, `CRC_Disabled`)

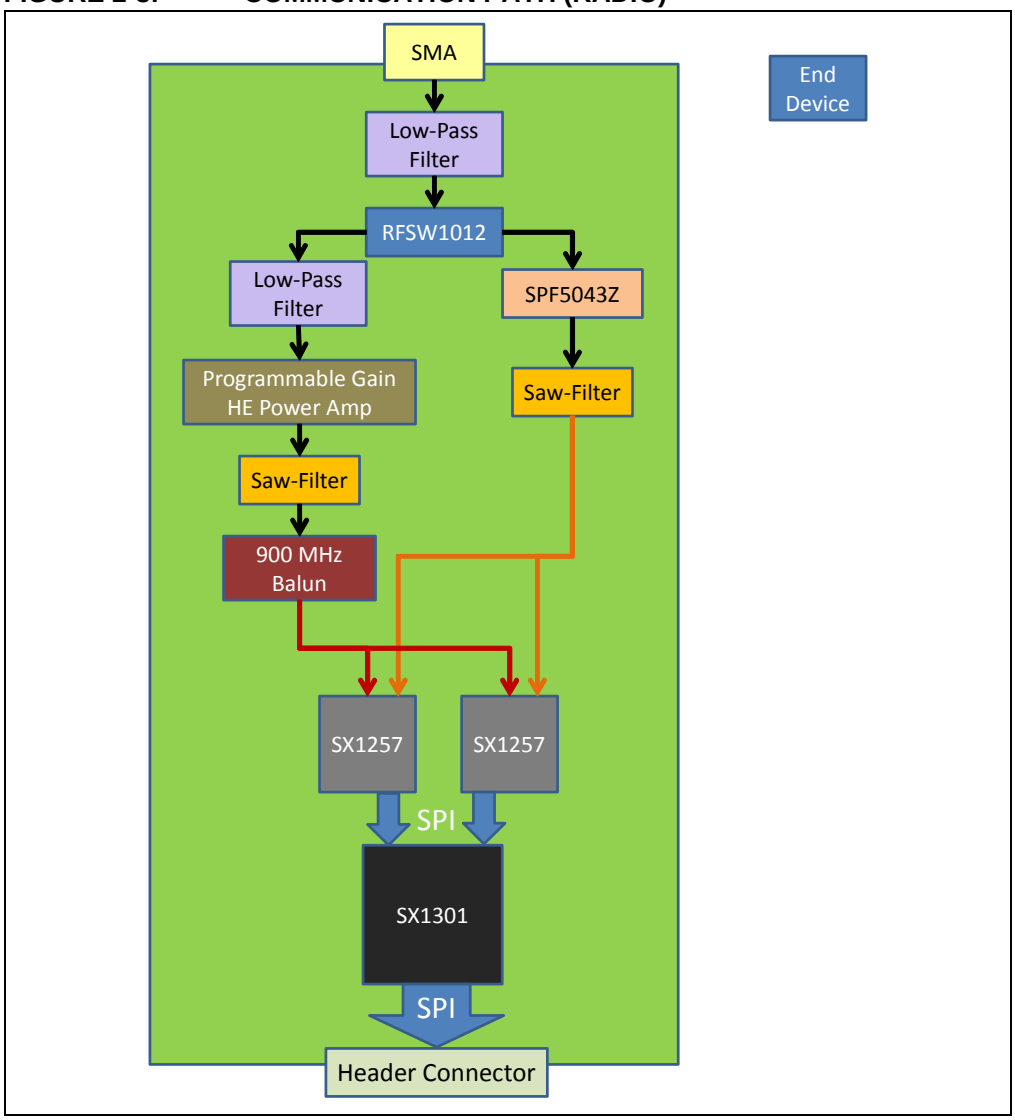
The LoRa Gateway Core can be configured in two ways, described below:

- Connecting a micro-USB (J2) to the Gateway Core board allows the user to configure the board by issuing serial commands at the baud rate of 57,600 (refer to **Section 2.5.4 "Command List and Server Parameters"**).
- If a microSD card (J3) is detected upon Reset/Power-on, the Gateway Core board will automatically read and configure it accordingly. Please refer to **Section 2.5.5 "SD Card Configuration"** for the configuration file, creation, description and example.

2.4 HARDWARE DESCRIPTION

2.4.1 Radio

FIGURE 2-3: COMMUNICATION PATH (RADIO)



The RF signal paths are connected to the SMA edge connector on the Radio board. The signal is fed into the (RFSW1012) RF single-pole double-throw (SPDT) switch. The signal is separated into two RF outputs and is filtered through two different frequencies, prior to being passed into the SX1257 Semtech transceivers for demodulation. The two SX1257 transceivers reference the same 32 MHz Oscillator (Y2) as a clock source. After capturing the RF signal, the SX1257s concentrate the data into the SX1301 through dedicated SPI communication pins. The concentrated SX1301 data is then communicated to the LoRa Gateway Core board through a dedicated SPI bus through the Terminal Strip connector (P1).

The power supplies on the Gateway Radio board are controlled by multiple on-board regulators, offering a wide range of stable voltage sources. The main power source for the Radio board is supplied via on-board micro-USB 5V USB connector, or via the connected terminal connector. It is recommended to power the radio board through the connected core. However, it is possible to independently use the Radio board through the 5V USB power connector, if the Core board is not being used. A MCP16311 (U13) regulator is used to supply 3.3V and a MCP1612 (U16) supplies 1.8V, respectively to be used by the SX1301.

Three MPC1824 regulators, U14, U15 and U17 supply dedicated 3.3V to the SX1257 transceivers and to the filter circuit. Each regulator is controlled independently by a dedicated IC shutdown pin. The LEDs populated next to each regulator circuit are used to indicate when the circuit is in use.

Note: The LoRa® Gateway Radio Board is populated with a 1.5A surface mount fuse for overcurrent protection (see **Section 1.2.1 "LoRa® Radio Board"**).

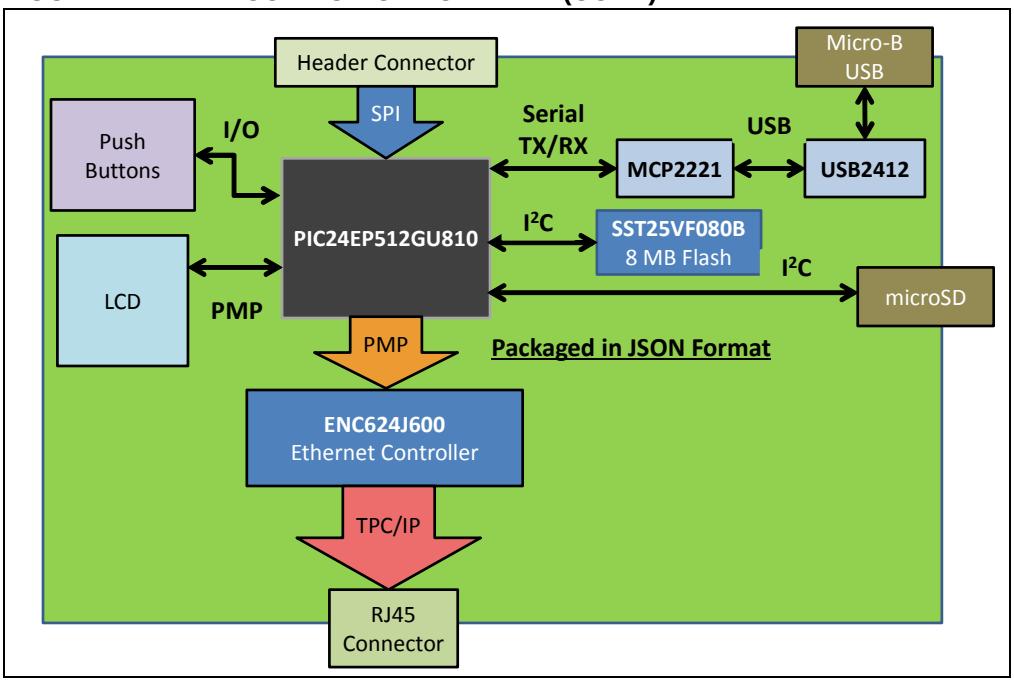
Table 2-1 shows the LoRa Gateway Radio board terminal breakout.

TABLE 2-1: LoRa® GATEWAY RADIO BOARD TERMINAL BREAKOUT

Pin Name	Description	Radio Board Connection	Core Board Connection
1, 2, 3, 4	+5V	Power Supply Source	Power Supply Source
5, 6, 7, 8	Ground	Ground Source	
18	RESET	SX1301 Pin 1 (RESET)	PIC24EP512GU810 Pin 17 (RF RESET)
20	PPS	n/a	PIC24EP512GU810 Pin 9 (PPS)
22	MOSI	SX1301 Pin 4 (HOST_MOSI)	PIC24EP512GU810 Pin 52 (HOST_SDO)
23	SCL	24AA02T Pin 1 (EEPROM)	PIC24EP512GU810 Pin 58 (SCL)
24	MISO	SX1301 Pin 3 (HOST_MISO)	PIC24EP512GU810 Pin 53 (HOST_SDI)
25	SDA	24AA02T Pin 3 (EEPROM)	PIC24EP512GU810 Pin 59 (SDA)
26	SCK	SX1301 Pin 2 (HOST_SCK)	PIC24EP512GU810 Pin 40 (HOST_SCK)
28	CSN	SX1301 Pin 5 (HOST_CSN)	PIC24EP512GU810 Pin 39 (HOST_CSN)

2.4.2 Core

FIGURE 2-4: COMMUNICATION PATH (CORE)



The LoRa Gateway Core board is populated with a PIC24EP512GU810 Microchip microcontroller. The MCU is responsible for capturing information passed by the LoRa Gateway Radio board, and forwarding the packet information to the Ethernet controller. The Radio board captures LoRa signals passively, concentrates the information, and passes data upon a fetch request by the connected board.

The Core board wraps the data afterwards into a JSON structure, then the ENC624J600 formats the required TCP/UDP headers prior to issuing the packet to the desired network server through a connected Ethernet cable. Communication between the PIC24 and ENC624J600 is done through the Parallel Master Port (PMP) peripheral support. Additionally, the PMP peripheral is used by the PIC24 to control, communicate and display information on the single-point touch-detect capable LCD.

The PIC24 MCU is also responsible for handling USB-Serial communication. A host PC may be connected using the micro-USB connector (J2), USB information is decoded by the USB2412 (U3) on-board IC prior to being communicated to the MCP2221 (U2). Dedicated peripheral pins are used by the PIC24 for serial communication with the MCP2221.

A dedicated Serial Peripheral has been allocated for communication with a GPS module (such as the MAX-M8Q), if the user chooses to purchase and populate the device. If populated, the GPS module can be used for positional information, acting also as a consistent and reliable timestamp source. It is the PIC24's responsibility to process said information.

Through the Header breakout (J7), an I^2C communication bus is connected between the Core board and the EEPROM device populated on the Radio board. This communication is used to distinguish the frequency band of the connected Radio board.

The PIC24EP512GU810 MCU is preprogrammed with the Microchip Easy Bootloader (www.microchip.com/EZBL) for easy updates through the console command line communication. Refer to **Section 2.5.6 "Bootload Implementation"** and **Section 2.5.7 "Bootload Execution"**.

Table 2-2 shows the major pin breakout for the PIC24EP512GU810.

TABLE 2-2: PIC24EP512GU810 PIN BREAKOUT

Pin #	Signal Name	Description	Board Connection
13	$\overline{\text{MCLR}}$	Reset	Switch (S1)
3, 4, 5, 93, 94, 98, 99, 100	PMD0 - PMD7	Parallel Master Port (PMP) Data	**TCP/IP Ethernet Controller** (ENC624J600): AD0 - AD7 **TFT LCD** (ER-TFT032-3): DB8 - DB15
87	MOSI	Master Out Slave In (SPI)	**MicroSD** (0475710001): CMD **Serial Flash EEPROM** (SST25VF080B): SI
88	MISO	Master In Slave Out (SPI)	**MicroSD** (0475710001): DAT0 **Serial Flash EEPROM** (SST25VF080B): SO
52	HOST_SDO	Data Out (SPI)	**LoRa® Gateway Radio Board Connector**; SX1301 MOSI
51	WRH	PSP Write High Strobe	**TCP/IP Ethernet Controller** (ENC624J600) Pin: 48
10, 11, 12, 14, 32, 33, 34, 35, 41, 42, 43, 44, 49, 50, 71	PMA0 - PMA14	Parallel Master Port (PMP) Address	**TCP/IP Ethernet Controller** (ENC624J600) Pins: A0 - A14
53	HOST_SDI	Data In (SPI)	**LoRa Gateway Radio Board Connector**; SX1301 MISO
40	HOST_SCK	Source Clock (SPI)	**LoRa Gateway Radio Board Connector**; SX1301 SCK
39	HOST_CSN	Chip Select (SPI)	**LoRa Gateway Radio Board Connector**; SX1301 CSN
90	SCK_FLASH	Source Clock (SPI)	**MicroSD** (0475710001): CLK **Serial Flash EEPROM** (SST25VF080B): SCK
89	CS_FLASH	Chip Select (SPI) for Flash Device	**Serial Flash EEPROM** (SST25VF080B): CS
56, 57	D_DNP2_P, D_DNP2_N	HID USB Communication	**Microchip Hi-Speed Hub Controller** (USB2412-DZK): D+/D-
96	GPS_TX	Serial Transmit (EUSART)	**GPS Module** (MAX-M8Q): TXD
97	GPS_RX	Serial Receive (EUSART)	**GPS Module** (MAX-M8Q): RXD
95	CS_SD	Chip Select (SPI)	**MicroSD** (0475710001): CD/DAT3
1	N/A	Digital I/O	Red LED (D4)
17	RF_RESET	Digital I/O	**LoRa Gateway Radio Board Connector**; SX1301 RESET
38	A	Peripheral Pin Select (PPS)	Debugging Through-Hole via
58	SCL	Clock Line (I^2C)	**USB Bridge** (MCP2221): SCL [Not Used] **Serial EEPROM on Radio** (24AA02T): SCL [Not Used]
59	SDA	Data Line (I^2C)	**USB Bridge** (MCP2221): SDA [Not Used] **Serial EEPROM on Radio** (24AA02T): SDA [Not Used]
60	N/A	Configuration Update; Digital I/O	Switch (S2)
61	N/A	Mode Select; Digital I/O	Switch (S3)
91	SDCARDIN	SD Card Detection; Digital I/O	**MicroSD** (0475710001): POL
92	D	Peripheral Pin Select (PPS)	Debugging Through-Hole via

