

MCS3142 Dual KEELOQ® Encoder Wireless Remote Control Development Kit User's Guide

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The development/evaluation tool is designed to be used for research and development in a laboratory environment. This development/evaluation tool is not intended to be a finished appliance, nor is it intended for incorporation into finished appliances that are made commercially available as single functional units to end users. This development/evaluation tool complies with 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).
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VP Development Tools

16-July-2013
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MCS3142 DUAL KEELOQ® ENCODER WIRELESS REMOTE CONTROL DEVELOPMENT KIT USER'S GUIDE

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Appendix B. SX1239 Receiver PICtail™ Daughter Board Schematics

Appendix C. Embedded Security Development Board Schematics

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Preface

INTRODUCTION

This chapter contains general information that will be useful to know before using the MCS3142 Dual KEELOQ® Encoder Wireless Remote Control Development Kit. Items discussed in this chapter include:

- Document Layout
- Conventions Used in this Guide
- Recommended Reading
- The Microchip Web Site
- Customer Support
- Document Revision History

DOCUMENT LAYOUT

This document describes how to use the MCS3142 Dual KEELOQ Encoder Wireless Remote Control Development Kit as a development tool to emulate and debug firmware on a target board. The manual layout is as follows:

- **Chapter 1. "Overview"**
- **Chapter 2. "Quick Start"**
- **Chapter 3. "Hardware Self-Test"**
- **Chapter 4. "MCS3142 Wireless Remote Key Fob"**
- **Chapter 5. "Embedded Security Development Board"**
- **Chapter 6. "Developing with the MCS3142 Wireless Security Remote Control Development Kit"**
- **Chapter 7. "KEELOQ MPLAB X Plugin"**
- **Chapter 8. "PC Application"**
- **Appendix A. "MCS3142 Transmitter Fob Schematic"**
- **Appendix B. "SX1239 Receiver PICtail™ Daughter Board Schematics"**
- **Appendix C. "Embedded Security Development Board Schematics"**

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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) { ... }`

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RECOMMENDED READING

This user's guide describes how to use the MCS3142 Dual KEELOQ Encoder Wireless Remote Control Development Kit. Other useful documents are listed below. The following Microchip documents are available and recommended as supplemental reference resources.

Read me Files

For the latest information on using other tools, read the tool-specific Readme files in the Readmes subdirectory of the MPLAB X® IDE installation directory. The Readme files contain update information and known issues that may not be included in this user's guide.

Design Center

Microchip has a KEELOQ design center which can be found on **www.microchip.com/keeloq**.

THE MICROCHIP WEB SITE

Microchip provides online support via our web site at www.microchip.com. This web site is used as a means to make files and information easily available to customers. Accessible by using your favorite Internet browser, the web site 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
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- Distributor or Representative
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- 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 web site at: http://support.microchip.com

DOCUMENT REVISION HISTORY

Revision A (February 2014)

- Initial Release of this Document.

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Chapter 1. Overview

1.1 INTRODUCTION

This document details how to use the stand-alone MCS3142 development kit, as well as the associated PC application and the MPLAB X plugin. The addition of a PC application allows much greater flexibility in accessing and viewing the captured wireless data. The MPLAB X plugin provides programming support for the MCS3142 as well as for the other KEELOQ devices.

The MCS3142 Dual KEELOQ Encoder Wireless Remote Kit contains a receiver platform and MCS3142 transmitter that are used in conjunction with each other to showcase the various technologies of KEELOQ: Classic KEELOQ and Ultimate KEELOQ.

For details on Classic KEELOQ and Ultimate KEELOQ, please refer to Microchip application notes AN1259, "*KEELOQ® Microcontroller-Based Code Hopping Encoder*".

1.2 KIT CONTENTS

- Embedded Security Development Board
- MCS3142 Wireless Remote Key Fob
- SX1239 Receiver PICtail™ Daughter Board
- USB A to Mini-B Cable
- CR2032 Coin Cell Battery

1.2.1 Downloadable Content

The following latest software builds should be obtained from the Microchip web site:

- Embedded Security Development Board source code
- MPLAB X Integrated Development Environment
  - KEELOQ Plugin (see **Chapter 7. "KEELOQ MPLAB X Plugin"**)
- KEELOQ Graphical Interface for the Embedded Security Development Board

Chapter 2. Quick Start

2.1 INTRODUCTION

The MCS3142 Dual KEELOQ Encoder Wireless Remote Control Development Kit uses an identical receiver module and demo board as seen in the Wireless Security Remote Control Development Kit User's Guide. (http://ww1.microchip.com/downloads/en/DeviceDoc/41646A.pdf). This chapter will explain how to setup the board and show the general operation.

2.2 USING THE STAND-ALONE DEMO

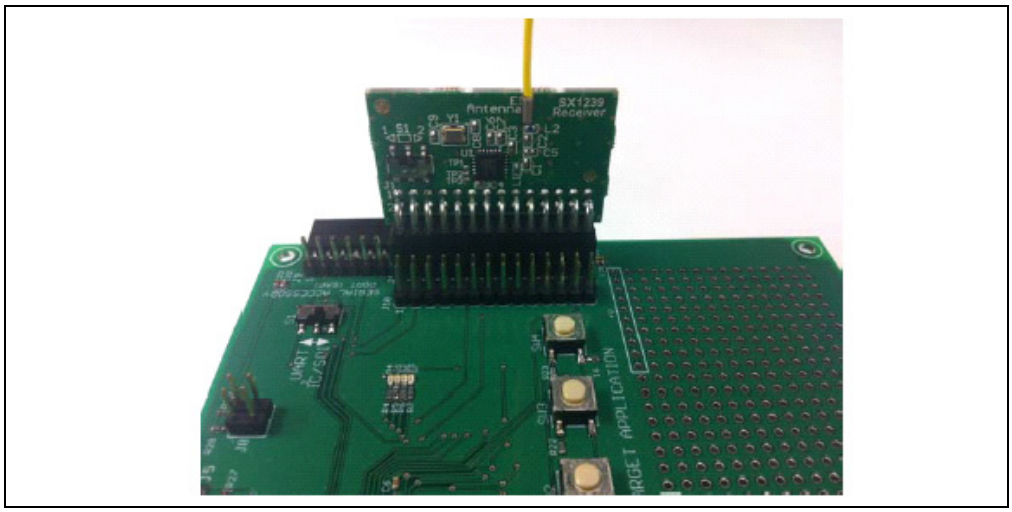
2.2.1 Setup

There are only a few steps to perform to get the stand-alone demo working:

1. Open the plastic enclosure of the red key fob by carefully prying apart the two halves with a flat-head screw driver. Observe the correct battery polarity and insert the coin battery into the holder. Put the key fob back together.
2. To verify that the key fob is properly installed, press any button and the LED should flash when a button is pressed.
3. Plug in the RF receiver daughter board on the PICtail slot of the demo board. Make sure that the RF receiver daughter board has the side with the RF receiver chip facing the center, as shown in Figure 2-1.

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FIGURE 2-1: ORIENTATION OF THE SX1239 RECEIVER PICtail™ DAUGHTER CARD



The board can be powered either from a USB cable or external power source.

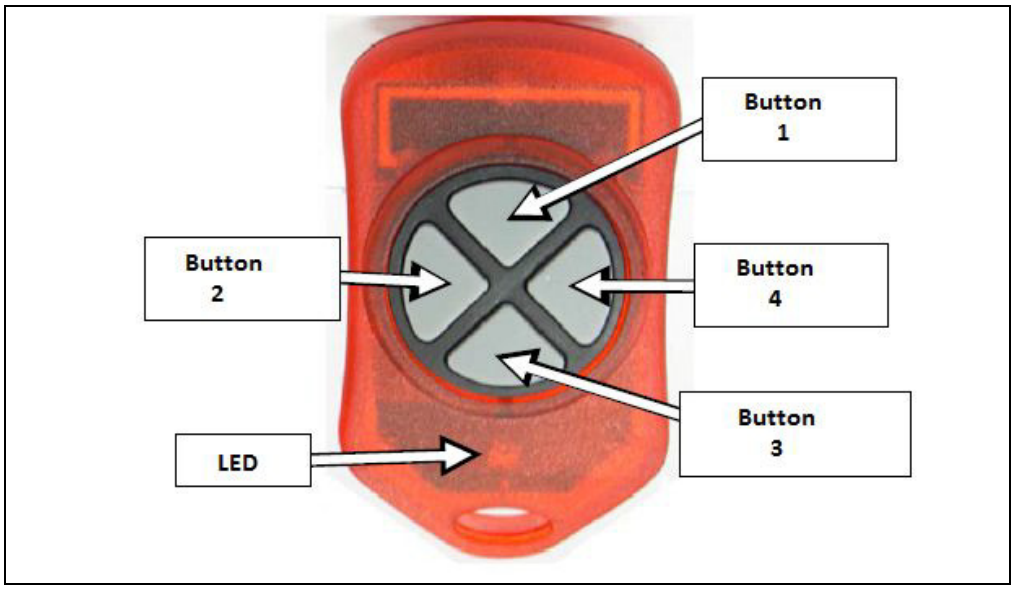
- To power by USB, connect a USB A to mini-B cable to the development board and an available USB port. Set jumper J6 to pins 1-2. No drivers are required to power the board; however, the MCP2200 driver may need to be installed for the PC to Board communication (see **Section 8.2 "Installation"**)
- To power from an external power supply, place jumper J6 to pins 2-3. Connect the test points labeled +VEXT and GND to a bench power supply that is set to 3.3 VDC.

2.2.2 Operation

The pre-programmed demo is used to demonstrate the operation of Microchip Remote Keyless Entry (RKE) solutions. The demo highlights the capabilities of transmitting and receiving secured data wirelessly. Two different methods, Classic KEELOQ and Ultimate KEELOQ, are used in this demo.

The pre-programmed demonstration shows how to secure information during data transmission.The transmitter sends out two types of packets. A Typical packet contains the device serial number, button code, synchronization counter, timer (Ultimate KEELOQ only) and various other parameters used in the decryption and validation process. A Seed packet contains special data related to the encoder's encryption key. A Seed packet is sent infrequently, and only used when pairing a transmitter to a receiver.

FIGURE 2-2: MCS3142 KEY FOB



Pressing any one of the four buttons on the red key fob will start the encryption process and eventual transmission of a KEELOQ packet. The LED will flash momentarily to indicate a transmission.Table 2-1 describes the transmitter buttons and their functions.

TABLE 2-1: TRANSMITTER BUTTONS AND FUNCTIONS

Button Combination	Description
Button 1	Transmit a Classic KEELOQ® Typical Packet
Button 2	Transmit a Classic KEELOQ Typical Packet
Button 3	Transmit an Ultimate KEELOQ Typical Packet
Button 4	Transmit an Ultimate KEELOQ Typical Packet
Button 1 + Button 2 simultaneously	Transmit a Classic KEELOQ Seed Packet
Button 3 + Button 4 simultaneously	Transmit an Ultimate KEELOQ Typical Packet

The kit is configured to use the Secure Learn pairing mechanism. This requires the encoders to transmit a special packet, called a Seed packet, with special information the receiver needs to properly decrypt transmissions. This kit is configured to transmit a Seed transmission with both buttons assigned to a particular encoder are pressed. The pairing phase also requires a Typical transmission to complete the pairing process.

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To pair a transmitter to the receiver using Secure learn:

1. Press SW3, the **Secure Learn** button on the Embedded Security Development Board to enable Secure Learn mode.
2. If learning the Classic KEELOQ encoder, press both buttons **1** and **2**. If learning the Ultimate KEELOQ encoder, press both buttons **3** and **4**. This will cause the special Seed packet to be sent.
3. The receiver will indicate reception of the Seed transmission.
4. If learning the Ultimate KEELOQ encoder, press either button **3** or **4** to send a Typical transmission.
5. The receiver will indicate successful pairing.

The kit also includes the SX1239 Receiver PICtail Daughter Board. It houses the Semtech SX1239 wideband receiver. The target application configured the receiver on start-up.

2.3 KEELOQ SCREENS

This section describes all of the LCD screens when used with the MCS3142 transmitter.

Note:	The receiver will always display the encoder serial number associated with a transmission, regardless of the transmitter's status with the receiver.

Only a message from a paired transmitter can be accepted by the receiver. If a packet is received from an unknown transmitter, the message '`Not Learned`' will be displayed on the LCD, as shown in Figure 2-3 and Figure 2-4. The type of transmission and the transmitter's serial number are also displayed on the screen.

FIGURE 2-3: CLASSIC KEELOQ® ENCODER NOT LEARNED



FIGURE 2-4: ULTIMATE KEELOQ® ENCODER NOT LEARNED



When a Classic KEELOQ packet is received from a paired transmitter, the contents of the packet is displayed on the LCD, as shown in Figure 2-5. Table 2-2 describes the data displayed on the screen.

TABLE 2-2: CLASSIC KEELOQ® TYPICAL TRANSMISSION DATA

'KLQ'	Indicates a Classic KEELOQ® encoder
'7989002'	The encoder's serial number
'C: 1008'	The encoder's synchronization counter value
'F: 2'	The encoder's function code

FIGURE 2-5: TYPICAL CLASSIC KEELOQ® TRANSMISSION



When a Classic KEELOQ packet is received from a paired transmitter, the contents of the packet is displayed on the LCD, as shown in Figure 2-6. Table 2-3 describes the data displayed on the screen.

