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- 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.
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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.

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

Derek Carlson
VP Development Tools

Date: 12-Sep-14
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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

<table>
<thead>
<tr>
<th>Description</th>
<th>Represents</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arial font:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Italic characters</td>
<td>Referenced books</td>
<td><em>MPLAB® IDE User’s Guide</em></td>
</tr>
<tr>
<td></td>
<td>Emphasized text</td>
<td><em>...is the only compiler...</em></td>
</tr>
<tr>
<td>Initial caps</td>
<td>A window</td>
<td>the Output window</td>
</tr>
<tr>
<td></td>
<td>A dialog</td>
<td>the Settings dialog</td>
</tr>
<tr>
<td></td>
<td>A menu selection</td>
<td>select Enable Programmer</td>
</tr>
<tr>
<td>Quotes</td>
<td>A field name in a window or dialog</td>
<td>“Save project before build”</td>
</tr>
<tr>
<td>Underlined, italic text with right angle bracket</td>
<td>A menu path</td>
<td><em>File&gt;Save</em></td>
</tr>
<tr>
<td>Bold characters</td>
<td>A dialog button</td>
<td>Click <em>OK</em></td>
</tr>
<tr>
<td></td>
<td>A tab</td>
<td>Click the <em>Power</em> tab</td>
</tr>
<tr>
<td>N'Rnnnn</td>
<td>A number in verilog format, where N is the total number of digits, R is the radix and n is a digit.</td>
<td>4'b0010, 2'hF1</td>
</tr>
<tr>
<td>Text in angle brackets ⟨⟩</td>
<td>A key on the keyboard</td>
<td>Press <em>&lt;Enter&gt;, &lt;F1&gt;</em></td>
</tr>
<tr>
<td>Courier New font:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plain Courier New</td>
<td>Sample source code</td>
<td><code>#define START</code></td>
</tr>
<tr>
<td></td>
<td>Filenames</td>
<td><code>autoexec.bat</code></td>
</tr>
<tr>
<td></td>
<td>File paths</td>
<td><code>c:\mcc18\h</code></td>
</tr>
<tr>
<td></td>
<td>Keywords</td>
<td><code>_asm, _endasm, static</code></td>
</tr>
<tr>
<td></td>
<td>Command-line options</td>
<td><code>-Opa+, -Opa-</code></td>
</tr>
<tr>
<td></td>
<td>Bit values</td>
<td><code>0, 1</code></td>
</tr>
<tr>
<td></td>
<td>Constants</td>
<td><code>0xFF, ‘A’</code></td>
</tr>
<tr>
<td>Italic Courier New</td>
<td>A variable argument</td>
<td><code>file.o, where file can be any valid filename</code></td>
</tr>
<tr>
<td>Optional arguments</td>
<td></td>
<td><code>mcci8 [options] file [options]</code></td>
</tr>
<tr>
<td>Curly brackets and pipe character: `{</td>
<td>Choice of mutually exclusive arguments; an OR selection</td>
<td>`errorlevel {0</td>
</tr>
<tr>
<td>Ellipses...</td>
<td>Replaces repeated text</td>
<td><code>var_name [, var_name...]</code></td>
</tr>
<tr>
<td></td>
<td>Represents code supplied by user</td>
<td><code>void main (void) { ... }</code></td>
</tr>
</tbody>
</table>
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.


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.


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.

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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
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)

**Note 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
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 I2C bus communication.

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

<table>
<thead>
<tr>
<th>Description</th>
<th>Part number</th>
</tr>
</thead>
<tbody>
<tr>
<td>LoRa® Gateway Core Board</td>
<td>02-10423</td>
</tr>
<tr>
<td>LoRa Gateway Radio Board</td>
<td>02-10424</td>
</tr>
<tr>
<td>Radio Board Antenna</td>
<td>RFA-09-C55-U-B70-2</td>
</tr>
<tr>
<td>Ethernet Cable</td>
<td>CAB-0025</td>
</tr>
<tr>
<td>Micro-USB Cable</td>
<td>CAB-0028</td>
</tr>
</tbody>
</table>
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

