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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
- Appendix B: In-Circuit Programming
- Appendix C: HCS500 Support
- Appendix D: Connectors

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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

Installing KEELOQ® Evaluation Kit II

2.0 INSTALLATION

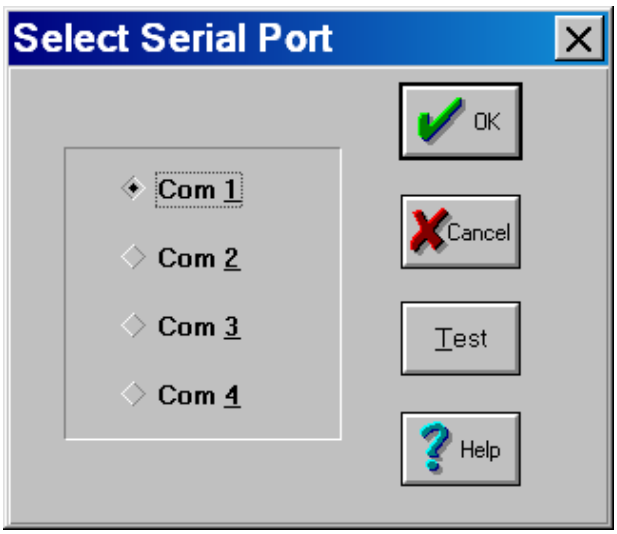
The software provided on the disk is based on the Windows operating system. The KEELOQ Evaluation Kit II software can be installed either in the default C:\HCS_EVAL directory or in another directory of choice.

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

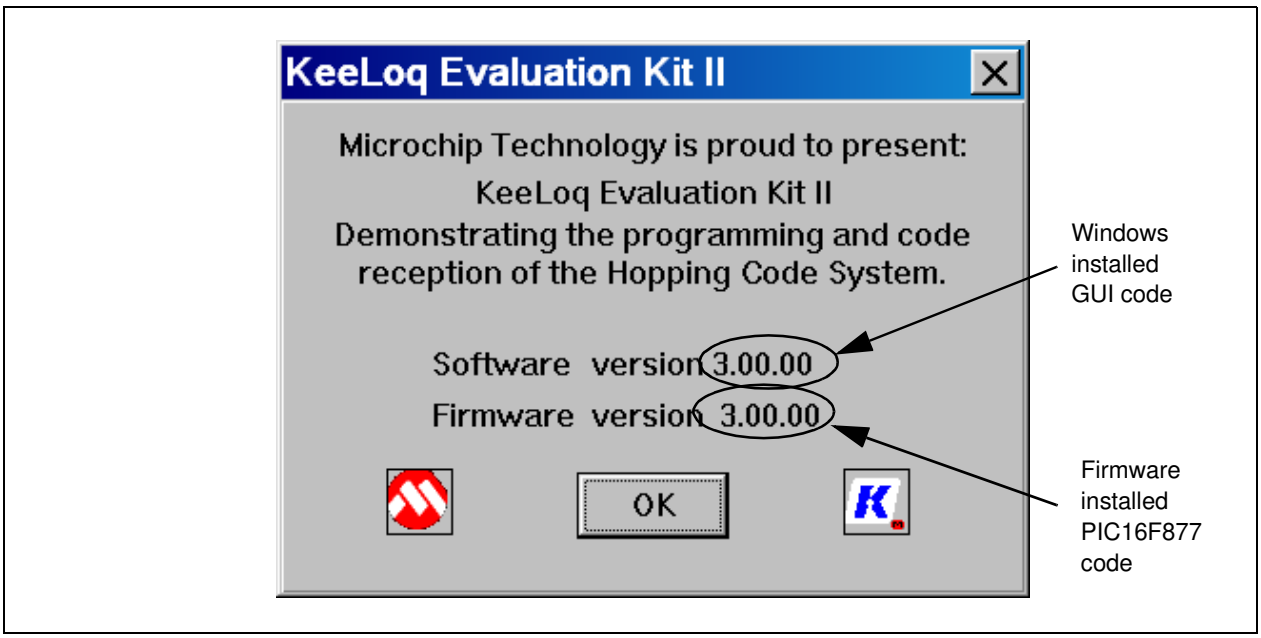


Test the selected serial port by connecting the programmer board to the appropriate COM port, power the programmer board and press the "Test" button. The software will display a message indicating whether the programmer has been found or not.