TABLE 2-2: PIC24EP512GU810 PIN BREAKOUT (CONTINUED)

Pin #	Signal Name	Description	Board Connection
28	TFT_CS	Digital I/O	**TFT LCD** (ER-TFT032-3): CS
29	TFT_RESET	Digital I/O	**TFT LCD** (ER-TFT032-3): RESET
66	TFT_DC	Digital I/O	**TFT LCD** (ER-TFT032-3): DC/SCL
67	E	Peripheral Pin Select (PPS)	Debugging Through-Hole via
22, 23, 24, 25	TP X-, TP X+, TP Y-, TP Y+	Digital I/O	**TFT LCD** (ER-TFT032-3): XL, XR, YU, YD
8	WAKEUP	Digital I/O	**GPS Module** (MAX-M8Q): RESET_N
9	PPS	Digital I/O (Input); Pulse Per Second (PPS)	**GPS Module** (MAX-M8Q): TIMEPULSE
63, 64	N/A	External Oscillator	8 MHz (Y3)
73, 74	N/A	External Oscillator	32 kHz (Y2)
72	ENC_INT	Digital I/O	**TCP/IP Ethernet Controller** (ENC624J600) INT/SPISEL
76	F	Peripheral Pin Select (PPS)	Debugging Through-Hole via
77	H	Peripheral Pin Select (PPS)	Debugging Through-Hole via
81	PMWR	Parallel Master Port (PMP)	**TCP/IP Ethernet Controller** (ENC624J600): SO/WR/WRL/EN/B0SEL **TFT LCD** (ER-TFT032-3): WR (D/R)
82	PMRD	Parallel Master Port (PMP)	**TCP/IP Ethernet Controller** (ENC624J600): SI/RD/RW **TFT LCD** (ER-TFT032-3): RD
70	PMCS2	Parallel Master Port (PMP)	**TCP/IP Ethernet Controller** (ENC624J600): CS
47	2200_TX	Serial Transmit (EUSART)	**USB Bridge** (MCP2221): UTX
48	2200_TX	Serial Receive (EUSART)	**USB Bridge** (MCP2221): RTX
General or Unused Pins			
18	AN20	Analog Input	**LoRa Gateway Radio Board** Connector [Pin 15]; N/C
19	AN21	Analog Input	**LoRa Gateway Radio Board** Connector [Pin 17]; N/C
20	GPIO2	Digital I/O (Input)	**LoRa Gateway Radio Board** Connector [Pin 10]; N/C
21	GPIO1	Digital I/O (Input)	**LoRa Gateway Radio Board** Connector [Pin 9]; N/C
26	PGC	ICSP™	Programming Pin
27	PGD	ICSP	Programming Pin
6	GPIO3	Digital I/O (Input)	**LoRa Gateway Radio Board** Connector [Pin 11]; N/C
7	GPIO4	Digital I/O (Input)	**LoRa Gateway Radio Board** Connector [Pin 12]; N/C
78	PMBE	Not Used	Not Used
83	GPIO5	Digital I/O (Input)	**LoRa Gateway Radio Board** Connector [Pin 13]; N/C
79	GPIO6	Digital I/O (Input)	**LoRa Gateway Radio Board** Connector [Pin 14]; N/C
68, 69, 80, 84	N/C	Not Connected	Not Connected

2.5 LoRa® GATEWAY APPLICATION DESCRIPTION

This section describes the basic operation of the LoRa Gateway Core and Radio boards.

The default LoRa Gateway application is meant to prove a basic implementation of concentrating LoRa RF communications, and forwarding the packet information to a specified server. Below are the descriptions of the basic application behavior, along with required server configurations for operation.

- LoRa Radio Board
- LoRa Core Board
- Required LoRa Server Configuration
- Command List and Server Parameters
- SD Card Configuration
- Bootloader Implementation
- Bootloader Execution

2.5.1 LoRa® Radio Board

On either available frequency band, LoRa Gateway Radio boards act passively and require no reprogramming. Out of the box, the SX1301 concentrator operates in default configuration. Upon power-on or Reset of the Core board, the PIC24EP512GU810 configures the SX1301 by preparing it for the desired operation through register setup, as well as firmware updates to the internal die MCUs.

2.5.2 LoRa® Core Board

After power-on, the LoRa Gateway Core board will do a check to see if a microSD has been inserted into the holder. If a card is detected, the configuration values stored on the card will automatically be read and written to the PIC24 for system behavior.

If no card is present, the board operates under predefined default parameter values. The user is capable of issuing commands through the micro-USB connection to configure custom parameter values.

CDC serial communication is achieved through the use of the MCP2221 and USB2412 IC devices. Microchip's USB Bus IC (USB2412) is responsible for capturing USB communication and formatting the data. The MCP2221 then converts the formatted USB data into serial format, which is passed to the PIC24 EUSART for processing. The on-board Orange (D1) and Green (D2), LEDs are used to display RX/TX activity.

The LoRa Gateway Core board can be populated with a GPS module capable of latitude, longitude and altitude measurements. The GPS module supplies a Pulse-Per-Second (PPS) signal which can be monitored by the PIC24 device. This signal is equivalent to a "heartbeat" and indicates that the module is functional. Data exchange with the GPS module is achieved through peripheral serial communication. Population of a GPS is highly recommended for any Gateway unit which is to be deplored into the field.

Timestamp and positional information are supplied to GPS as data from its currently active satellite connection. A Coin Cell Battery (B1) can be inserted on the Core board to aid retention of Satellite information on the GPS if loss of power source occurs.

LoRa communications captured by the Gateway Radio board are exchanged through SPI bus communications between the SX1301 and PIC24 devices. Once the data has properly been communicated to the PIC24, it processes and converts the information to a JSON data structure. After doing so, the PIC24 forwards the packet information through Microchip's Ethernet Controller (ENC624J600) before exchanging data with the specified servers through a UDP payload.

The on-board LCD is currently used to display start-up configuration information. Once the Gateway is running, a splash screen with an icon will be displayed. The Core board will then run through its basic initialization process, during which parameter configurations along with general status information will be displayed.

The initial screen will indicate the frequency of the connected Radio board, or if no board is currently present or detectable. It will additionally show the Interface mode currently used by the Core board for IP allocation, along with the currently used Board IP address. The Server IP being forwarded to, and Up/Down port are also shown. Finally, the Gateway ID, Heart Rate, Statistic Update Rate, and CRC settings are displayed.

After initial setup is completed, the LCD display will change to show active Upstream/Downstream activity currently occurring on that LoRa Gateway unit.

By pressing and holding the (S2) push button, the user can swap between Configuration and Traffic displays on the LCD screen.

2.5.3 Required LoRa® Server Configuration

The LoRa Gateway Core board requires a few key configurations to successfully be able to interact with a server. These configuration parameters can be loaded into the Core board through the microSD card, or by issuing specific commands through a Serial Com. Default values are used by the Gateway Core Board if no microSD card is present, and are given in **Section 2.5.4 "Command List and Server Parameters"** below.

2.5.4 Command List and Server Parameters

LoRa Gateway Core board commands begin with the system keyword 'sys', and include the categories shown in Table 2-3. The LoRa Gateway Core Board Communicates at a baud rate of 57,600.

TABLE 2-3: GATEWAY CORE BOARD COMMANDS

Command	Description
System Commands	
`save`	Save current configurations to inserted microSD card
`log`	Configure the type of information output by the debug logger
Get ONLY Commands	
`ver`	Request LoRa® Gateway Version Number
`build`	Request Build date on Firmware
`report`	Request Statistic Report Information
Get/Set Server Commands	
`gwid`	Request/Configure the LoRa Gateway Unique User ID (UUID)
`ifmode`	Request/Configure the Interface Mode the LoRa Gateway acquires its IP address
`ifip`	Request/Configure the Interface IP Address given to the LoRa Gateway board(1)
`ifgw`	Request/Configure the Interface IP Address for the Network Gateway (Router)(1)
`ifmsk`	Request/Configure the Interface Network (Router) Subnet Mask(1)
`svip`	Request/Configure the LoRa Server IP Address the Gateway is using to packet forward
`svup`	Request/Configure the Server Port used for Up Link Communications
`svdn`	Request/Configure the Server Port used for Down Link Communications
`heart`	Request/Configure the current "Keep Alive Interval", time interval in seconds the Gateway sends a pull request to the Sever
`stat`	Request/Configure the timer interval in which LoRa Statistics are updated
`crcvd`	Request/Configure CRC Valid check for packet forwarding
`crcer`	Request/Configure CRC Error check for packet forwarding
`crc`	Request/Configure CRC check for packet forwarding
`sync`	Request/Configure Sync Word used by the Gateway

Note 1: Only required in Static mode.

The response of '`invalid_param`' will always be returned if the entered command is out of range. If the command send is not supported, a response will be returned indicating which element of the command was invalid.

For example:

Format: [cmd word 0]" "[cmd word 1]" "[cmd word 3]" "[Data; if applicable]

Incorrect Command: `sys sat heart 10`

Response: `Invalid cmd word 1`

Meaning: The 2nd part of the command is incorrect.

More detailed descriptions of the LoRa Gateway Core board – commands, syntax, responses, descriptions, and format of parameter or variables affected can be found below:

Save

Command: `sys save`

Responses: `OK` – The command was executed

`fail` – There was an error in execution

When received by the LoRa Gateway Core board, the Save command will attempt to read from the microSD card inserted, if the microSD card contains a valid '`config.json`' file with server and Gateway information. If the file is successfully able to reconfigure the desired parameter, the response of "`OK`" will be returned. If the file is incorrectly formatted, or there is an issue accepting the file, the response of "`fail`" will be returned. For more detailed descriptions of the failure reason, the user can enable the CONFIG debug logger.

Example: **`sys save`**
`OK` // Save Successful

Log

Default: `off`

Command: `sys log <logLevel>`

Responses:`ok`

< `logType` > string representing different log levels. Parameter values can be: `off, error, warning, info, debug, verbose`

The Log command is used to configure the type of messages output by the Debug Logger on the Serial micro-USB connection. There are existing messages inside the LoRa Gateway firmware useful for evaluation system performance or debugging issues. Additionally, these tags can be used in expansion of the firmware for advanced users. Refer to LOG_XXXXXX implementations in code; e.g., LOG_DEBUG.

The default state is OFF; in this mode, the Core board will either update a parameter, or generate a response based upon the received command. Additionally, if a microSD card is inserted, the Save command can write current settings to ensure the proper retention of parameter values upon if a Reset or Power Cycle occurs; otherwise, default values will be restored.

When the logic level is not OFF, the Core board will print out appropriate message with preFix characters { [E], [W], [I], [D], [V] } to designate levels. Modes are incremental, so all lower level logs will also be printed. For example, if logLevel is set to Warning[logLevel2], error messages[logLevel1] will also be printed out.

Example: **`sys log verbose`**
`ok`
[E] Error message……..
[W] Warning message……..
[I] Info message……..
[D] Debug message……..
[V] Verbose message……..

Version

Command: `sys get ver`

Responses: `Microchip LoRa Gateway Version X.Y.Z`

X – Major Revision

Y – Minor Update

Z – Patch/Errata Fixes

The version command is used to indicate the Gateway hardware type, and firmware which is being used. This will allow users and existing systems to understand Microchip Gateway features if/when different solutions become available.

Example: **`sys get ver`**

`Microchip LoRa Gateway Version 0.1.0    //Version number`

Build

Command: `sys get build`

Responses: Build on MM DD YYYY at HH:MM:SS

M – Month

D – Day

Y – Year

H – Hour

M – Minute

S – Second

The build command is used to indicate the exact build timestamp for the currently running LoRa Gateway Firmware.

Example: **`sys get build`**

`Build on Oct 7 2015 at 12:39:42    //Build information`

Report

Command: `sys get report`

Responses: All values represented in the report are [16-bit value; 2-bye value] in size.

[rxReceived] [rxOkRatio] [rxBadRatio] [rxNoCrc] [upPacketForwad] [payloadByteSize] [pushByteSize] [pushDataSent] [pushAckRatio] [pullSent] [pullAckRatio] [pullDataRx] [pullByteSize] [pullPayload] [txOkCount] [txFailCount]

TABLE 2-4: DESCRIPTION OF REPORT PARAMETERS RETURNED

Command	Description
rxReceived	Number of LoRa® packets received by Gateway
rxOkRatio	Number of valid LoRa packets received; CRC Valid
rxBadRatio	Number of invalid LoRa Packets received; CRC error
rxNoCrc	Number of valid LoRa Packets received; No CRC
upPacketForward	Number of LoRa packets forwarded by Gateway to the server
payloadByteSize	Byte size of the last packet payload received
pushByteSize	Byte size of the packet being forwarded from Gateway to the server
pushDataSent	Data of the packet being forwarded from Gateway to the server
pushAckRatio	Ratio of the messages from the Gateway acknowledged by the server
pullSent	Number of pull requests issued by the Gateway to the server
pulAckRatio	Number of pull requests acknowledged by the server
pullDataRx	Last received data after a pull request was done by the Gateway
pullByteSize	Byte size of the last data received from pull requests
pullPayload	Data of the payload requested by the pull
txOkCount	Valid Number of successful transmissions done by the Gateway
txFailCount	Number of attempts where the Gateway failed to transmit

The Report command is used to get a full comprehensive report of the statistics information currently being maintained, monitored by the Gateway Core board. This command is specifically formated to allow all information to be passed in a single string.