TABLE 2-3: ULTIMATE KEELOQ® TYPICAL TRANSMISSION DATA

'ULT'	Indicates an Ultimate KEELOQ® encoder
'12345666'	The encoder's serial number
'T: 00330A1F'	The encoder's time-stamp
'F: 04'	The encoder's function code

FIGURE 2-6: TYPICAL ULTIMATE KEELOQ® TRANSMISSION



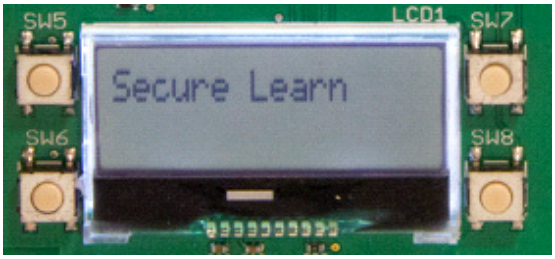
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The kit can pair transmitters using Normal Learn or Secure Learn (note, though, that the included transmitters are configured to pair only using Secure Learn). When the receiver enters Normal Learn mode, text similar to Figure 2-7 is displayed. For Secure Learn, text similar to Figure 2-8 is shown.

FIGURE 2-7: ENTER NORMAL LEARN MODE



FIGURE 2-8: ENTER SECURE LEARN MODE



The receiver must complete the learn process within a fixed window. If the necessary data is not received from the transmitters within this window, the process will abort and a message similar to Figure 2-9 is displayed.

FIGURE 2-9: LEARN MODE TIMEOUT

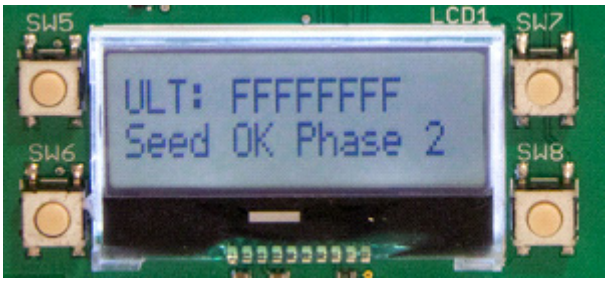


Secure Learn requires a Seed transmission from the encoder. Once received, a message similar to Figure 2-10 is displayed for Classic KEELOQ or Figure 2-11 for Ultimate KEELOQ.

FIGURE 2-10: CLASSIC KEELOQ® SEED RECEIVED



FIGURE 2-11: ULTIMATE KEELOQ® SEED RECEIVED



Ultimate KEELOQ requires an explicit transmission of a Typical packet. Once received, a message similar to the one shown in Figure 2-12 is displayed.

FIGURE 2-12: ULTIMATE KEELOQ® PAIRING COMPLETE



A message similar to Figure 2-13 is shown if an otherwise valid Classic KEELOQ packet is received, but is not a Seed transmission.

FIGURE 2-13: CLASSIC KEELOQ® NO SEED TRANSMISSION



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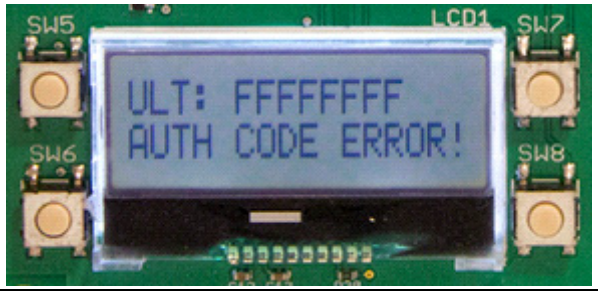
The synchronization counter is used to validate Classic KEELOQ transmissions. If the transmitted value falls outside the acceptable boundaries of the receiver's copy, an error similar to Figure 2-14 is displayed.

FIGURE 2-14: CLASSIC KEELOQ SYNCHRONIZATION ERROR



Packets from Ultimate KEELOQ encoders are always validated initially by confirming the Authorization Code portion of the transmission. If this check fails, a message similar to Figure 2-15 is displayed. Note that, this may be seen while completing the Secure Learn process and does not necessarily indicate an error.

FIGURE 2-15: AUTHORIZATION CODE INVALID



The kit allows the user to erase, or 'forget', all paired transmitters. If done, the LCD will display a message similar to Figure 2-16.

FIGURE 2-16: DELETE EEPROM



Chapter 3. Hardware Self-Test

3.1 INTRODUCTION

A hardware self-check can be performed to ensure the hardware integrity of the Embedded Security Development Board. The instruction of the hardware self-check is displayed on the LCD. The test result is either checked by firmware and displayed on the LCD, or verified by user observation.

To initiate the hardware self-check, press and hold push button **SW1** before powering-up the Embedded Security Development Board. SW1 can then be released when "`HDW Self Tests`" is displayed on the LCD screen.

3.2 BUTTON TESTS

"`Button Test`" will be displayed on the first line of the LCD display. Test instructions of pressing individual buttons will be displayed on the second line of the LCD display. Once a required push button is pressed, the test instruction message will be changed for the next push button. Once all push buttons have been tested, **SW1** needs to be pressed to move forward to the LED test.

3.3 LED TESTS

There are two sets of LEDs. When the LED tests start, the message "`LEDs Flashing`" will be displayed on the first line of the LCD display. During the tests, two sets four LEDs (D4-D7) and seven LEDs (D8-D14) will flash in a pattern. The user should observe that all LEDs are turned on and off with flashing intervals of roughly one second. Once the user has verified the LED test, SW1 needs to be pressed to move forward to the RTCC test.

3.4 RTCC TEST

When RTCC tests are initiated, the LCD display will show the clock and calendar. If no coin battery for the RTCC has been installed, the time displayed will be close to the reset time of January the 1st, 2012. If a coin battery for RTCC is installed, the time displayed will be based on whatever was previously set, plus the time that has passed. Observe that the clock is advancing. Once the RTCC test is done, SW1 needs to be pressed to move forward to the SPI test.

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3.5 SPI TEST

The SPI test in hardware self-check is performed to the SPI bus that connects the target application microcontroller and the SX1239 Receiver PICtail Daughter Board. Therefore, the SX1239 Receiver PICtail Daughter Board must have been plugged in before this test starts. Once the SPI test starts, the target application microcontroller requests specific information from the SX1239 receiver through the SPI bus. If the expected response is received, then the "`Successful`" status will appear; otherwise, the "`Fail`" status will be displayed.

Note: If a PICtail daughter board, other than the SX1239 Receiver PICtail™ Daughter Board, is plugged into the PICtail connector (even though the SPI bus may still be working), the SPI test might show failure status. The demo board expects an SX1239 to be identified on the SPI interface.

Chapter 4. MCS3142 Wireless Remote Key Fob

4.1 INTRODUCTION

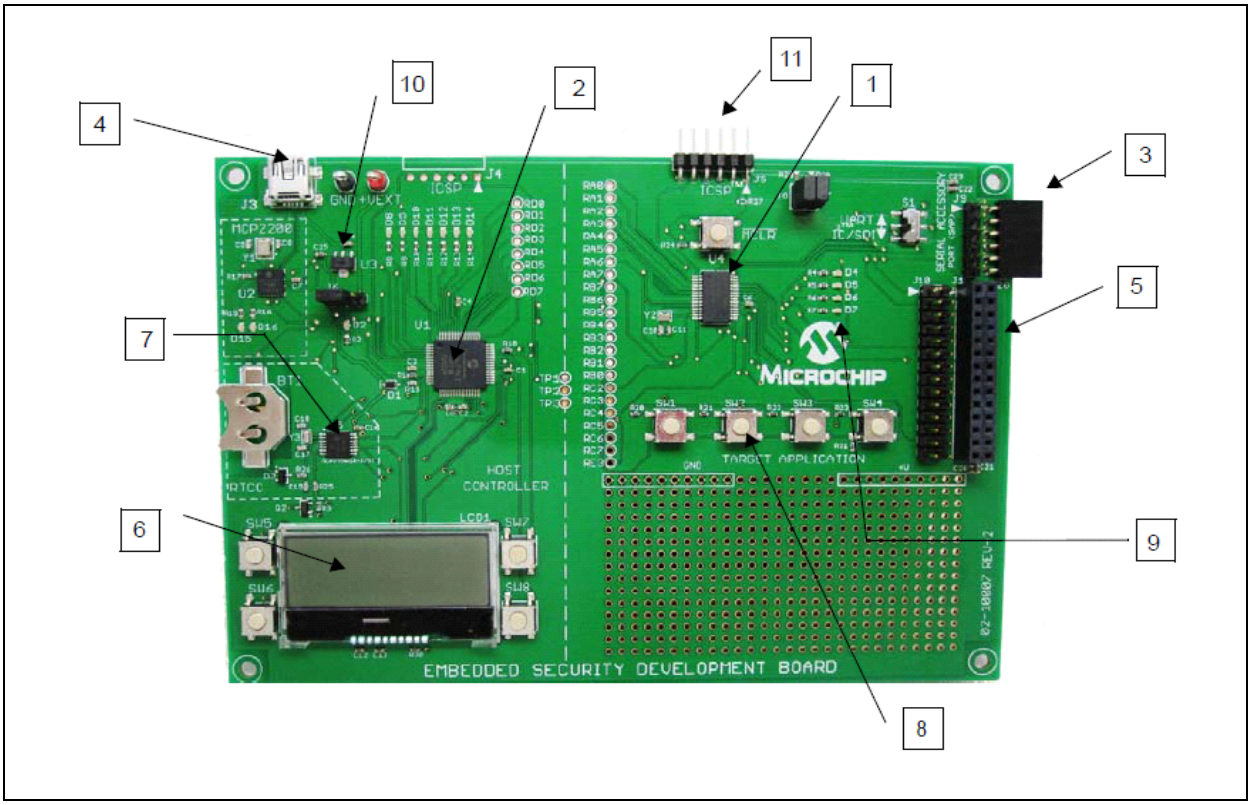
The MCS3142 Wireless Remote Key Fob is a demonstration and development platform for wireless security remote control applications. Please see http://ww1.microchip.com/downloads/en/DeviceDoc/41646A.pdf for similar information about the transmitter printed circuit board and its antenna design.

Chapter 5. Embedded Security Development Board

5.1 INTRODUCTION

This section gives a detailed description of the development board. The layout can be seen in Figure 5-1.

FIGURE 5-1: EMBEDDED SECURITY DEVELOPMENT BOARD



The following main blocks are defined on the Embedded Security Development Board in Table 5-1:

TABLE 5-1: EMBEDDED SECURITY MODULE DEFINITIONS

1	Target Application microcontroller U4
2	Host microcontroller U1
3	Serial Accessory Port P20
4	USB Interface Port J3
5	PICtail™ Connector J1
6	16x2 character LCD display
7	Real-Time Clock and Calendar (RTCC) module U5
8	Push Buttons
9	LEDs
10	Voltage Regulator
11	ICSP™ Programming Ports, J4 for Host; J5 for Target Application

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5.2 SERIAL COMMUNICATIONS CONNECTIONS

The Embedded Security Development Board is divided into two halves. The left side is the host controller half. The right side is the target application half. The two halves are connected by three wires, easily accessible by test points, labeled TP1, TP2 and TP3. Table 5-2 lists the respective microcontroller I/O port connections:

TABLE 5-2: SERIAL CONNECTIONS BETWEEN DEVICES

Host Controller MCS3142	Test Points	Target Application PIC16LF1947 (Master)
RF5	TP1	RB7/ICSPDAT
RB2	TP2	RB6/ICSPCLK
RF4	TP3	RE3/$\overline{\text{MCLR}}$/VPP

The host side half is controlled by a PIC16LF1947 microcontroller. The PIC16LF1947 microcontroller communicates with a 16x2 character LCD display (LCD1), an MCP2200 USB to UART communications IC (U2), an MCP795W10 SPI Real-Time Clock Calendar IC (U5), four push button switches (SW5-SW8), and seven LEDs (D8-D14). The PIC16LF1947 microcontroller can be programmed and debugged via the ICSP™ header (J4).

The target application half has a PIC16LF1938 microcontroller. The PIC16LF1938 microcontroller communicates with the 28-pin PICtail connector (J1), the Serial Accessory Port (P20), four push button switches (SW1-SW4), and four LEDs (D4-D7). The PIC16LF1938 microcontroller can be programmed/debugged via the ICSP (J5). The Embedded Security Development Board schematic is shown in **Appendix C. "Embedded Security Development Board Schematics"** as Figure C-2.

5.3 SERIAL ACCESSORY PORT (P20)

The Serial Accessory Port provides a simple serial interface for the external modules. These modules may be either an external sensor or an accessory board. The partial list of Microchip boards with SAP capabilities includes the following:

- LCD Serial Accessory Board
- RS-232 Serial Accessory Board

For more information about the existing accessory boards, visit http://www.microchip.com or refer to the "*RS-232 Serial Accessory Board User's Guide*" (DS70649). The following interfaces are supported by the Serial Accessory Port:

- 3 or 4-wire SPI
- I^2C™
- USART

Jumpers J7 and J8 connect pull-up resistors, typically useful when I^2C is selected and the pull-up resistors are not available on the daughter board.

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5.4 USB INTERFACE PORT

The Microchip MCP2200 provides USB to UART support. The USB interface port can also be used to power the Embedded Security Development Board directly. Please see **Section 8.2 "Installation"** for more information about connecting the board to a PC.

5.5 PICtail™ PORT

The PICtail port is a 28-pin interface port that supports Microchip's RF-based daughter cards. The PICtail port provides the following interfaces to the daughter cards:

- Power Supply
- SPI interface
- Interrupt request lines
- Other digital/analog I/O lines

> **Note:** The user must be careful about the PICtail port pins that share different functions of the board. The user needs to check the schematics before assigning functions for any port pin.

There are many Microchip accessory daughter cards, which have PICtail port connectivity. When not used as one of the components in the Wireless Security Remote Control Development Kit, the Embedded Security Development Board can be connected with any daughter board with the PICtail port, and perform different functionalities. Refer to the Microchip web site http://www.microchip.com for accessory daughter boards with PICtail port.

5.6 LCD DISPLAY

The Embedded Security Development Board supports 16x2 character LCD display with backlight. The LCD is controlled by the host microcontroller through the SPI port.

