HI-8436 32 Sensor Array with Ground/Open or Supply/Open Sensors and SPI interface. Evaluation Board

User Guide
Sept, 2013

INTRODUCTION

This board demonstrates the features of the HI-8436 32 Sensor IC. The Holt HI-8436 Evaluation Board was originally designed for the HI-8435; because of this there are references to HI-8435 support material. To a large extent these numbers can used interchangeably, as the devices differ only in the input sensor thresholds. The board and the HI-8436 run from a single 3.3V ±5% supply voltage. The sensor input thresholds are programmable from 0.4V to 5.2V. The EVM (Evaluation Module) plugs into a Holt "General Purpose SPI Evaluation Board", based on a 16 bit, Freescale MC9S12XDT512 microcontroller. The Holt CD, included with the evaluation kit, contains example source code, providing an easy path for the customer to develop their own control software. The mother board MCU uses an SPI interface to communicate with the HI-8436. Switches and LEDs help navigate the operating modes and confirm data and status information. A Serial UART output from the MCU provides debug and data messages to be sent to a PC using any terminal emulation program such as HyperTerminal. The HI-8436 Evaluation Board (shown on the right in the picture below) and plugs into to the Holt General Purpose SPI board, shown on the left below.
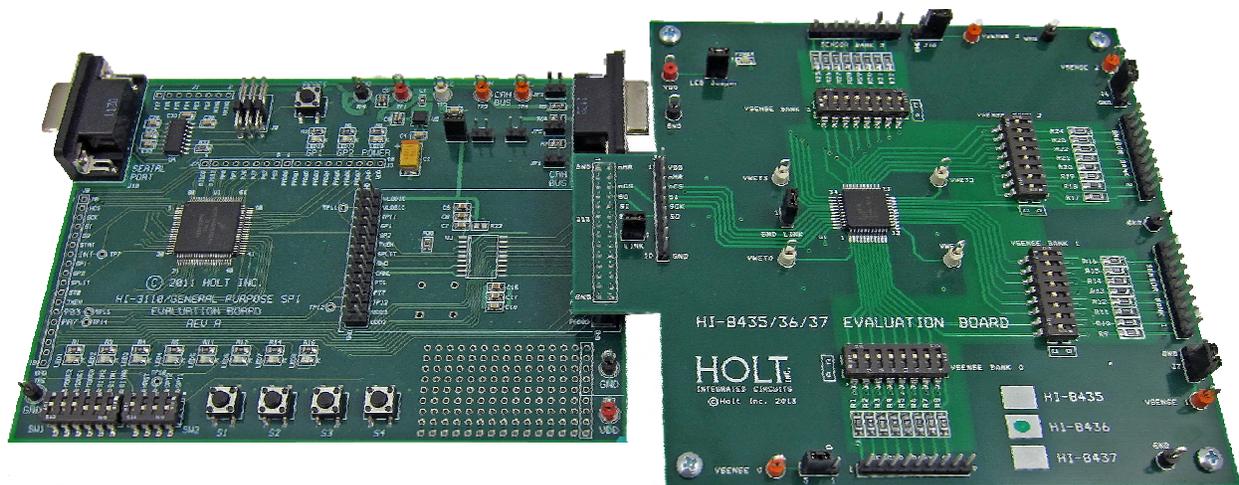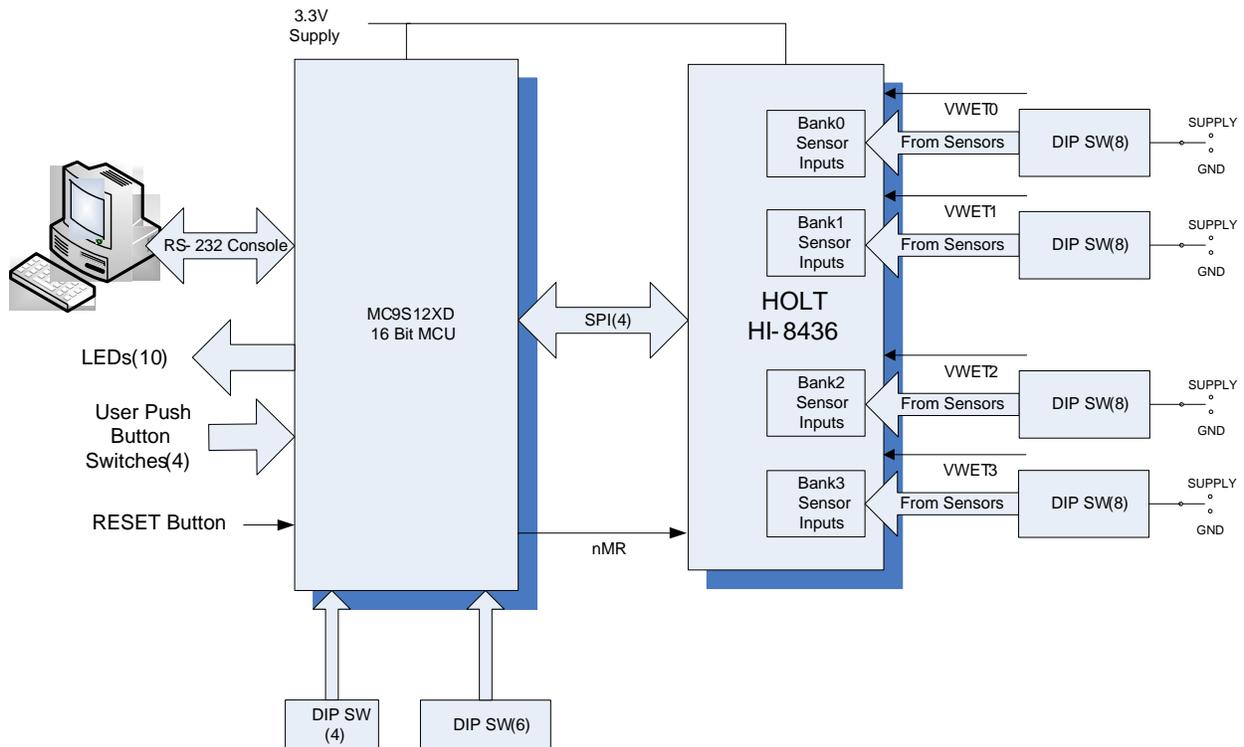

This guide summarizes how to set up and get running quickly. Additional support material is provided on CD-ROM.

KIT CONTENTS

- This User Guide.
- General Purpose SPI Evaluation board (MCU board).
- HI-8436 Evaluation Board (daughter card).
- CD with HI-8436 Users Guide and example source code.
- RS-232 9 Pin Serial Cable.

Demonstration Set-up

Default Jumper and Switch Settings

HI-8436 Board

JUMPER	POSITION	DESCRIPTION
J8	ON	GND Link for HI-8436 supply
J9	ON	VDD Link for LED supply current (disconnect to measure HI-8436 supply current at TP13)
J5	3	Bank 0 = Left Supply/Open, Right = GND/Open
J6	3	Bank 1 = Left Supply/Open, Right = GND/Open
J7	3	Bank 2 = Right Supply/Open, Left = GND/Open
J10	3	Bank 3 = Right Supply/Open, Left = GND/Open
J9	ON	VDD Link FOR HI-8436 and LED supply current (disconnect and use ammeter to measure HI-8436 supply current, after removing LED jumper)

SW1	POSITION	DESCRIPTION
1-8	All ON	Sensor input for Bank0, Sensors 0-7
SW2	**POSITION**	**DESCRIPTION**
1-8	All ON	Sensor input for Bank1, Sensors 8-15
SW3	**POSITION**	**DESCRIPTION**
1-8	All ON	Sensor input for Bank2, Sensors 16-23
SW4	**POSITION**	**DESCRIPTION**
1-8	All ON	Sensor input for Bank3, Sensors 24-31

SPI Board

JP	POSITION	DESCRIPTION
1	Open	
2	Open	
3	ON	VDD to daughter board
4	Open	
5	Open	
6	Open	
7	Open	

SW1	POSITION	DESCRIPTION
1	ON	BITR0
2	ON	BITR1
3	ON	BITR2
4	ON	Mode0
5	Open	Mode1
6	Open	Mode2