Example: **`sys get report 10 15 5 15 10 20 42 15 20 15 42 10 9 11 12 3`**

Gateway Board ID

Default: 1234567887654321
Parameter: `uint64_t config_lgwm`
Command: `sys get gwid`
`sys set gwid <gatewayID>`
`<value>` 64 Bit; [8] Byte Hexadecimal value representing the Gateway ID

This command reads/configures the Gateway ID currently used by the development board. This ID is 64 bytes in length, and should be modified to ensure a UUID for the Gateway Core board within the user's LoRa network. This ID should exist for the life of the device on the network. If the Gateway is changing LoRa networks, its ID can be updated to ensure a UUID.

Example: **sys set gwid FEDCBA987654321**
ok
sys get gwid
0xFEDCBA987654321 //Gateway ID

Gateway Board IP Address

Default: 192.168.1.101
Parameter: `uint32_t config_gw_if_ip_addr`
Command: `sys get ifip`
`sys set ifip <ipAddress>`

`<ipAddress>` 32 Bit; [4] Byte Decimal value presented as the Gateway Board IP Address

This command reads/configures the LoRa Gateway development board's IP address. The IP address will be entered in the generic form, with Decimal for numeric values, and '.' between the values for separation. The command will be parsed and formatted into a Hexadecimal form for retention. When the IP address is requested, it will be presented in the standard format.

Example: **sys set ifip 192.168.10.151**
ok
sys get ifip
192.168.10.151 //Static IP Address

Network Gateway IP Address

Default: 192.168.1.1
Parameter: `uint32_t config_gw_if_gateway`
Command: `sys get ifgw`
`sys set ifgw <net Address>`

`<netAddress>` 32 Bit; [4] Byte Decimal value presented as the Network Gateway IP Address

This command reads/configures the Network Gateway being used by the LoRa Gateway Core board. This is typically a personal router or a network switch. The IP address can be entered in the generic form, with Decimal for numeric values, and '.' between the values for separation. The command will be parsed and formatted into a Hexadecimal form for retention. When the IP address is requested, it will be presented in the standard format.

Example: **sys set iggw 192.168.1.5**
ok
sys get ifgw
192.168.1.5 //Static Network Gateway IP

Network Subnet Mask IP Address

Default: 255.255.255.0
Parameter: `uint32_t config_gw_if_netmask`
Command: `sys get ifmsk`
`sys set ifmsk <netMask>`
`<netMask>` 32 Bit; [4] Byte Decimal value presented as the Network Subnet Mask IP Address

This command reads/configures the Network Subnet-Mask IP Address being used by the LoRa Gateway Core board. The Subnet Mask is used to divide an IP address into network and host addresses. The Subnet Mask can be entered in the generic form, with Decimal for numeric values, and '.' between the values for separation. The command will be parsed and formatted into a Hexadecimal form for retention. When the IP address is requested, it will be presented in the standard format.

Example:
```
sys set ifmsk 255.255.255.199
ok
sys get ifmsk
255.255.255.199         //Static Network Subnet Mask IP
```

Server IP Address

Default: 192.168.1.100
Parameter: `uint32_t config_server_ip`
Command: `sys get svip`
`sys set svip <serverIP>`
`<serverIP>` 32 Bit; [4] Byte Decimal value presented as the Server IP Address

This command reads/configures the Server IP Address to which the LoRa Gateway is forwarding LoRa packet information. The Server IP represents the location where the LoRa network server is currently being hosted. Once the LoRa packet has been received by the network server, the network will be responsible for determining to which application server the LoRa packet should be forwarded. The IP address can be entered in the generic form, with Decimal for numeric values, and '.' between the values for separation. The command will be parsed and formatted into a Hexadecimal form for retention. When the IP address is requested, it will be presented in the standard format.

Example:
```
sys set svip 198.162.42.105
ok
sys get svip
198.162.42.105         //Server IP Address
```

Server Uplink Port Number

Default: 1700
Parameter: `uint16_t config_server_up_port`
Command: `sys get svup`
`sys set svup <upPort>`

`<upPort>` 16 Bit; [2] Byte Decimal value presented as the Server Uplink Port Number

This command reads/configures the Server Uplink Port Number used by the network server for the TCP/IP communication. Based on this configuration, the server will communicate all Uplink actions to the specified port number.

Example:
```
sys set svup 1780
ok
sys get svup
1780                    //Server Uplink Port Number
```

Server Downlink Port Number

Default: 1700
Parameter: `uint16_t config_server_down_port`
Command: `sys get svdn`
`sys set svdn <downPort>`
`<downPort>` 16 Bit; [2] Byte Decimal value presented as the Server Downlink Port Number

This command reads/configures the Server Downlink Port Number used by the network server for the TCP/IP communication. Based on this configuration, the server will communicate all Uplink actions to the specified port number.

Example:
```
sys set svdn 1782
ok
sys get svdn
1782                    //Server Downlink Port Number
```

Keep Alive Interval

Default: 10
Parameter: `uint16_t config_keepalive`
Command: `sys get heart`
`sys set heart <keepAlive>`

`<keepAlive>` 16 Bit; [2] Byte Decimal value presented as length of time in seconds

This command reads/configures the Keep Alive Interval, or 'Heartbeat' of communication between the LoRa Gateway Core board and LoRa server. This represents the length of time between a 'Pull Request' being sent to the server. A pull request is sent to the server to maintain a constant connection; it allows the server to know that the Gateway in use is still active. It is the responsibility of the device to maintain connection with the server; otherwise the server will remove the device for resource management. The rate at which pull request must be received is determined by the server.

Example: **`sys set heart 30`**
`ok`
`sys get heart`
`30 //Keep Alive Interval; Heartbeat`

Statistics Printout Interval

Default: 30
Parameter: `uint16_t config_stat_interval`
Command: `sys get heart`
`sys set heart <statRate>`
`<statRate>` 16 Bit; [2] Byte Decimal value presented as length of time in seconds

This command reads/configures the Statistics printout interval. This represents the length of time between the Statistics being output to the Debug Logger. Statistics is part of the [I]nfo type, so the `sys log info` command is required to be displayed.

Example: **`sys set stat 60`**
`ok`
`sys get stat`
`60 //Statistics Printout Rate`

CRC Valid Packet Forward

Default: ON
Parameter: `bool config_fwd_valid_pkt`
Command: `sys get crcvd`
`sys set crcvd <fwdValid>`
`<fwdValid>` string representing mode. Parameter values can be: `on, off`

This command reads/configures if the LoRa Gateway Core board will forward LoRa Packets which have had a CRC check and were considered valid. When configured as Off and CRC checking is enabled, any packets which pass the CRC check will not be forwarded.

Example:
```
sys set crcvd off
ok
sys get crcvd
off                    //CRC Valid Packets Forward State
```

CRC Error Packet Forward

Default: OFF
Parameter: `bool config_fwd_error_pkt`
Command: `sys get crcer`
`sys set crcer <fwdError>`
`<fwdError>` string representing mode. Parameter values can be: `on, off`

This command reads/configures if the LoRa Gateway Core board will forward LoRa Packets which have had an error reported during CRC. When configured as OFF, and CRC checking is enabled, any packets which fail the CRC check will not be forwarded.

Example:
```
sys set crcer on
ok
sys get crcer
on                     //CRC Error Packets Forward State
```

CRC

Default: ON
Parameter: `bool config_fwd_nocrc_pkt`
Command: `sys get crc`
`sys set crc <doCheck>`
`<doCheck>` string representing mode. Parameter values can be: `on, off`

This command reads/configures if the LoRa Gateway Core board will complete a CRC check on all received LoRa Packets. If OFF, all received LoRa Packets by the Gateway will automatically be forwarded to the server.

Example:
```
sys set crc on
ok
sys get crc
on                    //CRC on LoRa Packets
```

SYNC

Default: 0x34
Parameter: `uint8_t config_gw_sync_word`
Command: `sys get sync`
`sys set sync <syncWord>`
`<syncWord>` 8-bit; [1] Byte Hex Value representing the valid used SyncWord

This command reads/configures the LoRa Gateway Core board valid SyncWord used during LoRa communication. By default, the SyncWord is configured to 0x34, which typically represents a public network; while a value of 0x12 represents a private network. It is possible to use other values for the SyncWord; however, at this time only the public/private values have been defined.

Example:
```
sys set sync 12
ok
sys get sync
12                    //Currently used Gateway SyncWord
```

2.5.5 SD Card Configuration

Upon Power-on/Reset, the LoRa Gateway Core board will attempt a read of the microSD card, if present. The configuration script should be saved in a JSON format, and must be the only file on the microSD.
The Script can be written in Notepad, Notepad++, or any basic Text Editor. It is required that the script be saved with a `.json` definition. Below is an example script which can be used for microSD card boot-up configuration.

EXAMPLE 2-1: SD CARD CONFIGURATION EXAMPLE

```
# Config file for Microchip LoRa Gateway
# All comments starts with # and will be ignored
# Config string should be a SINGLE-LINE json string
# The following fields can be configured:
#   gateway_id: 16 Bytes /* gateway uuid */
#   gw_if_mode:{"dchp"|"static"}/* gateway eth interface mode */
#   gw_if_ip_addr: 4 Bytes /* LoRa gateway board Ip address, needef if
gw_if_mode=="static", ignored otherwise */
#   gw_if_gateway: 4 Bytes /* Network gateway (router) Ip address, needef if
gw_if_mode=="static", ignored otherwise */
#   gw_if_netmask: 4 Bytes/* Network subnet mask, needef if gw_if_mode=="static",
ignored otherwise */
#   server_ip:  4  Bytes      /* server ip address */
#   server_up_port: 0-65535          /* server port for up link communication */
#   server_down_port: 0-65535    /* server port for down link communication */
#   keepalive_interval: 0-65535 /* keep alive interval, pull request send to server
every keepalive_interval seconds */
#   stat_interval:0-65535 /* statistics interval, LoRa statistics update, in seconds
*/
#   forward_crc_valid:{true|false}/* flag indicating if crc valid packet will be
forwarded */
#   forward_crc_error:{true|false}/* flag indicating if crc failed packet will be
forwarded */
#   forward_crc_disabled:{true|false}/* flag indicating if crc check should be
disabled */
#   sync_word: 1 Byte      /* LoRa network Sync Word, 0x12:Private, 0x34:Public */
#
# Below is the actual setup
#
{"gateway_id":"AABBCCDD00112233","gw_if_mode":"dhcp","gw_if_ip_addr","192.168.1.99","
gw_if_gateway":"192.168.1.100","gw_if_netmask":"255.255.255.0"
,"server_ip":"192.168.0.101",”server_up_port":1700,"server_down_port":1700,"keepalive
_interval":10,"stat_interval":30,"push_timeout_ms":100,"forward_crc_valid":true,"forw
ard_crc_error":true,"forward_crc_disabled":false,”sync_word”:34}
```

In this example, the parameters were configured as follows:
Gateway ID: AABBCCDD00112233
Interface Mode: dhcp
Board IP Address: 192.168.1.99
Router IP Address: 192.168.1.100
Subnet Mask: 255.255.255.0
Server IP: 192.168.0.101
Server Up Port: 1700
Server Down Port: 1700
Keep Alive Interval: 10
Statistic Interval: 30
Push Timeout: 100
CRC Valid: True
CRC Error: True
CRC: False
Sync Word: 34

2.5.6 Bootload Implementation

The Core board microcontroller is preprogrammed with the supporting EZBL (Easy Bootloader) application. The EZBL works through the manipulation of the linker script of the Makefile for the Gateway Application Project. These additions to the linker allow a `.blob` file to be created with each project build. The code necessary to complete the generation of the `.blob` file has already been added to the post build script in the Gateway project Makefile.

FIGURE 2-5: BLOB CREATION MAKEFILE EDITS

```
@echo EZBL: Converting .hex file to a binary .blob
${MP_JAVA_PATH}java -jar "ezbl/ezbl_tools.jar" --blobber -artifact="${DISTDIR}/${PROJECTNAME}.${IMAGE_TYPE}.hex"
```

Comments can be added to the project build output by @echo EZBL as shown in Figure 2-6.

FIGURE 2-6: MAKEFILE/BUILD OUTPUT COMMENTS

${MP_JAVA_PATH} – This maps to the java path directory of the project where the [ezbl] folder exist.

java – jar “ezbl/ezbl_tools.jar”– Execute the ezbl_tools.jar file within the [ezbl] folder.

--blooper –artifact = “${DISTDIR}/${PROJECTNAME}.${IMAGE_TYPE}.hex” – Produces a blooper file type from the hex file generated and loaded in the Gateway [dist] folder on project build.

2.5.7 Bootload Execution

There are two methods of applying a bootloader update to the Gateway board:

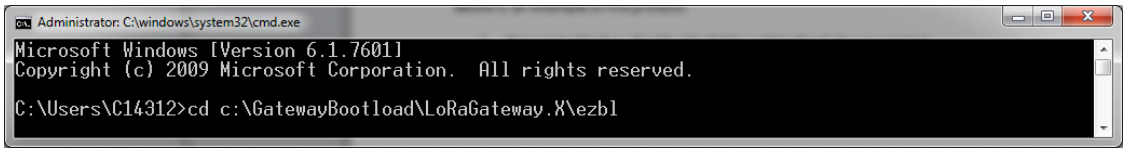
- Manual
- Automatic

Manual updates can be booloaded to the Gateway board through the use of the console command line interface. The user is capable of browsing, and selecting the `ezbl_tools.jar` Java executable. Through interaction with the Java executable, the user can select the latest `.blob` file and request a bootload process to be launched.

