# KEELOQ® EVALUATION KIT II User's Guide

INCLUDES:

- About the KEELOQ Evaluation Kit II
- Installing KEELOQ Evaluation Kit II
- Evaluation Kit II GUI Software
- Monitoring KEELOQ Transmissions
- KEELOQ Encoders
- Demonstrating Transmitters
- The Main Board
- Appendix A: Schematic Diagrams
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- Appendix D: Connectors

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- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the PICmicro microcontroller in a manner outside the operating specifications contained in the data sheet. The person doing so may be engaged in theft of intellectual property.
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# About the KEELOQ® Evaluation Kit II

## 1.0 INTRODUCTION

The KEELOQ® Evaluation Kit II provides the opportunity to evaluate KEELOQ Code Hopping Technology quickly and easily without having to make a large capital investment. The evaluation kit contains all the hardware and software necessary to implement a fully functional remote control system and demonstrate all operating modes of the following devices:

- HCS101, HCS200, HCS201, HCS300, HCS301, HCS320, HCS360, HCS361, HCS362, HCS365 and HCS370 encoders
- SIMPLE (AN663/AN659), NORMAL (AN661/AN642), SECURE (AN662/AN652) Software Decoders and related Application Notes
- HCS500 (8-pin), HCS512 (18-pin) and HCS515 (14-pin) Decoders

The kit can also be used to program and demonstrate the Encoder functionality of the HCS410, HCS412 and HCS473 transponders (trans-coders).

The included Windows®-based software can be used to program the demonstration transmitters and the DIP samples provided in the sample kit. Encryption keys, configuration information and other user selectable information are automatically programmed into the encoder's EEPROM. Although many interdependent parameters must be taken into account when programming the encoder and decoder combination, the process is automated and transparent to the user.

### 1.1 Evaluation Kit Contents

The KEELOQ Evaluation Kit contains the following hardware, software and documentation:

- Programmer and Decoder Demonstration Board
- Two Demo KEELOQ Transmitter Boards
- KEELOQ Secure Data Product CD-ROM
- Sample Kit containing various KEELOQ encoder and decoder samples

The KEELOQ Secure Data Product CD-ROM contains:

- All KEELOQ Devices data sheets
- All KEELOQ, Security related Application Notes
- All KEELOQ Related Software Tools, including:
  - the Windows GUI software for the Evaluation Kit II
  - MPLAB - PRO MATE II support software for KEELOQ
- This User's Guide (DS41155)
- Multiple introductory KEELOQ presentations and Training material

A Separate Accessory Kit (AC162048) can be purchased providing:

- Power Supply Unit (100 – 240V input, 9V output)
- RS-232 Cable

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# Installing KEELOQ® Evaluation Kit II

## 2.0 INSTALLATION

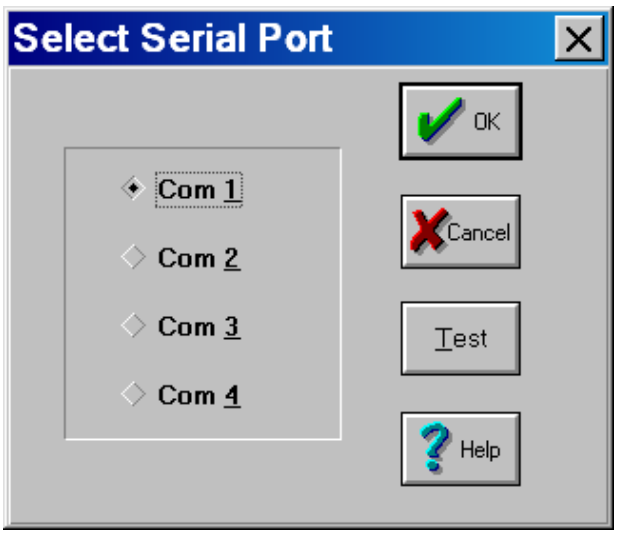
The software provided on the disk is based on the Windows operating system. The KEELOQ Evaluation Kit II software can be installed either in the default C:\HCS_EVAL directory or in another directory of choice.

1. Insert the KEELOQ Secure Data Products CD-ROM into the CD drive (in the following we will refer to it as drive D).
2. If you are using Windows® 3.1, from the Program Manager *File > Run* command, type **D:\tools\HCS_EVAL\SETUP**.
   If you are using Windows 95, 98 or Windows NT® 4.0, click on the **Start** button, select Run and type **D:\tools\HCS_EVAL\SETUP**.
   The Setup screen will appear requesting to confirm the installation.
   Click **OK** to continue, or **Cancel** to abort the installation.
3. The Setup program will then display the "Select Destination" dialog box.
   Click **OK** after selecting where the software is to be installed or click **Cancel** to abort the installation.
4. The "Make Backups?" dialog box will appear.
   Click **Yes** to backup files being replaced.
   Click **No** to overwrite files without backup.
   Click **Cancel** to abort the installation.
5. If **Yes** was selected in the previous step the "The Select Backup Directory" dialog box appears.
   Click **OK** after selecting a directory where backups will be stored.
   Click **Cancel** to abort the installation.
6. After the files have been installed the "Install Icons" dialog box appears
   Click **Yes** to add the software Icons.
   Click **No** to skip adding the Icons.
   Click **Cancel** to abort installation.
7. After the software has been successfully installed, a "Setup Complete" message will appear.

### 2.1 Serial Port Selection

The KEELOQ software uses a serial port to communicate with the programmer board. The active serial port defaults to COM1 but can be changed in the "Com Port" dialog box (Figure 2-1). The dialog box is displayed by selecting "Com Port" from the "Options" menu.

**FIGURE 2-1: SERIAL PORT SELECTION DIALOG BOX**





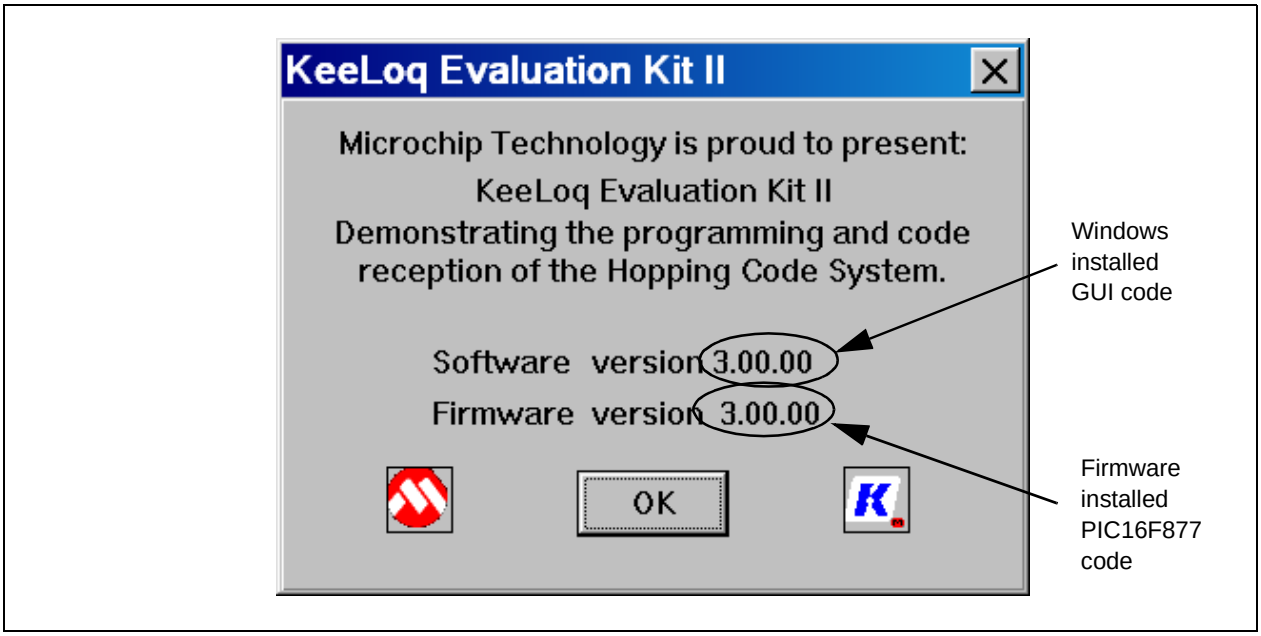
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Test the selected serial port by connecting the programmer board to the appropriate COM port, power the programmer board and press the "Test" button. The software will display a message indicating whether the programmer has been found or not.

## 2.2 Checking Windows Software and Installed Firmware Versions

The Windows Graphical User Interface (GUI) software version and the programmer/receiver demo board firmware version may be verified from the main menu: Help-> About. The programmer/receiver demo board must be powered (with a 9V battery or an external power supply) and connected to the computer's serial port for the firmware verification.

**FIGURE 2-2: THE ABOUT DIALOG BOX .**




The About command in fact exercises the currently selected serial port (or the default one) and verifies the programmer/receiver board's presence.

If a board is not found or is not powered at the time of the test, an error message will be displayed in place of the firmware version numbers.

The two version numbers most probably will differ as new firmware and software revisions will be released to improve or add support for new devices and features.

# Evaluation Kit II GUI Software

## 3.0 THE GRAPHICAL USER INTERFACE

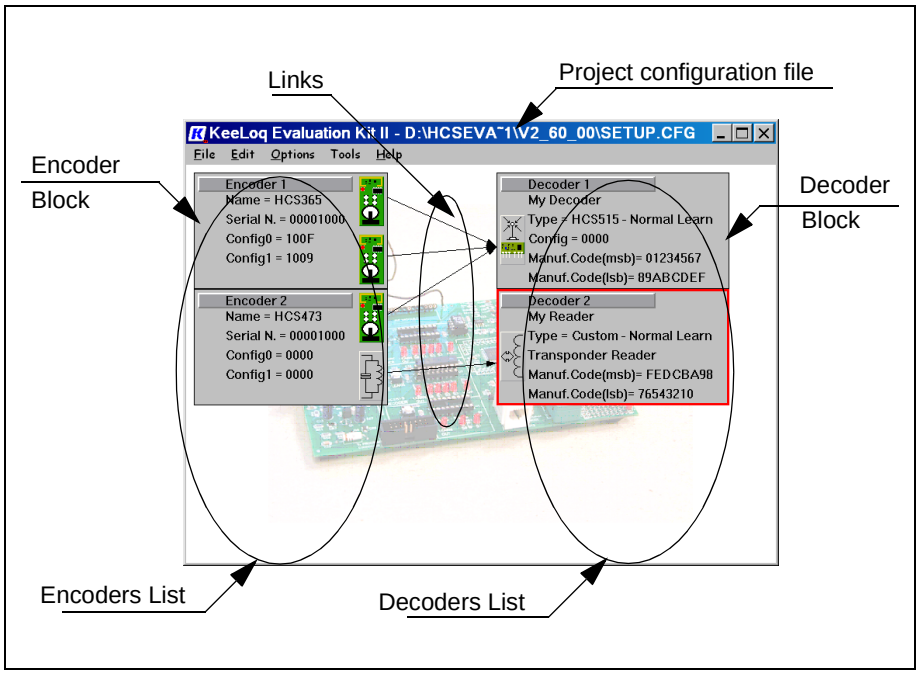
The Evaluation Kit II's new Graphical User Interface (GUI) is centered around a simple paradigm. The user creates a Project by assembling encoder blocks (up to four) and decoder blocks (up to four) in the project window and then visually defines their relationship.

Figure 3-1 shows an example configuration screen shot. The user is defining a system composed of two encoders; an HCS365 Advanced Dual Encoder and an HCS473 3-axis transcoder. There are also two decoders: (1) an HCS515 Integrated 14-pin Decoder and (2) a Custom defined Transponder Reader.

The Links, represented graphically as arrows, illustrate how the various encoders are bound to the HCS515 decoder (currently configured for Normal Learn). The encoders will therefore be programmed with both a matching Key Generation Algorithm (Normal Learn) and a matching Manufacturer Code (in this case, the default value: 0123456789ABCDEF $_{HEX}$).

The transponder portion of the HCS473 is linked, instead, to the custom defined Transponder Reader so the Key used for Authentication (IFF) will match both the Key Generation Algorithm (Simple Learn in this case) and the Reader's Manufacturers Code ( in this example, the value FEDCBA9876543210 $_{HEX}$).

**FIGURE 3-1: THE EVALUATION KIT II GUI**

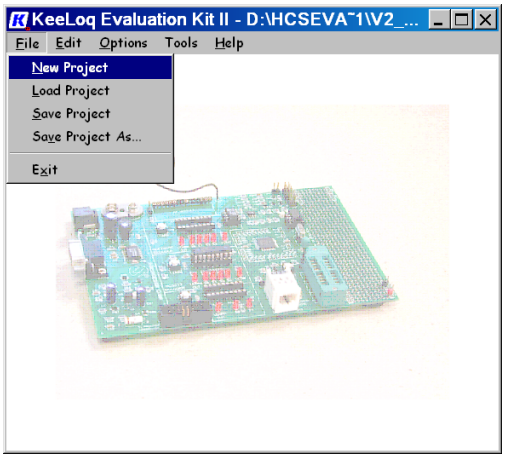



### 3.0.1 CREATING A NEW PROJECT

The user will typically create a new project using the File->New Project menu. A prompt will confirm the intention to erase any components of the previous project and start from scratch with an empty project window.


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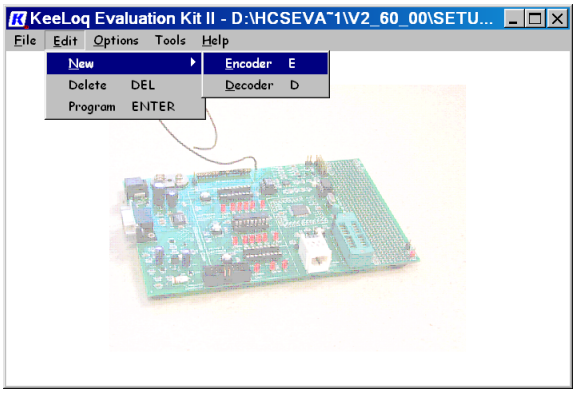
**FIGURE 3-2: THE FILE NEW PROJECT MENU**




### 3.0.2 ADDING NEW ENCODERS AND DECODERS

Select the Edit->New->Encoder or the Edit->New->Decoder command (see Figure 3-3) from the main menu to add an encoder or decoder block to the current project. Keyboard "E" or "D", respectively, may be used as shortcuts. (refer also to Figure 3-1 for the encoder and decoder list aspect).

**FIGURE 3-3: ADDING ENCODERS AND DECODERS TO A PROJECT**




The program will immediately display a New Encoder or Decoder Dialog Box (see Figure 3-4 and Figure 3-5) allowing the user to select a desired model.

The device selection dialog boxes show lists of available and supported models to choose from. One of the many distinguishing characteristics of each device is indicated: HCS301 operating voltage, HCS201's adjustable internal oscillator and HCS473 three-axis transponder.