5.7 REAL-TIME CLOCK AND CALENDAR (RTCC) MODULE

The Embedded Security Development Board RTCC module can be used to set and track clock and calendar precisely. The RTCC functionality is achieved with the Microchip MCP795W10. The RTCC module is controlled by the host microcontroller through the SPI interface. The RTCC is commonly used with Ultimate KEELOQ, which relies on the system clock as part of its security.

The RTCC module can be powered either by the 3.3V power from the Embedded Security Development Board, or by a separate coin battery when external power is not available. For details on operating this RTCC module, refer to the data sheet of the MCP795W10 at http://www.microchip.com/MCP795W10.

5.8 PUSH BUTTONS

The Embedded Security Development Board has two sets of push buttons. **SW1**-**SW4** on the target application side and SW5 on the host controller side.

The four push buttons for the target application microcontroller are read as a single analog input. Depending on the different ratios of pull-up and pull-down resister values, the input analog voltages to the master microcontroller are different. Therefore, through the ADC on the target application microcontroller, the button that is pressed can be identified. Such design is used to save I/O pin requirement for the target application microcontroller.

The four push buttons for the host microcontroller are four separate digital inputs to the slave microcontroller, due to the abundant I/O pin availability for the slave microcontroller. All buttons are assigned to the individual interrupt lines of the microcontroller and are not driven by external pull-up circuitry to save power consumption. The user software must enable the PORTB pull-ups of the microcontroller before evaluating the button state.

The **MCLR** push button is connected to the RE3/MCLR pin of the target application microcontroller. The RE3/MCLR pin of the target application microcontroller is also one of the SPI lines that control the host microcontroller. When the target application and host microcontrollers are interconnected, the RE3/MCLR pin of target application microcontroller is configured to be a normal digital I/O pin; therefore, the **MCLR** push button is ineffective. Otherwise, if an I^2C intercommunication is not required between the target application and host microcontroller, the pin can be configured as Reset and the **MCLR** button can be used.

5.9 LEDS

There are two sets of LEDs that are controlled by the target application and the host microcontrollers, respectively. The target application MCU controls a set of four LEDs through the digital output pins. The host MCU controls a set of six LEDs through digital output pins. The two sets of LEDs may be useful in the demo or debugging process.

LEDs D15 and D16 on the left half are used to identify the TX and RX operation of MCP2200. The default configuration of the MCP2200 does not enable this feature, but it may be enabled using the MCP2200 configuration utility (see **Section 7.2 "Install"**). LEDs D12 and D13 are used by the preprogrammed demo firmware to identify the TX and RX communication between the host and target microcontrollers.

LED D2 indicates the power availability. This LED cannot be controlled by the target application or by the host microcontroller.

5.10 POWER SUPPLY

The Embedded Security Development Board can be powered by one of the following two sources:

- USB port
- External 3.3V power source through GND and +VEXT connectors

Jumper J6 is used to choose the power source. When the left side, pins 1-2 of J6 are closed, USB power is selected; when the right side, pins 2-3 of J6 are closed, external power source is selected.

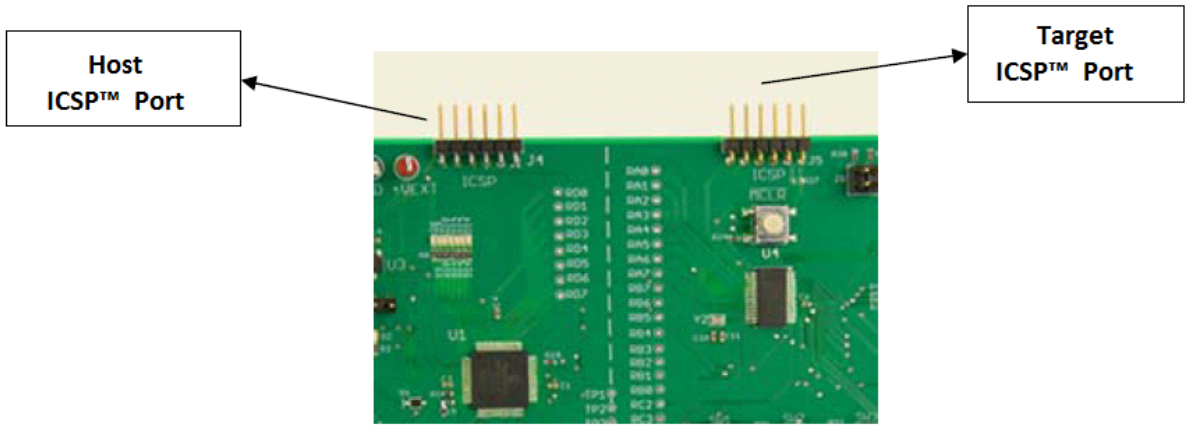
When the USB port is used to power the board, the input voltage is stabilized by a Microchip MCP1703, LDO regulator U3.

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5.11 ICSP™ PROGRAMMING/DEBUGGING PORTS

There are two ICSP™ programming/debugging ports on the Embedded Security Development Board. The ICSP port J4 on the left is used to program the host microcontroller. The ICSP port J5 on the right is used to program the target application microcontroller. Figure 5-2 shows the ICSP ports.

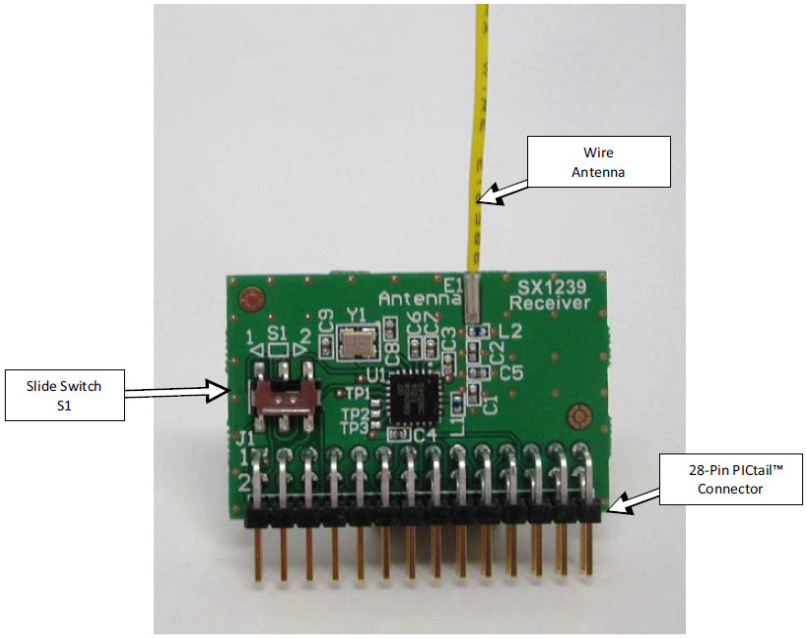
FIGURE 5-2: ICSP HEADERS FOR BOTH MICROS



5.12 SX1239 RECEIVER PICtail DAUGHTER BOARD

The SX1239 PICtail Receiver Daughter Board is a demonstration and development platform for wireless security remote control applications. Figure 5-3 shows the SX1239 Receiver PICtail Daughter Board. The schematic, PCB layout, and Bill of Materials are listed in **Appendix B. "SX1239 Receiver PICtail™ Daughter Board Schematics"**.

FIGURE 5-3: SX129 PICtail™ DAUGHTER BOARD



The daughter board features the Semtech SX1239 Low-Power Integrated UHF Receiver (http://www.semtech.com/wireless-rf/rf-receivers/sx1239/). The PICtail daughter board can plug into the 28-pin PICtail connector, featured on many Microchip Technology development tools.

The antenna connection has a pin socket for plugging a wire antenna. This demonstrates a simple and low-cost antenna option.

The antenna pin socket can be removed by heating it with a soldering iron and cleaning the connection. An SMA or reverse polarity SMA (RP-SMA) connector can be soldered in place on the PCB. A whip or sleeve dipole antenna can then be used.

If an SMA+ different antenna is used, the matching circuit will be less ideal. Pre-made antennas have a fixed, lower impedance. The wire used has a higher impedance.

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Chapter 6. Developing with the MCS3142 Wireless Security Remote Control Development Kit

6.1 INTRODUCTION

The software on the demo board was constructed so that a developer can easily customize the existing code base. The entire code is written in 'C' and has clearly documented sections where the developer can insert custom code.

6.2 PROGRAMMING THE MCS3142

Since the MCS3142 is a hardware encoder, its entire memory map cannot be programmed. Only portions of the MCS3142 memory are programmable. Please see **Section 7.3.3 "Generate Source"** for more information on how to generate code for the MCS3142 via the MPLAB X KEELOQ plugin.

To modify the configuration data in the key fob, the developer needs to open the red plastic enclosure. The ICSP™ port is available on the key fob PCB as six contact areas. The following steps need to be followed to program the MCS3142:

- Remove the PCB board from the plastic enclosure and lay the PCB board on a non-conductive surface.
- Align the six ICSP pins to the contact areas on the PCB. Push the ICSP pins to the contact areas and avoid any movement during programming.

Note: Avoid touching the PCB antenna when testing.

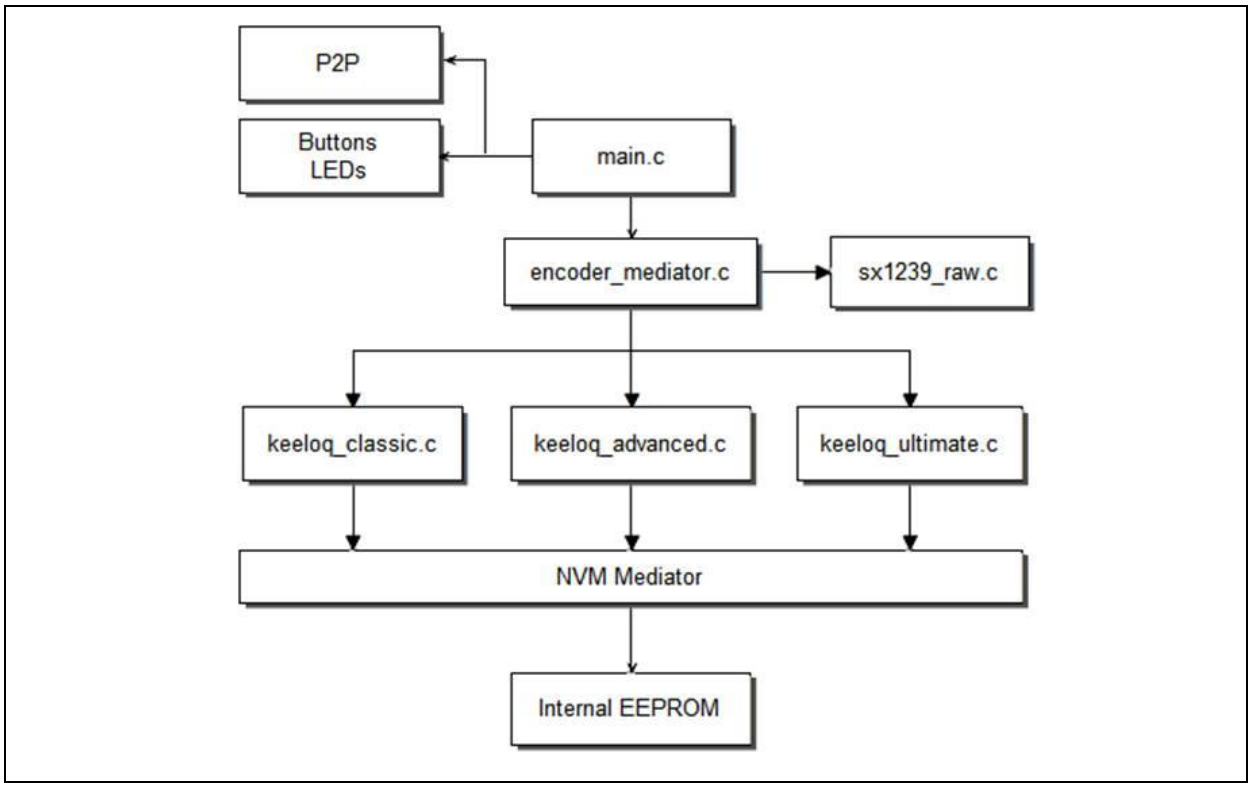
6.3 DEVELOPING WITH THE EMBEDDED SECURITY BOARD

The Embedded Security Development Board acts as a receiver in the MCS3142 Wireless Security Remote Control Development Kit. The target application microcontroller on the right side of the development board interacts with the receiver. All data receiving and KEELOQ security functionalities are performed by the target application microcontroller. The host microcontroller is only used to drive the LCD display and package data for the PC interface. The developer should only need to develop on the target side. The prototyping area under the four push buttons for target application controller can be used to prototype the application.

6.3.1 Software Design

The software was written so that a developer can easily use it. All of the KEELOQ decoding is abstracted away from the developer, leaving the important properties of the final result to the developer. The following figure shows a top-level diagram of the software layout.

FIGURE 6-1: BLOCK DIAGRAM DESIGN OF THE SOFTWARE ON THE TARGET CONTROLLER



Encoder Mediator

This file contains the place where custom code can be entered after the algorithm is done checking for a valid response.

EXAMPLE 6-1: KEELOQ MEDIATOR CODE SNIPPET

```
  if (Decode_Classic_KeeLoq(&inData) != NOT_VALID_PACKET) {
     //Custom code to interpret a valid Classic Keeloq Packet.
} else if (Decode_Advanced_KeeLoq(&inData) != NOT_VALID_PACKET) {
     //Custom code to interpret a valid Advanced Keeloq Packet.
} else if (Decode_Ultimate_KeeLoq(&inData) != NOT_VALID_PACKET) {
     //Custom code to interpret a valid Ultimate Keeloq Packet.
} else {
     validated_packet.type = INVALID_ENCODER;
   }
```


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Intra-Board Communication

This file contains the necessary communications between the two sides. The PC application needs to be informed of any updates relating to KEELOQ. As a consequence, there are numerous places within the target application code that grab data and send to the host controller. This code should be left untouched since it has no effect on the actual data manipulation of KEELOQ.