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

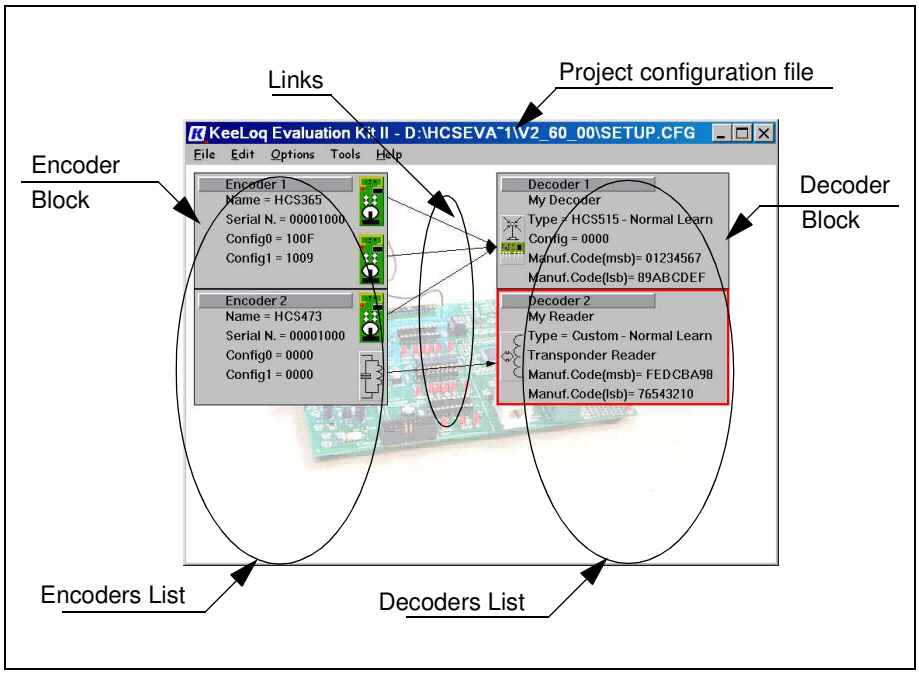
The Evaluation Kit II's new Graphical User Interface (GUI) is centered around a simple paradigm. The user creates a Project by assembling encoder blocks (up to four) and decoder blocks (up to four) in the project window and then visually defines their relationship.

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 $_{HEX}$).

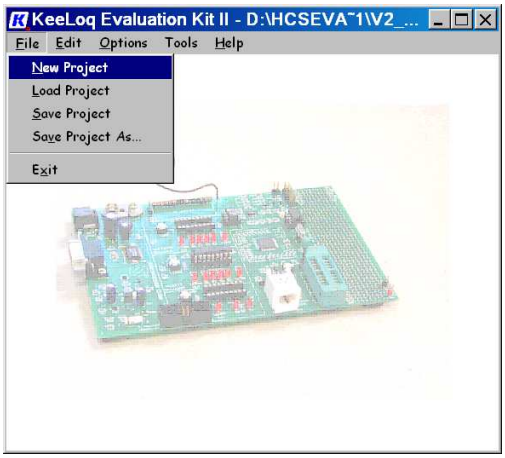
FIGURE 3-1: THE EVALUATION KIT II GUI



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.

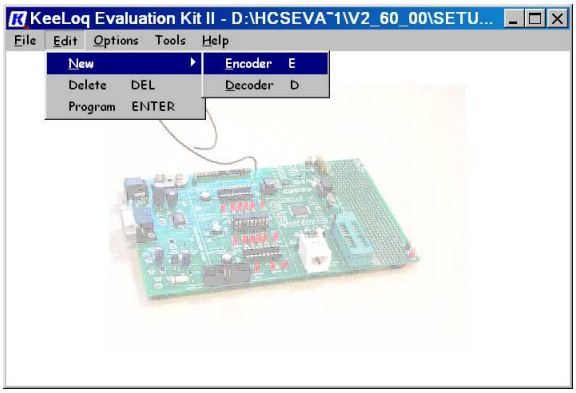
FIGURE 3-2: THE FILE NEW PROJECT MENU



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

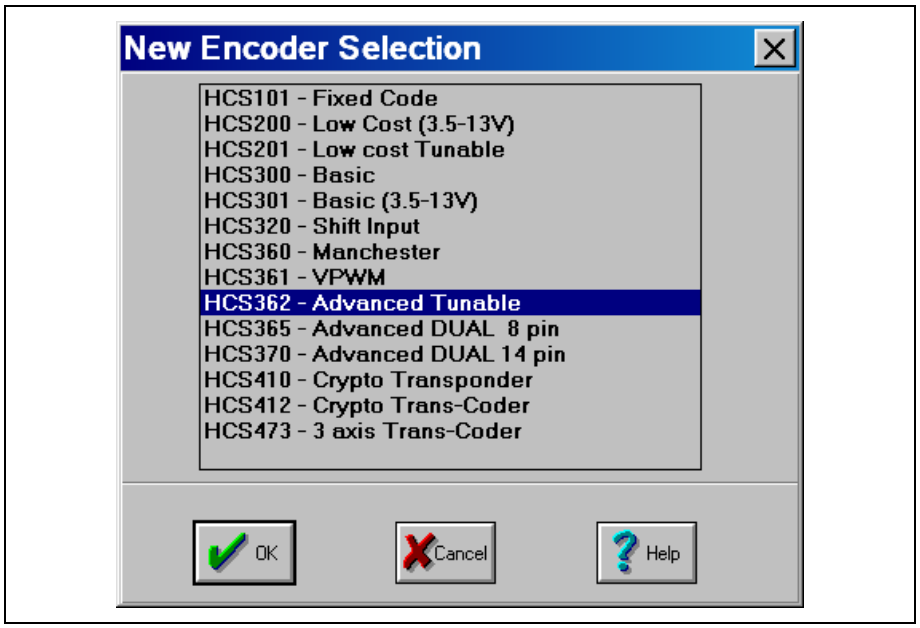
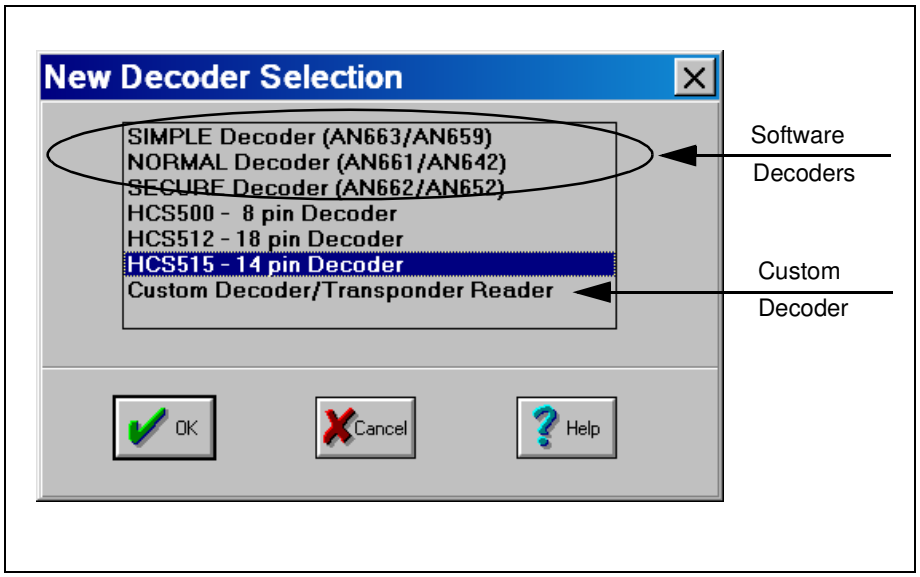