Below is an example of this process:

1. Browse to the Easy Bootloader folder within the Gateway project.

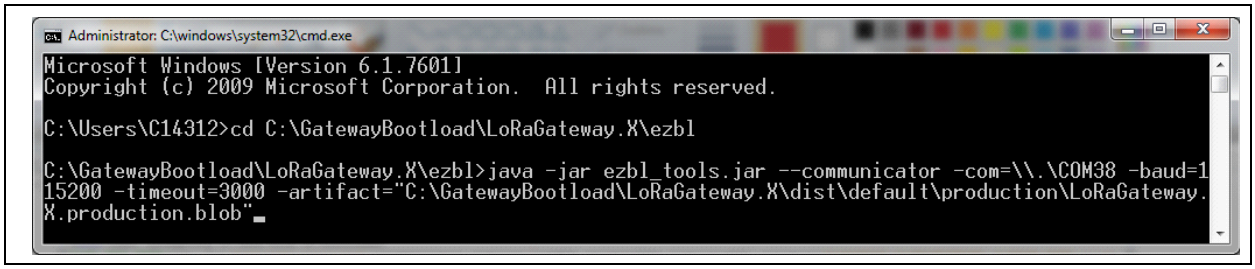
FIGURE 2-7: BROWSING BY COMMAND LINE



2. Write the following command line to launch the `.jar`, and apply the select generated `.blob` file:

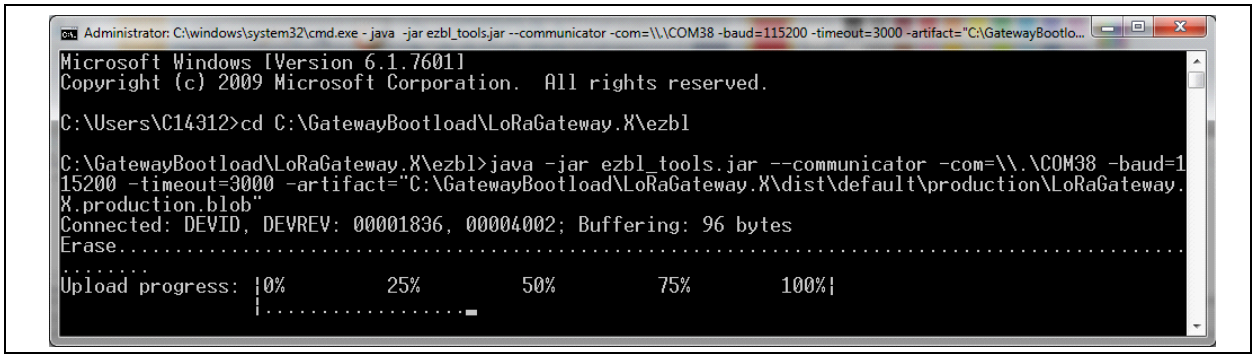
```
java –jar ezbl_tool.jar –communicator –com=\\.\[COM PORT]
–baud=115200 –timeout=3000 –artifact=”[Blob Dir]”
```

FIGURE 2-8: BLOB FILE SELECTION



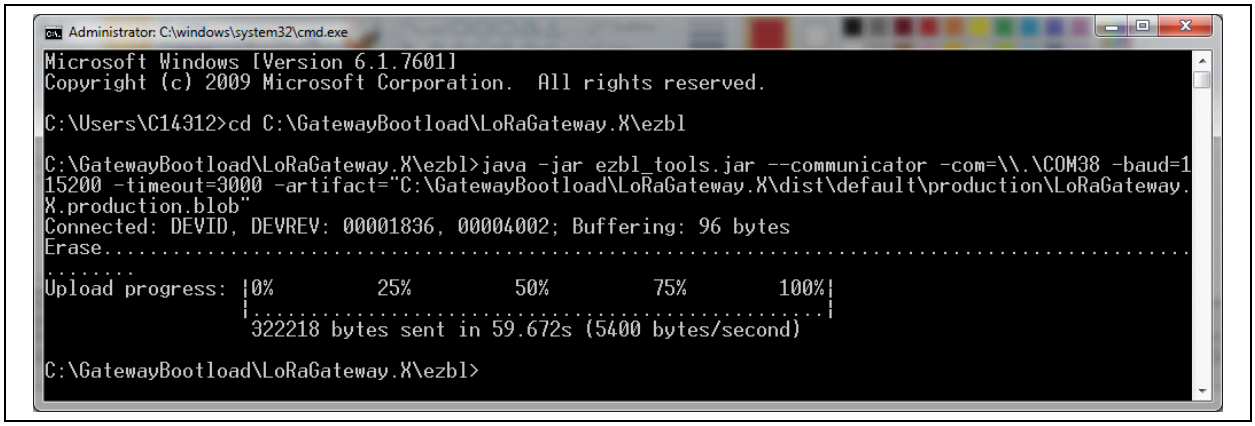
3. Press enter to execute the `.jar` and allow update. It is required to press the **Reset** button on the Gateway board within the three seconds (time-out) period. Afterwards, the console will indicate the progress.

FIGURE 2-9: BOOTLOAD EXECUTION



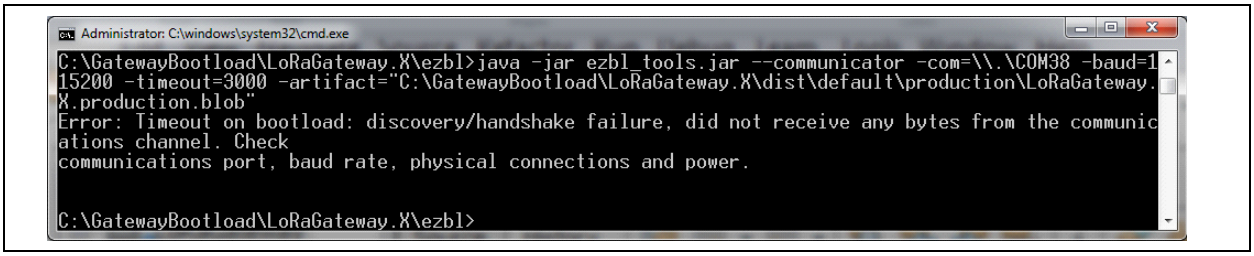
4. Once indicated the project has been updated, the console will show how many bytes were sent, and at what rate. After the application code has been flashed, the Gateway board will automatically restart.

FIGURE 2-10: COMMAND LINE BOOTLOADING SUCCESS



5. Process is completed.

FIGURE 2-11: COMMAND LINE BOOTLOADING FAILURE



Note: If the bootloader fails to establish communication with the Gateway board, or if the time-out overlaps prior to pressing the **Reset** button, the command console will indicate the failure condition.

Automatic updates can be executed by the Gateway MPLAB® X project by uncommenting the specific code added to the Makefile. This allows for every build of the project to also attempt the update over the specified COM port.

Below is the optional additional code:

FIGURE 2-12: BUILD TIME MAKEFILE CODE ADDITIONS

```
@echo EZBL: Attempting to send blob to bootloader
${MP_JAVA_PATH}java -jar "ezbl/ezbl_tools.jar" --communicator -com=\\\\.\\COM38 -baud=115200 -timeout=3000 -artifact="${DISTDIR}/${PROJECTNAME}.${IMAGE_TYPE}.blob"
```

Much of the code is the same as previously described, with the only addition text being shown below:

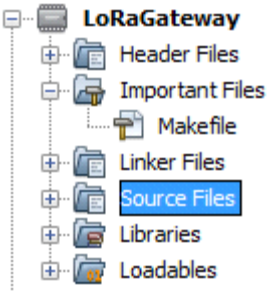
```
--communicator -com=\\\\.\\COM38 -baud=115200 -timeout=3000
```

As above in the manual console command example, serial communication is requested on COM38, at a baud rate of 115,200 and applies a timeout of three seconds for board activity.

Below is an example of this process:

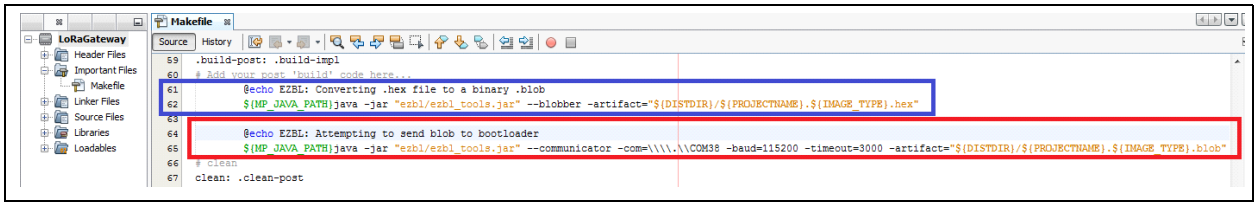
1. Load the LoRa Gateway project inside of MPLAB X.

FIGURE 2-13: PROJECT LOADING AND MAKEFILE LOCATION



2. Inside the project's Makefile, confirm the .blob file is being generated (Blue Box) and that the bootloader .jar application will be attempted at the specified settings (Red Box).

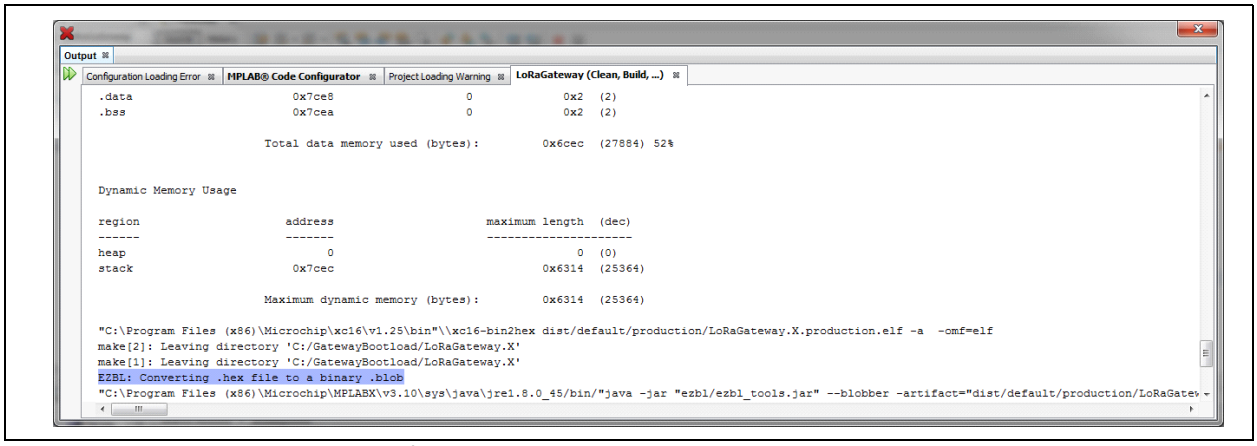
FIGURE 2-14: BUILD TIME BLOB CREATION AND BOOTLOAD EXECUTION



3. Do a "Build and Clean" on the project. 

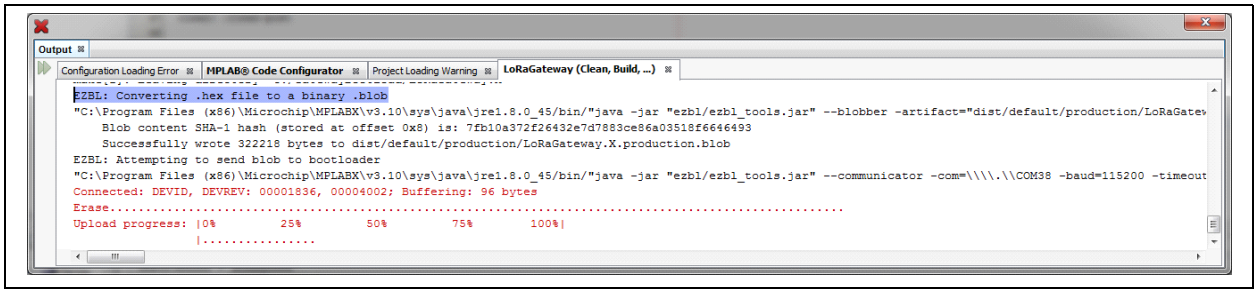
4. Observe the build "Output". After the first @echo message is printed; press the **Reset** button on the Gateway board.

FIGURE 2-15: BLOB CREATION SUCCESS COMMENT



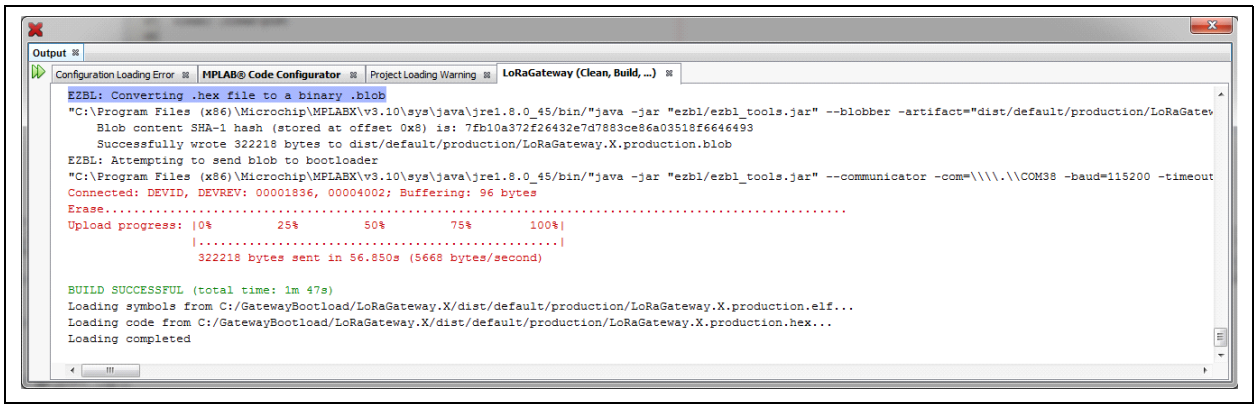
5. After the 2nd Echo message, the board is ready for the .blob file to be passed within the time-out period. The Output console will indicate progress.

FIGURE 2-16: BOARD RESET AT BUILD TIME



6. Once indicated the project has been updated, the Output will show how many bytes were sent, and at what rate. It will additionally indicate a Build Success.