SX1239

This is the receiver that the target uses for receiving demodulated data. It uses SPI communication for its configuration. Please see the SX1239 data sheet for more information regarding its numerous registers and settings.

NVM Mediator

The “nonvolatile” mediator provides access to the EEPROM where learned devices and their settings are saved. The developer should access this using the `find(), write(), read()` methods.

Chapter 7. KEELOQ MPLAB X Plugin

7.1 INTRODUCTION

The KEELOQ plugin is a utility that provides Serialized Quick Turn Programming (SQTP) file generation for all HCS/MCS devices. Since the entire configuration is done within the context of an existing MPLAB X project, it can be used as a general KEELOQ programmer.

7.2 INSTALL

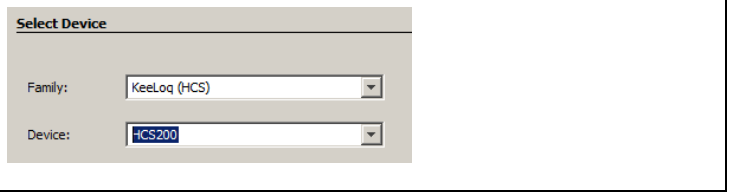
The plugin requires an existing MPLAB X project with an appropriate KEELOQ device selected as its target to be set as the main project. The tool uses the current main project inside of MPLAB X to select the correct device and workspace to attach the generated code.

The KEELOQ plugin is available from the Plugin Center of MPLAB X.

To manually install, open up MPLAB X and browse to: `Tools->Plugins->Available Plugins` and then locate the KEELOQ plugin in the available plugins list.

1. An MPLAB X project must first be created or opened with the correct KEELOQ device selected. Select `File->New Project` to start a new project. Follow the rest of the steps, making sure to select a device from the KEELOQ Family.

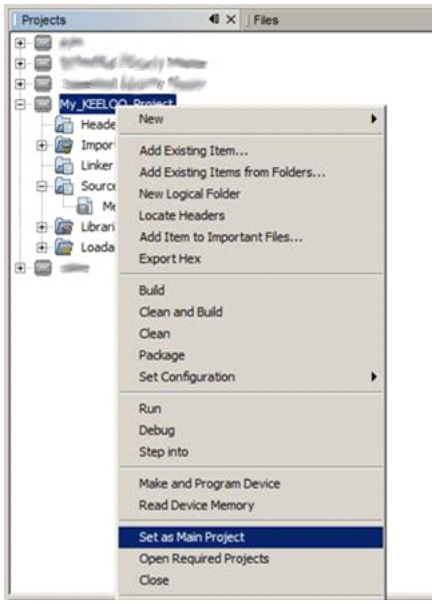
FIGURE 7-1: SELECTING AN HCS200 KEELOQ DEVICE IN STEP 2 OF THE NEW PROJECT CREATION INSIDE OF MPLAB X



For more information about MPLAB X New Project Creation, please see the MPLAB X documentation.

2. Right-click your project and select `Set As Main Project.`

FIGURE 7-2: THE KEELOQ® PROJECT MUST BE THE MAIN PROJECT SO THAT THE PLUGIN CORRECTLY RECOGNIZES THE DEVICE

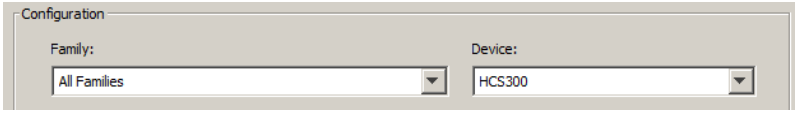


Usage

The plugin can be launched via: `Tools->Embedded->Keeloq.`

Note: Make sure that a KEELOQ device is selected in the main project settings

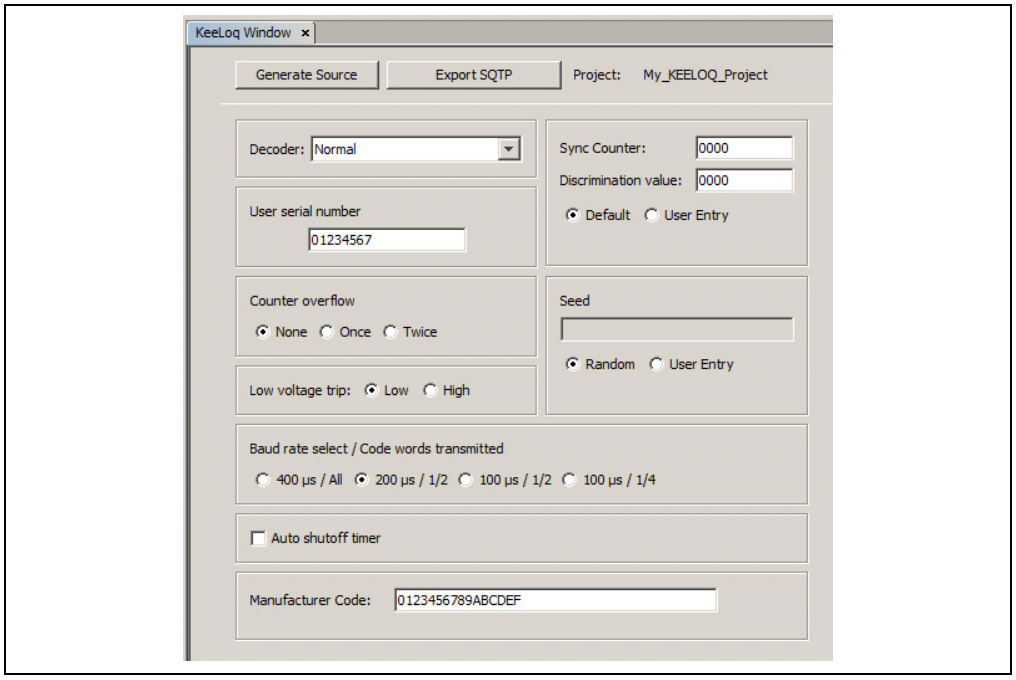
FIGURE 7-3: THE PLUGIN REQUIRES A MAIN PROJECT THAT HAS A KEELOQ® DEVICE SELECTED



The device for this project can be easily modified by: `(Right-Click) project-> Properties`

The following figure is what should be displayed for a HCS300 device selected.

FIGURE 7-4: SCREEN DISPLAYED FOR AN HCS300 DEVICE



This will be displayed with the MPLAB X IDE in a tabularized window.

Most of the KEELOQ devices require a unique set of inputs, which consequently change the plugin's display. Every device will have two buttons display: **Generate Source** and **Export SQTP**.

7.3 EXPORT SQTP

7.3.1 SQTP File Generation

Serialized Quick Turn Programming serialization is a method of programming 8-bit microcontrollers, whereby each chip is programmed with a slightly different code. Typically, all locations are programmed with the same basic code except for a few contiguous bytes which are programmed with a different number (referred to as 'key' or 'ID number' or 'serial number') in each member. Typical applications of such programming are remote transmitters for car alarms or garage door openers where each unit must have a different access code.

Microchip offers a flexible SQTP program for customers who wish to have their devices programmed by the factory with unique settings. By using the MPLAB X KEELOQ plugin, all the user has to do is specify key parameters such as manufacturer's code and encryption algorithm. The utility can then output a file that can be sent to Microchip for production programming or used on a variety of Microchip and third party programmer tools.

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7.3.2 File format

After clicking the **Export SQTP** button and inputting the range of serial numbers to be produced, the utility will save a `.NUM` file. Each line in the this file represents a single unique KEELOQ device. The line-to-line format of the SQTP file follows the INHX8M format.

EXAMPLE 7-1: FILE EXPORT EXAMPLE

```
:18000000B0B8C53F37D7B3FF0000000000000000177AA5500000000020
:BBAAAATTHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHCC
```

TABLE 7-1: EXPORT FILE FORMAT

Format	BBAAAATTHHHH....HHCC
BB	18, the number of data bytes
AAAA	0000, the starting address for this line. All HCS devices will use 0000 as the starting address
TT	00. Always 0 for 8-bit data, will be 1 for the “End of File” line
CC	20, the line checksum, appended to the line
HH	Data

The data is byte-addressable, so each HH is one byte. For HCS devices, this directly corresponds to the device’s memory map which is shown in the data sheet and programming specification.

Note: Some devices are word-aligned and some are byte-aligned.

The HCS300 has a memory map like this, starting from the lowest address. All of these fields are 16-bit values.

```
[KEY_0] [KEY_1] [KEY_2] [KEY_3] [SYNC] [RESERVED] [SER_0]
[SER_1] [SEED_0] [SEED_1] [RESERVED] [CONFIG]
```

Taking the sample data and adding these brackets to make it more readable:

```
[B0 B8] [C5 3F] [37 D7] [B3 FF] [00 00] [00 00] [00 00]
[00 00] [17 7A] [A5 50] [00 00] [00 00]
```

TABLE 7-2: EXPORT FILE DATA

Format	BBAAAATTHHHH....HHCC
64-bit Key	0xB0B8C53F37D7
Synchronization	0x0000
Serial	0x00000000
Seed	0x177AA550
Configuration	0x0000

Please consult with your specific encoder data sheet for more information about the various key generation methods.

7.3.3 Generate Source

The utility helps streamline the process of configuration generation to the physical programming of a KEELOQ device.

The **Generate Source** button will place a single assembly file labeled `MemoryMap.asm` into the project's workspace under `Source Files`. This file contains the calculated values, such as the encryption key, sync, serial, etc, to be placed into programming memory. The user can now connect to the programmer and Flash a KEELOQ device. To program the KEELOQ device, simply click on the **Make and Program Device Main Project** button located on the MPLAB X toolbar.

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Chapter 8. PC Application

8.1 INTRODUCTION

The MCS3142 can be used in conjunction with a PC application in order to view and edit data.

8.1.1 PC Application Features

- View graphically all KEELOQ transactions
- Graphical calculator
- Change receiver settings
- Tooltip text for every data entry

8.1.2 PC Requirements

The application is cross-platformed and has been tested for the following operating systems:

- Windows® XP, Vista, 7, 8
- Mac OS® X (Intel) 10.7 and later
- Linux (Intel x86/x64)

It also requires the Java Runtime Environment (JRE) version 6 or later.

Please note the version restriction on the Mac OS X platform. Mac OSX 10.7+ is a restriction from using the MCP2200 as a USB<->Serial device. Only MAC platforms that meet this requirement will be able to correctly connect to the board.

8.2 INSTALLATION

8.2.1 Installing the Wireless Security Remote Kit GUI

The installer can be downloaded from the Microchip website at: http://www.microchip.com/keeloq. Install the program by following the installation instructions that come with the package installer.

8.2.2 Installing the MCP2200 USB Driver

The MCP2200 is a USB-to-UART serial converter which enables USB connectivity in application that have a UART interface. The installer includes this driver if installing on a Windows machine. Additionally, the Windows installer can be downloaded here: www.microchip.com/mcp2200.

Mac OS X 10.7 or later systems do not need any driver installation.

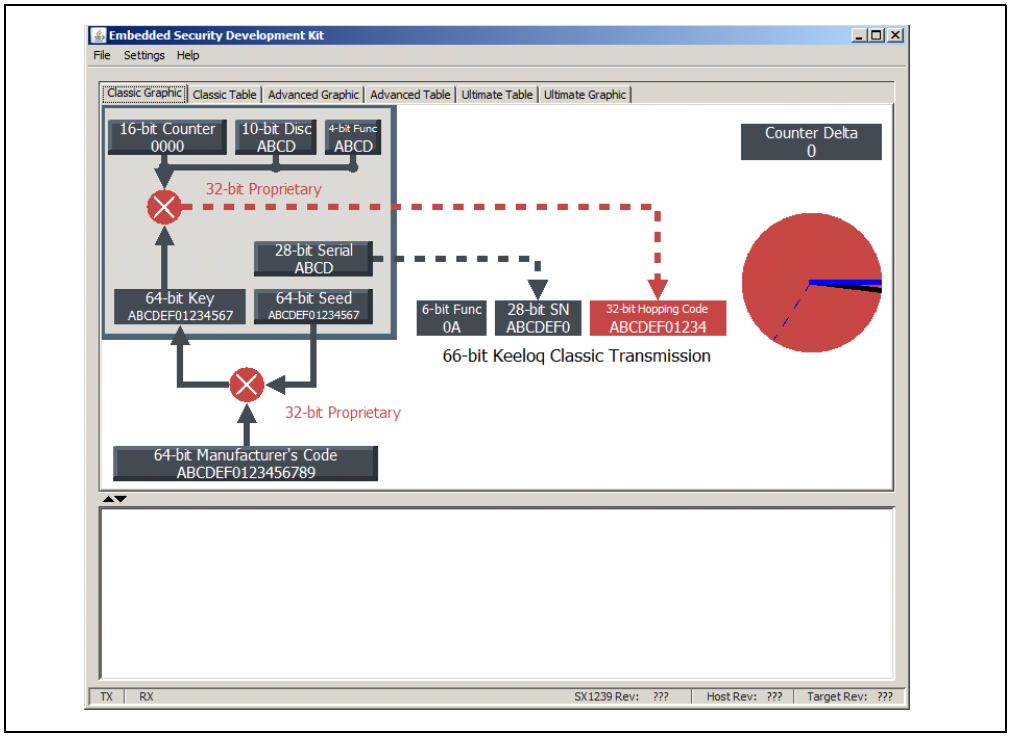
In order to be able to use the MCP2200 with Linux, the kernel must have support for USB CDC class drivers. For more information, Linux users should read the readme installation notes found here: http://ww1.microchip.com/downloads/en/DeviceDoc/mcp2200_linux_driver_readme.txt.

8.3 PC QUICK-START

8.3.1 Connecting to the board

Upon launching the application, a similar diagram will be displayed:

FIGURE 8-1: MAIN LANDING SCREEN



Please note that the subsequent screen captures of the program may change in later releases of the program software. A default Windows 7 look and feel was used for all figures.