**FIGURE 3-4: THE NEW ENCODER DIALOG BOX**

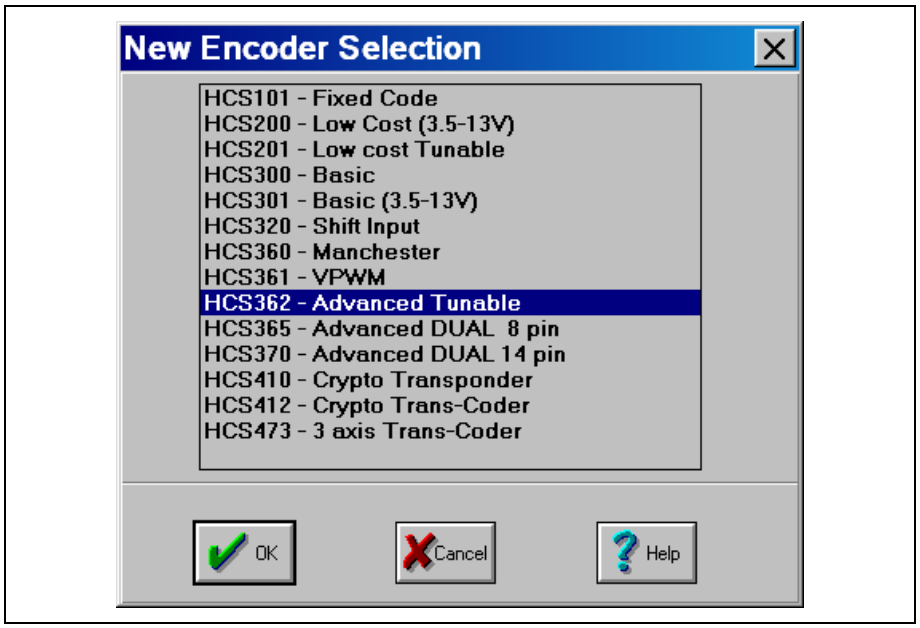
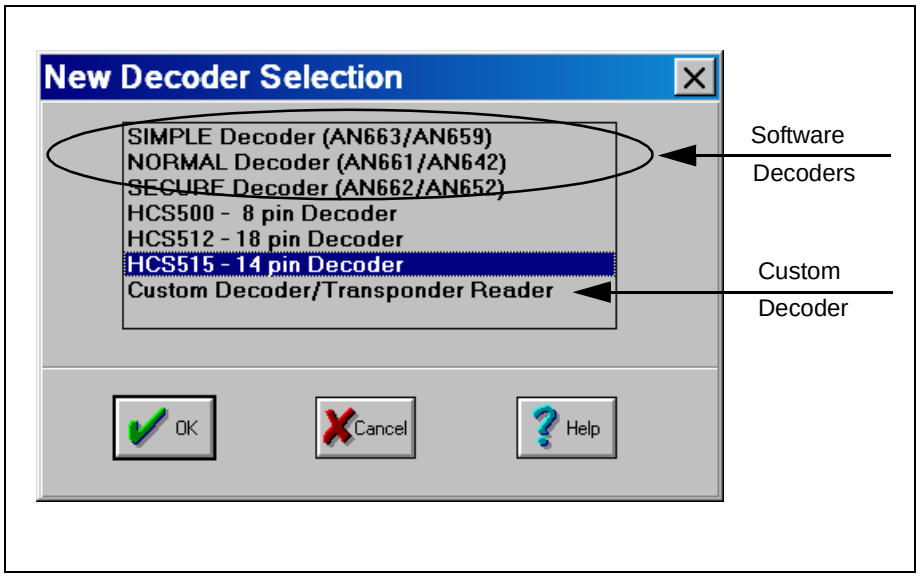



**FIGURE 3-5: THE NEW DECODER DIALOG BOX**



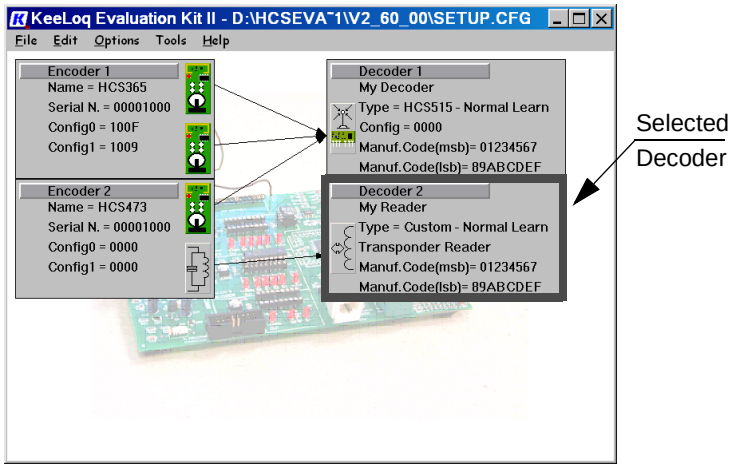

### 3.0.3 SELECTING AND DELETING AN ENCODER OR DECODER

Using the mouse, click on any encoder/decoder block to select it; its "selected" graphical block representation will change to a red border (see Figure 3-6). The keyboard arrow up and arrow down keys change the selection to adjacent encoders or decoders in the same list. The keyboard arrow left and arrow right keys will switch between the lists.

Hitting the DELETE (DEL) key or selecting the Edit->Delete function from the main menu removes the selected block from the project window. A dialog box will pop-up asking to confirm the operation before the actual deletion.


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**FIGURE 3-6: THE SELECTED ENCODER/DECODER**



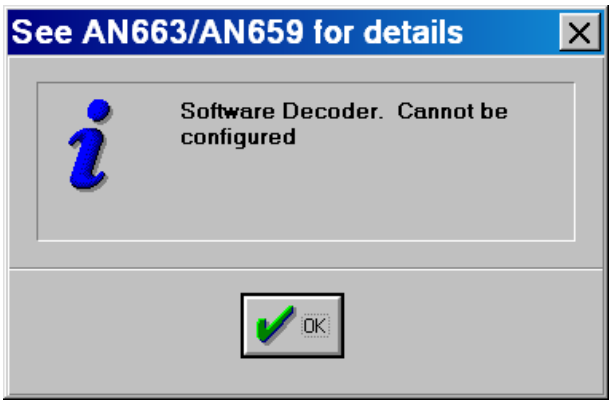

### 3.0.4 ENCODER AND DECODER CONFIGURATION

A selected Encoder/Decoder block may be configured by either pressing the ENTER key, double clicking with the mouse or by selecting the Edit->Configure option from the main menu.

The type and model of the currently selected device determines what Configuration Dialog Box aspects will immediately open.

Software decoders, based on their respective Application Note's source code, are the only devices that cannot be configured; their parameters are defined in firmware. To change software decoder parameters one must modify the source code, re-assemble it and program new samples (using a PICSTART Plus or a PRO MATE II Universal Programmer).

**FIGURE 3-7: THE SOFTWARE DECODERS WARNING MESSAGE**




### 3.0.5 DEFINING CUSTOM DECODERS

A user may wish to define a decoder component derived from Application Note software or other Custom Code developed to fulfill a requirement no existing decoder could. A Manchester reception based decoder using a 40-pin PIC16F77 FLASH microcontroller, for example.

Such a Custom decoder is but one device in a larger project. Definition of both its Learning Method and Manufacturer Code is essential when programming the linked encoders. For this reason, the last option in the New Decoder Dialog Box (Figure 3-5) allows the definition of such a Custom Decoder.

**FIGURE 3-8: CUSTOM DECODER CONFIGURATION**

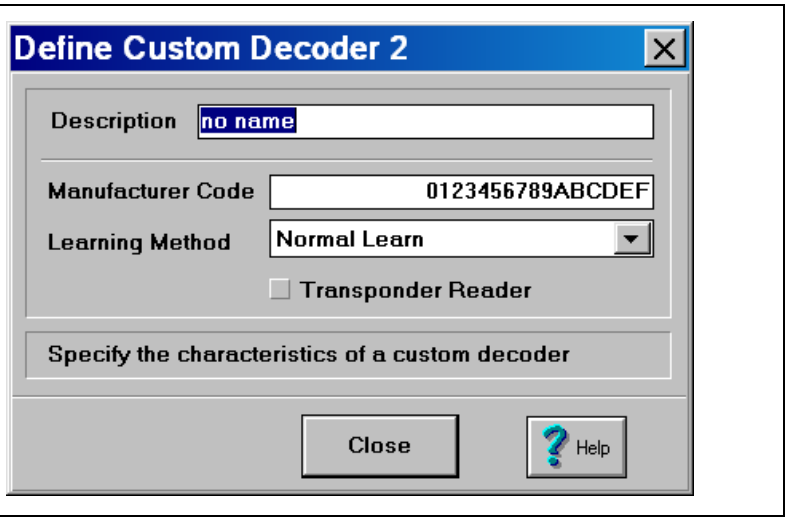



Figure 3-8 shows what information to specify in defining a Custom Decoder.

The **Description** field allows a "name" or brief textual description be assigned to the decoder documenting its role in the project. The Description may be up to 16 characters.

Perhaps something like "Manch - PIC16F77", "MyCode rev. 2.5" or any text string significant to the project.

The importance of this Description field will be more clear later when analyzing Encoder Configuration and Linking.

The **Manufacturer Code** is simply a 16-digit hex number (64-bit) that defines the Key unique to this Manufacturer/Project.

The **Learning Method** specifies what scheme will be used to derive the Encryption and Decryption keys unique to each Encoder in the Project.

Finally, the **Transponder Reader** check-box helps the Evaluation Kit software graphically represent the decoder. No standard readers exist for KEELOQ Transponders like the HCS410, HCS412 and HCS473. Their base station, or Reader, must be a custom design (perhaps derived from an Application Note) and it must be represented as such in the Project. Based on custom software, the only means of configuring such devices is by changing source code, re-assembling it and programming a new PICmicro® microcontroller (MCU) using a standard Microchip programmer like a PICSTART Plus or a PRO MATE II.


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### 3.0.5.1 HCS512 Configuration and Programming

If the selected decoder block is an HCS512, the corresponding Configuration Dialog Box will allow the user to configure:

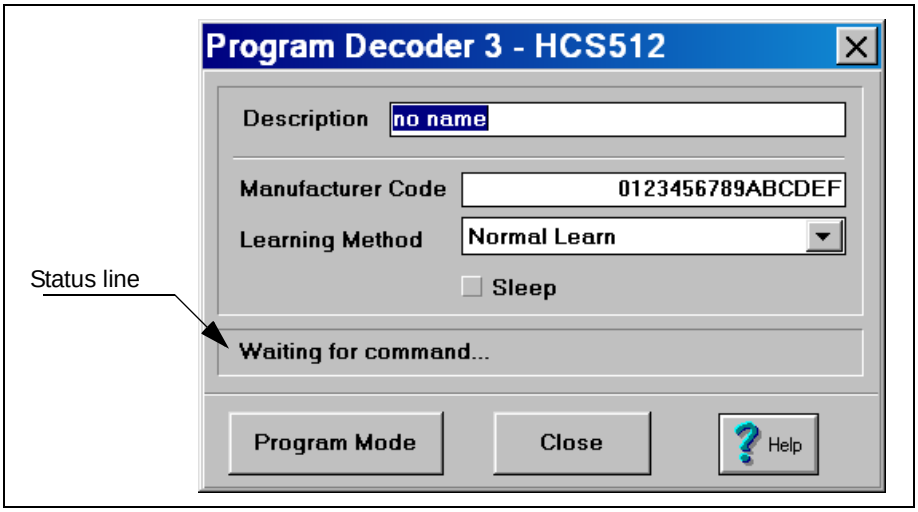
- Description
- Manufacturer Code
- Learning Method
- Enable/Disable the Sleep Mode

An HCS512 DIP sample must be installed in the appropriate Main Board socket to complete the device programming attempt.

Pressing the "Program Mode" button will first result in an internal evaluation of the various configuration values. The input fields will then be disabled, grayed-out, safely freezing the configuration for the following programming step. The "Program Mode" button will reflect this state by changing its caption to "Program". Subsequent button activations will now perform the actual programming attempts.

Failure, success or any serial communication error will be reported on the status line.

**FIGURE 3-9: PROGRAMMING THE HCS512**




### 3.0.5.2 HCS515 Configuration and Programming

If the selected decoder block is an HCS515, the corresponding Configuration Dialog Box will allow the user to configure:

- Description
- Manufacturer Code
- Learning Method
- Enable/Disable the Repeat Mode

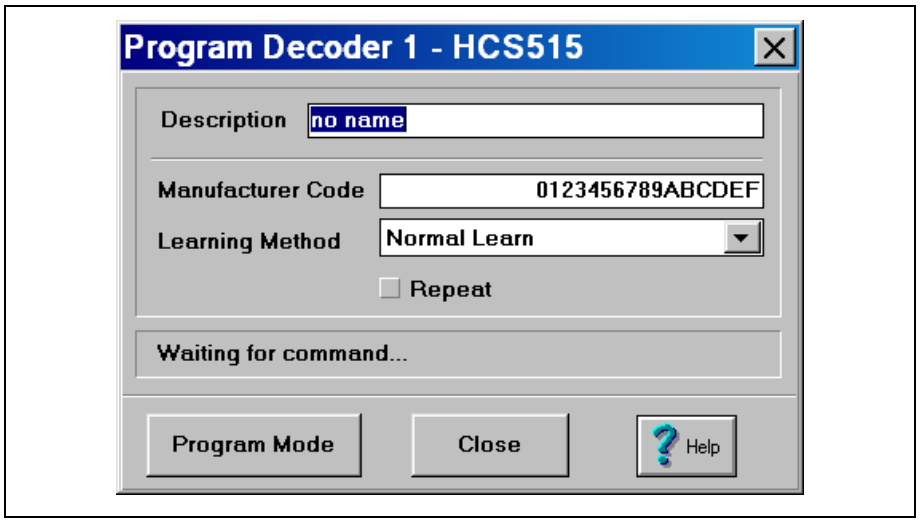
An HCS515 DIP sample must be installed in the appropriate Main Board socket to complete the device programming attempt.

Pressing the "Program Mode" button will first result in an internal evaluation of the various configuration values. The input fields will then be disabled, grayed-out, safely freezing the configuration for the following programming step. The "Program Mode" button will reflect this state by changing its caption to "Program". Subsequent button activations will now perform the actual programming attempts.

Failure, success, or any serial communication error will be reported on the status line.

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**FIGURE 3-10: HCS515 DECODER CONFIGURATION DIALOG BOX**




### 3.0.5.3 HCS500 Configuration and Programming

The HCS500 decoder promises to be obsoleted by the newer HCS515 model. The Evaluation Kit II Main Board therefore requires minor hardware modifications to support the device. The required modifications are detailed in Appendix C.

If the selected decoder block is an HCS500, the corresponding Configuration Dialog Box will allow the user to configure:

- Description
- Manufacturer Code
- Learning Method
- Enable/Disable the Repeat Mode

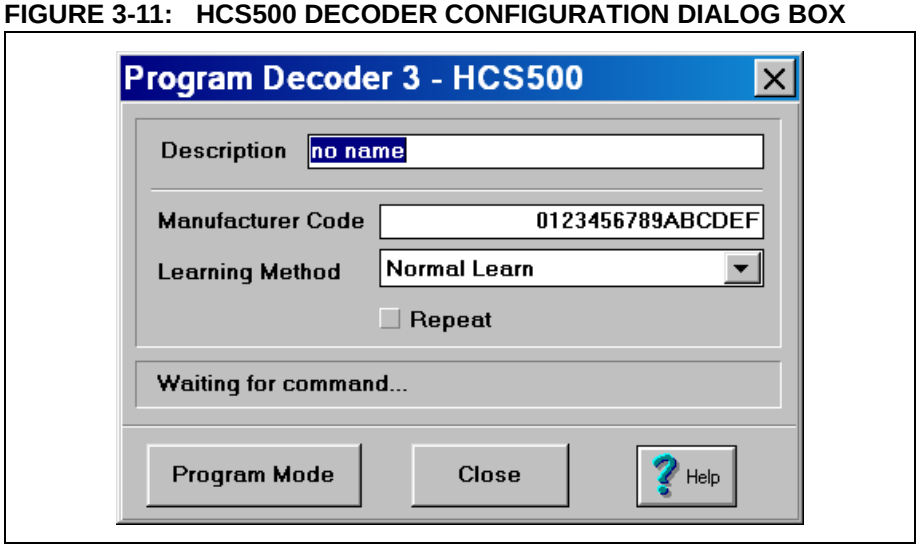
An HCS500 DIP sample and companion 24LC0X eeprom must be installed in the appropriately modified Main Board to complete the device programming attempt.

| **Note:** | When programmed, the HCS500 saves the configuration data in the companion 24LC0X memory. |
|---|---|

Pressing the "Program Mode" button will first result in an internal evaluation of the various configuration values. The input fields will then be disabled, grayed-out, safely freezing the configuration for the following programming step. The "Program Mode" button will reflect this state by changing its caption to "Program". Subsequent button activations will now perform the actual programming attempts.

Failure, success or any serial communication error will be reported on the status line.

