INTRODUCTION

A number of devices in the PIC® microcontroller family have a Synchronous Serial Port (SSP) or Master Synchronous Serial Port (MSSP) peripheral capable of implementing the I²C™ communication protocols. Using these peripherals, a PIC microcontroller device programmed as a KEELOQ® receiver/decoder can be interfaced into a larger system, such as a home security system, via the I²C protocol. This application note describes a simple system that uses a PIC16F690 as a KEELOQ receiver and decoder, and also uses I²C communication to send and receive status and command messages.

For more information on I²C protocol specification, please refer to the Section “REFERENCES”.

BACKGROUND

Traditionally, KEELOQ is viewed as a stand-alone system. An RF receptor PCB with a KEELOQ device is located in proximity of the device being secured (garage door, vehicle access, etc.). The KEELOQ decoder then waits for an incoming RF transmission, decodes the transmission and decides if it is valid. If valid, an appropriate output is activated. All housekeeping routines are entered through buttons in the decoder assembly: learn transmitters, erase transmitters command, etc.

Some systems, such as home security and automation, require the security of KEELOQ, but also need the KEELOQ decode module to be part of a larger automation system controlled by a main processor, such as the system shown in Figure 1. The KEELOQ module only decodes the signal, decides if it comes from a valid transmitter and sends the decoded function to the main processor. For example, in a home automation system, this main processor receives the function code from the KEELOQ receiver and decides what action to take; deactivate the main alarm, open the garage door, etc., and send the command to the appropriate module.

The main processor also instructs the KEELOQ module when to enter into Learn mode, when to erase a transmitters’ information, or when to send a status message.

A practical solution is to implement the KEELOQ decoding algorithm in a microcontroller and perform all the housekeeping via I²C communication between the central processor and the KEELOQ microcontroller. The KEELOQ microcontroller will be operating in I²C Slave mode.
FIGURE 1: **KEELOQ® DECODER AS A MODULE IN AN I²C™ BUS SYSTEM**

![Diagram](image)

**IMPLEMENTATION**

Figure 2 shows the implementation of an I²C interface with a KEELOQ decoder. For this application note, a PIC16F886 having an MSSP module is used. This implementation can also be implemented on a device with a SSP module, such as a PIC16F690.

The I²C Slave mode portion of the application is implemented as shown in AN734, "Using the PIC® Devices’ SSP and MSSP Modules for Slave I²C™ Communication".

In I²C there are two types of events: write operation and read operation. When an SSP interrupt is detected, the SSP module will indicate what I²C event has occurred. An I²C write operation will let the receiver know what command will need to be executed. An I²C read operation requests the receiver to provide a current status.

For this implementation the write operation will consider the following commands:

**EXAMPLE 1: COMMANDS**

<table>
<thead>
<tr>
<th>Value</th>
<th>Command</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Learn Transmitter</td>
</tr>
<tr>
<td>02</td>
<td>Erase All Transmitters</td>
</tr>
<tr>
<td>03</td>
<td>Confirm Transmitter Learned</td>
</tr>
</tbody>
</table>
KEELOQ decoding is implemented as shown in AN672, “PIC® MCU Mid-range MCU Code Hopping Decoder”.

The KEELOQ receiving routine is interrupt driven based on Timer0. With the I²C communications this give us two sources of interrupts: SSP for I²C communication, and TMR0 for KEELOQ reception. The interrupt routine flow diagram is shown in Figure 3.
In this application, the main processor (it could be a PC or another microcontroller), will be operating in \( ^2 \text{C} \) Master mode and sends commands as detailed in Example 2.

The write request consists of three bytes: module address, task byte and a third byte for additional information, as needed.

**EXAMPLE 2: WRITE REQUEST**

<table>
<thead>
<tr>
<th>Byte 1</th>
<th>Keeloq Module Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>Byte 2</td>
<td>Command Byte</td>
</tr>
<tr>
<td>Byte 3</td>
<td>Additional Info</td>
</tr>
</tbody>
</table>

The command byte indicates to the Keeloq module what task to perform.

The Keeloq decoder microcontroller can receive a variety of commands via \( ^2 \text{C} \), such as: Learn a Transmitter, Erase All Transmitters, Decoder Status, etc.

A read request is used to retrieve status data from the Keeloq module. Status data includes the reception of a valid transmitter signal. The data sent from the Keeloq module is in the following format:

**EXAMPLE 3: SENT DATA FORMAT**

<table>
<thead>
<tr>
<th>Byte 1</th>
<th>Master Controller Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>Byte 2</td>
<td>Command Performed</td>
</tr>
<tr>
<td>Byte 3</td>
<td>Transmitter Information</td>
</tr>
</tbody>
</table>

**ADVANTAGES**

The main advantage of this type of system is that the Keeloq receiver can be designed as a “plug-in” module to the overall system, releasing the processor to do other housekeeping tasks. The system is secure since all the encryption and decryption is done inside the microcontroller.

**CONCLUSION**

A decoding Keeloq based controller, that is part of a larger system, can be interfaced to other microcontroller units via \( ^2 \text{C} \). This adds flexibility to system designs because the decoder commands can be managed through a separate microcontroller without compromising security. Only decoded data and commands travel through the \( ^2 \text{C} \) bus.