SW2	POSITION	DESCRIPTION
1	ON	Opt1
2	ON	Opt2
3	ON	
4	Open	Master Reset

Initial Board Set up

1. Make sure the daughter board jumpers and switch positions match the picture below. J12 (VDD LINK) and J8 (GND LINK) connect VDD and GND to the HI-8436 and can be used to measure the device supply current. The 'LED Jumper' disconnects the LED so an accurate current measurement can be made.
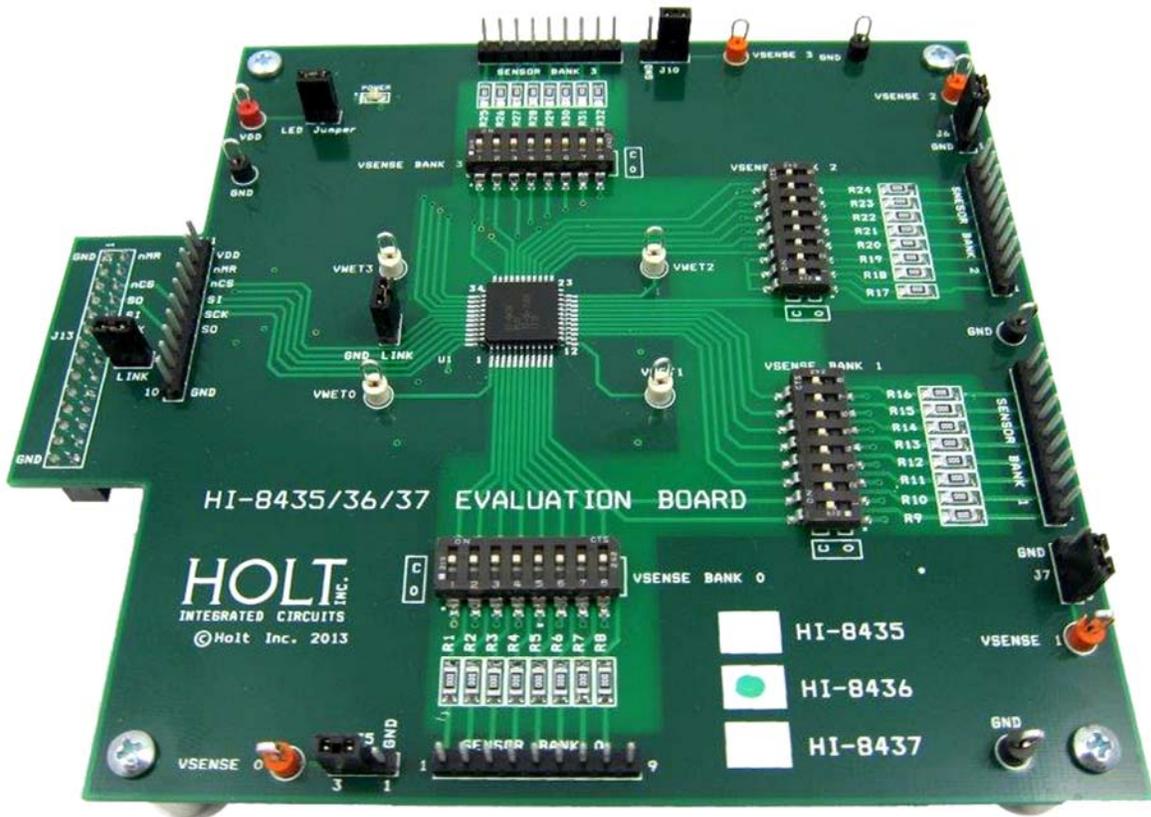
2. On the MCU board, set SW1 positions 6:1 are set to binary '110000', verify SW2 position 4 (MRST) is in the open position, otherwise the MCU will be held in the reset state. This MRST DIP switch allows easy interface of an external MCU to the HI-8436. Closing SW2 position 4 keeps the RESET pin low, forcing the Freescale MCU GPIOs into a high impedance state. For normal operation, keep this switch open and use the RESET button to reset the MCU during testing.

3. Connect a +3.3V power supply to TP1 (RED) and ground to TP6 (BLK) on the Motherboard. This also supplies the HI-8436 daughter board with the same voltage. This is the only power supply needed by this demo.

4. After a power-on reset, the program switches all LEDs on for 3 seconds; the software revision is then displayed on the LEDs for two seconds in binary format, where LED1 is the LSB. After two seconds, the LEDs are turned off.

   A text message is also sent to the Console Port.

5. All control of the HI-8436 is done through the 'Control Console'. This requires use of a terminal emulator for communication, such as HyperTerminal or Tera Term running on your computer.

   Windows versions earlier than Windows Vista

   Open HyperTerminal by clicking **Start** then **All Programs;** click the Windows **Accessories** then **Communications** program group. Double-click HyperTerminal to run it.

   Windows versions Vista or later

   If HyperTerminal is not available (as in recent Windows versions) then use Tera Term, (supplied on the CD). Run teraterm-4.71.exe installer program from the Holt CD. Accept the license agreement stating redistribution is permitted provided that copyright notice is retained. The notice can be displayed from the Tera Term window by clicking **Help** then clicking **About Tera Term**. Continuing to install…

   - Accept the default install destination and click **Next**.
   - At the Select Components screen, unselect all options except Additional Plugin = TTXResizeMenu and click **Next**.
   - Select the installed language, then click **Next**.
   - Accept the default Start Menu folder, then click **Next**.
   - Select any desired shortcuts, then click **Next**.
   - At the Ready to Install screen, click **Install**.

   Run the Tera Term program. At the **New Connection** screen, tick the **Serial** box and choose the selected COM port, find the correct COM port using **Device Manager**.

6. Click **Setup** then **Serial Port** to open the serial port setup window.

   Choose these settings: Baud Rate: 115200, Data: 8 bits, Parity: none, Stop: 1 bit, Flow Control: none

If your PC has a serial port, using the DB-9 serial cable provided, connect the MCU board to the computer serial (COM) port. If your PC only has USB connectors, then use a USB to serial converter (dongle) to connect (not provided).

7. The evaluation software is already installed in the Motherboard microcontroller; this was pre-loaded at the Holt Applications Support Center. On power up, the software displays a message on the monitor, as shown below.

```
COM3:115200baud - Tera Term VT
File  Edit  Setup  Control  Window  Help

Demonstration Software for Holt HI-8436 Revision 0.7

Serial Console Commands  -  Holt HI-8436

 Read  all registers                             0
 Reset device  using the MRB pin                 1
 Program Sense Banks                             2
 Set Input Test Mode                             3
 GND/OPEN Threshold and Hysteresis              4
 SUPPLY/OPEN Threshold and Hysteresis           5
 Write to a register 1 byte                      7
 Read a register. 1 byte                         8
 Monitor a sensor Bank on LEDs1-8 & PA7          9
 Set Test Mode                                   t
 Monitor Sensors  (hit any key to exit)          m
 Set Preset Threshold and Hysteresis            P
 Soft Reset                                      R
 Self Test digital section                       S

 Enter Selection:
```

8. Note: If under any circumstances, this software locks up, use the 'RESET' key on the SPI board to recover.

9. Press key '1' to perform a Hardware Reset. Then press key '0' to read and display values of all read registers, it shows the default state as shown below:

```
COM3:115200baud - Tera Term VT
File  Edit  Setup  Control  Window  Help
 Enter Selection: 0

 Read all device Registers

Control Reg                              0x00
Sense Bank Control Reg                   0x00
GND/OPEN Hysteresis      Reg BA.1        0x00
GND/OPEN Threshold       Reg BA.0        0x00
Supply/OPEN Hysteresis  Reg BC.1         0x00
Supply/OPEN Threshold   Reg BC.0         0x00
Test Mode Reg                            0x00
Sensor Bank 0                            0x00
Sensor Bank 1                            0x00
Sensor Bank 2                            0x00
Sensor Bank 3                            0x00

Sensors - All Banks                      0x00
                                         0x00
                                         0x00
                                         0x00

 Press any key to return to main menu
```

10. DIP switches SW1-4 set a voltage level on the sensors inputs; there is one set of switches for each bank of sensors. The voltage source to the switches is selected using jumpers J4-7, with the jumper in the inner position the source is ground. When jumpers J4-7 are in position 3 the test point adjacent to the jumper is used to connect a sensor supply.

11. Initially it is easier to test the Supply/Open sense mode as no VWET current is required. To do this, verify all switches and jumpers are in the default positions as shown at the beginning of this guide.