FIGURE 3-5: THE NEW DECODER DIALOG BOX

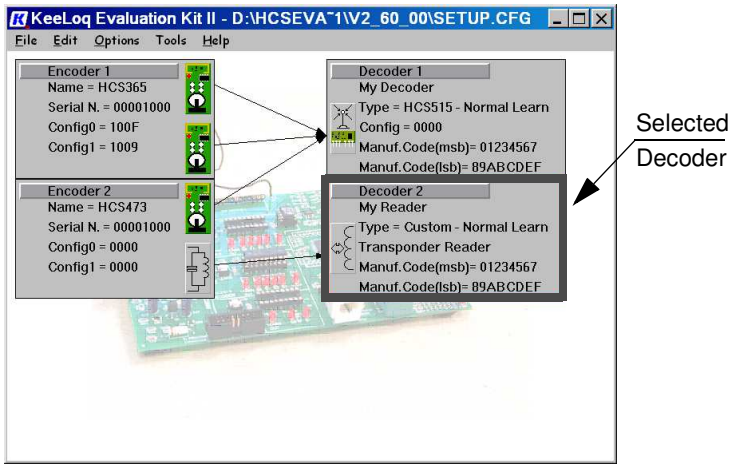


3.0.3 SELECTING AND DELETING AN ENCODER OR DECODER

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.

FIGURE 3-6: THE SELECTED ENCODER/DECODER



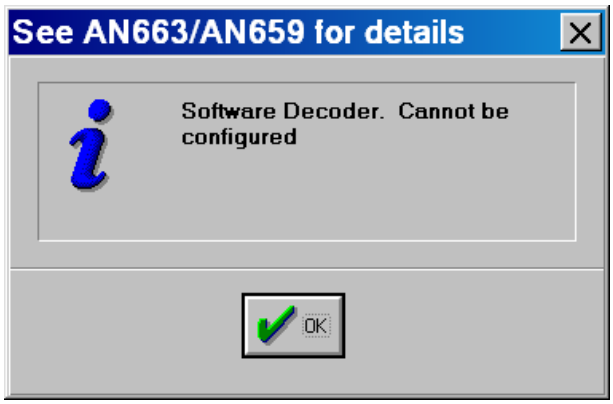
3.0.4 ENCODER AND DECODER CONFIGURATION

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

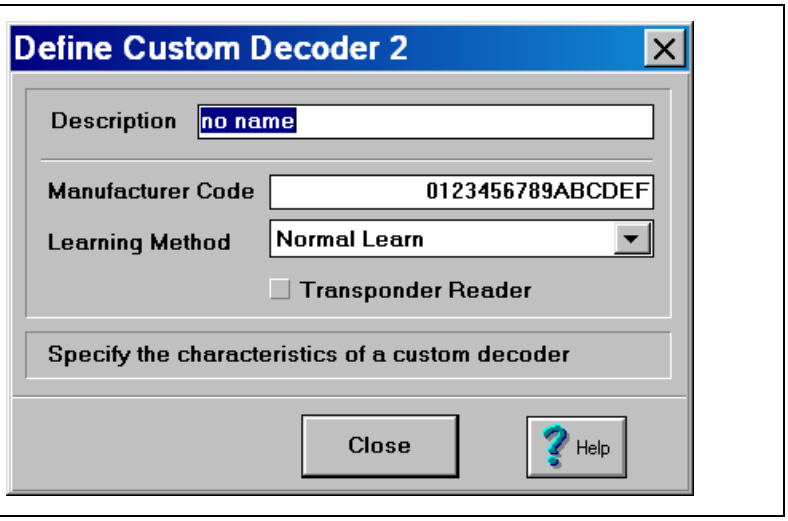


Figure 3-8 shows what information to specify in defining a Custom Decoder.