FIGURE 2-17: BUILD TIME BOOTLOADING SUCCESS

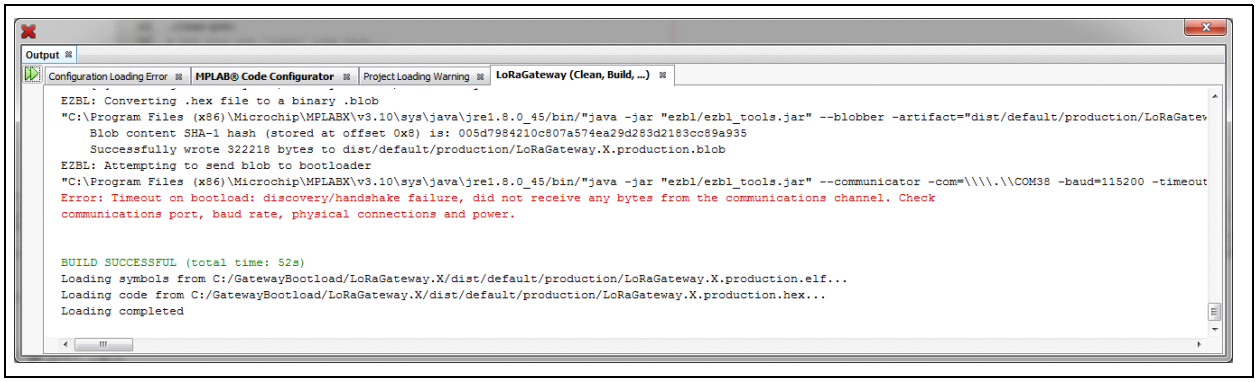


7. After the application code has been flashed, the Gateway board will automatically restart and the process is complete.

FIGURE 2-18: BUILD TIME BOOTLOADING COMPLETION

Note: If the bootloader fails to establish communication with the Gateway board, or if the time out overlaps prior to pressing the Reset button, the output console will indicate the Failure condition.

FIGURE 2-19: BUILD TIME BOOTLOADING FAILURE



For additional information or materials regarding the EZBL, please refer to the Launch Page www.microchip.com/EZBL.

NOTES:

Appendix A. Board Schematics and Bill of Materials

A.1 INTRODUCTION

This appendix provides the LoRa® Gateway Core and Radio board schematics and Bill of Materials (BOM).

- Board Schematics
- Bill of Materials

A.2 BOARD SCHEMATICS

Figure A-1 to Figure A-6 show the board schematics.