    With software displaying the Main Menu, screen press key 2. This brings up the Program Sense Menu as shown below:
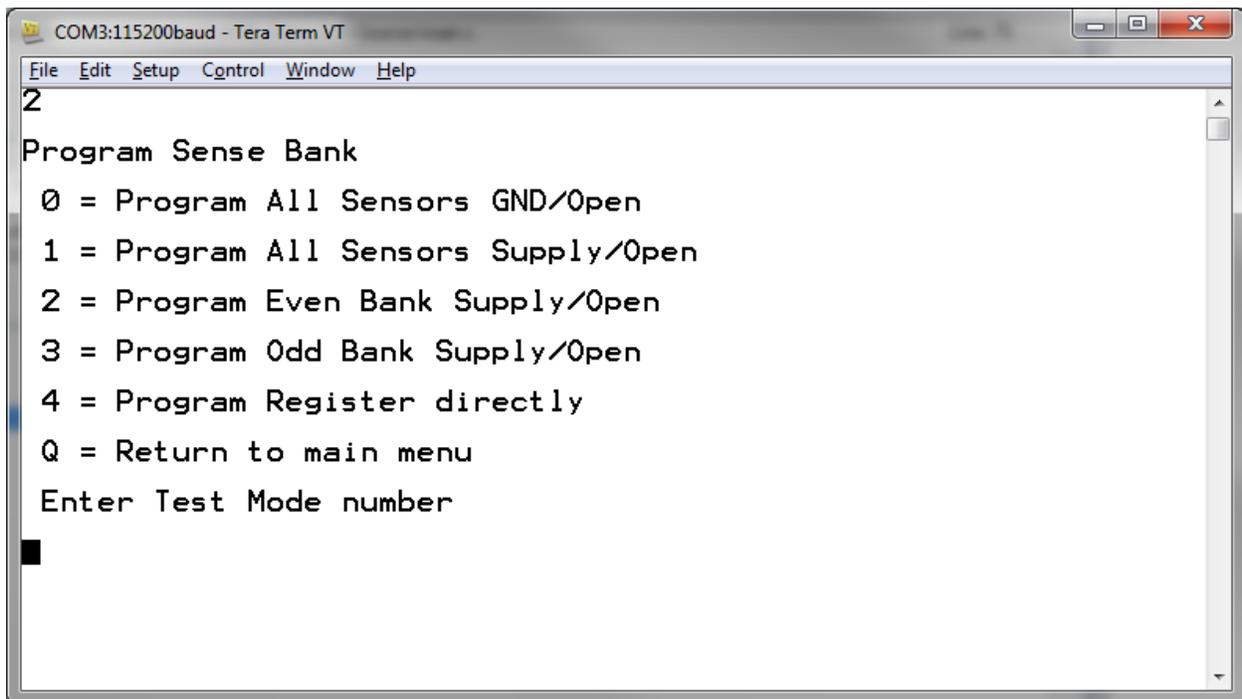
```
COM3:115200baud - Tera Term VT                    ─ □ ✕

File  Edit  Setup  Control  Window  Help

2

Program Sense Bank

 0 = Program All Sensors GND/Open

 1 = Program All Sensors Supply/Open

 2 = Program Even Bank Supply/Open

 3 = Program Odd Bank Supply/Open

 4 = Program Register directly

 Q = Return to main menu

Enter Test Mode number

█
```

    Select 'Program All Sensors Supply/Open' by pressing key '1', then 'q' to return to Main Menu. Press '0' again to read registers and verify that the Sense Bank Control reads 0x0F, see below. All 32 sensors are now set to detect the Supply/Open states.

```
COM3:115200baud - Tera Term VT                                    [─][□][✕]
File  Edit  Setup  Control  Window  Help
 Enter Selection: 0

 Read all device Registers

Control Reg                              0x00
Sense Bank Control Reg                   0x0F
GND/OPEN Hysteresis    Reg BA.1          0x00
GND/OPEN Threshold     Reg BA.0          0x00
Supply/OPEN Hysteresis Reg BC.1          0x00
Supply/OPEN Threshold  Reg BC.0          0x00
Test Mode Reg                            0x00
Sensor Bank 0                            0xFF
Sensor Bank 1                            0xFF
Sensor Bank 2                            0xFF
Sensor Bank 3                            0xFF

Sensors - All Banks                      0xFF
                                         0xFF
                                         0xFF
                                         0xFF


 Press any key to return to main menu
```

12. Return to the main menu. The thresholds now need to be set. There are two ways to do this:

> 1: Preset software settings, key 'p'.

> 2: Manual threshold selection, keys '4' and '5'

If using the preset method, a screen like that shown below is displayed. Select the preset that fits your usage; for example key '1', 'Data Sheet example'. This programs the VTHL and VTHH thresholds as shown below:

GND/Open:

> VTLO is $(2 – 2/2) = 1.0V$

> VTHI is $(2 + 2/2) = 3.0V$

Supply/Open

> VTLO is $(3.5 – 3/2) = 2.0V$

> VTHI is $(3.5 + 3/2) = 5.0V$

```
COM3:115200baud - Tera Term VT
File  Edit  Setup  Control  Window  Help
SUPPLY/OPEN Threshold and Hysteresis     5
Write to a register 1 byte               7
Read a register. 1 byte                  8
Monitor a sensor Bank on LEDs1-8 & PA7   9
Set Test Mode                            t
Monitor Sensors  (hit any key to exit)   m
Set Preset Threshold and Hysteresis      p
Soft Reset                               R
Self Test digital section                S

Enter Selection: p

Stored Settings


0 = Minimum (Thresh = 0.5V, Hyst = 0.2V)

1 = Data sheet example :-
        GND/Open Thresh     = 2V,    Hyst = 2V
        Supply/Open Thresh = 3.5V, Hyst = 3V

2 = Maximum (Thresh = 5.1V, Hyst = 0.2V)

Q = Return to main menu

Enter preset number, one digit
```

13. If preferred, use the second option; manually setting thresholds and hysteresis, using keys 4 and 5. See screen below:


```
COM3:115200baud - Tera Term VT
File  Edit  Setup  Control  Window  Help
SUPPLY/OPEN Threshold and Hysteresis     5
Write to a register 1 byte               7
Read a register. 1 byte                  8
Monitor a sensor Bank on LEDs1-8 & PA7   9
Set Test Mode                            t
Monitor Sensors  (hit any key to exit)   m
Set Preset Threshold and Hysteresis      p
Soft Reset                               R
Self Test digital section                S

Enter Selection: 4

Set GND/Open Threshold/Hysteresis Register

Hysteresis is set at   = 0x0A

Threshold is set at    = 0x14


Enter Hysteresis value (two Hex digits) or q/Q to quit

Enter number : █
```

Enter the hysteresis value as two hex digits, (0A) then threshold (14), press q. If Supply/Open sensors are required press 5 and set thresholds for the Supply/Open.

Press 'q' to return to the main menu. Do a register read again to verify that register values were set correctly, see screen below:

```
COM3:115200baud - Tera Term VT                                    □ ▣ ✕
File  Edit  Setup  Control  Window  Help
 Read all device Registers

Control Reg                              0x00
Sense Bank Control Reg                   0x0F
GND/OPEN Hysteresis     Reg BA.1         0x0A
GND/OPEN Threshold      Reg BA.0         0x14
Supply/OPEN Hysteresis  Reg BC.1         0x0F
Supply/OPEN Threshold   Reg BC.0         0x23
Test Mode Reg                            0x00
Sensor Bank 0                            0xFF
Sensor Bank 1                            0xFF
Sensor Bank 2                            0xFF
Sensor Bank 3                            0xFF

Sensors - All Banks                      0xFF
                                         0xFF
                                         0xFF
                                         0xFF

 Press any key to return to main menu
█
```

14. If you used the example values, a threshold of 3.5V is set with a hysteresis of 3V for the Supply/Open mode, this results in VTHL = 2V and VTHH = 5V. This can be tested by connecting a voltage source to the test point on VSENSE0. Make sure all DIP switches are in the default position.