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.

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:

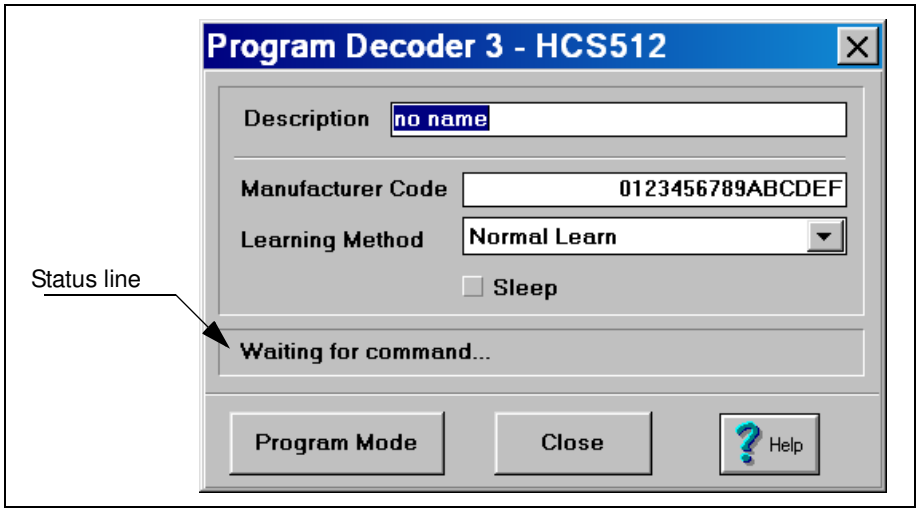
- Description
- Manufacturer Code
- Learning Method
- Enable/Disable the Sleep Mode

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:

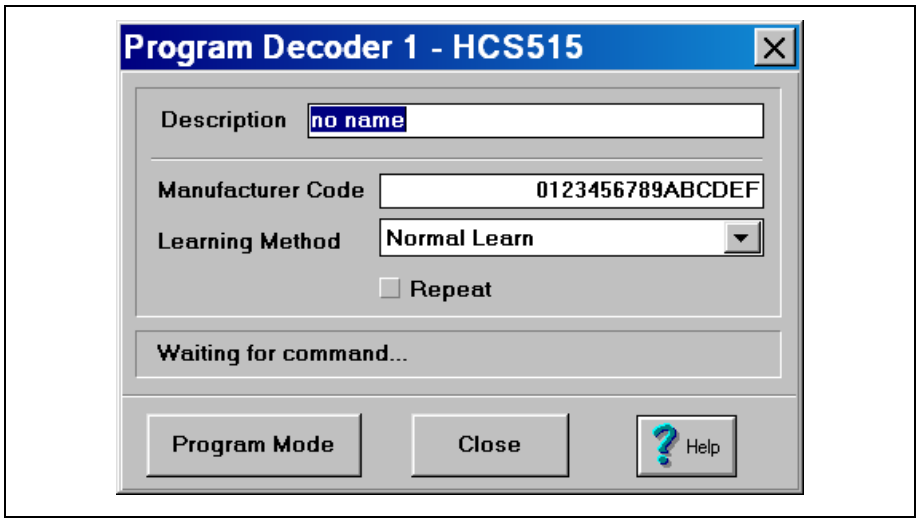
- Description
- Manufacturer Code
- Learning Method
- Enable/Disable the Repeat Mode

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.

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

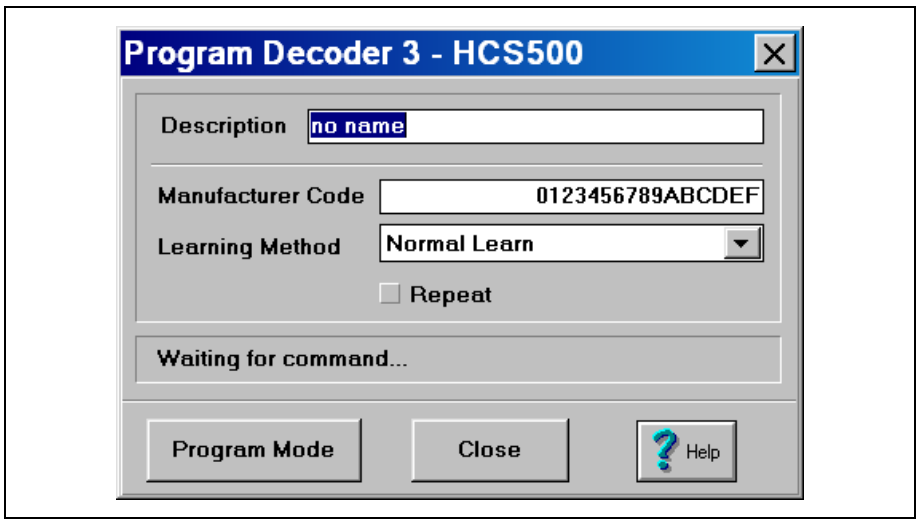
An HCS500 DIP sample and companion 24LC0X eeprom must be installed in the appropriately modified Main Board to complete the device programming attempt.

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.