FIGURE A-1: LoRa® GATEWAY CORE BOARD SCHEMATIC 1

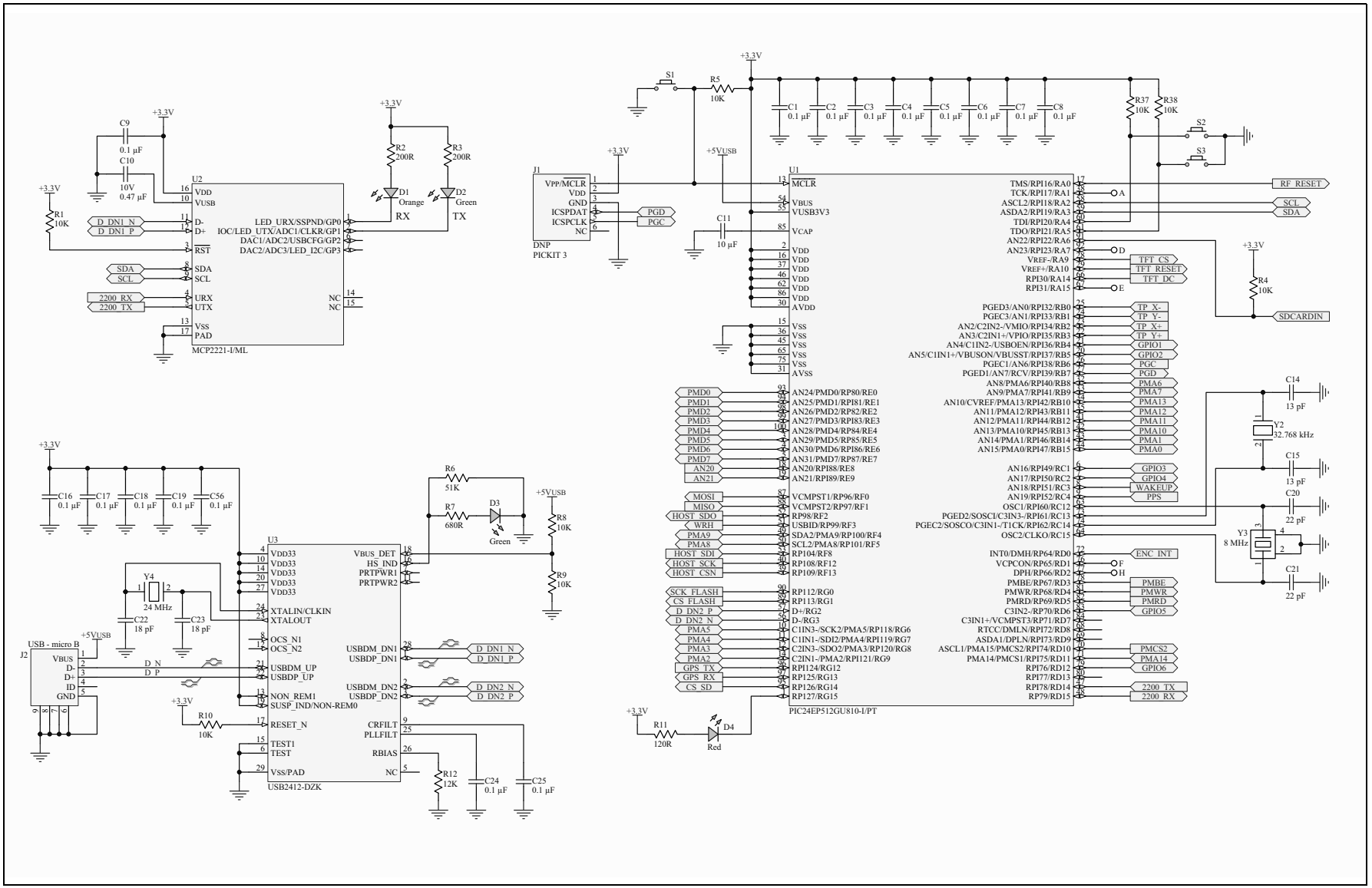


FIGURE A-2: LoRa® GATEWAY CORE BOARD SCHEMATIC 2

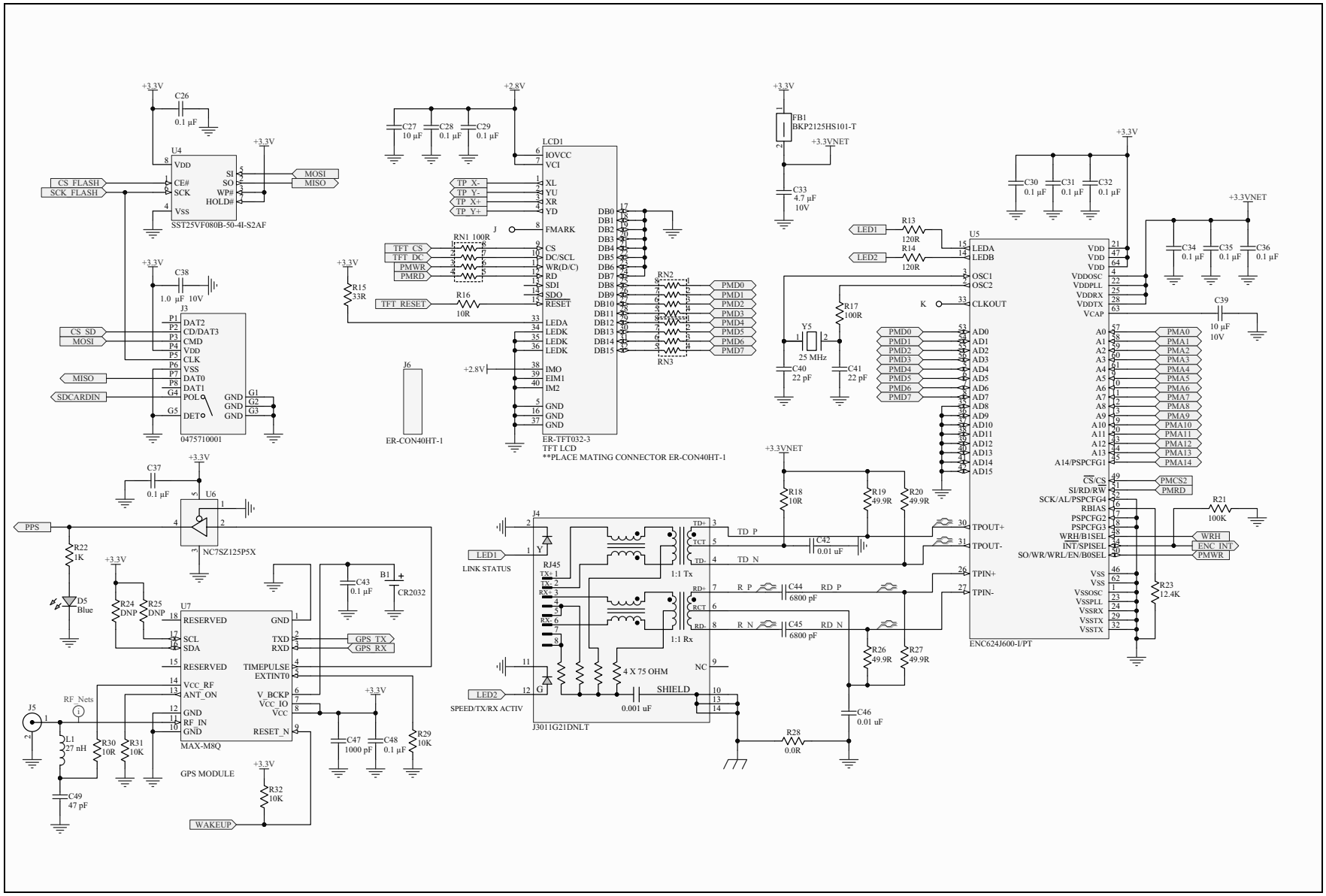


FIGURE A-3: LoRa® GATEWAY CORE BOARD SCHEMATIC 3

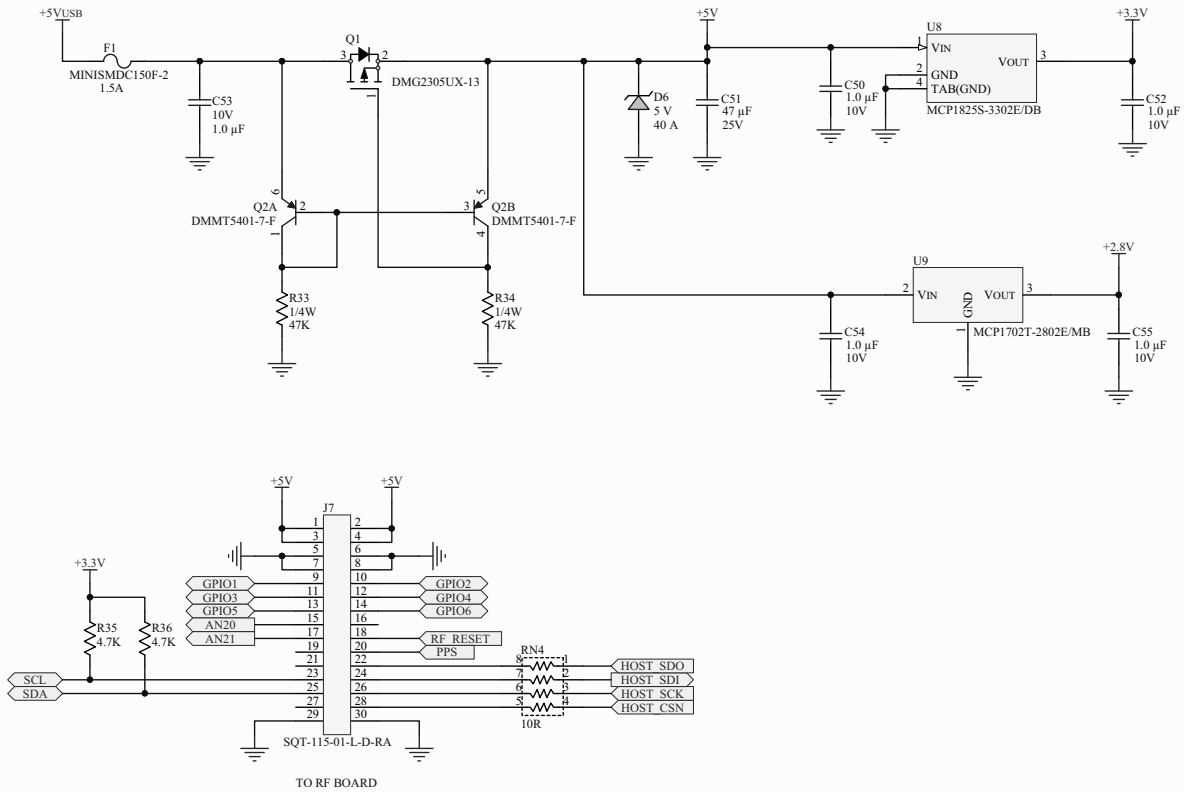


FIGURE A-4: LoRa® GATEWAY RADIO BOARD SCHEMATIC 1

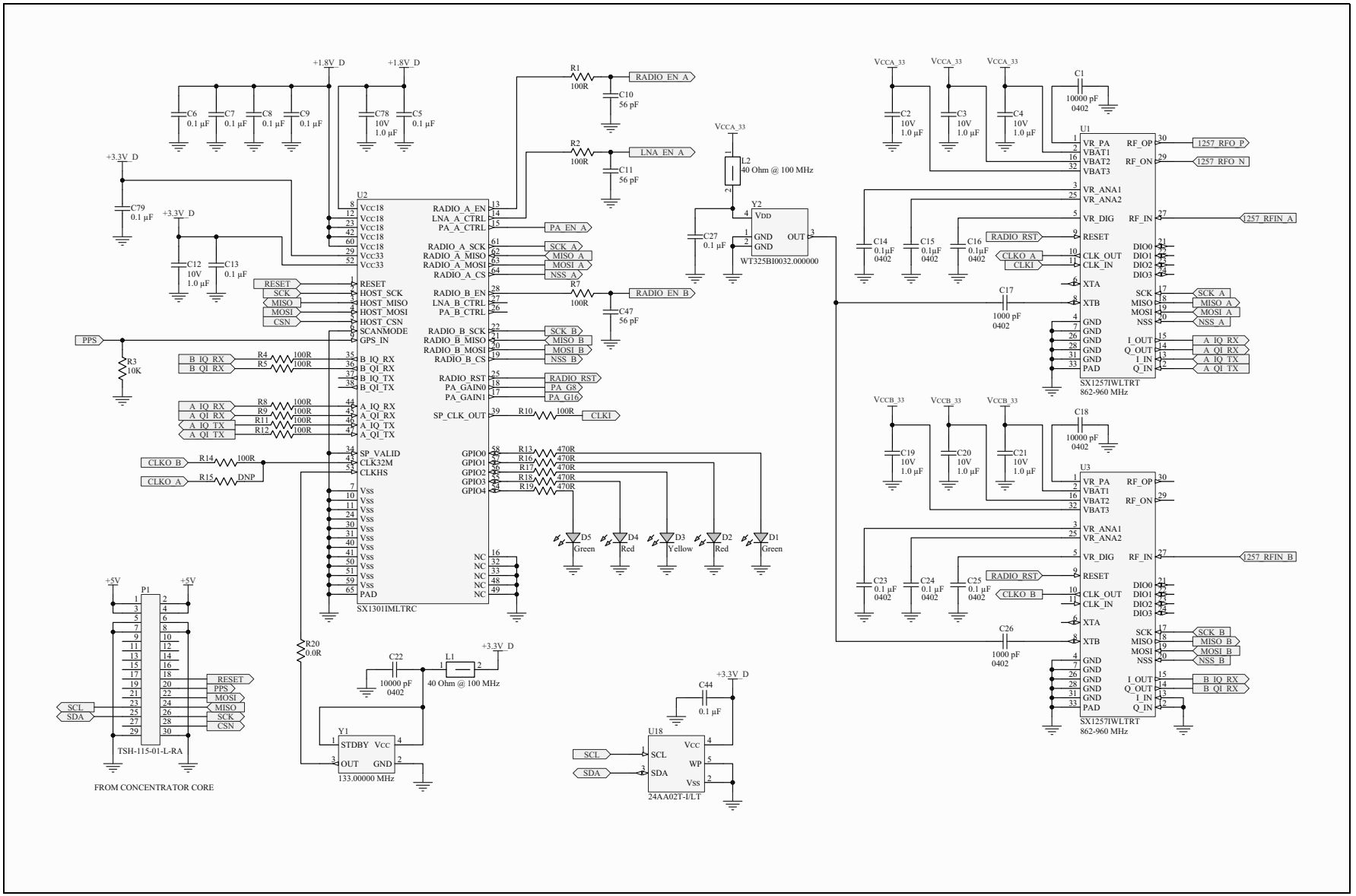
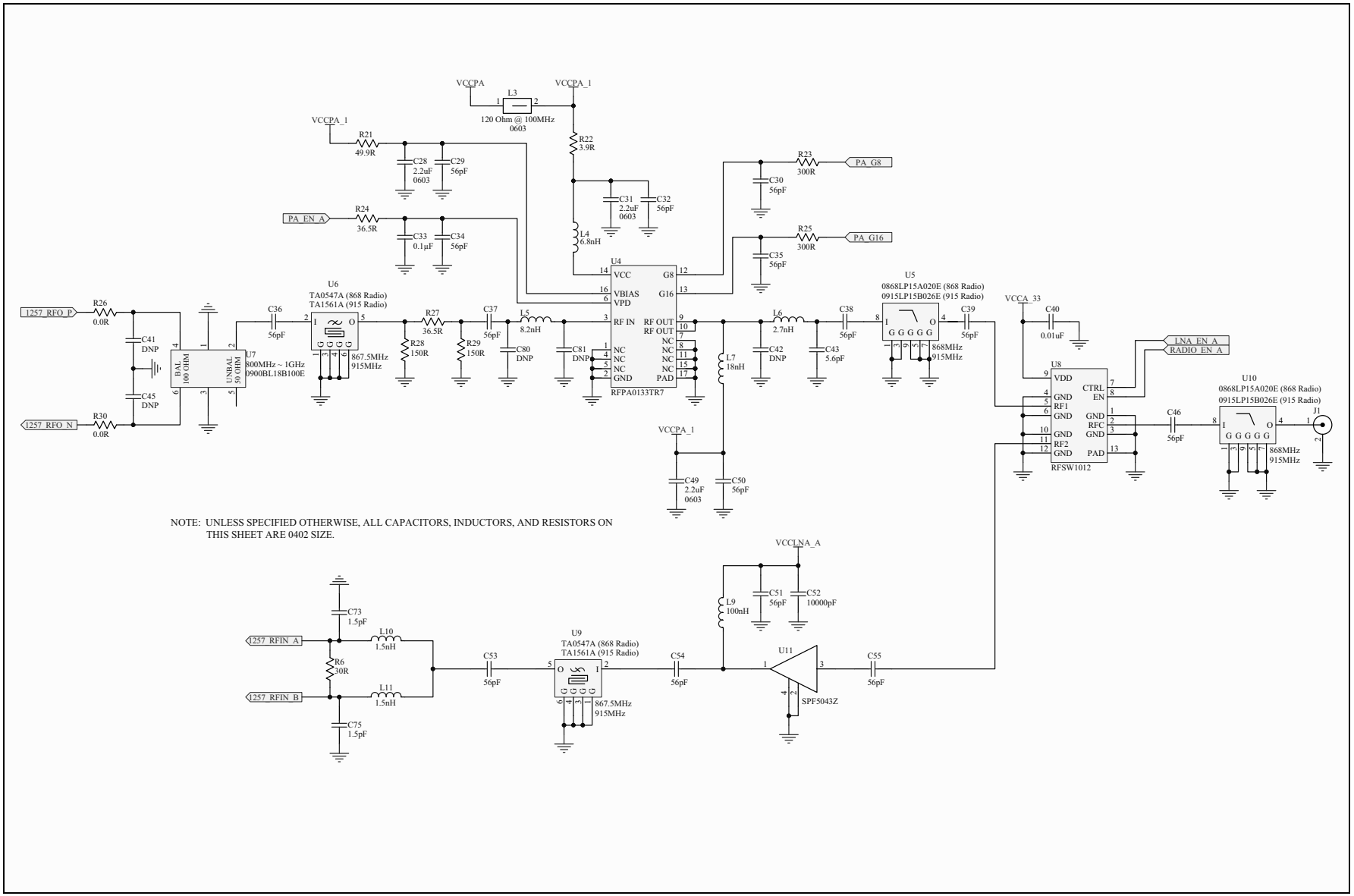


FIGURE A-5: LoRa® GATEWAY RADIO BOARD SCHEMATIC 2



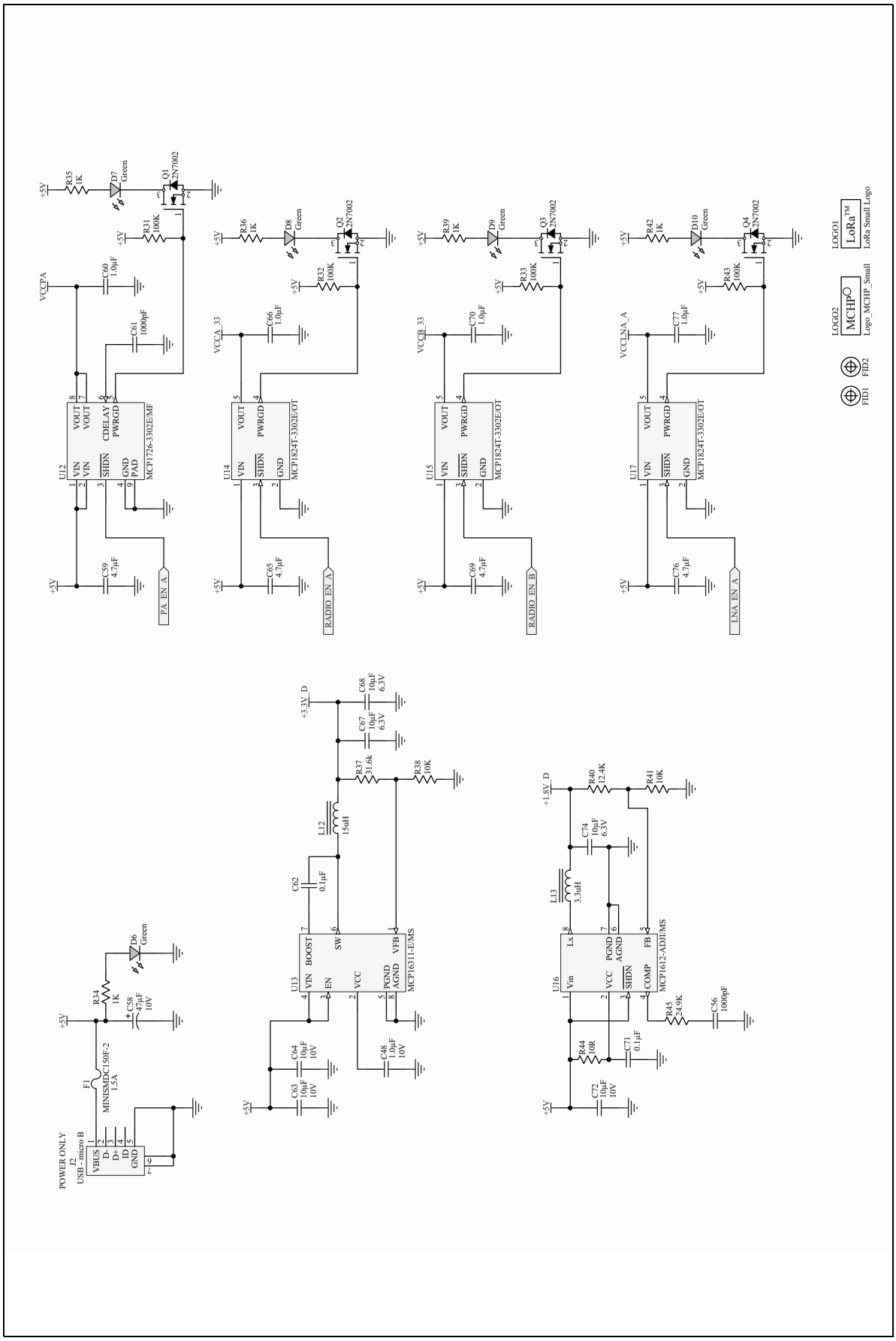


FIGURE A-6: LoRa® GATEWAY RADIO BOARD SCHEMATIC 3

A.3 BILL OF MATERIALS

TABLE A-1: LoRa® GATEWAY CORE BOARD BILL OF MATERIALS (BOM)

Quantity	Designator	Description	Manufacturer 1	Manufacturer Part Number 1	Supplier 1	Supplier Part Number 1
1	B1	Battery, CR2032 Coin Cell, Linx BAT-HLD-001 Holder	Linx Technologies	BAT-HLD-001	Mouser	712-BAT-HLD-001
28	C1, C2, C3, C4, C5, C6, C7, C8, C9, C16, C17, C18, C19, C24, C25, C26, C28, C29, C30, C31, C32, C34, C35, C36, C37, C43, C48, C56	Cap, Ceramic, 0.1 uF, 50V X5R	TDK Corporation	C1608X7R1H104M080AA	Digi-Key	445-5098-1-ND
1	C10	Cap, Ceramic, 0.47 uF, 10V, 10% X7R	Samsung Electro-Mechanics America, Inc	CL10B474KP8NNNC	Digi-Key	1276-1247-1-ND
2	C11, C27	Cap, Ceramic, 10 uF, 6.3V X5R 20%	Murata Electronics North America	GRM188R60J106ME47D	Digi-Key	490-3896-1-ND
2	C14, C15	Cap, Ceramic, 13 pF, 50V, 5% NP0	Murata Electronics North America	GRM1885C1H130JA01D	Digi-Key	490-1406-1-ND
4	C20, C21, C40, C41	Cap, Ceramic, 22 pF, 50V, 5% C0G	TDK Corporation	C1608C0G1H220J080AA	Digi-Key	445-1273-1-ND
2	C22, C23	Cap, Ceramic, 18 pF, 50V, 5% C0G	TDK Corporation	C1608C0G1H180J080AA	Digi-Key	445-1272-1-ND
1	C33	Cap, Ceramic, 4.7 uF, 10V 10% X5R	Kemet	C0603C475K8PACTU	Digi-Key	399-5503-1-ND
6	C38, C50, C52, C53, C54, C55	Cap, Ceramic, 1 uF, 10V X5R	Kemet	C0603C105M8PACTU	Digi-Key	399-8992-1-ND
1	C39	Cap, Ceramic, 10 uF, 10V X5R 10%	TDK Corporation	C1608X5R1A106M	Digi-Key	445-6853-1-ND
2	C42, C46	Cap, Ceramic, 0.01 uF, 50V X7R	TDK Corporation	C1608X7R1H103M080AA	Digi-Key	445-5090-1-ND
2	C44, C45	Cap, Ceramic, 6800 pF, 50V, 10% X7R	Yageo	CC0603KRX7R9BB682	Digi-Key	311-1084-1-ND
1	C47	Cap, Ceramic, 1000 pF(0.001 uF), 50V X7R	Kemet	C0603C102M5RACTU	Digi-Key	399-7837-1-ND
1	C49	Cap, Ceramic, 47 pF, 50V, 5% C0G	Murata Electronics North America	GRM1885C1H470JA01D	Digi-Key	490-1419-1-ND
1	C51	Cap, Ceramic, 10 uF, 16V X5R	TDK Corporation	C2012X5R1C106M125AC	Digi-Key	445-4115-1-ND
4	C57, C58, C59, C60	Cap, Ceramic, 0.022 uF, 500V, 10%, X7R	Johanson Dielectrics Inc.	501R18W223KV4E	Digi-Key	709-1028-1-ND
2	C61, C62	Cap, Ceramic, 1000 pF, 2 KV 10% X7R	Johanson Dielectrics Inc.	202R18W102KV4E	Digi-Key	709-1036-1-ND
1	D1	LED, SMD, AMBER, 0603 package	Lite-On Inc	LTST-C190AKT	Digi-Key	160-1180-1-ND
4	D2, D3, D7, D8	LED, SMD, GRN, 0603 package	Kingbright	APT1608SGC	Digi-Key	754-1121-1-ND
1	D4	LED, SMD, RED, 0603 package	Kingbright	APT1608EC	Digi-Key	754-1117-1-ND
1	D5	LED, SMD, BLUE, 0603 package	Kingbright	APT1608QBC/D	Digi-Key	754-1434-1-ND
1	D6	Diode, TVS, Uni-Dir, 5Vr, 24A 350W SOD323	Diodes Incorporated	SD05-7	Digi-Key	SD05DICT-ND
4	D9, D10, D11, D12	Diode, Transient Voltage Suppressor, 3.3 VWM, 9.5 VC	Semtech Corporation	UCLAMP3301D.TCT	Digi-Key	UCLAMP3301DCT-ND
1	F1	PTC_1.5A_3.0A_Trip 1812	TE Connectivity Raychem Circuit Protection	MINISMDC150F-2	Digi-Key	MINISMDC150FCT-ND
1	FB1	Ferrite Chip, 100 Ohm, 2.5A, 0805	Taiyo Yuden	BKP2125HS101-T	Digi-Key	587-1929-1-ND