Return to the main menu then select the monitor mode by pressing button 'm'. This displays a screen that continually monitors the sensor banks. A screen like the one below will appear.

```
COM3:115200baud - Tera Term VT                                    □ ▣ ✕
File  Edit  Setup  Control  Window  Help
                                         0xFF
                                         0xFF
                                         0xFF

Sensor Bank All Banks                    0xFF
                                         0xFF
                                         0xFF
                                         0xFF

Sensor Bank All Banks                    0xFF
                                         0xFF
                                         0xFF
                                         0xFF

Sensor Bank All Banks                    0xFF
                                         0xFF
                                         0xFF
                                         0xFF

Sensor Bank All Banks                    0xFF
                                         0xFF
                                         0xFF
                                         0xFF
```

15. The screen above is monitoring the four register banks. 0xFF means all 8 sensor bits are at a '1' state. In Supply/Open, this means Opens are detected. Now connect a 0V source to the VSENSE0 test point. Increase the voltage up to just below +5V. Now slowly increase the voltage to 5V, close to 5V, Bank0 should start reading 0x00, indicating a closed switch has been detected, as shown in the screen below.

```
COM3:115200baud - Tera Term VT                                       [_][□][X]
File  Edit  Setup  Control  Window  Help
                                                    0xFF                    ▲
                                                    0xFF
                                                    0xFF
Sensor Bank All Banks                               0x00
                                                    0xFF
                                                    0xFF
                                                    0xFF

Sensor Bank All Banks                               0x00
                                                    0xFF
                                                    0xFF
                                                    0xFF

Sensor Bank All Banks                               0x00
                                                    0xFF
                                                    0xFF
                                                    0xFF

Sensor Bank All Banks                               0x00
                                                    0xFF
                                                    0xFF
                                                    0xFF                    ▼
```
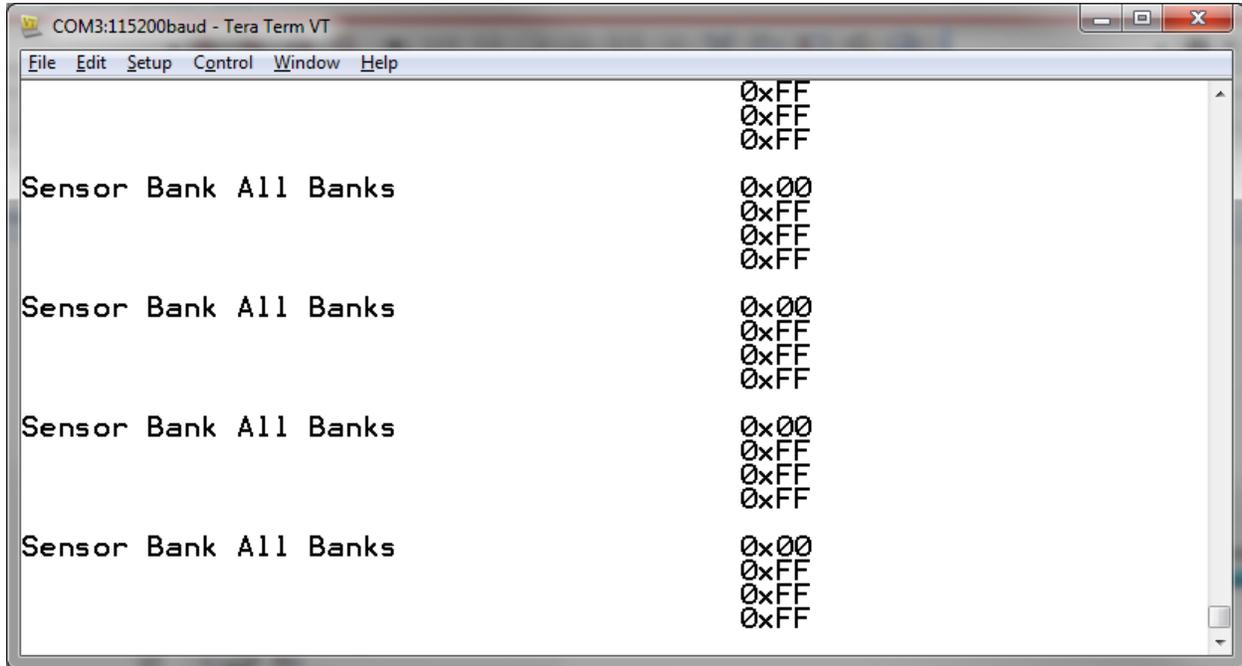
16. Now slowly reduce the voltage. Approaching 2V, Bank 0 should start reading 0xFF again. This verifies the threshold levels.

17. Return to the main menu by pressing any key. The GND/Open mode will be evaluated next. Press key '2' and then key '0'. Then press 'q' to return to Main Menu. Press '0' again to read registers and check that the 'Sense Bank Control Reg' reads 0x00, see below. All 32 sensors are now set to detect the GND/Open states.

```
COM3:115200baud - Tera Term VT                                    ─□ �X

File  Edit  Setup  Control  Window  Help
 Read all device Registers

Control Reg                              0x00
Sense Bank Control Reg                   0x00
GND/OPEN Hysteresis    Reg BA.1          0x0A
GND/OPEN Threshold     Reg BA.0          0x14
Supply/OPEN Hysteresis Reg BC.1          0x0F
Supply/OPEN Threshold  Reg BC.0          0x23
Test Mode Reg                            0x00
Sensor Bank 0                            0x00
Sensor Bank 1                            0x00
Sensor Bank 2                            0x00
Sensor Bank 3                            0x00

Sensors - All Banks                      0x00
                                         0x00
                                         0x00
                                         0x00


 Press any key to return to main menu

■
```

18. If the thresholds use the example values (threshold = 14 and hysteresis = 0A) this sets a center threshold of 2V and a hysteresis of 2V, corresponding to a VTHL = 1.0V and VTHH = 3.0V.

19. A sensor bank or an individual sensor can also be monitored using the '9' key. For example press key '9', then key 0, to select Bank 0. You then have a choice of selecting all sensors from that Bank, or selecting just one. Press key '1'. The selected the sensor outputs are shown on LEDs 1-8 of the micro board, corresponding to sensors 0-7 of that bank.

```
COM3:115200baud - Tera Term VT                                    ─□ X

File  Edit  Setup  Control  Window  Help
 Set Input Test Mode                               3
 GND/OPEN Threshold and Hysteresis                 4
 SUPPLY/OPEN Threshold and Hysteresis              5
 Write to a register 1 byte                        7
 Read a register. 1 byte                           8
 Monitor a sensor Bank on LEDs1-8 & PA7            9
 Set Test Mode                                     t
 Monitor Sensors  (hit any key to exit)            m
 Set Preset Threshold and Hysteresis               P
 Soft Reset                                        R
 Self Test digital section                         S

 Enter Selection: 9

SPI Read a register


 Enter Sensor Bank to monitor (one digit 0-3)

 Enter number : 0



 Enter Sensor # to monitor (one digit 0-7), A for All

 Enter number : 1

Press any key to stop ■
```

20. To test sensor 1, bank 0 connect a voltage source to test point VSENSE0, all SW1 switches should be in the 'OFF' position, except switch 2 should be 'ON'. With 0V, LED2 should be lit. Ramp up the voltage on VSENSE; at around 3V the LED should go off, indicating the sensor has detected an OPEN. Slowly reduce voltage; at around 1V the LED should come back on, indicating the sensor has detected a CLOSED.

21. In this monitor mode, the sensor state can also be monitored on pin PA7 of the SPI mother board, when the sensor changes state; so does the level on PA7. This output can be used to trigger an oscilloscope or a data logger to capture the threshold trigger point.

Connecting external sensors

To connect an external sensor, first make sure the corresponding DIP switch on switches SW1-4 is in the 'OPEN' state. The sensor wires can be connected to the board on the pin headers J1 to J4, see table below.

When using GND/Open sensors, the VWET terminal must be used to pull up the sensors to the higher VWET voltage. With VWET at 28V and VLOGIC at 3.3V, the wetting current will be approximately 0.88mA. If additional wetting current is required, connect an external resistor from VWET to the sense line. There are four VWET terminals, one for each bank of sensors, so the voltage should be applied to the corresponding VWET terminal on the board for that bank. See datasheet for more guidance on wetting current tables and adjustment.

Pin Number	Sensor Number			
	J1	J2	J3	J4
1	0	8	16	24
2	1	9	17	25
3	2	10	18	26
4	3	11	19	27
5	4	12	20	28
6	5	13	21	29
7	6	14	22	30
8	7	15	23	31
9	GND	GND	GND	GND

Connection pins for external sensors

Stand Alone Operation

The evaluation board can be used in a standalone mode (without the lower MCU board). It requires the customer to have access to a SPI interface. Power should be connected between the VDD terminal and ground. The SPI controller should then be connected to J11, using the following pin connections:

Pin Number	Label	Description
1	VDD	VDD, 3.3V Supply
2	nMR	Master Reset
3	CSn	Chip Select
4	SI	Serial Input to HI-8436
5	SCK	Serial Clock Input (up to 20MHz)
6	SO	Serial Output from HI-8436
7	-	Not Used
8	-	Not Used
9	-	Not Used
10	Supply Ground (0V)	GND

J11 connection pins, for external SPI

Other Modes

The HI-8436 has an internal test mode. This can be selected up by hitting key 't' from the main menu. Hit key '3'. Another screen will appear allowing the HI-8436 to internally set the sensor inputs. This test mode can set the internal sensors input to:

a)   All Inputs Set Low (GND)

b)   All Inputs Set High (VDD)

c)   Odd Inputs Set Low (GND)

d)   Odd Inputs Set High (VDD)

After setting the inputs and the sensors bits, use the key '0' command to read back the sensor data to verify correct operation. To exit test mode, a Hardware or Software reset should be used. Note that before using the test mode, the minimum thresholds should be set, otherwise false failures could occur.