Place the jumper on J6 on the Embedded Security Development Board in its left-most position to enable USB power.

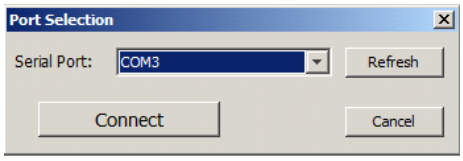
Fit the SX1239 Receiver PICtail into its slot on the demo board.

Connect a USB cable into the Embedded Security Development Board. D2 should now be lit. In Windows, a notification stating that the MCP2200 device was installed and found successfully will show. If not, the MCP2200 driver may need to be installed manually as stated in the **Section 8.2 "Installation"**.

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Click “Settings” in the menu bar and then “Port Selection” to see the figure shown below:

FIGURE 8-2: PORT SELECTION SCREEN



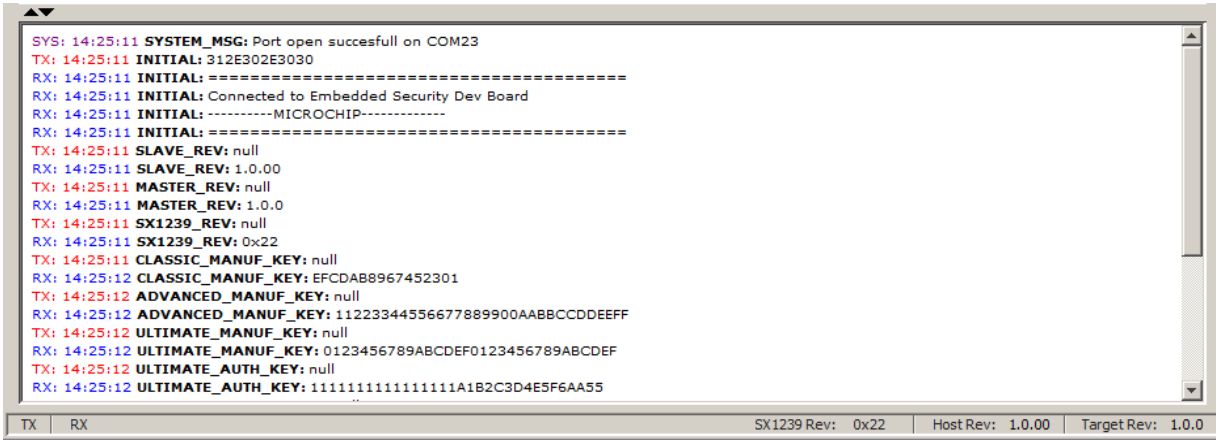
If the expected COM port is not listed, click the **Refresh** button. If it still does not exist, the MCP220 device is not being recognized. MAC and Linux systems will be presented with additional options that are used to help select the MCP2200 port. The default pattern matching is `tty.`. The MCP2200 should be listed as a `tty.usbmodemXX` device.

Note: Mac OS X systems must be 10.7 or greater to connect to an MCP2200 device.

Click the **Connect** button to initiate communication between the demo board.

If successful, the dialog box will disappear and the Main window will contain similar text as below:

FIGURE 8-3: DIALOG OUTPUT IMMEDIATELY FOLLOWING A SUCCESSFUL CONNECTION



Notice how the toolbar lists the software revisions of the Host and Target microcontrollers. The GUI will only communicate with known revisions of the firmware. The SX1239 is the identification number of the SemTech receiver module. Please see the SemTech data sheet for much more information regarding their receiver. Other settings such as learned devices and manufacturing numbers are also displayed and saved.

The demo board should now display the version of the PC application on its LCD.

8.3.2 Viewing Data

Each of the three KEELOQ technologies contains two panels. One is a graphical view and another is a textual-based logger with an accompanying table with two available rows. Each row of the table represents a single learned device. The **Table** tab will show relevant information to any learned device that corresponds to its KEELOQ technology.

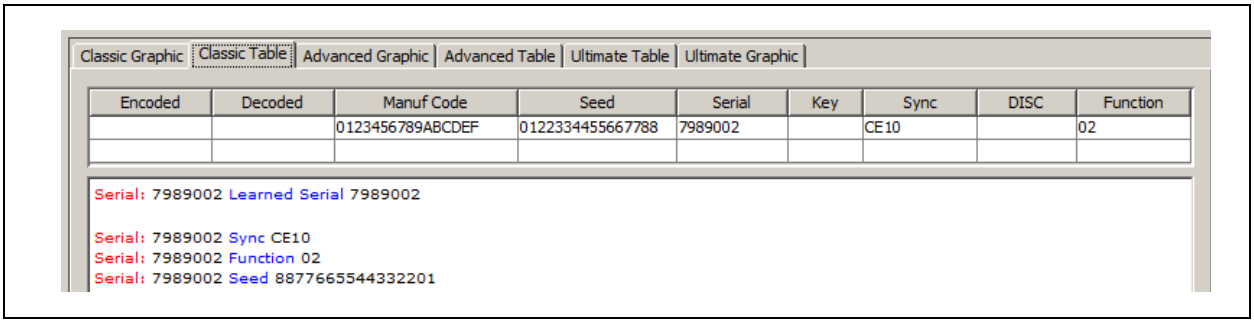
Any data that is changed will momentarily change to a red coloring. The **Panel's** tab in which the data changed will also have its tab color change.

8.4 PAIRING A TRANSMITTER

The demo board and PC application are now synchronized with one another. Once successfully paired, a text box will be populated with the learned data being sent to the PC for it to keep its own records. Since each paired transmitter is kept in nonvolatile memory, this data only needs to be saved once unless a resynchronization is required. The application reads out every saved device upon a successful connection to the board.

Once a device is saved in the application, a row in one of the KEELOQ table updates itself. The following figure shows a single device that is just learned.

FIGURE 8-4: CLASSIC TABLE TAB UPDATED WITH A SINGLE LEARNED CLASSIC TRANSMITTER

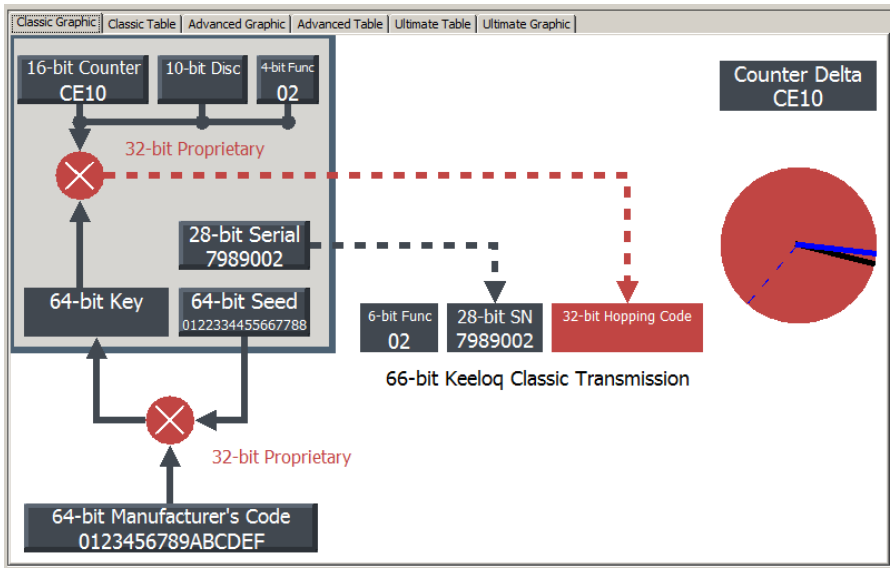


Not all of the columns are populated since those depend on the transmitter being active.

The **Graphic** tab will also update with new data as seen below:

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FIGURE 8-5: CLASSIC GRAPHIC UPDATED WITH A SINGLE LEARNED CLASSIC TRANSMITTER



Note: The graphic will always be updated to the most recent transmitter data.

8.5 NORMAL OPERATION

The GUI will update the graphic blocks and text boxes as the **Transmit** button on the learned fob is pressed. The figures below show the two panels that have been updated after the previously learned device has its transmission received by the demo board.

FIGURE 8-6: CLASSIC TABLE UPDATED WITH A SINGLE TRANSMISSION BY A PREVIOUSLY LEARNED DEVICE

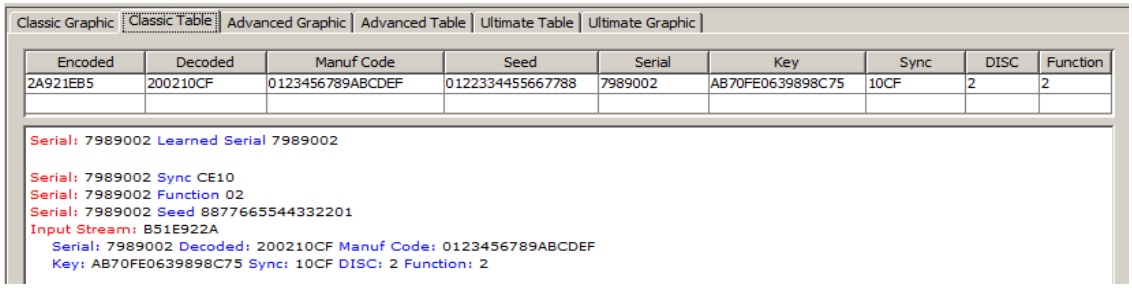
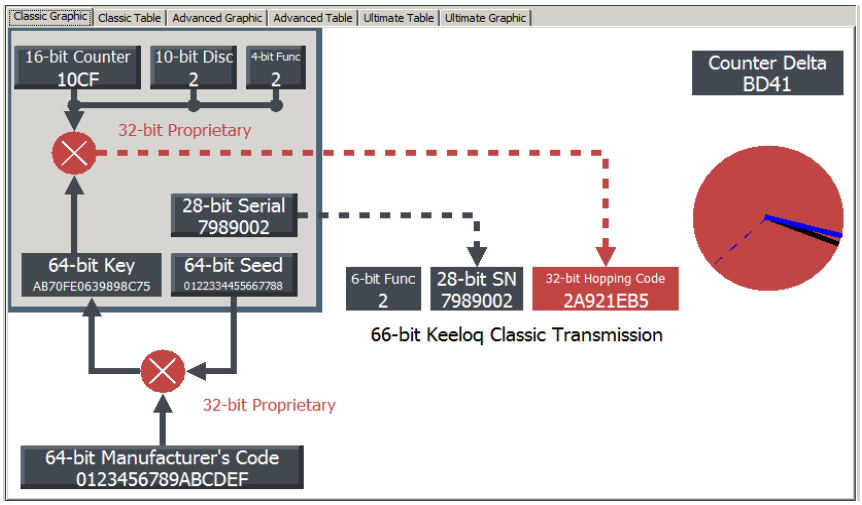


FIGURE 8-7: CLASSIC GRAPHIC UPDATED WITH A SINGLE TRANSMISSION BY A PREVIOUSLY LEARNED DEVICE



8.5.1 KEELOQ Graphic Specifics

Each graphic contains a "Pie" on the right-hand side of the panel. Every KEELOQ technology provides its own set of unique features.

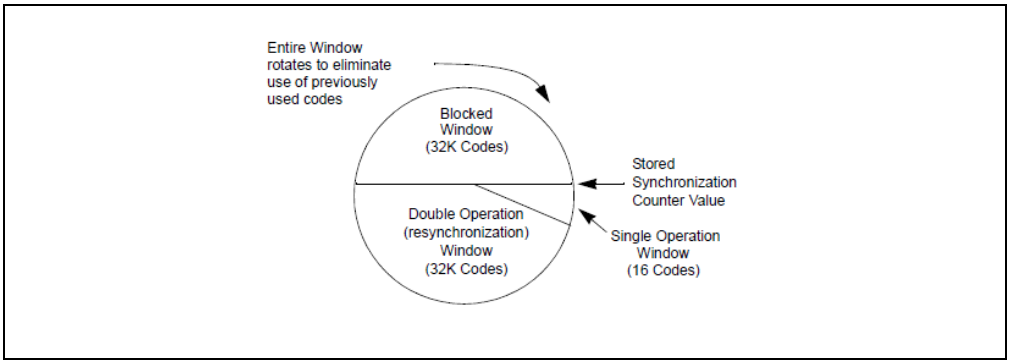
© 2014 Microchip Technology Inc.

Classic KEELOQ

The **Counter Delta** box indicates the difference between two transmitters' sync counter values. Since the graphic updates only to the latest transmitter received, this value is sometimes invalid until at least two transmissions from a single device are performed.

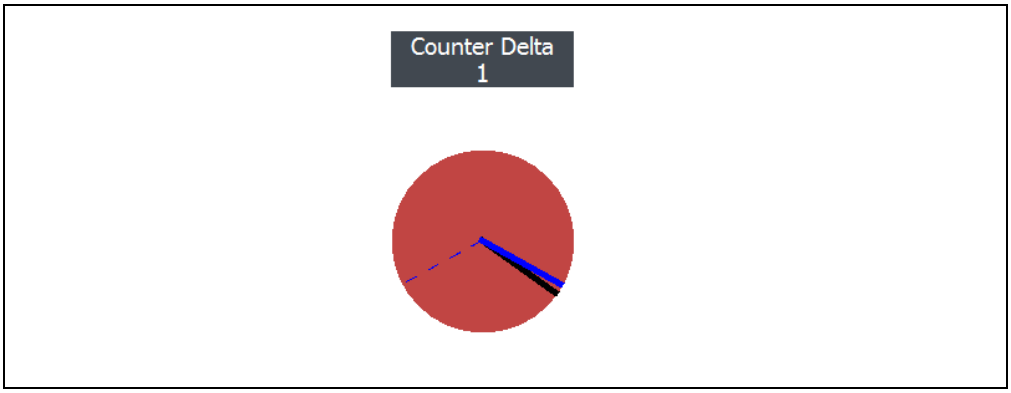
The red circle represents a simplified Synchronization window as shown in Figure 8-8. The size of the pie is arbitrary, but the technique is fundamental.