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>
<thead>
<tr>
<th>Pin Name</th>
<th>Description</th>
<th>Radio Board Connection</th>
<th>Core Board Connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 2, 3, 4</td>
<td>+5V</td>
<td>Power Supply Source</td>
<td>Power Supply Source</td>
</tr>
<tr>
<td>5, 6, 7, 8</td>
<td>Ground</td>
<td>Ground Source</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>RESET</td>
<td>SX1301 Pin 1 (RESET)</td>
<td>PIC24EP512GU810 Pin 17 (RF RESET)</td>
</tr>
<tr>
<td>20</td>
<td>PPS</td>
<td>n/a</td>
<td>PIC24EP512GU810 Pin 9 (PPS)</td>
</tr>
<tr>
<td>22</td>
<td>MOSI</td>
<td>SX1301 Pin 4 (HOST_MOSI)</td>
<td>PIC24EP512GU810 Pin 52 (HOST_SDO)</td>
</tr>
<tr>
<td>23</td>
<td>SCL</td>
<td>24AA02T Pin 1 (EEPROM)</td>
<td>PIC24EP512GU810 Pin 58 (SCL)</td>
</tr>
<tr>
<td>24</td>
<td>MISO</td>
<td>SX1301 Pin 3 (HOST_MISO)</td>
<td>PIC24EP512GU810 Pin 53 (HOST_SDI)</td>
</tr>
<tr>
<td>25</td>
<td>SDA</td>
<td>24AA02T Pin 3 (EEPROM)</td>
<td>PIC24EP512GU810 Pin 59 (SDA)</td>
</tr>
<tr>
<td>26</td>
<td>SCK</td>
<td>SX1301 Pin 2 (HOST_SCK)</td>
<td>PIC24EP512GU810 Pin 40 (HOST_SCK)</td>
</tr>
<tr>
<td>28</td>
<td>CSN</td>
<td>SX1301 Pin 5 (HOST_CSN)</td>
<td>PIC24EP512GU810 Pin 39 (HOST_CSN)</td>
</tr>
</tbody>
</table>
2.4.2 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 I²C 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”.