TABLE A-1: LoRa® GATEWAY CORE BOARD BILL OF MATERIALS (BOM) (CONTINUED)

Quantity	Designator	Description	Manufacturer 1	Manufacturer Part Number 1	Supplier 1	Supplier Part Number 1
1	J2	Receptacle, Micro-USB, Type B, with Solder Tabs	FCI	10118194-0001LF	Digi-Key	609-4618-6-ND
1	J3	Connector, microSD, push-pull, with Detect Pin	Molex, LLC	0475710001	Digi-Key	WM9731CT-ND
1	J4	Conn, RJ45, Mode Jack, 8P8C, R/A	FCI	54602-908LF	Digi-Key	609-1046-ND
1	J5	SMA Jack, 50 Ohm, Edge Mount	Samtec	SMA-J-P-H-ST-EM1	Samtec	SMA-J-P-H-ST-EM1
1	J6	FFC Connector, Horizontal, 40 pos, 0.5 mm Top Contact	EastRising Technology	ER-CON40HT-1	BuyDisplay.com	ER-CON40HT-1
1	J7	Socket Strip, 15 pos, 2 mm sp, Dbl Row, RA	Samtec	SQT-115-01-L-D-RA	Samtec	SQT-115-01-L-D-RA
1	L1	Chip Inductor, Ceramic, 27 nH, 300 mA, 0603	Johanson Technology Inc.	L-14C27NJV4T	Digi-Key	712-1439-1-ND
1	LCD1	TFT LCD Module, 3.2 inch, SPI, 8/16-Bit Parallel	BuyDisplay.com	ER-TFT032-3	BuyDisplay.com	ER-TFT032-3
1	Q1	P-CHAN Enhancment Mode MOSFET, 20V, 4.2A	Diodes Incorporated	DMG2305UX-13	Mouser	621-DMG2305UX-13
1	Q2	Matched PNP Transistors, 150V, 0.2A SOT23-6	Diodes Incorporated	DMMT5401-7-F	Digi-Key	DMMT5401-FDICT-ND
16	R1, R4, R5, R8, R9, R10, R18, R21, R29, R31, R32, R35, R36, R37, R38, R39	Res, 10K, 1/10W 1%	Panasonic Electronic Components	ERJ-3EKF1002V	Digi-Key	P10.0KHCT-ND
7	R2, R3, R7, R11, R13, R14, R22	Res, 470 Ohm, 1/10W 1%	Stackpole Electronics Inc.	RMCF0603FT470R	Digi-Key	RMCF0603FT470RCT-ND
1	R6	Res, 51K 1/10W 1%	Stackpole Electronics Inc.	RMCF0603FT51K0	Digi-Key	RMCF0603FT51K0CT-ND
1	R12	Res, 12K, 1/10W 1%	Stackpole Electronics Inc	RMCF0603FT12K0	Digi-Key	RMCF0603FT12K0CT-ND
1	R15	Res, 33 Ohm, 1/10W 1%	Stackpole Electronics Inc.	RMCF0603FT33R0	Digi-Key	RMCF0603FT33R0CT-ND
3	R16, R30, R47	Res, 10 Ohm, 1/10W 1%	Stackpole Electronics Inc.	RMCF0603FT10R0	Digi-Key	RMCF0603FT10R0CT-ND
1	R17	Res, 100 Ohm, 1/10W 1%	Stackpole Electronics Inc.	RMCF0603FT100R	Digi-Key	RMCF0603FT100RCT-ND
4	R19, R20, R26, R27	Res, 49.9 Ohm, 1/4W 1%	Vishay Dale	CRCW060349R9FKEAHP	Digi-Key	541-49.9SCT-ND
1	R23	Res, 12.4K, 1/10W 1%	Panasonic Electronic Components	ERJ-3EKF1242V	Digi-Key	P12.4KHCT-ND
1	R28	Resistor, 0.0R, 1/2W, 1% 2010	Rohm Semiconductor	MCR50JZHJ000	Digi-Key	RHM0.0BGCT-ND
2	R33, R34	Res, 47K 1/4W 1%	Vishay Dale	CRCW060347K0FKEAHP	Digi-Key	541-47.0KSCT-ND
4	R43, R44, R45, R46	Resistor, 75R, 2/3W 5%	Panasonic Electronic Components	ERJ-P08J750V	Digi-Key	P75ALCT-ND
3	RN1, RN2, RN3	Resistor Network, 100R Series 743C, 4 resistors, Isolated	CTS Resistor Products	743C083101JP	Digi-Key	743C083101JPCT-ND
1	RN4	Resistor Network, 10R Series 743C, 4 resistors, Isolated	CTS Resistor Products	743C083100JP	Digi-Key	743C083100JPCT-ND
3	S1, S2, S3	Switch, Tact, PB MOM SPST-NO, 0.5A, 12V	C&K Components	PTS645SM43SMTR92 LFS	Digi-Key	CKN9112CT-ND

TABLE A-1: LoRa® GATEWAY CORE BOARD BILL OF MATERIALS (BOM) (CONTINUED)

Quantity	Designator	Description	Manufacturer 1	Manufacturer Part Number 1	Supplier 1	Supplier Part Number 1
1	T1	Single Port 10/100Base-TX PoE Transformer, SMD	Halo Electronics	TG110-RP55N5RL	Future Electronics	TG110-RP55N5RL
1	TAPE1	Tape, Double-Coated, 1.00W X 0.50L X 0.008T	3M (TC)	1-5-9088	Digi-Key	3M11466-ND
1	TAPE2	Tape, Double-Coated, 1.00W X 2.00L X 0.008T	3M (TC)	1-5-9088	Digi-Key	3M11466-ND
1	U1	16-bit Microcontroller with USB, Enhanced Performance Flash Memory, 512 KB Program Memory, 100-Pin TQFP	Microchip Technology	PIC24EP512GU810-I/PT	Digi-Key	PIC24EP512GU810-I/PT-ND
1	U2	USB 2.0 to UART/I^2C BRIDGE QFN16	Microchip Technology	MCP2221-I/ML	Digi-Key	MCP2221-I/ML-ND
1	U3	2-Port USB 2.0 Hi-Speed Hub Controller	Microchip Technology	USB2412-DZK	Digi-Key	638-1114-ND
1	U4	8 Mb SPI Serial Flash Memory	Microchip Technology	SST25VF080B-50-4I-S2AF	Digi-Key	SST25VF080B-50-4I-S2AF-ND
1	U5	10/100 Ethernet Controller, SPI/Parallel Interface	Microchip Technology	ENC624J600-I/PT	Mouser	579-ENC624J600-I/PT
1	U6	UHS Buffer, 3-State Output	Fairchild Semiconductor	NC7SZ125P5X	Digi-Key	NC7SZ125P5XCT-ND
1	U7	Standalone GNSS Module, Dual Frequency RF FE	u-blox	MAX-M8Q	u-blox	MAX-M8Q
1	U8	Regulator, LDO, 3.3V, 500 mA, SOT223	Microchip Technology	MCP1825S-3302E/DB	Digi-Key	MCP1825S-3302E/DB-ND
1	U9	Pos 2.8V 250 mA, LDO Regulator SOT-89	Microchip Technology	MCP1702T-2802E/MB	Digi-Key	MCP1702T-2802E/MBCT-ND
1	Y2	Crystal, 32.768 kHz, 9 pF, SMD AB06 SERIES	Abracon LLC	ABS06-32.768KHZ-9-T	Digi-Key	535-10246-1-ND
1	Y3	Crystal, 8.000 MHz, 18 pF, SMD	Abracon LLC	ABM3B-8.000MHZ-B2-T	Digi-Key	535-9720-1-ND
1	Y4	Crystal, 24.0000 MHz, 18 pF, SMD ABM7	Abracon Corporation	ABM7-24.000MHZ-D-2-Y-T	Digi-Key	535-9845-1-ND
1	Y5	Crystal, 25.000 MHz, 18 pF, SMD ABM7	Abracon Corporation	ABM7-25.000MHZ-D2Y-T	Digi-Key	535-9847-1-ND

TABLE A-2: LoRa® GATEWAY RADIO BOARD BILL OF MATERIALS (BOM)

Quantity	Designator	Description	Manufacturer 1	Manufacturer Part Number 1	Supplier 1	Supplier Part Number 1
4	C1, C18, C22, C52	Cap, Ceramic, 10000 pF, 50V, +/-10% X7R	Yageo	CC0402KRX7R9BB103	Digi-Key	311-1349-1-ND
13	C2, C3, C4, C12, C19, C20, C21, C48, C60, C66, C70, C77, C78	Cap, Ceramic, 1 uF, 10V X5R	Kemet	C0603C105M8PACTU	Digi-Key	399-8992-1-ND
16	C5, C6, C7, C8, C9, C13, C14, C15, C16, C23, C24, C25, C27, C33, C62, C79	Cap, Ceramic, 0.1 uF, 50V +/-10% X7R	TDK Corporation	C1005X7R1H104K050BB	Digi-Key	445-5932-1-ND
18	C10, C11, C29, C30, C32, C34, C35, C36, C37, C38, C39, C46, C47, C50, C51, C53, C54, C55	Cap, Ceramic, 56 pF, 50V +/-5% C0G	TDK Corporation	C1005C0G1H560J050BA	Digi-Key	445-1244-1-ND
2	C17, C26	Cap, Ceramic, 1000 pF, 50V, +/-5% X7R	Yageo	CC0402JRX7R9BB102	Digi-Key	311-1351-1-ND
3	C28, C31, C49	Cap, Ceramic, 2.2 uF, 16V X5R	TDK Corporation	C1608X5R1C225K080AB	Digi-Key	445-5157-1-ND
1	C40	Cap, Ceramic, 0.01 uF, 50V X7R	TDK Corporation	C1608X7R1H103M080AA	Digi-Key	445-5090-1-ND
1	C43	Cap, Ceramic, 5.6 pF, 50V +/-0.5pF NP0	Murata Electronics North America	GRM1555C1H5R6DZ01D	Digi-Key	490-1275-1-ND
2	C44, C71	Cap, Ceramic, 0.1 uF, 50V X5R	TDK Corporation	C1608X7R1H104M080AA	Digi-Key	445-5098-1-ND
1	C56	Cap, Ceramic, 1000pF, 50V, 5% NP0	Murata Electronics North America	GRM1885C1H102JA01D	Digi-Key	490-1451-1-ND
1	C58	Capacitor, Tantalum, 47 uF, 10V 1210	AVX Corporation	TPSB476M010R0650	Digi-Key	478-9093-1-ND
4	C59, C65, C69, C76	Cap, Ceramic, 4.7 uF, 10V 10% X5R	Kemet	C0603C475K8PACTU	Digi-Key	399-5503-1-ND
1	C61	Cap, Ceramic, 1000 pF(0.001 uF), 50V X7R	Kemet	C0603C102M5RACTU	Digi-Key	399-7837-1-ND
4	C63, C64, C72	Cap, Ceramic, 10 uF, 10V X5R 10%	TDK Corporation	C1608X5R1A106M	Digi-Key	445-6853-1-ND
4	C67, C68, C74	Cap, Ceramic, 10 uF, 6.3V X5R 20%	Murata Electronics North America	GRM188R60J106ME47D	Digi-Key	490-3896-1-ND
2	C73, C75	Cap, Ceramic, 1.5 pF, 50V, +/-0.25 pF NP0	TDK Corporation	C1005C0G1H1R5C050BA	Digi-Key	445-4859-1-ND
7	D1, D5, D6, D7, D8, D9, D10	LED, SMD, GRN, 0603 package	Kingbright	APT1608SGC	Digi-Key	754-1121-1-ND
2	D2, D4	LED, SMD, RED, 0603 package	Kingbright	APT1608EC	Digi-Key	754-1117-1-ND
1	D3	LED, SMD, YEL, 0603 package	Kingbright	APT1608YC	Digi-Key	754-1125-1-ND
1	F1	PTC_1.5A_3.0A_Trip 1812	TE Connectivity Raychem Circuit Protection	MINISMDC150F-2	Digi-Key	MINISMDC150FCT-ND
1	J1	SMA Jack, 50 Ohm, Edge Mount	Samtec	SMA-J-P-H-ST-EM1	Samtec	SMA-J-P-H-ST-EM1
1	J2	Receptacle, Micro USB, Type B, with Solder Tabs	FCI	10118194-0001LF	Digi-Key	609-4618-6-ND
2	L1, L2	Ferrite Chip Bead, 40 OHM@100 MHz	TDK Corporation	MMZ1005Y400CTD25	Digi-Key	445-172801-1-ND
1	L3	Ferrite Chip, 120 Ohm, 2A, 0603	Murata Electronics North America	BLM18PG121SN1D	Digi-Key	490-1037-1-ND
1	L4	Inductor, 6.8 nH, 300 mA, Air-Core, +/- 5%	Murata Electronics North America	LQG15HS6N8J02D	Digi-Key	490-2621-1-ND
1	L5	Inductor, 8.2 nH, 300 mA, Air-Core, +/-5%	Murata Electronics North America	LQG15HS8N2J02D	Digi-Key	490-2622-1-ND