FIGURE 8-8: SYNCHRONIZATION WINDOW FOR THE CLASSIC KEELOQ ALGORITHM



The synchronization counter is an always-incrementing event counter. It increments whenever a new packet is prepared on the transmitter. Each time a transmission is authenticated, the intended function is executed and the transmission's synchronization counter value is stored in EEPROM. From the currently stored counter value there is an initial "Single Operation" forward window of 16 codes. This 16-code "window" is represented by the dotted blue line. The current sync value is represented by the black line and the previous received by the blue line.

FIGURE 8-9: COUNTER DELTA 1



If the difference between a received synchronization counter and the last stored counter is within 16, the intended function will be executed on the single button press and the new synchronization counter will be stored. Storing the new synchronization counter value effectively rotates the entire Synchronization window.

Note:	The proportional aspects of the pie have been manipulated so that it is easier to view the fundamental operation

A delta of '1' is typical under normal operation. To easily see this delta grow, press the **Transmit** button on the fob multiple times while being out of range from the receiver. Then come back towards the receiver and press again. The delta will now be greater than '1'.

When the sync counter gets to its maximum value, the fob needs to be reprogrammed in order to resume normal operation again.

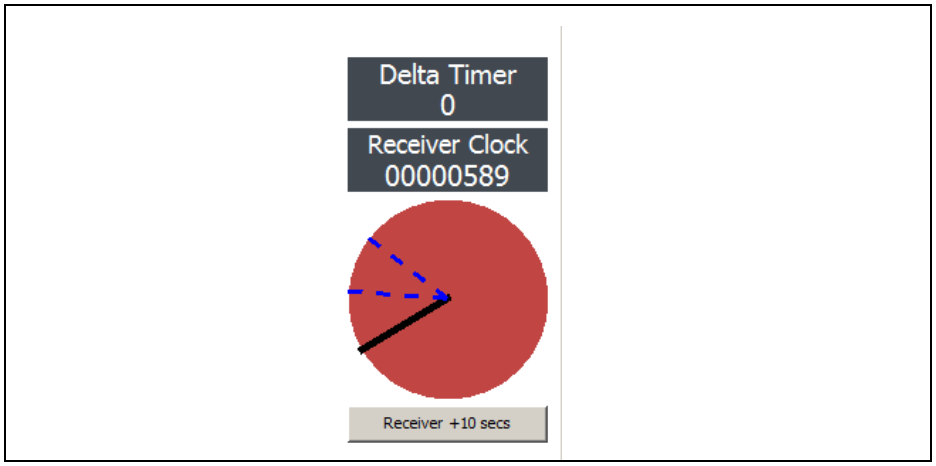
Advanced KEELOQ

Please see the previous section regarding how the Sync Counter window works. KEELOQ'S Advanced Sync window has identical operation compared to Classic KEELOQ with the exception that Advanced has a larger, 32-bit sync counter.

Ultimate KEELOQ

The pie in the Ultimate KEELOQ graphic uses the time-stamps between the transmitter and receiver to construct a delta.

FIGURE 8-10: ULTIMATE KEELOQ TIME-STAMP WINDOW



In the absence of a transmission, the PC will continuously increment its clock every ¼ second. A transmission will update the Receiver Clock block with the receiver's time. The transmitter's time is symbolized by the black line and should land directly in-between the two blue lines. The blue lines represent the acceptable drift between the receiver and transmitter's clocks. If the receiver has determined that the transmitter is out of sync, it will force a re-sync event. The **Receiver +10 secs** button can be used to simulate this re-sync event. The Delta Timer block holds the time difference between the receiver's clock and transmitter's clock.

The KEELOQ block indicates the battery voltage on the recently received transmitter.

8.6 CALCULATOR

The GUI can also be used as a graphical calculator.

Some of the blocks appear raised than the others, indicating an input. The mouse pointer will also transform into a hand as the mouse hovers over a raised block. These special blocks are inputs to the calculator and can be used to manipulate the graphic.

Note:	All inputs to the system are in hexadecimal format.

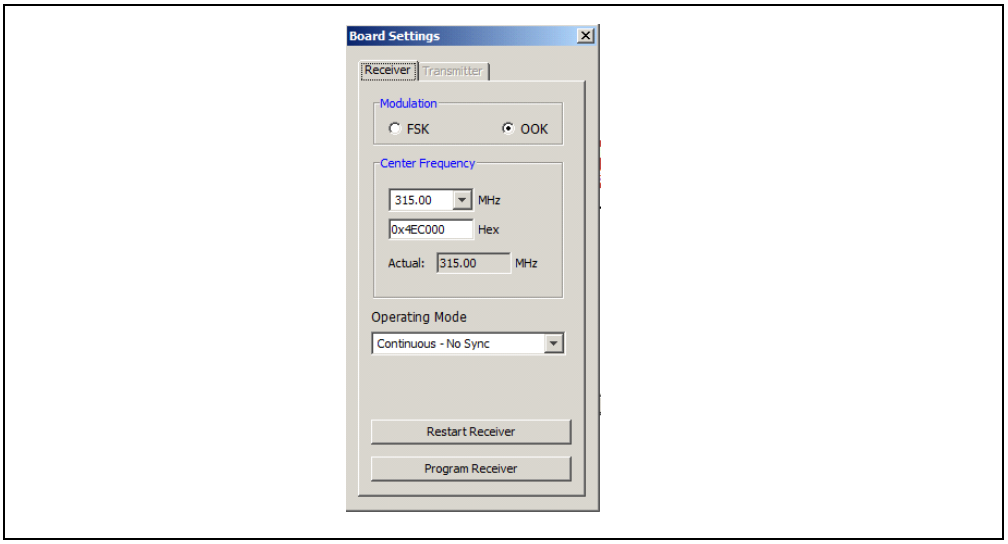
After applying the changes, the graphic will update itself from the new stimulus. Note that the effects are not saved to the transmitter, receiver, or inside the learned devices table. These changes do not persist between sessions.

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8.7 RECEIVER SETTINGS

The receiver settings can manipulated via the GUI. To access these options, navigate to `Settings->Board Options` to see a similar screen as below:

FIGURE 8-11: BOARD SETTINGS DIALOG



The drop-down options for the center frequency contain common settings for the receiver. The Hex input box provides a convenient way to visual the decimal frequency in a hexadecimal format. The modulation can also be configured between OOK and FSK. When satisfied, press the **Program Receiver** button to apply the changes to the board. The kits come with a receiver that has a matching circuit that is designed to a specific frequency. Changing the frequency far from its originally designed center frequency will have adverse affects on the receiving range.

Note:	These settings will not persist between power cycles of the demo board.

8.8 VERSIONING

It is advised that the latest PC application and Host/Target firmware be downloaded from the web at www.microchip.com/keeloq. The Help window will list the firmware of the development board and of the application.

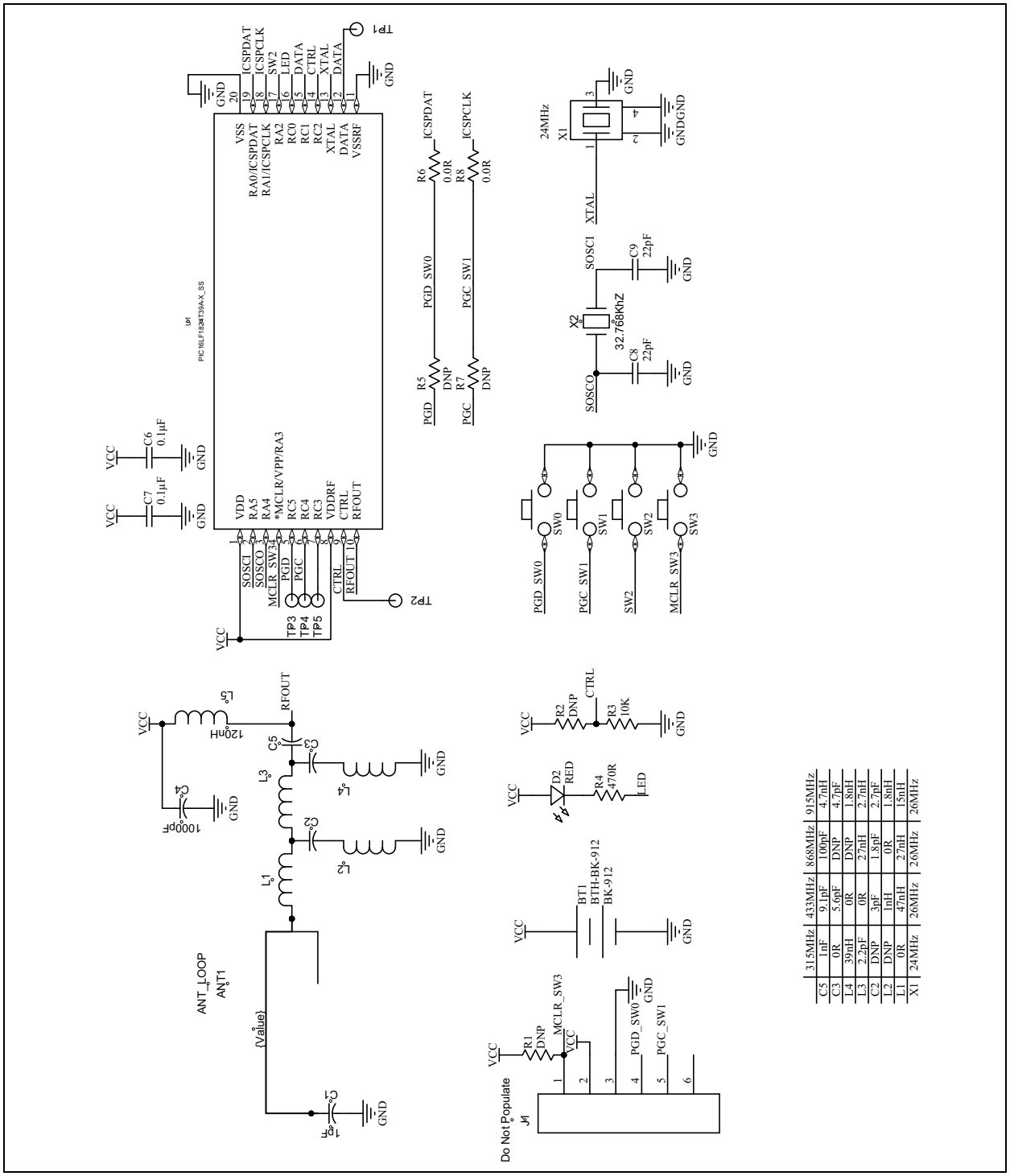
References

1. AN1265 – *KEELOQ® with AES Microcontroller-Based Code Hopping Encoder*
2. DS41646 – *Wireless Security Remote Control Development Kit User's Guide*
3. MCS3142 Dual KEELOQ® Encoder Data sheet
4. DS41378 – KEELOQ 3 Development Kit

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Appendix A. MCS3142 Transmitter Fob Schematic

FIGURE A-1: KEY FOB SCHEMATIC



	315MHz	433MHz	868MHz	915MHz
C5	1nF	9.1pF	100pF	4.7nH
C3	0R	5.6pF	DNP	4.7pF
L4	39nH	0R	DNP	1.8nH
L3	2.2pF	0R	27nH	2.7nH
C2	DNP	3pF	1.8nF	2.7pF
L2	DNP	1nH	0R	1.8nH
L1	0R	47nH	27nH	15nH
X1	24MHz	26MHz	26MHz	26MHz

TABLE A-1: MCS3142 TRANSMITTER BILL OF MATERIALS

	Designator	Value	Description	Vendor	Part Number
Common	ANT1	N/A	Antenna Loop	N/A	N/A
	BT1	N/A	Battery Holder	MPD	BK-912
	C4	1000 pF	Capacitor	Murata	GRM1555C1H102JA01D
	C6, C7	0.1 µF	Capacitor	Murata	GRM155R71C104KA88D
	C8, C9	22 pF	Capacitor	Murata	GRM1555C1H220JA01D
	D2	N/A	LED	Osram	LS Q976-NR-1-0-20-R18
	J1	N/A	PICkit™ 2 ICSP™ Header	N/A	N/A
	R1	DNP	Do Not Populate	DNP	DNP
	R2	DNP	Do Not Populate	DNP	DNP
	R3	10 kW	Resistor	Yageo	RC0402JR-0710KL
	R4	470 kW	Resistor	Yageo	RC0402JR-07470RL
	R5, R7	0 kW	Resistor	Yageo	RC0402JR-070RL
	R6, R8	DNP	Do Not Populate	DNP	DNP
	SW0, SW1, SW2, SW3	N/A	Switch Pad	N/A	N/A
	TP1, TP2, TP3, TP4, TP5	N/A	Test Point	N/A	N/A
	U1	Microcontroller	MCS3142-I/SS	Microchip	MCS3142-I/SS
	N/A	N/A	Enclosure	Polycase	FB-20-4*9
	X2	32.768 kHz	Crystal	Abracon	AB26TRB-32.768KHZ-T
315 MHz	C5	1 nF	Capacitor	Murata	GRM1555C1H102JA01D
	C3	0 kW	Resistor	Yageo	RC0402JR-070RL
	C1	1 pF	Capacitor	Murata	GRM1555C1H1R0CA01D
	L5	120 nH	Inductor	Murata	LQG15HSR12J02D
	L4	39 nH	Inductor	Murata	LQG15HS39NJ02D
	L3	2.2 pF	Capacitor	Murata	GRM1555C1H2R2BA01D
	C2	DNP	DNP	DNP	DNP
	L2	DNP	DNP	DNP	DNP
	L1	0 kW	Resistor	Yageo	RC0402JR-070RL
	X1	24 MHz	Crystal	Abracon	ABM8G-26.000MHZ-18-D2Y-T
433.92 MHz	C5	0 kW	Resistor	Yageo	RC0402JR-070RL
	C3	10 pF	Capacitor	Murata	GRM1555C1H100FA01D
	C1	1 pF	Capacitor	Murata	GRM1555C1H1R0CA01D
	L5	120 nH	Inductor	Murata	LQG15HSR12J02D
	L4	3 nH	Inductor	Murata	LQG15HS3N0S02D
	L3	18 nH	Inductor	Murata	LQG15HS18NJ02D
	C2	8.2 pF	Capacitor	Murata	GRM1555C1H8R2CA01D
	L2	1.8 nH	Inductor	Murata	LQG15HS1N8S02D
	L1	0 kW	Resistor	Yageo	RC0402JR-070RL
	X1	26 MHz	Crystal	Abracon	ABM8G-26.000MHZ-18-D2Y-T

