AN217

KEELOQ® HCS30X, HCS200 Stand-Alone Programmer

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OVERVIEW

This application note describes how to implement a KEELOQ stand-alone programmer using a Microchip PIC16F84A microcontroller.

The PIC16F84A is a FLASH microcontroller with 64 bytes of internal EEPROM that, in this design, is used to store the incremental serial number programmed into HCS encoders every time. All the other HCS configuration parameters are defined as constants in the FLASH program memory of the PIC16F84A.

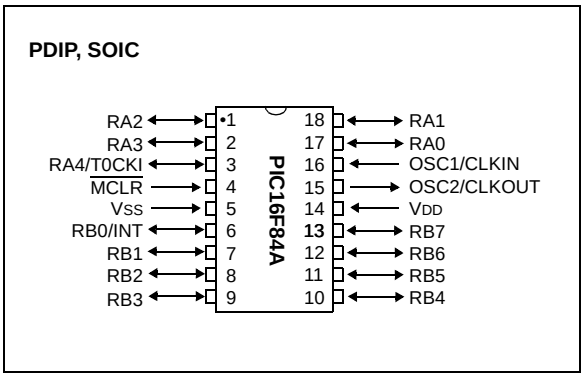
Two learning schemes are implemented:

- The simple learning scheme for which you can find the complete software in this application note.
- The normal learning scheme with the applicable software included in the KEELOQ license agreement disks (this software includes the KEELOQ decryption routine).

In the first scheme, the Encryption Key programmed in the HCS encoders is always the same and equal to the Manufacturer's Code.

In the second scheme, before starting to program the encoder, the PIC16F84A calculates the Encryption Key for that encoder using the 64-bit Manufacturer's Code and the 28-bit serial number running the KEELOQ decryption algorithm.

FIGURE 1: PIC16F84A PIN OUT

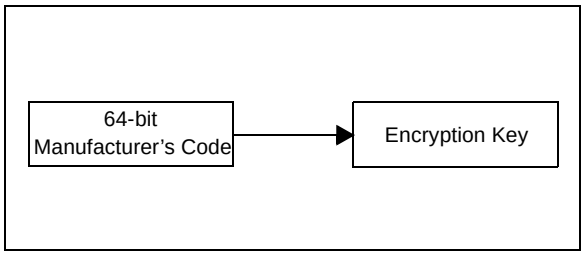


KEELOQ SIMPLE LEARNING SCHEME

(Fixed Key)

This learning scheme implements the lowest level of security for a KEELOQ based security system. With this method, every programmed encoder has a different serial number, but the same fixed Encryption Key is equal to the chosen Manufacturer's Code.

FIGURE 2: SIMPLE LEARNING SCHEME



An explanation of the different security levels can be found in the *"Secure Data Products Handbook"* (Comparison Chart, Section 1 [DS40168]).

The application note AN659 (*KEELOQ Simple Code Hopping Decode* [DS00663]), implements a decoder that can be used with an encoder using the simple learning method.

KEELOQ NORMAL LEARNING SCHEME

(Serial Number Derived System)

In this case, every transmitter is programmed with an incremental unique serial number. This serial number is used in conjunction with the 64-bit Manufacturer's Code and the KEELOQ algorithm to generate the Encryption Key. This Encryption Key is programmed into the encoder, thus, every transmitter has a different key that is used to encrypt the data.

A detailed explanation of this learning scheme can be found in the Technical Brief TB001 [DS91000A], part of the *Microchip Secure Data Products Handbook*.

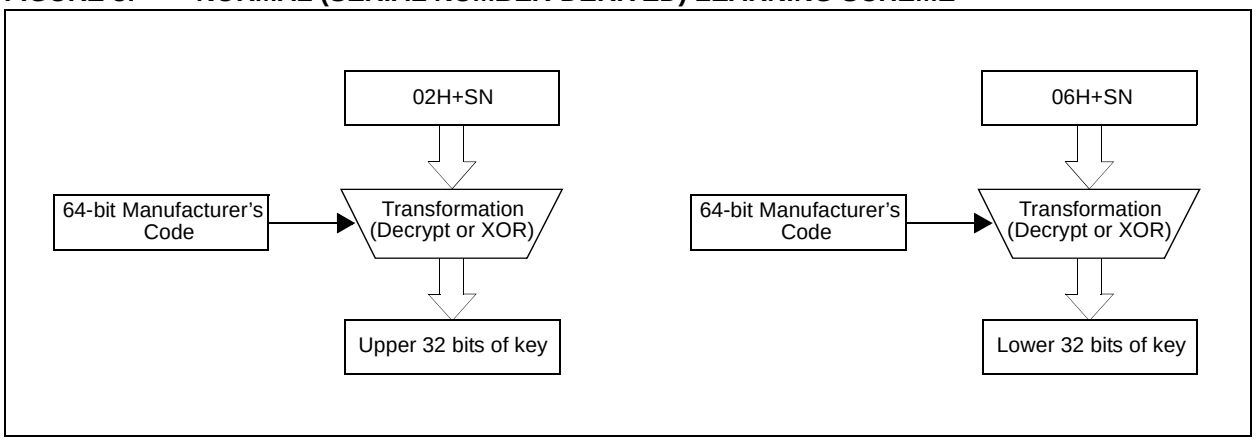
The application note AN642 (*KEELOQ Code Hopping Decoder Using a PIC16C56,* [DS00642]), implements a decoder that can be used with the HCS programmed in this normal method.

Notice:

This is a non-restricted version of Application Note AN218 which is available under the KEELOQ License Agreement. The license agreement can be ordered from the Microchip Literature Center as DS40149.

The key generation scheme is shown below:

FIGURE 3: NORMAL (SERIAL NUMBER-DERIVED) LEARNING SCHEME



OTHER POSSIBLE LEARNING SCHEMES

(Secure Seed-Derived System)

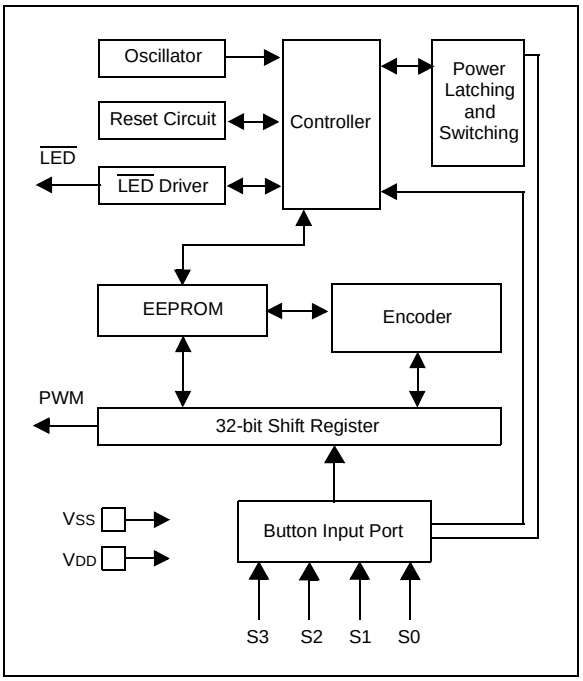
The two learning methods implemented in this application note are not the only schemes applicable. Refer to Technical Brief TB001 for more information on Secure Learning schemes.

Furthermore, custom learning scheme solutions can also be implemented.

ENCODER EEPROM MEMORY ORGANIZATION

The KEELOQ encoders are EEPROM based devices with a built-in oscillator, wake-up on button press, reset circuit and internal logic state machine (Figure 4).

FIGURE 4: HCS300 BLOCK DIAGRAM



The HCS200, HCS300 and HCS301 contain 192 bits (12 * 16-bit words) of EEPROM memory (Table 1). This EEPROM array is used to store the Encryption Key, the synchronization value, the serial number, etc.

A detailed description of the memory map is represented in Table 1.

TABLE 1: HCS30X EEPROM MEMORY MAP

WORD ADDRESS	MNEMONIC	DESCRIPTION
0	KEY_0	64-bit Encryption Key (word 0)
1	KEY_1	64-bit Encryption Key (word 1)
2	KEY_2	64-bit Encryption Key (word 2)
3	KEY_3	64-bit Encryption Key (word 3)
4	SYNC	16-bit Synchronization Value
5	RESERVED	Set to 0000H
6	SER_0	Device Serial Number (word 0)
7	SER_1	Device Serial Number (word 1)
8	SEED_0	Seed Value (word 0)
9	SEED_1	Seed Value (word 1)
10	EN_KEY	16-bit Envelope Key
11	CONFIG	Config Word

Note: The MSb of the serial number contains a bit used to select the auto shut-off timer.

In order to create the encrypted message transmitted to the receiver, the encoder uses the 64-bit Encryption Key and the 16-bit synchronous counter.

Certain configuration options can be selected for the different encoders. Table 2 shows the configuration word for the HCS300/1.

TABLE 2: HCS30X CONFIGURATION WORD

BIT NUMBER	BIT DESCRIPTION
0	Discrimination Bit 0
1	Discrimination Bit 1
2	Discrimination Bit 2
3	Discrimination Bit 3
4	Discrimination Bit 4
5	Discrimination Bit 5
6	Discrimination Bit 6
7	Discrimination Bit 7
8	Discrimination Bit 8
9	Discrimination Bit 9
10	Overflow bit 0 (OVR0)
11	Overflow bit 1 (OVR1)
12	Low Voltage Trip Point Select
13	Baud Rate Select Bit 0 (BSL0)
14	Baud Rate Select Bit 1 (BSL1)
15	Envelope Encryption Select (EENC)

Note: Please refer to the HCS200 data sheet [DS40138] for configuration details.