Self Test

The self test feature (key 'S' in the menu) runs through the internal test modes; testing the only the digital section of the device. If a register fails, this will be reported. If a sensor fails, the Bank and pattern that failed will be shown on the screen.

Soft Reset

This resets all registers to the default state.
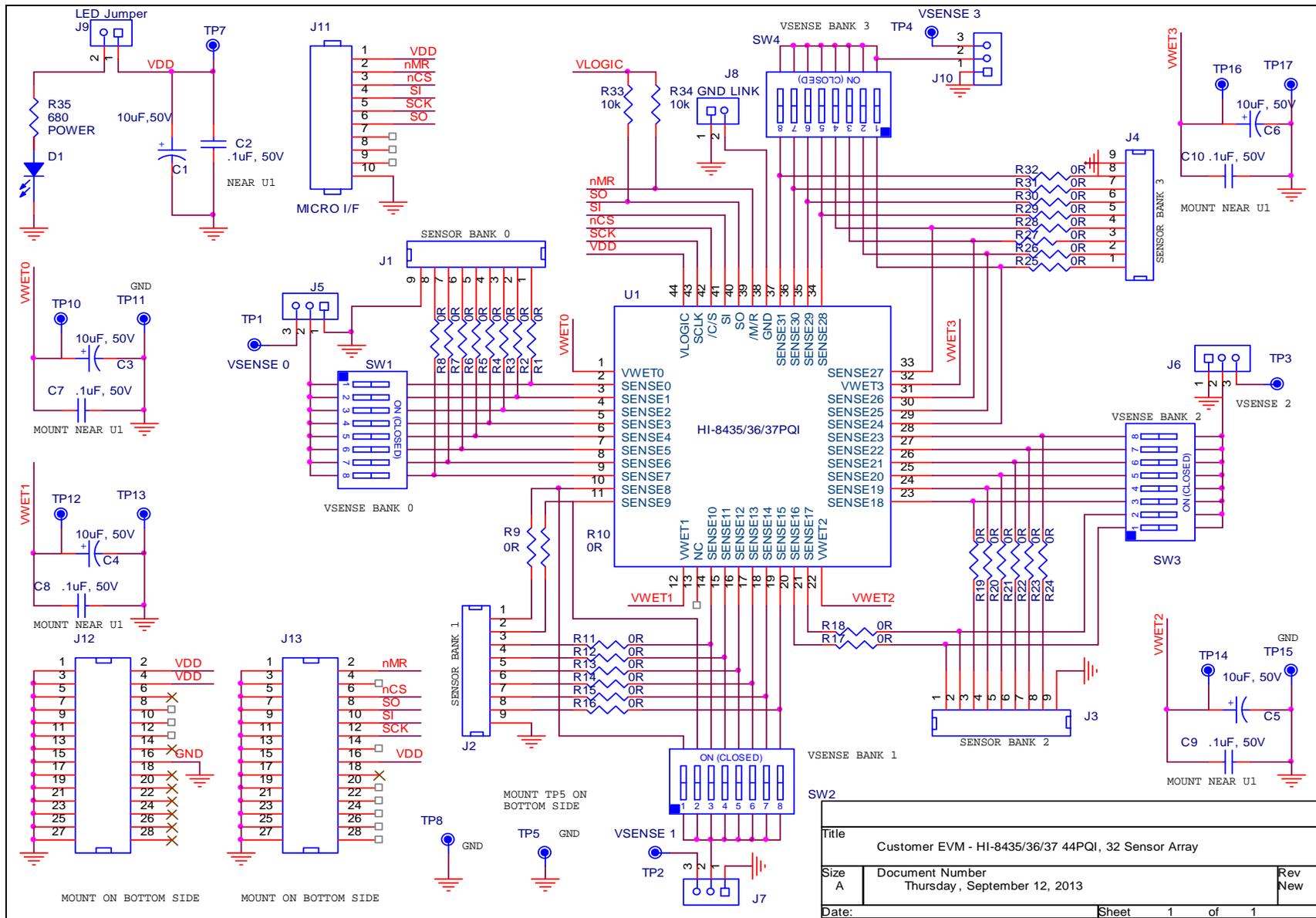
AN-8436, Rev. New   HOLT INTEGRATED CIRCUITS   Sept 2013

	Bill of Materials		HI-8436 Evaluation Board		Revised: 09/12/13
Qty	Description	Reference	DigiKey		Mfr P/N
5	Capacitor, Cer 0.1uF 20% 50V Z5U 0805	C2,C7,C8,C9,C10	399-1176-1-ND		Kemet C0805C104M5UACTU
5	Cap Alum 10uF 50V 20% SMD	C1,C3,C4,C5,C6	493-6255-1-ND		Nichicon UUT1H100MCL1GS
4	Header, Male 1x9, .1" Pitch	J1,J2,J3,J4	S1012E-09-ND		Sullins S1012E-09-ND
4	Header, Male 1x3, .1" Pitch	J4,J5,J6,J10	S1012E-03-ND		Sullins S1012E-03-ND
3	Header, Male 1x2, .1" Pitch	J8,J9,J12	S1012E-02-ND		Sullins S1012E-02-ND
1	Header, Male 1x10, .1" Pitch	J11	S1012E-10-ND		Sullins S1012E-10-ND
1	Header, Female 2x14, .1" Pitch	J13	S7082-ND		Sullins PPTC142LFBN-RC
1	LED Green 0805	D1	160-1179-1-ND		LiteOn LTST-C170GKT
32	Resistor, 0 5% 1/4W 1206	R1- R32	P0.0ECT-ND		Panasonic ERJ-8GEY0R00V
1	Resistor, 680 5% 1/4W 1206	R35	P680ECT-ND		Panasonic ERJ-8GEYJ681V
2	Resistor, 10K 5% 1/4W 1206	R33,R34	P10KECT-ND		Panasonic ERJ-8GEYJ103V
4	Switch Tape Seal 8Pos SMD	SW1,SW2,SW3,SW4	CT2198MST-ND		CTS 219-8MST
1	Test Point, Red Insulator, 0.062" hole	TP7	5010K-ND		Keystone 5010
6	Test Point, Black Insulator, 0.062" hole	TP11,TP13,TP8,TP5,TP15,TP17	5011K-ND		Keystone 5011
4	Test Point, White Insulator, 0.062" hole	TP10,TP12,TP14,TP16	5012K-ND		Keystone 5012
4	Test Point, Orange Insulator, 0.062" hole	TP1,TP2,TP3,TP4	5013K-ND		Keystone 5013
1	HI-8436PQI - 44PQFP	U1	HOLT IC		Holt IC
4	Stand-off, Threaded #4-40F, 3/4" Long Round	Any	3481K-ND		Keystone 3481
4	Machine Screw, #4-40 x 1/4"	Any	H343-ND		PMS 440 0031 PH
4	Lock Washer, Int.Tooth #4-40	Any	H236-ND		B&F Intlwz 004

