# AN714

# Wireless Home Security Implementing KEELOQ® and the PICmicro® Microcontroller

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## INTRODUCTION

This application note describes a Microchip system solution for a low end/power wireless home security system. This design implements an HCS200 encoder for the intruder sensor signal encryption, one PIC12C508A PICmicro® for sensor monitoring and RF signal initiation, HCS515 decoders for decrypting the received intruder sensor signal and a PIC16C77 PICmicro for base station panel monitoring and control. Other support logic is included, such as a battery back-up circuit, simple single stage lead acid battery charger and external siren control, but the focus of the application is the implementation of Microchip KEELOQ® and PICmicro products for a complete solution.

## APPLICATIONS

Applications implementing low power RF wireless systems are entering the marketplace with ever increasing acceptance, fueled in part by growing awareness of the consumer. Low power wireless systems usually transmit less than 1mW of power and do not require user licenses for operation. These systems operate over distances of 5 to 100 meters, depending on the application.

Wireless systems are being implemented in the automotive, residential, personal and commercial arenas with increasing growth rates every year. Wireless systems in these areas include, but are not limited to: vehicle alarm arming and disarming, home garage and gate door openers, home lighting control, home security and fire alarm systems, pagers, cellular phones, utility meters for near-field readings, warehouse inventory control systems and RF LANs.

In many of these applications, different levels of security are required. The level of security required is dependent on the application and customer demands. For instance, a warehouse inventory control or utility meter system may require little or no security features whereas automobile access and home security alarm systems will require more.

No matter what level of security features are implemented, one vulnerable link in low power RF wireless based security systems is the actual RF signal itself. An RF based system could allow for the would be intruder/thief to use a code scanning or a code grabbing system to possibly gain unauthorized access to the home, car or other less secure system.

Code scanning is an effective tool for the would be thief on systems with limited number of possible code combinations which are found in quite a number of remote control systems. Patience, time and a hand-held microprocessor based system are all the intruder would need.

Code grabbing is a far easier way of gaining unauthorized access. In this method, the thief would monitor and capture the RF signal used in opening the home garage door or car. The thief would then wait until an opportune moment and then retransmit this code to gain access.

It is apparent that secure remote control systems can be implemented, if two conditions are met. The KEELOQ code hopping system meets both these conditions with ease.

1. A large number of possible combinations must be available.

   A 66-bit transmission code is used to make scanning impossible. The 32-bit encrypted portion provides for more than 4 billion code combinations. A complete scan would take 17 years! If the 34-bit fixed portion is taken into account, the time required for a complete scan jumps to 5,600 billion years.

2. The system may never respond twice to the same transmitted code.

   The random code algorithm will never respond to the same code twice over several lifetimes of a typical system.

Every time a remote control button is pushed, the system will transmit a different code. These codes appear random to an outsider, therefore, there is no apparent relationship between any code and the previous or next code.

For more information on code scanning, code grabbing and an introduction to KEELOQ Code Hopping, see Technical Brief TB003, titled “An Introduction to KEELOQ Code Hopping”. Refer to the Secure Data

Products Handbook, Microchip document number DS40168 for additional information on KEELOQ® products.

With the arrival of the Microchip KEELOQ code hopping security products, secure remote control systems can be implemented. Microchip provides a complete security solution with a full range of encoders and decoders that incorporate the Company's patented KEELOQ code hopping technology algorithm, allowing you to get the most advanced security technology. KEELOQ encoders are designed to be the transmitters and KEELOQ decoders, the receiver of secure remote keyless entry (RKE) systems.

The KEELOQ encoders feature on-chip, error corrected EEPROM for non-volatile operation and, therefore, reduce the required components normally external to the encoder. The only additional circuitry required are push buttons, battery and RF circuitry.

The KEELOQ decoders are single-chip solutions that employ normal and secure learning mechanisms, and operate over a wide voltage range. Microchip decoders are also full-featured with serial interface to PICmicro microcontrollers, allowing designers to integrate the decoder with system functionality.

## SYSTEM OVERVIEW

The Microchip KEELOQ solution is being implemented into more and more systems requiring proven security. Systems such as, but not limited to:

- Automotive security
- Gate and garage door openers
- Identity tokens
- Software protection
- Commuter access
- Industrial tagging
- Livestock tagging
- Parking access
- Secure communications
- Residential security

One simple example implementing the KEELOQ solution is a home security system. The home security system described herein utilizes KEELOQ code hopping security products and a PICmicro microcontroller.

Some specific system design goals for this low end/ power security system were:

- Wireless solution
- Secure RF transmissions
- Battery operation of intruder sensors for a minimum of 1.5 years
- Sensor module flexibility to operate with various off-the-shelf switches for doors and windows
- Microcontroller based system
- Battery back-up system which provided for up to 10 hours of operation at a load draw of 400mA
- System remote arm and disarm by means of the existing garage door opener (not completely implemented in the current release)

The three main hardware components, which comprise this home security system are, the Base Station Panel, Intruder Sensor Modules and the Battery Charger/ Accessory Unit.

## SYSTEM DESCRIPTION

The following sections provide a greater in depth look into each of the three main hardware components.

### BASE STATION PANEL

The home security base station panel provides for:

- Monitoring of sensor module initiated RF signals
- User interface and system setup via the 4x4 keypad
- Visual feedback via the 2x16 character Liquid Crystal Display (LCD) module
- On-board piezo buzzer control
- Real-time clock
- Monitoring of a single stage battery charger unit
- Automatic DC power selection circuit

The base station can be functionally divided into 4 main components:

1. KEELOQ HCS515 decoder interface.
2. Power supply switching circuit.
3. Battery charger unit monitoring.
4. LCD and 4x4 keypad interface.

Base Station Operation

One of the more important tasks the base station's microcontroller (PIC16C77) must handle, is to monitor and process the output data of the two HCS515 decoders. Each decoder is capable of learning up to seven sensor modules or "zones". Within each zone, there are four different message types which the PIC16C77 must decode and process (See Appendix A, Figure 6 for the following text description).

For example, a sensor module may send an alarm, okay, test or learn transmission. In turn, the PIC16C77 reads the data (up to 80-bits) from the HCS515 decoder, evaluates the message contents and initiates the appropriate action. If an alarm condition occurs, the external siren will be activated and the internal panel piezo buzzer, (BZ1) will sound, if enabled. For any valid signal reception, such as a test, learn, sensor okay condition or alarm transmission, the history profile for that sensor module will be updated. This update consists of a time stamp and the sensor's module battery status. If the sensor battery status indicates a low battery state, then the base panel piezo buzzer will beep (if enabled) four times every minute until the condition is resolved. The user can determine which sensor module battery is low through proper keypad selections and individual zone battery status displayed on the LCD.

The base station can be placed into a “learn” mode so as to learn up to seven sensors (zones). Through proper keypad selections, the PICmicro commands the HCS515 decoder into the learn mode. (See Figure 1 and Table 1). Once placed in this mode, two consecutive transmissions by the sensor are required to complete a successful learn. Once a sensor is learned, a “key” name for that zone must be selected. A menu will automatically appear on the LCD for this selection process. Currently up to 15 different key names are available to choose from. The selected key name is then stored in the HCS515 EE user space.

The history profile of each sensor is written to the available user EEPROM in the HCS515 decoder. The total EEPROM data space available in the HCS515 is 2Kbits. System data space is 1Kbits and user memory space is the remaining 1Kbits. System data space is not accessible by the user (See Table 2 for the user EEPROM memory map). The demodulated data input into the decoders is obtained from a super regenerative data receiver referenced RF1 (See Appendix A, Figure 7, Part Number RR3-433.92 - Manufactured by Telecontrolli). The receiver has a typical RF sensitivity of -105dBm and consumes 3mA, maximum.

A Microchip microcontroller supervisory circuit, MCP130-475, is used to ensure the required system panel operating voltage range is adhered to. The brown-out feature on the PIC16C77 was not used since the base panel system operating voltage range is 4.5 to $5.5V_{DC}$.

The base station panel is designed to operate from one of two available DC input sources: the converted AC line power or the 12V lead-acid battery back-up (See Appendix A, Figure 5 for the following text description).

Both DC sources are fed into the panel via connector, JP1. From JP1, each source is input to separate adjustable voltage regulators. The primary DC source regulator, U2, has its Vout set to $5.50V_{DC}$, while the secondary DC source regulator, U3, has its Vout set to $5.05V_{DC}$. Both regulator outputs are fed into separate inputs of the automatic battery back-up switch, U1.

Switch U1, is an 8-pin monolithic CMOS I.C. which senses the DC level of the two input sources and connects the supply of the greater potential to its output, pin 1. This is a break-before-make switch action and switching typically occurs in 50µs. Capacitor C9 is used to minimize the switching transient during the transition.

One limitation of the switch is its current switching capabilities. Maximum continuous current of the switch is exceeded by this panel design so two PNP transistors were added which provides for greater power switching.

The implementation of the PNP transistors is such that when the primary source is the greater of the two, pin 6 of U1, labeled “PBAR”, is effectively tied to ground internally and therefore Q1 is biased into saturation. During this configuration, Q3 is in the off state because pin 3, labeled “SBAR”, is at hi-impedance.

When the secondary DC source is the greater of the two, Q3 will be biased into saturation and Q1 will be off. In either state, the load is handled through the transistors and the “VO” pin of U1 is no longer required. However, the “VO” pin is configured for driving LEDs, which indicate the DC source selected.

The PIC16C77 receives status back relating to the switch selection via the signal labeled “PSOURCE”. The state of this feedback signal is active low when the primary DC source is selected, and active high if the secondary source is selected.

This power switching circuit also allows for the PIC16C77 to select the secondary source, even if the primary source is present. If the signal labeled “BATSEL” is asserted high by the PIC16C77, NPN transistor Q2 will be turned on and effectively reduce Vout of U2 to $1.25V_{DC}$. U1 will detect the drop and switch to the backup source. This feature can be used as a test-mechanism. Finally, $V_{OUT}$ of U3 supplies the voltage reference, $V_{REF}$, for the Analog-to-Digital module on the PIC16C77. This signal is labeled “VBAT”.

As with any home security system, it is important to provide for backup power in the event of a primary source failure. A simple single stage back-up/charger unit is provided for this requirement. Based upon a load draw of 400mA, 10 hours of operation are provided for. This is a worse case scenario, which includes a 170mA (typical) current draw from the external siren.

The PIC16C77 samples the battery voltage, once per minute. If the sampled battery voltage is less than ~$12.75V_{DC}$, then the current limit resistor, R15, is switched in or if >$12.75V_{DC}$, then bypassed (See Appendix A, Figure 9 and Appendix A, Figure 10). The user can view the battery voltage on the LCD by pressing the appropriate keys on the 4x4 keypad. (See Table 1).

The system LCD and 4x4 keypad provide for system status feedback and setup. Status information, such as sensor module battery state, zone faults and time-of-day are displayed on the 2x16 character LCD. The LCD is updated by the PIC16C77 through data transfers on PORTD (See Appendix A, Figure 6 and Appendix A, Figure 7).

System parameter setup such as enabling the internal piezo buzzer, time-of-day setup, zone naming and alarm initiating is provided through the 4x4 keypad. System test modes are also entered through the keypad. The keypad is interfaced to PORTB which utilizes the interrupt on change feature.

***FIGURE 1:*** *4x4 Keypad Layout*

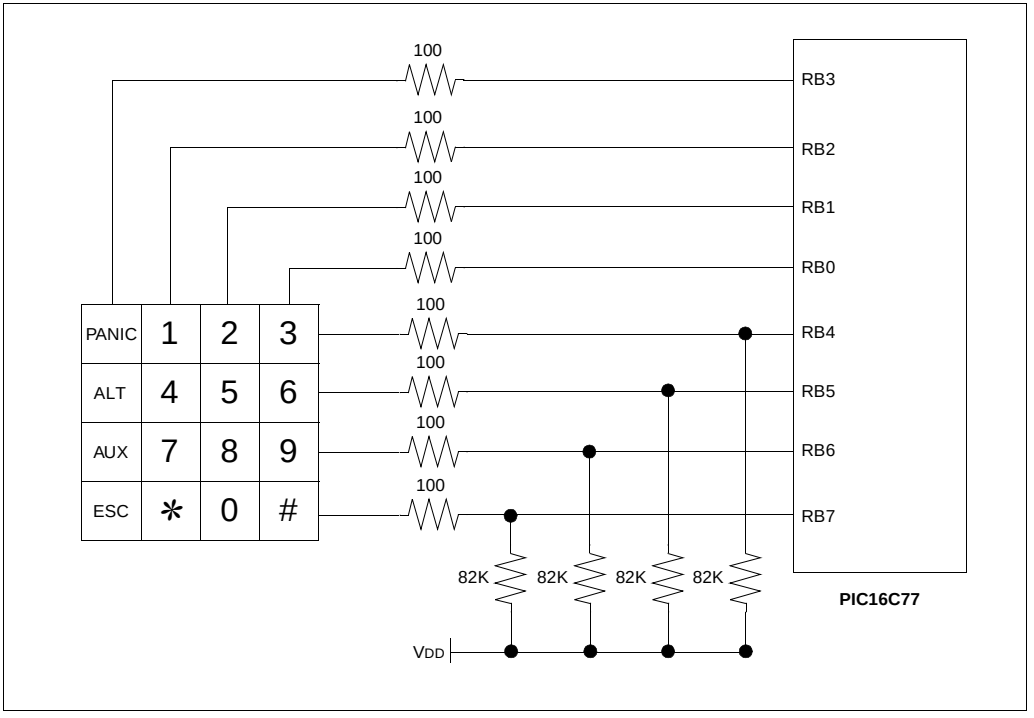


***TABLE 1:*** *4x4 Keypad Selections versus Respective System Response*

| Primary 4x4 Keypad Entry | Secondary 4x4 Keypad Entry | Final 4x4 Keypad Entry | System Response |
|---|---|---|---|
| PANIC | * | N/A | Arm System Immediately w/o entry of User Code and w/o Arm time delay |
| | # | N/A | Arm System via entry of User Code and enable arm time delay ( 5 minutes ) |
| | 1 | N/A | Enable Internal Piezo Buzzer to sound if selected |
| ALT | 5 | 1 | Select Battery as Power Source to System |
| | | 2 | Monitor Battery Voltage if primary is Selected |
| | | 3 | Review Battery on/off cycle time and daily cycle count |
| | 6 | 1 | Review number of learned transmitters ( sensor modules/ zones ) |
| | | 2 | Review sensor module battery status and check time-of-day last received |
| | 7 | N/A | Check on Alarm conditions for system. ( was an Alarm signal received ) |
| AUX | 6 | 1 | Place HCS515 decoder in 'Learn' mode and execute |
| | | 2 | Place HCS515 decoder in 'Erase All' mode and execute |
| | 7 | 1 | Toggle if time-of-day will be displayed on LCD |
| | | 2 | Set / Change time-of-day via keypad entries<br>Keys 1 & 4 for incrementing/decrementing hours count<br>Keys 2 & 5 for incrementing/decrementing minutes count<br>Keys 3 & 6 for incrementing/decrementing seconds count |
| | 8 | N/A | Entry of 4-digit User Code. The 4-digit Master Code must be known and entered before the User code can be changed. Master code in ROM via SQTP |
| | 9 | N/A | Set time for key wait expiration. |
| ESC | # | N/A | Disable System Armed State with Entry of User Code |
| | 0 | N/A | Clear LCD Screen |
| | 1 | N/A | Disable Internal Piezo Buzzer from sounding if selected |
| | PANIC | N/A | Clear Alarm Zone Trip Status for LCD |
| | ESC | N/A | Toggle LCD Backlight |

***TABLE 2:*** *HCS515 Decoder User EEPROM Map*

| ADDR | Description | ADDR | Description | ADDR | Description | ADDR | Description | ADDR | Description |
|---|---|---|---|---|---|---|---|---|---|
| 80 | USER_COD1 | 9E | ZONE4_NM | BC | XMTR_CNT | DA | | F8 | ALRM_HRS |
| 81 | USER_COD1 | 9F | TOD4_HRS | BD | | DB | | F9 | ALRM_MIN |
| 82 | USER_COD1 | A0 | TOD4_MIN | BE | | DC | | FA | ALRM_SEC |
| 83 | USER_COD1 | A1 | TOD4_SEC | BF | | DD | | FB | ALRM_STAT |
| 84 | USER_COD1 | A2 | BATT4_ST | C0 | USER_COD2 | DE | | FC | |
| 85 | | A3 | | C1 | USER_COD2 | DF | | FD | |
| 86 | MSTR_CODE | A4 | | C2 | USER_COD2 | E0 | | FE | |
| 87 | | A5 | ZONE5_NM | C3 | USER_COD2 | E1 | | FF | LAST_XMIT |
| 88 | | A6 | TOD5_HRS | C4 | USER_COD2 | E2 | | | |
| 89 | ZONE1_NM | A7 | TOD5_MIN | C5 | | E3 | | | |
| 8A | TOD1_HRS | A8 | TOD5_SEC | C6 | | E4 | | | |
| 8B | TOD1_MIN | A9 | BATT5_ST | C7 | | E5 | | | |
| 8C | TOD1_SEC | AA | | C8 | | E6 | | | |
| 8D | BATT1_ST | AB | | C9 | | E7 | | | |
| 8E | | AC | ZONE6_NM | CA | | E8 | | | |
| 8F | | AD | TOD6_HRS | CB | | E9 | | | |
| 90 | ZONE2_NM | AE | TOD6_MIN | CC | | EA | | | |
| 91 | TOD2_HRS | AF | TOD6_SEC | CD | | EB | | | |
| 92 | TOD2_MIN | B0 | BATT6_ST | CE | | EC | | | |
| 93 | TOD2_SEC | B1 | | CF | | ED | | | |
| 94 | BATT2_ST | B2 | | D0 | | EE | | | |
| 95 | | B3 | ZONE7_NM | D1 | | EF | | | |
| 96 | | B4 | TOD7_HRS | D2 | | F0 | BT_ON_CNT | | |
| 97 | ZONE3_NM | B5 | TOD7_MIN | D3 | | F1 | BT_ON_HRS | | |
| 98 | TOD3_HRS | B6 | TOD7_SEC | D4 | | F2 | BT_ON_MIN | | |
| 99 | TOD3_MIN | B7 | BATT7_ST | D5 | | F3 | BT_ON_SEC | | |
| 9A | TOD3_SEC | B8 | | D6 | | F4 | BT_OFF_HRS | | |
| 9B | BATT3ST | B9 | | D7 | | F5 | BT_OFF_MIN | | |
| 9C | | BA | | D8 | | F6 | BT_OFF_SEC | | |
| 9D | | BB | | D9 | | F7 | | | |

**LEGEND:**

| | |
|---|---|
| USER_CODx | User Code ( 2 locations ) |
| ZONEx_NM | Zone Name ( where x is the zone number ) |
| TODx_HRS | Time of Day ( Hours , where x is the zone number ) |
| TODx_MIN | Time of Day ( Minutes ) |
| TODx_SEC | Time of Day ( Seconds ) |
| BATTx_ST | Battery Status ( Sensor Module Battery )<br>- 0xF0 ( High )<br>- 0x0F ( Low ) |
| BT_ON_CNT | Daily count for battery cycles ( on/off ) |
| BT_ON_HRS | Time of Day ( hours ) when battery is last selected |
| BT_ON_MIN | Time of Day ( minutes ) when battery is last selected |
| BT_ON_SEC | Time of Day ( seconds ) when battery is last selected |
| BT_OFF_HRS | Time of Day ( hours ) when battery is last de-selected |

**LEGEND: (Continued)**

| | |
|---|---|
| BT_OFF_MIN | Time of Day ( minutes ) when battery is last de-selected |
| BT_OFF_SEC | Time of Day ( seconds ) when battery is last de-selected |
| ALRM_STAT | Alarm Status<br>- 0x41 ( Alarm )<br>- 0xBE ( Clear ) |
| ALRM_HRS | Alarm Condition ( hours ) when alarm is activated |
| ALRM_MIN | Alarm Condition ( minutes ) when alarm is activated |
| ALRM_SEC | Alarm Condition ( seconds ) when alarm is activated |
| XMTR_CNT | Number of transmitters learned |
| LAST_XMIT | Last decoder transmission type received and recorded |
| MSTR_CODE | Currently not used |

A 32.768KHz watch crystal is connected to the Timer1 external oscillator pins for the generation of a real time clock. Specific system data, such as alarm time, battery on/off cycle time and all valid decoded RF signals are time-tagged. The clock time is setup/changed via the 4x4 keypad and operates using the military time format, i.e., 2:30PM will display as 14:30:00, while 2:30AM will display as 02:30:00.

## INTRUDER SENSOR MODULE

The four main functions of the intruder sensor modules are:

1. Intruder detection.
2. Sensor battery status.
3. Sensor learn.
4. Sensor test.

For each of these functions, an input to the HCS200 KEELOQ encoder is asserted (active high) by the PIC12C508A. The end result is a 66-bit encrypted code word transmission, via RF, to the base station panel for decryption and processing.

In order to provide for these functions, additional logic is implemented to complement the HCS200 encoder. The logic consists of a PIC12C508A microcontroller, a relaxation type oscillator circuit, N-channel MOSFET for signal level translation, Colpitts oscillator used for the Amplitude Shift Keying (ASK) transmitter, and a few additional passive components.

See Appendix A, Figure 11 and Figure 12 for the following sensor operation discussion.

One important operational requirement of the sensor module besides reliable signal decoding and secure RF transmission, is low current consumption. With the components selected, sensor battery life is calculated to be a minimum of 1.5 years.

Sensor operation

The KEELOQ HCS200 encoder is a perfect fit for implementation into the sensor modules. The HCS200 encoder provides for:

Security

- Programmable 28-bit serial number
- Programmable 64-bit encryption key
- Each transmission is unique
- 66-bit transmission code length
- 32-bit hopping code
- 28-bit serial number, 4-bit function code, VLOW indicator transmitted
- Encryption keys are read protected

Operating

- 3.5–13.0V operation
- Three button inputs
- Seven functions available
- Selectable baud rate
- Automatic code word completion
- Battery low signal transmitted to receiver
- Non-volatile synchronization data

Other

- Easy to use programming interface
- On-chip EEPROM
- On-chip oscillator and timing components
- Button inputs have internal pulldown resistors

The HCS200 combines a 32-bit hopping code generated by a powerful non-linear encryption algorithm, with a 28-bit serial number and 6 information bits to create a 66-bit transmission stream. The length of the transmission eliminates the threat of code scanning and the code hopping mechanism makes each transmission unique, thus rendering code capture-and-resend schemes useless. (See Figure 2, Figure 3 and Figure 4 for code word organization and formats).

The encryption key, serial number and configuration data are stored in EEPROM, which is not accessible via any external connection. This makes the HCS200 a very secure unit.

***FIGURE 2:*** *Code Word Organization.*

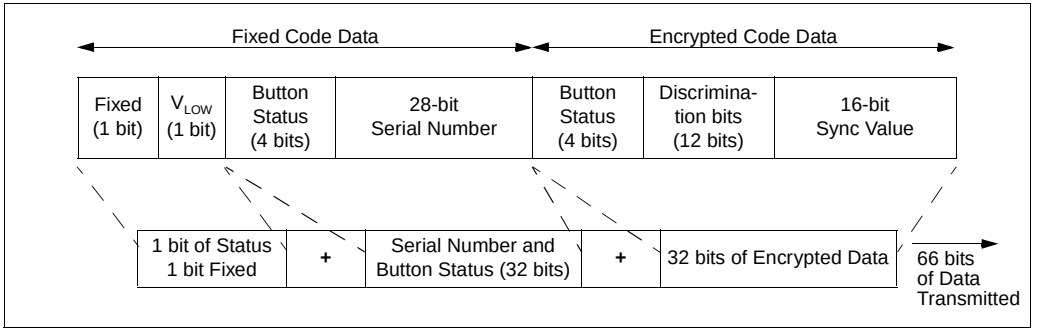
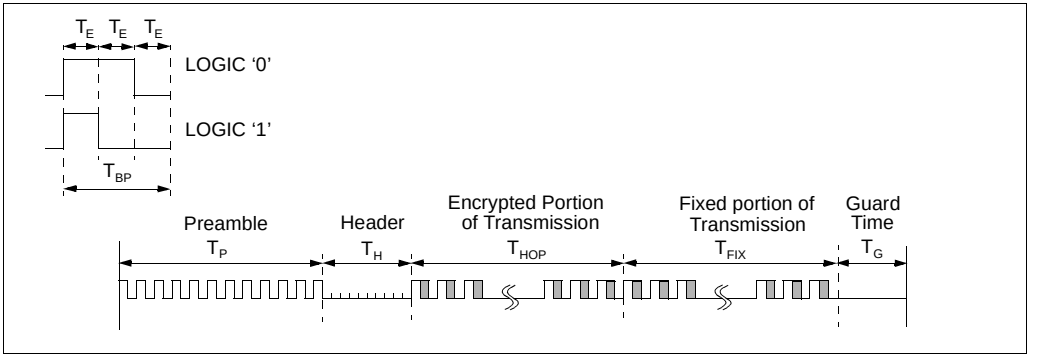



***FIGURE 3:*** *Code Word/PWM Transmission Format .*




$T_E$ - Basic pulse element *

$T_{BP}$ - PWM bit pulse width *

$T_P$ - Preamble duration *

$T_H$ - Header Duration *

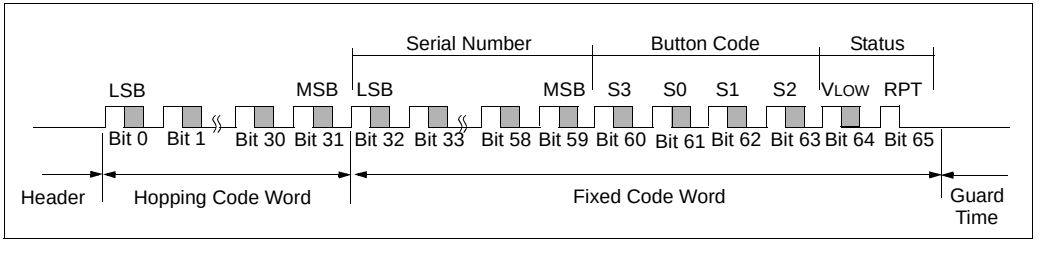
$T_{HOP}$ - Hopping code duration *

$T_{FIX}$ - Fixed code duration *

$T_G$ - Guard Time *

* - See Data Sheet (DS40168) for parameter timing specifics

***FIGURE 4:*** *Data Word Format.*



The HCS200 responds to input signals initiated by the PIC12C508A. The PIC12C508A provides for the sensor signal detection and decoding and RF signal initiation. The PIC12C508A is configured to operate on the internal RC oscillator with the wake-up on pin change feature enabled. The PIC12C508A is placed in the "sleep" mode for about 99% of the time, based on the overall repeated time period of 1.5 hrs (discussed later). While the wake-up on pin change feature is utilized, the internal weak pull-ups are disabled and larger ohmic external resistors are used. This reduces the current consumption, while retaining the wake-up on pin change feature.