PROGRAMMING/VERIFY WAVEFORM

The programming cycle allows programming of the 192-bits representing the serial number, the Encryption Key, the configuration word, etc., in a serial data stream into the encoder EEPROM.

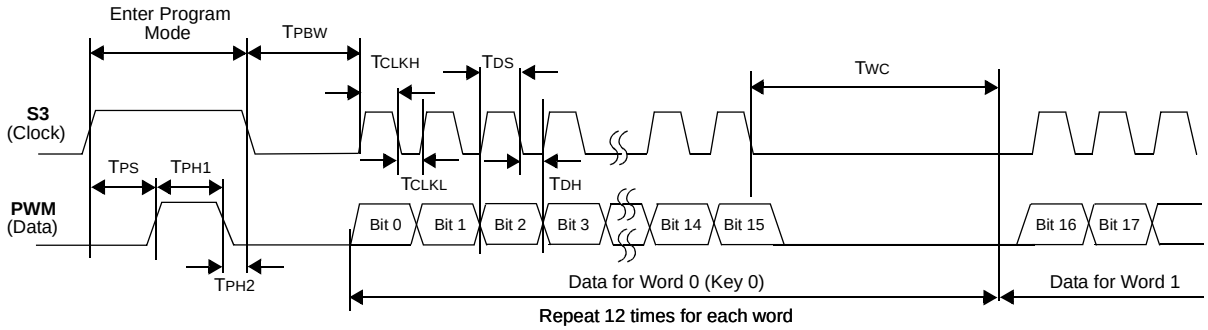
Programming is initiated by forcing the PWM line high, after the S2 line has been held high for the appropriate length of time (TPS).

After the program mode is entered, a delay must be allowed during which the device erases the entire memory. This writes all locations in the EEPROM to zeros. The device can then be programmed by clocking in 16 bits at a time, using S2 as the clock line and PWM as the data in line. After each 16-bit word is loaded, a programming delay is required for the internal program cycle to complete. This delay can take up to TWC (see Table 3).

At the end of the programming cycle, the device can be verified (Figure 6) by reading back the EEPROM. Clocking the S2 line reads back the data on the PWM line. For security reasons, it is not possible to execute a verify function without first programming the EEPROM.

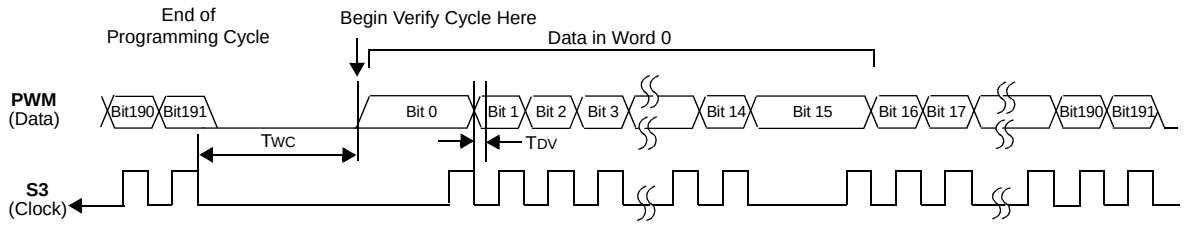
A verify operation can only be done once, immediately following the program cycle. This is important to prevent reading the internal memory of the encoder once it has been programmed.

FIGURE 5: PROGRAMMING WAVEFORMS



Note 1: Unused button inputs to be held to ground during the entire programming sequence.
2: The VDD pin must be taken to ground after a program/verify cycle.

FIGURE 6: VERIFY WAVEFORMS



Note: If a Verify operation is to be done, then it must immediately follow the Program cycle.

Note: For the HCS300 and HCS301, both the S2 pin and the S3 pin can be used as programming clock lines, and for the HCS200, only the S2 pin can be the clock line.

TABLE 3: PROGRAMMING/VERIFY TIMING REQUIREMENTS

V_{DD} = 5.0V ± 10% 25°C ± 5°C				
Parameter	**Symbol**	**Min.**	**Max.**	**Units**
Program Mode Setup Time	T_{PS}	3.5	4.5	ms
Hold Time 1	T_{PH1}	3.5	—	ms
Hold Time 2	T_{PH2}	50	—	µs
Bulk Write Time	T_{PBW}	—	2.2	ms
Program Delay Time	T_{PROG}	—	2.2	ms
Program Cycle Time	T_{WC}	—	36	ms
Clock Low Time	T_{CLKL}	25	—	µs
Clock High Time	T_{CLKH}	25	—	µs
Data Setup Time	T_{DS}	0	—	µs
Data Hold Time	T_{DH}	18	—	µs
Data Out Valid Time	T_{DV}	10	24	µs

SOFTWARE IMPLEMENTATION

The software that implements the encoder programmer runs on the PIC16F84A.

The 64-bit Manufacturer's Code is stored in the internal PIC16F84A FLASH memory. This cannot be read if the device is code protected.

All the other parameters in the configuration word of the encoder are in the FLASH program memory of the PIC16F84A, where they are defined as constants.

The serial number programmed every time into the encoder is located instead, in the internal EEPROM data memory of the PIC16F84A.

In order to change the Manufacturer Code (MKEY_X), or some parameter of the configuration word, as the voltage selection (VLOW), the baud rates transmission (BSL0, BSL1), etc., a change in the firmware is required. The following define can be modified in the assembly code:

```
;*******************************************************************************
MODIFYABLE PROGRAMMING DEFINE
;*******************************************************************************

#DEFINE     KEY_METHOD 1           ; MUST BE 1 IF NORMAL KEY GEN METHOD TO BE USED
                                   ; MUST BE 0 IF SIMPLE KEY GEN METHOD TO BE USED
                                   ; (ENCRYPTION KEY= MANUFACTURER KEY)

#DEFINE     HCS30X     1           ; MUST BE 1 IF PROGRAMMING HCS300-301,
                                   ; MUST BE 0 IF PROGRAMMING HCS200

#DEFINE     MCODE_0    0xCDEF      ; LSWORD
#DEFINE     MCODE_1    0x89AB
#DEFINE     MCODE_2    0x4567
#DEFINE     MCODE_3    0x0123      ; MSWORD

#DEFINE     SYNC       0X0000      ; SYNCRONOUS COUNTER

#DEFINE     SEED_0     0x0000      ; 2 WORD SEED VALUE
#DEFINE     SEED_1     0x0000

#DEFINE     ENV_KEY    0x0000      ; ENVELOPE KEY (NOT USED FOR HCS200)

#DEFINE     AUTOFF     1           ; AUTO SHUT OFF TIMER ( NOT USED FOR HCS200)

#DEFINE     DISC70     0x00        ; DISCRIMINATION BIT7-BIT0
#DEFINE     DISC8      0           ; DISCRIMINATION BIT8
#DEFINE     DISC9      0           ; DISCRIMINATION BIT9
#DEFINE     OVR0       0           ; OVERFLOW BIT0 (DISC10 for HCS200)
#DEFINE     OVR1       0           ; OVERFLOW BIT1(DISC11 for HCS200)
#DEFINE     VLOW       1           ; LOW VOLTAGE TRIP POINT SELECT BIT (1=High voltage)
#DEFINE     BSL0       0           ; BAUD RATE SELECT BIT0
#DEFINE     BSL1       0           ; BAUD RATE SELECT BIT1(RESERVED for HCS200)
#DEFINE     EENC       0           ; ENVELOPE ENCRYPTION SELECT(RESERVED for
                                   ; HCS200)

#DEFINE     DISEQSN    1           ; IF DISEQSN=1 SET DISCRIMINANT EQUAL TO
                                   ; SERNUM BIT10-0 IF DISEQSN=0 SET DISCRIMINANT
                                   ; AS DEFINED ABOVE

;*******************************************************************************
```

Note: The PIC16F84A program to build the HCS EEPROM memory map uses all these parameters.

The software given with this application note implements the Simple Key generation method, while the software that implements the Normal Key method is contained in the KEELOQ License agreement disks.

The software is composed of four main functions:

- Main loop routines
- Encryption Key generation routines
- Programming HCS routines
- Verify HCS routines

Main Loop Routine (M_KEY_GEN: SIMPLE_KEY_GEN, NORMAL_KEY_GEN, MAP_SET)

The program simply waits for a button press to proceed to the programming routines.

Encryption Routines (M_KEY_GEN: SIMPLE_KEY_GEN, NORMAL_KEY_GEN, MAP_SET)

The M_KEY_GEN routine can be different, by just changing the parameter called KEY_METHOD from 0 to 1 in the modifiable table.

With the Simple Key generation method, the SIMPLE_KEY_GEN routine sets the Encryption Key equal to the Manufacturer Code. The NORMAL_KEY_GEN routine uses the KEELOQ decryption algorithm in order to create the Encryption Key, starting from the Manufacturer Code and the current serial number read from the PIC16F84A internal data memory.