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

<table>
<thead>
<tr>
<th>Pin #</th>
<th>Signal Name</th>
<th>Description</th>
<th>Board Connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>MCLR</td>
<td>Reset</td>
<td>TCP/IP Ethernet Controller (ENC624J600); AD0 - AD7</td>
</tr>
<tr>
<td>3, 4, 5, 93, 94, 98, 99, 100</td>
<td>PMD0 - PMD7</td>
<td>Parallel Master Port (PMP) Data</td>
<td>TCP/IP Ethernet Controller (ENC624J600); AD0 - AD7</td>
</tr>
<tr>
<td>87</td>
<td>MOSI</td>
<td>Master Out Slave In (SPI)</td>
<td>MicroSD (0475710001); CMD Serial Flash EEPROM (SST25VF080B); SO</td>
</tr>
<tr>
<td>88</td>
<td>MISO</td>
<td>Master In Slave Out (SPI)</td>
<td>MicroSD (0475710001); DAT0 Serial Flash EEPROM (SST25VF080B); SO</td>
</tr>
<tr>
<td>52</td>
<td>HOST_SDO</td>
<td>Data Out (SPI)</td>
<td>LoRa® Gateway Radio Board Connector; SX1301 MOSI</td>
</tr>
<tr>
<td>51</td>
<td>WRH</td>
<td>PSP Write High Strobe</td>
<td>TCP/IP Ethernet Controller (ENC624J600) Pin: 48</td>
</tr>
<tr>
<td>10, 11, 12, 14, 32, 33, 34, 35, 41, 42, 43, 44, 49, 50, 71</td>
<td>PMA0 - PMA14</td>
<td>Parallel Master Port (PMP) Address</td>
<td>TCP/IP Ethernet Controller (ENC624J600) Pins: A0 - A14</td>
</tr>
<tr>
<td>53</td>
<td>HOST_SDI</td>
<td>Data In (SPI)</td>
<td>LoRa® Gateway Radio Board Connector; SX1301 MOSI</td>
</tr>
<tr>
<td>40</td>
<td>HOST_SCK</td>
<td>Source Clock (SPI)</td>
<td>LoRa® Gateway Radio Board Connector; SX1301 SCK</td>
</tr>
<tr>
<td>39</td>
<td>HOST_CSN</td>
<td>Chip Select (SPI)</td>
<td>LoRa® Gateway Radio Board Connector; SX1301 CSN</td>
</tr>
<tr>
<td>90</td>
<td>SCK_FLASH</td>
<td>Source Clock (SPI)</td>
<td>MicroSD (0475710001); CLK Serial Flash EEPROM (SST25VF080B); SCK</td>
</tr>
<tr>
<td>89</td>
<td>CS_FLASH</td>
<td>Chip Select (SPI) for Flash Device</td>
<td>Serial Flash EEPROM (SST25VF080B); CS</td>
</tr>
<tr>
<td>56, 57</td>
<td>D_DNP2_P, D_DNP2_N</td>
<td>HID USB Communication</td>
<td>Microchip Hi-Speed Hub Controller (USB2412-D2K); D+/D-</td>
</tr>
<tr>
<td>96</td>
<td>GPS_TX</td>
<td>Serial Transmit (EUSART)</td>
<td>GPS Module (MAX-M8Q): TXD</td>
</tr>
<tr>
<td>97</td>
<td>GPS_RX</td>
<td>Serial Receive (EUSART)</td>
<td>GPS Module (MAX-M8Q): RXD</td>
</tr>
<tr>
<td>95</td>
<td>CS_SD</td>
<td>Chip Select (SPI)</td>
<td>MicroSD (0475710001); CD/DAT3</td>
</tr>
<tr>
<td>1</td>
<td>N/A</td>
<td>Digital I/O</td>
<td>Red LED (D4)</td>
</tr>
<tr>
<td>17</td>
<td>RF_RESET</td>
<td>Digital I/O</td>
<td>LoRa® Gateway Radio Board Connector; SX1301 RESET</td>
</tr>
<tr>
<td>38</td>
<td>A</td>
<td>Peripheral Pin Select (PPS)</td>
<td>Debugging Through-Hole via</td>
</tr>
<tr>
<td>58</td>
<td>SCL</td>
<td>Clock Line (I²C)</td>
<td>USB Bridge (MCP2221): SCL [Not Used] Serial EEPROM on Radio (24AA02T): SCL [Not Used]</td>
</tr>
<tr>
<td>59</td>
<td>SDA</td>
<td>Data Line (I²C)</td>
<td>USB Bridge (MCP2221): SDA [Not Used] Serial EEPROM on Radio (24AA02T): SDA [Not Used]</td>
</tr>
<tr>
<td>60</td>
<td>N/A</td>
<td>Configuration Update; Digital I/O</td>
<td>Switch (S2)</td>
</tr>
<tr>
<td>61</td>
<td>N/A</td>
<td>Mode Select; Digital I/O</td>
<td>Switch (S3)</td>
</tr>
<tr>
<td>91</td>
<td>SDCARDIN</td>
<td>SD Card Detection; Digital I/O</td>
<td>MicroSD (0475710001); POL</td>
</tr>
<tr>
<td>92</td>
<td>D</td>
<td>Peripheral Pin Select (PPS)</td>
<td>Debugging Through-Hole via</td>
</tr>
</tbody>
</table>
### TABLE 2-2: PIC24EP512GU810 PIN BREAKOUT (CONTINUED)