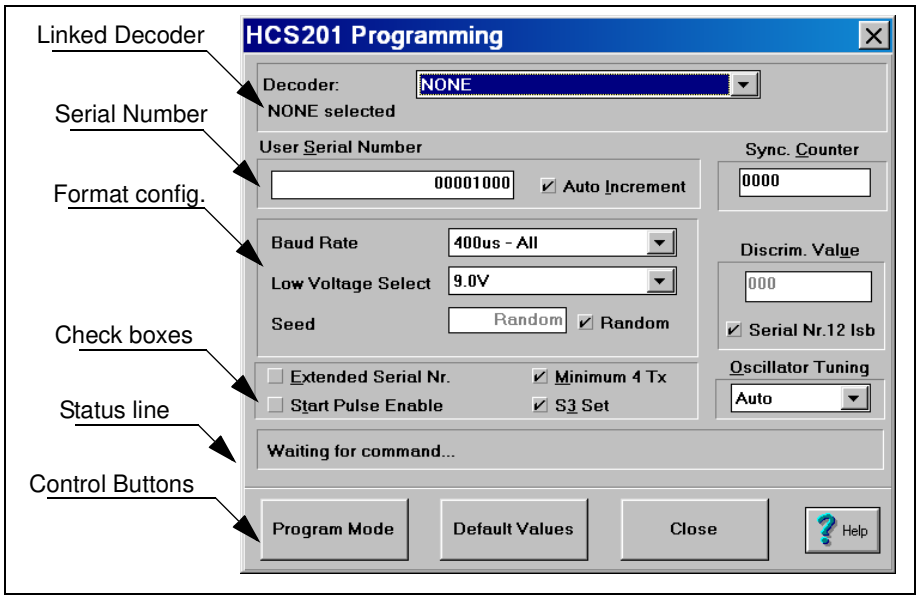
FIGURE 3-11: HCS500 DECODER CONFIGURATION DIALOG BOX



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.

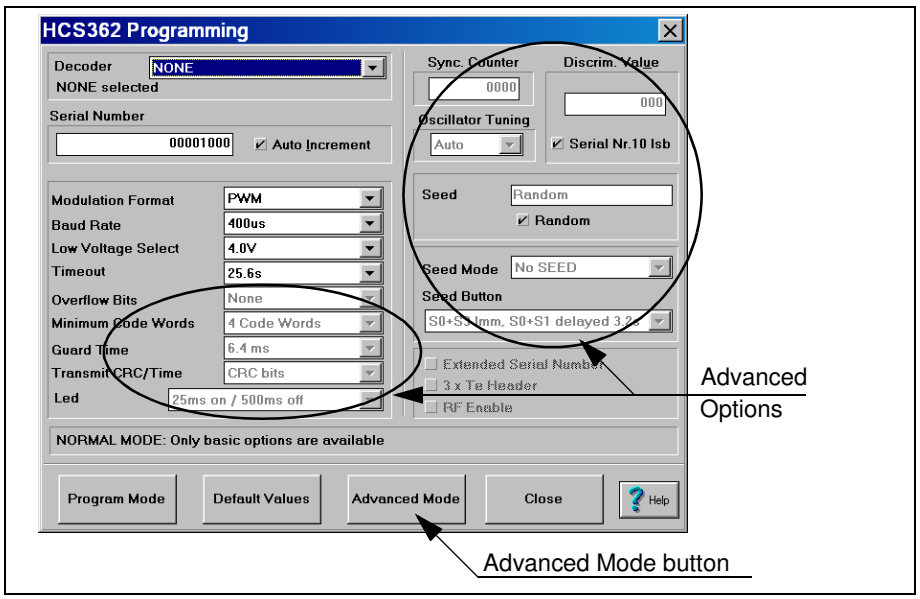
As previously mentioned, Encoder DIP samples may be programmed either by placing them in the appropriate Programming Socket or by "In-Circuit Programing", if mounted on a demo transmitter connected to the Transmitter Programming Connector.

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.