The MAP_SET routine prepares the 12 words (WORD0 - WORD11) to be programmed in the HCS EEPROM map.

Programming HCS Routines (M_PROGRAMMING)

This routine starts driving the PWM line high, after the S2 line has been held high for the appropriate length of time, in order to bulk erase the encoder after 2.2 ms (TPBW).

Then, the M_NEW_WORD routine outputs the first word to be programmed on the PWM line synchronously with the clock S2 line and waits for the 36 ms of programming time (TWC).

This routine is repeated 12 times completing the entire programming of the HCS EEPROM memory map.

The WAIT_uS and WAIT_WMSEC implements software delay routines to wait micro or milliseconds.

Verify HCS Routines (M_VERIFY)

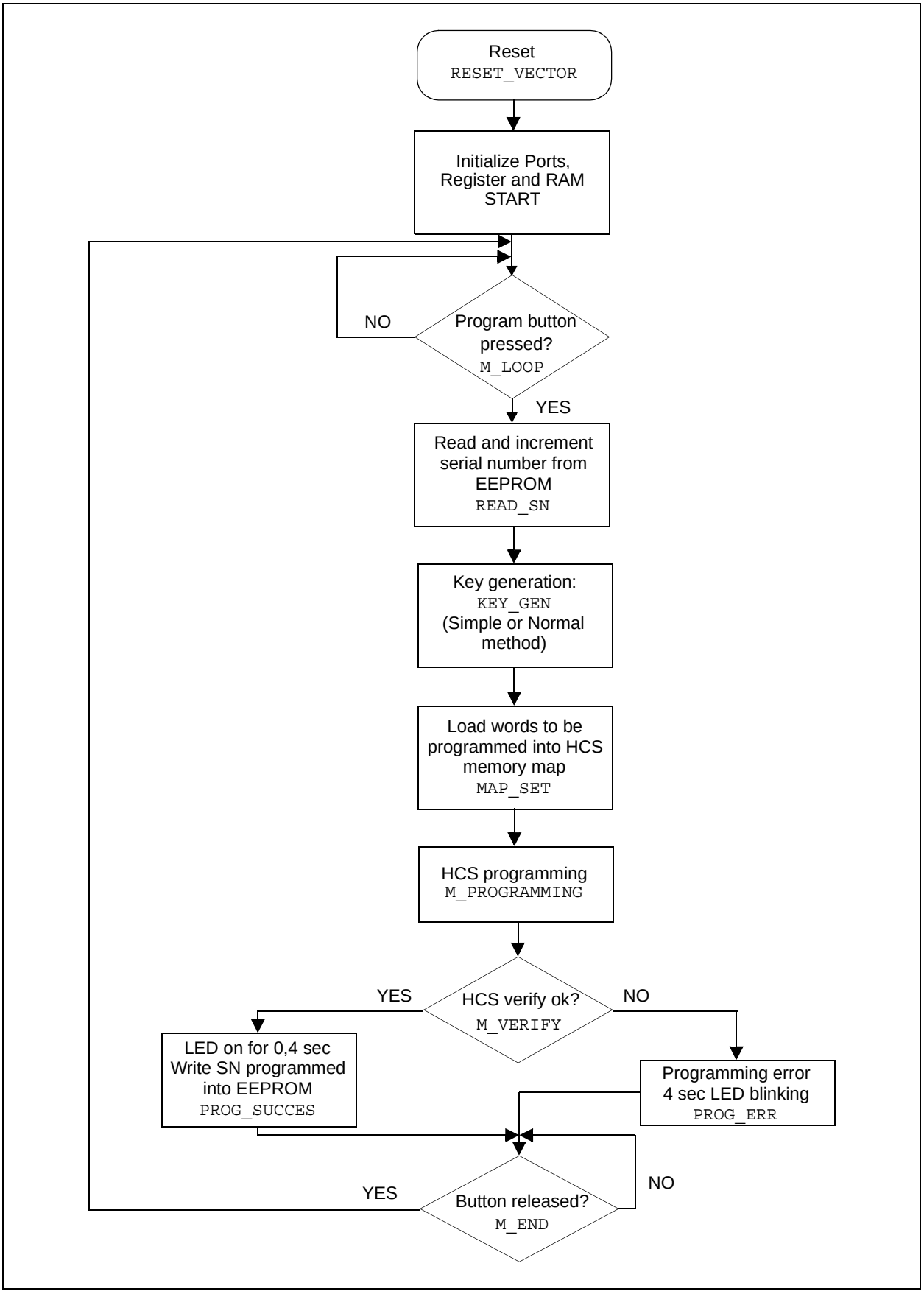
At the end of the 12th word programmed, the M_VERIFY routine continues to drive the clock line S2, reading back the EEPROM memory and verifying what was programmed before.

If the verify is right, it is indicated by 0.4 seconds LED on (PROG_SUCCESS). If not, the LED will blink for 4 seconds (PROG_ERR) before going back to the M_LOOP.

For further analysis, consult the following literature:

KEELOQ Code Hopping Decoder on a PIC16C56	AN642	DS00642
Converting NTQ105/106 Designs to HCS200/300s	AN644	DS00644
Code Hopping Security System on a PIC16C57	AN645	DS00645
Secure Learn Code Hopping Decoder on a PIC16C56	AN652	DS00652
KEELOQ Simple Code Hopping Decoder	AN659	DS00659
KEELOQ Code Hopping Decoder on a PIC16C56 (public version)	AN661	DS00661
Secure Learn Code Hopping Decoder on a PIC16C56 (public version)	AN662	DS00662
KEELOQ Simple Code Hopping Decoder (public version)	AN663	DS00663
Using KEELOQ to Generate Hopping Passwords	AN665	DS00665
PICmicro Mid-Range MCU Code Hopping Decoder	AN662	DS00672
HCS410 Transponder Decoder using a PIC16C56	AN675	DS00675
Modular PICmicro Mid-Range MCU Code Hopping Decoder	AN742	DS00742
Modular Mid-Range PICmicro KEELOQ Decoder in C	AN744	DS00744
Secure Learning RKE Systems Using KEELOQ Encoders	TB001	DS91000
An Introduction to KEELOQ Code Hopping	TB003	DS91002
A Guide to Designing for EuroHomelink Compatibility	TB021	DS91021
KEELOQ Decryption & IFF Algorithms	TB030	DS91030
KEELOQ Decryption Routines in C	TB041	DS91041
Interfacing a KEELOQ Encoder to a PLL Circuit	TB042	DS91042
KEELOQ CRC Verification Routines	TB043	DS91043

FIGURE 7: PROGRAMMING FLOW DIAGRAM



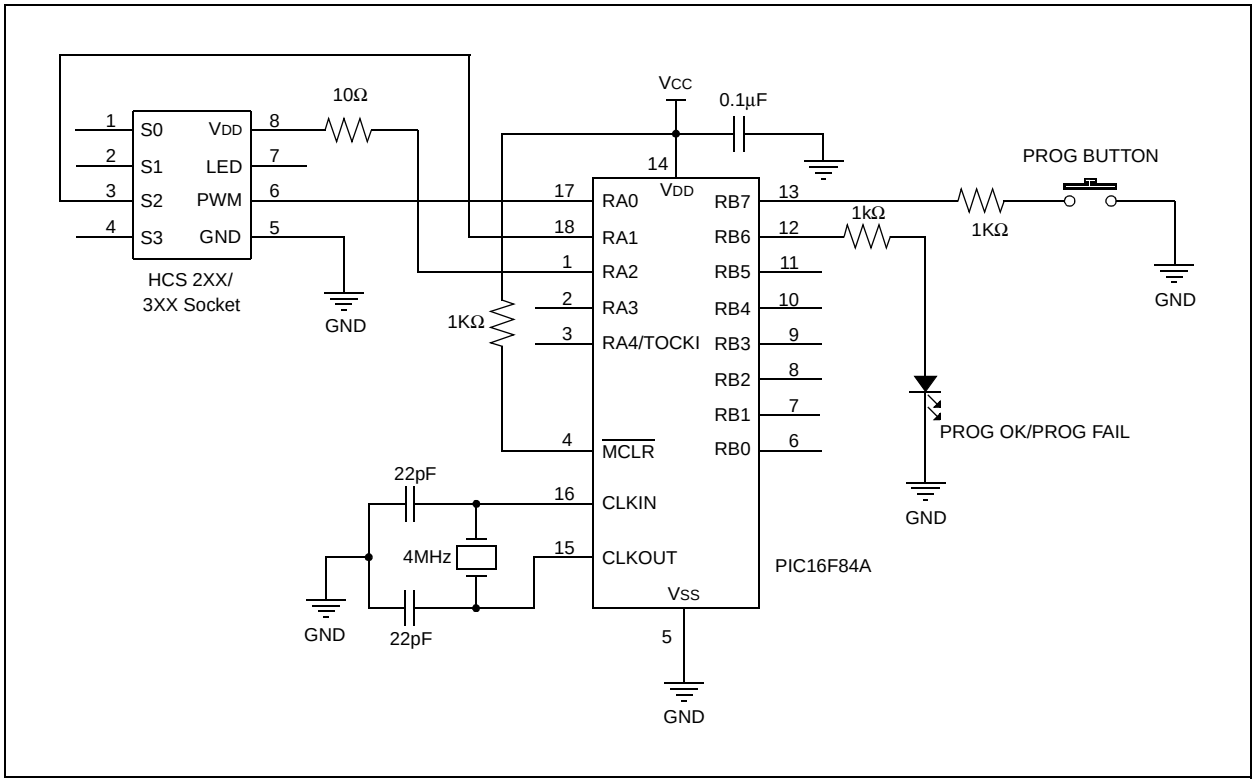
CONCLUSION

This application note describes a very low cost and simple stand-alone KEELOQ encoder programmer, which could be easily modified for additional features. For example, a LCD display could be added showing some parameters, such as the serial number and the Seed programmed every time. Also, a RF or infrared module receiver can be integrated to receive the encoder transmission after every program operation and test the transmitter hardware. One additional feature would be to add a manufacturer code verification step before programming a device.