<table>
<thead>
<tr>
<th>Pin #</th>
<th>Signal Name</th>
<th>Description</th>
<th>Board Connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>28</td>
<td>TFT_CS</td>
<td>Digital I/O</td>
<td>TFT LCD (ER-TFT032-3): CS</td>
</tr>
<tr>
<td>29</td>
<td>TFT_RESET</td>
<td>Digital I/O</td>
<td>TFT LCD (ER-TFT032-3): RESET</td>
</tr>
<tr>
<td>66</td>
<td>TFT_DC</td>
<td>Digital I/O</td>
<td>TFT LCD (ER-TFT032-3): DC/SCL</td>
</tr>
<tr>
<td>67</td>
<td>E</td>
<td>Peripheral Pin Select (PPS)</td>
<td>Debugging Through-Hole via</td>
</tr>
<tr>
<td>22, 23, 24, 25</td>
<td>TP X-, TP X+, TP Y-, TP Y+</td>
<td>Digital I/O</td>
<td>TFT LCD (ER-TFT032-3): XL, XR, YU, YD</td>
</tr>
<tr>
<td>8</td>
<td>WAKEUP</td>
<td>Digital I/O</td>
<td>GPS Module (MAX-M8Q): RESET_N</td>
</tr>
<tr>
<td>9</td>
<td>PPS</td>
<td>Digital I/O (Input); Pulse Per Second (PPS)</td>
<td>GPS Module (MAX-M8Q): TIMEPULSE</td>
</tr>
<tr>
<td>63, 64</td>
<td>N/A</td>
<td>External Oscillator</td>
<td>8 MHz (Y3)</td>
</tr>
<tr>
<td>73, 74</td>
<td>N/A</td>
<td>External Oscillator</td>
<td>32 kHz (Y2)</td>
</tr>
<tr>
<td>72</td>
<td>ENC_INT</td>
<td>Digital I/O</td>
<td>TCP/IP Ethernet Controller (ENC624J600): INT/SPISEL</td>
</tr>
<tr>
<td>76</td>
<td>F</td>
<td>Peripheral Pin Select (PPS)</td>
<td>Debugging Through-Hole via</td>
</tr>
<tr>
<td>77</td>
<td>H</td>
<td>Peripheral Pin Select (PPS)</td>
<td>Debugging Through-Hole via</td>
</tr>
<tr>
<td>81</td>
<td>PMWR</td>
<td>Parallel Master Port (PMP)</td>
<td>TCP/IP Ethernet Controller (ENC624J600): SO/WR/WRL/EN/B0SEL</td>
</tr>
<tr>
<td>82</td>
<td>PMRD</td>
<td>Parallel Master Port (PMP)</td>
<td>TCP/IP Ethernet Controller (ENC624J600): SI/RD/RW/TFT LCD (ER-TFT032-3): RD</td>
</tr>
<tr>
<td>70</td>
<td>PMCS2</td>
<td>Parallel Master Port (PMP)</td>
<td>TCP/IP Ethernet Controller (ENC624J600): CS</td>
</tr>
<tr>
<td>47</td>
<td>2200_TX</td>
<td>Serial Transmit (EUSART)</td>
<td>USB Bridge (MCP2221): UTX</td>
</tr>
<tr>
<td>48</td>
<td>2200_TX</td>
<td>Serial Receive (EUSART)</td>
<td>USB Bridge (MCP2221): RTX</td>
</tr>
</tbody>
</table>