Monitoring KEELOQ® Transmissions

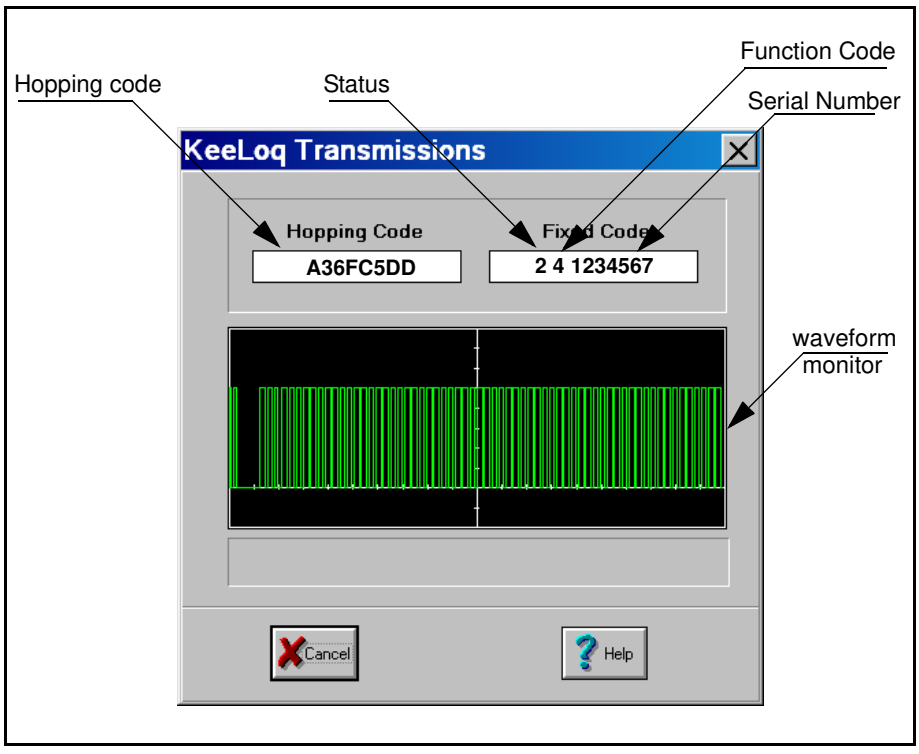
4.0 DESCRIPTION

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.

KEELOQ® Encoders

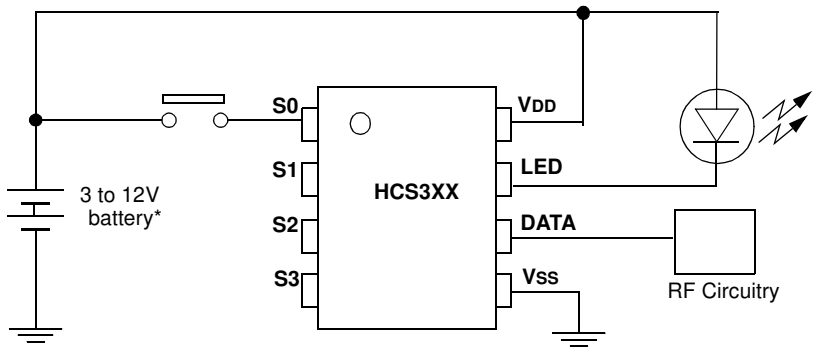
5.0 GENERAL DESCRIPTION

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.

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.

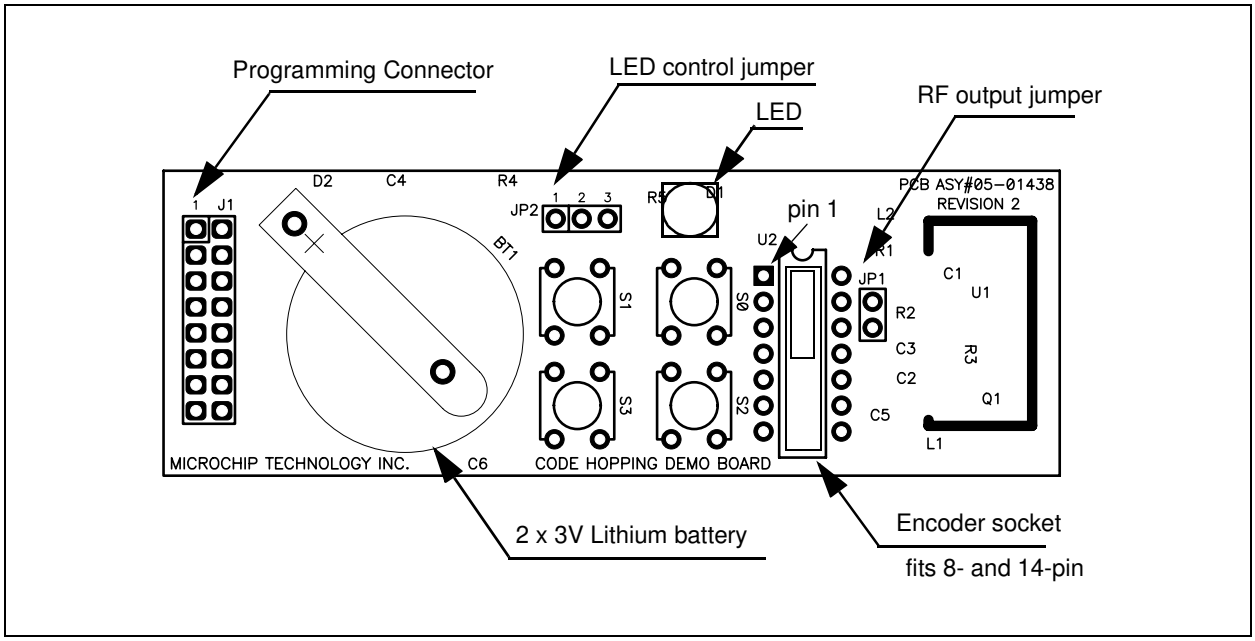
The encoder socket U2 supports 8-pin and 14-pin encoders inserted with pin 1 in the corresponding pin 1 of the 14-pin socket (Figure 6-1). The demo transmitter PCB leaves pins 5 through 9 unconnected to accommodate the different and sometimes conflicting pin functionalities on the HCS473, HCS370 and 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



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).