Another improvement could be to introduce the possibility to modify the programming parameters by implementing a serial port that can interface to a PC. In this way, we will no longer have a stand-alone programmer, only because it will be possible to update the Manufacturer Key, the Seed, the configuration word, etc., with simple PC software.

These configuration parameters can also be stored in the internal EEPROM data memory, resulting in a stand-alone programmer.

FIGURE 8: PROGRAMMER SCHEMATIC CIRCUIT



MEMORY USAGE

Program Memory Words Used: 471

File Registers Used: 50

KEY WORDS

Programmer, KEELOQ, HCS200, HCS201, HCS300, HCS301, HCS320 and PIC16F84A

APPENDIX A: PROGHCS SOURCE CODE

```
MPASM 02.40 Released          PROGHCS.ASM   8-1-2000  9:55:22         PAGE  1


LOC  OBJECT CODE     LINE SOURCE TEXT
  VALUE

                     00001     LIST n=0,c=132
                     00002 ;=============================================================================================
                     00003 ; MICROCHIP KEELOQ HCS200 - HCS300 - HCS301 STANDALONE PROGRAMMER
                     00004 ;=============================================================================================
                     00005
                     00006 ; THIS STANDALONE PROGRAMMER APPLY THE SIMPLE LEARN SCHEME TO PROGRAM
                     00007 ; THE HCS ENCODERS.
                     00008 ; THE SERIAL NUMBER IS INCREMENTED EVERY TIME A HCS PROGRAMMING HAPPEN
                     00009 ; AND IS STORED IN THE INTERNAL DATA EEPROM OF THE PIC16F84A
                     00010 ;
                     00011 ; THE HCS MANUFACTURER CODE AND THE CONFIGURATION WORD CAN BE CHANGED
                     00012 ; IN THE SECTION BELOW NAMED "MODIFYABLE PROGRAMMING DEFINE"
                     00013
                     00014 ;=============================================================================================
                     00015 ;       VERSION 1.0,    09/03/99
                     00016 ;=============================================================================================
                     00017
                     00018         PROCESSOR       PIC16F84A
                     00019         RADIX           DEC
                     00020
                     00021         INCLUDE         "P16F84A.INC"
                     00001         LIST
                     00002 ; P16F84A.INC  Standard Header File, Version 2.00    Microchip Technology, Inc.
                     00134         LIST
                     00022
2007   3FF5          00023         __CONFIG        _XT_OSC & _CP_OFF & _WDT_ON & _PWRTE_ON
                     00024
                     00025 ;=============================================================================================
                     00026 ;
                     00027 ;                         PIC16F84A
                     00028 ;                      -------_--------
                     00029 ;             HCSVDD | 1 RA2    RA1 18| CLK      (to HCS slave: S2)
                     00030 ;                    | 2 RA3TC  RA0 17| DATA     (to HCS slave: PWM)
                     00031 ;                    | 3 RA4   OSC1 16| OSCin
                     00032 ;              reset | 4 MCLR  OSC2 15| OSCtest
                     00033 ;                Vss | 5 Vss    Vdd 14| Vdd
                     00034 ;                    | 6 RB0    RB7 13| PROG
                     00035 ;                    | 7 RB1    RB6 12| LED
                     00036 ;                    | 8 RB2    RB5 11|
                     00037 ;                    | 9 RB3    RB4 10|
                     00038 ;                     ----------------
                     00039 ;
                     00040 ;=============================================================================================
                     00041 ; MACROS
                     00042
                     00043 #DEFINE BANK0   bcf     STATUS,RP0
                     00044 #DEFINE BANK1   bsf     STATUS,RP0
                     00045
                     00046 ;=============================================================================================
                     00047 ; I/O PORT ASSIGNEMENT
                     00048
                     00049 ; PORTA BIT DEFINITIONS
                     00050 #DEFINE DATA    PORTA,0                 ; (IN/OUT) Data (PWM) for Programming HCS
                     00051 #DEFINE CLK     PORTA,1                 ; (OUT) Clock (S2) for Programming HCS
                     00052 #DEFINE HCSVDD  PORTA,2                 ; (OUT) HCS Vdd line
                     00053
                     00054 ; PORTB BIT DEFINITIONS
                     00055 #DEFINE LED     PORTB,6                 ; (OUT) Program/failure led indicator
```

```
                  00056 #DEFINE PROG    PORTB,7                 ; (IN)  Programming Key
                  00057 #DEFINE SWRES   PORTB,7                 ; (IN)  Sw reset Key on programming failure
                  00058
                  00059 ;---------------
                  00060 ; PORT DIRECTION DEFINE REG
                  00061 #DEFINE K_MASKPA        B'11111000'     ; PORTA: TRI-STATE VALUE
                  00062 #DEFINE K_MASKPB        B'10111111'     ; PORTB: TRI-STATE VALUE
                  00063 #DEFINE K_MASKPA_PROG   B'11111000'     ; PORTB: TRI-STATE FOR PROGRAMMING HCS
                  00064 #DEFINE K_MASKPA_VERI   B'11111001'     ; PORTB: TRI-STATE FOR VERIFY HCS
                  00065
                  00066 #DEFINE K_OPTION        B'00000111'     ; OPTION REGISTER SETTING
                  00067                                 ; PORTB PULL-UP ON, TMR0 associated to Tcy, Prescaler=1:256
                  00068
                  00069 ;*******************************************************************************************
                  00070
                  00071 ; GENERAL PURPOSE RAM REGISTERS
                  00072
                  00073         CBLOCK  0x0C
                  00074
                  00075 ; Word clocked into HCS
0000000C          00076                 WRD_HI, WRD_LO
                  00077 ; Words to be programmed into HCS (HCS MEMORY MAPPING)
0000000E          00078                 WORD0:2, WORD1:2, WORD2:2, WORD3:2
00000016          00079                 WORD4:2, WORD5:2, WORD6:2, WORD7:2
0000001E          00080                 WORD8:2, WORD9:2, WORD10:2, WORD11:2
                  00081 ; Other Variable for programming HCS
00000026          00082                 TXNUM                                   ; Number of bit clocked
00000027          00083                 TMP_CNT                                 ; Temporary Counter
00000028          00084                 MYCONT                                  ;       "
00000029          00085                 COUNT_HI, COUNT_LO                      ; Counter for Timing
                  00086
                  00087 ; Generated Encryption KEY
0000002B          00088                 KEY7, KEY6, KEY5, KEY4
0000002F          00089                 KEY3, KEY2, KEY1, KEY0
                  00090 ; Circular Buffer used in decryption routine
00000033          00091                 CSR4, CSR5, CSR6, CSR7
00000037          00092                 CSR0, CSR1, CSR2, CSR3
                  00093 ; Counter used in decryption routine
0000003B          00094                 CNT0, CNT1
                  00095 ; Mask register used in decryption routine
0000003D          00096                 MASK
                  00097 ; Temporary Register
0000003E          00098                 TMP0, TMP1, TMP2, TMP3                  ; Temp register
                  00099
                  00100         ENDC
                  00101
                  00102 ; End of define general purpose RAM register
                  00103
                  00104 ;*******************************************************************************************
                  00105 ; **************  DECRYPTION REGISTER RE-MAPPINGS ******************
                  00106 ; NOTE : INDIRECT ADDRESSING USED, DO NOT CHANGE REGISTER ASSIGNMENT
                  00107 ; ***************************************************************
                  00108 ; 32 BIT HOPCODE BUFFER
                  00109
                  00110 #DEFINE HOP1    CSR0
                  00111 #DEFINE HOP2    CSR1
                  00112 #DEFINE HOP3    CSR2
                  00113 #DEFINE HOP4    CSR3
                  00114
                  00115 ; 28 BIT SERIAL NUMBER
                  00116
00000036          00117 SER_3   EQU     CSR7                    ; LSB
00000035          00118 SER_2   EQU     CSR6
00000034          00119 SER_1   EQU     CSR5
00000033          00120 SER_0   EQU     CSR4                    ; MSB
                  00121
                  00122 ;*******************************************************************************************
                  00123 ; MODIFYABLE PROGRAMMING DEFINE
                  00124 ;*******************************************************************************************
                  00125
                  00126 #DEFINE KEY_METHOD 0            ; MUST BE 1 IF NORMAL KEY GENERATION METHOD TO BE USED
                  00127                                 ; MUST BE 0 IF SIMPLE KEY GENERATION METHOD TO BE USED
                  00128                                 ; (ENCRYPTION KEY= MANUFACTURER KEY)
                  00129
                  00130 #DEFINE HCS30X  1               ; MUST BE 1 IF PROGRAMMING HCS300-301,
                  00131                                 ; MUST BE 0 IF PROGRAMMING HCS200
                  00132
                  00133 #DEFINE MCODE_0 0xCDEF          ; MANUFACTURER CODE, LSWORD
                  00134 #DEFINE MCODE_1 0x89AB
                  00135 #DEFINE MCODE_2 0x4567
                  00136 #DEFINE MCODE_3 0x0123          ; MSWORD
                  00137
                  00138 #DEFINE SYNC    0X0000          ; SYNCRONOUS COUNTER
                  00139
                  00140 #DEFINE SEED_0  0x0000          ; 2 WORD SEED VALUE
                  00141 #DEFINE SEED_1  0x0000
                  00142 #DEFINE ENV_KEY 0x0000          ; ENVELOPE KEY                  ( NOT USED FOR HCS200)
```

```