TABLE A-1: MCS3142 TRANSMITTER BILL OF MATERIALS

	Designator	Value	Description	Vendor	Part Number
868 MHz	C5	100 pF	Capacitor	Murata	GRM1555C1H101JDD5D
	C3	DNP	DNP	DNP	DNP
	C1	1 pF	Capacitor	Murata	GRM1555C1H1R0CA01D
	L5	120 nH	Inductor	Murata	LQG15HSR12J02D
	L4	DNP	DNP	DNP	DNP
	L3	27 nH	Inductor	Murata	LQG15HS27NJ02D
	C2	1.8 pF	Capacitor	Murata	GRM1555C1H1R8CZ01D
	L2	0 kW	Resistor	Yageo	RC0402JR-070RL
	L1	27 nH	Inductor	Murata	LQG15HS27NJ02D
	X1	26 MHz	Crystal	Abracon	ABM8G-26.000MHZ-18-D2Y-T
915 MHz	C5	0 W	Resistor	Yageo	RC0402JR - 070RL
	C3	6.8 pF	Capacitor	Murata	GRM1555C1H6R8DA01D
	C1	0.5 pF	Capacitor	Murata	GRM1555C1HR50WA01D
	L5	150 nH	Inductor	Murata	LQG15HSR15J02D
	L4	0 kW	Resistor	Yageo	RC0402JR-070RL
	L3	12 nH	Inductor	Murata	LQG15HS12NJ02D
	C2	2.7 pF	Capacitor	Murata	GRM1555C1H2R7BA01D
	L2	0 kW	Resistor	Yageo	RC0402JR-070RL
	L1	12 nH	Inductor	Murata	LQG15HS12NJ02D
	X1	26 MHz	Crystal	Abracon	ABM8G-26.000MHZ-18-D2Y-T

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Appendix B. SX1239 Receiver PICtail™ Daughter Board Schematics

FIGURE B-1: SX1239 RECEIVER PICtail™ PCB ASSEMBLY

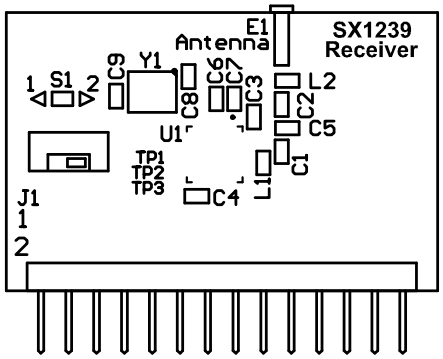
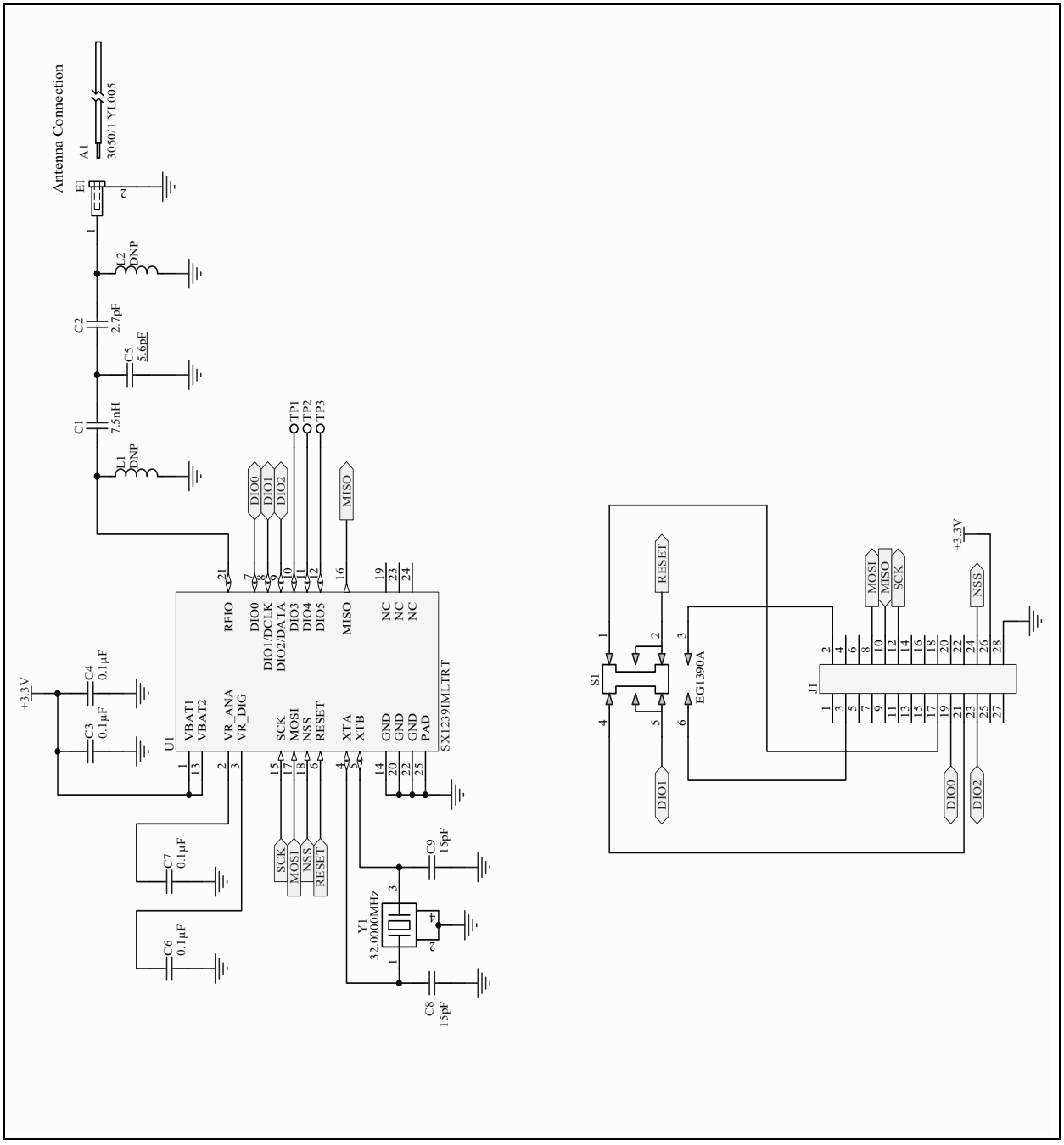


FIGURE B-2: RECEIVER PICtail™ SCHEMATIC



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TABLE B-1: SX1239 RECEIVER PICtail™ BILL OF MATERIALS

Designator	Value	Description	Vendor	Part number
C6, C7, C8, C9	15 pF	Capacitor	Murata	GRM1555C1H150JZ01D
C3, C4	0.1 µF	Capacitor	Murata	GRM155R71C104KA88D
A1	N/A	Wire, 24 AWG	Alpha Wire	3050/1 YL005
E1	N/A	Pin Receptacle	Mill-max	0667-0-15-01-30-27-10-0
J1	N/A	Terminal strip	SAMTEC	TSW-114-08-F-D-RA
S1	N/A	Switch, DPDT	E-Switch	EG1390A
U1	SX1239	RF Receiver	Semtech	SX1239IMLTRT
Y1	32 MHz	Crystal	TXC	7M-32.000MEEQ-T
C2	2.7 pF	Capacitor	Murata	GRM1555C1H2R7CA01D
C1	7.5 nH	Inductor	Murata	LQG15HS7N5J02D
C5	5.6 pF	Capacitor	Murata	GRM1555C1H5R6DA01D
L1	DNP	Do not populate	DNP	DNP
L2	DNP	Do not populate	DNP	DNP