Since the HCS200 and RF circuitry are only required after the PIC12C508A awakens by a pin state change and with the requirement to reduce additional current draw from the battery, the HCS200 and RF circuitry are powered through I/O pin, GP5. The current sourcing capability of the PIC12C508A is sufficient for this requirement. This configuration reduces the overall current draw by 1μA (typically) during sleep mode.

The PIC12C508A detects and responds to one of the four input pin state changes, which are:

1. Intruder sensor activation on input pin GP3 (active high).
2. Sensor test transmission activated by switch closure on input pin GP1 (active high).
3. Sensor learn transmission activation by switch closure on input pin GP1 (active high).
4. 1.5 hr timing cycle on input pin GP0 (active high). This signal is used to generate a sensor battery status transmission.

Once the wake-up signal has been decoded, the HCS200 and RF circuitry are powered-up via pin GP5, labeled "CNTPWR". (See Appendix A, Figure 11 and Figure 12). A 3μs delay is allowed for power-up stabilization and then the PIC12C508A asserts an active high signal to U2 inputs S0, S1 or both, depending on the wake-up signal decoded. The HCS200 input pin states are as follows:

1. Pin S0 asserted only - alarm condition.
2. Pin S1 asserted only - 1.5 hr elapsed time sensor update.
3. Pin S0 and S1 asserted simultaneously, Learn or test mode entered.

The alarm condition is in response to a possible intruder detection at the door or window. The switches used for monitoring door and window access are FORM C and SPST type, respectively. The FORM C door switches used are specifically designed for steel skin doors, but are well suited for use in wooden doors. SENTROL, INC manufactures both switch types used. The door and window switch part numbers used are 1078C and 3650W, respectively.

Jumpers JP1 and JP2 are configured, based on whether the sensor is to be used for a door or window. If the sensor is used for a door, JP1 is closed and JP2 is open. For a window application, JP2 is closed and JP1 is open. These jumpers can be used for implementing different resistor values, based upon the sensor switch implemented.

It is imperative that the correct switches are specified to eliminate a source of false alarm conditions. Items such as door to frame gap and door material construction contribute a big part in selecting the appropriate switch sensor.

The 1.5 hr elapsed time sensor update is developed using a relaxation timing circuit. The timing circuit consists of a JFET configured as a constant current source set to 400nA, a Programmable Unijunction Transistor (PUT), an N-channel MOSFET for signal level translation and a reverse biased diode to reduce PUT discharge time.

This timing circuit is configured to produce a state change on pin GP0 approximately every 100 seconds. The constant current source charges up the low leakage 10μF capacitor, C1. When the voltage across C1 equals the firing voltage of the PUT, which is the peak point emitter voltage termed $V_P$, and if the current is large enough, the PUT will enter into the negative resistance region and begin to discharge. The maximum firing current required by the 2N6028 for a RG value = 1M is 150nA. RG = (R2*R3)/(R2+R3).

Resistors R2 and R3 set the voltage $V_p$. This voltage is $V_P$ = ~(VBat * R2)/(R2 + R3). Diode D1, which is reversed biased during the PIC12C508A sleep period is used to reduce the PUT discharging time period. When the PIC12C508A wakes from sleep, diode D1 is forward biased and provides a low impedance path to ground for C1 discharge (See Appendix A, Figure 11). When the diode is not used, the discharge period was observed to be about 7-8ms. With the diode, the discharge time period was reduced to tens of microseconds. The savings of several milliseconds, reduces the time the PIC12C508A is awake and therefore helps to extend the battery life of the sensor module.

The N-channel MOSFET, Q2, provides for signal level translation from the PUT. If the voltage level set by resistors R2 and R3 (~ 4VDC for new batteries) is applied directly to pin GP0, additional current consumption would be realized, since this voltage on a Complimentary Metal Oxide Semiconductor (CMOS) input would be near its threshold.

The N-channel MOSFET is configured as a switch, such that the drain channel is tied to VBat through a 6.8Mohm resistor and the source channel is grounded. Then, by tying the drain channel to pin GP0, the voltage on GP0 is either VBat or ground, depending on the PUT state applied to the gate of Q2.

Changing the R2 to R3 ratio could increase voltage, $V_P$. If the voltage level was set such that it falls outside the CMOS input threshold, then Q2 and R1 could be eliminated.

When the PIC12C508A wakes from sleep, it increments a counter variable and then returns to sleep. This process repeats until the counter variable equals 54, which equates to approximately 1.5 hrs. At this 1.5 hr time cycle, the PIC12C508A initiates an 'OKAY' signal. This signal is received and decoded by the base panel for determining the state of the sensor module battery.

The PIC12C508A then resets the cycle count variable to zero and starts the time cycle process over again. Since the battery status is embedded into all 66-bit code word transmissions, if an alarm, learn or test condition is activated, the counter variable will also be reset to zero.

A test or learn transmission is initiated if switch S1 is depressed. The learn sequence will be recognized if the base station is placed in the learn mode. In either case, the switch closure wakes the PIC12C508A from sleep. The PIC12C508A then decodes the inputs and asserts the proper signals on the S0 and S1 pins of the HCS200.

With any RF link, noise is an issue that must be considered. There are some ways to control transmission integrity such as error detection/correction algorithms, repeated transmissions (simplex mode - one way) or with high end systems, the master queues each sensor for a transmission (half-duplex). The system described in this application note is configured for the simplex mode of operation and implements repeated signal transmissions for alarm conditions.

As the number of sensor modules installed in the home increases, 14 possible with this design, the odds increase that two or more sensors may converge in time for initiating a transmission cycle. The result would be a RF signal collision at the receiver and most likely all data would be lost. Once this condition occurs and since the time base for each system is not at the exact same frequency, they will typically diverge until the next occurrence.

The time base for the sensor module is the PIC12C508A which is clocked internally by the on-chip RC oscillator operating at ~ 4 MHz.

While the sensor module initiates up to four different RF transmission cycles, the most important one is the alarm condition. If the PIC12C508A detects an alarm condition, repeated RF transmissions are sent to ensure the base station receives the alarm signal. In the event that an 'OKAY' signal transmission from sensor module A and an alarm transmission from sensor module B occur at the exact same time, the alarm transmission will be received because of repeated alarm transmissions. The 'OKAY' signal only sends 1 code word transmission, while the alarm condition results in up to 5 code words transmitted.

The simple RF circuit implemented in the sensor module is an Amplitude Shift Keying (ASK) type consisting of a Colpitts oscillator with a SAW resonator. The resonator provides for a stable resonant frequency of 433.92 MHz (See Appendix A, Figure 12).

The PWM data output of the HCS200 encoder is applied to the base of the Colpitts oscillator and therefore amplitude modulates the carrier by turning the carrier on/off. The data rate is typically 833 bps.

## SENSOR MODULE BATTERY CAPACITY CALCULATIONS

Before the expected battery life of the sensor module can be calculated, an operational cyclic time period must be defined. The cyclic period for the sensor module is composed of three distinct operational states: sleep, housekeeping and intentional radiation. These three states repeat on a continual basis, therefore, creating an operational cyclic profile. The profile is then used to calculate the battery capacity requirements.

For the sensor module, the cyclic time interval is approximately 1.5 hours. During this 1.5 hours, the PIC12C508A is placed in sleep 54 times. Of these 54 times, the processor wakes-up from sleep 53 times to perform some minor housekeeping and on the 54th wake-up from sleep, the intentional radiation state is executed. This is the "OK" transmission.

There is also the power-up state. This state is only executed once (initial power-up), and exhibits no significant impact on the overall battery life.

The active times for each of these states is defined below. The processor wake-up time from sleep (typical 400μs) is included in the two wake-up states.

Timing states known:

- Sleep state - typical 100 seconds (each occurrence)
- Housekeeping state – typical 56 ms (each occurrence)
- Intentional radiation state – typical 700 ms (each occurrence)

Therefore, cyclic time period is:

= (54 x 100s) + (53 x 56mS) + 700mS

= 5403.7 seconds

= 1.5010 hours

Current consumption variables known:

Sleep state current consumption:

- 3.2µA @ 6.4$V_{DC}$ (new batteries)
- 2.0µA @ 3.3$V_{DC}$ (battery EOL)

Housekeeping state current consumption:

- 0.70mA @ 6.4$V_{DC}$
- 0.30mA @ 3.3$V_{DC}$

Intentional radiation state current consumption:

- 4.64mA peak @ 6.4$V_{DC}$
- 2.22mA peak @ 3.3$V_{DC}$

With these operational parameters known, we can now calculate the expected battery life respective to new battery voltage. It should be noted that this is the worst case scenario and the actual battery capacity required may be less.

Calculate As Follows:

1. Calculate the percentage of time spent in each state relative to the overall cyclic time period.

Sleep state%:

- (5400s/5403.7s) x 100 = 99.932%

Housekeeping state%:

- (2.9680s/5403.7s) x 100 =.054925%

Intentional radiation state%:

- (700mS/5403.7s) x 100 =.012954%

2. Calculate the number of hours in 18 and 24 months.
   - 18 months (547.5 days) x 24hrs/day = 13,140 hours
   - 24 months (730 days) x 24hrs/day = 17,520 hours
3. With the hours, percentages and current variables known the battery capacity required for the sensor module can be developed.

For 18 months:

Sleep state:

- 13,140 hours x 99.932% x 3.2uA = 42mAh

Housekeeping state:

- 13,140 hours x .054925% x .70mA = 5.052mAh

Intentional radiation state:

- 13,140 hours x .012954% x 4.64mA = 7.899mAh

Total battery capacity required = 54.95mAh

For 24 months:

Sleep state:

- 17,520 hours x 99.932% x 3.2uA = 56.02mAh

Housekeeping state:

- 17,520 hours x .054925% x .70mA = 6.736mAh

Intentional radiation state:

- 17,520 hours x .012954% x 4.64mA = 10.530mAh

Total battery capacity required = 73.29mAh

From these calculations, we can see that if the desired operational life of the sensors is 1.5 years, the battery capacity would need to be ~55mAh. It is noted that these calculations do not take into consideration the operational characteristics of the batteries such as leakage and self discharge.

## BATTERY CHARGER/ACCESSORY UNIT

The battery charger/accessory unit provides for system back-up power in the event of primary power loss. Approximately 10 hours of system operation is provided with battery operation.

This unit also contains some system peripheral circuitry and is divided into 4 main components:

1. Single stage constant voltage (constant potential) battery charger.
2. Enclosure door tamper switch feedback.
3. External piezo siren drive.
4. System remote arm/disarm using existing garage door opener. (currently not fully implemented)

Theory of Operation

The single stage battery charger consists of an adjustable voltage regulator, U1, operational amplifiers (op-amp) U2 and U3, P-channel MOSFET Q4, NPN transistor Q6, current limit resistor R15, and Schottky diode D1 (See Appendix A, Figure 9 and Figure 10). The battery used in this system is a NP4-12 Yuasa-Exide lead acid type.

The standby (float) service is a battery operational state where a constant voltage is maintained on the battery, until the battery is called on to discharge.

In this system, a constant voltage (constant potential) charging circuit is implemented to generate this maintenance voltage. The manufacturer recommends a 2.3 volts/cell maintenance voltage during this float mode. This equates to a total maintenance voltage requirement of 13.8 volts. In the event of a deep discharge cycle, the initial charging current could approach 8 amps (2CA). For this application, the initial charging current is limited to approximately 630 mA. (.16CA) When charging at 2.30 volts/cell, charging current at the final stage of charging will drop to as little as 0.002CA.

During the charge cycle, the charge current will decrease and the battery voltage will increase. When the battery voltage approaches 12.75$V_{DC}$, the current limit resistor will be switched out of the charge loop through turning on Q6. This will shorten the remaining battery recovery time.

NP batteries are designed to operate in standby service for approximately 5 years based upon a normal service condition, in which float charge voltage is maintained between 2.25 and 2.30 volts per cell in an ambient temperature of approximately 20°C (68°F).

In general, to assure optimum battery life, a temperature compensated charger is recommended. If the operational temperature range is between 5°C to 40°C (41°F to 104°F), it is not necessary to provide a temperature compensation function. If a temperature compensated charger is not implemented, the manufacturer recommends the maintenance voltage be set to a voltage which closely reflects the average ambient temperature based upon a compensation factor of -3mV/°C for standby (float) use.

For example:

Standard center point voltage temperature is:

- 13.8 volts @ 20°C.

Estimated average temperature is:

- 29.44°C (~85°F).

Compensated charging voltage is:

- 13.8 volts + (-3mV (29.44° - 20°)) = 13.772 volts.

For this design, the battery maintenance voltage is set to 13.77 volts. Adjustable voltage regulator, U1, is adjusted to approximately 14.00$V_{DC}$. This voltage accounts for the forward voltage drop of diode, D1.

This charging circuit is operating in an open loop configuration in the sense that the regulator output is manually set. If a voltage trim is required, potentiometer R18, must be adjusted.

In order to provide for some feedback to the base panel controller, a differential amplifier is configured with op-amps, U2 and U3. This amplifier configuration is such that a reference 5.1$V_{DC}$ zener voltage is subtracted from the battery voltage. This difference is amplified and routed to TB1, pin 7. The PIC16C77 base station controller will periodically sample this voltage. If this voltage falls outside the required battery maintenance voltage, then the PIC16C77 will indicate such on the LCD and an adjustment will be required.

An airflow fan is implemented in the accessory enclosure to dissipate any gases generated by the battery and provide for moderate enclosure cooling. Air inlet and exhaust ports are provided in the enclosure. The steel enclosure dimensions are 10Hx8Wx4D. The fan current draw is approximately 100 mA @ 12$V_{DC}$.

For added security, an enclosure door tamper switch is utilized. If the enclosure door is opened, the PIC16C77 will be notified at pin RA2 and an alarm sequence is initiated, if the system is armed. This switch is interfaced to TB5, pins 1 and 2. While the enclosure door is closed, the feedback signal developed across R3 is active low, else if the enclosure door is opened, an active high signal is observed across R3.

In the event that an alarm condition has been initiated, the base station PIC16C77 controller will turn on NPN transistor, Q1. When Q1 is on, its collector junction will be switched to ground, and this state will turn on Q3. The drain channel of Q3 is connected to TB2, pin 1 through a 56-ohm/10W current limit resistor for direct connection to the external piezo siren. The siren implemented operates at 12$V_{DC}$, typically, with a current draw of ~170mA while exhibiting a ~116dBm sound pressure level annunciation. This circuit can be easily modified to allow for additional current draw should a louder siren be desired.

An eight conductor overall shielded cable provides the interface link between the base station panel and the battery charger/accessory unit.

This system also allows for an existing garage door system to arm and disarm the security system. (This feature is not completely implemented at this time)

## REGULATORY CONSIDERATIONS

While low power wireless products do not need to be individually licensed, they are subject to regulation. Before low power wireless systems can be marketed in most countries, they must be certified to comply with specific technical regulations. In the U.S., the FCC issues certification. In the U.K., it is DTI, in Germany it is the FTZ, and so on.

### FCC Compliance

It is noted here that Microchip Technology Incorporated does not guarantee compliance with any FCC or other regulatory requirements for this home security system, although FCC guidelines were followed and adhered to, when possible. It is the responsibility of the designer to ensure that the design is compliant to local standards.

## SUMMARY

Automobile, Home or Office. All aspects of today's daily life require security. Consumers have a key pad in their hand, a security keypad on their wall and a smart card to get in the door.

The KEELOQ family of patented code hopping devices has quickly become the world standard for security applications by providing a simple yet highly secure solution for remote control locking devices, house keys, garage door openers, and home security.

From the low-cost, low-end HCS200 encoder to the high-end HCS410 encoder and transponder, Microchip's KEELOQ code hopping solutions incorporate high security, a small package outline, and low cost - an ideal combination for multifunctional, unidirectional remote keyless entry (RKE) systems. For logical and physical access control applications, such as cellular phones and smart cards, the KEELOQ family offers convenience and security in one package.

Microchip provides a complete security solution with a full range of encoders and decoders that incorporate the Company's patented KEELOQ code hopping algorithm, allowing you to get the most advanced security technology for practically a steal.

As with all security systems, it is important that the end user understand the level of security, which is required for the assets you are wanting to protect. The strength of the security system is only as strong as the weakest link. Microchips KEELOQ Security devices are proven not be a weak link.

| | |
|---|---|
| **Note:** | Information contained in the application note regarding device applications and the like is intended through suggestion only and may be superseded by updates. No representation or warranty is given and no liability is assumed by Microchip Technology Incorporated with respect to the accuracy or use of such information, or infringement of patents or other intellectual property rights arising from such use or otherwise. |

## GLOSSARY OF TERMS

| | |
|---|---|
| ASK | Amplitude Shift Keying |
| EEPROM | Electrically Erasable Programmable Read Only Memory |
| Encryption | Method by which if "plain text" is known and the keying variables are known the "cipher text" can be produced |
| KEELOQ Algorithm | Nonlinear algorithm for generation of "cipher text" |
| JFET | Junction Field Effect Transistor |
| LAN | Local Area Network |
| LCD | Liquid Crystal Display |
| MOSFET | Metal Oxide Semiconductor Field Effect Transistor |
| PICmicro | Microchip Technology Microcontroller |
| PUT | Programmable Unijunction Transistor |
| PWM | Pulse Width Modulation |
| RKE | Remote Keyless Entry |
| RF | Radio Frequency |

## REFERENCE MATERIAL


1. Application Manual, *Yuasa-Exide Incorporated, 1996.*
2. Handbook of Batteries, *2nd Edition, McGraw-Hill, David Linden, 1995.*
3. Secure Data Products Handbook, Microchip Technology Inc., *Document # DS40168, 1997 .*
4. Embedded Control Handbook, Microchip Technology Inc., *Document # DS00092, 1997.*
5. PIC16C7X Data Sheet, *Document # DS30390, 1997.*
6. FCC Code of Federal Regulations, Title 47 - Telecommunication, Chapter I - Federal Communication Commission, Part 15 - Radio Frequency Devices, (http://frwebgate.access.gpo.gov/cgi-bin/multidb.cgi).