                    00143
                    00144 #DEFINE AUTOFF  1               ; AUTO SHUT OFF TIMER           ( NOT USED FOR HCS200)
                    00145
                    00146 #DEFINE DISC70  0x00            ; DISCRIMINATION BIT7-BIT0
                    00147 #DEFINE DISC8   0               ; DISCRIMINATION BIT8
                    00148 #DEFINE DISC9   0               ; DISCRIMINATION BIT9
                    00149 #DEFINE OVR0    0               ; OVERFLOW BIT0                 (DISC10 for HCS200)
                    00150 #DEFINE OVR1    0               ; OVERFLOW BIT1                 (DISC11 for HCS200)
                    00151 #DEFINE VLOW    1               ; LOW VOLTAGE TRIP POINT SELECT BIT (1=High voltage)
                    00152 #DEFINE BSL0    0               ; BAUD RATE SELECT BIT0
                    00153 #DEFINE BSL1    0               ; BAUD RATE SELECT BIT1         (RESERVED for HCS200)
                    00154 #DEFINE EENC    0               ; ENVELOPE ENCRYPTION SELECT    (RESERVED for HCS200)
                    00155
                    00156 #DEFINE DISEQSN 1               ; IF DISEQSN=1 SET DISCRIMINANT EQUAL TO SERNUM BIT10-0
                    00157                                 ; IF DISEQSN=0 SET DISCRIMINANT AS DEFINED ABOVE
                    00158
                    00159 ;*******************************************************************************************
                    00160 ; OTHER EQUATE
                    00161 ;*******************************************************************************************
                    00162
                    00163 #DEFINE NUM_WRD .12             ; NUMBER OF WORD TO PROGRAM INTO HCS
                    00164 #DEFINE RES     0X0000          ; RESERVED WORD
                    00165
                   00166 #DEFINE CONF_HI ((EENC<<7)|(BSL1<<6)|(BSL1<<5)|(VLOW<<4)|(OVR1<<3)|(OVR0<<2)|(DISC9<<1)|DISC8)
                    00167
                    00168 ; ****** HCS TIME PROGRAMMING EQUATE ********
                    00169 #DEFINE Tps     .4              ; PROGRAM MODE SETUP TIME 4mS   (3,5mS min, 4,5 max)
                    00170 #DEFINE Tph1    .4              ; HOLD TIME 1             4mS   (3,5mS min)
                    00171 #DEFINE Tph2    .19             ; HOLD TIME 2             62uS  (50uS min)
                    00172 #DEFINE Tpbw    .3              ; BULK WRITE TIME         3mS   (2,2mS min)
                    00173 #DEFINE Tclkh   .10             ; CLOCK HIGH TIME         35uS  (25uS min)
                    00174 #DEFINE Tclkl   .10             ; CLOCK LOW TIME          35uS  (25uS min)
                    00175 #DEFINE Twc     .40             ; PROGRAM CYCLE TIME      40mS  (36mS min)
                    00176
                    00177
                    00178 ; NOTE: FOR mS TIME DELAY USE WAIT_WMSEC SUBROUTINE ( W * 1mSec )
                    00179 ;       FOR uS TIME DELAY USE WAIT_uS SUBROUTINE ( 5 + Txxx*3 uS )
                    00180
                    00181
                    00182 ;*******************************************************************************************
                    00183 ;*******************************************************************************************
                    00184
                    00185 ;*******************************************************************************************
                    00186 ; FUNCTION     : RESET ()
                    00187 ; DESCRIPTION  : PROGRAM RESET ROUTINE
                    00188 ;*******************************************************************************************
                    00189
0000                00190         ORG     0x00
0000                00191 RESET_VECTOR
0000   28DB         00192         goto    START
                    00193
                    00194 ;*******************************************************************************************
                    00195 ; FUNCTION     : ISR_VECTOR ()
                    00196 ; DESCRIPTION  : INTERRUPT SERVICE ROUTINE VECTOR
                    00197 ;*******************************************************************************************
                    00198
0004                00199         ORG     0x04
0004                00200 ISR_VECTOR
0004   0009         00201                 retfie
                    00202
                    00203 ;*******************************************************************************************
                    00204
                    00205 ;*******************************************************************************************
                    00206 ;*******************************************************************************************
                    00207 ; SUBROUTINES   SUBROUTINES     SUBROUTINES     SUBROUTINES     SUBROUTINES
                    00208 ;*******************************************************************************************
                    00209 ;*******************************************************************************************
                    00210
                    00211 ;*******************************************************************************************
                    00212 ; FUNCTION     : INITREG
                    00213 ; DESCRIPTION  : REGISTER INIZIALIZATION
                    00214 ;*******************************************************************************************
                    00215
0005   0183         00216 INITREG         clrf    STATUS
0006   018B         00217                 clrf    INTCON                  ; INTERRUPT DISABLED
0007   0185         00218                 clrf    PORTA                   ; RESET PORTA
0008   0186         00219                 clrf    PORTB                   ; RESET PORTB
0009   1683         00220         BANK1
000A   3007         00221                 movlw   K_OPTION                ; INT CLK, PRESCALER TO TMR0, ON PULL-UP
000B   0081         00222                 movwf   OPTION_REG
000C   30F8         00223                 movlw   K_MASKPA                ; SETUP PORTA
000D   0085         00224                 movwf   TRISA
000E   30BF         00225                 movlw   K_MASKPB                ; SETUP PORTB
000F   0086         00226                 movwf   TRISB
0010   1283         00227         BANK0
0011   0181         00228                 clrf    TMR0
0012   0008         00229                 return
```

```
                     00230
                     00231 ;*******************************************************************************
                     00232 ; FUNCTION     : INITREG
                     00233 ; DESCRIPTION  : REGISTER INIZIALIZATION
                     00234 ;*******************************************************************************
                     00235
0013   300C          00236 CLEAR_RAM       movlw   0x0C
0014   0084          00237                 movwf   FSR
0015   0180          00238 CLEAR_RAM_LOOP  clrf    INDF
0016   0A84          00239                 incf    FSR,F
0017   3050          00240                 movlw   0x50
0018   0604          00241                 xorwf   FSR,W
0019   1D03          00242                 skpz
001A   2815          00243                 goto    CLEAR_RAM_LOOP
001B   0008          00244                 return
                     00245
                     00246 ;*******************************************************************************
                     00247 ; FUNCTION      : WAIT_uS ()
                     00248 ; DESCRIPTION   : WAIT 5+W*3 MICROSECOND SUBROUTINE
                     00249 ;*******************************************************************************
                     00250
001C   00AA          00251 WAIT_uS         movwf   COUNT_LO
001D   0BAA          00252 WAIT_uS_A       decfsz  COUNT_LO, F
001E   281D          00253                 goto    WAIT_uS_A
001F   0008          00254                 return
                     00255
                     00256 ;*******************************************************************************
                     00257 ; FUNCTION      : DEBOUNCE - WAIT_16MSEC - WAIT_WMSEC ()
                     00258 ; DESCRIPTION   : WAIT 16mSec or W mSec SUBROUTINE
                     00259 ;*******************************************************************************
                     00260
0020                 00261 DEBOUNCE
0020   3010          00262 WAIT_16MSEC     movlw   .16
0021   00A9          00263 WAIT_WMSEC      movwf   COUNT_HI
0022   30FA          00264 WAITSET         movlw   .250
0023   00AA          00265                 movwf   COUNT_LO
0024   0064          00266 WAITLOOP        clrwdt
0025   0BAA          00267                 decfsz  COUNT_LO,F
0026   2824          00268                 goto    WAITLOOP
0027   0BA9          00269                 decfsz  COUNT_HI,F
0028   2822          00270                 goto    WAITSET
0029   0008          00271                 return
                     00272
                     00273 ;*******************************************************************************
                     00274 ; FUNCTION      : BUTTON RELEASE ()
                     00275 ; DESCRIPTION   : WAIT FOR BUTTON RELEASE
                     00276 ;*******************************************************************************
                     00277
002A   0064          00278 BUTTON_RELEASE  clrwdt
002B   1F86          00279                 btfss   PROG
002C   282A          00280                 goto    BUTTON_RELEASE
002D   2020          00281                 call    DEBOUNCE
002E   0008          00282                 return
                     00283
                     00284 ;*******************************************************************************
                     00285 ; FUNCTION      : READ_SN ()
                     00286 ; DESCRIPTION   : READ LAST SERIAL NUMBER STORED IN THE PIC16F84A EEPROM DATA,
                     00287 ;                 AND INCREMENT IT INTO NEW SER_x
                     00288 ;*******************************************************************************
                     00289
002F   3036          00290 READ_SN         movlw   SER_3