Appendix C. Embedded Security Development Board Schematics

FIGURE C-1: EMBEDDED SECURITY DEVELOPMENT BOARD PCB ASSEMBLY

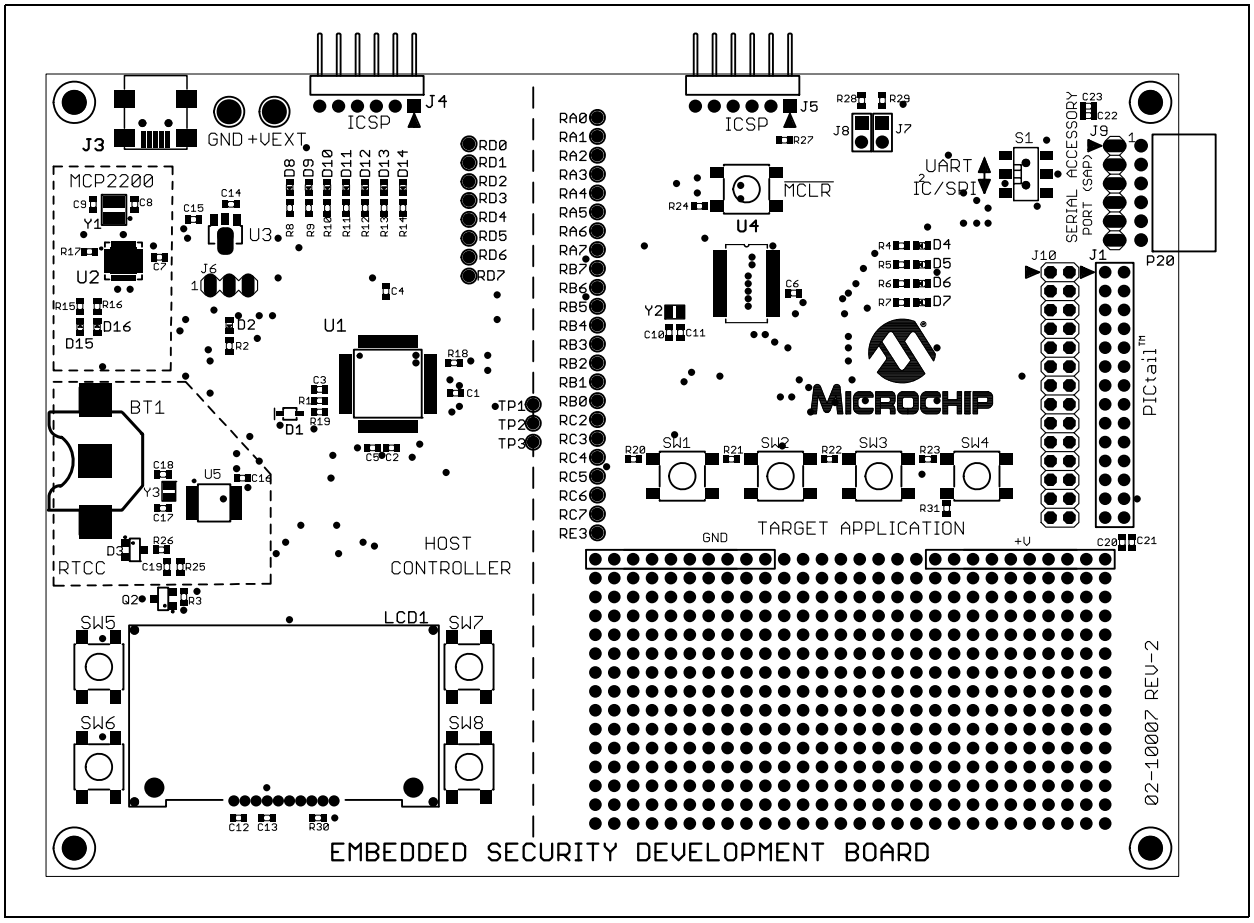


FIGURE C-2: HOST CONTROLLER OF THE EMBEDDED SECURITY DEVELOPMENT BOARD SCHEMATIC

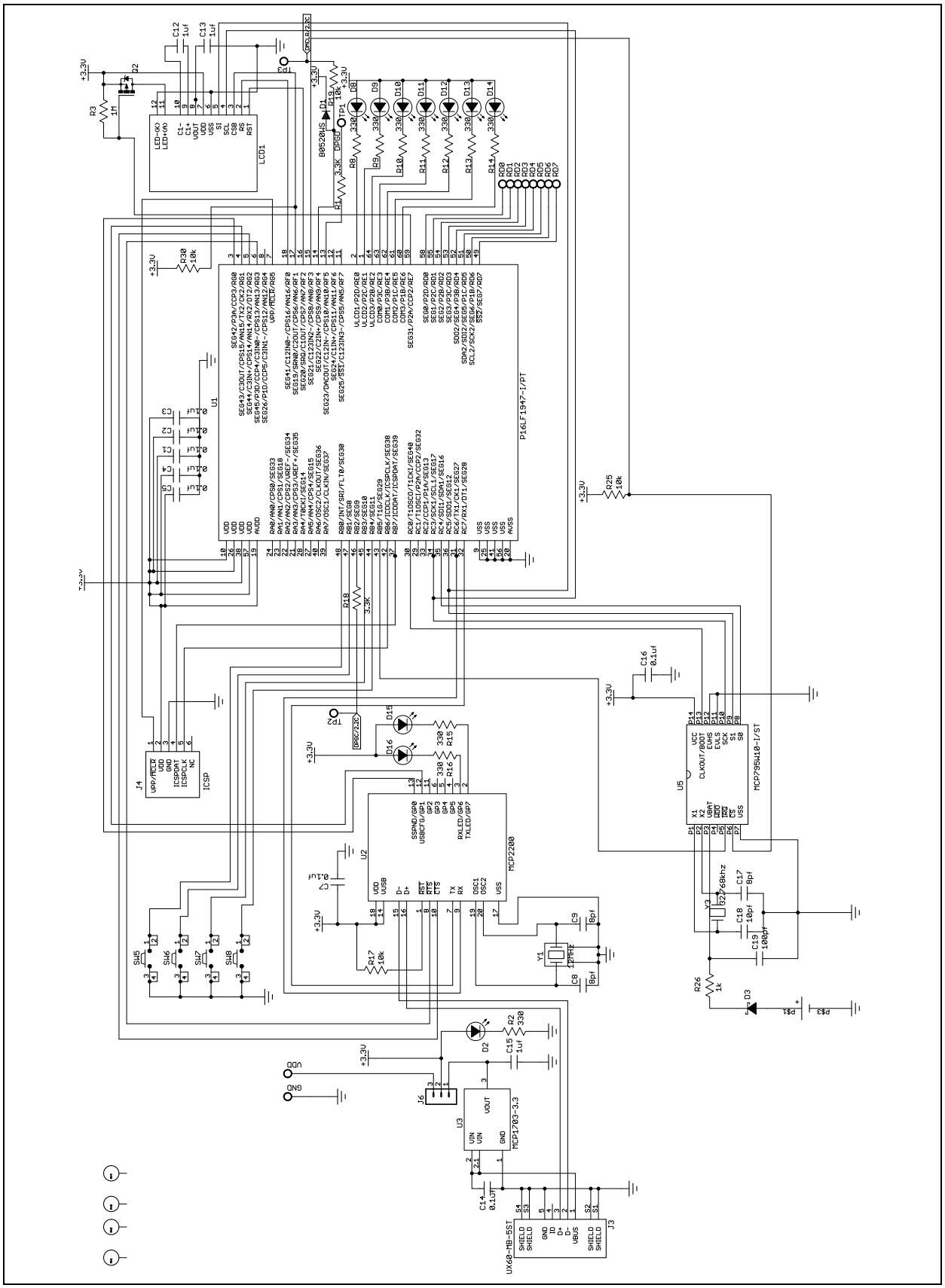
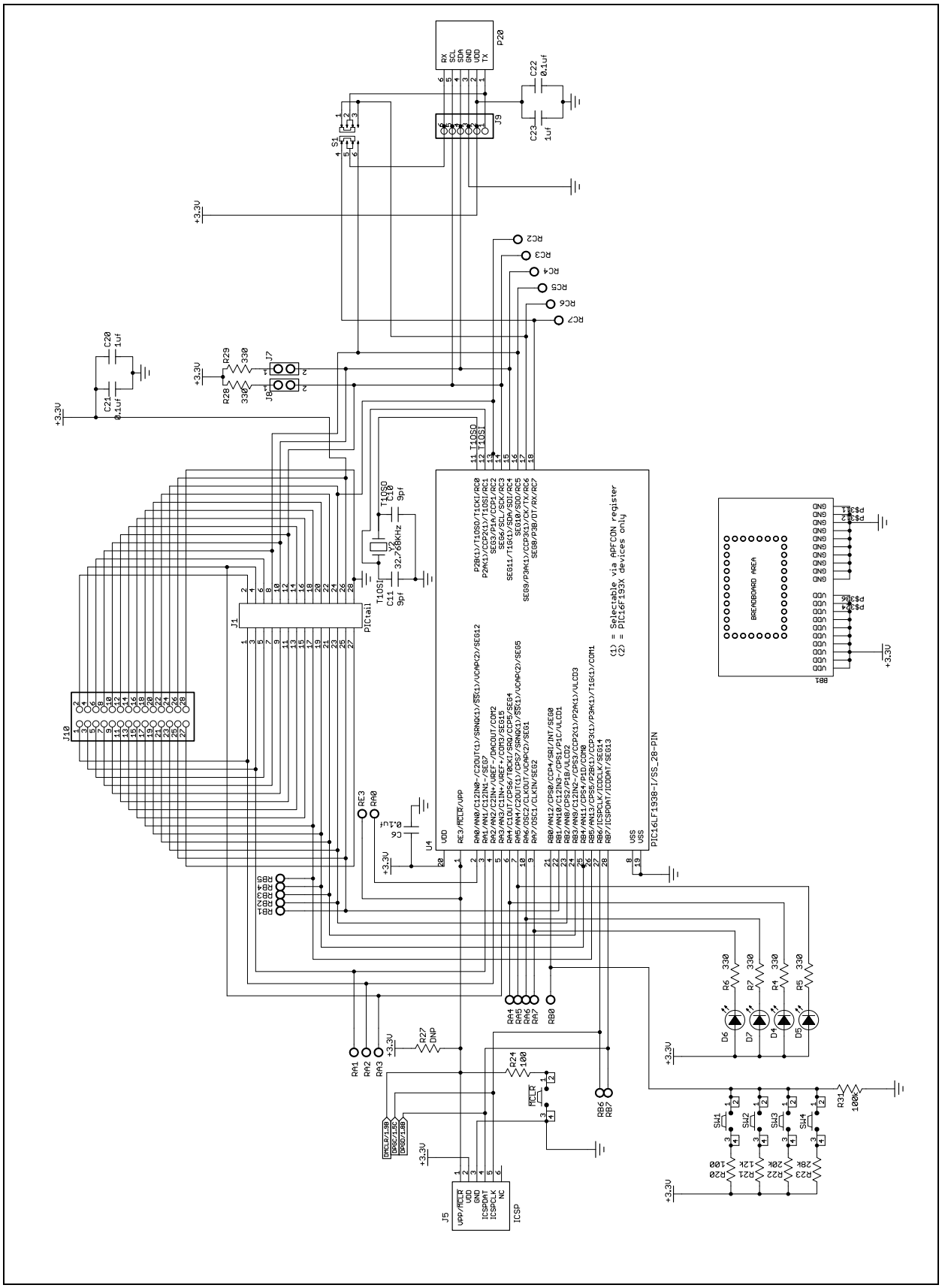


FIGURE C-3: TARGET APPLICATION OF THE EMBEDDED SECURITY DEVELOPMENT BOARD SCHEMATIC



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TABLE C-1: EMBEDDED SECURITY BOARD BILL OF MATERIALS

Qty	Part	Value	Manufacturer	MFG Part Number
1	VDD	VDD	Keystone	5010
	GND	GND	Keystone	5011
1	BT1	BK-885	MPD	BK-885
3	C8	8 pF	TDK Corporation	C1608C0G1H080D
	C9	8 pF	TDK Corporation	C1608C0G1H080D
	C17	8 pF	TDK Corporation	C1608C0G1H080D
2	C10	9 pF	TDK Corporation	C1608C0G1H090D
	C11	9 pF	TDK Corporation	C1608C0G1H090D
1	C18	10 pF	TDK Corporation	C1608C0G1H100D
1	C19	100 pF	TDK Corporation	C1608C0G1H101J
11	C1	0.1 µF	Murata	GRM188R71E104KA01D
	C2	0.1 µF	Murata	GRM188R71E104KA01D
	C3	0.1 µF	Murata	GRM188R71E104KA01D
	C4	0.1 µF	Murata	GRM188R71E104KA01D
	C5	0.1 µF	Murata	GRM188R71E104KA01D
	C6	0.1 µF	Murata	GRM188R71E104KA01D
	C7	0.1 µF	Murata	GRM188R71E104KA01D
	C14	0.1 µF	Murata	GRM188R71E104KA01D
	C16	0.1 µF	Murata	GRM188R71E104KA01D
	C21	0.1 µF	Murata	GRM188R71E104KA01D
	C22	0.1 µF	Murata	GRM188R71E104KA01D
5	C12	1 µF	Murata	GRM188R61A105MA61D
	C13	1 µF	Murata	GRM188R61A105MA61D
	C15	1 µF	Murata	GRM188R61A105MA61D
	C20	1 µF	Murata	GRM188R61A105MA61D
	C23	1 µF	Murata	GRM188R61A105MA61D
1	D1	B0520WS	Diodes Inc.	B0520WS-7-F
1	D3	—	Fairchild Semiconductor	BAT54
	D2	—	Lite-On	LTST-C191GKT
	D4	—	Lite-On	LTST-C191GKT
	D5	—	Lite-On	LTST-C191GKT
	D6	—	Lite-On	LTST-C191GKT
	D7	—	Lite-On	LTST-C191GKT
	D8	—	Lite-On	LTST-C191GKT
	D9	—	Lite-On	LTST-C191GKT
	D10	—	Lite-On	LTST-C191GKT

TABLE C-1: EMBEDDED SECURITY BOARD BILL OF MATERIALS

Qty	Part	Value	Manufacturer	MFG Part Number
	D11	—	Lite-On	LTST-C191GKT
	D12	—	Lite-On	LTST-C191GKT
	D13	—	Lite-On	LTST-C191GKT
	D14	—	Lite-On	LTST-C191GKT
	D15	—	Lite-On	LTST-C191GKT
	D16	—	Lite-On	LTST-C191GKT
1	J1	PICtail™	Sullins	PPPC142LFBN-RC
1	J3	UX60-MB-5ST	Hirose Electric Co Ltd	UX60-MB-5ST
1	J4	DNP		Do Not Populate
1	J5	ICSP™	Sullins	PBC06SBAN
1	J6	—	Sullins	PBC03SAAN
1	J7, J8	—	Sullins	PBC02DAAN
1	J9	—	Sullins	PBC06SAAN
1	J10	—	Sullins	PBC14DAAN
1	LCD1	—	Newhaven Displays	C0216CZ-FSW-FBW-3V3
1	P20	—	Sullins	PPPC061LGBN-RC
1	Q2	—	International Rectifier	IRLML6302TRPBF
2	R1	3.3 kΩ	Stackpole Electronics International	RMCF0603FT3K3
	R18	3.3 kΩ	Stackpole Electronics International	RMCF0603FT3K3
2	R20	100 Ω	Stackpole Electronics International	RMCF0603FT100R
	R24	100 Ω	Stackpole Electronics International	RMCF0603FT100R
16	R2	330 Ω	Stackpole Electronics International	RMCF0603FT330R
	R4	330 Ω	Stackpole Electronics International	RMCF0603FT330R
	R5	330 Ω	Stackpole Electronics International	RMCF0603FT330R
	R6	330 Ω	Stackpole Electronics International	RMCF0603FT330R
	R7	330 Ω	Stackpole Electronics International	RMCF0603FT330R
	R8	330 Ω	Stackpole Electronics International	RMCF0603FT330R
	R9	330 Ω	Stackpole Electronics International	RMCF0603FT330R
	R10	330 Ω	Stackpole Electronics International	RMCF0603FT330R
	R11	330 Ω	Stackpole Electronics International	RMCF0603FT330R
	R12	330 Ω	Stackpole Electronics International	RMCF0603FT330R
	R13	330 Ω	Stackpole Electronics International	RMCF0603FT330R
	R14	330 Ω	Stackpole Electronics International	RMCF0603FT330R
	R15	330 Ω	Stackpole Electronics International	RMCF0603FT330R
	R16	330 Ω	Stackpole Electronics International	RMCF0603FT330R
	R28	330 Ω	Stackpole Electronics International	RMCF0603FT330R
	R29	330 Ω	Stackpole Electronics International	RMCF0603FT330R

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TABLE C-1: EMBEDDED SECURITY BOARD BILL OF MATERIALS

Qty	Part	Value	Manufacturer	MFG Part Number
1	R26	1 kΩ	Stackpole Electronics International	RMCF0603FT1K00
5	R17	10 kΩ	Stackpole Electronics International	RMCF0603FT10K0
	R19	10 kΩ	Stackpole Electronics International	RMCF0603FT10K0
	R25	10 kΩ	Stackpole Electronics International	RMCF0603FT10K0
	R27	DNP	Do not Populate	Do Not Populate
	R30	10 kΩ	Stackpole Electronics International	RMCF0603FT10K0
1	R21	12 kΩ	Stackpole Electronics International	RMCF0603FT12K0
1	R22	20 kΩ	Stackpole Electronics International	RMCF0603FT20K0
1	R23	28 kΩ	Stackpole Electronics International	RNCP0603FTD28K0
1	R31	100 kΩ	Stackpole Electronics International	RMCF0603FT100K
1	R3	1 MΩ	Stackpole Electronics International	RMCF0603FT1M00
1	S1	—	E-Switch	EG1390B
9	SW1	—	Omron	B3S-1000P
	SW2	—	Omron	B3S-1000P
	SW3	—	Omron	B3S-1000P
	SW4	—	Omron	B3S-1000P
	SW5	—	Omron	B3S-1000P
	SW6	—	Omron	B3S-1000P
	SW7	—	Omron	B3S-1000P
	SW8	—	Omron	B3S-1000P
	$\overline{\text{MCLR}}$	—	Omron	B3S-1000P
1	U1	P16LF1947-I/PT	Microchip Technology Inc.	PIC16LF1947-I/PT
1	U2	MCP2200	Microchip Technology Inc.	MCP2200-I/MQ
1	U3	MCP1703-3.3	Microchip Technology Inc.	MCP1703T-3302E/MB
1	U4	PIC16LF1938-I/SS_28-PIN	Microchip Technology Inc.	PIC16LF1938-I/SS
1	U5	MCP795W10-I/ST	Microchip Technology Inc.	MCP795W10-I/ST
1	Y1	12 MHz	NDK	NX3225SA-12.000000MHZ
2	Y2	32.768 kHz	Abracon	ABS06-32.768KHZ-T
	Y3	32.768 kHz	Abracon	ABS06-32.768KHZ-T

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Fax: 86-28-8665-7889

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Fax: 86-23-8980-9500

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Tel: 86-571-2819-3187
Fax: 86-571-2819-3189

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Fax: 86-27-5980-5118

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

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Fax: 86-756-3210049

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