General Purpose SPI Evaluaton Board)
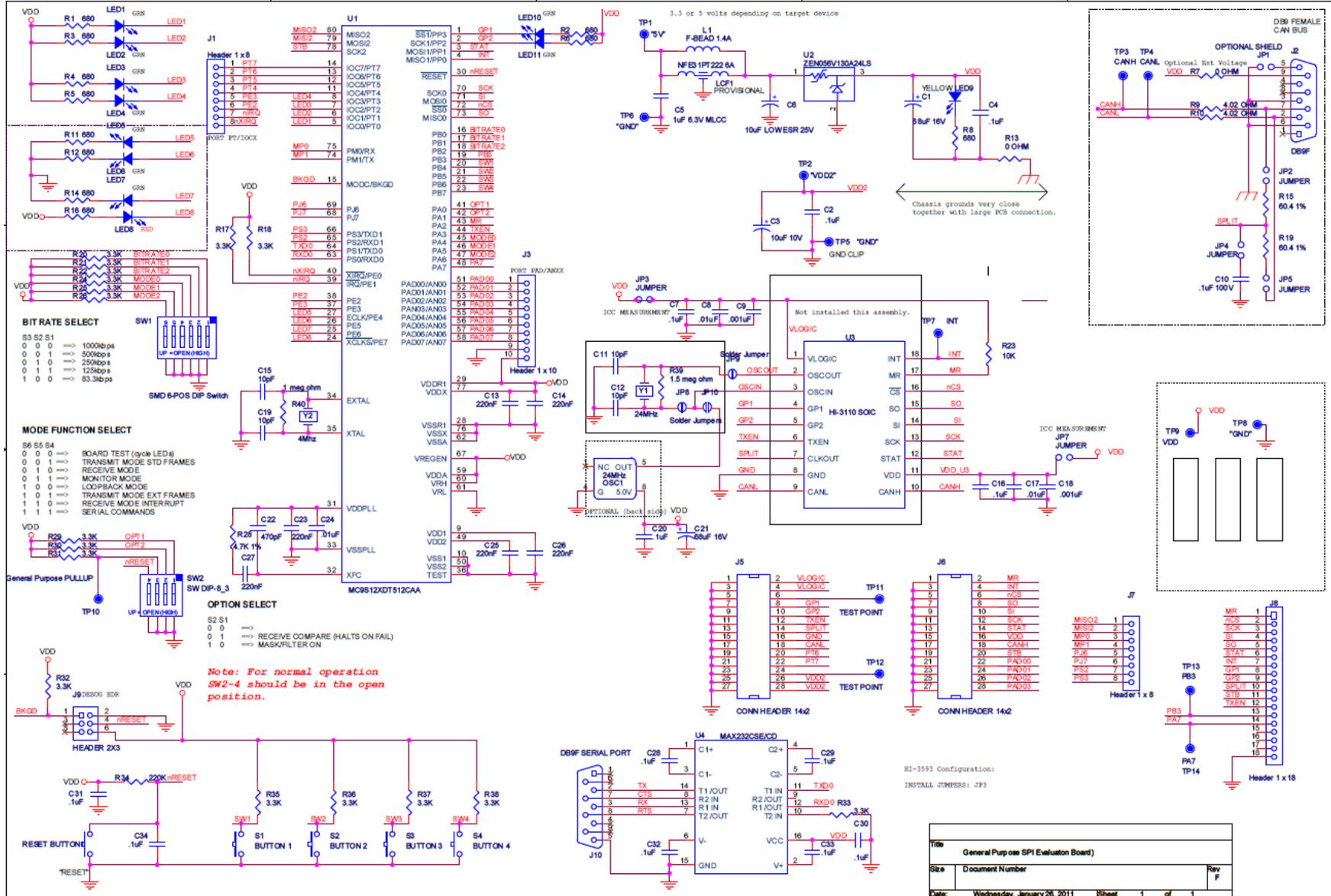
Appendix 1   Lightning Protection

All sense inputs are protected to RTCA/DO-160G, Section 22, Categories AZ and BZ, Waveforms 3, 4, 5A, without external components. In addition, all inputs are also protected to ZZ, Waveforms 3 and 5B, to provide more robustness in composite airframe applications. For details of the Z levels, please see the latest datasheet.

The level of lightning protection can be increased by adding a resistor in series with the sensor input. On the Evaluation Board these resistors, R1-32, are populated with 0 ohm links, the value of R1 to R32 can be changed. Refer to Application Note AN-305, available from the Holt website.

The layout of a HI-8436 board should always have low conductivity paths from the device power/ground pin to the relevant power or ground origin. These paths should avoid proximity to sense or other signal traces; this applies to conductors above, below and horizontally adjacent. It is good practice to have a power and ground 'moat' beneath the sense line to prevent disturbance on these lines during a 'lightning' event.

Appendix 2   Demo software overview

This overview flow chart shows the demo program at a glance.

```
                    ┌─────────────────┐
                    │  Main.c Start   │
                    └─────────────────┘
                             │
        ┌──────────────────────────────────────┐
        │ Initialize global variables + arrays │
        │ Initialize Peripherals               │
        │ Initialize Interrupts                │
        │ Initialize Timer                     │
        │ Configure MCU SPI bus                │
        │ Display LEDs                         │
        │ Display SW rev. on LEDs              │
        │ Configure UART                       │
        │ Set SPI clock rate                   │
        │ Display console header               │
        │ Perform HW Reset                     │
        └──────────────────────────────────────┘
```

Scan SW1 for Board Mode — Mode = '111' → Device # 8435

Scan SW1 for Board Mode — Mode = '110' → Device # 8436

Scan SW1 for Board Mode — Mode = '101' → Device # 8437

Mode = '000' → Perform Board LED and Switch Test

Display Control Menu

Scan Keyboard for Menu Selection

Valid function selected? — Y → Goto Case Key commands

N

At reset the program can enter either of two modes, Board Test mode or Serial Command mode, this is selected by the three mode switches. To restart in a different mode, reconfigure the mode switches and reset the board. Board test mode is just used to test some basic functions on the main SPI board, such a switches and LEDs.

Serial Command mode is used for the demonstration of the HI-8436.
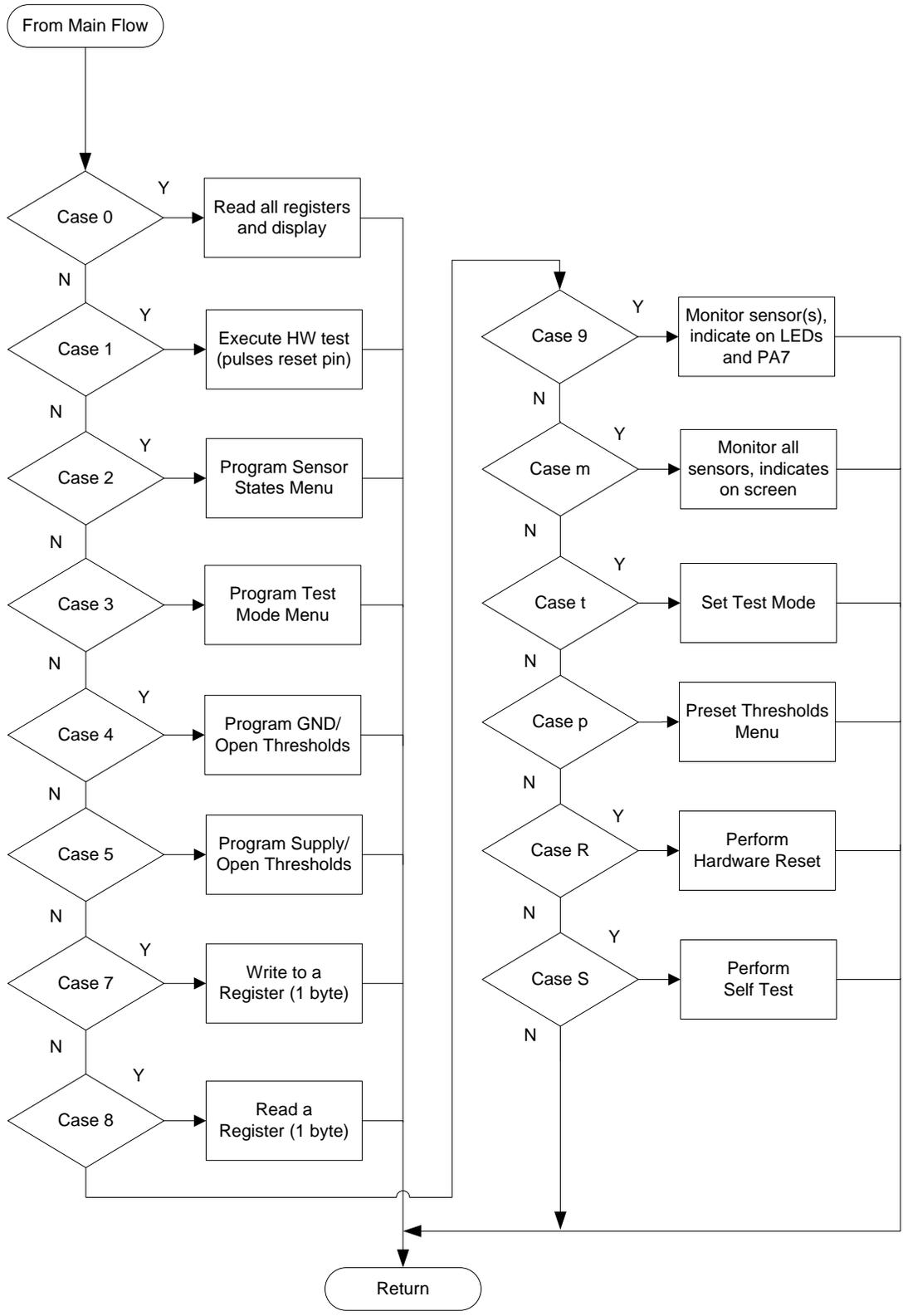
MCU Clock and SPI Frequencies

The Freescale MC9S12XDT512 (MCU) on the main board uses a 4MHz crystal for operation and the built-in PLL multiplies this by 20 to achieve an 80MHz system clock. This system clock is divided by two for a 40MHz Bus Clock, used internally for the MCU peripherals.