0030   0084          00291                 movwf   FSR
0031   01A8          00292                 clrf    MYCONT                  ; COUNTER OF BYTE
                     00293                                                 ; READ FROM DATA EEPROM
0032   0064          00294 READ_SN_A       clrwdt
0033   0828          00295                 movf    MYCONT,W
0034   0089          00296                 movwf   EEADR
0035   1683          00297         BANK1
0036   1408          00298                 bsf     EECON1, RD              ; do a read
0037   0064          00299                 clrwdt
0038   1808          00300                 btfsc   EECON1, RD              ; Read done ?
0039   2837          00301                 goto    $-2
003A   1283          00302         BANK0
003B   0808          00303                 movf    EEDATA,W
003C   0080          00304                 movwf   INDF
003D   0AA8          00305                 incf    MYCONT, F
003E   3004          00306                 movlw   .4
003F   0628          00307                 xorwf   MYCONT, W               ; TEST IF 4 BYTE READ
0040   1903 2844     00308                 bz      READ_SN_INC
0042   0384          00309                 decf    FSR, F
0043   2832          00310                 goto    READ_SN_A
                     00311
0044   0FB6          00312 READ_SN_INC     incfsz  SER_3, F                ; LOW BYTE: INCREMENT SN
0045   284B          00313                 goto    READ_SN_X
0046   0FB5          00314                 incfsz  SER_2, F
0047   284B          00315                 goto    READ_SN_X
0048   0FB4          00316                 incfsz  SER_1, F
```

```
0049   284B           00317                goto    READ_SN_X
004A   0AB3           00318                incf    SER_0, F
                      00319
004B   0008           00320 READ_SN_X      return
                      00321
                      00322 ;*****************************************************************************
                      00323 ; FUNCTION      : WRITE_SN ()
                      00324 ; DESCRIPTION   : SAVE INTO PIC16F84A  EEPROM DATA THE LAST PROGRAMMED SERIAL
                      00325 ;               : NUMBER
                      00326 ;*****************************************************************************
                      00327
004C   0064           00328 WRITE_SN       clrwdt
004D   3036           00329                movlw   SER_3
004E   0084           00330                movwf   FSR
004F   01A8           00331                clrf    MYCONT                  ; COUNTER OF BYTE
                      00332                                                ; WRITTEN TO DATA EEPROM
0050   0064           00333 WRITE_SN_BYTE  clrwdt
0051   0828           00334                movf    MYCONT, W
0052   0089           00335                movwf   EEADR
0053   0800           00336                movf    INDF, W
0054   0088           00337                movwf   EEDATA
0055   1683           00338        BANK1
0056   1208           00339                bcf     EECON1, EEIF
0057   1508           00340                bsf     EECON1, WREN            ; enable Write
0058   3055           00341                movlw   0x55
0059   0089           00342                movwf   EECON2
005A   30AA           00343                movlw   0xAA
005B   0089           00344                movwf   EECON2
005C   1488           00345                bsf     EECON1, WR
005D   0064           00346 WRITE_SN_A     clrwdt
005E   1888           00347                btfsc   EECON1, WR              ; Write complete ?
005F   285D           00348                goto    WRITE_SN_A
0060   1108           00349                bcf     EECON1, WREN            ; disable Write
0061                  00350 VERIFY_WRITE
0061   1283           00351        BANK0
0062   0808           00352                movf    EEDATA, W
0063   1683           00353        BANK1
0064   1408           00354                bsf     EECON1, RD              ; do a read
0065   0064           00355                clrwdt
0066   1808           00356                btfsc   EECON1, RD              ; Read done ?
0067   2865           00357                goto    $-2
0068   1283           00358        BANK0
0069   0608           00359                xorwf   EEDATA, W
006A   1D03 2961      00360                BNZ     EE_ERR                  ; EEPROM WRITE ERROR
                      00361
006C   0AA8           00362                incf    MYCONT, F
006D   3004           00363                movlw   .4
006E   0628           00364                xorwf   MYCONT, W               ; TEST IF WRITTEN ALL THE 4 BYTES
006F   1903 2873      00365                BZ      WRITE_SN_X
0071   0384           00366                decf    FSR, F
0072   2850           00367                goto    WRITE_SN_BYTE
0073   0008           00368 WRITE_SN_X     return
                      00369
                      00370 ;*****************************************************************************
                      00371 ; FUNCTION      : MEM_MAP ()
                      00372 ; DESCRIPTION   : PREPARE THE WORDS TO BE PROGRAMMED INTO HCS
                      00373 ;*****************************************************************************
                      00374
0074   300E           00375 MAP_SET        movlw   WORD0
0075   0084           00376                movwf   FSR
0076                  00377 WORD_0                                          ; ENCRYPTION KEY (4 WORD)
0076   0832           00378 WORD_0_LO      movf    KEY0,W
0077   0080           00379                movwf   INDF
0078   0A84           00380                incf    FSR, F
0079   0831           00381 WORD_0_HI      movf    KEY1,W
007A   0080           00382                movwf   INDF
007B   0A84           00383                incf    FSR, F
007C                  00384 WORD_1
007C   0830           00385 WORD_1_LO      movf    KEY2,W
007D   0080           00386                movwf   INDF
007E   0A84           00387                incf    FSR, F
007F   082F           00388 WORD_1_HI      movf    KEY3,W
0080   0080           00389                movwf   INDF
0081   0A84           00390                incf    FSR, F
0082                  00391 WORD_2
0082   082E           00392 WORD_2_LO      movf    KEY4,W
0083   0080           00393                movwf   INDF
0084   0A84           00394                incf    FSR, F
0085   082D           00395 WORD_2_HI      movf    KEY5,W
0086   0080           00396                movwf   INDF
0087   0A84           00397                incf    FSR, F
0088                  00398 WORD_3
0088   082C           00399 WORD_3_LO      movf    KEY6,W
0089   0080           00400                movwf   INDF
008A   0A84           00401                incf    FSR, F
008B   082B           00402 WORD_3_HI      movf    KEY7,W
008C   0080           00403                movwf   INDF
```

```
008D   0A84          00404                 incf    FSR, F
008E                 00405 WORD_4                                          ; SYNC COUNTER (1 WORD)
008E   3000          00406 WORD_4_LO       movlw   LOW(SYNC)
008F   0080          00407                 movwf   INDF
0090   0A84          00408                 incf    FSR, F
0091   3000          00409 WORD_4_HI       movlw   HIGH(SYNC)
0092   0080          00410                 movwf   INDF
0093   0A84          00411                 incf    FSR, F
0094                 00412 WORD_5                                          ; RESERVED (1 WORD)
0094   3000          00413 WORD_5_LO       movlw   LOW(RES)
0095   0080          00414                 movwf   INDF
0096   0A84          00415                 incf    FSR, F
0097   3000          00416 WORD_5_HI       movlw   HIGH(RES)
0098   0080          00417                 movwf   INDF
0099   0A84          00418                 incf    FSR, F
009A                 00419 WORD_6                                          ; SERIAL NUMBER (2 WORD)
009A   0836          00420 WORD_6_LO       movf    SER_3, W                ; LSByte
009B   0080          00421                 movwf   INDF
009C   0A84          00422                 incf    FSR, F
009D   0835          00423 WORD_6_HI       movf    SER_2, W
009E   0080          00424                 movwf   INDF
009F   0A84          00425                 incf    FSR, F
00A0                 00426 WORD_7
00A0   0834          00427 WORD_7_LO       movf    SER_1, W
00A1   0080          00428                 movwf   INDF
00A2   0A84          00429                 incf    FSR, F
00A3   0833          00430 WORD_7_HI       movf    SER_0, W                ; MSByte
00A4   390F          00431                 andlw   B'00001111'
00A5   3880          00432                 iorlw   (AUTOFF<<7)             ; SET THE AUTO SHUT-OFF TIMER
00A6   0080          00433                 movwf   INDF
00A7   0A84          00434                 incf    FSR, F
00A8                 00435 WORD_8                                          ; SEED VALUE ( 2 WORD)
00A8   3000          00436 WORD_8_LO       movlw   LOW(SEED_0)
00A9   0080          00437                 movwf   INDF
00AA   0A84          00438                 incf    FSR, F
00AB   3000          00439 WORD_8_HI       movlw   HIGH(SEED_0)
00AC   0080          00440                 movwf   INDF
00AD   0A84          00441                 incf    FSR, F
00AE                 00442 WORD_9
00AE   3000          00443 WORD_9_LO       movlw   LOW(SEED_1)
00AF   0080          00444                 movwf   INDF
00B0   0A84          00445                 incf    FSR, F
00B1   3000          00446 WORD_9_HI       movlw   HIGH(SEED_1)
00B2   0080          00447                 movwf   INDF
00B3   0A84          00448                 incf    FSR, F
00B4                 00449 WORD_10                                         ; ENVELOPE KEY (1 WORD)
                     00450                                                 ; (RESERVED FOR HCS200 SET TO 0x0000)
00B4   3000          00451 WORD_10_LO      movlw   (LOW(ENV_KEY) * HCS30X)
00B5   0080          00452                 movwf   INDF
00B6   0A84          00453                 incf    FSR, F
00B7   3000          00454 WORD_10_HI      movlw   (HIGH(ENV_KEY) * HCS30X)
00B8   0080          00455                 movwf   INDF