TABLE A-2: LoRa® GATEWAY RADIO BOARD BILL OF MATERIALS (BOM) (CONTINUED)

Quantity	Designator	Description	Manufacturer 1	Manufacturer Part Number 1	Supplier 1	Supplier Part Number 1
1	L6	Inductor, 2.7 nH, 400 mA, Non-Mag, 0.3nH	Panasonic Electronic Components	ELJ-RF2N7DFB	Digi-Key	PCD1928CT-ND
1	L7	Inductor, 18 nH, 240 mA, Non-Mag, 5%	Panasonic - ECG	ELJ-RF18NJFB	Digi-Key	PCD1938CT-ND
1	L9	Inductor, 100 nH, 120 mA, WW,Air Core, 5%	Murata Electronics North America	LQW15ANR10J00D	Digi-Key	490-4090-1-ND
2	L10, L11	Inductor, 1.5 nH, 300 mA, Air-Core, +/- 0.3 nH	Murata Electronics North America	LQG15HS1N5S02D	Digi-Key	490-2612-1-ND
1	L12	Power Inductor, 15 uH Shielded, 1.16A	Coilcraft	MSS6132-153MLB	Coilcraft	MSS6132-153MLB
1	L13	Power Inductor, 3.3 uH, 1.6A, Series ME3220	Coilcraft	ME3220-332MLB	Coilcraft	ME3220-332MLB
1	P1	Terminal Strip, Shrouded, 15 pos, 2 mm sp, Dbl Row, RA	Samtec	TSH-115-01-L-RA	Samtec	TSH-115-01-L-RA
4	Q1, Q2, Q3, Q4	N-CHAN MOSFET, 60V 115 mA	Fairchild Semiconductor	2N7002	Digi-Key	2N7002NCT-ND
11	R1, R2, R4, R5, R7, R8, R9, R10, R11, R12, R14	Res, 100R, 1/16W 1%	Samsung Electro-Mechanics America, Inc	RC1005F101CS	Digi-Key	1276-3429-1-ND
1	R3	Res, 10K 1/16W 1%	Yageo	RC0402FR-0710KL	Digi-Key	311-10.0KLRCT-ND
1	R6	Res, 30R 1/10W 1%	Panasonic Electronic Components	ERJ-2RKF30R0X	Digi-Key	P30.0LCT-ND
5	R13, R16, R17, R18, R19	Res, 470R 1/16W 1%	Yageo	RC0402FR-07470RL	Digi-Key	311-470LRCT-ND
3	R20, R26, R30	Res, 0 Ohm, 1/10W	Panasonic Electronic Components	ERJ-2GE0R00X	Digi-Key	P0.0JCT-ND
1	R21	Res, 49.9R, TF, 1/16W, 1%	Vishay Dale	CRCW040249R9FKED	Digi-Key	541-49.9LCT-ND
1	R22	Res, 3.90R, TF, 1/16W, 1%	Vishay Dale	CRCW04023R90FKED	Digi-Key	541-3.90LLCT-ND
2	R23, R25	Res, 300R, TF, 1/16W, 1%	Vishay Dale	CRCW0402300RFKED	Digi-Key	541-300LCT-ND
2	R24, R27	Res, 36.5R, TF, 1/16W, 1%	Vishay Dale	CRCW040236R5FKED	Digi-Key	541-36.5LCT-ND
2	R28, R29	Res, 150R, TF, 1/16W, 1%	Vishay Dale	CRCW0402150RFKED	Digi-Key	541-150LCT-ND
4	R31, R32, R33, R43	Res, 100K, 1/10W 1%	Stackpole Electronics Inc	RMCF0603FT100K	Digi-Key	RMCF0603FT100KCT-ND
5	R34, R35, R36, R39, R42	Res, 1K 1/10W 1%	Panasonic Electronic Components	ERJ-3EKF1001V	Digi-Key	P1.00KHCT-ND
1	R37	Res, 31.6K 1/10W 1%	Panasonic Electronic Components	ERJ-3EKF3162V	Digi-Key	P31.6KHCT-ND
2	R38, R41	Res, 10K, 1/10W 1%	Panasonic Electronic Components	ERJ-3EKF1002V	Digi-Key	P10.0KHCT-ND
1	R40	Res, 12.4K, 1/10W 1%	Panasonic Electronic Components	ERJ-3EKF1242V	Digi-Key	P12.4KHCT-ND
1	RA4	Res, 10 Ohm, 1/10W 1%	Stackpole Electronics Inc.	RMCF0603FT10R0	Digi-Key	RMCF0603FT10R0CT-ND
1	R45	Res, 24.9K, 1/10w 1%	Panasonic Electronic Components	ERJ-3EKF2492V	Digi-Key	P24.9KHCT-ND
2	U1, U3	RF to Digital FE Transceiver, 862-960 MHz QFN32	Semtech	SX1257IWLTRT	Semtech	SX1257IWLTRT
1	U2	Base Band Processor and Data Concentrator	Semtech	SX1301IMLTRC	Semtech	SX1301IMLTRC
1	U4	3-5V Programmable Gain HE Power Amp	RFMD	RFPA0133TR7	Digi-Key	689-1079-1-ND
2	U5, U10	Low Pass Filter, GSM/CDMA 868 MHz, SMD (868 Radio) Low Pass Filter, GSM/CDMA 915 MHz, 0.5dB IL, SMD (915 Radio)	JOHANSON TECHNOLOGY	0868LP15A020E (868 Radio) 0915LP15B026E (915 Radio)	Farnell (868 Radio) Mouser (915 Radio)	2148529RL (868 Radio) 609-0915LP15B026E (915 Radio)

TABLE A-2: LoRa® GATEWAY RADIO BOARD BILL OF MATERIALS (BOM) (CONTINUED)

Quantity	Designator	Description	Manufacturer 1	Manufacturer Part Number 1	Supplier 1	Supplier Part Number 1
2	U6, U9	Saw Filter, 867.7 MHz Center, 15 MHz Bandwidth, 860-875 MHz; SMD (868 Radio) 915 Center, 26 MHz Bandwidth, 902-928 MHz; SMD (915 Radio)	Taisaw	TA0547A (868 Radio) TA1561A (915 Radio)	Taisaw	TA0547A (868 Radio) TA1516A (915 Radio)
1	U7	Balun, GSM/DCS/PCS/CDMA, 900 MHz SMD	Johanson Technology Inc	0900BL18B100E	Digi-Key	712-1023-1-ND
1	U8	Broadband SPDT Switch	RFMD	RFSW1012		
1	U11	50-4000 MHz Low-Noise MMIC Amplifier, SMD	RFMD	SPF5043Z	Digi-Key	689-1101-1-ND
1	U12	Regulator, LDO, 3.3V, 1A	Microchip Technology	MCP1726-3302E/MF	Digi-Key	MCP1726-3302E/MF-ND
1	U13	Integrated Synch Switch Step-Down Regulator, 1A	Microchip Technology	MCP16311-E/MS	Digi-Key	MCP16311-E/MS-ND
3	U14, U15, U17	Regulator, LDO, 3.3V, 300 mA, SOT23-5	Microchip Technology	MCP1824T-3302E/OT	Digi-Key	MCP1824T-3302E/OTCT-ND
1	U16	1.4 MHz Synchronous Buck Regulator, 1A	Microchip Technology	MCP1612-ADJI/MS	Digi-Key	MCP1612-ADJI/MS-ND
1	U18	Serial EEPROM, 2K, I2C SC70-5	Microchip Technology	24AA02T-I/LT	Digi-Key	24AA02T-I/LTCT-ND
1	Y1	Crystal Clock Oscillator, CMOS, 133.00000 MHz	NDK	2725T-133.00000M		
1	Y2	Oscillator, TXCO, 32.0000 MHz	Pericom	WT325BI0032.000000	Digi-Key	WT325BI0032.000000CT-ND

NOTES:

Worldwide Sales and Service

AMERICAS

Corporate Office
2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 480-792-7200
Fax: 480-792-7277
Technical Support:
http://www.microchip.com/support
Web Address:
www.microchip.com

Atlanta
Duluth, GA
Tel: 678-957-9614
Fax: 678-957-1455

Austin, TX
Tel: 512-257-3370

Boston
Westborough, MA
Tel: 774-760-0087
Fax: 774-760-0088

Chicago
Itasca, IL
Tel: 630-285-0071
Fax: 630-285-0075

Cleveland
Independence, OH
Tel: 216-447-0464
Fax: 216-447-0643

Dallas
Addison, TX
Tel: 972-818-7423
Fax: 972-818-2924

Detroit
Novi, MI
Tel: 248-848-4000

Houston, TX
Tel: 281-894-5983

Indianapolis
Noblesville, IN
Tel: 317-773-8323
Fax: 317-773-5453

Los Angeles
Mission Viejo, CA
Tel: 949-462-9523
Fax: 949-462-9608

New York, NY
Tel: 631-435-6000

San Jose, CA
Tel: 408-735-9110

Canada - Toronto
Tel: 905-673-0699
Fax: 905-673-6509

ASIA/PACIFIC

Asia Pacific Office
Suites 3707-14, 37th Floor
Tower 6, The Gateway
Harbour City, Kowloon

Hong Kong
Tel: 852-2943-5100
Fax: 852-2401-3431

Australia - Sydney
Tel: 61-2-9868-6733
Fax: 61-2-9868-6755

China - Beijing
Tel: 86-10-8569-7000
Fax: 86-10-8528-2104

China - Chengdu
Tel: 86-28-8665-5511
Fax: 86-28-8665-7889

China - Chongqing
Tel: 86-23-8980-9588
Fax: 86-23-8980-9500

China - Dongguan
Tel: 86-769-8702-9880

China - Hangzhou
Tel: 86-571-8792-8115
Fax: 86-571-8792-8116

China - Hong Kong SAR
Tel: 852-2943-5100
Fax: 852-2401-3431

China - Nanjing
Tel: 86-25-8473-2460
Fax: 86-25-8473-2470

China - Qingdao
Tel: 86-532-8502-7355
Fax: 86-532-8502-7205

China - Shanghai
Tel: 86-21-5407-5533
Fax: 86-21-5407-5066

China - Shenyang
Tel: 86-24-2334-2829
Fax: 86-24-2334-2393

China - Shenzhen
Tel: 86-755-8864-2200
Fax: 86-755-8203-1760

China - Wuhan
Tel: 86-27-5980-5300
Fax: 86-27-5980-5118

China - Xian
Tel: 86-29-8833-7252
Fax: 86-29-8833-7256

ASIA/PACIFIC

China - Xiamen
Tel: 86-592-2388138
Fax: 86-592-2388130

China - Zhuhai
Tel: 86-756-3210040
Fax: 86-756-3210049

India - Bangalore
Tel: 91-80-3090-4444
Fax: 91-80-3090-4123

India - New Delhi
Tel: 91-11-4160-8631
Fax: 91-11-4160-8632

India - Pune
Tel: 91-20-3019-1500

Japan - Osaka
Tel: 81-6-6152-7160
Fax: 81-6-6152-9310

Japan - Tokyo
Tel: 81-3-6880- 3770
Fax: 81-3-6880-3771

Korea - Daegu
Tel: 82-53-744-4301
Fax: 82-53-744-4302

Korea - Seoul
Tel: 82-2-554-7200
Fax: 82-2-558-5932 or
82-2-558-5934

Malaysia - Kuala Lumpur
Tel: 60-3-6201-9857
Fax: 60-3-6201-9859

Malaysia - Penang
Tel: 60-4-227-8870
Fax: 60-4-227-4068

Philippines - Manila
Tel: 63-2-634-9065
Fax: 63-2-634-9069

Singapore
Tel: 65-6334-8870
Fax: 65-6334-8850

Taiwan - Hsin Chu
Tel: 886-3-5778-366
Fax: 886-3-5770-955

Taiwan - Kaohsiung
Tel: 886-7-213-7828

Taiwan - Taipei
Tel: 886-2-2508-8600
Fax: 886-2-2508-0102

Thailand - Bangkok
Tel: 66-2-694-1351
Fax: 66-2-694-1350

EUROPE

Austria - Wels
Tel: 43-7242-2244-39
Fax: 43-7242-2244-393

Denmark - Copenhagen
Tel: 45-4450-2828
Fax: 45-4485-2829

France - Paris
Tel: 33-1-69-53-63-20
Fax: 33-1-69-30-90-79

Germany - Dusseldorf
Tel: 49-2129-3766400

Germany - Karlsruhe
Tel: 49-721-625370

Germany - Munich
Tel: 49-89-627-144-0
Fax: 49-89-627-144-44

Italy - Milan
Tel: 39-0331-742611
Fax: 39-0331-466781

Italy - Venice
Tel: 39-049-7625286

Netherlands - Drunen
Tel: 31-416-690399
Fax: 31-416-690340

Poland - Warsaw
Tel: 48-22-3325737

Spain - Madrid
Tel: 34-91-708-08-90
Fax: 34-91-708-08-91

Sweden - Stockholm
Tel: 46-8-5090-4654

UK - Wokingham
Tel: 44-118-921-5800
Fax: 44-118-921-5820

07/14/15