The PLL is programmed to multiply by 20 by this line of code in the Peripherals.c module:

```
    SYNR = 9;                        // 80MHz PLL system clock
```

The SPI frequency is set by this code in the main.c module:

```
    if(!SW4)                          // Set SPI to 10Mhz if SW4 pressed at power up
  {
    SPI0BR = 0x01;                // 10MHz SPI
    xprint("SPI = 10MHz  ");
  } else
    SPI0BR = 0x00;                // 20MHz SPI

 if(!SW3) {

   SPI0BR = 0x02;                 // 5MHz SPI
   xprint("SPI = 5MHz  ");
```

The maximum SPI frequency for the HI-8436 is 20MHz and is set by default. By pressing SW4 during reset a 10MHz clock can be set. Similarly a 5MHz clock can be set by pressing SW3.

Timing and Delay Functions

These functions provide the basic timing for the program. The Delay100us() can be used anywhere an accurate delay is needed in the program .

The global g_count100us variable is decremented at the 100us timer rate. This variable is used by a general delay function which can be called with a specified number of delay intervals. The g_count100us variable is a 16-bit integer so the delay ranges from 100us to 6.5536 seconds.

```
    // -----------------------------------
    // General timer tick 100us for delays
    // -----------------------------------
    void Delay100us(unsigned int delay){
        g_count100us=delay;
        while(g_count100us);

    }
```

```
        Timer_ISR                              Delay100us(delay)

   Reload for next interrupt                  G_count100us=delay;
   Decrement  g_count100us tick
```
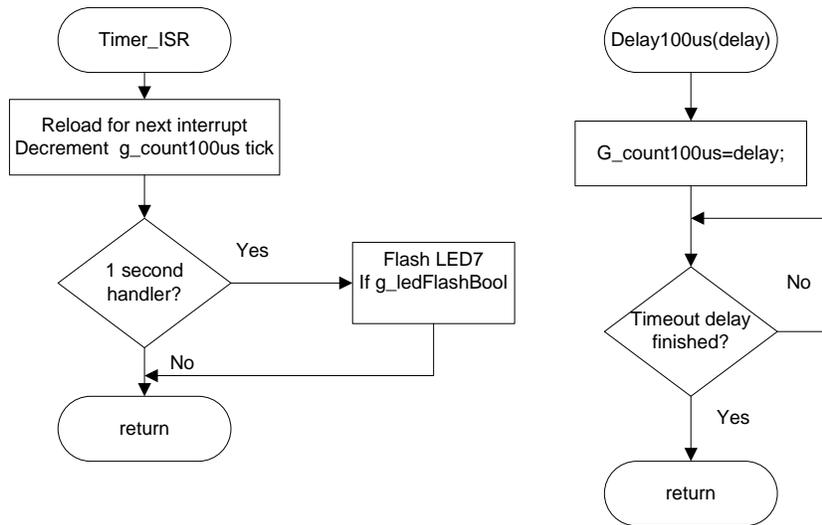

A number of predefined constants are defined which can be used in function calls.

```
#define K_1MS   10          // 1ms
#define K_10MS  100         // 10ms
#define K_100MS 1000        // 100ms
#define K_1SEC  10000       // 1 second
```

Usage: Delay100us(K_1SEC); // delay of 10000*100us (one second)

A one second interrupt handler in the TIMER_ISR is provided. Any code placed here automatically executes every second.

```
if(!count100us)
  {                                       // 1 second scheduler
      count100us = K_1SEC;
      if(ON==g_ledFlashBool)              // Flash the LED7 if enabled
        LED7 ^= TOGGLE;
  }
```

SPI Driver Functions

There are five SPI functions used in the program, these primitive SPI functions make up the basic read and write functions to access the SPI interface of the HI-8436. More complicated functions perform multi-byte reads or writes; these are basically derivatives of the simpler single-byte functions. All HI-8436 SPI driver functions are included in the 8435Driver.c module and its 8435Driver.h header file. The MCU /SS pin is connected to the HI-8436 /CS pin.

```
     ┌─────────────────┐                              ┌─────────────────┐
     │    R_Register   │                              │  MultiByteRead  │
     └────────┬────────┘                              └────────┬────────┘
              │                                                │
   ┌──────────▼──────────┐                          ┌──────────▼──────────┐
   │ Reconfigure /SS as  │                          │ Reconfigure /SS as  │
   │ GPIO  Set /SS low   │                          │ GPIO  Set /SS low   │
   └──────────┬──────────┘                          └──────────┬──────────┘
              │                                                │
   ┌──────────▼──────────┐                          ┌──────────▼──────────┐
   │ Transmit the Opcode │                          │ Transmit the Opcode │
   └──────────┬──────────┘                          └──────────┬──────────┘
              │                                                │
           ◇ Transmit complete?  No                        ◇ Transmit complete?  No
              │ Yes                                            │ Yes
   ┌──────────▼──────────┐                          ┌──────────▼──────────┐
   │ Transmit dummy byte │                          │ Transmit dummy byte │
   │  to receive data    │                          │  to receive data    │
   └──────────┬──────────┘                          └──────────┬──────────┘
              │                                                │
           ◇ Received Byte ?  No                            ◇ Received Byte ?  No
              │ Yes                                            │ Yes
                                                            ◇ Last Byte ?  No
                                                               │ Yes
   ┌──────────▼──────────┐                          ┌──────────▼──────────┐
   │ Clear SPI status reg│                          │ Clear SPI status reg│
   │ Load SPI data reg   │                          │ Load SPI data reg   │
   │ with cmd            │                          │ with cmd            │
   └──────────┬──────────┘                          └──────────┬──────────┘
              │                                                │
     ┌────────▼────────┐                              ┌────────▼────────┐
     │  Return R_Reg   │                              │  Return R_Reg   │
     └─────────────────┘                              └─────────────────┘
```
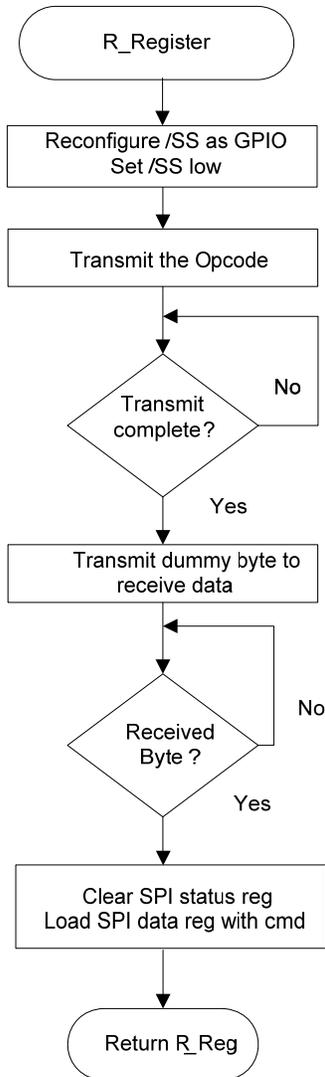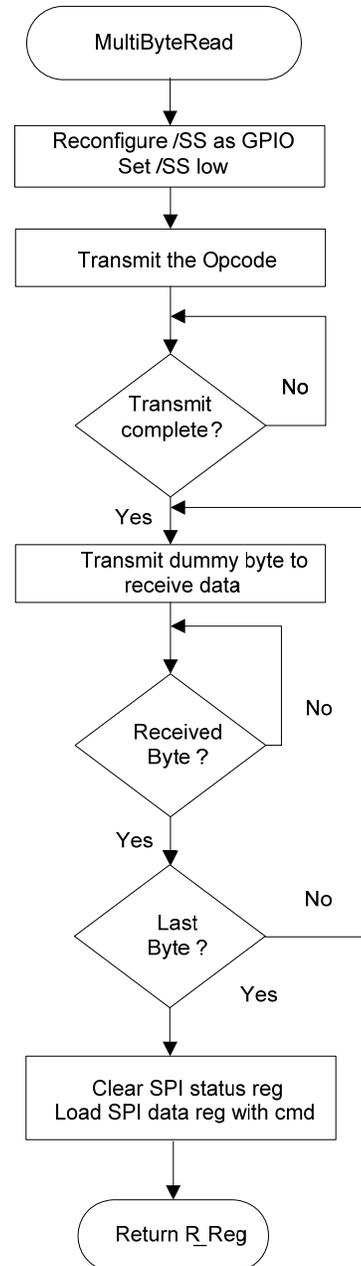
SPI Read Functions