00B9   0A84          00456                 incf    FSR, F
00BA                 00457 WORD_11
00BA   0836          00458 WORD_11_LO      movf    SER_3, W                ; CONFIGURATION WORD
00BB   0080          00459                 movwf   INDF                    ; LOWER BYTE=LOWEST BYTE OF SERIAL NUMBER
00BC   0A84          00460                 incf    FSR, F
00BD   0835          00461 WORD_11_HI      movf    SER_2, W
00BE   3903          00462                 ANDLW   B'00000011'             ; MASK BIT OF SER. NUM.
00BF   3810          00463                 IORLW   CONF_HI                 ; MASK OTHER BIT OF CONFIG WORD
00C0   0080          00464                 movwf   INDF
00C1   0A84          00465                 incf    FSR, F
00C2   0008          00466                 return
                     00467
                     00468 ;*****************************************************************************************
                     00469 ; FUNCTION      : PREPARE_WRD ()
                     00470 ; DESCRIPTION   : PUT IN WRD_LO & WRD_HI THE WORD TO BE CLOCKED OUT (PWM)
                     00471 ;*****************************************************************************************
                     00472
00C3   0800          00473 PREPARE_WRD     movf    INDF, W
00C4   008D          00474                 movwf   WRD_LO
00C5   0A84          00475                 incf    FSR, F
00C6   0800          00476                 movf    INDF, W
00C7   008C          00477                 movwf   WRD_HI
00C8   0A84          00478                 incf    FSR, F
00C9   0008          00479                 return
                     00480
                     00481 ;*****************************************************************************************
                     00482 ; This include File is provided with the Keeloq License disk in order to
                     00483 ; implement the NORMAL KEY GENERATION SCHEME METHOD
                     00484
                     00485 ;               INCLUDE "DECRYPT.INC"
                     00486
                     00487 ;*****************************************************************************************
                     00488
                     00489 ;*****************************************************************************************
                     00490 ; FUNCTION      : GET KEY or SIMPLE_KEY_GEN ()
```

```
                    00491 ; DESCRIPTION   : ENCRYPTION KEY =  MANUFACTURER CODE STORED IN ROM
                    00492 ;*****************************************************************************
                    00493
00CA   3001         00494 SIMPLE_KEY_GEN  movlw   HIGH(MCODE_3)           ; COPY THE MANUFACTURER CODE INTO
00CB   00AB         00495                 movwf   KEY7                    ; ENCRYPTION KEY (BYTE)
00CC   3023         00496                 movlw   LOW(MCODE_3)
00CD   00AC         00497                 movwf   KEY6
00CE   3045         00498                 movlw   HIGH(MCODE_2)
00CF   00AD         00499                 movwf   KEY5
00D0   3067         00500                 movlw   LOW(MCODE_2)
00D1   00AE         00501                 movwf   KEY4
00D2   3089         00502                 movlw   HIGH(MCODE_1)
00D3   00AF         00503                 movwf   KEY3
00D4   30AB         00504                 movlw   LOW(MCODE_1)
00D5   00B0         00505                 movwf   KEY2
00D6   30CD         00506                 movlw   HIGH(MCODE_0)
00D7   00B1         00507                 movwf   KEY1
00D8   30EF         00508                 movlw   LOW(MCODE_0)
00D9   00B2         00509                 movwf   KEY0
00DA   0008         00510                 return
                    00511
                    00512
                    00513 ;*****************************************************************************
                    00514
                    00515 ;*****************************************************************************
                    00516 ;*****************************************************************************
                    00517 ;       END SUBROUTINES       END SUBROUTINES        END SUBROUTINES
                    00518 ;*****************************************************************************
                    00519 ;*****************************************************************************
                    00520
                    00521 ;*****************************************************************************
                    00522 ; FUNCTION     : START ()
                    00523 ; DESCRIPTION  : PROGRAM START ROUTINE
                    00524 ;*****************************************************************************
                    00525
00DB   2005         00526 START           call    INITREG
00DC   2013         00527                 call    CLEAR_RAM
                    00528
00DD   1706         00529                 bsf     LED                     ; LED ON PWUP
00DE   30FA         00530                 movlw   .250                    ; WAIT 250Msec with LED ON
00DF   2021         00531                 call    WAIT_WMSEC
00E0   1306         00532                 bcf     LED                     ; LED OFF
00E1   28E2         00533                 goto    M_LOOP
                    00534
                    00535 ;*****************************************************************************
                    00536 ; FUNCTION      : M_LOOP ()
                    00537 ; DESCRIPTION   : MAIN PROGRAM ROUTINE
                    00538 ;*****************************************************************************
                    00539
00E2   0064         00540 M_LOOP          clrwdt                          ; WAIT FOR PROGRAMMING BUTTON PRESS
00E3   1B86         00541                 btfsc   PROG
00E4   28E2         00542                 goto    M_LOOP
00E5   2020         00543                 call    DEBOUNCE
                    00544
                    00545 ;-----------------------------------------------------------------------------
                    00546 ; PROGRAMMING ROUTINES
                    00547 ;-----------------------------------------------------------------------------
00E6   202F         00548 M_KEY_GEN       call    READ_SN                 ; READ FROM EE SN TO BE PROGRAMMED
00E7   0064         00549                 clrwdt
                    00550
                    00551         if      KEY_METHOD==1
                    00552                 call    NORMAL_KEY_GEN
                    00553         else
00E8   20CA         00554                 call    SIMPLE_KEY_GEN
                    00555         endif
                    00556
00E9   2074         00557                 call    MAP_SET                 ; PREPARE EEPROM MEMORY MAP
                    00558
                    00559 ;---------------                                ; ENTER IN PROGRAMMING MODE AND BULK ERASE
00EA                00560 M_PROGRAMMING
00EA   1005         00561 M_PROG_INIT     bcf     DATA                    ; DATA=0
00EB   1085         00562                 bcf     CLK                     ; CLK=0
00EC   1505         00563                 bsf     HCSVDD                  ; HCS POWER ON
00ED   1683         00564         BANK1
00EE   30F8         00565                 movlw   K_MASKPA_PROG
00EF   0085         00566                 movwf   TRISA
00F0   1283         00567         BANK0
00F1   2020         00568                 call    WAIT_16MSEC
                    00569
00F2   1485         00570 M_PROG_SETUP    bsf     CLK                     ; DATA=0, CLK=1
00F3   3004         00571                 movlw   Tps                     ; WAIT Program mode Setup Time (Tps)
00F4   2021         00572                 call    WAIT_WMSEC
                    00573
00F5   1405         00574                 bsf     DATA                    ; DATA=1, CLK=1
00F6   3004         00575                 movlw   Tph1                    ; WAIT Program Hold Time 1 (Tph1)
00F7   2021         00576                 call    WAIT_WMSEC
                    00577
```

```
00F8  1005          00578                 bcf     DATA                    ; DATA=0, CLK=1
00F9  3013          00579                 movlw   Tph2                    ; WAIT Program Hold Time 2 (Tph2)
00FA  201C          00580                 call    WAIT_uS
                    00581
00FB  1085          00582 M_PROG_BULK_ER  bcf     CLK                     ; DATA=0, CLK=0
00FC  3003          00583                 movlw   Tpbw                    ; WAIT Program Bulk Write Time (Tpbw)
00FD  2021          00584                 call    WAIT_WMSEC
                    00585
                    00586 ;---------------                                ; CLOCK INTO HCS THE WORDS TO BE PROGRAMMED
00FE  01A7          00587                 clrf    TMP_CNT                 ; NUMBER OF WORD TRASMITTED
00FF  300E          00588                 movlw   WORD0                   ; SET INDIRECT PONTER TO INIT EE MAP
0100  0084          00589                 movwf   FSR
                    00590
0101  20C3          00591 M_NEW_WORD      call    PREPARE_WRD
                    00592
                    00593 ;---------------                                ; OUTPUT WORD ROTATE
0102  01A6          00594                 clrf    TXNUM                   ; NUMBER OF BIT TRASMITTED FOR EACH WORD
                    00595
0103  1485          00596 M_TX_BIT        bsf     CLK                     ; CLK=1
0104  1003          00597                 clrc
0105  0C8C          00598                 rrf     WRD_HI, F               ; ROTATE BIT TO OUTPUT
0106  0C8D          00599                 rrf     WRD_LO, F               ;  into CARRY FLAG
0107  1803          00600                 skpnc
0108  290C          00601                 goto    M_PROG_DHI
0109  0000          00602                 nop
010A  1005          00603 M_PROG_DLO      bcf     DATA                    ; DATA=0
010B  290D          00604                 goto    M_PROG_BIT
010C  1405          00605 M_PROG_DHI      bsf     DATA                    ; DATA=1
                    00606
010D  300A          00607 M_PROG_BIT      movlw   Tclkh
010E  201C          00608                 call    WAIT_uS                 ; DELAY