## APPENDIX A: SYSTEM SCHEMATICS

***FIGURE 5:*** *Base Station Panel (1 of 4)*

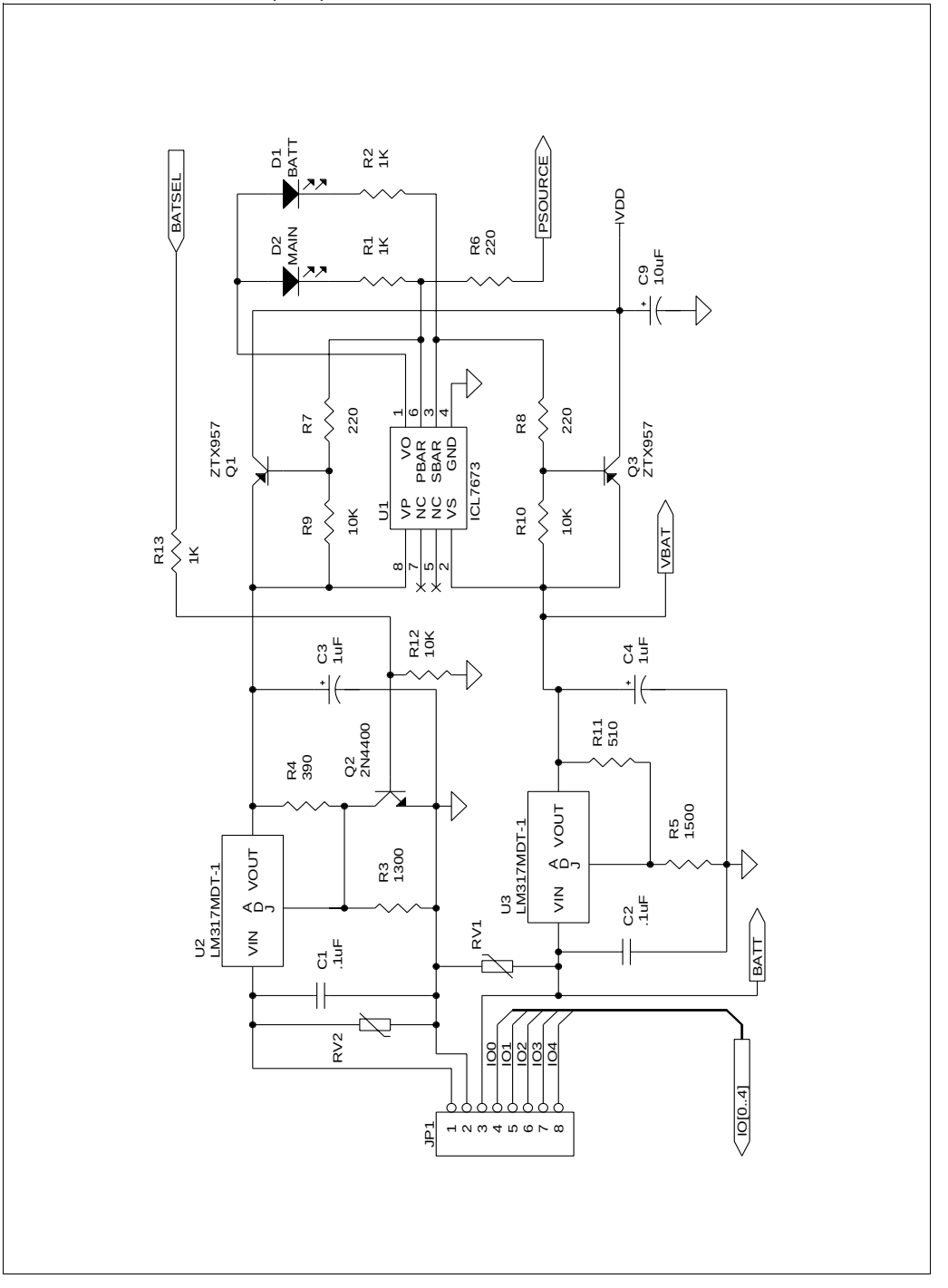


***FIGURE 6:*** *Base Station Panel (2 of 4)*

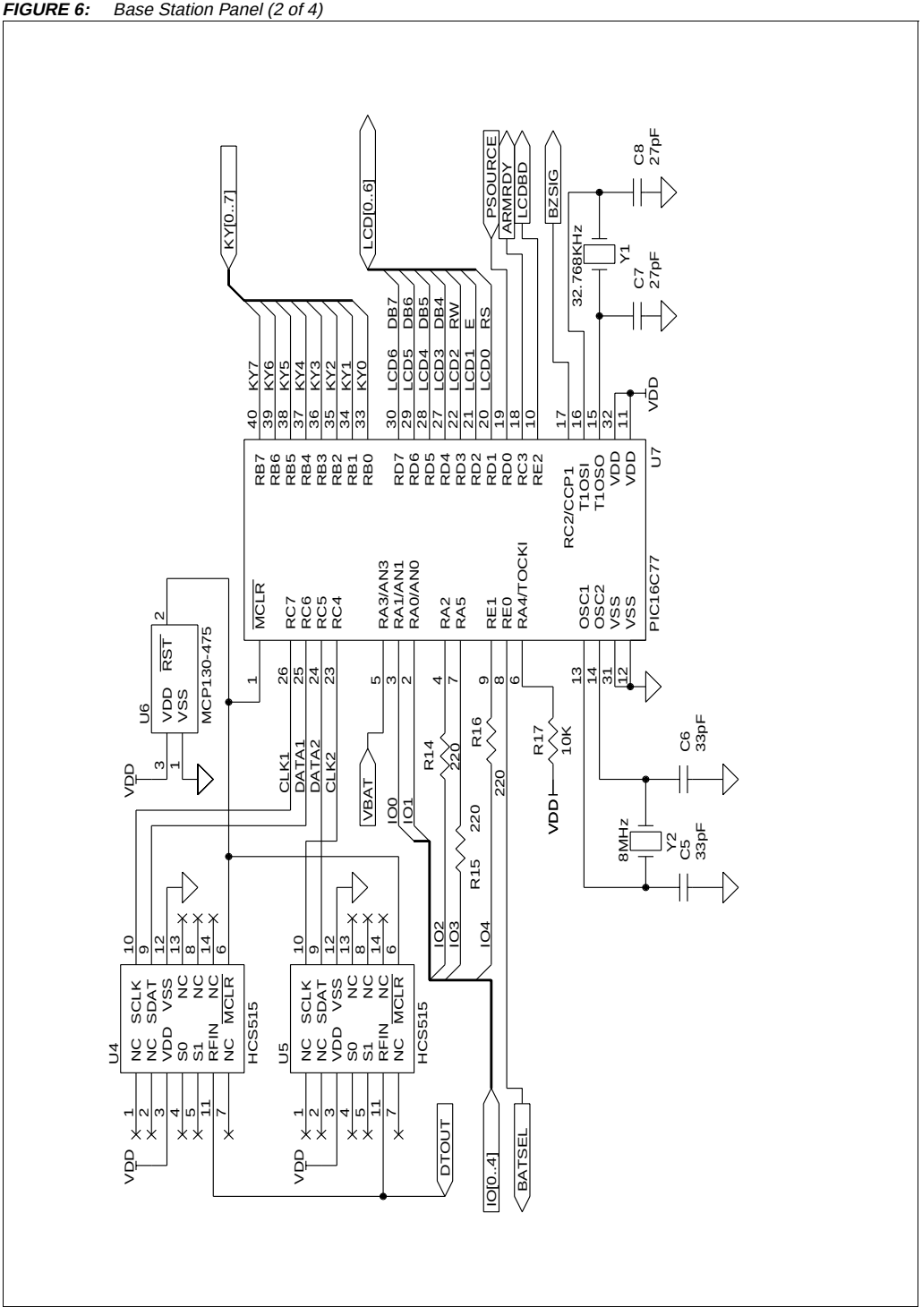


***FIGURE 7:*** *Base Station Panel (3 of 4)*

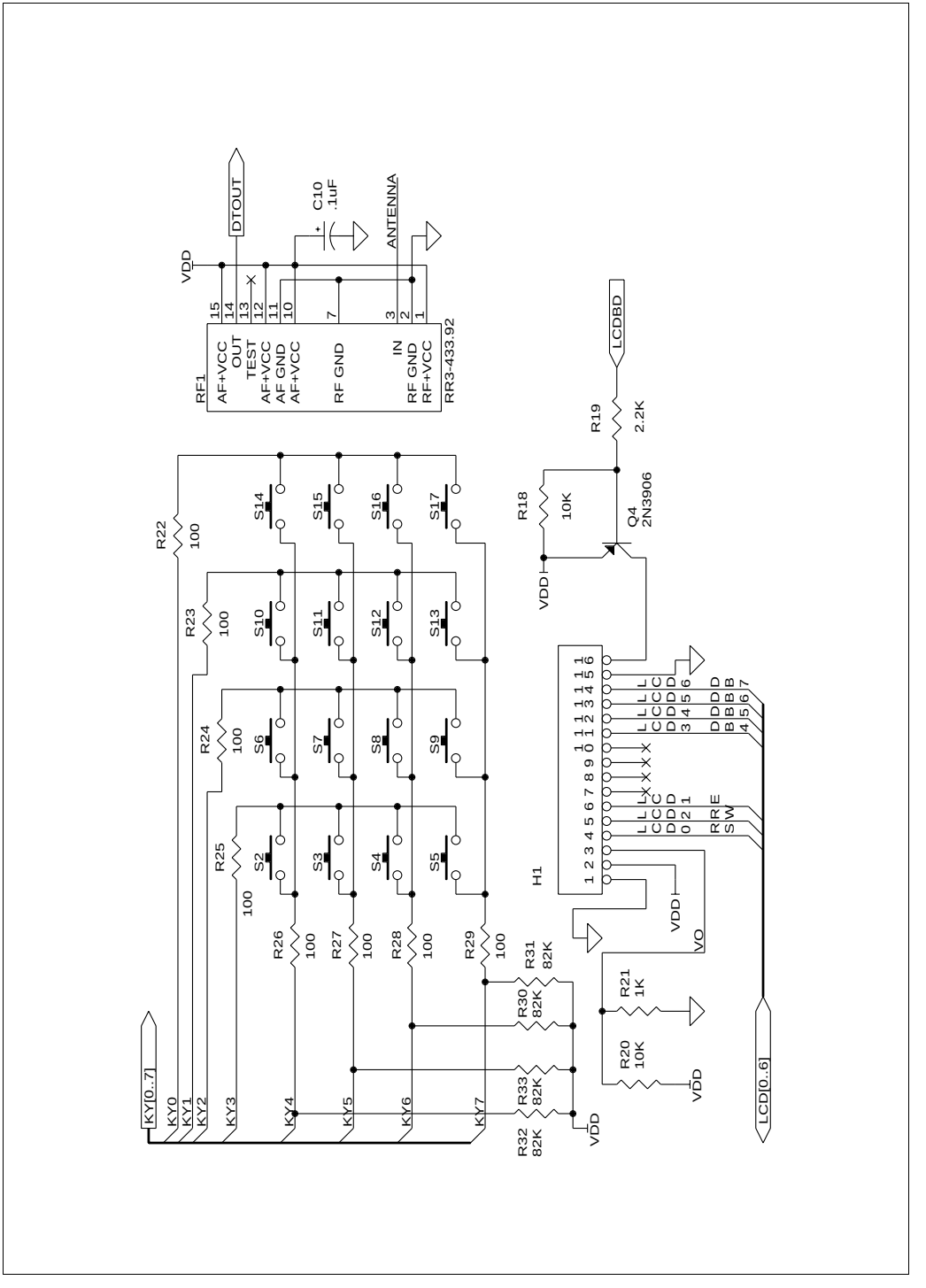


***FIGURE 8:*** *Base Station Panel (4 of 4)*

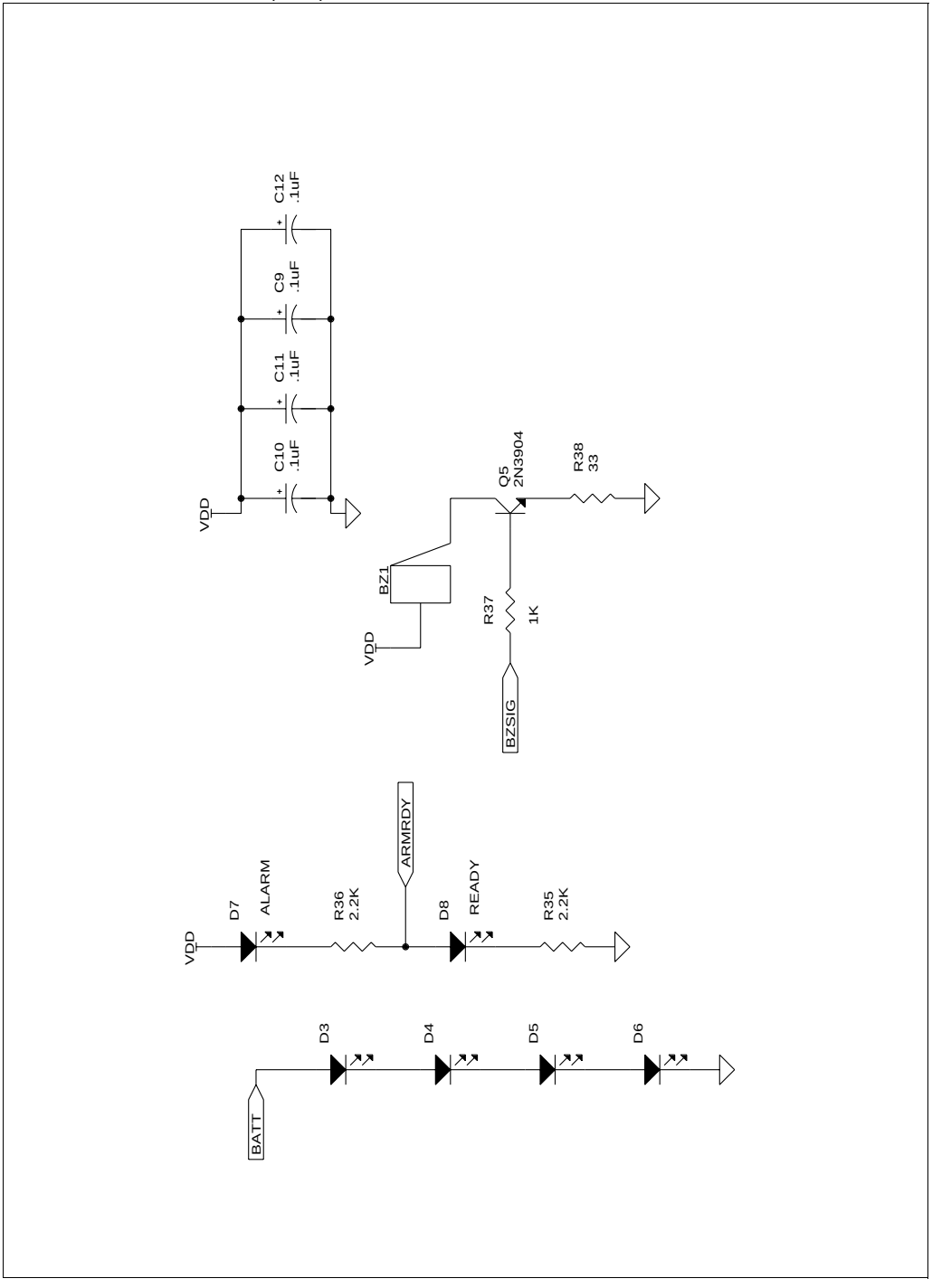


***FIGURE 9:*** *Battery Charger/Accessory Panel (1 of 2)*

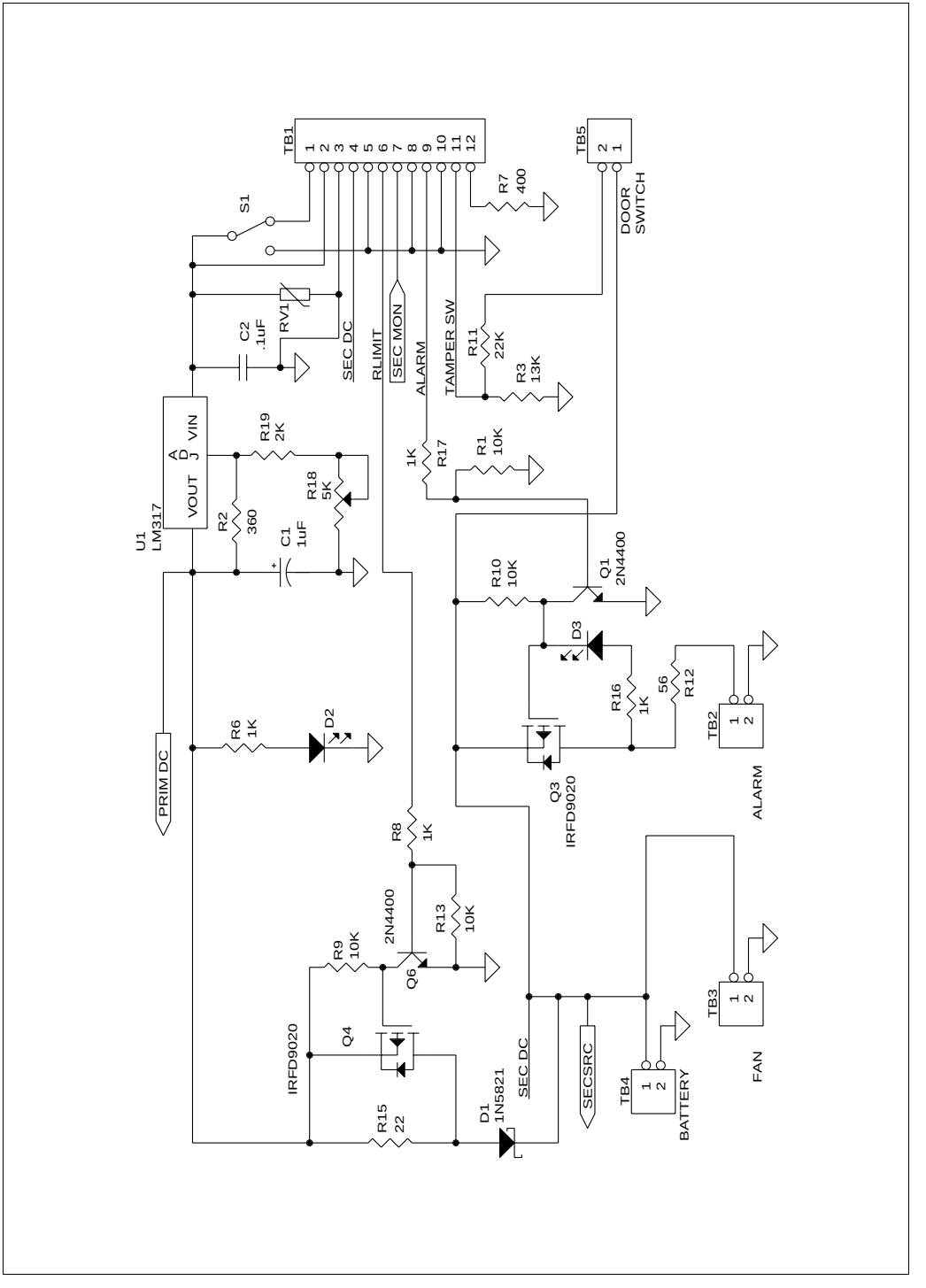


***FIGURE 10:*** *Battery Charger/Accessory Panel (2 of 2)*

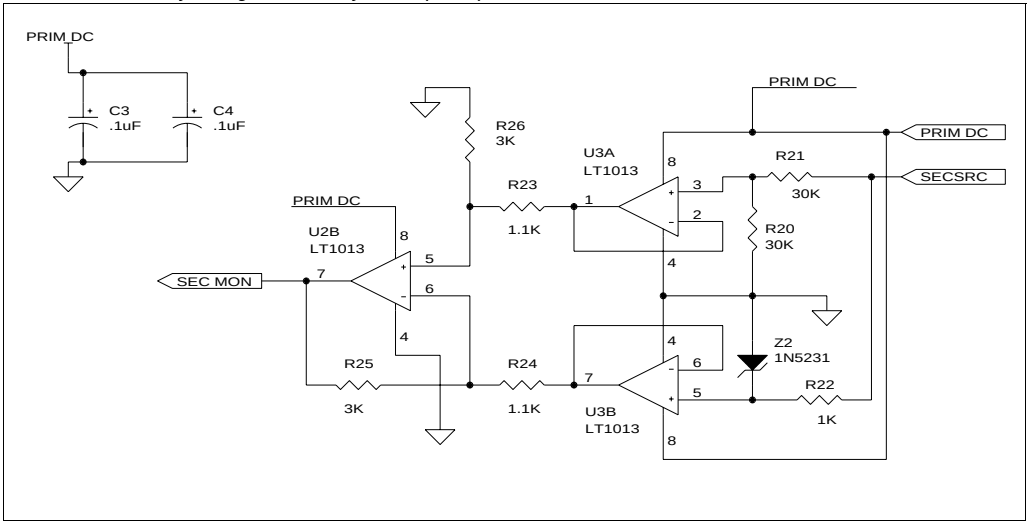



***FIGURE 11:*** *Sensor Module (1 of 2)*

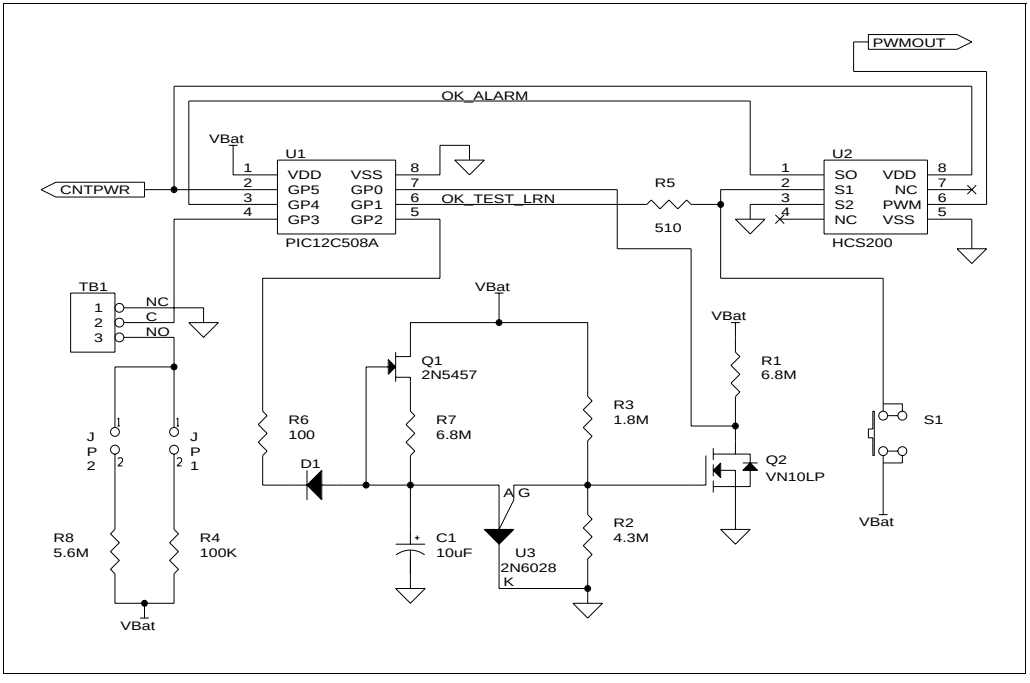
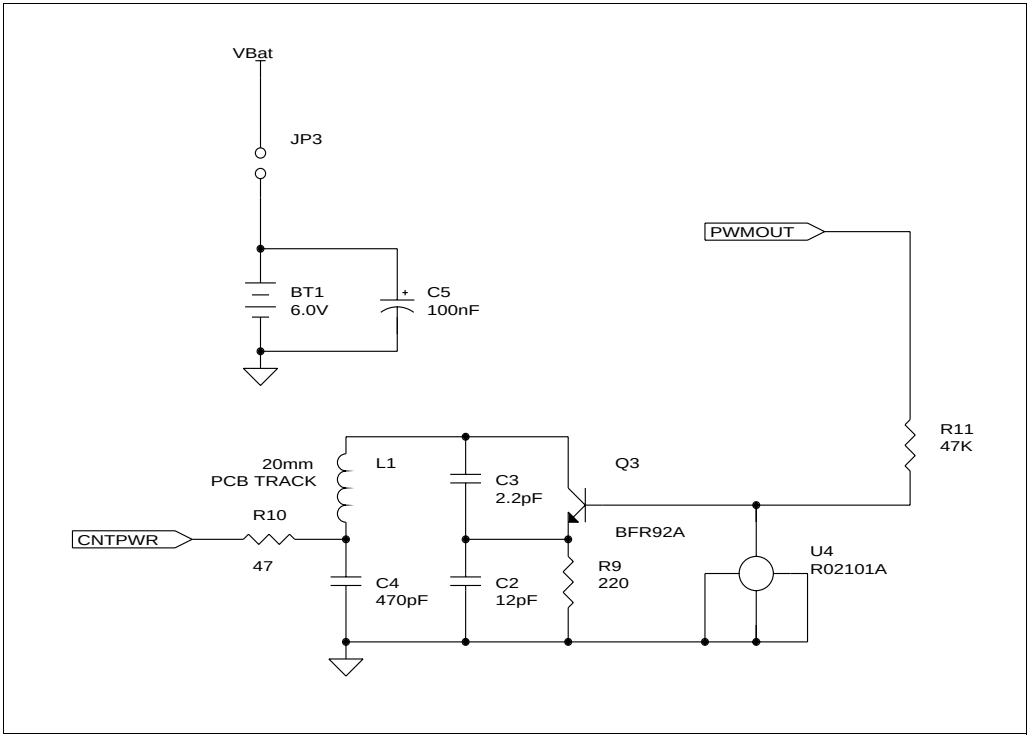