**General or Unused Pins**

<table>
<thead>
<tr>
<th>Pin #</th>
<th>Signal Name</th>
<th>Description</th>
<th>Board Connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>AN20</td>
<td>Analog Input</td>
<td>LoRa Gateway Radio Board Connector [Pin 15]; N/C</td>
</tr>
<tr>
<td>19</td>
<td>AN21</td>
<td>Analog Input</td>
<td>LoRa Gateway Radio Board Connector [Pin 17]; N/C</td>
</tr>
<tr>
<td>20</td>
<td>GPIO2</td>
<td>Digital I/O (Input)</td>
<td>LoRa Gateway Radio Board Connector [Pin 10]; N/C</td>
</tr>
<tr>
<td>21</td>
<td>GPIO1</td>
<td>Digital I/O (Input)</td>
<td>LoRa Gateway Radio Board Connector [Pin 9]; N/C</td>
</tr>
<tr>
<td>26</td>
<td>PGC</td>
<td>ICSP™</td>
<td>Programming Pin</td>
</tr>
<tr>
<td>27</td>
<td>PGD</td>
<td>ICSP</td>
<td>Programming Pin</td>
</tr>
<tr>
<td>6</td>
<td>GPIO3</td>
<td>Digital I/O (Input)</td>
<td>LoRa Gateway Radio Board Connector [Pin 11]; N/C</td>
</tr>
<tr>
<td>7</td>
<td>GPIO4</td>
<td>Digital I/O (Input)</td>
<td>LoRa Gateway Radio Board Connector [Pin 12]; N/C</td>
</tr>
<tr>
<td>78</td>
<td>PMBE</td>
<td>Not Used</td>
<td>Not Used</td>
</tr>
<tr>
<td>83</td>
<td>GPIO5</td>
<td>Digital I/O (Input)</td>
<td>LoRa Gateway Radio Board Connector [Pin 13]; N/C</td>
</tr>
<tr>
<td>79</td>
<td>GPIO6</td>
<td>Digital I/O (Input)</td>
<td>LoRa Gateway Radio Board Connector [Pin 14]; N/C</td>
</tr>
<tr>
<td>68, 69, 80, 84</td>
<td>N/C</td>
<td>Not Connected</td>
<td>Not Connected</td>
</tr>
</tbody>
</table>
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 deployed 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>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Commands</td>
<td></td>
</tr>
<tr>
<td>save</td>
<td>Save current configurations to inserted microSD card</td>
</tr>
<tr>
<td>log</td>
<td>Configure the type of information output by the debug logger</td>
</tr>
<tr>
<td>Get ONLY Commands</td>
<td></td>
</tr>
<tr>
<td>ver</td>
<td>Request LoRa® Gateway Version Number</td>
</tr>
<tr>
<td>build</td>
<td>Request Build date on Firmware</td>
</tr>
<tr>
<td>report</td>
<td>Request Statistic Report Information</td>
</tr>
<tr>
<td>Get/Set Server Commands</td>
<td></td>
</tr>
<tr>
<td>gwid</td>
<td>Request/Configure the LoRa Gateway Unique User ID (UUID)</td>
</tr>
<tr>
<td>ifmode</td>
<td>Request/Configure the Interface Mode the LoRa Gateway acquires its IP address</td>
</tr>
<tr>
<td>ifip</td>
<td>Request/Configure the Interface IP Address given to the LoRa Gateway board(1)</td>
</tr>
<tr>
<td>ifgw</td>
<td>Request/Configure the Interface IP Address for the Network Gateway (Router)(1)</td>
</tr>
<tr>
<td>ifmsk</td>
<td>Request/Configure the Interface Network (Router) Subnet Mask(1)</td>
</tr>
<tr>
<td>svip</td>
<td>Request/Configure the LoRa Server IP Address the Gateway is using to packet forward</td>
</tr>
<tr>
<td>svup</td>
<td>Request/Configure the Server Port used for Up Link Communications</td>
</tr>
<tr>
<td>svdn</td>
<td>Request/Configure the Server Port used for Down Link Communications</td>
</tr>
<tr>
<td>heart</td>
<td>Request/Configure the current “Keep Alive Interval”, time interval in seconds the Gateway sends a pull request to the Sever</td>
</tr>
<tr>
<td>stat</td>
<td>Request/Configure the timer interval in which LoRa Statistics are updated</td>
</tr>
<tr>
<td>crcvd</td>
<td>Request/Configure CRC Valid check for packet forwarding</td>
</tr>
<tr>
<td>crcer</td>
<td>Request/Configure CRC Error check for packet forwarding</td>
</tr>
<tr>
<td>crc</td>
<td>Request/Configure CRC check for packet forwarding</td>
</tr>
<tr>
<td>sync</td>
<td>Request/Configure Sync Word used by the Gateway</td>
</tr>
</tbody>
</table>

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-byte value] in size.
[rxReceived] [rxOkRatio] [rxBadRatio] [rxNoCrc] [upPacketForward] [payloadByteSize]
[pushByteSize] [pushDataSent] [pushAckRatio] [pullSent] [pullAckRatio] [pullDataRx]
[pullByteSize] [pullPayload] [txOkCount] [txFailCount]
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 formatted 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>`  

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

TABLE 2-4: DESCRIPTION OF REPORT PARAMETERS RETURNED

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 formatted 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>`  