010F  1085          00609                 bcf     CLK                     ; CLK=0
0110  300A          00610                 movlw   Tclkl
0111  201C          00611                 call    WAIT_uS                 ; DELAY
                    00612 ;---------------
0112  0AA6          00613 M_PROG_CHK_WORD incf    TXNUM, F                ; INCREMENT NUMBER OF BIT TRASMITTED
0113  3010          00614                 movlw   .16                     ; CHECK IF END OF WORD TRASMITTED (16 BITS)
0114  0626          00615                 xorwf   TXNUM, W
0115  1D03          00616                 skpz
0116  2903          00617                 goto    M_TX_BIT                ; TRASMIT NEXT BIT
                    00618
                    00619 ;---------------                                ; END OUTPUT WORD
0117  1005          00620 M_END_WORD      bcf     DATA                    ; DATA=0
0118  3028          00621                 movlw   Twc                     ; WAIT FOR WORD Write Cycle Time (Twc)
0119  2021          00622                 call    WAIT_WMSEC
                    00623
                    00624 ;---------------
011A  0AA7          00625 M_CECHK_PRG_END incf    TMP_CNT, F              ; INCREMENT NUMBER OF WORD PROGRAMMED
011B  300C          00626                 movlw   NUM_WRD                 ; CHECK NUMBER OF WORD TRASMITTED
011C  0627          00627                 xorwf   TMP_CNT, W
011D  1D03          00628                 skpz
011E  2901          00629                 goto    M_NEW_WORD              ; PROGRAM NEW WORD
                    00630
                    00631 ;-----------------------------------------------------------------------------------------
                    00632 ; VERIFY ROUTINE
                    00633 ;-----------------------------------------------------------------------------------------
011F                00634 M_VERIFY
011F  1683          00635         BANK1
0120  30F9          00636                 movlw   K_MASKPA_VERI           ; I/O TRISTATE FOR VERIFY
0121  0085          00637                 movwf   TRISA
0122  1283          00638         BANK0
0123  0064          00639                 clrwdt
0124  300E          00640                 movlw   WORD0                   ; SET INDIRECT POINTER TO INIT EE MAP
0125  0084          00641                 movwf   FSR
                    00642
0126  01A7          00643                 clrf    TMP_CNT                 ; NUMBER OF WORDS RECIVED
0127  01A6          00644                 clrf    TXNUM                   ; NUMBER OF BIT RECEIVED FOR EACH WORD
                    00645 ;---------------
0128  1003          00646 M_VER_BITIN     clrc                            ; RECIVE DATA BIT FROM HCS FOR VERIFY
0129  1805          00647                 btfsc   DATA                    ; TEST and ROTATE RECEIVED BIT INTO WORD BUFFER
012A  1403          00648                 setc
012B  0C8C          00649                 rrf     WRD_HI, F
012C  0C8D          00650                 rrf     WRD_LO, F
012D  0AA6          00651                 incf    TXNUM, F
012E  3010          00652                 movlw   .16
012F  0626          00653                 xorwf   TXNUM, W                ; TEST IF RECEIVED A COMPLETE WORD
0130  1D03          00654                 skpz
0131  2942          00655                 goto    M_VER_CLKHI
                    00656 ;---------------
0132  080D          00657 M_VERIFY_WORD   movf    WRD_LO, W               ; 16th BIT RECIVED (WORD) -> VERIFY WORD
0133  0600          00658                 xorwf   INDF, W
0134  1D03          00659                 skpz
0135  2950          00660                 goto    PROG_ERR                ; WORD LOW VERIFY ERROR
0136  0A84          00661                 incf    FSR, F
0137  080C          00662                 movf    WRD_HI, W
0138  0600          00663                 xorwf   INDF, W
0139  1D03          00664                 skpz
```

```
013A   2950           00665                 goto    PROG_ERR                ; WORD HIGH VERIFY ERROR
013B   0A84           00666                 incf    FSR, F
013C   0AA7           00667                 incf    TMP_CNT, F
013D   300C           00668                 movlw   NUM_WRD
013E   0627           00669                 xorwf   TMP_CNT, W              ; TEST IF RECEIVED ALL THE WORDS PROGRAMMED
013F   1903           00670                 skpnz
0140   2949           00671                 goto    PROG_SUCCESS            ; ALL 12 WORDS VERIFIED WITH SUCCESS
0141   01A6           00672                 clrf    TXNUM
                      00673 ;---------------
0142   1485           00674 M_VER_CLKHI     bsf     CLK                     ; CLK=1
0143   300A           00675                 movlw   Tclkh                   ; WAIT TIME CLOCK HIGH
0144   201C           00676                 call    WAIT_uS
                      00677
0145   1085           00678 M_VER_CLKLO     bcf     CLK                     ; CLK=0
0146   300A           00679                 movlw   Tclkl                   ; WAIT TIME CLOCK LOW
0147   201C           00680                 call    WAIT_uS
0148   2928           00681                 goto    M_VER_BITIN
                      00682
                      00683 ;-------------------------------------------------------------------------------
0149   204C           00684 PROG_SUCCESS    call    WRITE_SN                ; WRITE LAST SN PROGRAMMED INTO
                      00685                                                 ; PIC16F84A EEPROM DATA
014A   1706           00686                 bsf     LED                     ; LED ON FOR 0,4SEC
014B   30C8           00687                 movlw   .200
014C   2021           00688                 call    WAIT_WMSEC              ; DELAY
014D   30C8           00689                 movlw   .200
014E   2021           00690                 call    WAIT_WMSEC              ; DELAY
014F   295D           00691                 goto    PROG_END
                      00692
                      00693 ;-------------------------------------------------------------------------------
                      00694 ; HCS PROGRAMMING ERROR
                      00695 ; WAIT FOR BUTTON PRESS
                      00696
0150   0185           00697 PROG_ERR        clrf    PORTA
0151   3014           00698                 movlw   .20                     ; 20 * 0,2SEC = 4SEC LED BLINKING
0152   00A7           00699                 movwf   TMP_CNT
0153   1706           00700 PROG_ERR_LEDON  bsf     LED                     ; LED ON FOR 0,1SEC
0154   3064           00701                 movlw   .100
0155   2021           00702                 call    WAIT_WMSEC              ; DELAY
                      00703
0156   1306           00704 PROG_ERR_LEDOFF bcf     LED                     ; LED OFF FOR 0,1SEC
0157   3064           00705                 movlw   .100
0158   2021           00706                 call    WAIT_WMSEC              ; DELAY
0159   0BA7           00707                 decfsz  TMP_CNT,F
015A   2953           00708                 goto    PROG_ERR_LEDON
                      00709
015B   1306           00710 PROG_ERR_X      bcf     LED
015C   295D           00711                 goto    PROG_END
                      00712
                      00713 ;-------------------------------------------------------------------------------
015D   1306           00714 PROG_END        bcf     LED
015E   1105           00715                 bcf     HCSVDD
015F   202A           00716                 call    BUTTON_RELEASE
0160   28E2           00717                 goto    M_LOOP
                      00718
                      00719 ;-------------------------------------------------------------------------------
                      00720 ; PIC16F84A DATA EEPROM WRITE ERROR; LED ON FOREVER
                      00721
0161   0185           00722 EE_ERR          clrf    PORTA
0162   1706           00723                 bsf     LED                     ; LED ON
0163   0064           00724                 clrwdt
0164   2963           00725                 goto    $-1
                      00726
                      00727 ;-------------------------------------------------------------------------------
                      00728 ; INIZIALIZE THE SER NUM STORED IN THE FIRST 4 BYTES OF THE INTERNAL EE DATA MEMORY
                      00729 ;-------------------------------------------------------------------------------
2100                  00730         ORG     0x2100
2100   0000           00731                 DE      0x00
2101   0000           00732                 DE      0x00
2102   0000           00733                 DE      0x00
2103   0000           00734                 DE      0x00
                      00735
                      00736 ;-------------------------------------------------------------------------------
                      00737
                      00738 ;===============================================================================
                      00739 ; END OF FILE
                      00740 ;===============================================================================
                      00741
                      00742
                      00743         END
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MEMORY USAGE MAP ('X' = Used,  '-' = Unused)

0000 : X---XXXXXXXXXXXX XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX
0040 : XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX
0080 : XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX
00C0 : XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX
```
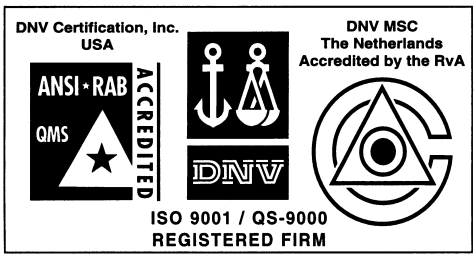

```
0100 : XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX
0140 : XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX XXXXX----------- ----------------
2000 : -------X-------- ---------------- ---------------- ----------------
2100 : XXXX------------ ---------------- ---------------- ----------------

All other memory blocks unused.

Program Memory Words Used:   354
Program Memory Words Free:   670


Errors   :     0
Warnings :     0 reported,     0 suppressed
Messages :    16 reported,     0 suppressed
```

NOTES:

NOTES:

NOTES:



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