***FIGURE 12:*** *Sensor Module (2 of 2)*



## APPENDIX B: BASE STATION CODE FILES

```
/************************************************************************
*                                                                       *
*   Wireless Home Security with Keeloq and the PICmicro                 *
*                                                                       *
************************************************************************
*                                                                       *
*   Filename:       base77.c                                            *
*   Date:           07/18/99                                            *
*   File Version:   1.00                                                *
*                                                                       *
*   Compiler:       Hi-Tech PIC C Compiler V7.83 PL3                    *
*                                                                       *
*   Author:         Richard L. Fischer                                  *
*   Company:        Microchip Technology Incorporated                   *
*                                                                       *
************************************************************************
*                                                                       *
*   System files required:                                              *
*                                                                       *
*                   powrup77.as  (Hi-Tech file, modified)               *
*                   basecode.as                                         *
*                   base77.c                                            *
*                   newmprnt.c   (Hi-Tech file)                         *
*                   baselcd.c                                           *
*                   hcsdec.c                                            *
*                   prockey.c                                           *
*                   timeset.c                                           *
*                   proctran.c                                          *
*                   diagfunc.c                                          *
*                   zonename.c                                          *
*                   codesel.c                                           *
*                   init.c                                              *
*                   delays.c                                            *
*                                                                       *
*                                                                       *
*                   pic.h        (Hi-Tech file)                         *
*                   sfr.h        (Hi-Tech file)                         *
*                   stdio.h      (Hi-Tech file)                         *
*                   string.h     (Hi-Tech file)                         *
*                   cnfig77.h                                           *
*                   base77.h                                            *
*                   baselcd.h                                           *
*                   hcsdec.h                                            *
*                   prockey.h                                           *
*                   time.h                                              *
*                   proctran.h                                          *
*                   diagfunc.h                                          *
*                   zonename.h                                          *
*                   code.h                                              *
*                   hcs515ee.h                                          *
*                                                                       *
*                                                                       *
************************************************************************
*                                                                       *
*   Notes:                                                              *
*                                                                       *
*   Device Fosc -> 8.00MHz external crystal                             *
*   Timer1 -> 32.768KHz external watch crystal                          *
*   WDT -> off                                                          *
*   Brownout -> off                                                     *
*   Powerup timer -> on                                                 *
*   Code Protect -> all                                                 *
*                                                                       *
*   Interrupt sources -                                                 *
*                     1.  4x4 Keypad on PortB                           *
*                     2.  Real-time clock - Timer1 (1sec. interval)     *
*                     3.  Timer0 (32mS interval)                        *
*                                                                       *
*                                                                       *
*                                                                       *
* Memory Usage Map:                                                     *
*                                                                       *
* User segment  $1FFA - $1FFE  $0005 (   5) bytes total User segment    *
* Program ROM   $0000 - $0002  $0003 (   3) words                       *
* Program ROM   $0004 - $180F  $180C (6156) words                       *
* Program ROM   $1AC7 - $1FF9  $0533 (1331) words                       *
* Program ROM   $2007 - $2007  $0001 (   1) words                       *
*                              $1D43 (7491) words total Program ROM     *
*                                                                       *
*                                                                       *
```

```
* Bank 0 RAM    $0020 - $0062  $0043 (  67) bytes                    *
* Bank 0 RAM    $0064 - $0069  $0006 (   6) bytes                    *
* Bank 0 RAM    $0070 - $007D  $000E (  14) bytes                    *
*                              $0057 (  87) bytes total Bank 0 RAM   *
*                                                                    *
* Bank 1 RAM    $00A0 - $00D6  $0037 (  55) bytes total Bank 1 RAM   *
* Bank 0 Bits   $0318 - $031A  $0003 (   3) bits  total Bank 0 Bits  *
*                                                                    *
*                                                                    *
*                                                                    *
**********************************************************************/


    #include <pic.h>              // processor if/def file
    #include <stdio.h>
    #include “cnfig77.h”          // configuration word definitions
    #include “base77.h”           // function prototypes, defines.
    #include “hcs515ee.h”         // HCS515 EE user memory map

  __CONFIG   ( CONBLANK & BODEN_OFF & PWRTE_ON & CP_ALL & WDT_OFF & HS_OSC );


/*********************************************************************

  MAIN PROGRAM BEGINS HERE

*********************************************************************/

void main(void)
{
    Init_Adc();                           // initiliaze ADC module
    Init_Pwm();                           // initialize PWM for internal piezo use
    Init_Timer1();                        // initialize Timer1 module
    Init_Timer0();                        // initialize Timer0
    Init_Portb();                         // initialize PortB for panel keypad
    Init_Lcd();                           // initialize panel LCD module
    Init_EE_Memory();                     // initialize HCS515 EE memory sections

    flag1.battery_off = 1;                // set initial state of flag
    flag1.buzzer = 1;                     // set buzzer default state
    flag1.new_day = 1;                    // set initial flag for indicating new day
    key_wait_limit = SEC4;                // set initial key wait time (4 seconds)

    printf(“ Home Security”);             // display initial message line 1
    Line_2();                             // position lcd cursor on line2 / position 1
    printf(“Keeloq Security”);            // display initial message line 2

    decoder2_ee[0] = CLEAR;               //
    temp = Write_User_EE2( ALRM_STAT, &decoder2_ee[0], 1 );//write alarm status (clear) byte to EE

    PORTB;                                // dummy read
    RBIF = 0;                             // ensure PORTB change flag is cleared
    PEIE = 1;                             // set peripheral enable bit
    GIE = 1;                              // set global interrupt enable bit


    while( 1 )                            // main program loop
    {
        if ( HCSDATA2 )                   // test if HCS515 initiated activity
        {
            Read_Decoder_Trans();         // process reception from HCS515
        }

        if ( flag1.keyread )              // housekeeping for processing keypad entry
        {
            Process_Key();                // process key entry
            flag1.keyread = 0;            // reset flag
        }

        if ( flag1.learn_entered )        // learn activated for decoder 2
        {
            Read_Learn( 2 );              // read two bytes of learn response
            if ( ( decoder2[0] & 0xFD )  == 0x84 ) // test if learn was successful
            {
                Zone_Name();              // assign name to sensor module (zone)
            }
            flag1.learn_entered = 0;      // reset flag
        }

        if ( flag1.time_update )          // housekeeping for realtime clock?
        {
            Display_Time();               // display and update TOD on LCD
```

```
        }

        if ( ( flag1.read_battery )  && ( !PSOURCE ) )  // battery voltage requires checking?
        {
            Test_Batt_Volt();                 // check once per hour
        }                                     // flag set in interrupt every hour

        Check_Battery_Time();                 // test if battery source was cycled on/off

        if ( flag1.arm_countdown == 1 )
        {
            Home_It();                        // set lcd cursor to line1/position 1
            printf( "Armed Countdown!" );     // format message for LCD

            if  ( time_to_arm == 0x00 )
            {
                flag2.alarm_set1= 1;          // set alarm state entry flag1
                ARMRDY = 0;                   // turn on base panel ARMED LED
                flag2.alarm_set2= 1;          // set alarm state entry flag2
                flag1.arm_countdown = 0;      // reset flag so as not to come into loop again
                flag1.arm_now = 1;            // set flag to indicate system is now ARMED
            }
        }

        if ( flag1.arm_now == 1 )             // test flag if system is ARMED now
        {
            Home_It();                        // set lcd cursor to line1/position 1
            printf("  System Armed  ");       // format message for LCD
        }

        if ( ( flag2.sensor_batt_low == 1 )  &&  ( seconds < 1 ) )
        {
            Sound_Piezo( 1 );                 // toggle internal piezo for 100mS
            Delay_100mS( 1 );                 // short delay
        }

        if ( TAMPER_SW )                      // test if accessory panel door is opened
        {
            if ( flag1.arm_now == 1 )         // is system ARMED?
            {
                ALARM_ON;                     // accessory panel door open and alarm mode set
            }
                if ( seconds < 1 )            // allow small for internal buzzer to sound
            {
                Sound_Piezo( 2 );             // toggle internal piezo for 200mS
                Delay_100mS( 1 );             // short delay
            }
        }

        if ( GARAGE_EN )                      // test for garage door open/close state change
        {
            NOP();                            // no code written/tested at this time

        }
    }
}


void mystartup( void )
{
    PORTA = 0b000000;                         // enable battery current limit, disable external
                                              // alarm
    porta_image = 0b000000;
    TRISA = 0b111001;                         // set RA1 as an output
    PORTC = 0b00001000;                       // powerup init code
    TRISC = 0b01100011;                       // RC0/1/5/6 inputs, all else outputs
    TRISD = 0b11111111;                       // ensure TRISD is set for inputs
    PORTE = 0b100;                            // LCD backdrive off
    TRISE = 0b00000010;                       // RE2/RE0 output, RE1 input

    asm( "ljmp start" );                      // return control back to program
}


void Delay_10mSb( char loop_count )           // approximate 10mS base delay
{
    unsigned int inner;                       // declare integer auto variable
    char outer;                               // declare char auto variable

    while ( loop_count )                      // stay in loop until done
    {
        for ( outer = 9; outer > 0; outer-- )
```

```
            for ( inner = 249; inner > 0; inner-- );
        loop_count--;
    }
}


void interrupt piv_isr( void )
{
    if ( T0IE && T0IF )                     // has Timer0 overflow event occurred?
    {
        if ( HCSDATA2 )                     // test for Keeloq decoder activity
        {
            key_wait = SEC4 +1;             // set key_wait to expiration time
            valid_key = ESC;                // set valid key for ESCape character
        }
        key_wait ++;                        // update key wait timer
        T0IF = 0;                           // reset Timer0 overflow flag
    }

    else if ( TMR1IE && TMR1IF )            // has Timer1 overflow event occurred?
    {
        if ( seconds < 59 )                 // is cummulative seconds < 59?
        {
            seconds++;                      // yes, so increment seconds
        }
        else                                // else seconds => 59
        {
            if ( flag1.arm_countdown )      // is countdown to ARM system flag set?
            {
                time_to_arm --;             // yes, so decrement time to arm count
            }

            seconds = 0x00;                 // reset seconds
            if ( minutes < 59 )             // is cummulative minutes < 59?
            {
                minutes++;                  // yes, so updates minutes
            }
            else                            // else minutes => 59
            {
                minutes = 0x00;             // reset minutes
                flag1.read_battery = 1;     // set flag for reading battery voltage
                if ( hours < 23 )           // is cummulative hours < 23
                {
                      hours ++;             // yes, so update hours
                }
                else
                {
                       hours = 0x00;        // reset time
                       flag1.new_day = 1;   // set flag to indicate new day
                }
            }
        }

    TMR1H |= 0x80;                          // reset Timer1 period for 1 second
    TMR1IF = 0;                             // reset Timer1 overflow flag
    }

else if ( RBIE && RBIF )                    // test for PORTB change event?
{
    Delay_10mSb( 2 );                       // 10mS delay
    switch ( valid_key = ( PORTB | 0x0F ) )
    {
        case ( 0x7F ):                      // test for single key in row 4
            key_index = 0x0C;               // 'ESC', '*', '0', '#'
            break;
        case ( 0xBF ):                      // test for single key in row 3
            key_index = 0x08;               // 'ALT', '7', '8', '9'
            break;
        case ( 0xDF ):                      // test for single key in row 2
            key_index = 0x04;               // 'PANIC', '4', '5', '6'
            break;
        case ( 0xEF ):                      // test for single key in row 1
            key_index = 0x00;               // 'AUX', '1', '2', '3'
            break;
        default:
            key_index = 0x10;               // no valid "single" key entered
            flag1.keyread = 0;              // set keyread processing flag to false
            break;
    }

    if ( key_index != 0x10 )                // if row = 1-4 valid
    {
```

```
        PORTB = 0xFF;                           // initialize PORTB outputs to logic 1's
            portb_image = 0b11101111;           // initialize mask byte for column detect
            PORTB;                              // initialize PORTB input conditions
            RBIF = 0;                           // reset interrupt flag
            portb_image >>= 1;                  // rotate mask value 1 position right

            while ( CARRY )
            {
                PORTB = portb_image;            // write key selection mask value to PORTB
                NOP();                          // small settling time for output drive
                if ( RBIF )                     // is change on PORTB flag set?
                {
                       flag1.keyread = 1;       // set keyread processing flag to true
                       flag1.keyhit = 1;        // set valid key hit flag
                       CARRY = 0;               // reset carry flag
                }
                else                            // no change on PORTB so ..
                {
                         key_index++;           // increment key index
                         portb_image >>= 1;     // update PORTB selection mask value
                }
            }
        }

        PORTB = 0xF0;                           // reset PORTB drive states
        if ( flag1.keyhit == 1 )                // test if there was valid key hit
        {
            valid_key = keypad[key_index];      // obtain selected key
            flag1.keyhit = 0;                   // invalid key hit
        }

        PORTB;                                  // PortB dummy read
        RBIF = 0;                               // reset flag
    }
}


void Display_Time( void )
{
    Line_2();                                   // position lcd cursor on line2 / position 1
    printf("Time-> %02u:%02u:%02u" ,hours,minutes,seconds );
}


void putch( char data )
{
    Write_Lcd_Data( data );                     // write data to LCD via "printf"
}
```

```
/************************************************************************
*                                                                       *
*   Filename:       base77.h                                            *
*   Date:           07/18/99                                            *
*   File Version:   1.00                                                *
*                                                                       *
*   Compiler:       Hi-Tech PIC C Compiler V7.83 PL3                    *
*                                                                       *
************************************************************************/


// ROM ARRAY STORAGE DEFINED HERE


#define   ESC           0x1B                // text sub. for Escape key
#define   ALT           0x40                // text sub. for Alternate key
#define   AUX           0x41                // text sub. for Auxillary key
#define   PANIC         0x50                // text sub. for Panic key

const char keypad[17] = {PANIC,'1','2','3',
                         ALT,'4','5','6',
                         AUX,'7','8','9',
                         ESC,'*','0','#','?'};


// FUNCTION PROTOTYPES

/* Functions defined in file base77.c */
void Display_Time( void );                  // function for displaying TOD
void Delay_10mSb( char loop_count);         // 10mS delay used for keypad debounce

/* Functions defined in file init.c */
extern void Init_Adc( void );               // reference linkage to defined function
extern void Init_Pwm( void);
extern void Init_Timer1( void );
extern void Init_Timer0( void );
extern void Init_Portb( void );
extern void Init_EE_Memory( void );

/* Functions defined in file baselcd.c */
extern void Init_Lcd( void );               // reference linkage to defined function
extern void Write_Lcd_Data (char data );
extern void Home_Clr( void );
extern void Home_It( void );
extern void Line_2( void );

/* Functions defined in file delays.c */
extern void Delay_100mS( char loop_count );  // reference linkage to defined function
extern void Delay_10mS( char loop_count );
extern void Delay_1mS( char loop_count );

/* Functions defined is file diagfunc.c */
extern void Sound_Piezo( char ontime );      // reference linkage to defined function
extern void Test_Batt_Volt( void );
extern void Check_Battery_Time( void );

/* Function defined in file prockey.c */
extern void Process_Key (void );             // reference linkage to defined function

/* Functions defined in file hcsdec.c */
extern void Read_Trans( char length );       // reference linkage to defined function
extern char Read_Learn( char length );
extern void Read_Decoder_Trans( void );
extern char Write_User_EE2( char address, char * wrptr, char length );

/* Function defined in file proctran.c */
extern void Process_Trans( void );           // reference linkage to defined function

/* Function defined in file zonename.c */    // reference linkage to defined function
extern void Zone_Name( void );


// VARIABLES ( DEFINED HERE )

struct event_bits1                           // bit structure for housekeeping flags
      {
        unsigned new_day        :1;          // flag for indicating new day
        unsigned arm_countdown  :1;          // flag set when counting down to arming system
        unsigned buzzer         :1;          // flag set when piezo buzzer will sound when called
        unsigned read_battery   :1;          // flag used for read battery voltage
        unsigned battery_on     :1;          // flag set when battery source is selected
```

```
        unsigned battery_off     :1;          // flag set when battery is not selected
        unsigned time_update     :1;          // flag used for updating LCD and E2 Memory
        unsigned erase_all       :1;          // flag set when HCS515 erase all operation complete
        unsigned battery_sel     :1;          // flag set when battery source is selected
        unsigned erase_entered   :1;          // flag set when HCS515 erase all operation entered
        unsigned arm_now         :1;          // flag set when system is immediately armed w/o user
                                              // code
        unsigned learn_entered   :1;          // flag set when HCS515 learn operation entered
        unsigned code_valid      :1;          // flag set after user security access code accepted
        unsigned code_entered    :1;          // flag set when user security access code entered
        unsigned keyread         :1;          // flag set for indicating keypad selection needs
                                              // processed
        unsigned keyhit          :1;          // flag set when valid key hit on 4x4 keypad is
                                              // detected
    } flag1;                                  // variable name

struct event_bits2                            // define bit structure for housekeeping flags
    {
        unsigned                 :1;          // bit padding
        unsigned alarm_set1      :1;          // flag set when system is armed ( 1 of 2 )
        unsigned                 :6;          // bit padding
        unsigned valid_rcv       :1;          // flag used if HCS515 demod data is correct
        unsigned sensor_batt_low :1;          // flag indicating if sensor module battery is low
        unsigned                 :5;          // bit padding
        unsigned alarm_set2      :1;          // flag set when system is armed ( 2 of 2 )
    } flag2;                                  // variable name


char porta_image;                             // define PortA image register
char portb_image;                             // define PortB image register
char key_index;                               // define key index variable for const array
char hours;                                   // define variable used for hours
char minutes;                                 // define variable used for minutes
char seconds;                                 // define variable used for seconds

bank1 char temp;
bank1 char key_wait;                          // define variable for key wait timer
bank1 char valid_key;                         // define variable for 4x4 keypad value
bank1 char key_wait_limit;                    // define variable for key wait timer



// VARIABLES ( REFERENCE DECLARATION )

//extern bank1 char decoder1[10];             // reference linkage, array storage for valid trans.
                                              // reception (decoder 1)
extern bank1 char decoder2[10];               // reference linkage, array storage for valid trans.
                                              // reception (decoder 2)
//extern bank1 char decoder1_ee[6];           // reference linkage to array variable
extern bank1 char decoder2_ee[6];             // reference linkage to array variable
extern bank1 char time_to_arm;                // reference linkage to defined variable



// PORTBITS ( DEFINED HERE )

#define PortBit(port,bit)    ((unsigned)&(port)*8+(bit))

static bit TAMPER_SW  @  PortBit(PORTA,5);    // Input from Accessory unit door tamper switch

static bit ARMRDY     @  PortBit(PORTC,3);    // Alarm/Ready Light bias control
static bit HCSCLK2    @  PortBit(PORTC,4);    // HSC515 clock input (Ref. U5)
static bit HCSDATA2   @  PortBit(PORTC,5);    // HCS515 data output (Ref. U5)
static bit HCSDATA1   @  PortBit(PORTC,6);    // HCS515 data output (Ref. U4)
static bit HCSCLK1    @  PortBit(PORTC,7);    // HCS515 clock input (Ref. U4)
static bit PSOURCE    @  PortBit(PORTD,0);    // Power Source indication status

static bit GARAGE_EN  @  PortBit(PORTE,1);    // Input from Existing garage door receiver
static bit LCDBD      @  PortBit(PORTE,2);    // LCD Back Drive on/off



// MACROS ( DEFINED HERE )

#defineNOP()asm(“ nop”)                       // define NOP macro

#define ALARM_ON       porta_image |= 0b000100;\
                       PORTA = porta_image;  // enable external alarm

#define ALARM_OFF      porta_image &= ~0b000100;\
                       PORTA = porta_image;  // enable external alarm

#define   SEC4           120                  //
```

```
/************************************************************************
*                                                                       *
*   Wireless Home Security with Keeloq and the PICmicro                 *
*                                                                       *
************************************************************************
*                                                                       *
*   Filename:       baselcd.c                                           *
*   Date:           07/18/99                                            *
*   File Version:   1.00                                                *
*                                                                       *
*   Compiler:       Hi-Tech PIC C Compiler V7.83 PL3                    *
*                                                                       *
*   Author:         Richard L. Fischer                                  *
*   Company:        Microchip Technology Incorporated                   *
*                                                                       *
************************************************************************
*                                                                       *
*   Files required:                                                     *
*                                                                       *
*                   baselcd.h                                           *
*                                                                       *
************************************************************************
*                                                                       *
*   Notes: The routines within this file are required for               *
*          communicating with the system LCD (2x16) module              *
*          connected to PORTD.                                          *
*                                                                       *
*                                                                       *
*   PORTD: RD4 - RD7 ( 4-bit data interface )                           *
*          RD3 -     ( R/W control signal )                             *
*          RD2 -     ( E control signal )                               *
*          RD1 -     ( RS control signal )                              *
*                                                                       *
*   PORTE: RE2 -     ( LCD backlight on/off / 60mA draw )               *
*                                                                       *
*                                                                       *
************************************************************************/

    #include “baselcd.h”                    // function prototypes, defines..


void Init_Lcd( void )                       // initialize LCD display
{
    CONTROL = 0x01;                         // initial state of control lines
    TRISCTRL = 0x01;                        // initialize control lines

    Delay15ms();                            // ~15mS delay upon powerup

    DATA = 0x30;                            // output setup data to LCD
    E = 1;                                  // set enable high
    NOP();
    E = 0;                                  // set enable low

    Delay5ms();                             // ~5mS delay

    DATA = 0x30;                            // output setup data to LCD
    E = 1;                                  // set enable high
    NOP();
    E = 0;                                  // set enable low

    Delay200us();                           // ~200uS delay

    DATA = 0x30;                            // output setup data to LCD
    E = 1;                                  // set enable high
    NOP();
    E = 0;                                  // set enable low
    Lcd_Busy();                             // test for lcd_busy state

    DATA = 0x20;                            // output setup data to LCD
    E = 1;                                  // set enable high
    NOP();
    E = 0;                                  // set enable low
    Lcd_Busy();                             // test for lcd_busy state

    Write_Lcd_Cmd( 0x28 );                  // define 4 bit interface, 2 lines. 5x7 dots
    Write_Lcd_Cmd( 0x0C );                  // display on, cursor on, blink off
    Write_Lcd_Cmd( 0x01 );                  // clear display
    Write_Lcd_Cmd( 0x06 );                  // entry mode set..
    Write_Lcd_Cmd( 0x28 );                  //
}
```

```
void Write_Lcd_Cmd( char cmd )              // subroutiune for lcd commands
{
    DATA = ( cmd & 0xF0 );                  // send upper 4 bits of command
    E = 1;                                  // set enable high
    NOP();
    E = 0;                                  // set enable low
    DATA = ( ( cmd << 4 ) & 0xF0 );         // now send lower 4 bits of command
    E = 1;                                  // set enable high
    NOP();
    E = 0;                                  // set enable low
    Lcd_Busy();                             // check lcd busy flag
}


void Write_Lcd_Data( char data )            // subroutine for lcd data
{
    DATA = 0x00;                            // set pins to defined state
    RS = 1;                                 // assert register select to 1
    DATA |= ( data & 0xF0 );                // send upper 4 bits of data
    E = 1;                                  // set enable high
    NOP();                                  //
    E = 0;                                  // set enable low
    DATA &= 0x0F;
    DATA |= ( data << 4 );                  // now send lower 4 bits of data
    E = 1;                                  // set enable high
    NOP();                                  //
    E = 0;                                  // set enable low
    RS = 0;                                 // negate register select to 0
    Lcd_Busy();                             // check lcd busy flag
}


void Lcd_Busy( void )
{
    TRISDATA_7 = 1;                         // make line an input
    RW = 1;                                 // assert R/W for read operation

    while( TRUE )                           // stay in loop until lcd not busy
    {
      E = 1;                                // set enable high
      NOP();                                // ensure tDDR spec is met before test
      if ( !DATA_7 )                        // is busy bit negated
      {
        E = 0;                              // set enable low
        RW = 0;                             // negate R/W for write operation
        TRISDATA_7 = 0;                     // return line to output
        return;                             // exit busy routine
      }
      else
      {
        E = 0;                              // set enable low
        NOP();
        E = 1;                              // set enable high
        NOP();
        E = 0;                              // set enable low
      }
    }
}


void Delay15ms( void )                      // approximate 15ms delay
{
    char outer, inner;
    for (outer = 24; outer > 0; outer--)
        for (inner = 250; inner > 0; inner--);
}


void Delay5ms( void )                       // approximate 5ms delay
{
    char outer, inner;
    for (outer = 8; outer > 0; outer--)
        for (inner = 253; inner > 0; inner--);
}


void Delay200us( void )                     // approximate 200us delay
{
    char delay;
        for (delay = 66; delay > 0; delay--);
}
```

```
void Cursor_Right( void )                   // shift lcd cursor right 1 position
{
    Write_Lcd_Cmd( 0x14 );
}

void Cursor_Left( void )                    // shift lcd cursor left 1 position
{
    Write_Lcd_Cmd( 0x10 );
}

void Display_Shift( void )                  // shift lcd display contents
{
    Write_Lcd_Cmd (0x1C );
}

void Home_Clr( void )                       // clear lcd and set cursor to line1/position 1
{
    Write_Lcd_Cmd( 0x01 );
}

void Home_It( void )                        // set lcd cursor to line1/position 1
{
    Write_Lcd_Cmd( 0x02 );
}

void Line_2( void )                         // clear lcd and set to line2/position 1
{
    Write_Lcd_Cmd (0xC0 );
}
```

```
/************************************************************************
*                                                                       *
*   Filename:       baselcd.h                                           *
*   Date:           07/18/99                                            *
*   File Version:   1.00                                                *
*                                                                       *
*   Compiler:       Hi-Tech PIC C Compiler V7.83 PL3                    *
*                                                                       *
************************************************************************/


// FUNCTION PROTOTYPES

/* Functions defined in file baselcd.c */
void Write_Lcd_Cmd( char cmd );              // write command to lcd
void Lcd_Busy( void );                       // busy flag check
void Delay15ms( void );                      // approximate 15ms delay
void Delay5ms( void );                       // approximate 5ms delay
void Delay200us( void );                     // approximate 200us delay

static unsigned char PORTD @ 0x08;           // reference/declare of PORTD variable
static unsigned char TRISD @ 0x88;           // reference/declare of TRISD variable


// MACROS ( DEFINED HERE )

#define  TRUE      1
#define  NOP() asm(" nop")

#define  CONTROL   PORTD                     // Port for lcd control lines
#define  TRISCTRL  TRISD                     // I/O setup for control Port
#define  DATA      PORTD                     // Port for lcd data
#define  TRISDATA  TRISD                     // I/O setup for data Port


// PORTBITS ( DEFINED HERE )

#define PortBit(port,bit)    ((unsigned)&(port)*8+(bit))

static bit DATA_7     @ PortBit(PORTD,7);    // DATA bit 7 for LCD busy check
static bit TRISDATA_7 @ PortBit(TRISD,7);    // TRIS bit 7 for LCD busy check
static bit RW         @ PortBit(PORTD,3);    // R/W control bit for LCD
static bit RS         @ PortBit(PORTD,1);    // Register select bit for LCD
static bit E          @ PortBit(PORTD,2);    // Enable/Clock for bit for LCD
```

```
/*********************************************************************
*                                                                    *
*   Wireless Home Security with Keeloq and the PICmicro              *
*                                                                    *
*********************************************************************
*                                                                    *
*   Filename:       delays.c                                         *
*   Date:           07/18/99                                         *
*   File Version:   1.00                                             *
*                                                                    *
*   Compiler:       Hi-Tech PIC C Compiler V7.83 PL3                 *
*                                                                    *
*   Author:         Richard L. Fischer                               *
*   Company:        Microchip Technology Incorporated                *
*                                                                    *
*********************************************************************
*                                                                    *
*   Files required:                                                  *
*                                                                    *
*                   pic.h                                            *
*                                                                    *
*                                                                    *
*********************************************************************
*                                                                    *
*   Notes: The delay routines within this file are used              *
*          by other system functions.                                *
*                                                                    *
*                                                                    *
*********************************************************************/

    #include <pic.h>                        // processor if/def file


#define   NOP() asm(“ nop”)                 // define NOP macro


void Delay_1S( char loop_count )            // approximate 1S base delay
{
    unsigned int  inner;                    // define/declare auto type int variable
    unsigned char outer;                    // define/declare auto type char variable

    while ( loop_count )
    {
        for ( outer = 145; outer > 0; outer-- )
            for ( inner = 985; inner > 0; inner-- )
            {
                NOP();
                NOP();
                NOP();
                NOP();
                NOP();
            }
        loop_count--;                       // decrement loop iteration counter
    }
}


void Delay_100mS( char loop_count )         // approximate 100mS base delay
{
    unsigned int  inner;                    // define/declare auto type int variable
    unsigned char outer;                    // define/declare auto type char variable

    while ( loop_count )
    {
        for ( outer = 87; outer > 0; outer-- )
            for ( inner = 255; inner > 0; inner-- );

        loop_count--;                       // decrement loop iteration counter
    }
}


void Delay_10mS( char loop_count )          // approximate 10mS base delay
{
    unsigned int  inner;                    // define/declare auto type int variable
    unsigned char outer;                    // define/declare auto type char variable

    while ( loop_count )
    {
        for ( outer = 9; outer > 0; outer-- )
            for ( inner = 246; inner > 0; inner-- );
```

```
        loop_count--;                           // decrement loop iteration counter
    }
}


void Delay_1mS( char loop_count )               // approximate 1mS base delay
{
    unsigned int  inner;                        // define/declare auto type int variable
    unsigned char outer;                        // define/declare auto type char variable

    while ( loop_count )
    {