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

`<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>

<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>

<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:{"dhcp"|"static"}/ gateway eth interface mode */
#  gw_if_ip_addr: 4 Bytes /* LoRa gateway board ip address, need if
# gw_if_mode=="static", ignored otherwise */
#  gw_if_gateway: 4 Bytes /* Network gateway (router) Ip address, need if
# gw_if_mode=="static", ignored otherwise */
#  gw_if_netmask: 4 Bytes/* Network subnet mask, need 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,"forward_crc_error":false,"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

```makefile
@echo EZBL: Converting .hex file to a binary .blob
${MP_JAVA_PATH}java -jar "ezbl/ezbl_tools.jar" --blooper -artifact="${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 boooloaded 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](image)

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](image)

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](image)
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

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**

![Image of successful build time bootloading]

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**

![Image of completion message]

**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**

![Image of failure message]

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

[Diagram of LoRa® GATEWAY CORE BOARD SCHEMATIC 1]
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

NOTE: UNLESS SPECIFIED OTHERWISE, ALL CAPACITORS, INDUCTORS, AND RESISTORS ON THIS SHEET ARE 0402 SIZE.
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)

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Designator</th>
<th>Description</th>
<th>Manufacturer 1</th>
<th>Manufacturer Part Number 1</th>
<th>Supplier 1</th>
<th>Supplier Part Number 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>B1</td>
<td>Battery, CR2032 Coin Cell, Linx BAT-HLD-001 Holder</td>
<td>Linx Technologies</td>
<td>BAT-HLD-001</td>
<td>Mouser</td>
<td>712-BAT-HLD-001</td>
</tr>
<tr>
<td>28</td>
<td>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, C44, C48, C56</td>
<td>Cap, Ceramic, 0.1 uF, 50V X5R</td>
<td>TDK Corporation</td>
<td>C1608XR1H104M080AA</td>
<td>Digi-Key</td>
<td>445-5098-1-ND</td>
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<tr>
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<td>C10</td>
<td>Cap, Ceramic, 0.47 uF, 10V, 10% X7R</td>
<td>Samsung Electro-Mechanics America, Inc</td>
<td>CL10B474KP8NNNC</td>
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<td>1276-1247-1-ND</td>
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<td>GRM188R60J06ME47D</td>
<td>Digi-Key</td>
<td>492-3396-1-ND</td>
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<tr>
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<td>C14, C15</td>
<td>Cap, Ceramic, 13 pF, 50V, 5% NP0</td>
<td>Murata Electronics North America</td>
<td>GRM1885C1H130J0101D</td>
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<td>490-1406-1-ND</td>
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<td>C1608CG1H220J080AA</td>
<td>Digi-Key</td>
<td>445-1327-1-ND</td>
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<td>Kemet</td>
<td>C0603C475K8PACTU</td>
<td>Digi-Key</td>
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<td>C38, C50, C52, C53, C54, C55</td>
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<td>399-7837-1-ND</td>
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<td>TDK Corporation</td>
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<td>Digi-Key</td>
<td>709-1028-1-ND</td>
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<td>Digi-Key</td>
<td>709-1036-1-ND</td>
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<td>Lite-On Inc</td>
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<td>Digi-Key</td>
<td>160-1180-1-ND</td>
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<td>Kingbright</td>
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<td>Panasonic Electronic Components</td>
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<td>L1, L2</td>
<td>Ferrite Chip Bead, 40 OHM@100 MHz</td>
<td>TDK Corporation</td>
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<td>Ferrite Chip, 120 Ohm, 2A, 0603</td>
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<td>Inductor, 6.8 nH, 300 mA, Air-Core, +/-5%</td>
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<td>N-CHAN MOSFET, 60V, 115 mA</td>
<td>Fairchild Semiconductor</td>
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<td>R1, R2, R4, R5, R7, R8, R9, R10, R11, R12, R14</td>
<td>Res, 100R, 1/16W 1%</td>
<td>Samsung Electro-Mechanics America, Inc</td>
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<td>Panasonic Electronic Components</td>
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<td>U1, U3</td>
<td>RF to Digital FE Transceiver, 862-960 MHz QFN32</td>
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<td>Low Pass Filter, GSM/CDMA 915 MHz, 0.5dB L., SMD (915 Radio)</td>
<td>JOHANSON TECHNOLOGY</td>
<td>0915LP15B026E (915 Radio)</td>
<td>Mouser (915 Radio)</td>
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<td>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)</td>
<td>Taisaw</td>
<td>TA0547A (868 Radio) TA1561A (915 Radio)</td>
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<td>Balun, GSM/DCS/PCS/CDMA, 900 MHz SMD</td>
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<td>Oscillator, TXCO, 32.0000 MHz</td>
<td>Pericom</td>
<td>WT325B0032.00000</td>
<td>Digi-Key</td>
<td>WT325B0032.00000CT-ND</td>
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</table>
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