**REFERENCES**

- AN734, “Using the PIC\(^\text{\textregistered}\) Devices’ SSP and MSSP Modules for Slave \( ^2 \text{C} \) Communication”
- AN672, “PIC\(^\text{\textregistered}\) MCU Mid-range MCU Code Hopping Decoder”
- The \( ^2 \text{C} \) Bus Specification, Philips Semiconductor, Version 2.1, 2000,
  - http://www.nxp.com/\( ^2 \text{C} \)
ADDITIONAL INFORMATION

Microchip’s Secure Data Products are covered by some or all of the following:
Code hopping encoder patents issued in European countries and U.S.A.
Secure learning patents issued in European countries, U.S.A. and R.S.A.

REVISION HISTORY

Revision B (June 2011)

• Added new section Additional Information
• Minor formatting and text changes were incorporated throughout the document
Note the following details of the code protection feature on Microchip devices:

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

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

Information contained in this publication regarding device applications and the like is provided only for your convenience and may be superseded by updates. It is your responsibility to ensure that your application meets with your specifications. MICROCHIP MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND WHETHER EXPRESS OR IMPLIED, WRITTEN OR ORAL, STATUTORY OR OTHERWISE, RELATED TO THE INFORMATION, INCLUDING BUT NOT LIMITED TO ITS CONDITION, QUALITY, PERFORMANCE, MERCHANTABILITY OR FITNESS FOR PURPOSE. Microchip disclaims all liability arising from this information and its use. Use of Microchip devices in life support and/or safety applications is entirely at the buyer’s risk, and the buyer agrees to defend, indemnify and hold harmless Microchip from any and all damages, claims, suits, or expenses resulting from such use. No licenses are conveyed, implicitly or otherwise, under any Microchip intellectual property rights.

Trademarks

The Microchip name and logo, the Microchip logo, dsPIC, KEELOG, KEELOG logo, MPLAB, PIC, PICmicro, PICSTART, PIC32™ logo, rPIC and Uni/O are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

FilterLab, Hampshire, HI-TECH C, Linear Active Thermistor, MXDEV, MXLAB, SEEVAL and The Embedded Control Solutions Company are registered trademarks of Microchip Technology Incorporated in the U.S.A.

Analog-for-the-Digital Age, Application Maestro, chipKIT, chipKIT logo, CodeGuard, dsPICDEM, dsPICDEM.net, dsPICWorks, dsSPEAK, ECAN, ECONOMONITOR, FanSense, Hi-TIDE, In-Circuit Serial Programming, ICSP, Mindi, MiWi, MPASM, MPLAB Certified logo, MPLIB, MPLINK, mTouch, Omniscent Code Generation, PICC, PICC-18, PICDEM, PICDEM.net, PICkit, PICtail, REAL ICE, rFLAB, Select Mode, Total Endurance, TSHARC, UniWinDriver, WiperLock and ZENA are trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

SQTP is a service mark of Microchip Technology Incorporated in the U.S.A.

All other trademarks mentioned herein are property of their respective companies.

© 2009-2011, Microchip Technology Incorporated, Printed in the U.S.A., All Rights Reserved.

Printed on recycled paper.

ISBN: 978-1-61341-262-6
## AMERICAS

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

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

**Boston**  
Westborough, MA  
Tel: 774-447-0087  
Fax: 774-447-0088

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

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

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

**Detroit**  
Farmington Hills, MI  
Tel: 248-538-2250  
Fax: 248-538-2260

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

**Los Angeles**  
Mission Viejo, CA  
Tel: 949-462-9523  
Fax: 949-462-9508

**Santa Clara**  
Santa Clara, CA  
Tel: 408-961-6444  
Fax: 408-961-6445

**Toronto**  
Mississauga, Ontario, Canada  
Tel: 905-673-0699  
Fax: 905-673-6509

## ASIA/PACIFIC

**Asia Pacific Office**  
Suites 3707-14, 37th Floor  
Tower 6, The Gateway  
Harbour City, Kowloon  
Hong Kong  
Tel: 852-2401-1200  
Fax: 852-2401-3431

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

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

**China - Chengdu**  
Tel: 86-28-8665-5111  
Fax: 86-28-8665-7889

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

**China - Hangzhou**  
Tel: 86-571-2819-3180  
Fax: 86-571-2819-3189

**China - Hong Kong SAR**  
Tel: 852-2401-1200  
Fax: 852-2401-3431

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

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

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

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

**China - Shenzhen**  
Tel: 86-755-8203-2660  
Fax: 86-755-8203-1760

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

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

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

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

## ASIA/PACIFIC

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

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

**India - Pune**  
Tel: 91-20-2566-1512  
Fax: 91-20-2566-1513

**Japan - Yokohama**  
Tel: 81-45-471-6166  
Fax: 81-45-471-6122

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

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

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

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

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

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

**Taiwan - Hsin Chu**  
Tel: 886-3-6578-300  
Fax: 886-3-6578-370

**Taiwan - Kaohsiung**  
Tel: 886-7-213-7830  
Fax: 886-7-330-9305

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

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

## EUROPE

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

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

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

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

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

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

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

**UK - Wokingham**  
Tel: 44-118-921-5869  
Fax: 44-118-921-5820

05/02/11