**FIGURE 3-11: HCS500 DECODER CONFIGURATION DIALOG BOX**



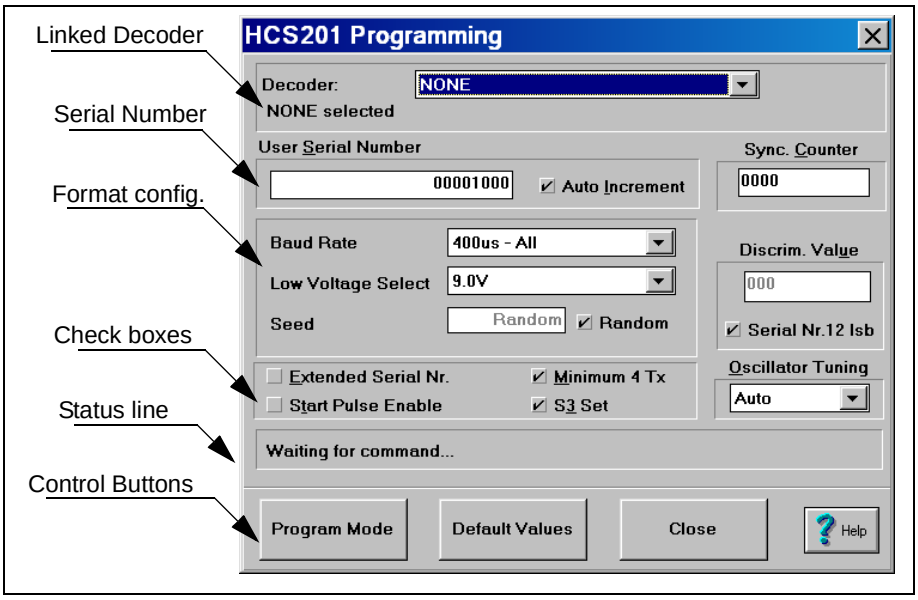


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### 3.0.6 ENCODER CONFIGURATION AND PROGRAMMING

Opening a selected Encoder or Trans-coder model allows the user to view and edit its functional parameters.

**FIGURE 3-12: AN EXAMPLE ENCODER CONFIGURATION DIALOG BOX**




While the number and type of configurable parameters vary from model to model, all dialog boxes share a similar template.

The **Decoder** field **Links** the Encoder to a particular decoder; the decoder which the encoder must be compatible with.

| **Note:** | At least one decoder must be defined in the project before an encoder can be programmed. |
|---|---|

The **Serial Number** field displays the most recently assigned encoder serial number in the current project.

There are several **Format configuration options**; Baud Rate (speed) selection field, Modulation format (PWM, Manchester) and Low Voltage Trip Point Select. The number of options varies with the selected Encoder model.

Several **Check Boxes** to enable and disable various feature like a Start Pulse or a Minimum number of Code Words per transmission

The standard **Status line** to communicate success and/or Failure of a Programming attempt.

Several Control Buttons:

- "Program Mode" freezes the current configuration. The button then changes to a "Program" button for subsequent programming attempts.
- "Default Values" restores a predetermined safe configuration (including grayed out advanced options).
- "Advanced Mode" enables additional input/ configuration fields that are otherwise disabled and grayed-out. The button is present only in complex encoder models and gives the user access to the most complete set of configuration options available for the part.
- "Close" will register any configuration changes and close the dialog box.
- "Help" gives access to a help page relative to the selected part.

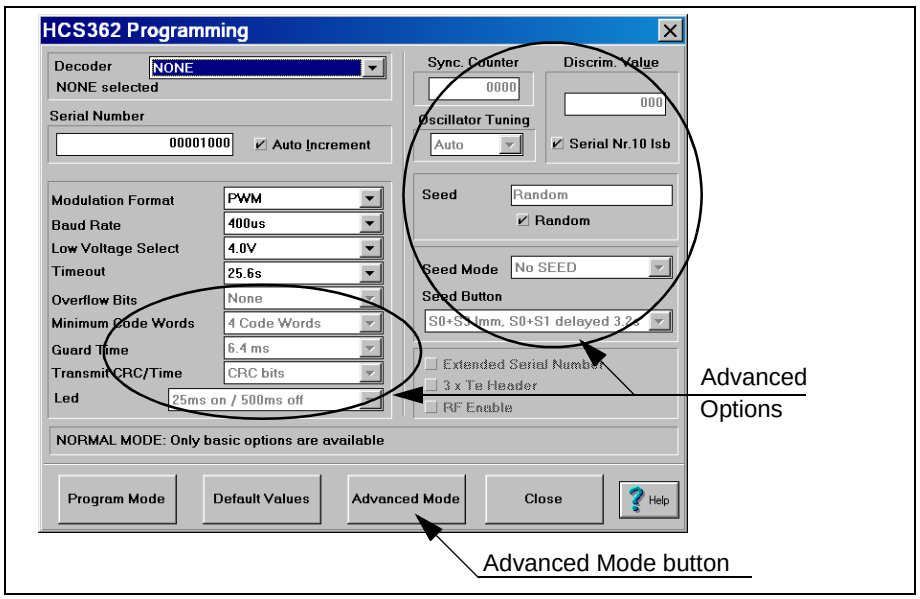
As previously mentioned, Encoder DIP samples may be programmed either by placing them in the appropriate Programming Socket or by "In-Circuit Programing", if mounted on a demo transmitter connected to the Transmitter Programming Connector.

### 3.0.7 ADVANCED ENCODER OPTIONS

A great number of configurable parameters exist in some more complex devices like the HCS365 and HCS370. The user is initially offered the option of editing only a part of them. The remaining options are still visible but the input fields are grayed-out indicating they are disabled. Modifying these advanced options will typically result in encoders being programmed with configurations incompatible with the evaluation kit's standard decoders.

The user can enable/disable the Advanced Options by selecting *Options>Advanced Options* on the main menu before opening an Encoder Configuration Dialog Box. The same result can be obtained by pressing the "Advanced Mode" button inside an Encoder Configuration Dialog Box. The button's caption changes to "Normal Mode" allowing the user to disable the advanced option input when finished. In general, these options should only be modified by users already familiar with KEELOQ encoders and decoders.

**FIGURE 3-13: ADVANCED OPTIONS**




### 3.0.8 SAVING A PROJECT

The **File->Save Project** and **File->Save As** options can be selected from the main menu to save the project's current status. Current status includes:

- the list of Encoders, and for every Encoder:
  - the full Encoder Configuration (including last Serial Number value)
- the list of Decoders and for every Decoder:
  - the full Decoder Configuration

The project file is saved with the assigned name and extension to the selected directory. Although the ".cfg" extension is suggested, any extension will suffice. The last project's configuration file is always remembered by the Evaluation Kit II software and automatically loaded at the next launch of the program.

### 3.0.9 LOADING A PROJECT

Similarly, selecting **File->Load Project** from the main menu allows the re-load of a previously saved Project (configuration file).

The user is warned that in doing so the current Project configuration is lost.

### 3.0.10 PRINTING A PROJECT CONFIGURATION FILE

Project configuration files are simply ASCII text files built using Microsoft Windows Private Profile functions.

Their content is organized in sections separated by section headers (like [Encoder 1]) and every section has item-value pairs used to store the unique configuration parameters values (like Seed_Type = 1).

As a result, a configuration file can be loaded using Notepad or any Text Editing program and then printed, e-mailed or faxed for documentation or support purposes.

| **Note:** | The user is recommended not to edit the configuration file contents by hand since this could lead to unexpected results when the Evaluation Kit II GUI Software re-loads the project. |
|---|---|


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# Monitoring KEELOQ® Transmissions

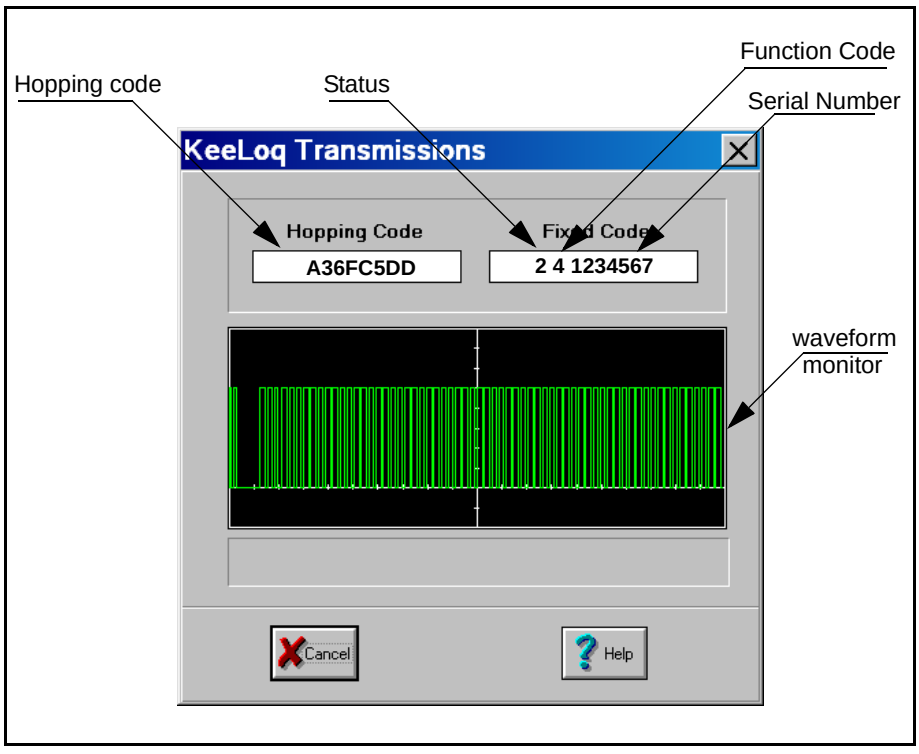
## 4.0 DESCRIPTION

The radio receiver module on the Main Board is connected to all three demonstration decoder sockets as well as to the main processor (PIC16F877).

The GUI software monitors the Evaluation Kit's radio receiver data by selecting the Tools->Monitor Radio option from the main menu. A Radio Transmission Monitor dialog box will appear and the GUI software will begin polling the Main Board for new transmissions at regular 1/second intervals. The GUI software receives notification of each new transmission, updates the Hopping code and Fixed code fields appropriately and reproduces an oscilloscope-like waveform display for demonstration purposes.

The initial firmware and software release (rev.3.00) supports only PWM modulation format and a limited subset of Baud Rates (200 – 400 µs TE). Attempting to Monitor transmissions from encoders configured for higher or lower Baud Rates or different modulation formats will fail, resulting in the transmission being ignored.

**FIGURE 4-1: THE RADIO TRANSMISSION MONITOR DIALOG BOX**



## 4.1 Receiving KEELOQ Transmissions

All Encoder models share a common code word format composed of:

- 32-bit Hopping Code portion containing the encrypted sychronization information
- 28-bit Serial Number that is the unique transmitter identifier
- 4-bit Function Code indicating what button(s) activated the transmitter. The Function Code is sometimes combined with the serial number creating a single 32-bit Extended Serial Number
- 1 Low Voltage indication bit communicating to the decoder the transmitter battery status
- 1 to 5, additional status bits depending on the encoder model.

The Evaluation Kit II firmware attempts to receive only the first 66 bits of any radio transmission. The GUI software separates this data into the appropriate dialog box fields after a successful reception.

The example in Figure 4-1 shows that:

- The **Hopping Code** received is $A36FC5DD_{16}$
- The transmitter **Serial Number** is $1234567_{16}$
- The Function Code transmitted is 4 (S1 activated on the transmitter)
- Status bits are `0` and `1` respectively. Assuming the encoder used was an HCS300 they can be interpreted as:
  - Low Voltage = `0`
  - Repeat = `1`

## 4.2 Troubleshooting

### PROBLEM:

The GUI software is unable to initialize the Main Board and a Serial Communication Error message is displayed.

### SOLUTIONS:

1. Check that the RS-232 cable between the PC and main board is in place.
2. Check that the Main Board is powered appropriately.
3. Check that the correct serial port has been selected.
4. Reset the main board.

### PROBLEM:

No transmissions are received:

### SOLUTIONS:

1. Check that the connection between the decoder and main board is correct.
2. Check that the RS-232 cable between the main board and PC is in place.
3. Check that the JP1 jumper on the main board is in place.
4. Check that the link JP1 on the Demo Transmitter board is in place.


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# KEELOQ® Encoders

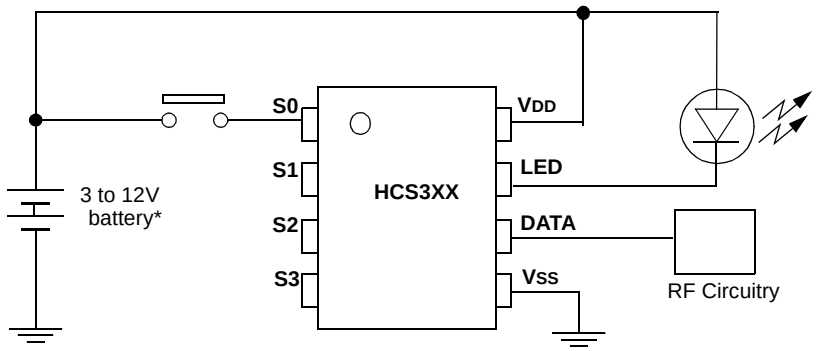
## 5.0 GENERAL DESCRIPTION

Microchip KEELOQ Code Hopping encoders are intended for secure authentication and remote control applications.

The encoders contain internal non-volatile memory (EEPROM) for data and configuration storage. They will retain information for several years, even when stored without power supply.

Minimal external components are required to implement a complete remote transmitter. All input pull down resistors, oscillator circuit components, voltage regulation, LED driving, voltage sensing and button debouncing circuits are integrated in the KEELOQ encoder silicon.

**FIGURE 5-1: TYPICAL KEELOQ TRANSMITTER**




(***Note:** depending on actual encoder model)

In addition to the IC, all that is required is a circuit for transmitting the information over the desired media (e.g., a UHF radio transmitter), a battery, and a button switch as shown in Figure 5-1. A single encoder can command a multifunction decoder to activate up to 15 specific functions/outputs. The user would select the desired function pressing one or more buttons on the transmitter.

For a complete list of all the features of the various KEELOQ encoders and a description of their features, consult the related data sheets included in the CD ROM or download them from the Microchip web site: http:\\www.microchip.com.

A brief summary of basic encoder features is given in Table 5-1.

### 5.1 Encoder Features

#### 5.1.1 ENCODER SYNCHRONIZATION

Every KEELOQ encoder has at least a 16-bit synchronization counter that is incremented each time the encoder is activated. The counter is encrypted and transmitted as part of a code hopping transmission. When decoder learns a transmitter, the encoder's received serial number, calculated encryption key and decrypted synchronization information are stored in EEPROM. It is then very easy for a decoder to check whether a given transmission is a valid transmission or a transmission re-transmitted by a code grabber. The received counter value must be greater than the stored synchronization counter value for a transmission to be valid.

In addition, provisions must be made for counter discrepancies caused by a user activating the transmitter while out of range of the decoder. KEELOQ decoders accommodate this by providing two synchronization windows. If the synchronization counter received is 1 to 16 counts above the stored counter, the decoder accepts the transmission as a valid transmission, updates the stored counter and activates the appropriate output. If the synchronization counter received is between 16 and 32k counts above the stored counter, the decoder temporarily stores the received counter and waits for a second transmission. The second transmission's counter is compared to the temporary counter. If they are consecutive, the decoder re-synchronizes by storing the latest counter and activates the appropriate output. Counter values outside of these windows, 32k – 64k counts above the stored counter value, are considered invalid and these transmissions are ignored.

### 5.1.2 ENCODER ACTIVATION

The encoder is activated when one or more of the encoder inputs (S0, S1, S2, S3) is pulled HIGH. The function code ("button code") is one part of the transmitted code word. The function code mirrors the encoder inputs and may be used to activate specific functions of a multifunction decoder. For example, S0 could be used to deactivate the alarm and unlock the car, S1 to open the trunk and when pressed together they activate a panic function.

### 5.1.3 TRANSMISSION BAUD RATES AND MODULATION FORMATS

Various modulation formats can be selected for the encoder data output signal. All KEELOQ encoders offer a Pulse Width Modulation (PWM) format. In addition, encoders like the HCS360 and HCS362 offer Manchester Encoding and the HCS361 and HCS365 offer Variable Pulse Width Modulation (VPWM).

Every encoder offers multiple transmission Baud Rates; expressed in terms of the an elementary time element ($T_E$) duration. $T_E$ typically ranges from a slowest Baud Rate pulse width of 800 µs to a fastest Baud Rate pulse width of 100 µs. The number of Baud Rate options and exact values vary with the chosen encoder model.