        for ( outer = 1; outer > 0; outer-- )
            for ( inner = 219; inner > 0; inner-- );

        loop_count--;                           // decrement loop iteration counter
    }
}


void Delay_200uS( void )                        // approximate 200us delay
{
    char delay;                                 // define/declare auto type char variable
        for ( delay = 66; delay > 0; delay-- );
}


void Delay_20uS( char loop_count )              // approximate 20us base delay
{
    char delay;                                 // define/declare auto type char variable

    for ( ; loop_count > 0 ; loop_count-- )
        for ( delay = 6; delay > 0; delay-- );
}


void Delay_10uS(void)                           // approximate 10us delay
{
    char delay;                                 // define/declare auto type char variable

    NOP();
    NOP();
        for ( delay = 2; delay > 0; delay-- );
}


void Delay_5uS(void)                            // approximate 5us delay
{
    NOP();
    NOP();
    NOP();
    NOP();
    NOP();
}
```

```
/*****************************************************************
*                                                                *
*   Wireless Home Security with Keeloq and the PICmicro          *
*                                                                *
*****************************************************************
*                                                                *
*   Filename:       diagfunc.c                                   *
*   Date:           07/18/99                                     *
*   File Version:   1.00                                         *
*                                                                *
*   Compiler:       Hi-Tech PIC C Compiler V7.83 PL3             *
*                                                                *
*   Author:         Richard L. Fischer                           *
*   Company:        Microchip Technology Incorporated            *
*                                                                *
*****************************************************************
*                                                                *
*   Files required:                                              *
*                                                                *
*                   pic.h                                        *
*                   stdio.h                                      *
*                   diagfunc.h                                   *
*                   hcs515ee.h                                   *
*                                                                *
*                                                                *
*                                                                *
*****************************************************************
*                                                                *
*                                                                *
*   Notes: The routines within this file are used for:           *
*                                                                *
*   1. Monitoring battery voltage and determining if current     *
*      limiting resistor is switched in or out.                  *
*   2. Converting ADC result to a floating point number          *
*   3. Initiating drive signal for piezo buzzer                  *
*   4. Monitoring and recording battery on/off T.O.D. and number *
*      of on/off cycles.                                         *
*                                                                *
*                                                                *
*****************************************************************/

    #include <pic.h>
    #include <stdio.h>
    #include “diagfunc.h”
    #include “hcs515ee.h”


void Test_Batt_Volt( void )
{
    ADON = 1;                               // power up ADC module
    NOP();                                  // short delay
    ADGO = 1;                               // start conversion
    while( ADGO );                          // wait here until conversion complete
    ADON = 0;                               // power down ADC module

    if ( ADRES > 0xBA )                     // is battery voltage > 12.75Vdc?
    {
        BATT_CURR_ON;                       // yes, so remove battery charge current limit
    }
    else
    {
        BATT_CURR_OFF;                      // no, so battery charge current limit on
    }
    flag1.read_battery = 0;                 // reset read battery status flag
}



void Battery_Voltage( void )
{
    Test_Batt_Volt();                       // perform conversion on scaled battery voltage
    battery_volts = ( ( ( ADRES * 0.019726562 ) / 2.7477 ) + 5.13 ) * 1.9984;
}



void Sound_Piezo( char ontime )
{
    if ( flag1.buzzer )                     // test if buzzer is enabled
    {
        GIE = 0;                            // disable global interrupt enable
        CCP1CON = 0b00001100;               // set CCP1 for PWM
```

```
        do                                      // loop
        {
            Delay_1mS( 100 );                   // ~99.91 mS
        } while ( --ontime );                   // number of 100mS loops

        CCP1CON = 0x00;                         // turn off CCP1 module
        GIE = 1;                                // re-enable global interrupt enable
    }
}


void Check_Battery_Time( void )
{

/* Test if battery has been selected and record time */
    if ( PSOURCE  &&  !flag1.battery_on )       // test if battery is selected
    {                                           // if PSOURCE == 1, then battery is selected
        decoder2_ee[0] = hours;                 // write hours count to buffer for EE write
        decoder2_ee[1] = minutes;               // write minutes count to buffer for EE write
        decoder2_ee[2] = seconds;               // write seconds count to buffer for EE write
        temp = Write_User_EE2( BT_ON_HRS, &decoder2_ee[0], 3 ); // write battery on-time to EE
                                                // memory

        flag1.battery_on = 1;                   // set flag to indicate battery is selected
        flag1.battery_off = 0;                  // reset flag for battery off time
    }

/* Test if battery is de-selected and record time */
    if ( !PSOURCE  &&  !flag1.battery_off )     // test if line is primary source
    {                                           // if !PSOURCE == 0, main power is on
        decoder2_ee[0] = hours;                 // write hours count to buffer for EE write
        decoder2_ee[1] = minutes;               // write minutes count to buffer for EE write
        decoder2_ee[2] = seconds;               // write seconds count to buffer for EE write
        temp = Write_User_EE2( BT_OFF_HRS, &decoder2_ee[0], 3 );// write battery off-time to EE
                                                // memory

        Delay_1mS( 5 );

        temp = Read_User_EE2( BT_ON_CNT, &decoder2_ee[0], 1 );// read battery on cycle count
        decoder2_ee[0] ++;

        Delay_1mS( 5 );
        temp = Write_User_EE2( BT_ON_CNT, &decoder2_ee[0], 1 ); // write updated battery on cycle
                                                // count

        flag1.battery_off = 1;                  // set flag to indicate battery is not selected
        flag1.battery_on = 0;                   // reset battery on status flag
    }

/* Test if new 24 hour period has began */
    if ( flag1.new_day )                        // test if new day flag has been set
    {
        decoder2_ee[0] = 0x00;                  // set array element to 0
        decoder2_ee[1] = 0x00;                  // set array element to 0
        decoder2_ee[2] = 0x00;                  // set array element to 0
        decoder2_ee[3] = 0x00;                  // set array element to 0
        decoder2_ee[4] = 0x00;                  // set array element to 0
        decoder2_ee[5] = 0x00;                  // set array element to 0

        temp = Write_User_EE2( BT_ON_CNT, &decoder2_ee[0], 1 );// reset daily battery on count
        temp = Write_User_EE2( BT_ON_HRS, &decoder2_ee[0], 6 );// reset battery on/off time to 0

        flag1.new_day = 0;                      // reset 24 hour flag
    }
}
```

```
/*********************************************************************
*                                                                    *
*   Filename:       diagfunc.h                                       *
*   Date:           07/18/99                                         *
*   File Version:   1.00                                             *
*                                                                    *
*   Compiler:       Hi-Tech PIC C Compiler V7.83 PL3                 *
*                                                                    *
*********************************************************************/



// FUNCTION PROTOTYPES

/* Functions defined in file hcsdec.c */
extern char Write_User_EE2( char address, char * wrptr, char length );
extern char Read_User_EE2( char address, char * rdptr, char length );

/* Function defined in file delays.c */
extern void Delay_1mS( char loop_count );    // reference linkage to defined function


// VARIABLES ( REFERENCE DECLARATION )

extern struct event_bits1                    // bit structure for housekeeping flags
      {
        unsigned new_day        :1;          // flag for indicating new day
        unsigned arm_countdown  :1;          // flag set when counting down to arming system
        unsigned buzzer         :1;          // flag set when piezo buzzer will sound when called
        unsigned read_battery   :1;          // flag used for read battery voltage
        unsigned battery_on     :1;          // flag set when battery source is selected
        unsigned battery_off    :1;          // flag set when battery is not selected
        unsigned time_update    :1;          // flag used for updating LCD and E2 Memory
        unsigned erase_all      :1;          // flag set when HCS515 erase all operation complete
        unsigned battery_sel    :1;          // flag set when battery source is selected
        unsigned erase_entered  :1;          // flag set when HCS515 erase all operation entered
        unsigned arm_now        :1;          // flag set when system is immediately armed w/o user
                                             // code
        unsigned learn_entered  :1;          // flag set when HCS515 learn operation entered
        unsigned code_valid     :1;          // flag set after user security access code accepted
        unsigned code_entered   :1;          // flag set when user security access code entered
        unsigned keyread        :1;          // flag set for indicating keypad selection needs
                                             // processed
        unsigned keyhit         :1;          // flag set when valid key hit on 4x4 keypad is
                                             // detected
    } flag1;                                 // variable name


extern bank1 char decoder2_ee[6];            // reference linkage to defined variable

extern bank1 char temp;                      // reference linkage to defined variable

extern char porta_image;                     // reference linkage to defined variable
extern char hours;                           // reference linkage to defined variable
extern char minutes;
extern char seconds;


// VARIABLES ( DEFINED HERE )

bank1 double battery_volts;                  // variable defined here


// PORTBITS ( DEFINED HERE )

#define PortBit(port,bit)    ((unsigned)&(port)*8+(bit))

static bit PSOURCE    @  PortBit(PORTD,0);   // Power Source indication status
static bit BATSEL     @  PortBit(PORTE,0);   // Battery Select (test only)


// MACROS ( DEFINED HERE )

#define NOP()asm(" nop")                     // define NOP macro

#define BATT_CURR_ON   porta_image |= 0b000010;\
                       PORTA = porta_image;  // enable maximum battery charge current

#define BATT_CURR_OFF  porta_image &= ~0b000010;\
                       PORTA = porta_image;  // enable maximum battery charge current
```

```
/*********************************************************************
*                                                                    *
*   Wireless Home Security with Keeloq and the PICmicro              *
*                                                                    *
*********************************************************************
*                                                                    *
*   Filename:       hcsdec.c                                         *
*   Date:           07/18/99                                         *
*   File Version:   1.00                                             *
*                                                                    *
*   Compiler:       Hi-Tech PIC C Compiler V7.83 PL3                 *
*                                                                    *
*   Author:         Richard L. Fischer                               *
*   Company:        Microchip Technology Incorporated                *
*                                                                    *
*********************************************************************
*                                                                    *
*   Files required:                                                  *
*                                                                    *
*                   pic.h                                            *
*                   stdio.h                                          *
*                   hcsdec.h                                         *
*                                                                    *
*                                                                    *
*                                                                    *
*********************************************************************
*                                                                    *
*                                                                    *
*   Notes: The routines within this file are required for            *
*          communicating with the system HCS515 decoders.            *
*                                                                    *
*                                                                    *
*                                                                    *
*********************************************************************/

    #include <pic.h>
    #include <stdio.h>
    #include “hcsdec.h”


void Read_Trans( char length )
{
    TRISDATA2 = 1;                          // ensure pin direction is input
    lrn_ptr = decoder2                      // initialize pointer

    Delay_20uS( 3 );                        // intervals of 20uS delay ( 61uS total )
    HCSCLK2 = 1;                            // assert clock - provide ack to HCS515

    Delay_20uS( 2 );                        // ~42uS ( Tclh )
    HCSCLK2 = 0;                            // negate clock
    Delay_20uS( 2 );                        // ~42uS ( Tcll )

    while ( length )                        // stay while length != 0
    {
        command.bit_counter = 8;            // initialize bit counter
        do
        {
            HCSCLK2 = 1;                    // set clock high (total high time - 26uS)
            NOP();                          // add in .5uS delay
            Delay_20uS( 1 );                // ~24uS delay
            HCSCLK2 = 0;                    // set clock low (sample data after falling edge )
                                            // (total low time - 31.5uS)
            temp_buffer >> = 1;>            // rotate buffer contents towards LSB
            if ( HCSDATA2 )                 // test if data line is logic 1
            {
                temp_buffer |= 0x80;        // set bit 7 to logic 1
            }
            Delay_20uS( 1 );                // ~24uS delay

        } while ( --command.bit_counter );  // decrement counter and test if complete

        *lrn_ptr++ = temp_buffer;           // save off read byte and update pointer
        length --;                          // decrement loop length counter
    }
}


char Read_Learn( char length )
{
    TRISDATA2 = 1;                          // ensure pin direction is input
    HCSCLK2 = 0;                            // ensure clock line is low
```

```
    lrn_ptr = decoder2;                         // initialize pointer
    command.treq_timeout = 0x0000;              // initialize union variable (integer element)

    do                                          // loop until HCS515 responds
    {                                           // or until ~35 seconds expires
        Delay_1mS( 2 );                         // intervals of 2mS delay
        Delay_20uS( 20 );                       // plus
        command.treq_timeout++;                 // increment response wait timer

        if ( HCSDATA2 == 1 )                    // has HCS515 responded ?
        {
            command.treq_timeout = TREQ +1;     // if so then set timeout expiration
        }
    } while ( command.treq_timeout <= TREQ );

    Home_Clr();                                 // clear lcd and set to line1 / position 1
    if ( HCSDATA2 == 0 )                        // is data line still low?
    {                                           // transmission has not been detected 35 sec.
        return ( TREQ_ERR );                    // return with error code
    }

// At this point the first of two learn transmissions has been received
    Delay_100mS( 1 );                           // delay of 100mS delay

    if ( HCSDATA2 != 0 )                        // data line should be lo at this pointw
    {
        return ( TREQ_ERR );                    // else, return with error code
    }

    command.treq_timeout = 0x0000;              // initialize union variable (integer element)

    printf("1st trans. rcv'd" );                // format message for LCD
    Line_2();                                   // position lcd cursor on line2 / position 1
    printf("30 seconds left " );                // format message for LCD

// wait here for second transmission
    do                                          // loop until HCS515 responds
    {                                           // or until ~30sec expires
        Delay_1mS( 1 );                         // intervals of 1.3mS delay
        Delay_20uS( 20 );                       // plus more
        command.treq_timeout++;                 // increment response wait timer

        if ( HCSDATA2 == 1 )                    // has HCS515 responded ?
        {
            command.treq_timeout = TREQ +1;     // if so then set timeout expiration
        }
    } while ( command.treq_timeout <= TREQ );

    Home_Clr();                                 // clear lcd and set to line1 / position 1
    if ( HCSDATA2 == 0 )                        // is data line still low?
    {
        return ( TREQ_ERR );                    // return with error code
    }

// At this point the second and final learn transmission has been received by the HCS515
    command.tack_timeout = 0x00;                // initialize union variable (char element)
    Delay_20uS( 4 );                            // Tcla wait period (spec - 50ouS min)
    HCSCLK2 = 1;                                // assert clock, send acknowledge to HCS515

    do                                          // loop until HCS515 responds
    {                                           // or until wait time expires
        Delay_5uS();
        command.tack_timeout++;                 // increment response wait timer

        if ( HCSDATA2 == 0 )                    // has HCS515 responded ?
        {
            command.tack_timeout = TACK +1;     // if so then set timeout expiration
        }
    } while ( command.tack_timeout <= TACK );

    if ( HCSDATA2 == 1 )                        // is data line still high?
    {
        return ( TACK_ERR );                    // return with error code
    }

    Delay_20uS( 2 );                            // ~42uS ( Tclh )
    HCSCLK2 = 0;                                // negate clock
    Delay_20uS( 2 );                            // ~42uS ( Tcll )
    TRISDATA2 = 1;                              // set data pin direction

// Read x number of bytes from the second transmission ( up to 10 )
    while ( length )
    {
```

```
        command.bit_counter = 8;              // initialize bit counter
        do
        {
            HCSCLK2 = 1;                      // set clock high
            NOP();                            // add in .5uS delay
            Delay_20uS( 1 );                  // ~22uS delay
            HCSCLK2 = 0;                      // set clock low ( data sampled on falling edge )

            temp_buffer >> = 1;               // rotate towards LSB position
            if ( HCSDATA2 )                   // test if carry bit set
            {
                temp_buffer |= 0x80;          // set bit 7 to logic 1
            }
            Delay_20uS( 1 );                  // ~22uS delay

        } while ( --command.bit_counter );    // decrement counter and test if complete

        *lrn_ptr++ = temp_buffer;             // save off learn status message and update pointer
        length --;                            // decrement byte counter
    }

    return ( NO_ERROR );                      // return with no read error
}



char Learn( void )
{
    flag1.learn_entered = 0;                  // reset learn entered flag

    temp = Command_Mode( ACTIVE_LRN, DUMMY, DUMMY ); // initiate command mode
    if ( temp != 0 )
    {
        return ( temp );                      // return with error code
    }

// At this point Command Mode for Learn has been sent to HCS515, wait for acknowledge
// HCS515 should respond within 20uS (max) after clock line is asserted
    TRISDATA2 = 1;                            // ensure data direction pin state is input
    Delay_20uS( 2 );                          // wait for ~ 40uS (Tlrn-20uS(min) Tlrn )
    HCSCLK2 = 1;                              // set clock high, begin TACK period

    command.tack_timeout = 0x00;              // initialize variable
    do                                        // loop until HCS515 responds with
    {                                         // data line high or until time expires
                                              // loop time ~8uS (total: 5*8us= 40uS)
        command.tack_timeout++;               // increment timeout counter

        if ( HCSDATA2 == 1 )                  // has HCS515 responded and entered learn mode ?
        {
            command.tack_timeout = TACK_LRN +1;// if so then set timeout expiration
        }
    } while ( ( !HCSDATA2 ) && ( command.tack_timeout <= TACK_LRN ) );

    if ( !HCSDATA2 )                          // is DATA line still low after TACK
    {
        return ( TACK_LRN_ERR );              // return with error code
    }

    Delay_20uS( 1 );                          // ~22uS delay (Tresp spec 20-1000uS)
    HCSCLK2 = 0;                              // set clock low
    Delay_20uS( 1 );                          // ~22uS delay (TACK2 spec 10uS max)

    flag1.learn_entered = 1;                  // set flag learn entered mode
    return ( NO_ERROR );                      // return with no error condition
}



char Erase_All( void )
{
    flag1.erase_all = 0;                      // reset flag for erase all status

    temp = Command_Mode( ERASE_ALL, SUBCOM0, DUMMY ); // initiate command mode
    if ( temp != 0 )
    {
        return ( temp );                      // return with error code
    }

    TRISDATA2 = 1;                            // ensure data direction pin state is input
    Delay_20uS( 2 );                          // wait for ~ 42uS( Tera time )
    HCSCLK2 = 1;                              // set clock high, begin TACK period
```

```
    command.tack_timeout = 0x00;             // initialize variable
    do                                       // loop until HCS515 responds with
    {                                        // driving data line high or until time expires
        Delay_20uS( 46 );                    // wait ~900uS per loop (spec - 210mS max)
        command.tack_timeout++;              // increment timeout counter

        if ( HCSDATA2 == 1 )                 // has HCS515 finished erasing xmtrs ?
        {
            command.tack_timeout = TACK_ERASE +1; // if so then set timeout expiration
        }
    } while ( ( !HCSDATA2 ) && ( command.tack_timeout <= TACK_ERASE ) );

    if ( !HCSDATA2 )                         // is DATA line still low after TACK (max)
    {
        return ( TACK_ERASE_ERR );           // return with error code
    }

    Delay_20uS( 1 );                         // ~22uS delay (Tresp)
    HCSCLK2 = 0;                             // set clock low
    Delay_20uS( 1 );                         // ~22uS delay (TACK2 wait)

    flag1.erase_all = 1;                     // set flag to indicate all xmtrs have been erased
    return ( NO_ERROR );                     // return with no error condition
}


char Read_User_EE2( char address, char * rdptr, char length )
{
    temp = Command_Mode( READ, address, DUMMY ); // initiate command mode
    if ( temp != 0 )
    {
        return ( temp );                     // return with error code
    }

    Delay_20uS( 50 );                        // Trd time period (1000 - 2000uS)
    TRISDATA2 = 1;                           // ensure data direction pin state is input

    while ( length )                         // test byte read counter is zero
    {
        command.bit_counter = 8;             // initialize bit counter
        do
        {
            HCSCLK2 = 1;                     // set clock high
            NOP();                           // add in .5uS delay
            Delay_20uS( 1 );                 // ~22uS delay
            HCSCLK2 = 0;                     // set clock low ( data sampled on falling edge )

            temp_buffer >> = 1;              // rotate towards LSB position
            if ( HCSDATA2 )                  // test if carry bit set
            {
                temp_buffer |= 0x80;         // set bit 7 to logic 1
            }
            Delay_20uS( 1 );                 // ~22uS delay

        } while ( --command.bit_counter );   // decrement counter and test if complete

    *rdptr++ = temp_buffer;                  // save off read byte and update pointer

    Delay_20uS( 50 );                        // Trd time period (1000 - 2000uS)
    length --;                               // decrement read counter
    }

    HCSDATA2 = 0;                            // ensure data line is set low
    TRISDATA2 = 1;                           // ensure direction of pin is input
    return ( NO_ERROR );                     // return with no error
}


char Write_User_EE2( char address, char * wrptr, char length )
{
    temp = Command_Mode( WRITE, address, WRITE ); // initiate command mode
    if ( temp != 0 )
    {
        return ( temp );                     // return with error code
    }

    while ( length )                         // test for end of string (null character)
    {
        TRISDATA2 = 0;                       // ensure data direction pin state is output
        command.bit_counter = 8;             // initialize bit counter
        temp_buffer = *wrptr;                // assign data to temp_buffer
```

```
        do
        {
            temp_buffer >> = 1;              // rotate LSB into carry
            if ( CARRY )                     // test if carry bit set
            {
                HCSDATA2 = 1;                // set data line high
            }
            else
            }
                HCSDATA2 = 0;                // set data line low
            }

            HCSCLK2 = 1;                     // set clock high
            Delay_20uS( 1 );                 // ~22uS delay
            HCSCLK2 = 0;                     // set clock low ( data sampled on falling edge )
            Delay_20uS( 1 );                 // ~22uS delay ( also provides for required Tds )

        } while ( --command.bit_counter );   // decrement counter and test if complete

        Delay_20uS( 1 );                     // wait for ~ 20uS (spec -20uS min  -Twr)
        HCSDATA2 = 0;                        // set data line low
        Delay_20uS( 1 );                     // wait for ~ 20uS
        TRISDATA2 = 1;                       // set pin direction for input
        HCSCLK2 = 1;                         // set clock high, begin TACK period

        Delay_1mS( 3 );                      // wait here 3mS to start

        command.tack_timeout = 0x40;         // initialize variable

        do                                   // loop until HCS515 responds (1 loop = 48uS)
        {                                    // or until ~9mS expires
            Delay_20uS( 2 ) ~41uS delay
            command.tack_timeout++;          // increment timeout counter

            if ( HCSDATA2 == 1 )             // has HCS515 responded ?
            {
                command.tack_timeout = TACK_WR +1;// if so then set timeout expiration
            }
        } while ( command.tack_timeout <= TACK_WR );

        Delay_20uS( 2 );                     // ~20uS delay (Tresp)
        HCSCLK2 = 0;                         // set clock low
        Delay_20uS( 1 );                     // ~20uS delay (TACK2 wait)

    length --;                               // decrement write count
    wrptr++;                                 // increment data pointer
    }

    TRISDATA2 = 1;                           // ensure data direction pin state is input
    Delay_1mS( 1 );
    return ( NO_ERROR );                     // return with no error condition
}



char Command_Mode( char decoder_command, char cmd_byte1, char cmd_byte2 )
{
    command.treq_timeout = 0x0000;           // initialize union variable (integer element)

    TRISDATA2 = 1;                           // ensure data direction pin state is input
    HCSCLK2 = 1;                             // set clock high to initiate command
    TRISCLK2 = 0;                            // ensure data direction pin state is output

    do                                       // loop until HCS515 responds (1 loop = 33uS)
    {                                        // or until ~500mS expires (total loop 660mS)
        Delay_20uS( 1 );                     // ~24uS delay
        command.treq_timeout++;              // increment response wait timer

        if ( HCSDATA2 == 1 )                 // has HCS515 responded ?
        {
            command.treq_timeout = TREQ +1;  // if so then set timeout expiration
        }
    } while ( command.treq_timeout <= TREQ );

    if ( HCSDATA2 == 0 )                     // is data line still low?
    {
        return ( TREQ_ERR );                 // return with error code
    }

// At this point the HCS515 has responded by asserting data line high
// so bring the clock low
    Delay_20uS( 2 );                         // (Tresp, spec-20uS(min)) ~42uS delay
    HCSCLK2 = 0;                             // bring clock low, ack to decoder
```

```
// At this point, HCS515 has acknowledged PICmicro by negating data line (low)
    Delay_20uS( 2 );                        // Tstart (20uS min) ~ 41.50uS delay
    TRISDATA2 = 0;                          // ensure data direction pin state is output

    command.bit_counter = 8;                // initialize bit counter
    temp_buffer = decoder_command;          // assign command to temp_buffer
    do
    {
        temp_buffer >> = 1;                 // rotate LSB into carry
        if ( CARRY )                        // test if carry bit set
        {
            HCSDATA2 = 1;                   // set data line high
        }
        else
        {
            HCSDATA2 = 0;                   // set data line low
        }

        HCSCLK2 = 1;                        // set clock high
        Delay_20uS( 1 );                    // ~23.5uS delay
        HCSCLK2 = 0;                        // set clock low( data sampled on falling edge )
        Delay_20uS( 1 );                    // ~23.5uS delay (also provides for required Tds)

    } while ( --command.bit_counter );      // decrement counter and test if complete


    command.bit_counter = 8;                // initialize bit counter
    temp_buffer = cmd_byte1;                // 1st byte after command byte to temp_buffer
    do
    {
        temp_buffer >> = 1;                 // rotate LSB into carry
        if ( CARRY )                        // test if carry bit set
        {
            HCSDATA2 = 1;                   // set data line high
        }
        else
        {
            HCSDATA2 = 0;                   // set data line low
        }

        HCSCLK2 = 1;                        // set clock high
        Delay_20uS( 1 );                    // ~20uS delay
        HCSCLK2 = 0;                        // set clock low ( data sampled on falling edge )
        Delay_20uS( 1 );                    // ~20uS delay ( also provides for required Tds)

    } while ( --command.bit_counter );      // decrement counter and test if complete

    if ( cmd_byte2 == WRITE )               // test if Write EE is using command mode function
    {
        return ( NO_ERROR );
    }

    command.bit_counter = 8;                // initialize bit counter
    temp_buffer = cmd_byte2;                // 2nd byte after command byte to temp_buffer
    do
    {
        temp_buffer >> = 1;                 // rotate LSB into carry
        if ( CARRY )    // test if carry bit set
        {
            HCSDATA2 = 1;                   // set data line high
        }
        else
        {
            HCSDATA2 = 0;                   // set data line low
        }

        HCSCLK2 = 1;                        // set clock high
        Delay_20uS( 1 );                    // ~20uS delay
        HCSCLK2 = 0;                        // set clock low( data sampled on falling edge )
        Delay_20uS( 1 );                    // ~20uS delay ( also provides for required Tds)

    } while ( --command.bit_counter );      // decrement counter and test if complete

    return ( NO_ERROR );                    // return with no error
}
```

```
/*********************************************************************
*                                                                    *
*   Filename:       hcsdec.h                                         *
*   Date:           07/18/99                                         *
*   File Version:   1.00                                             *
*                                                                    *
*   Compiler:       Hi-Tech PIC C Compiler V7.83 PL3                 *
*                                                                    *
*********************************************************************/



// FUNCTION PROTOTYPES

/* Functions defined in file hcsdec.c */
char Learn( void );                         // reference linkage to defined function
void Read_Trans( char length );
char Erase_All( void );
char Read_User_EE2( char address, char * rdptr, char length );
char Write_User_EE2( char address, char * wrptr, char length );
char Command_Mode( char decoder_command, char cmd_byte1, char cmd_byte2 );

/* Functions defined in file baselcd.c */
extern void Home_Clr( void );               // reference linkage to defined function
extern void Line_2( void );

/* Functions defined in file delays.c */
extern void Delay_5uS( void );              // reference linkage to defined function
extern void Delay_20uS( char loop_count );
extern void Delay_1mS( char loop_count );
extern void Delay_100mS( char loop_count );
extern void Delay_10mS( char loop_count );



// VARIABLES ( REFERENCE DECLARATION )

extern struct event_bits1                   // bit structure for housekeeping flags
      {
        unsigned new_day         :1;        // flag for indicating new day
        unsigned arm_countdown   :1;        // flag set when counting down to arming system
        unsigned buzzer          :1;        // flag set when piezo buzzer will sound when called
        unsigned read_battery    :1;        // flag used for read battery voltage
        unsigned battery_on      :1;        // flag set when battery source is selected
        unsigned battery_off     :1;        // flag set when battery is not selected
        unsigned time_update     :1;        // flag used for updating LCD and E2 Memory
        unsigned erase_all       :1;        // flag set when HCS515 erase all operation complete
        unsigned battery_sel     :1;        // flag set when battery source is selected
        unsigned erase_entered   :1;        // flag set when HCS515 erase all operation entered
        unsigned arm_now         :1;        // flag set when system is immediately armed w/o user
                                            // code
        unsigned learn_entered   :1;        // flag set when HCS515 learn operation entered
        unsigned code_valid      :1;        // flag set after user security access code accepted
        unsigned code_entered    :1;        // flag set when user security access code entered
        unsigned keyread         :1;        // flag set for indicating keypad selection needs
                                            // processed
        unsigned keyhit          :1;        // flag set when valid key hit on 4x4 keypad is
                                            // detected
    } flag1;                                // variable name

extern struct event_bits2                   // define bit structure for housekeeping flags
    {
        unsigned                 :1;        // bit padding
        unsigned alarm_set1      :1;        // flag set when system is armed ( 1 of 2 )
        unsigned                 :6;        // bit padding
        unsigned valid_rcv       :1;        // flag used if HCS515 demod data is correct
        unsigned sensor_batt_low:1;         // flag indicating if sensor module battery is low
        unsigned                 :5;        // bit padding
        unsigned alarm_set2      :1;        // flag set when system is armed ( 2 of 2 )
    } flag2;                                // variable name


extern bank1 char temp;// reference linkage to defined variable



// VARIABLES ( DEFINED HERE )

bank1 char * bank1 lrn_ptr;                 // define pointer
bank1 char decoder1[10];                    // array storage for valid trans.
                                            // reception (decoder 1)
bank1 char decoder2[10];                    // array storage for valid trans.
                                            // reception (decoder 2)
```

```
bank1 char decoder1_ee[6];                  // array for reading/writing to HCS515 EE
bank1 char decoder2_ee[6];                  // array for reading/writing to HCS515 EE

bank1 char temp_buffer;                     // temp buffer for writing/reading data ( HCS515 )

bank1 union notify {
       unsigned int treq_timeout;           // integer element
       unsigned int tack_wr_timeout;        // integer element
       unsigned char tresp_timeout;         // char element
       unsigned char tack_timeout;          // char element
       unsigned char bit_counter;           // char element
} command;                                  // variable defined


// PORTBITS ( DEFINED HERE )

#define PortBit(port,bit)    ((unsigned)&(port)*8+(bit))

static bit HCSDATA1   @  PortBit(PORTC,6);   // declare bit for HCS515 data line
static bit HCSDATA2   @  PortBit(PORTC,5);   // declare bit for HCS515 data line
static bit HCSCLK1    @  PortBit(PORTC,7);   // declare bit for HCS515 clock line
static bit HCSCLK2    @  PortBit(PORTC,4);   // declare bit for HCS515 clock line

static bit TRISDATA1  @  PortBit(TRISC,6);   // declare bit for HCS515 data pin direction
static bit TRISDATA2  @  PortBit(TRISC,5);   // declare bit for HCS515 data pin direction
static bit TRISCLK1   @  PortBit(TRISC,7);   // declare bit for HCS515 clock pin direction
static bit TRISCLK2   @  PortBit(TRISC,4);   // declare bit for HCS515 clock pin direction


// MACROS DEFINED HERE

#defineNOP()asm(“ nop”)                     // define NOP macro


// DEFINE HCS515 DECODER COMMANDS

#define READ        0xF0                    // Read a byte from the user
#define WRITE       0xE1                    // Write a byte to the user
#define ACTIVE_LRN  0xD2                    // Activate a learn sequence
#define ERASE_ALL   0xC3                    // Activate an erase all
#define SUBCOM0     0x00                    // Erase all Subcommand byte
#define SUBCOM1     0x01                    // Erase all Subcommand byte


#define TREQ         20000                  //
#define TACK  50                            //
#define TACK_WR        240
#define TACK_LRN         5                  // timeout constant for Learn (Tack)
#define TACK_ERASE     250

#define NO_ERROR         0
#define TREQ_ERR         1