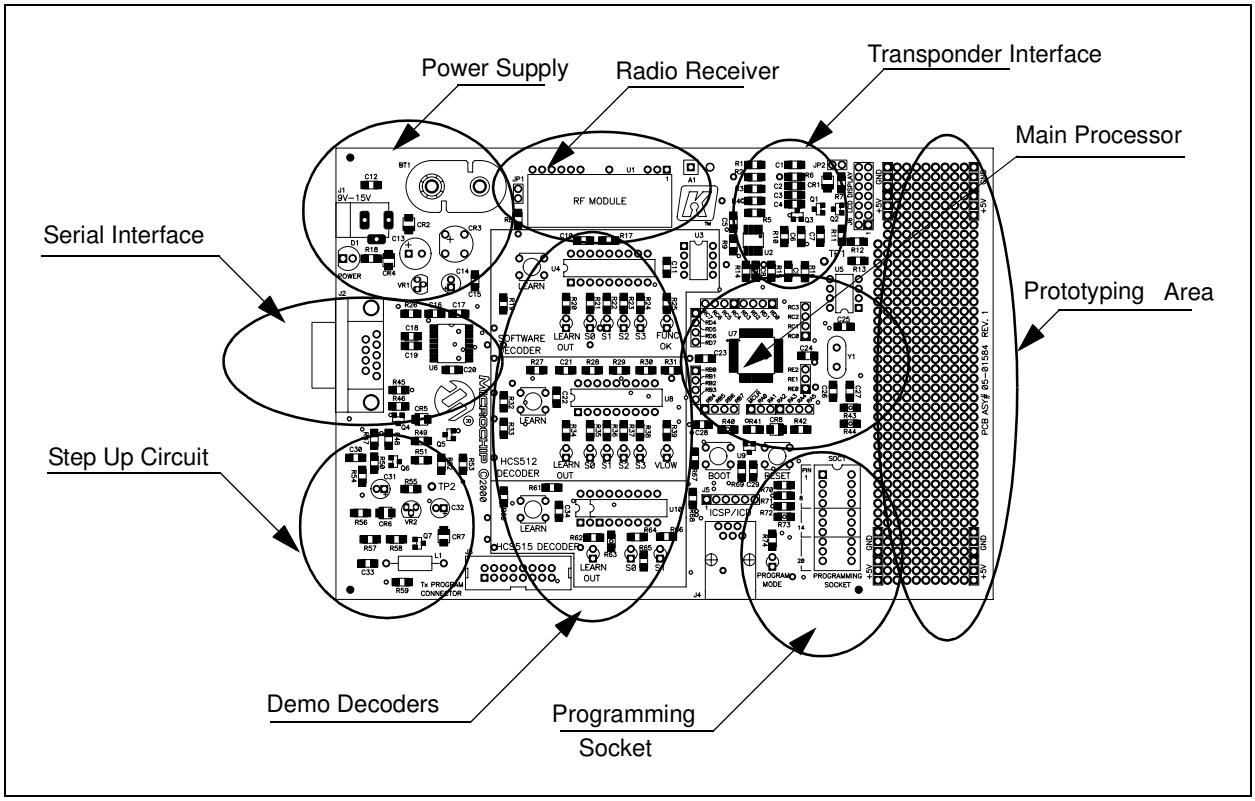
The Main Board

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



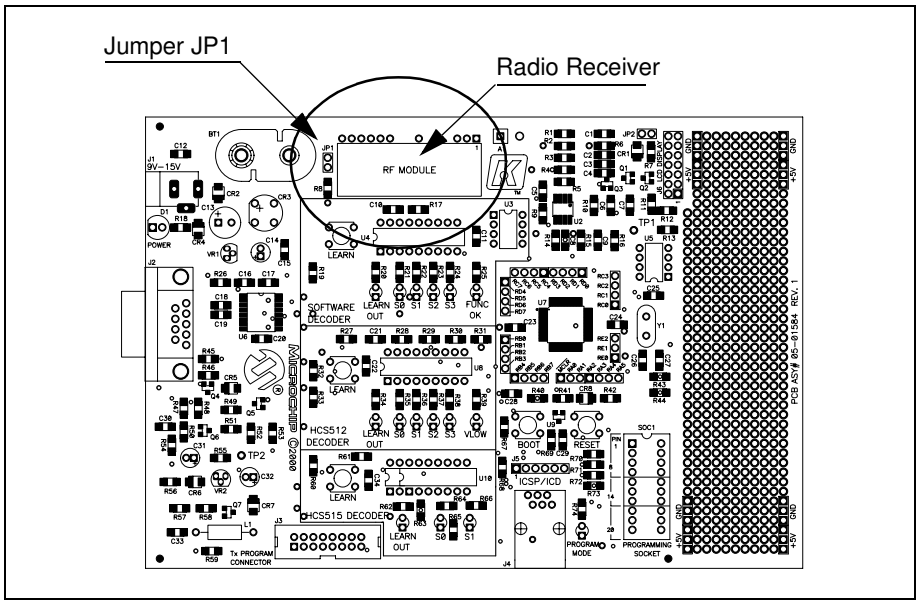
7.1 Radio Receiver

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:

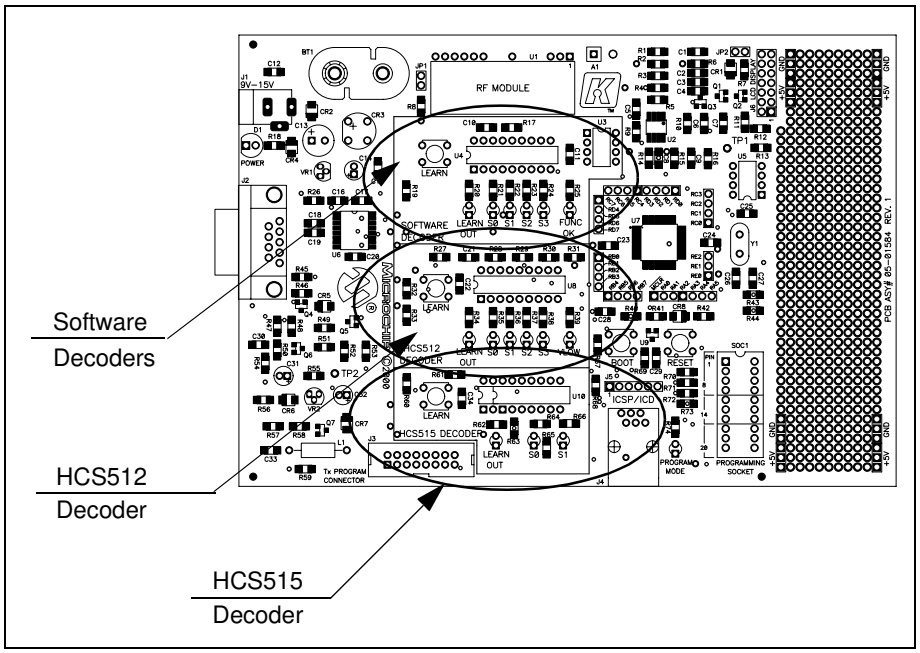
1. Software Decoders
2. HCS512 Decoder
3. HCS515 Decoder

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.

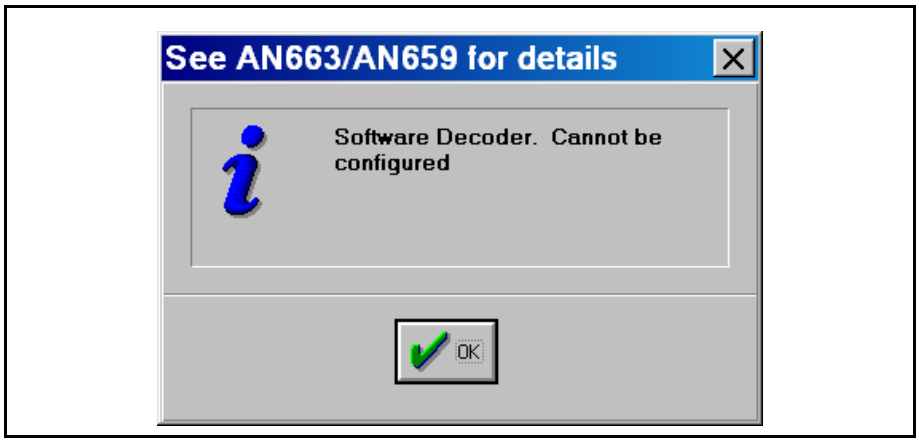
An official introduction to KEELOQ and its different Learning Schemes can be found in either the Application Notes or Technical Briefs TB001 and TB003. In short:

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.

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



7.2.2 HCS512 DECODER

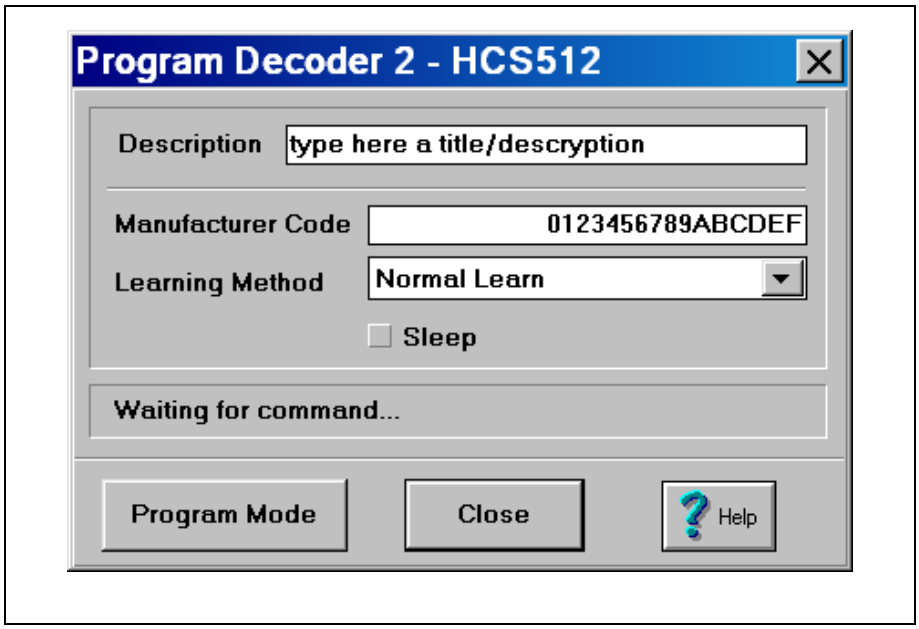
The HCS512 is a fully integrated KEELOQ decoder since it contains the necessary non-volatile memory to store the Serial Number and Synchronization Information for up to four transmitters.

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.