### 5.1.4 OPERATING VOLTAGE

The KEELOQ encoder product line covers a wide range of operating voltages. Most models operate from 2V to 6V which is ideal for applications using one or two 3V lithium batteries. Selected models operate directly from a 9V to 12V battery which is convenient for applications where a standard 9V battery or a common 12V (type GP23) battery is used.

### 5.1.5 LOW VOLTAGE DETECTION

All KEELOQ encoders include a low voltage status bit in each transmission. The bit is set when the encoder detects the supply voltage has dropped below a set threshold. This allows the decoder/receiver to indicate when the transmitter battery needs replacement. Consult the individual encoder data sheets for the exact threshold levels available.

### 5.1.6 COUNTER OVERFLOW

A 16-bit synchronization counter, minimum, is incremented, encrypted, and transmitted each time the encoder is activated. The 16-bit length of the synchronization counter allows 10 activations per day for 18 years before the cycle begins to repeat. Should the system designer conclude this is not adequate, then the overflow bits can be used to extend this cycle. One of the two overflow bits is cleared each time the counter wraps 0000. Therefore, utilizing one overflow bit doubles the range of the synchronization counter and utilizing both triples the range of the synchronization counter.

### 5.1.7 AUTO-SHUTOFF

An auto-shutoff function is available on KEELOQ encoders. If enabled, the auto-shutoff function stops the device from transmitting if a button is continuously pressed for a long period of time. This prevents the encoder from draining the battery if a button is accidentally pressed while in a pocket or purse. The time-out period is typically 25 seconds but some devices have shorter or programmable time-out periods essential for certification in some countries.


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**TABLE 5-1: SUMMARY OF KEELOQ ENCODER DIFFERENCES**

| Encoder | PWM | Manchester | VPWM | 13V | Overflow Bits | Function Inputs | LED |
|---|---|---|---|---|---|---|---|
| HCS101 | X | — | — | X | — | 3 | — |
| HCS200 | X | — | — | X | — | 3 | — |
| HCS201 | X | — | — | X | — | 3 | — |
| HCS300 | X | — | — | — | — | 3 | — |
| HCS301 | X | — | — | X | 2 | 4 | X |
| HCS320 | X | — | — | X | 2 | 4 | X |
| HCS360 | X | X | — | — | 1 | 4 | X |
| HCS361 | X | — | X | — | 1 | 4 | X |
| HCS362 | X | X | — | — | 2 | 4 | X |
| HCS365 | X | X | X | — | 2 | 4 | X |
| HCS370 | X | X | X | — | 2 | 6 | X |
| HCS410 | X | X | — | — | 2 | 3 | X |
| HCS412 | X | X | — | — | 2 | 3 | X |
| HCS473 | X | X | X | — | 2 | 4 | X |

# Demonstration Transmitters

## 6.0 DEMONSTRATION TRANSMITTERS

The evaluation kit demonstration transmitters support any 8- or 14-pin DIP KEELOQ encoder as shown in Figure 6-1.

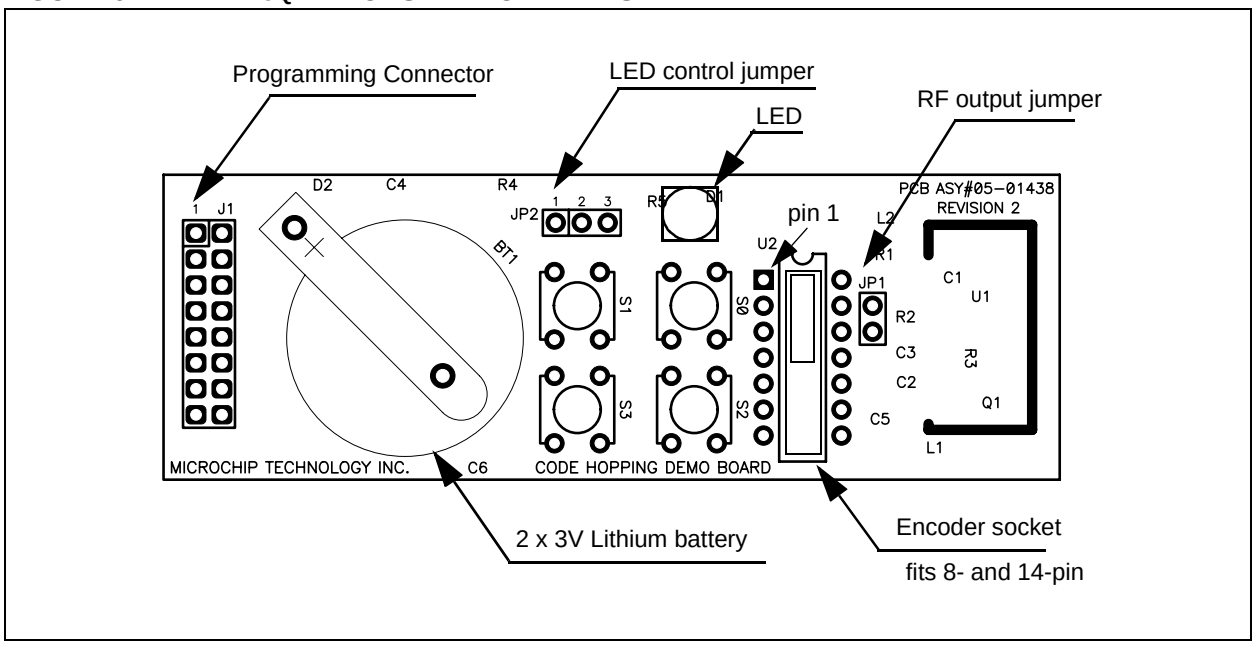
The encoder socket U2 supports 8-pin and 14-pin encoders inserted with pin 1 in the corresponding pin 1 of the 14-pin socket (Figure 6-1). The demo transmitter PCB leaves pins 5 through 9 unconnected to accommodate the different and sometimes conflicting pin functionalities on the HCS473, HCS370 and future products. The user is advised to avoid hand contact with those pins as there may be only weak internal pull ups on the most sensitive inputs. Inadvertent input signals could trigger unexpected responses from the device confusing the demonstration.

The **four buttons** (S0..S3) on the demonstration transmitters are connected to the appropriate inputs on the encoder (S0 through S3). The user may activate any combination of encoder inputs transmitting any of the 15 possible function codes. The RFEN output is not used by the demonstration transmitter and should be disabled as several encoders share its output with a button input. If enabled, a button input may be lost.

The **RF oscillator** uses a Surface Acoustic Wave (SAW) resonator to operate at 433.92 MHz. Note that this is not sufficient to ensure compliance with EC and/or FCC regulations.

**Jumper JP1** connects the DATA output of the encoder to the RF transmitter modulator circuit input. If removed, it can be used to monitor the digital encoder output while the RF section is disabled.

**FIGURE 6-1: KEELOQ DEMONSTRATION TRANSMITTER**





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The **battery holder BT1** accepts one or two CR2016 3V lithium batteries, positive side up. While most encoder models will demonstrate reliable operation down to 2V, the demo RF oscillator circuit is only ensured to operate properly down to 4.5V.

The **LED** functionality varies with the encoder model mounted in the transmitter's socket. Its connection changes with the encoder model as well. **Jumper JP2** must be set according to the following Table 6-1:

**TABLE 6-1:**

| Encoder | LED | When Flashing Indicates | Jumper 2 setting |
|---|---|---|---|
| HCS101 | NO | — | Disconnect |
| HCS200 | NO | — | Disconnect |
| HCS201 | NO | — | Disconnect |
| HCS300 | YES | Low Battery | 1-2 |
| HCS301 | YES | Low Battery | 1-2 |
| HCS320 | YES | Shift Level | 1-2 |
| HCS360 | YES | Low Battery | 1-2 |
| HCS361 | YES | Low Battery | 1-2 |
| HCS362 | YES | Low Battery | 1-2 |
| HCS365 | YES | Once = Low Battery | 2-3 |
| HCS370 | YES | Once = Low Battery | 2-3 |
| HCS410 | NO | — | Disconnect |
| HCS412 | YES | Once = Low Battery | 1-2 |
| HCS473 | YES | Once = Low Battery | 2-3 |

The **Programming Connector** (J1) on the left side of Figure 6-1 enables the transmitter's direct connection to the programmer board for In-Circuit Serial Programming™ (ICSP™). Each demo transmitter can therefore be re-configured without removing the encoder from the transmitter board.

**Note:** Although the kit's included Demonstration Transmitters connect multiple lines (up to 8 out of 16 available) to the Programming Connector, **only four** lines are typically required for production In-Circuit Serial Programming (ICSP).

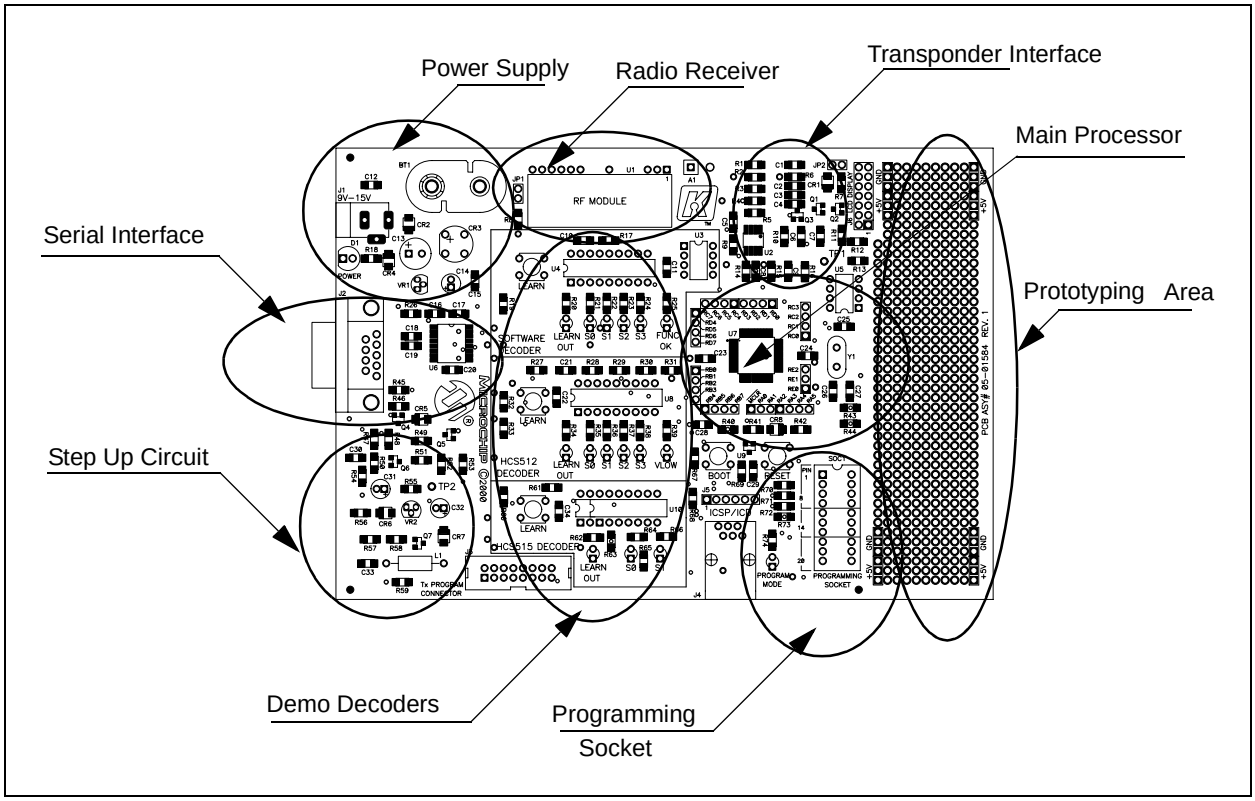
# The Main Board

## 7.0 THE MAIN BOARD

The following chapters examine the main board by dividing it into areas of specific functionalities (see Figure 7-1):

- Radio Receiver
- Demo Decoders
- Main Processor
- Serial Interface
- Programming Socket
- Transponder Interface
- Power Supply
- Step Up Circuit
- Prototyping Area

**FIGURE 7-1: THE MAIN BOARD**





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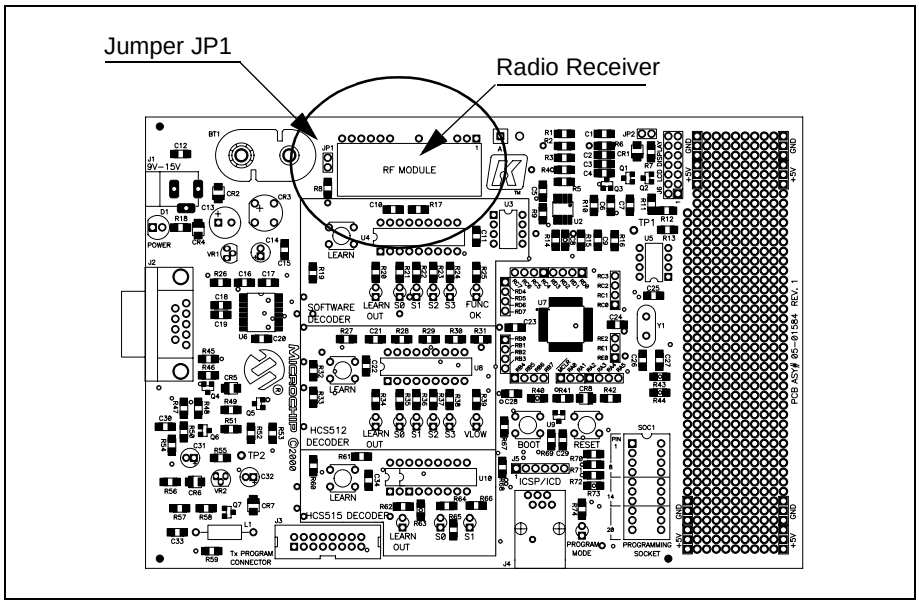
## 7.1 Radio Receiver

The Demo Board contains an ASK Radio Receiver module that serves the Decoders as well as the Main Processor.

The module is a standard thick-film hybrid circuit module tuned by the manufacturer to 433.92 MHz. The demodulated digital output signal may be directly fed into any microcontroller I/O pin.

This type of radio receiver module is common, low cost and recommended to those without RF design capabilities. The pin-out is standard. Thus, it may be easily replaced with similar models accommodating various frequencies, sensitivity levels, modulation methods (ASK vs. FSK) as well as complying to various international certification standards.

**FIGURE 7-2: THE RADIO RECEIVER**




Jumper JP1 allows the radio receiver output to be disconnected from the decoders. This permits monitoring the receiver output on an oscilloscope or injecting an encoder's digital output directly into the decoder

## 7.2 Demonstration Decoders

The Decoder area is subdivided into three sections:

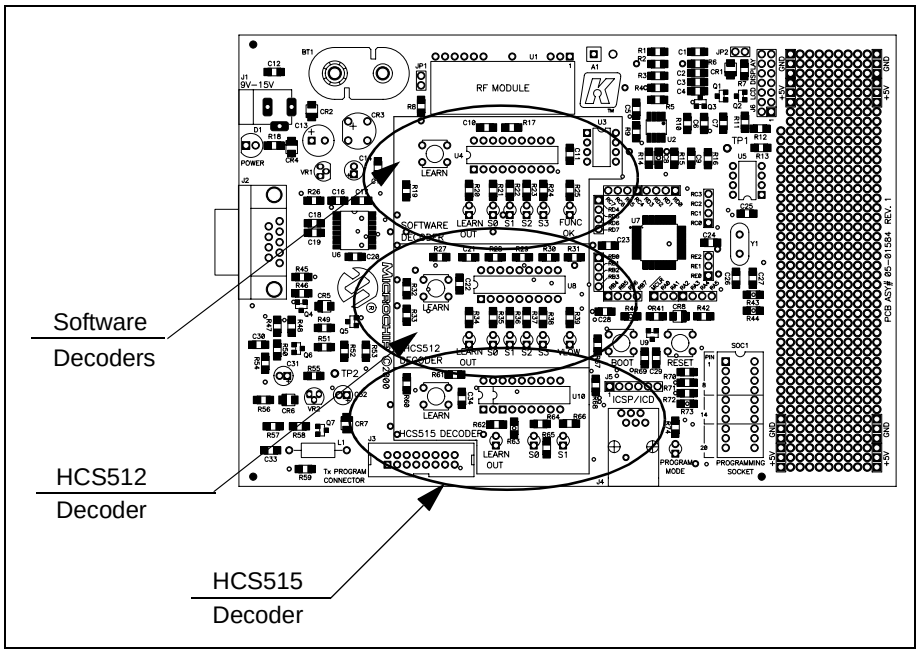
1. Software Decoders
2. HCS512 Decoder
3. HCS515 Decoder

Each section has a Learn button, an RC oscillator circuit and a set of LEDs to show the Decoder's output status but they share the radio receiver output at JP1.