#define TACK_ERR         2
#define TACK_WR_ERR      4
#define TACK_LRN_ERR    10
#define TACK_ERASE_ERR  20

#define DUMMY         0x81
```

```
/*********************************************************************
*                                                                    *
*   Wireless Home Security with Keeloq and the PICmicro              *
*                                                                    *
*********************************************************************
*                                                                    *
*   Filename:       init.c                                           *
*   Date:           07/18/99                                         *
*   File Version:   1.00                                             *
*                                                                    *
*   Compiler:       Hi-Tech PIC C Compiler V7.83 PL3                 *
*                                                                    *
*   Author:         Richard L. Fischer                               *
*   Company:        Microchip Technology Incorporated                *
*                                                                    *
*********************************************************************
*                                                                    *
*   Files required:                                                  *
*                                                                    *
*                   pic.h                                            *
*                                                                    *
*********************************************************************
*                                                                    *
*   Notes: The routines within this file are required for            *
*          initializing PICmicro peripherals and the HCS515 EE.      *
*                                                                    *
*                                                                    *
*********************************************************************/

    #include <pic.h>                        // processor if/def file


extern char Write_User_EE2( char address, char * wrptr, char length );
extern const char zone_name_address[];      // 89,90,97,9E,A5,AC,B3
extern bank1 char decoder2_ee[6];
extern bank1 char temp;



void Init_Adc( void )
{
    ADCON1 = 0b101;                         // RA0/RA1 analog, RA3 Vref
    ADCON0 = 0b10000000;                    // Tosc32, channel 0
}


void Init_Pwm( void )
{
    PR2 = 122;                              // set for frequency of ~4KHz
    CCPR1L = 40;                            // duty cycle ~33%
    T2CON = 0b00000001;                     // set TMR2 prescale for 4
    TMR2ON = 1;                             // turn on TMR2
}


void Init_Timer1( void )
{
    TMR1CS = 1;                             // Timer1 clock select, external
    T1OSCEN = 1;                            // enable Timer1 oscillator mode
    TMR1L = 0x00;
    TMR1H = 0x80;                           // initialize timer1
    TMR1IF = 0;                             // reset Timer1 overflow flag
    TMR1IE = 1;                             // enable TMR1 Overflow interrupt
    TMR1ON = 1;                             // turn on Timer1 module
}


void Init_Timer0( void )
{
    OPTION = 0b11010111;                    // set Timer0 for 1:256, internal clock
    TMR0 = 0x00;                            // set Timer0 for initial state
    T0IF = 0;                               // reset Timer0 overflow flag
    T0IE = 1;                               // enable Timer0 Overflow interrupt
}


void Init_Portb( void )
{
    PORTB = 0b11110000;                     // PortB setup
    TRISB = 0b11110000;                     // RB7-RB4 inputs, RB3-RB0 outputs
    PORTB;                                  // dummy read of PortB
    RBIF = 0;                               // reset flag
```

```
    RBIE = 1;                               // set PortB interrupt on change
}


void Init_EE_Memory( void )
{
    char index = 0;                         // define auto type variable
    decoder2_ee[0] = 0x00;                  // set array element to known state
    decoder2_ee[1] = 0x00;                  // set array element to known state
    decoder2_ee[2] = 0x00;                  // set array element to known state
    decoder2_ee[3] = 0x00;                  // set array element to known state

    do
    {
        temp = Write_User_EE2( ( ( zone_name_address[index] ) + 1 ), &decoder2_ee[0], 4 );
        index++;
    } while ( index < 7 );
}
```

```
/*********************************************************************
*                                                                    *
*   Wireless Home Security with Keeloq and the PICmicro              *
*                                                                    *
*********************************************************************
*                                                                    *
*   Filename:       prockey.c                                        *
*   Date:           07/18/99                                         *
*   File Version:   1.00                                             *
*                                                                    *
*   Compiler:       Hi-Tech PIC C Compiler V7.83 PL3                 *
*                                                                    *
*   Author:         Richard L. Fischer                               *
*   Company:        Microchip Technology Incorporated                *
*                                                                    *
*********************************************************************
*                                                                    *
*   Files required:                                                  *
*                                                                    *
*                   pic.h                                            *
*                   stdio.h                                          *
*                   string.h                                         *
*                   prockey.h                                        *
*                   hcs515ee.h                                       *
*                                                                    *
*********************************************************************
*                                                                    *
*   Notes: The routines within this file are required for            *
*          processing the 4x4 keypad selections.                     *
*                                                                    *
*   This file generates ~ 650 words of code. If additional           *
*   requirements are required, the file may need to be reduced into  *
*   4 smaller separate nodes.                                        *
*                                                                    *
*   Possible: 1 node for PANIC Key                                   *
*             1 node for ALTnerate Key                               *
*             1 node for AUXiliary Key                               *
*             1 node for ESCape Key                                  *
*                                                                    *
*   It is also noted here that there are many tasks generated        *
*   within this file which include user menus. The menus can be      *
*   reduced or removed and still retain system functionality         *
*   and operation. This approach would also reduce the overall       *
*   code size of this node. However, the menus do help with user     *
*   interaction.                                                     *
*                                                                    *
*********************************************************************/

    #include <pic.h>                          // processor if/def file
    #include <stdio.h>
    #include <string.h>
    #include “prockey.h”                      // function prototypes, variables, defines..
    #include “hcs515ee.h”



void Process_Key( void )
{
    int i;                                    // define auto type integer variable

    switch ( valid_key )
    {
        case ( PANIC ):                       // if ‘PANIC’ key has been pressed

        key_wait = 0x00;                      // reset key wait timer
        while ( ( valid_key != ESC ) && ( key_wait < key_wait_limit ) )
        {
            if ( valid_key == ‘*’ )           // labled ‘*’  on keypad
            {
/* Arm System here w/o entry of User Code and w/o “ARM” time delay */
               flag2.alarm_set1= 1;           // set alarm state entry flag1
               ARMRDY = 0;                    // turn on base panel ARMED LED
               Home_It();                     // set lcd cursor to line1/position 1
               printf(“  System Armed  “);    // format message for LCD
               flag2.alarm_set2= 1;           // set alarm state entry flag2
               flag1.arm_now = 1;             // set immediate alarm entry flag true
               key_wait = SEC4 + 1;           // set key wait timer to expire
               flag1.arm_countdown = 0;       // reset flag for ARMED countdown
            }
```

```
/* Arm System here with entry of User Code and enable “ARM” time delay */
          else if ( ( valid_key ==  ‘#’ )  &&  ( !flag1.arm_now ) )
          {
              codestring[4] = 0x00;         // initialize variable
              csindex = 0;                  // initialize array index
              flag1.keyread = 0;            // reset key read flag

              Home_Clr();                   // clear lcd and set cursor to line1/position 1
              printf( “To Arm... Enter” );  // format message for LCD
              Line_2();                     // set lcd cursor to line2/position 1
              printf( “User Code-> “ );     // format message for LCD

              Code_Select();                // function for entering Master/User code

              temp = Read_User_EE2( USER_CODE, &tempstring[0], 4 ); // read User Code from EE

              Home_Clr();                    // clear lcd and set cursor to line1/position 1
              if ( ( i = strcmp( codestring, tempstring ) )  < 0  )
              {
              flag1.code_valid = 0;         // flag set false, invalid Master Code entered
              }
          else if ( i > 0 )
              {
              flag1.code_valid = 0;         // flag set false, invalid Master Code entered
              }
          else
              {
              printf(“Armed Countdown!”);   // format message for LCD
              Sound_Piezo( 1 );             // 100ms enable of internal piezo
              flag1.code_valid = 1;         // flag set true, valid master code entered
              flag1.arm_countdown = 1;      // set flag to indicate ARM countdown state
              time_to_arm = 6;              // set time to arm for ~ 6 minutes
          }

          if ( !flag1.code_valid )          // test if there was a Invalid Master Code entry
          {
              printf( “* Invalid User *” ); // format message for LCD
              Line_2();                     // set lcd cursor to line2/position 1
              printf( “* Code Entered *” ); // format message for LCD
              Sound_Piezo( 1 );             // 100ms enable of internal piezo
              Delay_100mS( 1 );             // short delay
              Sound_Piezo( 1 );             // 100ms enable of internal piezo
              Delay_100mS( 6 ) ;            // short delay for user to view LCD message
              Home_Clr();                   // clear lcd and set cursor to line1/position 1
          }
      }

      else if ( valid_key ==  ‘1’ )         // labled 1 on keypad
      {
          flag1.buzzer = 1;                 // set flag so piezo buzzer will sound
          key_wait = SEC4 + 1;              // set key wait timer to expire
      }
  }
  break;


  case ( ALT ):                             // if ‘ALTernate’ key has been pressed

  key_wait = 0x00;// reset key wait timer
  while ( ( valid_key != ESC ) && ( key_wait < key_wait_limit ) )
  {
      if ( valid_key == TEST )              // TEST == 5 on keypad (labeled TEST)
      {
          Home_Clr();                       // clear lcd and set cursor to line1/position 1
          printf( “Battery.. Sel[1]” );     // format message for LCD
          Line_2();                         // set lcd cursor to line2/position 1
          printf( “Vdc[2],  Time[3]” );     // format message for LCD

          key_wait = 0x00;                  // reset key wait timer
          while ( ( valid_key != ESC ) && ( key_wait < key_wait_limit ) )
          {
              if ( valid_key == ‘1’ )       // is battery select option chosen?
              {
                if ( LCDBD )                // test if backlight is on
                {
                  BATSEL ^= 1;              // toggle battery backup select
                  flag1.battery_sel ^= 1;   // set flag indicating battery is selected
              }
              key_wait = SEC4 + 1;          // set key wait timer to expire
          }
```

```
        else if ( valid_key == '2' )      // is battery voltage option chosen?
        {
            while ( valid_key != ESC )    // stay in loop until ESCape key is pressed
            {
                Home_It();                // set lcd cursor to line1/position 1
                if ( !PSOURCE )           // test if primary power is on
                {
                    Battery_Voltage();    // perform conversion on ADC channel 0
                    printf("Battery Voltage:" ); // format message for LCD
                    Line_2();             // set lcd cursor to line2/position 1
                    printf("   %.3f Vdc   ", battery_volts ); // format message for LCD
                }
                else                      // primary is not on
                {
                    printf(" Battery Source " ); // format message for LCD
                    Line_2();             // set lcd cursor to line2/position 1
                    printf("  is selected   " ); // format message for LCD
                }
                Delay_100mS( 1 );         // ~100 mS delay
            }
        }

        else if ( valid_key == '3' )      // display recorded battery on time
        {
            Home_Clr();                   // clear lcd and set cursor to line1/position 1
            temp = Read_User_EE2( BT_ON_HRS, &decoder2_ee[0], 6 ); // read recorded time of
                                          // battery on
            printf( "on:  -> %02u:%02u:%02u " , decoder2_ee[0],decoder2_ee[1],decoder2_ee[2] );
            Line_2();                     // set lcd cursor to line2/position 1
            printf( "off:--> %02u:%02u:%02u" , decoder2_ee[3],decoder2_ee[4],decoder2_ee[5] );
            valid_key = 0x20;             // reset key
            while ( valid_key != ESC );   // stay in loop until ESCape key is pressed
            Home_Clr();                   // clear lcd and set cursor to line1/position 1
            printf( "Battery daily  " );  // format message for LCD
            Line_2();                     // set lcd cursor to line2/position 1
            temp = Read_User_EE2( BT_ON_CNT, &decoder2_ee[0], 1 ); // read daily battery cycle
                                          // count

            printf( "cycle count= %02u" , decoder2_ee[0] ); // format message for LCD
            valid_key = 0x20;             // reset key
            while ( valid_key != ESC );   // stay in loop until ESCape key is pressed
        }
    }
}

else if ( valid_key == ALARM_STATUS )     // ALARM_STATUS == 7 on keypad (labeled INSTANT)
{
    Home_It();                            // set lcd cursor to line1/position 1
    temp = Read_User_EE2( ALRM_HRS, &decoder2_ee[0], 4 ); // read alarm status and time info

    if ( decoder2_ee[3] == CLEAR )
    {
        printf( " No Zone Fault! " );     // format message for LCD
    }

    else if ( decoder2_ee[3] == ALRM )
    {
        printf( "Fault:  %02u:%02u:%02u", decoder2_ee[0],decoder2_ee[1],decoder2_ee[2] );
        temp = ( decoder2[1] - 1 ) & 0x0F;
        temp = Read_User_EE2( zone_name_address[temp], &decoder2_ee[0], 1 );// read zone name
        Line_2();                         // set lcd cursor to line2/position 1
        ptr = &room_name[decoder2_ee[0]][0];// pointer initialization
        printf("%s", ptr );               // format message for LCD
    }

    else
    {
          printf( "Error Condition " ); // format message for LCD
    }

    while ( valid_key != ESC );           // stay here until ESCape key is pressed
}

else if ( valid_key == BYPASS )           // BYPASS == 6 on keypad (labeled INSTANT)
{
    Home_Clr();                           // clear lcd and set cursor to line1/position 1
    printf("Lrn'd Xmtr's[1]");            // format message for LCD
    Line_2();                             // set lcd cursor to line2/position 1
    printf("Battery Stat[2]");            // format message for LCD

    key_wait = 0x00;                      // reset key wait timer
    while ( ( valid_key != ESC ) && ( key_wait < key_wait_limit ) )
    {
```

```
            if ( valid_key == '1' )
            {
                temp = Read_User_EE2( XMTR_CNT, &decoder2_ee[0], 1 );
                                        // read # of Xmtrs learned to EE
                Home_Clr();// clear lcd and set cursor to line1/position 1
                printf("Number of Xmtr's");   // format message for LCD
                Line_2();               // set lcd cursor to line2/position 1
                printf(" Learned-> %u", decoder2_ee[0]); // format message for LCD
                while ( valid_key !=  ESC );  // stay here until ESCape key is pressed
            }
            else if ( valid_key == '2' )
            {
                char index = 0x00;
                while ( valid_key != ESC )    // loop until ESCape key is pressed
                {
                    temp = Read_User_EE2( zone_name_address[index], &decoder2_ee[0], 5 ); // read
                    Home_It();              // set lcd cursor to line1/position 1
                    printf("Zone%u-> %02u:%02u:%02u", index+1, decoder2_ee[1], decoder2_ee[2],
                                            decoder2_ee[3] );
                    Line_2();               // set lcd cursor to line2/position 1
                    if ( decoder2_ee[4] == 0xAA )// test if battery state is Okay
                    {
                      printf("Battery Vdc:Okay" ); // format message for LCD
                    }
                    if ( decoder2_ee[4] == 0x55 )// test if battery state is Low
                    {
                      printf("Battery Vdc:Low " );// format message for LCD
                    }
                    else                    // else batteyr state not reported
                    {
                      printf("Battery Vdc:??? " ); // format message for LCD
                    }
                    index ++;               // increment zone name index
                    if ( index > 6 )        // test for more than 7 (0-6) zones
                    {
                      index = 0x00;         // increment zone name index
                    }
                    Delay_100mS( 1 );       // short delay
                    valid_key = 0x20;       // reset valid_key contents
                    while ( ( valid_key !=  '#' )  &&  ( valid_key !=  ESC ) );
                }

                temp = Read_User_EE2( LAST_XMIT, &decoder2_ee[0], 1 );
                Home_Clr();                 // clear lcd and set cursor to line1/position 1
                printf(" Last Reception " );  // format message for LCD
                Line_2();                   // set lcd cursor to line2/position 1
                if ( decoder2_ee[0] == ALRM )// test for Alarm transmission
                {
                    printf(" was an Alarm!  " ); // format message for LCD
                }
                if ( decoder2_ee[0] == CLEAR )// test for non-Alarm tranmsission
                {
                    printf(" was a non-Alarm" ); // format message for LCD
                }
                if ( decoder2_ee[0] == TST_LRN )// test for Learn/Test tranmsission
                {
                    printf("was a Test/Learn" );// format message for LCD
                }
                if ( decoder2_ee[0] == OKAY ) // test for 1.5 hour cycle transmission
                {
                    printf("was a Sensor OK " ); // format message for LCD
                }
                valid_key = 0x20;           // reset valid key contents
                while ( valid_key !=  ESC  ); // stay here until ESCape key is pressed
            }
        }
    }
}
Home_Clr();                             // clear lcd and set cursor to line1/position 1
break;


case ( AUX ):                           // if 'AUXiliary' key has been pressed

key_wait = 0x00;                        // reset key wait timer
while ( ( valid_key != ESC ) && ( key_wait < key_wait_limit ) )
{
       if ( valid_key == CHIME )  // CHIME == 9 on panel
       {
           Home_Clr();                  // clear lcd and set cursor to line1/position 1
           printf( "Enter key wait.." );     // format message for LCD
           Line_2();                    // set lcd cursor to line2/position 1
           printf( "[1]2Sec  [2]4ec " );     // format message for LCD
```

```
            key_wait = 0x00;                // reset key wait timer
            while ( ( valid_key != ESC ) && ( key_wait < key_wait_limit ) )
            {
                switch ( valid_key )
                {
                    case ( '1' ):
                      key_wait_limit = SEC2;
                      key_wait = SEC4 + 1;    // set key wait timer to expire
                      break;
                    case ( '2' ):
                      key_wait_limit = SEC4;
                      key_wait = SEC4 + 1;    // set key wait timer to expire
                      break;
                      default:
                        break;
                    }
                }
                Home_Clr();// clear lcd and set cursor to line1/position 1
            }

            else if ( valid_key == CODE )     // CODE == 8 on keypad
            {
                codestring[4] = 0x00;         // initialize variable
                csindex = 0;                  // define and initialize auto variable
                flag1.keyread = 0;            // reset key read flag

                Home_Clr();                   // clear lcd and set cursor to line1/position 1
                printf( " Enter 4-digit  " ); // format message for LCD
                Line_2();                     // set lcd cursor to line2/position 1
                printf( " Master Code..  " ); // format message for LCD

                Delay_100mS( 11 ) ;           // short delay for user to view LCD message
                Home_Clr();                   // clear lcd and set cursor to line1/position 1
                printf( "Mstr Code-> " );     // format message for LCD

                Code_Select();                // function for entering Master/User code
                codestring[0] &= 0x0F;        //
                codestring[1] &= 0x0F;        //
                codestring[2] &= 0x0F;        //
                codestring[3] &= 0x0F;        //

/* At this point the 4-digit Master code may have been entered? */

                Home_Clr();                   // clear lcd and set cursor to line1/position 1
                if ( ( i = strcmp( codestring, master_code ) ) < 0 )
                {
                    flag1.code_valid = 0;     // flag set false, invalid master code entered
                }
                else if ( i > 0 )
                {
                    flag1.code_valid = 0;     // flag set false, invalid master code entered
                }
                else
                {
                    printf( "Valid Mastr Code" ); // format message for LCD
                    flag1.code_valid = 1;     // flag true if valid master code entered
                    Sound_Piezo( 1 );         // 100ms enable of internal piezo
                    Delay_100mS( 1 );         // short delay
                    Sound_Piezo( 1 );         // 100ms enable of internal piezo
                }

                if ( !flag1.code_valid )      // test if there was a Invalid Master Code entry
                {
                    printf( "* Wrong Master *" ); // format message for LCD
                    Line_2();                 // set lcd cursor to line2/position 1
                    printf( "* Code Entered *" ); // format message for LCD
                    Sound_Piezo( 1 );         // 100ms enable of internal piezo
                    Delay_100mS( 10 ) ;       // short delay for user to view LCD message
                    valid_key = ESC;          // ste valid_key for EScape key
                }

                else if ( flag1.code_valid )  // else test if there was a Valid Master Code entry
                {
                    Delay_100mS( 11 ) ;       // short delay for user to view LCD message
                    codestring[4] = 0x00;     // initialize variable
                    csindex = 0;              // define and initialize auto variable
                    valid_key = '#';          // set key entry point
                    flag1.keyread = 0;        // reset key read flag
                }

                while ( valid_key != ESC )    // stay in loop until ESCape is detected
                {
```

```
            if ( valid_key == '#' )   // test for # key detection
            {
              Home_Clr();             // clear lcd and set cursor to line1/position 1
              printf( " Enter 4-digit  " ); // format message for LCD
              Line_2();               // set lcd cursor to line2/position 1
              printf( " User Code..    " ); // format message for LCD

              Delay_100mS( 11 ) ;     // short delay for user to view LCD message
              Home_Clr();             // clear lcd and set cursor to line1/position 1
              printf( "User Code-> " );// format message for LCD

              Code_Select();          // function for entering Master/User code

              valid_key = 0x20;       // reset valid_key

              Home_Clr();             // clear lcd and set cursor to line1/position 1
              printf( "Accept Code:%s", &codestring[0] ); // format message for LCD
              Line_2();               // set lcd cursor to line2/position 1
              printf( "Yes[1] or No[2] " ); // format message for LCD

              while ( ( valid_key != ESC )  &&  ( valid_key != '#' ) )
              {
                if ( valid_key == '1' )// test if key 1 is pressed
                {
                  Home_Clr();         // clear lcd and set cursor to line1/position 1
                  printf( "  Code entered  " );// format message for LCD
                  Line_2();           // position lcd cursor on line2 / position 1
                  printf( "   Accepted!!   " );// format menu selection for LCD
                  temp = Write_User_EE2( USER_CODE, &codestring[0], 4 );// write to EE
                  Delay_100mS( 10 ) ;  // short delay for user to view LCD message
                  valid_key = ESC;
                }

                else if ( valid_key == '2' )
                {
                  Home_Clr();         // clear lcd and set cursor to line1/position 1
                  printf( "  Code entered  " );// format message for LCD
                  Line_2();           // position lcd cursor on line2 / position 1
                  printf( "  not Accepted! " );// format message for LCD
                  csindex = 0x00;     // reset code array index
                  flag1.keyread = 0;  // reset key read flag
                  Delay_100mS( 7 );   // short delay for user to view LCD message
                  valid_key = '#';    // set valid_key to stay in loop
                }
              }
            }
        }
        Home_Clr();                   // clear lcd and set cursor to line1/position 1
    }

    else if ( valid_key == TIME )        // TIME == 7 on keypad
    {
        Home_Clr();                   // clear lcd and set cursor to line1/position 1
        printf( " Toggle Time[1] " ); // format message for LCD
        Line_2();                     // set lcd cursor to line2/position 1
        printf( " or Set Time[2] " ); // format message for LCD

        key_wait = 0x00;              // reset key wait timer
        while ( ( valid_key != ESC ) && ( key_wait < key_wait_limit ) )
        {
            if ( valid_key ==  DISPLAY_TIME ) // DISPLAY_TIME == 1 on keypad
            {
              flag1.time_update ^= 1;  // toggle time on/off
              Home_Clr();             // clear lcd and set cursor to line1/position 1

              if ( flag1.time_update != 1) // LCD toggled off
              {
                Line_2();             // set lcd cursor to line2/position 1
                printf( "      " );   // format message for LCD
              }
              key_wait = SEC4 + 1;    // set key wait timer to expire
            }

            else if ( valid_key == SET_TIME ) // SET_TIME == 2 on keypad
            {
              flag1.keyread = 0;      // reset key read flag
              Set_Time();             // function to set time
              key_wait = SEC4 + 1;    // set key wait timer to expire
            }
        }
    }

    else if ( valid_key == LEARN )    // LEARN == 6 on keypad (labled BYPASS on panel)
```

```
    {
        Home_Clr();                 // clear lcd and set cursor to line1/position 1
        printf( “  Learn Mode[1] “ ); // format message for LCD
        Line_2();                   // set lcd cursor to line2/position 1
        printf( “or Erase All[2] “ ); // format message for LCD

        key_wait = 0x00;            // reset key wait timer
        while ( ( valid_key != ESC ) && ( key_wait < key_wait_limit ) )
        {
            if ( valid_key == LEARN_DEC )// LEARN_DEC == 1 on keypad
            {
              Home_Clr();           // clear lcd and set cursor to line1/position 1
              temp = Learn();       // execute decoder learn function
              if ( temp == 0 )      // chekc for no error during learn
              {
                printf(“ Learn Entered! “ ); // format message for LCD
                Line_2();           // set lcd cursor to line2/position 1
                printf(“ 35sec. timeout “ ); // format message for LCD
                Delay_100mS( 4 );   // short delay
                Sound_Piezo( 1 );   // quick toggle of internal piezo
              }
              else
              {
                printf(“Lrn Entry Error!” ); // format message for LCD
              }
              key_wait = SEC4 + 1;  // set key wait timer to expire
            }

            else if ( valid_key == ERASE )   // ERASE == 2 on keypad
            {
              Home_Clr();           // clear lcd and set cursor to line1/position 1
              temp = Erase_All();   // execute decoder erase all function
              if ( temp == 0 )      // check for no error during erase all
              {
                printf(“   Erase All    “ ); // format message for LCD
                Line_2();           // set lcd cursor to line2/position 1
                printf(“  Successful!   “ ); // format message for LCD
                Delay_100mS( 4 );   // short delay
                Sound_Piezo( 1 );   // quick toggle of internal piezo
                decoder2_ee[0] = 0x00;
                temp = Write_User_EE2( XMTR_CNT,  &decoder2_ee[0], 1 );
              }
              else
              {
                printf(“Erase Entry Err “ ); // format message for LCD
              }
              Home_Clr();           // clear lcd and set cursor to line1/position 1
              key_wait = SEC4 + 1;  // set key wait timer to expire
            }
        }
    }
}
break;


case ( ESC ):

    key_wait = 0x00;                // reset key wait timer
    valid_key = 0x00;               // reset valid key contents
    while ( ( valid_key != ESC ) && ( key_wait < key_wait_limit ) )
    {
        if ( valid_key ==  ‘#’ )    // labled ‘#’ on keypad
        {
            Home_Clr();             // clear lcd and set cursor to line1/position 1
            if ( ( !flag2.alarm_set1 )  &&  ( !flag2.alarm_set2 )  &&
                                    //  ( !flag1.arm_countdown ) )
            {
              printf( “System not Armed” ); // format message for LCD
              Delay_100mS( 10 ) ;   // short delay for user to view LCD message
              Home_Clr();           // clear lcd and set cursor to line1/position 1
              valid_key = ESC;      // set valid_key contents to ESCape
            }

            else
            {
              codestring[4] = 0x00;   // initialize variable
              csindex = 0;            // define and initialize auto variable
              flag1.keyread = 0;      // reset key read flag

              printf( “To Disarm..Enter” ); // format message for LCD
              Line_2();               // set lcd cursor to line2/position 1
              printf( “User Code-> “ );// format message for LCD
```

```
                    Code_Select();          // function for entering Master/User code

                    temp = Read_User_EE2( USER_CODE, &tempstring[0], 4 ); // read from to EE

                    Home_Clr();              // clear lcd and set cursor to line1/position 1
                    if ( ( i = strcmp( codestring, tempstring ) ) < 0 )
                    {
                      flag1.code_valid = 0;  // flag set false, invalid master code entered
                    }
                    else if ( i > 0 )
                    {
                      flag1.code_valid = 0;  // flag set false, invalid master code entered
                    }
                    else
                    {
                      Home_It();            // set lcd cursor to line1/position 1
                      printf("System DisArmed!"); // format message for LCD
                      ALARM_OFF;            // turn off external Alarm drive
                      ARMRDY = 1;           // turn on base panel ARMED LED
                      Sound_Piezo( 1 );     // 100ms enable of internal piezo
                      flag1.code_valid = 1; // flag set false, invalid master code entered
                      flag2.alarm_set1= 0;  // reset alarm state entry flag1
                      flag2.alarm_set2= 0;  // reset alarm state entry flag2
                      flag1.arm_now = 0;    // reset immediate alarm entry flag
                      flag1.arm_countdown = 0;// ensure flag is reset
                    }

                    if ( !flag1.code_valid )// test if there was a Invalid Master Code entry
                    {
                      printf( "* Invalid Code *" ); // format message for LCD
                    }

                    Delay_100mS( 10 ) ;     // short delay for user to view LCD message
                    Home_Clr();             // clear lcd and set cursor to line1/position 1
                    valid_key = ESC;
                  }
              }

              else if ( valid_key == '0' )  //
              {
                  Home_Clr();// clear lcd and set cursor to line1/position 1
                  valid_key = ESC;// set valid key contents to ESCape
              }


              else if ( valid_key ==  '1' ) // labled 1 on keypad
              {
                  flag1.buzzer = 0;// clear flag so piezo buzzer will not sound
                  valid_key = ESC;// set valid key contents to ESCape
              }

              else if ( valid_key ==  PANIC )//
              {
                  decoder2_ee[0] = CLEAR;   // write non-alarm status byte to buffer
                  temp = Write_User_EE2( ALRM_STAT, &decoder2_ee[0], 1 ); // write alarm time to
                                            // EE memory
              }

              else if ( valid_key ==  ESC )//
              {
                  if  ( !flag1.battery_sel )
                  {
                    BATSEL ^= 1;            // toggle battery backup select
                  }

                  LCDBD ^= 1;               // toggle LCD backlight on/off
              }
          }
        break;

        default:
        break;
    }
}
```

```
/*********************************************************************
*                                                                    *
*   Filename:       prockey.h                                        *
*   Date:           07/18/99                                         *
*   File Version:   1.00                                             *
*                                                                    *
*   Compiler:       Hi-Tech PIC C Compiler V7.83 PL3                 *
*                                                                    *
*********************************************************************/



// FUNCTION PROTOTYPES

/* Functions defined in file baselcd.c */
extern void Home_Clr( void );               // reference linkage to defined function
extern void Home_It( void );
extern void Line_2( void );

/* Functions defined in file diagfunc.c */
extern void Sound_Piezo( char ontime );     // reference linkage to defined function
extern void Battery_Voltage( void );

/* Functions defined in file delays.c */
extern void Delay_1S( char loop_count );    // reference linkage to defined function
extern void Delay_100mS( char loop_count );
extern void Delay_1mS( char loop_count );

/* Functions defined in file hcsdec.c */
extern char Learn( void );                  // reference linkage to defined function
extern char Erase_All( void );
extern char Read_User_EE2( char address, char * rdptr, char length );
extern char Write_User_EE2( char address, char * wrptr, char length );

/* Function defined in file timeset.c */
extern void Set_Time( void );               // reference linkage to defined function

/* Function defined in file codesel.c */    // reference linkage to defined function
extern void Code_Select( void );


// VARIABLES ( REFERENCE DECLARATION )

extern struct event_bits1                   // bit structure for housekeeping flags
      {
        unsigned new_day        :1;         // flag for indicating new day
        unsigned arm_countdown  :1;         // flag set when counting down to arming system
        unsigned buzzer         :1;         // flag set when piezo buzzer will sound when called
        unsigned read_battery   :1;         // flag used for read battery voltage
        unsigned battery_on     :1;         // flag set when battery source is selected
        unsigned battery_off    :1;         // flag set when battery is not selected
        unsigned time_update    :1;         // flag used for updating LCD and E2 Memory
        unsigned erase_all      :1;         // flag set when HCS515 erase all operation complete
        unsigned battery_sel    :1;         // flag set when battery source is selected
        unsigned erase_entered  :1;         // flag set when HCS515 erase all operation entered
        unsigned arm_now        :1;         // flag set when system is immediately armed w/o user
                                            // code
        unsigned learn_entered  :1;         // flag set when HCS515 learn operation entered
        unsigned code_valid     :1;         // flag set after user security access code accepted
        unsigned code_entered   :1;         // flag set when user security access code entered
        unsigned keyread        :1;         // flag set for indicating keypad selection needs
                                            // processed
        unsigned keyhit         :1;         // flag set when valid key hit on 4x4 keypad is
                                            // detected
    } flag1;                                // variable name


extern struct event_bits2                   // define bit structure for housekeeping flags
    {
        unsigned                :1;         // bit padding
        unsigned alarm_set1     :1;         // flag set when system is armed ( 1 of 2 )
        unsigned                :6;         // bit padding
        unsigned valid_rcv      :1;         // flag used if HCS515 demod data is correct
        unsigned sensor_batt_low:1;         // flag indicating if sensor module battery is low
        unsigned                :5;         // bit padding
        unsigned alarm_set2     :1;         // flag set when system is armed ( 2 of 2 )
    } flag2;                                // variable name


extern char porta_image;                    // reference linkage to defined variable in bank0