A non-volatile memory is available to the software decoders; 93C46 EEPROM, socket U3. Voltage supervising (Brown out Reset) circuitry and power supply are common with the Main Processor.

The HCS512 and HCS515 decoders are connected to the Main Processor with separate pairs of clock and data lines such that they may be independently configured. Although the current firmware release does not support it, the decoder coprocessor functionality could be demonstrated.

**FIGURE 7-3: THE THREE DECODERS**




### 7.2.1 SOFTWARE DECODERS

Three basic Software Decoders may be demonstrated in this portion of the board:

1. SIMPLE Learn Decoder (AN659_Confidential/AN663_Non Restricted)
2. NORMAL Learn Decoder (AN642_Confidential/AN661_Non Restricted)
3. SECURE Learn Decoder (AN652_Confidential/AN662_Non Restricted)

The decoder functionalities are described in the related Application Notes. Both the Non-Restricted and Confidential versions describe the functionality and methodologies for the different Learning Schemes. The Confidential version further explains the decryption and adds the full source code.

An official introduction to KEELOQ and its different Learning Schemes can be found in either the Application Notes or Technical Briefs TB001 and TB003. In short:

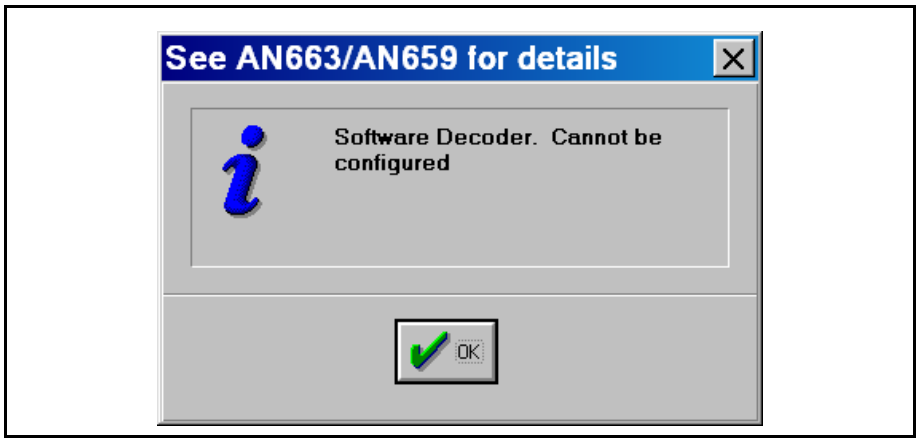
1. The SIMPLE Learn Decoder uses a single common key for all encoders. Such a key is hard-coded in the decoder's firmware. The Learning phase requires only a single encoder transmission for the decoder to memorize the encoder's unique Serial Number and Synchronization Information. The values are stored in the non-volatile memory.
2. The NORMAL Learn Decoder generates a different key for every encoder. The encoder Serial Number is one input to the Key Generation algorithm which is in fact the Decrypt algorithm. Learning requires two consecutive Hopping Code transmissions.
3. The SECURE Learn Decoder uses a random Seed value transmitted by the encoder and either the XOR algorithm or the Decryption algorithm (selectable in the application note source code) as the Key Generation algorithm.

The Manufacturer's Key for the Software Decoder samples is by default set to $0123456789ABCDEF_{16}$.

Since the software decoders are based on OTP microcontrollers (PIC16C54 and PIC16C56) they cannot be configured by the Evaluation Kit software.


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**FIGURE 7-4: WARNING RECEIVED WHEN TRYING TO CONFIGURE A DECODER**




### 7.2.2 HCS512 DECODER

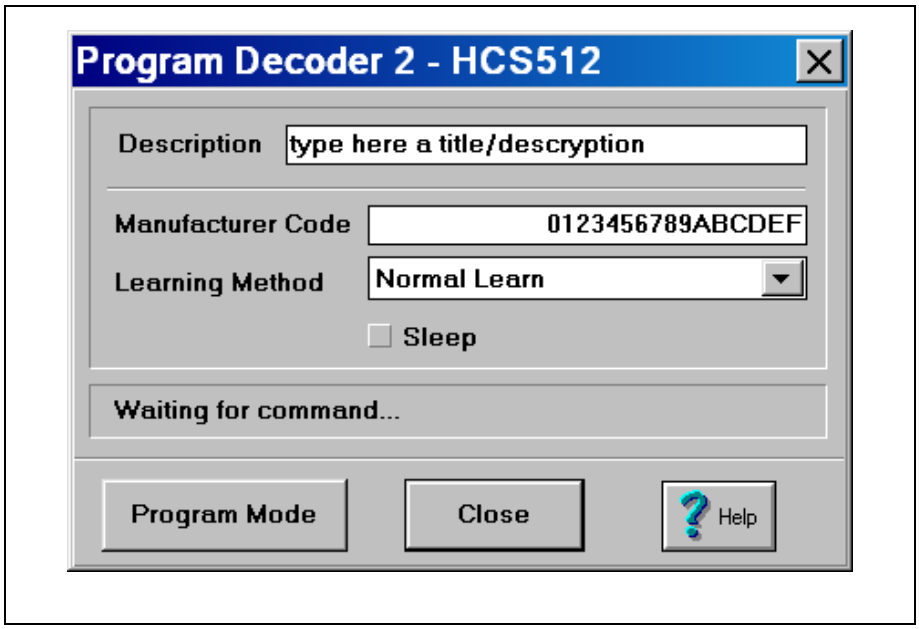
The HCS512 is a fully integrated KEELOQ decoder since it contains the necessary non-volatile memory to store the Serial Number and Synchronization Information for up to four transmitters.

The HCS512 can be used either as a stand-alone decoder, connecting the S0:S3 outputs directly to system outputs, or used in "co-processor mode" in conjunction with a microcontroller when the CLOCK and DATA synchronous communication lines are used.

A Sleep Mode is available for low power applications.

The HCS512 decoder can be configured by the Evaluation Kit software to perform Normal Learn or Secure Learn operation using XOR or Decrypt Algorithm as the Key Generation algorithm.

**FIGURE 7-5: THE HCS512 CONFIGURATION DIALOG BOX.**




In the dialog box above the user can:

- assign text as a title or description of the decoder. The entry will be recorded in the project configuration file for documentation purposes.
- change the Manufacturer Code used for the Key Generation process during Learning
- select the desired learning scheme among:
  - Normal Learn
  - Secure Learn - XOR
  - Secure Learn - Decrypt
- enable the Sleep feature to reduce power consumption when there is no signal coming from the radio.

### 7.2.3 HCS515 DECODER

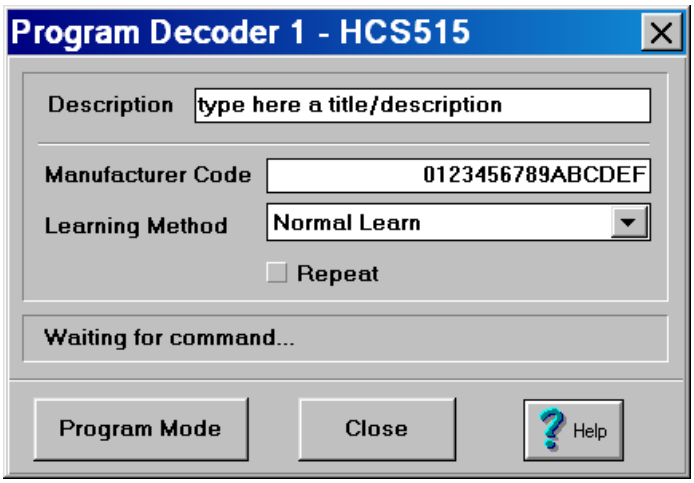
The HCS515 is a low cost integrated KEELOQ decoder in a convenient 14-pin package.

The decoder contains non-volatile memory (EEPROM) to store the Serial Number and Synchronization Information of up to seven transmitters. There is also an additional 1 Kbit of User storage space.

The HCS515 can be used in "stand-alone mode", connecting the S0:S1 outputs directly to system outputs, or used in "co-processor mode" in conjunction with a microcontroller when the CLOCK and DATA synchronous communication lines are used.

The HCS515 decoder can be configured by the Evaluation Kit software to perform Normal Learn or Secure Learn operation using the Decrypt Algorithm as the Key Generation algorithm.

**FIGURE 7-6: THE HCS515 CONFIGURATION DIALOG BOX.**




In this dialog box the user can:

- assign text as a title or description of the decoder. The entry will be recorded in the project configuration file for documentation purposes.
- change the Manufacturer Code used for the Key Generation process during Learning
- select the desired learning scheme among:
  - Normal Learn
  - Secure Learn - Decrypt
- enable the Repeat feature. Repeat instructs the decoder to maintain the outputs active as long as the user presses an encoder button.

## 7.3 Demo Decoders Outputs

**S0:S3** – The outputs mirror the buttons pressed on a learned transmitter.

**LEARN OUT** – The learn output gives the user feedback during a learn sequence. During normal operation the LEARN LED flashes briefly whenever a KEELOQ transmission is received.

**FUNC OK** – The FUNC OK output is activated when the received function code matches the function code received when the decoder was learned

**VLOW** – The output is activated when the VLOW bit is set in a transmission. A KEELOQ encoder sets this bit when the battery supply voltage drops below the predetermined threshold.

**TABLE 7-1: DECODER SUMMARY**

| Decoder | S0:S3 | Learn | FUNC OK | VLOW | Maximum Transmitters |
|---|---|---|---|---|---|
| SIMPLE | X | X | — | — | 15 |
| NORMAL | X | X | X | — | 6 |
| SECURE | X | X | X | — | 6 |
| HCS512 | X | X | — | X | 4 |
| HCS515 | S0:S1 | X | — | — | 7 |


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## 7.4 Learning New Transmitters

All KEELOQ decoders support transmitter learning; adding new transmitters to the system without the need to reprogram the system. During the learning process, the decoder identifies the transmitter and stores its parameters (key and synchronization information) in non-volatile memory for future use. After learning, the decoder will recognize the transmitter and respond to it normally.

The decoder's learning capability also simplifies the replacement of lost transmitters. When a transmitter is lost, the user can "teach" the decoder the key of the replacement transmitter. Different decoders have different capacities in terms of maximum number of transmitters that can be learned (see Table 7-1).

When a transmitter is lost, it is advisable to erase the memory and re-learn the existing transmitters. This will deny the lost transmitter access to the system.

Learning a transmitter is a two-phase process. During the learn process a key is generated by the decoder. The key is stored with the transmitter's serial number and synchronization information after the key has been verified.

The key generation process has three inputs. The first is the source of the key generation. The source can be the encoder's serial number (normal learn) or the encoder's seed (secure learn). The second input is the key generation algorithm; the decryption algorithm or the XOR algorithm. The third input to the system is a manufacturer's key. The manufacturer's key tailors the key generation algorithm to a specific manufacturer. Customizing the key generation algorithm means competitors cannot clone another manufacturer's transmitters.

With the exception of the Simple Decoder, two transmissions are needed by the decoder during learn: one to generate a key and the second to validate the key. If the key generation source is the serial number then both transmissions will be normal Code Hopping transmissions. If the user chooses secure learn (Seed value as the key generation source) the first transmission should be a Code Hopping transmission and the second transmission a "Seed transmission". Seed transmissions are obtained by pressing a special combination of buttons. In the case of the HCS300, a seed transmission is activated by simultaneously pressing all four buttons S0 – S3.

The Evaluation Kit II software and PRO MATE II software (Microchip Universal Programmer) have been designed so that the Encoder Key Generation phase is transparent to the user.

### 7.4.1 LEARNING PROCEDURE STEP BY STEP

Learning a transmitter on the NORMAL,SECURE software decoders and HCS512 decoders is accomplished as follows:

1. Press and release the decoder's LEARN button. The LEARN OUT LED will turn on to indicate that the decoder has entered Learn mode.
2. Press a transmitter button. The LEARN LED will turn off, indicating a transmission has been received.
3. Press a transmitter button a second time. The LEARN LED will flash several times to indicate that the transmitter was learned successfully

| **Note:** | The second transmission must be a SEED transmission when secure learn is used. |
|---|---|

4. The learning attempt will fail if the transmitter is not configured to operate in the same Learn Scheme as the decoder, the Manufacturer Code is different, two non-sequential codes are received, two acceptable codes are not received within 30 seconds, or simply if the radio transmission was corrupted by noise. The decoder indicates a failed learn by making the LED flash briefly once. Try again starting from step 1.
   If Learning fails again, the user is recommended to verify the Manufacturer's Code and Learning Scheme of the encoder and decoder match.
5. If step 3 succeeded, repeat steps 1-3 to learn up to the maximum number of transmitters.

### 7.4.2 LEARNING ON A SIMPLE DECODER STEP BY STEP

In SIMPLE Learn all encoders and decoders share a common key that coincides with the Manufacturer's Code. As a consequence, the system security is diminished but the decoder code to implement it is shorter. The learn procedure flows as follows:

1. Press and release the LEARN button. The LEARN OUT LED will turn on while the button is pressed and turn off when the button is released.
2. Press any transmitter button.
3. The LEARN OUT LED will turn on for a second if the Learn is successful. If the transmission is not acceptable the decoder will return to normal operation. Unacceptable transmissions result if the encoder is configured with a different Manufacturer's Code or a transmission is not received within 30 seconds

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### 7.4.3 LEARNING ON AN HCS515 DECODER STEP BY STEP

1. Press and hold the LEARN button until the LEARN OUT LED first turns on and then off about a second later.
2. Press any transmitter button.
3. The LEARN OUT LED will flash briefly.
4. Press any transmitter button if configured for NORMAL Learn or the SEED button combination if configured for SECURE Learn.
5. The LEARN OUT LED will flash for a second time.
6. Press the transmitter again to determine if the Learning attempt was successful. The LEARN OUT LED will flash only if the transmitter was successfully learned.

### 7.4.4 TRANSMITTER ERASING ON HCS512 AND SOFTWARE DECODERS

Erasing all the learned transmitters from memory is accomplished by pressing and holding the LEARN button for 8 seconds. The LED will turn off at the end of the 8 seconds to indicate that the non-volatile memory has been erased.

### 7.4.5 TRANSMITTER ERASING ON HCS515 DECODER

Press and hold the LEARN button. It will turn on for about a second and then off again. Continue holding for about 10 seconds until the LED turns on again. Only then release the LEARN button. The LED will finally turn off to indicate that the non-volatile memory has been erased.

## 7.5 The Main Processor

The main processor area contains a TQFP PIC16F877 operating with a 20 MHz crystal clock (HS mode).

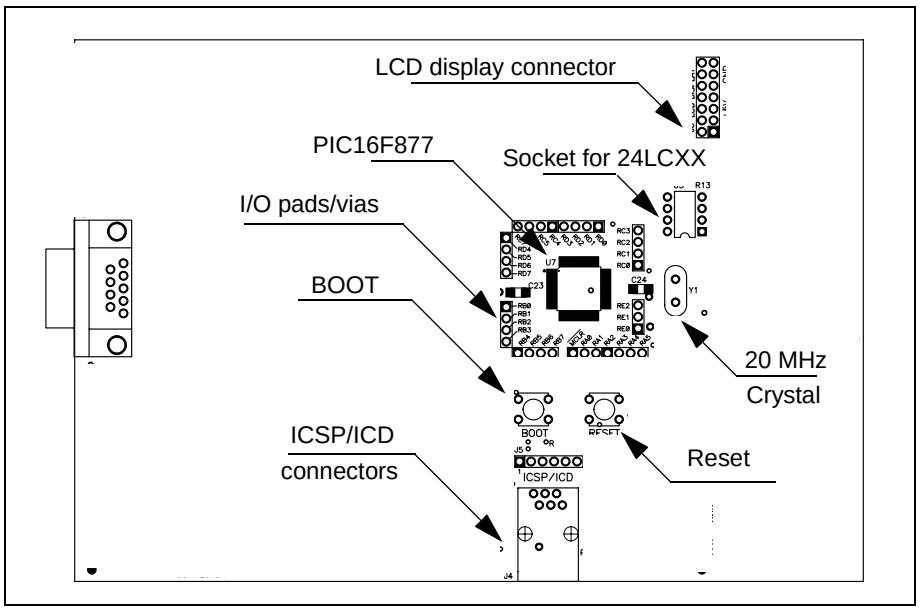
The microprocessor's internal brown out circuit is disabled as an external Microchip voltage supervisor device MCP120 – 450 is used. The voltage supervisor provides reset to both the PICmicro MCU and the decoders when the supply drops below 4.5V; except the HCS512 decoder, see below. 4.5V is the minimum operating voltage of the PICmicro MCU when operating at 20MHz.