extern char hours;                          // reference linkage to defined variable in bank0
extern char minutes;                        // reference linkage to defined variable in bank0
```

```
extern char seconds;                        // reference linkage to defined variable in bank0
extern char key_index;                      // reference linkage to defined variable in bank0
extern bank1 char key_wait;                 // reference linkage to defined variable in bank1
extern bank1 char valid_key;                // reference linkage to defined variable in bank1
extern bank1 char key_wait_limit;           // reference linkage to defined variable in bank1
extern bank1 char temp;                     // reference linkage to defined variable in bank1

extern bank1 char decoder2[10];             // reference linkage, array storage for valid trans.
                                            // reception (decoder 2)
extern bank1 char decoder2_ee[6];           // reference linkage to defined variable in bank1
extern bank1 double battery_volts;          // reference linkage to defined variable in bank2


extern const char zone_tod_address[];
extern const char zone_name_address[];
extern const char room_name[][17];

extern const char *ptr;
extern const char master_code[];            // Master code required for changing user code


// VARIABLES ( DEFINED HERE )

bank1 char codestring[5];                   // define array variable in bank1
bank1 char csindex;                         // define array index variable in bank1
bank1 char tempstring[5];                   // define array variable for temp storage
bank1 char time_to_arm;                     // define variable


// PORTBITS ( DEFINED HERE )

#define PortBit(port,bit)    ((unsigned)&(port)*8+(bit))

static bit ALARM_DRV  @  PortBit(PORTA,2);   // Alarm drive state
static bit ARMRDY     @  PortBit(PORTC,3);   // Alarm/Ready Light bias control
static bit PSOURCE    @  PortBit(PORTD,0);   // Power Source indication status
static bit BATSEL     @  PortBit(PORTE,0);   // Battery Select (test only)
static bit LCDBD      @  PortBit(PORTE,2);   // LCD Back Drive on/off


// MACROS ( DEFINED HERE )

#define NOP() asm(“ nop”)// define NOP macro

#define ALARM_ON     porta_image |= 0b000100;\
                     PORTA = porta_image;    // enable external alarm

#define ALARM_OFF    porta_image &= ~0b000100;\
                     PORTA = porta_image;    // enable external alarm

#define BATT_CURR_ON porta_image |= 0b000010 ;\
                     PORTA = porta_image;    // enable maximum battery charge current

#define BATT_CURR_OFFporta_image &= ~0b000010 ;\
                     PORTA = porta_image;    // enable maximum battery charge current


#define    SEC2         61                  //
#define    SEC4         120                 //

#define    ESC          0x1B                // text sub. for Escape key
#define    AWAY         0x31                // text sub. for ‘1’ key
#define    YES          0x31                // text sub. for ‘1’ key
#define    DISPLAY_TIME 0x31                // text sub. for ‘1’ key
#define    LEARN_DEC    0x31                // text sub. for ‘1’ key

#define    OFF          0x32                // text sub. for ‘2’ key
#define    SET_TIME     0x32                // text sub. for ‘2’ key
#define    ERASE        0x32                // text sub. for ‘1’ key

#define    TEST         0x35                // text sub. for ‘5’ key
#define    LEARN        0x36                // text sub. for ‘6’ key
#define    BYPASS       0x36                // text sub, for ‘6’ key
#define    TIME         0x37                // text sub. for ‘7’ key
#define    ALARM_STATUS 0x37                // text sub. for ‘7’ key
#define    CODE         0x38                // text sub. for ‘8’ key
#define    CHIME        0x39                // text sub. for ‘9’ key

#define    ALT          0x40                // text sub. for ALTernate key
#define    AUX          0x41                // text sub. for Auxillary key
#define    PANIC        0x50                // text sub. for PANIC key
```

```
/*********************************************************************
*                                                                    *
*   Wireless Home Security with Keeloq and the PICmicro              *
*                                                                    *
*********************************************************************
*                                                                    *
*   Filename:       proctran.c                                       *
*   Date:           07/18/99                                         *
*   File Version:   1.00                                             *
*                                                                    *
*   Compiler:       Hi-Tech PIC C Compiler V7.83 PL3                 *
*                                                                    *
*   Author:         Richard L. Fischer                               *
*   Company:        Microchip Technology Incorporated                *
*                                                                    *
*********************************************************************
*                                                                    *
*   Files required:                                                  *
*                                                                    *
*                   pic.h                                            *
*                   proctran.h                                       *
*                   hcs515ee.h                                       *
*                   errcode.h                                        *
*                                                                    *
*********************************************************************
*                                                                    *
*   Notes: The routines within this file are required for            *
*          determining what type of transmission has been received   *
*          from the HCS515 decoder(s).                               *
*                                                                    *
*   Currently only 1 decoder is implemented.                         *
*                                                                    *
*********************************************************************/

    #include <pic.h>
    #include “proctran.h”                    // function prototypes, defines..
    #include “hcs515ee.h”

bit alarm_detect;                           // define bit
bit ok_detect;                              // define bit
bit test_detect;                            // define bit


void Read_Decoder_Trans( void )
{
    char maj_detect = 0;                    // initialize variable for majority detect

    alarm_detect = 0;                       // initialize bit
    ok_detect = 0;                          // initialize bit
    test_detect = 0;                        // initialize bit
    flag2.valid_rcv = 0;                    // reset valid reception flag

    Delay_1mS( 2 );                         // wait 2mS
    if ( HCSDATA2 )                         // is data line high?
        maj_detect ++;                      // yes so increment majority detect count

    Delay_1mS( 2 );                         // wait 2mS
    if ( HCSDATA2 )                         // is data line high?
        maj_detect ++;                      // yes so increment majority detect count

    Delay_1mS( 20 );                        // wait 20mS

    if ( HCSDATA2 )                         // is data line high?
        maj_detect ++;                      // yes so increment majority detect count

    Delay_1mS( 2 );                         // wait 2mS
    if ( HCSDATA2 )                         // is data line high?
        maj_detect ++;                      // yes so increment majority detect count

    if ( maj_detect == 4 )                  // majority detect == 4?
    {
        Read_Trans( 10 );                   // can read up to 10 bytes of received message

/* Test here if received function codes indicate a possible “ALARM” transmission */
       if (  (( decoder2[0] & 0x78 ) == 0x08 )  &&  (( decoder2[5] & 0xF0 ) == 0x20 )  )
       {
           alarm_detect = 1;
           flag2.valid_rcv = 1;             // if here then there is a valid reception
       }

/* Test here if received function codes indicate a “TEST/LEARN” transmission */
       else if (  (( decoder2[0] & 0x78 ) == 0x10 )  &&  (( decoder2[5] & 0xF0 ) == 0x40 )  )
       {
```

```
            test_detect = 1;
            flag2.valid_rcv = 1;              // if here then there is a valid reception
        }

/* Test here if received function codes indicate a possible “OKAY” transmission */
        else if (  (( decoder2[0] & 0x78 ) == 0x18 )  &&  (( decoder2[5] & 0xF0 ) == 0x60 )  )
        {
            ok_detect = 1;
            flag2.valid_rcv = 1;              // if here then there is a valid reception
        }
        maj_detect = 0;                       // reset majority detect count
    }

    if ( flag2.valid_rcv )                    // test if there was a valid transmission
    {
        decoder2_ee[0] = hours;               // write hours count to buffer for EE write
        decoder2_ee[1] = minutes;             // write minutes count to buffer for EE write
        decoder2_ee[2] = seconds;             // write seconds count to buffer for EE write

        if ( alarm_detect )
        {
            if ( ( flag2.alarm_set1 == 1 )  &&  ( flag2.alarm_set2 == 1 ) ) // is system ARMED?
            {
                ALARM_ON;                     // yes, so turn on external alarm
                Sound_Piezo( 5 );             // toggle internal piezo for 500mS
                Delay_100mS( 1 );             // short delay
                Sound_Piezo( 1 );             // toggle internal piezo for 100mS
                decoder2_ee[3] = ALRM;        // write “ALARM ON” status byte to buffer for EE
write
            }
            else                              // if here zone trip occurred but system is NOT ARMED
            {
                ALARM_OFF;                    // ensure alarm is off
                Sound_Piezo( 1 );             // toggle internal piezo for 100mS
                Delay_100mS( 1 );             // short delay
                Sound_Piezo( 5 );             // toggle internal piezo for 500mS
                decoder2_ee[3] = CLEAR;       // write “CLEAR” status byte to buffer for EE write
            }
            temp = Write_User_EE2( ALRM_HRS, &decoder2_ee[0], 4 ); // write alarm condition status
                                              // and time to EE
        }

        else if ( test_detect )
        {
            Sound_Piezo( 1 );// toggle internal piezo for 100mS
            decoder2_ee[3] = TST_LRN;         // write “TEST/LEARN” status byte to buffer for EE
                                              // write
        }


        else if ( ok_detect )
        {
            Sound_Piezo( 1 );                 // toggle internal piezo for 100mS
            Delay_100mS( 1 );                 // short delay
            Sound_Piezo( 1 );                 // toggle internal piezo for 100mS
            decoder2_ee[3] = OKAY;            // write “OKAY” status byte to buffer for EE write
        }

        temp = Write_User_EE2( LAST_XMIT, &decoder2_ee[3], 1 ); // write last transmission type
                                              // code to EE

        if ( ( decoder2[0] & 0x04 ) )         // test for Vlow bit in sensor module transmission
        {
            decoder2_ee[3] = LOW;             // write battery “LOW” status code to buffer for EE
                                              // write
            flag2.sensor_batt_low = 1;        // set flag indicating zone battery is low
        }
        else
        {
            decoder2_ee[3] = HIGH;            // write battery “HIGH” status code to buffer for EE
                                              // write
            flag2.sensor_batt_low = 0;        // reset flag
        }

/* Write battery status and respective time stamp to appropriate zone tag in EE memory */
            temp = ( decoder2[1] - 1) & 0x0F;// determine which transmitter block was received
            temp = Write_User_EE2( zone_tod_address[temp], &decoder2_ee[0], 4 ); // write alarm
                                              // time to EE memory
    }
}
```

```
/*********************************************************************
*                                                                    *
*   Filename:       proctran.h                                       *
*   Date:           07/18/99                                         *
*   File Version:   1.00                                             *
*                                                                    *
*   Compiler:       Hi-Tech PIC C Compiler V7.83 PL3                 *
*                                                                    *
*********************************************************************/



// FUNCTION PROTOTYPES

/* Functions defined in file delays.c */
extern void Delay_100mS( char loop_count );  // refercene linkage to defined function
extern void Delay_10mS( char loop_count );
extern void Delay_1mS( char loop_count );

/* Function defined is file diagfunc.c */
extern void Sound_Piezo( char ontime );      // reference linkage to defined function

/* Functions defined in file hcsdec.c */
extern void Read_Trans( char length );       // reference linkage to defined function
extern char Write_User_EE2( char address, char * wrptr, char length );
extern char Read_User_EE2( char address, char * rdptr, char length );


const char zone_tod_address[] = { 0x8A, 0x91, 0x98, 0x9F, 0xA6, 0xAD, 0xB4 };



// VARIABLES ( REFERENCE DECLARATION )

extern struct event_bits2                    // define bit structure for housekeeping flags
    {
        unsigned                :1;          // bit padding
        unsigned alarm_set1     :1;          // flag set when system is armed ( 1 of 2 )
        unsigned                :6;          // bit padding
        unsigned valid_rcv      :1;          // flag used if HCS515 demod data is correct
        unsigned sensor_batt_low:1;          // flag indicating if sensor module battery is low
        unsigned                :5;          // bit padding
        unsigned alarm_set2     :1;          // flag set when system is armed ( 2 of 2 )
    } flag2;                                 // variable name


extern char porta_image;                     // reference linkage to defined variable (SFR)
extern char hours;                           // reference linkage to defined variable in bank0
extern char minutes;                         // reference linkage to defined variable in bank0
extern char seconds;                         // reference linkage to defined variable in bank0


extern bank1 char decoder2[10];              // reference linkage, array storage for valid trans.
                                             // reception (decoder 2)
extern bank1 char decoder1_ee[6];            // reference linkage to defined array variable in
                                             // bank1
                                             // reception (decoder 2)
extern bank1 char decoder2_ee[6];            // reference linkage to defined array variable in
                                             // bank1

extern bank1 char temp;                      // reference linkage to defined variable in bank1



// PORTBITS ( DEFINED HERE )

#define PortBit(port,bit)    ((unsigned)&(port)*8+(bit))

static bit HCSDATA2   @  PortBit(PORTC,5);   // declare bit for HCS515 data line



// MACROS ( DEFINED HERE )

#define NOP()asm(“ nop”)                     // define NOP macro

#define ALARM_ON       porta_image |= 0b000100;\
                       PORTA = porta_image;  // enable external alarm

#define ALARM_OFF      porta_image &= ~0b000100;\
                       PORTA = porta_image;  // enable external alarm
```

```
/*****************************************************************
*                                                                *
*   Wireless Home Security with Keeloq and the PICmicro          *
*                                                                *
*****************************************************************
*                                                                *
*   Filename:       timeset.c                                    *
*   Date:           07/18/99                                     *
*   File Version:   1.00                                         *
*                                                                *
*   Compiler:       Hi-Tech PIC C Compiler V7.83 PL3             *
*                                                                *
*   Author:         Richard L. Fischer                           *
*   Company:        Microchip Technology Incorporated            *
*                                                                *
*****************************************************************
*                                                                *
*   Files required:                                              *
*                                                                *
*                   pic.h                                        *
*                   stdio.h                                      *
*                   time.h                                       *
*                                                                *
*****************************************************************
*                                                                *
*   Notes: The routine within this file is used for              *
*          setting the time-of-day via 4x4 keypad selections.    *
*                                                                *
*   Key         Function                                         *
*                                                                *
*    1          Increment hours count                            *
*    4          Decrement hours count                            *
*                                                                *
*    2          Increment minutes count                          *
*    5          Decrement minutes count                          *
*                                                                *
*    3          Increment seconds count                          *
*    6          Decrement seconds count                          *
*                                                                *
*                                                                *
*****************************************************************/

    #include <pic.h>                        // processor if/def file
    #include <stdio.h>
    #include “time.h”                       // function prototypes, variables, defines..


void Set_Time( void )
{
    TMR1IE = 0;                             // disable real-time clock interrupts
    Home_Clr();                             // clear lcd and set cursor to line1/position 1

    while ( valid_key != ESC )
    {
        Line_2();                           // set lcd cursor to line2/position 1
        Delay_10mS( 15 );                   // short delay
        printf( “Time-> %02u:%02u:%02u” ,hours,minutes,seconds );

        switch ( valid_key )                // evaluate expression
        {
            case ( ‘1’ ):                   // test if hours will be incremented
                hours++;                    // increment hours
                if ( hours > 23 )           // test if hours will roll over
                {
                    hours = 0x00;           // yes, so reset hours
                }
                break;                      // exit from switch evaluation

            case ( ‘2’ ):                   // test if minutes will be incremented
                minutes++;                  // increment minutes
                if ( minutes > 59  )        // test if minutes will roll over
                {
                    minutes = 0x00;         // yes, so reset minutes
                }
                break;                      // exit from switch evaluation

            case ( ‘3’ ):                   // test if seconds will be incremented
                seconds++;                  // increment seconds
                if ( seconds > 59 )         // test if seconds will roll over
                {
                    seconds = 0x00;         // yes, so reset seconds
                }
```

```
                break;                          // exit from switch evaluation

            case ( '4' ):                       // test if hours will be decremented
                hours--;                        // decrement hours
                if ( hours > 23 )               // test if hours will underflow
                {
                     hours = 23;                // yes, so reset hours
                }
                break;                          // exit from switch evaluation

            case ( '5' ):                       // test if minutes will be decremented
                minutes--;                      // decrement minutes
                if ( minutes > 59 )             // test if minutes will underflow
                {
                     minutes = 59;              // yes, so reset minutes
                }
                break;                          // exit from switch evaluation

            case ( '6' ):                       // test if seconds will be decremented
                seconds--;                      // decrement seconds
                if ( seconds > 59 )             // test if seconds will underflow
                {
                seconds = 59;                   // yes, so reset seconds
                }
                break;                          // exit from switch evaluation

            default:                            // if no match occurs
                break;                          // exit from switch evaluation
        }
    }

    TMR1IF = 0;                                 // reset Timer 1 interrupt flag
    TMR1IE = 1;                                 // re-enable Timer 1 interrupts
    Home_It();                                  // set lcd cursor to line1/position 1
    printf( " Time Entered!  ");                // format message for display
    Delay_100mS( 10 );                          // short delay
    Home_Clr();                                 // clear lcd and set cursor to line1/position 1
    flag1.time_update = 1;                      // set flag for displaying time
}
```

```
/*********************************************************************
*                                                                    *
*   Filename:       time.h                                           *
*   Date:           07/18/99                                         *
*   File Version:   1.00                                             *
*                                                                    *
*   Compiler:       Hi-Tech PIC C Compiler V7.83 PL3                 *
*                                                                    *
*********************************************************************/



// FUNCTION PROTOTYPES

/* Functions defined in file baselcd.c */
extern void Home_Clr(void);                  // reference linkage to defined function
extern void Home_It(void);
extern void Line_2(void);

/* Functions defined in file delays.c */
extern void Delay_100mS( char loop_count );  // reference linkage to defined function
extern void Delay_10mS( char loop_count );


// VARIABLES ( REFERENCE DECLARATION )

extern struct event_bits1                    // bit structure for housekeeping flags
      {
        unsigned new_day         :1;         // flag for indicating new day
        unsigned arm_countdown   :1;         // flag set when counting down to arming system
        unsigned buzzer          :1;         // flag set when piezo buzzer will sound when called
        unsigned read_battery    :1;         // flag used for read battery voltage
        unsigned battery_on      :1;         // flag set when battery source is selected
        unsigned battery_off     :1;         // flag set when battery is not selected
        unsigned time_update     :1;         // flag used for updating LCD and E2 Memory
        unsigned erase_all       :1;         // flag set when HCS515 erase all operation complete
        unsigned battery_sel     :1;         // flag set when battery source is selected
        unsigned erase_entered   :1;         // flag set when HCS515 erase all operation entered
        unsigned arm_now         :1;         // flag set when system is immediately armed w/o user
                                             // code
        unsigned learn_entered   :1;         // flag set when HCS515 learn operation entered
        unsigned code_valid      :1;         // flag set after user security access code accepted
        unsigned code_entered    :1;         // flag set when user security access code entered
        unsigned keyread         :1;         // flag set for indicating keypad selection needs
                                             // processed
        unsigned keyhit          :1;         // flag set when valid key hit on 4x4 keypad is
                                             // detected
    } flag1;                                 // variable name

extern char hours;                           // reference linkage to defined variable in bank0
extern char minutes;                         // reference linkage to defined variable in bank0
extern char seconds;                         // reference linkage to defined variable in bank0
extern bank1 char valid_key;                 // reference linkage to defined variable in bank1



// MACROS DEFINED HERE

#define NOP()  asm(“ nop”)                   // define NOP macro

#define   SEC4      120                      //
#define   ESC      0x1B                      // text sub. for Escape key
```

```
/*********************************************************************
*                                                                    *
*   Wireless Home Security with Keeloq and the PICmicro              *
*                                                                    *
*********************************************************************
*                                                                    *
*   Filename:       zonename.c                                       *
*   Date:           07/18/99                                         *
*   File Version:   1.00                                             *
*                                                                    *
*   Compiler:       Hi-Tech PIC C Compiler V7.83 PL3                 *
*                                                                    *
*   Author:         Richard L. Fischer                               *
*   Company:        Microchip Technology Incorporated                *
*                                                                    *
*********************************************************************
*                                                                    *
*   Files required:                                                  *
*                                                                    *
*                   pic.h                                            *
*                   stdio.h                                          *
*                   zonename.h                                       *
*                   hcs515ee.h                                       *
*                                                                    *
*********************************************************************
*                                                                    *
*   Notes: The routine within this file are used for                 *
*          assigning key (room) names to learned sensor              *
*          modules (zones).                                          *
*                                                                    *
*                                                                    *
*********************************************************************/

    #include <pic.h>
    #include <stdio.h>
    #include “zonename.h”                    // function prototypes, defines..
    #include “hcs515ee.h”                    // HCS515 EE memory defines


void Zone_Name( void )
{
    char room_index = 0x00;                 // define and init auto variable
    T0IE = 0;                               // disable Timer0 interrupts

    Home_Clr();                             // clear lcd & set cursor to line1/position1
    printf( “Select Zone Name” );           // format message for LCD
    Delay_100mS( 15 );                      // ~1.5 second delay
    Home_Clr();                             // clear lcd & set cursor to line1/position1
    printf( “[ESC] == choice “ );           // format message for LCD
    valid_key = 0x20;                       // reset valid key buffer contents

    while ( valid_key != ESC )              // loop until ESC key is detected
    {
        Line_2();                           // set cursor to line2 / position 1
        ptr = &room_name[room_index][0];    // pointer initialization to names for rooms
        printf(“%s”, ptr );                 // format message for LCD
        Delay_10mS( 8 );                    // short response delay

        if ( valid_key == ‘1’ )             // are we scrolling through zone names?
        {
            room_index++;                   // increment room index count
            valid_key = 0x20;               // reset valid key entry
            if ( room_index > max_rooms )   // test if room index exceeds max # of rooms
            {
                room_index = 0x00;          // reset room index count
            }
        }
    }

    decoder2_ee[0] = ( ( decoder2[1]  >> 4 ) & 0x0F ); // determine number of Xmtrs learned
    temp = Write_User_EE2( XMTR_CNT, &decoder2_ee[0], 1 ); // write number Xmtrs learned to EE

    decoder2_ee[0] = room_index;            // acquire reference count for zone name
    temp = ( decoder2[1] - 1 ) & 0x0F;      // determine which transmitter block was just
                                            // received
    temp = Write_User_EE2( zone_name_address[temp], &decoder2_ee[0], 1 ); // write zone name to EE
                                            // memory

    Home_Clr();                             // clear lcd & set cursor to line1/ position1
    valid_key = 0x20;
    T0IE = 1;                               // re-enable Timer0 based interrupts
}
```

```
/*********************************************************************
*                                                                    *
*   Filename:       zonename.h                                       *
*   Date:           07/18/99                                         *
*   File Version:   1.00                                             *
*                                                                    *
*   Compiler:       Hi-Tech PIC C Compiler V7.83 PL3                 *
*                                                                    *
*********************************************************************/



// FUNCTION PROTOTYPES

/* Functions defined in file baselcd.c */
extern void Home_Clr(void);                 // reference linkage to defined function
extern void Line_2(void);

/* Functions defined in file delays.c */
extern void Delay_10mS( char loop_count );   // reference linkage to defined function
extern void Delay_100mS( char loop_count );


// VARIABLES ( DEFINED HERE )

const char *ptr;                            // define general purpose const pointer

const char zone_name_address[] = { 0x89, 0x90, 0x97, 0x9E, 0xA5, 0xAC, 0xB3 };

const char room_name[][17] = { "  Family Room  ","  Living Room  ","  Great Room  ",
                               "  Dining Room  ","  Den  ","  Office  ",
                               "  Master Bedroom  ","  Bedroom #1  ","  Bedroom #2  ",
                               "  Bedroom #3  ","  Garage Door  ","  Service Door ",
                                "  Laundry Door  ","  Patio Door  ","  Sliding Door  " };
#define max_rooms  14



// VARIABLES ( REFERENCE DECLARATION )

extern struct event_bits2                   // define bit structure for housekeeping flags
    {
        unsigned                :1;         // bit padding
        unsigned alarm_set1     :1;         // flag set when system is armed ( 1 of 2 )
        unsigned                :6;         // bit padding
        unsigned valid_rcv      :1;         // flag used if HCS515 demod data is correct
        unsigned sensor_batt_low:1;         // flag indicating if sensor module battery is low
        unsigned                :5;         // bit padding
        unsigned alarm_set2     :1;         // flag set when system is armed ( 2 of 2 )
    } flag2;                                // variable name


extern bank1 char key_wait;                 // reference linkage to defined variable in bank1
extern bank1 char valid_key;                // reference linkage to defined variable in bank1
extern bank1 char temp;                     // reference linkage to defined variable in bank1

extern bank1 char decoder2_ee[6];
extern bank1 char decoder2[10];             // array storage for valid trans.

extern char Write_User_EE2( char address, char * wrptr, char length );



// MACROS ( DEFINED HERE )

#define NOP() asm(" nop")                   // define NOP macro

#define   ESC           0x1B                // text sub. for Escape key
```

```
;*****************************************************************
;                                                                 *
;   Wireless Home Security with Keeloq and the PICmicro           *
;                                                                 *
;*****************************************************************
;                                                                 *
;   Filename:       powerup77.as                                  *
;   Date:           07/18/99                                      *
;   File Version:   1.00                                          *
;                                                                 *
;*****************************************************************
;                                                                 *
;   Notes: This assembly file provides for a remapped processor   *
;          code startup location.                                 *
;                                                                 *
;                                                                 *
;   Within the  "#if defined(_PIC14)" section below the new startup  *
;   code  called "mystartup" is executed upon successful completion  *
;   of a reset state. The function "mystartup" is located in the     *
;   base77.c file.                                                *
;                                                                 *
;                                                                 *
;*****************************************************************

    #include"sfr.h"


    global  powerup,start
    psect   powerup,class=CODE,delta=2

extrn  _mystartup

powerup
#if defined(_12C508) || defined(_12C509)
    movwf   5       ;store calibration to OSCCAL
#endif
#if defined(_PIC14)
    movlw   high _mystartup
    movwf   PCLATH
    goto    (_mystartup & 0x7FF)
#endif
#if defined(_PIC16)
    movlw   start>>8
    movwf   PCLATH
    movlw   start & 0xFF
    movwf   PCL
#endif
    end powerup
```

```
/************************************************************************
*                                                                       *
*   Filename:       cnfig77.h                                           *
*   Date:           07/18/99                                            *
*   File Version:   1.00                                                *
*                                                                       *
*   Compiler:       Hi-Tech PIC C Compiler V7.83 PL3                    *
*                                                                       *
************************************************************************/

/*****  CONFIGURATION BIT DEFINITIONS FOR PIC16C77 PICmicro  *****/


#define    CONBLANK     0x3FFF

#define    CP_ALL       0x00CF
#define    CP_75        0x15DF
#define    CP_50        0x2AEF
#define    CP_OFF       0x3FFF
#define    BODEN_ON     0x3FFF
#define    BODEN_OFF    0x3FBF
#define    PWRTE_OFF    0x3FFF
#define    PWRTE_ON     0x3FF7
#define    WDT_ON       0x3FFF
#define    WDT_OFF      0x3FFB
#define    LP_OSC       0x3FFC
#define    XT_OSC       0x3FFD
#define    HS_OSC       0x3FFE
#define    RC_OSC       0x3FFF
```

```
;*****************************************************************
;                                                                *
;   Wireless Home Security with Keeloq and the PICmicro          *
;                                                                *
;*****************************************************************
;                                                                *
;   Filename:       basecode.as                                  *
;   Date:           07/18/99                                     *
;   File Version:   1.00                                         *
;                                                                *
;*****************************************************************
;                                                                *
;   Notes: This assembly file provides for the Master Code       *
;          which can be placed into EPROM at programming time.   *
;                                                                *
;   The address location in EPROM for this PSECT ( accesscode )  *
;   is 1FFAh.                                                    *
;                                                                *
;   To place this PSECT at this address the following option     *
;   is inserted on the Additional Command Line Options for the   *
;   target filename hex node.                                    *
;                                                                *
;   -L-Paccesscode=1FFAh                                         *
;                                                                *
;*****************************************************************

    psect accesscode,class=CODE,delta=2
    global _master_code


_master_code:

    retlw 0x01                          ; 1st digit of code
    retlw 0x02                          ; 2nd digit of code
    retlw 0x03                          ; 3rd digit of code
    retlw 0x04                          ; 4th digit of code
    retlw 0x00                          ; null character for string

    end
```

```
/************************************************************************
*                                                                       *
*   Filename:       hcs515ee.h                                          *
*   Date:           07/18/99                                            *
*   File Version:   1.00                                                *
*                                                                       *
*   Compiler:       Hi-Tech PIC C Compiler V7.83 PL3                    *
*                                                                       *
************************************************************************/


#define USER_CODE    0x80
#define MSTR_CODE    0x86                   // define EE address for Master Code entry
#define XMTR_CNT     0xBC                   // define EE address learned XMTR count

#define BT_ON_CNT    0xF0                   // define EE address for battery cycle count
#define BT_ON_HRS    0xF1                   // define EE address for battery on TOD
#define BT_OFF_HRS   0xF4                   // define EE address for battery off TOD

#define ALRM_HRS     0xF8                   // define EE address for Alarm TOD
#define ALRM_STAT    0xFB                   // define EE address for Alarm Status
#define LAST_XMIT    0xFF                   // define EE address for last XMTR type


#define LOW          0x55                   // define byte for label “LOW”
#define HIGH         0xAA                   // define byte for label “HIGH”

#define ALRM         0x41                   // define byte for label “ALRM”
#define CLEAR        0xBE                   // define byte for label “CLEAR”
#define TST_LRN      0xB1                   // define byte for label “TST_LRN”

#define OKAY         0x4F                   // define byte for label “OKAY”
#define ERROR        0xB0                   // define byte for label “ERROR”
```