The PCB area surrounding the PICmicro microcontroller provides easy access to the PICmicro MCU's I/O's through about 40 pads/vias. The access points are available for testing or connecting to the prototype area.

Two button switches are available: RESET and BOOT. The BOOT button is connected to the RB4 I/O pin as well as to the HCS512 decoder's separate reset line.

The BOOT button is used by the BOOT loader to download new firmware into the Main Processor from the Serial Port and bootstrap it into execution.

**FIGURE 7-7: THE MAIN PROCESSOR AREA**





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A socket (U5) for an additional external **I²C™ EEPROM (24LCXX)** is provided for future expansion as well as a standard 14-pin **LCD display** connector (J6).

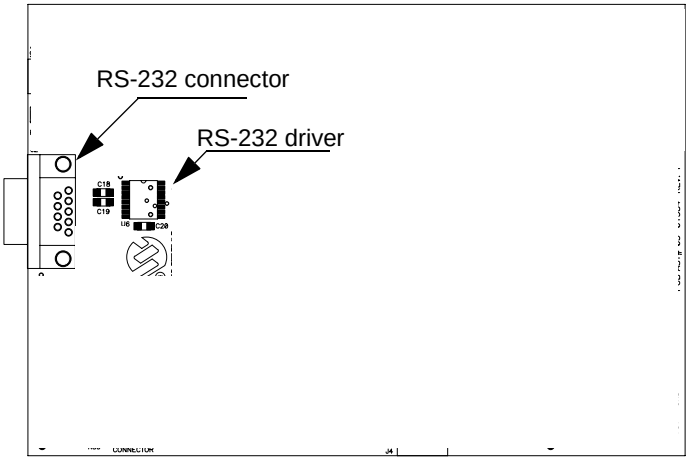
An **In-Circuit Debugger** compatible connector J4 (RJ11 type) can be mounted below the two buttons to allow connection with the standard Microchip Flash ICD Development Tool.

### 7.5.1 THE SERIAL INTERFACE

A DB9 RS-232 serial interface connector is located on the left side of the board. Four I/O lines connect the Main Processor to the serial port. The RX and TX signals connect directly to the RC6 and RC7 UART pins on the PICmicro MCU. The RTS and CTS hardware handshake signals connect to the PICmicro microcontroller although the initial software release does not make use of them.

A Microchip TC232C driver chip, or compatible, performs full translation of the I/O levels to comply to RS-232C specifications.

**FIGURE 7-8: THE SERIAL INTERFACE**




### 7.5.2 POWER SUPPLY AND PROTOTYPING AREA

The power supply circuit is designed to regulate a maximum current of 100 mA at 5V from two possible sources:

- An external 9V battery, useful for demonstrations and ease of transport,
- A power supply unit capable of providing an unregulated 9V – 15V.

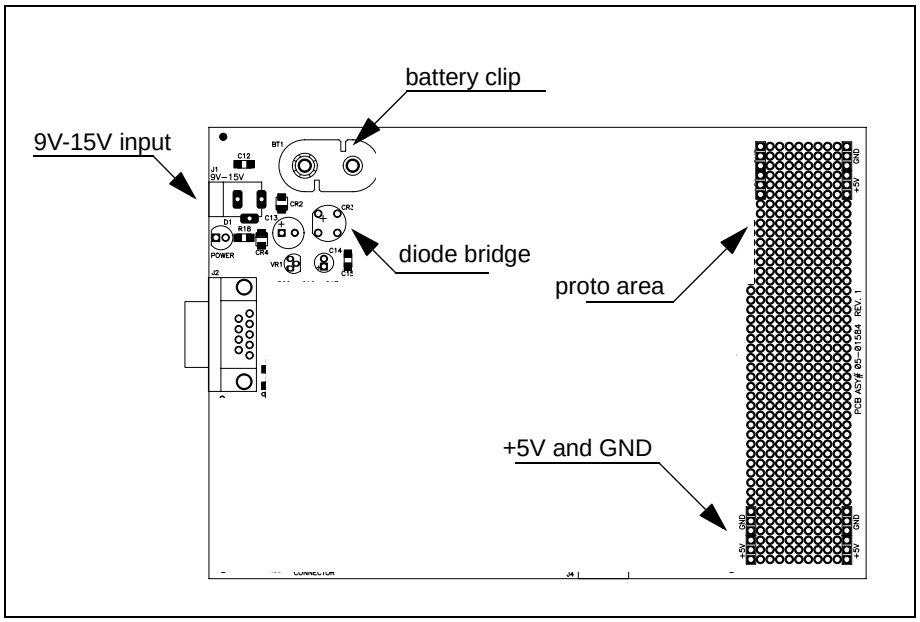
An internal diode bridge allows the use of AC or DC external power supply units; connector polarity is irrelevant.

A diode in the 9V battery circuit protects the board from accidental reverse battery connections.

The Red and Black terminals in the Prototyping area provide convenient +5V and GND connections, respectively, to the custom circuitry.

The user must guarantee that the Prototype area custom circuit current draw added to the Main Board consumption (varying with the number of decoders mounted and their use) does not exceed the 100 mA total limit.

**FIGURE 7-9: THE POWER SUPPLY AND PROTOTYPING AREA**



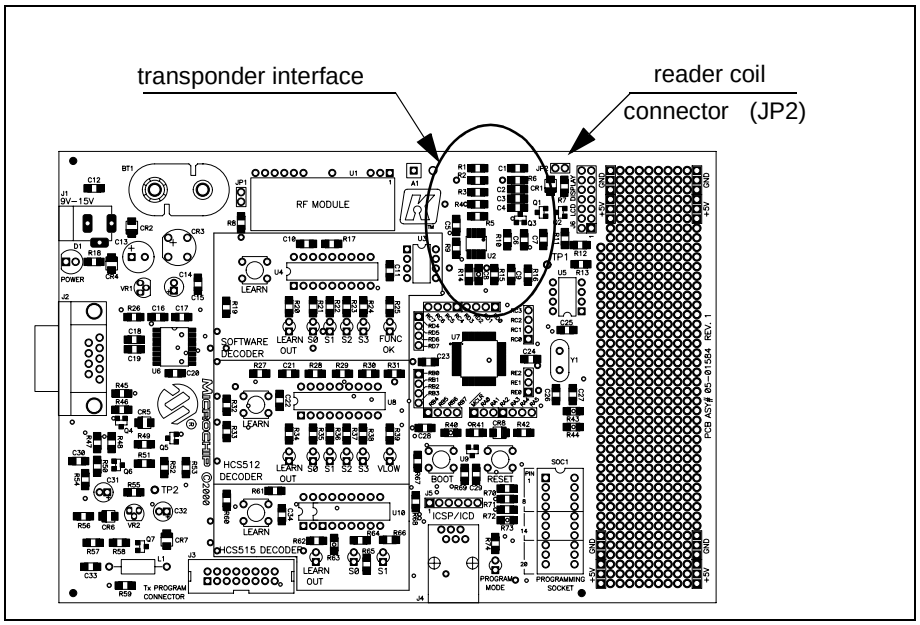

### 7.5.3 THE TRANSPONDER INTERFACE

The transponder interface is left unpopulated by default. It is provided for future expansion only and is not supported in the initial firmware release.

The interface circuit requires a reader coil of appropriate inductance connected to JP2. Capacitors C2, C3, and C4 are used to tune the resulting resonant circuit frequency; typically to 125 kHz.

The PIC16F877's second internal PWM module can directly control the carrier signal (pin RC1), while a filtered and amplified Read signal is received on the standard RE1 I/O pin. A Write signal (pin RB0), can also control the resonant circuit through a MOSFET driver.

**FIGURE 7-10: THE TRANSPONDER INTERFACE CIRCUIT**



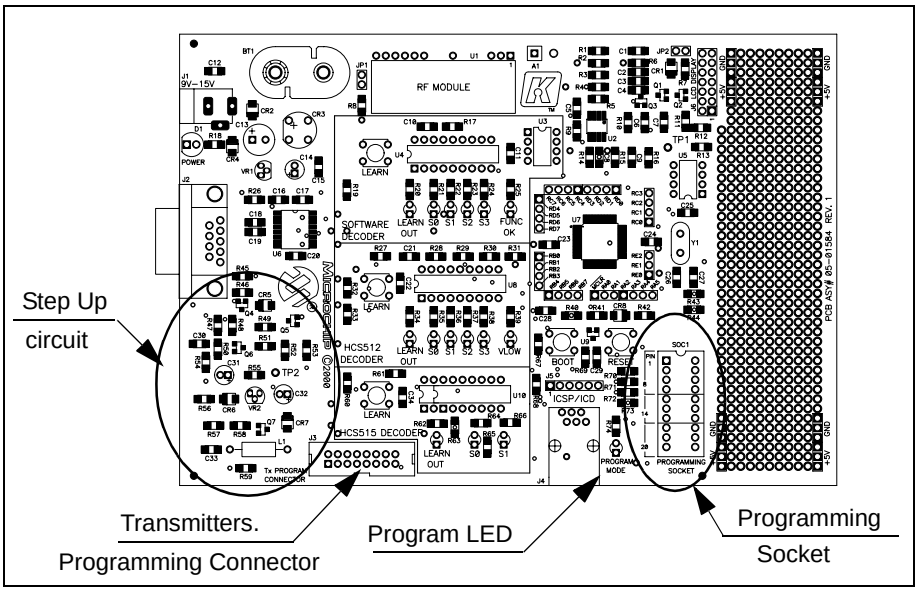


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### 7.5.4 THE PROGRAMMING SOCKET, CONNECTOR AND STEP UP CIRCUIT

The step up circuit, controlled by the Main Processor PWM module, boosts the +5V main power supply to a programming voltage ($V_{PP}$) of up to 12.5V. The higher voltage is used to program some encoder models such as the HCS365, HCS370 and HCS473.

**FIGURE 7-11: THE PROGRAMMING SOCKET AND STEP UP CIRCUIT**




The Evaluation Kit provides two methods of programming the encoders:

- In-Socket allows programming and serialization of DIP samples before they are mounted on the demo transmitters.
- In-Circuit programs the encoders directly on the Demo Transmitter board.

When programming In-Socket, the user will always align the part to the top; pin 1 of the encoder into pin 1 of the socket.

The socket only allows the insertion of encoder DIP samples in 8-, 14- and 20-pin packages. The 20-pin capability provides for future compatibility. Special third party adaptors may be purchased converting the DIP interface to another desired package.

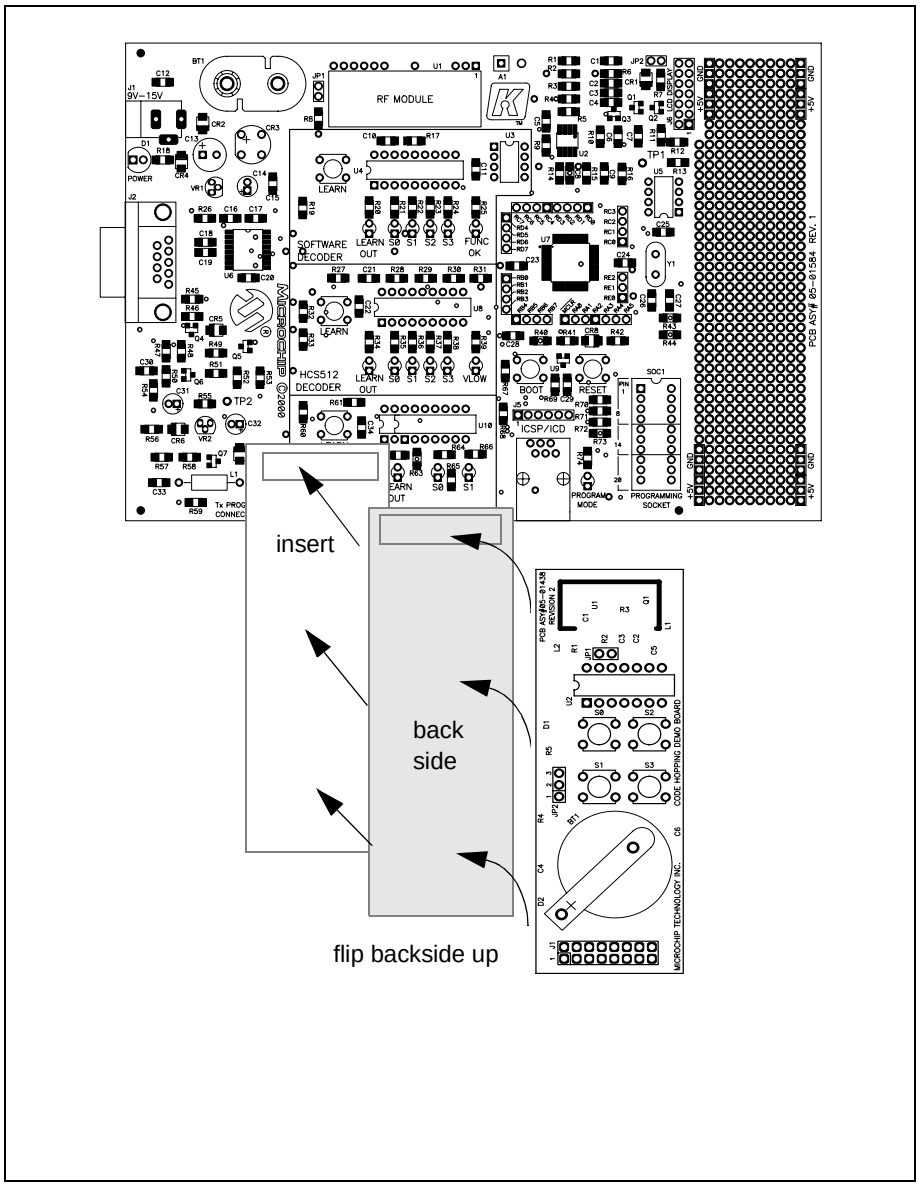
The Evaluation Kit is designed to be a teaching and prototyping tool. It is not designed to be a production programmer and therefore is not capable of performing more than a few programming sessions per day.

The user is encouraged to use the PRO MATE II Microchip Universal Programmer and the appropriate interchangeable programming sockets when programming quantities of devices. The interchangeable programming sockets support the DIP, SOIC, TSSOP packages and In-Circuit Serial Programming, as necessary.

The Eval Kit's In-Circuit Programming is restricted to the Demonstration Transmitters included in the kit.

The Transmitter's Programming Connector, Figure 7-12, provides connection to the Main Board.

**FIGURE 7-12: IN-CIRCUIT PROGRAMMING OF A DEMO TRANSMITTER**





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# Appendix A: Schematic Diagrams

**FIGURE A-1: ENCODER SCHEMATIC**

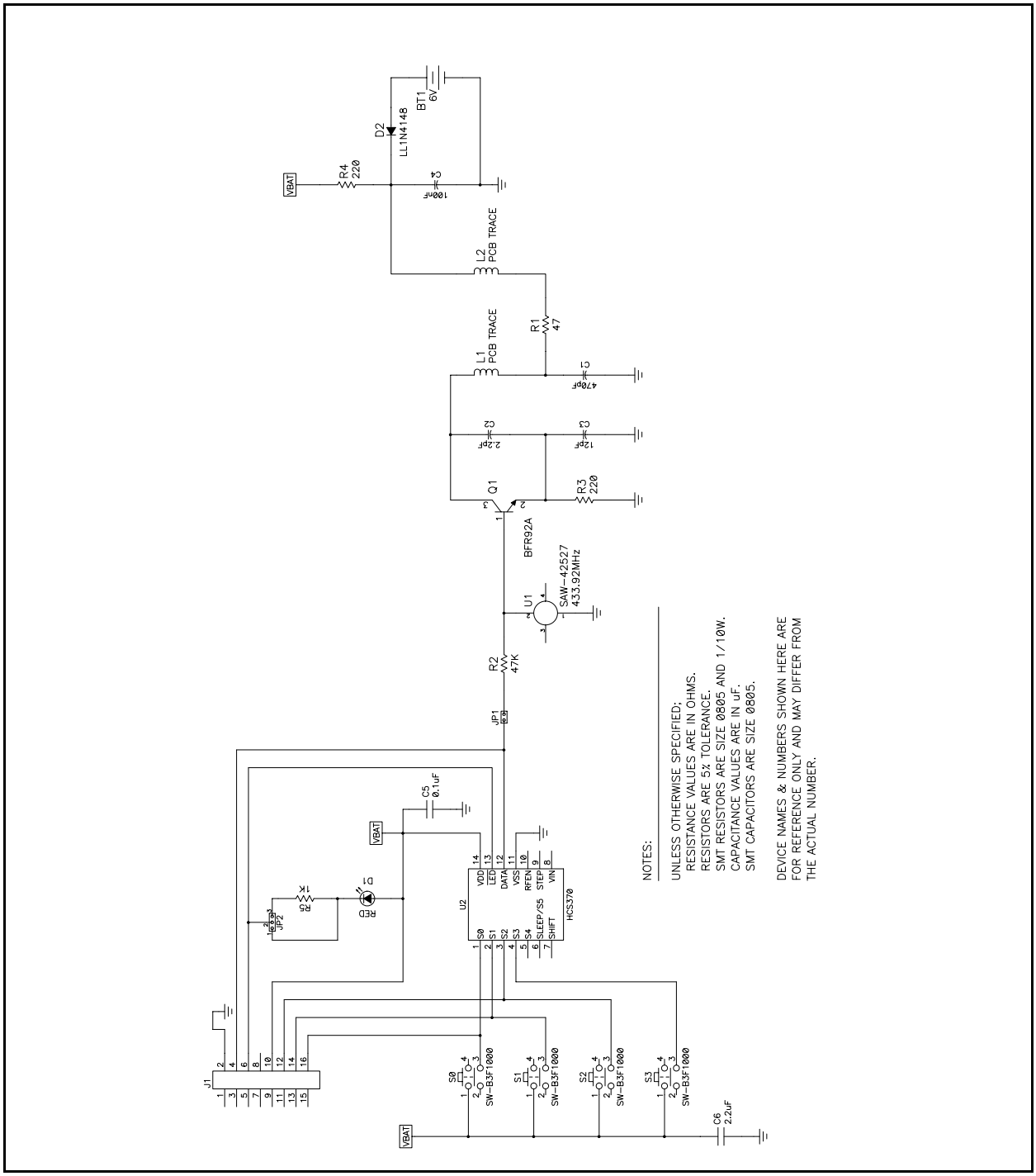
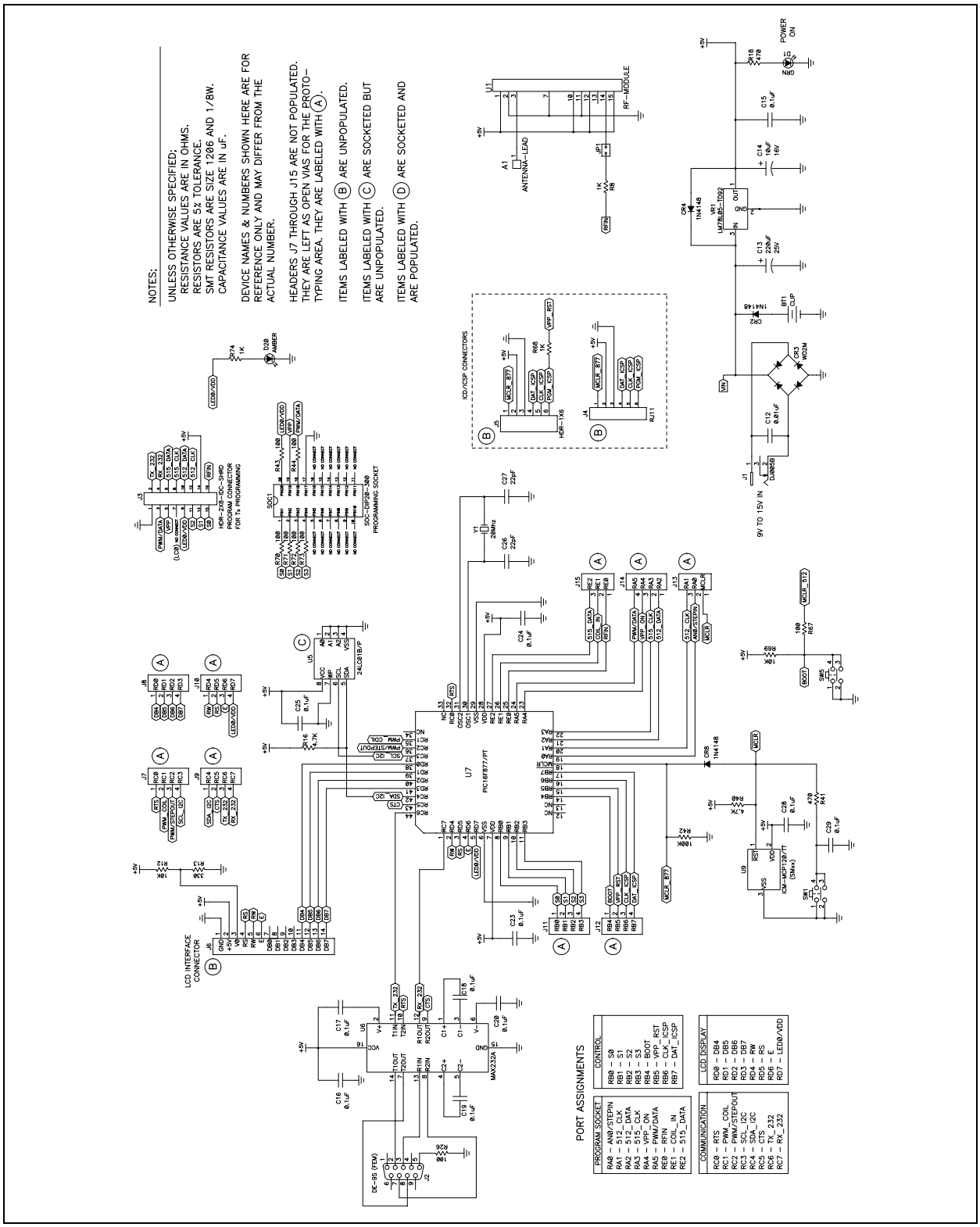


**FIGURE A-2: MAIN BOARD SCHEMATIC**





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**FIGURE A-3: KEELOQ DECODER SCHEMATIC**

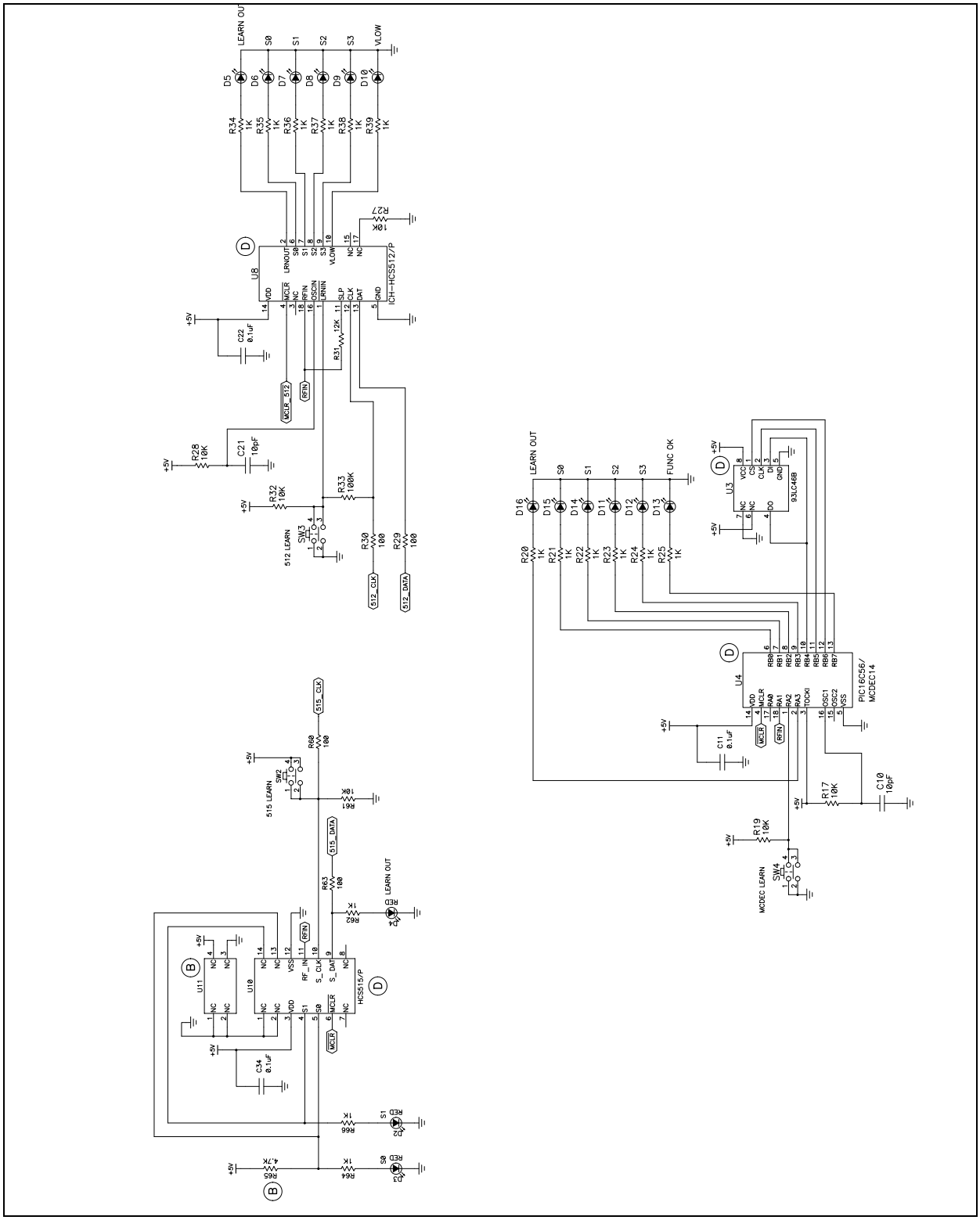
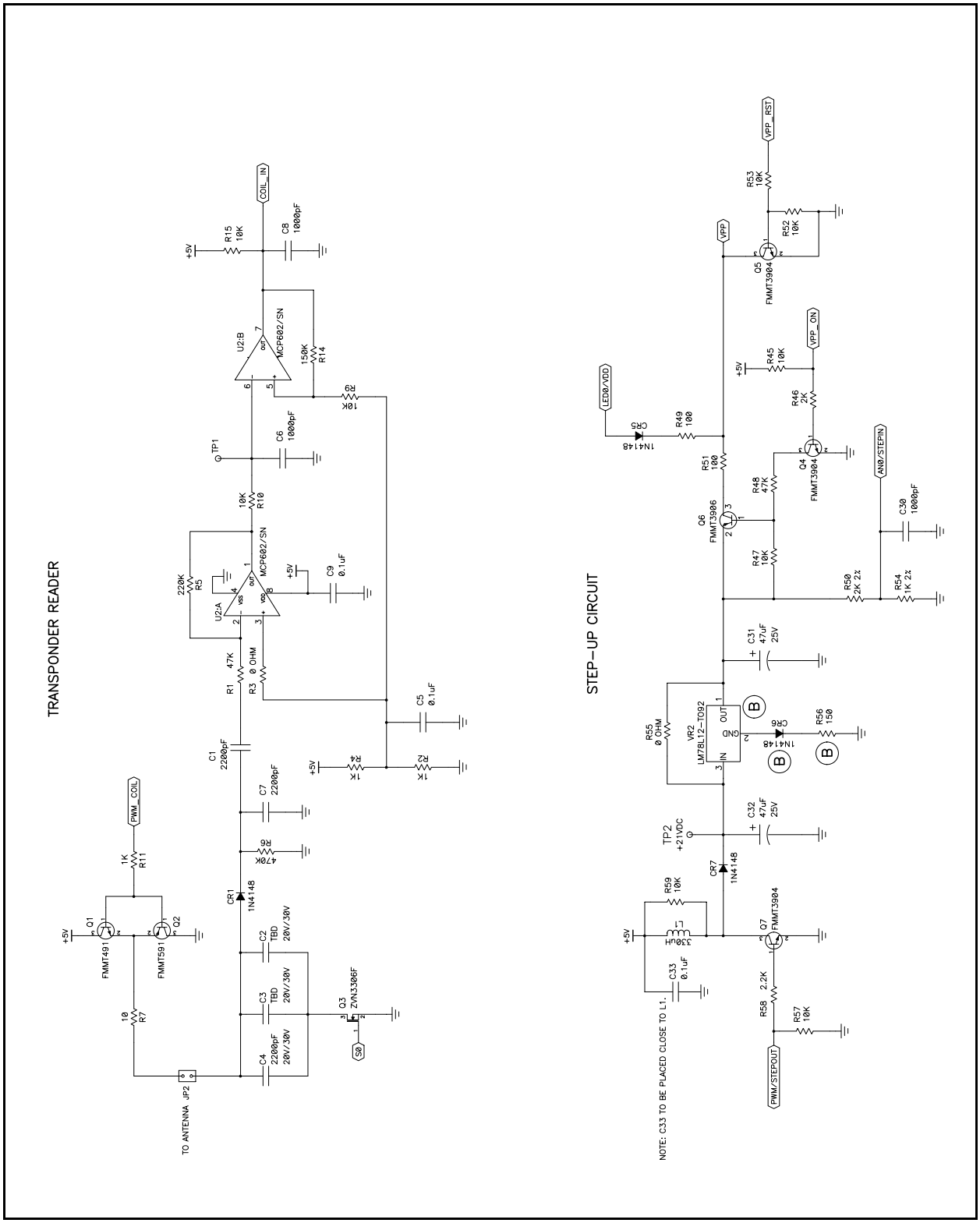


**FIGURE A-4: TRANSPONDER READER & STEP UP CIRCUIT**





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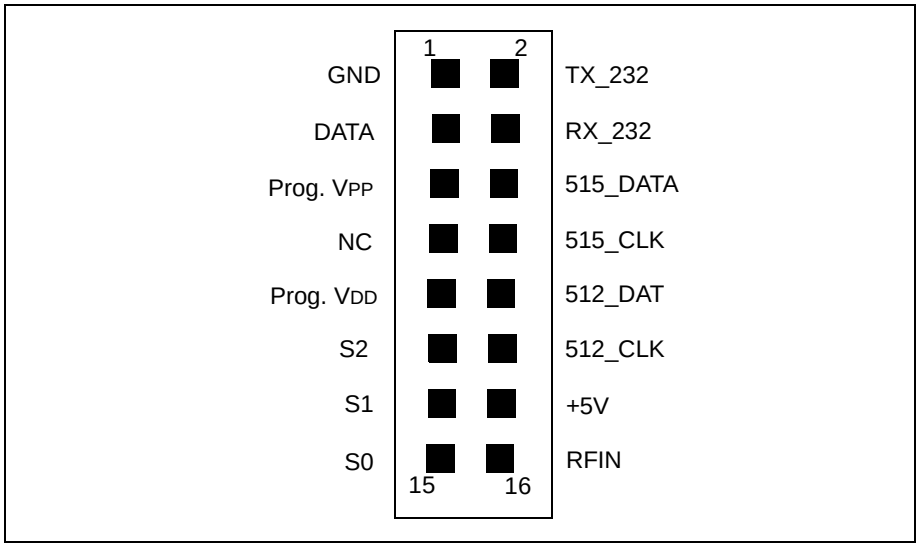
# Appendix B: In-Circuit Programming

The KEELOQ Evaluation Kit can be used to In-Circuit program most prototype encoders and all of the decoders.

When performing In-Circuit Programming, verify that the Encoder Programming Socket and Demo Decoders Sockets are empty!

The following sections will provide a detailed description of the required connections between the J3 connector and the various encoders and decoders models.