## APPENDIX C: SENSOR MODULE CODE FILES

```
/************************************************************************
*                                                                       *
*   Wireless Home Security with Keeloq and the PICmicro                 *
*                                                                       *
************************************************************************
*                                                                       *
*   Filename:       sensor08.c                                          *
*   Date:           05/24/99                                            *
*   File Version:   1.00                                                *
*                                                                       *
*   Compiler:       Hi-Tech PIC C Compiler V7.83 PL3                    *
*                                                                       *
*   Author:         Richard L. Fischer                                  *
*   Company:        Microchip Technology Incorporated                   *
*                                                                       *
************************************************************************
*                                                                       *
*   Files required:                                                     *
*                                                                       *
*                   pic.h        (Hi-Tech file)                         *
*                   cnfig50x.h                                          *
*                                                                       *
*                   sensor08.c   (Sensor Module code)                   *
*                   powerup08.as (Hi-Tech file, modified)               *
*                   delay12.as   (Delay Routine code)                   *
*                                                                       *
************************************************************************
*                                                                       *
*   Notes:                                                              *
*                                                                       *
*   PICmicro -> PIC12C508A                                              *
*   Fosc -> Internal RC                                                 *
*   Weak-pull-ups disabled (current constraints)                        *
*   Wakeup from sleep --> typical 400uS                                 *
*   Wake-up from sleep until test of GPWUF --> typical 20.03mS          *
*   Current consumption in sleep mode:  (sleep duration -> ~100sec)     *
*                                  -> ~3.2uA @ 6.4Vdc (new battery)     *
*                                  -> ~2.0uA @ 3.3Vdc (battery EOL)     *
*                                                                       *
*   Sensor operational lower-limit voltage:                             *
*                              -> 4Vdc (Low voltage status to base)     *
*                                                                       *
*                                                                       *
*   Current consumption during wakeup:                                  *
*                        housekeeping only: (typical 56mS)              *
*                                  -> ~ 0.70mA @ 6.4Vdc                 *
*                                  -> ~ 0.30mA @ 3.3Vdc                 *
*                        intentional radiation: (typical 700mS)         *
*                                  -> ~ 4.64mA @ 6.4Vdc                 *
*                                  -> ~ 2.22mA @ 3.3Vdc                 *
*                                                                       *
*                                                                       *
* Memory Usage Map:                                                     *
*                                                                       *
* User segment  $0000 - $0002  $0003 (   3) bytes total User segment    *
* Program ROM   $0000 - $01FE  $01FF ( 511) words                       *
* Program ROM   $0FFF - $0FFF  $0001 (   1) words                       *
*                              $0200 ( 512) words total Program ROM     *
*                                                                       *
* Bank 0 RAM    $0007 - $000C  $0006 (   6) bytes total Bank 0 RAM      *
*                                                                       *
************************************************************************/

#include <pic.h>                            // processor if/def processor file
#include “cnfig50x.h”                       // configuration bit definitions


  __CONFIG   (CONBLANK & MCLRE_OFF & CP_OFF & WDT_OFF & IntRC_OSC);


extern void Delay_Ms_4MHz(char delay);      //prototype for delay function

// MACROS DEFINED HERE
#define  PUT_COUNT   54                     // define number of PUT fires on pin GP0
                                            // before initiating sensor okay signal
                                            // each PUT fire sequence is 100 seconds,
                                            // total time is therefore 1.5hrs

#define  SLEEP   asm (“sleep”)              // macro for sleep instruction
                                            // RF and begin PUT discharge
#define  NOP     asm (“NOP”);               // power-up stabilization period (3uS)
```

```
#define PortBit(port,bit)    ((unsigned)&(port)*8+(bit))
static bit AUTO_CYCLE   @ PortBit(GPIO,0);   // define auto cycle pin
static bit LEARN_TEST   @ PortBit(GPIO,1);   // define okay/learn/test pin
static bit ALARM_SIGNAL @ PortBit(GPIO,3);   // define alarm signal pin


// GLOBALS DEFINED HERE
persistent char auto_transmit;               // variable used for counting PUT based
                                             // wake-ups


//*****************************************************************
//*****************************************************************
/* Determine source of wake-up from SLEEP. Wake-up source is either:

   1. Alarm sensor trip via active high on pin GP3.
   2. Auto wake-up via Programmable Unijunction Transistor (PUT)
      firing active high on pin GP0.
   3. Learn/test active high on pin GP1.

*/

void Identify_wakeup(void)
{
   if (ALARM_SIGNAL)                         // has alarm sensor been activated?
   {
     GPIO = 0b111010;                        // set GP5 pin state to turn on HCS200 & RF
                                             // also set GP2 for PUT discharge state
     TRIS = 0b011011;                        // set GP5 as output, power up HCS200 and
                                             // RF and begin PUT discharge
     NOP;                                    // power-up stabilization period (3uS)
     NOP;
     NOP;

     TRIS = 0b001011;                        // set GP4 as output, assert S0 on HCS200
     Delay_Ms_4MHz(255);                     // ensure multiple alarm transmissions
     Delay_Ms_4MHz(255);                     // ensure multiple alarm transmissions
     Delay_Ms_4MHz(80);                      // ensure multiple alarm transmissions
                                             // want 5 transmissions at 3.3Vdc @ 4MHz

     auto_transmit = 0;                      // reset auto cycle counter since alarm
   }                                         // tripped

   else if (LEARN_TEST)                      // learn/test condition entered?
   {
     GPIO = 0b111010;                        // set GP5 pin state to turn on HCS200 & RF
                                             // also set GP2 for PUT discharge state

     TRIS = 0b011011;                        // set GP5 as output, power up HCS200 and
                                             // RF and begin PUT discharge
     NOP;                                    // power-up stabilization period (3uS)
     NOP;
     NOP;

     TRIS = 0b011001;                        // set GP1 as output, assert S1 on HCS200
     Delay_Ms_4MHz(120);                     // ensure single transmission time
                                             // want 1 transmission at 3.3Vdc @ 4MHz
     auto_transmit = 0;                      // reset auto cycle counter since learn/test
                                             // has been activated
   }

   else                                      // else PUT fired (Vgs = 0Vdc)
   {
     if (++auto_transmit < PUT_COUNT)        // time for initiating sensor okay?
     {
       GPIO = 0b011010;                      // set GP2 and GP5 pin latches to logic low
       TRIS = 0b011011;                      // set GP2 and GP5 pin direction to outputs
                                             // begin PUT discharge immediately
       Delay_Ms_4MHz(30);                    // PUT discharge time period (minimum)
     }

     else                                    // else it is time for initiating sensor okay?
     {
       GPIO = 0b111010;                      // set GP5 pin state to turn on HCS200 & RF
                                             // also set GP2 for PUT discharge state
       TRIS = 0b011011;                      // set GP5 as output, power up HCS200 and RF
                                             // and begin PUT discharge
       NOP;                                  // power-up stabilization period (3uS)
       NOP;
       NOP;
```

```
       TRIS = 0b001001;                    // set GP1/GP5 as output, assert S0/S1 on HCS200
       Delay_Ms_4MHz(255);                 // ensure multiple sensor okay transmissions
       Delay_Ms_4MHz(10);                  // ensure multiple sensor okay transmissions
                                           // want 2 transmissions at 3.3Vdc @ 4MHz (worst case)
       auto_transmit = 0;                  // reset auto cycle counter
     }
   }
}


void main(void)
{

   if (GPWUF)                              // has wake-up on pin-change occurred?
   {
     OPTION = 0b11011111;                  // enable GP2 for I/O

     GPIO = 0b011110;                      // GPIO pin latch state is not affected by
     TRIS = 0b011011;                      // wake-up, keep I/O direction same as in
                                           // sleep to ensure valid read of Vih on pin

     Delay_Ms_4MHz(20);                    // short delay for debounce and pin state
                                           // stabilization

     Identify_wakeup();                    // determine source of wake-up from sleep

     GPIO = 0b011010;                      // set GP2 & GP5 pin latches to logic low
     TRIS = 0b011011;                      // power off to HCS200 and RF
     GPWUF = 0;                            // reset wake-up status bit
   }

   else if (TO && PD)                      // else, is it a power up condition?
   {
     auto_transmit = 0;                    // initialize wake-up counter, powerup only
   }

                                           // code to do all the time independant of reset
                                           // condition (GPWUF or Power-up)

   OPTION = 0b01011111;                    // enable wake-up on change and GP2 I/O
   GPIO = 0b011010;                        // set GP2 to logic low, PUT discharge state
   TRIS = 0b011011;                        // set GP0 and GP1 for inputs, GP2 output
                                           // power off to HCS200 and RF

   GPIO = 0b011110;                        // start PUT cycle via release of pin GP2
   GPIO;                                   // dummy read prior to entering sleep
   SLEEP;                                  // go to sleep

 #asm
   rept 0x165
   goto 0x1FF                              // fill unused memory with goto 0x1FF
   endm
 #endasm

}
```

```
;*****************************************************************
;                                                                *
;   Wireless Home Security with Keeloq and the PICmicro          *
;                                                                *
;*****************************************************************
;                                                                *
;   Filename:       delay12.as                                   *
;   Date:           07/18/99                                     *
;   File Version:   1.00                                         *
;                                                                *
;*****************************************************************
;                                                                *
;   Notes:                                                       *
;                                                                *
;   The file is contains the assembly code for executing intervals   *
;   of a 1mS delay. The timing is based upon the PIC12C508A          *
;   internal RC oscillator of 4MHz.                              *
;                                                                *
;*****************************************************************

        psect   text0,class=CODE,local,delta=2
        global_Delay_Ms_4MHz                ; make function scope global
        signat_Delay_Ms_4MHz,4216           ; signature for link time

extrn   string_table

_Delay_Ms_4MHz
        nop
        movwf   ((?a_Delay_Ms_4MHz+0) &0x7F)  ; init outerloop count
outer:
        movlw   0xF9
        movwf   ((?a_Delay_Ms_4MHz+1) &0x7F)  ; init innerloop count
inner:
         nop
         decfsz  ((?a_Delay_Ms_4MHz+1) &0x7F) ; decrement innerloop count
         goto    inner
         decfsz  ((?a_Delay_Ms_4MHz+0) &0x7F) ; decrement outerloop count
         goto    outer

        movf    0x08,w                      ; restore w for jump table access
        goto    string_table                ; go to string table

FNSIZE _Delay_Ms_4MHz,2,1                   ; inform linker of argument and local variable
                                            ; sizes for function
global  ?a_Delay_Ms_4MHz                    ; declare symbol as public

        end                                  end assembly
```

```
;*****************************************************************
;                                                                *
;   Wireless Home Security with Keeloq and the PICmicro          *
;                                                                *
;*****************************************************************
;                                                                *
;   Filename:       powrup08.as                                  *
;   Date:           07/18/99                                     *
;   File Version:   1.00                                         *
;                                                                *
;*****************************************************************
;                                                                *
;                                                                *
;                                                                *
;*****************************************************************
;


    #include“sfr.h”

    global  powerup,start
;   psect   powerup,class=CODE,delta=2

extrn  _main

powerup
#if defined(_12C508) || defined(_12C509)
    movwf   5       ;store calibration to OSCCAL
    goto    _main
#endif
#if defined(_PIC14)
    clrf    STATUS
    movlw   start>>8
    movwf   PCLATH
    goto    start & 7FFh
#endif
#if defined(_PIC16)
    movlw   start>>8
    movwf   PCLATH
    movlw   start & 0xFF
    movwf   PCL
#endif
    end     powerup
```

```
/*****************************************************************
*                                                                *
*   Filename:       cnfig50x.h                                   *
*   Date:           07/18/99                                     *
*   File Version:   1.00                                         *
*                                                                *
*   Compiler:       Hi-Tech PIC C Compiler V7.83 PL3              *
*                                                                *
*****************************************************************/

/*****  CONFIGURATION BIT DEFINITIONS FOR PIC12C508(A) and PIC12C509(A) PICmicro  *****/

#define    CONFIGADD    0xFFF
#define    CONBLANK     0xFFF

#define    MCLRE_ON     0xFFF
#define    MCLRE_OFF    0xFEF
#define    CP_ON        0xFF7
#define    CP_OFF       0xFFF
#define    WDT_ON       0xFFF
#define    WDT_OFF      0xFFB
#define    LP_OSC       0xFFC
#define    XT_OSC       0xFFD
#define    IntRC_OSC    0xFFE
#define    ExtRC_OSC    0xFFF
```

**NOTES:**

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