**FIGURE B-1: PINOUTS OF J3 TRANSMITTER PROGRAMMING CONNECTOR**




## B.1 HCS101/HCS200/HCS201 HCS300/HCS301/HCS320 ICSP Connection

These devices can be programmed In-Circuit using the Demo Transmitter (directly inserted in connector J6) or by providing custom In-Circuit connections as described in the following table:

**TABLE B-1: HCS101/HCS200/HCS201/HCS300/HCS301/HCS320 ICSP**

| J3 Pin | Description | Encoder Pin | Description |
|---|---|---|---|
| 1 | GND | 5 | GND |
| 11 | CLOCK | 3 | S2 |
| 3 | DATA | 6 | DATA |
| 14 | Prog. VDD | 8 | VDD |

## B.2 HCS360/HCS361 ICSP Connection

These devices can be programmed In-Circuit using the Demo Transmitter (directly inserted in connector J6) or by providing custom In-Circuit connections as described in the following table:

**TABLE B-2: HCS360/HCS361 ICSP**

| J3 Pin | Description | Encoder Pin | Description |
|---|---|---|---|
| 1 | GND | 5 | GND |
| 11 | CLOCK | 3 | S2 |
| 13 | S1 | 2 | S1 |
| 3 | DATA | 6 | DATA |
| 14 | Prog. VDD | 8 | VDD |

## B.3 HCS362/HCS410/HCS412 ICSP Connection

These devices can be programmed In-Circuit using the Demo Transmitter (directly inserted in connector J6) or by providing custom In-Circuit connections as described in the following table:

**TABLE B-3: HCS362/HCS410/HCS412 ICSP**

| J3 Pin | Description | Encoder Pin | Description |
|---|---|---|---|
| 1 | GND | 5 | GND |
| 11 | CLOCK | 3 | S2 |
| 3 | DATA | 6 | DATA |
| 14 | Prog. VDD | 8 | VDD |

## B.4 HCS365/HCS370/HCS473 ICSP Connection

These devices **can not** be programmed In-Circuit using the Demo Transmitter.


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In-Circuit Programming is possible only providing connections to a target transmitter as described in the following table:

**TABLE B-4: HCS365/HCS370/HCS473 ICSP**

| J3 Pin | Description | Encoder Pin | Description |
|---|---|---|---|
| 1 | GND | 5 | GND |
| 15 | S0(DATA) | 1 | S0 |
| 13 | S1(CLOCK) | 2 | S1 |
| 5 | Prog. VPP | 7(13)* | VPP |
| 14 | Prog. VDD | 8(14)* | VDD |

**Note:** Encoder Pins in parenthesis are related to the 14-pin packages (HCS370 and HCS473).

## B.5 HCS500 ICSP Connection

The HCS500 decoder can be Programmed In-Circuit using the connections described in the following table:

**TABLE B-5: HCS500 ICSP**

| J3 Pin | Description | Decoder Pin | Description |
|---|---|---|---|
| 1 | GND | 5 | GND |
| 8 | CLK_515 | 6 | CLOCK |
| 6 | DAT_515 | 5 | DATA |

The HCS500 must be connected to the companion 24LC01 (or 24LC02) memory and both parts must be powered.

**Note:** Refer to Appendix C for a description of the modifications required to the Main Board to provide direct support for this decoder.

## B.6 HCS512 ICSP Connection

The HCS515 decoder can be Programmed In-Circuit using the connections described in the following table:

**TABLE B-6: HCS512 ICSP**

| J3 Pin | Description | Decoder Pin | Description |
|---|---|---|---|
| 1 | GND | 5 | GND |
| 12 | CLK_512 | 12 | CLOCK |
| 10 | DAT_512 | 13 | DATA |
| RB4* | MCLR_512 | 4 | MCLR |

The HCS512 decoder target board must be powered ($V_{DD}$ = 5V) and the target oscillator circuit must be running at 4 MHz (verify pin 15 output = square wave @ 1 MHz).

| | |
|---|---|
| **Note:** | Pin RB4 is only accessible through the prototyping pads around the main processor in this revision of the Evaluation Kit II board (01584 rev. B). |

## B.7 HCS515 ICSP Connection

The HCS515 decoder can be Programmed In-Circuit using the connections described in the following table:

**TABLE B-7: HCS500 ICSP**

| J3 Pin | Description | Decoder Pin | Description |
|---|---|---|---|
| 1 | GND | 12 | GND |
| 8 | CLK_515 | 10 | CLOCK |
| 6 | DAT_515 | 9 | DATA |

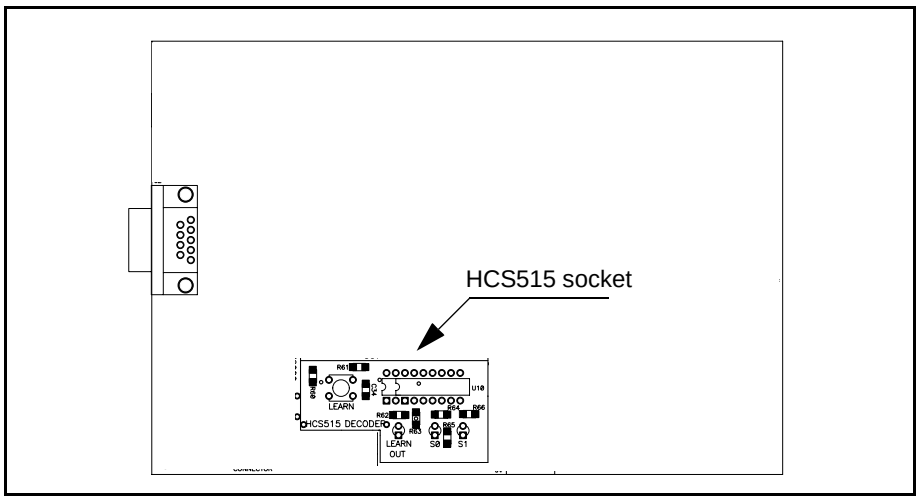
The HCS515 decoder target board must be powered up ($V_{DD}$ = 5V)


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# Appendix C: HCS500 Support

It is possible to modify the Evaluation Kit II Main Board to directly support and demonstrate the HCS500 decoder functionality. Following the next few simple steps the HCS515 demonstration/programming socket will be modified to host an HCS500 decoder and its companion 24LC02 memory.

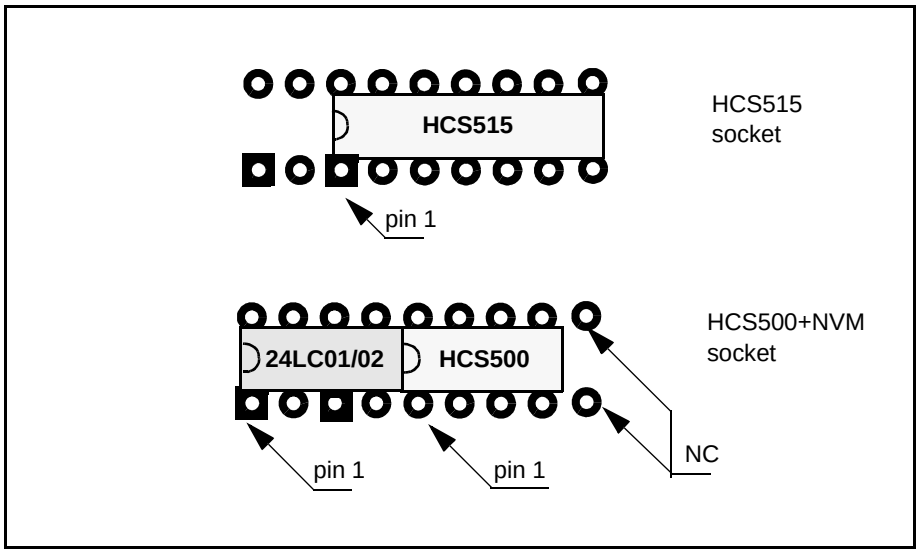
**FIGURE C-1: THE HCS515 DEMONSTRATION SOCKET**




**Step 1.** Remove the 14-pin DIP socket. Be extremely careful not to break any PCB connection.

**Step 2.** Insert two 8-pin DIP sockets starting from pin 1 (squared) on the left and leaving the last row empty as illustrated in .

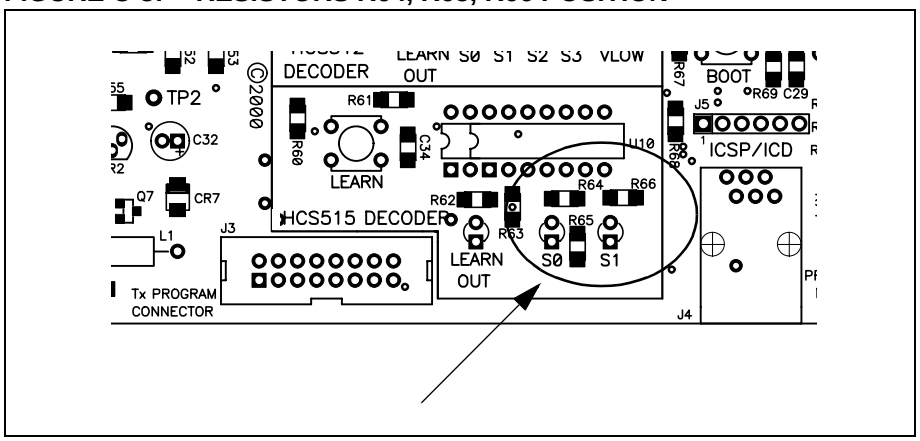
**FIGURE C-2: INSERTING THE HCS500 SOCKET**




**Step 3.** Remove R64 and R66 (1 KΩ SMD resistors).

**Step 4.** Insert R65 (4.7 KΩ SMD resistor).

**FIGURE C-3: RESISTORS R64, R65, R66 POSITION**



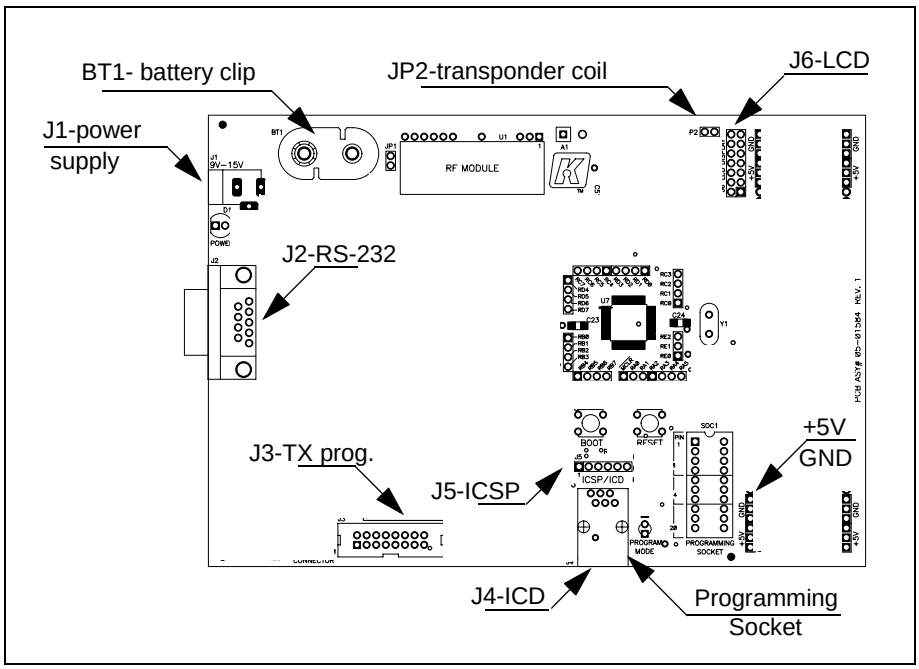

| **Note:** | After the modifications, the LEARN OUT LED assumes the functionality of the HCS500 decoder's single output. |
|---|---|


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# Appendix D: Connectors

## D.1 Connectors Layout

**FIGURE D-1: CONNECTORS AND TEST POINTS LAYOUT**




### D.1.1 J1- POWER SUPPLY

Power Supply, 9V – 15V input.

AC/DC input, (NO polarity)

### D.1.2 BT1- BATTERY CLIP

9V battery clip

Polarity is dictated by the clip mechanics.

A diode (CR2) protects from reversed polarity insertion and inverse currents should the power supply be used at the same time.

### D.1.3 TEST POINTS ON PROTOTYPING AREA

Red +5V TP and corresponding Black GND TP

Provides regulated 5V output for proto area.

The voltage regulator (VR1) is capable of 100 mA max. The current draw of the prototype area must be limited to keep total board consumption (varying with the number 100 mA limit.

### D.1.4 J2- RS-232 (9-PIN)

| Pin | Signal | MCU pin |
|---|---|---|
| 1 | NC | — |
| 2 | TX | RC6 |
| 3 | RX | RC7 |
| 4 | NC | — |
| 5 | GND | VSS |
| 6 | NC | — |
| 7 | CTS | RC5 |
| 8 | RTS | RC0 |
| 9 | NC | — |

Hardware handshake is not used in revision (v.3.00.00) of the firmware


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D.1.5 J3- TX PROGRAM CONNECTOR

| Pin | Signal | MCU pin | Pin | Signal | MCU pin |
|---|---|---|---|---|---|
| 1 | GND | Vss | 2 | TX_232 | RC6 |
| 3 | DATA | RA5 | 4 | RX_232 | RC7 |
| 5 | VPP | — | 6 | 515_DATA | RE2 |
| 7 | NC | — | 8 | 515_CLK | RA3 |
| 9 | LED0/Vdd | RD7 | 10 | 512_DAT | RA2 |
| 11 | S2 | RB2 | 12 | 512_CLK | RA1 |
| 13 | S1 | RB1 | 14 | +5V | VDD |
| 15 | S0 | RB0 | 16 | RFIN | RE0 |

D.1.6 J4- ICD (RJ11 TYPE)

| Pin | Signal | MCU pin |
|---|---|---|
| 1 | MCLR | MCLR |
| 2 | +5V | VDD |
| 3 | GND | VSS |
| 4 | DAT_ICSP | RB7 |
| 5 | CLK_ICSP | RB6 |
| 6 | VPP | RB3 |

D.1.7 J5- ICSP (6 POLES IN LINE)

| Pin | Signal | MCU pin |
|---|---|---|
| 1 | MCLR | MCLR |
| 2 | +5V | VDD |
| 3 | GND | VSS |
| 4 | DAT_ICSP | RB7 |
| 5 | CLK_ICSP | RB6 |
| 6 | VPP | RB3 |


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D.1.8 SOC1- PROGRAMMING SOCKET

| Pin | Signal | MCU pin | Pin | Signal | MCU pin |
|---|---|---|---|---|---|
| 1 | S0 | RB0 | 11 | Prog. VDD | RD7 |
| 2 | S1 | RB1 | 12 | VPP | — |
| 3 | S2 | RB2 | 13 | DATA | RA5 |
| 4 | S3 | RB3 | 14 | GND | VSS |
| 5 | — | — | 15 | — | — |
| 6 | — | — | 16 | — | — |
| 7 | — | — | 17 | — | — |
| 8 | — | — | 18 | — | — |
| 9 | —- | — | 19 | — | — |
| 10 | — | — | 20 | — | — |

## D.2 Future Expansion

D.2.1 J6- LCD DISPLAY

| Pin | Signal | MCU pin |
|---|---|---|
| 1 | GND | Vss |
| 2 | +5V | Vdd |
| 3 | V0 contrast | — |
| 4 | RS | RD5 |
| 5 | RW | RD4 |
| 6 | E | RD6 |
| 7 | DB0 | NC |
| 8 | DB1 | NC |
| 9 | DB2 | NC |
| 10 | DB3 | NC |
| 11 | DB4 | RD0 |
| 12 | DB5 | RD1 |
| 13 | DB6 | RD2 |
| 14 | DB7 | RD3 |

This connector allows for control of the LCD in "4-bit Upper Nibble Mode"

D.2.2 JP2- TRANSPONDER COIL

Provides for the connection of a transponder reader coil.

The inductance of the coil has to match the capacitance value of C2 + C3 + C4 for resonance at 125 kHz.

Other frequencies can be obtained by changing the PWM output frequency of the PIC16F877, but will require also the optimization of the input filter.

**NOTES:**


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**NOTES:**

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