W_Command

```
        ( W_Command )
             │
             ▼
  ┌──────────────────────┐
  │ Reconfigure /SS as   │
  │ GPIO  Set /SS low    │
  └──────────────────────┘
             │
             ▼
  ┌──────────────────────┐
  │ Clear SPI status reg │
  │ Load SPI data reg    │
  │ with cmd             │
  └──────────────────────┘
             │
             ▼
         ╱Transmit╲  No
        ╱ complete? ╲──┐
        ╲          ╱  │
         ╲        ╱   │
           Yes
             │
             ▼
  ┌──────────────────────┐
  │ Clear SPI status reg │
  │ Load SPI data reg    │
  │ with cmd             │
  └──────────────────────┘
             │
             ▼
        ( return )
```

TransmitCommandAndData

```
   ( TransmitCommandAndData )
             │
             ▼
  ┌──────────────────────┐
  │ Reconfigure /SS as   │
  │ GPIO  Set /SS low    │
  └──────────────────────┘
             │
             ▼
  ┌──────────────────────┐
  │ Transmit the cmd     │
  │ Opcode               │
  └──────────────────────┘
             │
             ▼
         ╱Transmit╲  No
        ╱ complete? ╲──┐
        ╲          ╱   │
           Yes
             │
             ▼
  ┌──────────────────────┐
  │ Transmit the 1st byte│
  └──────────────────────┘
             │
             ▼
         ╱Transmit╲  No
        ╱ complete? ╲──┐
        ╲          ╱   │
           Yes
             │
             ▼
  ┌──────────────────────┐
  │ Transmit the 2nd byte│
  └──────────────────────┘
             │
             ▼
         ╱Transmit╲  No
        ╱ complete? ╲──┐
        ╲          ╱   │
           Yes
             │
             ▼
  ┌──────────────────────┐
  │ Clear SPI status reg │
  │ Load SPI data reg    │
  │ with cmd             │
  └──────────────────────┘
             │
             ▼
        ( Return )
```

W_CommandValue

```
      ( W_CommandValue )
             │
             ▼
  ┌──────────────────────┐
  │ Reconfigure /SS as   │
  │ GPIO  Set /SS low    │
  └──────────────────────┘
             │
             ▼
  ┌──────────────────────┐
  │ Transmit the cmd     │
  │ Opcode               │
  └──────────────────────┘
             │
             ▼
         ╱Transmit╲  No
        ╱ complete? ╲──┐
        ╲          ╱   │
           Yes
             │
             ▼
  ┌──────────────────────┐
  │ Transmit the value   │
  └──────────────────────┘
             │
             ▼
         ╱Transmit╲  No
        ╱ complete? ╲──┐
        ╲          ╱   │
           Yes
             │
             ▼
  ┌──────────────────────┐
  │ Clear SPI status reg │
  │ Load SPI data reg    │
  │ with cmd             │
  └──────────────────────┘
             │
             ▼
        ( Return )
```

SPI Write Functions

Special handling of the /SS SPI signal:

All HI-8436 SPI Op-Codes require the $\overline{CS}$ to remain low for the complete duration of the data transfer including multi-byte reads and writes. Refer to figures 6 and 7 of the data sheet for timing diagram examples.

On the Freescale MCU the $\overline{CS}$ is driven by the SPI slave select line $\overline{SS}$, this must by default be configured as a GPIO and controlled directly by software. This technique is common for devices requiring the $\overline{CS}$ line to remain low during multi-byte transfers. All SPI accesses will consist of an integer number of 8-bit segments, either an opcode or data. The first positive SCK edge must occur after $\overline{CS}$ is asserted low; the last falling SCK edge must occur before the $\overline{CS}$ is negated high as shown in the following diagram:
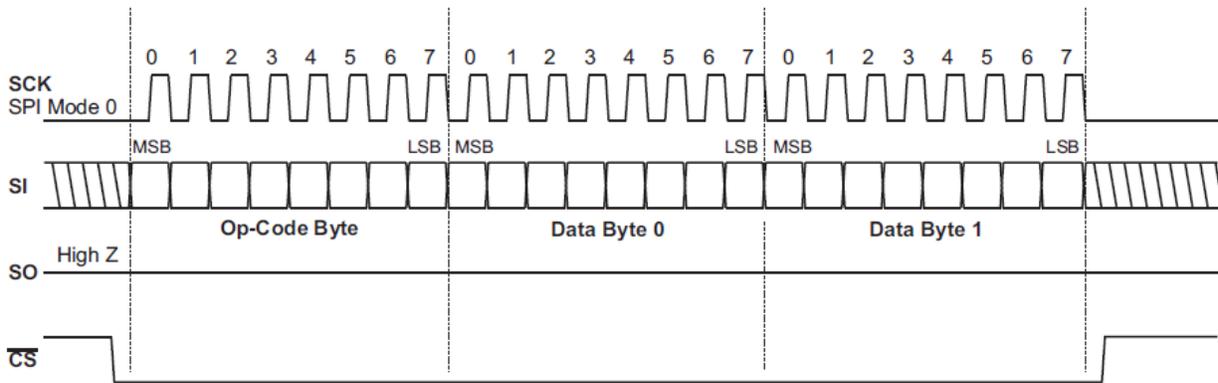
Uart.c   Serial Port (RS-232)

The drivers supporting the serial port (console) are contained in this module. Some function drivers allow messages to be sent and received on the UART. This is useful to log status or data messages on HyperTerminal or any other terminal program. It currently uses polling to determine when the data receive or transmit registers can be read or written.

LEDs
LED1-LED8

These LEDs are controlled by a function in the program. LED1-LED4s and LED8 are active-low logic and LED5-LED7s are active-high logic. Using this support function allows a universal way to turn the LEDs on and off from the program. The Freescale MC9S12DT part uses the pins PE5, PE6, PE7 for configuration sense pins during reset, so the logic on these three pins must be reversed so the MCU sees a low at reset time.

```
// -----------------------------------------------------
// Control LED1 - LED8
// ledNumber: LED_1,LED_2,LED_3,LED_4....LED_8 [1-8]
// OnOff: 1=ON, 0=OFF
// -----------------------------------------------------
void LED_CTL(uint8 ledNumber, uint8 OnOff){
#if NEWBOARD
    if(ledNumber>4 && ledNumber<8)// LEDs 5-7 have reversed HW logic so invert
                                    these 3
#else
    if(ledNumber>4)         // Old board.
#endif

        OnOff = ~OnOff;
    switch (ledNumber){
        case 1:  LED1=OnOff;  break;
        case 2:  LED2=OnOff;  break;
        case 3:  LED3=OnOff;  break;
        case 4:  LED4=OnOff;  break;
        case 5:  LED5=OnOff;  break;
        case 6:  LED6=OnOff;  break;
        case 7:  LED7=OnOff;  break;
        case 8:  LED8=OnOff;  break;
        default: break;
    }
}
```

Usage examples:

```
LED_CTL(LED_1,OFF);         // turns off LED1
LED_CTL(LED_1,ON);          // turns on LED1
```

A similar function, LED_BYTE(uint8 LEDByte), sends a byte to control LED1 though LED8, with a '1' powering up the LED and a '0' turning it off. LED1-LED8 map to bits 0 to 7.

LED 9

When illuminated this indicates the VDD supply is present.

LED 10, 11

These are not used in this program.

HI-8436 demo Codewarrior Software Project

The software project is built with Freescale's CodeWarrior version 5.9.0 using the free limited 32K version. The current code size of the demo is approximately 16K. The main functions are in main.c and the low level HI-8436 drivers are in the 8435Driver.c file. The software project "HI-8436 Demo" will

normally be distributed in a zip file on a CD-ROM with the same name. **To develop, debug and download this software into the board, a PE Micro "USB Multilink Interface" debug cable is necessary. It is not provided in this kit.** To purchase this cable, go to the PE Micro website or purchase it from Digi-Key. See the links at the end of this document.

Project Files

Source Files
|	
main.c	Main code
8435Driver.C	SPI low-level drivers for the HI-8436
Peripherals.c	GPIO, PLL frequency setup and SPI configuration
BoardTest.c	Board Test functions
Uart.c	Low-level UART drivers
datapage.c	Freescale IDE support file

Include Files

Main.h	
8435Driver.h	HI-8435 header
Peripherals.h	
BoardTest.H	
Uart.h	
Common.h	Common defines for the project
Derivative.h	Freescale IDE support file
Mc9s12xdt512.h	Freescale IDE target part support file

CodeWarrior and Software Project Installation:

1. Download and install the CodeWarrior IDE from the Freescale website. The download links are provided below.

2. Unzip the HI-8436 zip file into the directory you plan to use for your project.

3. Navigate to the HI-8436 project folder and double click the HI-8435 Demo.mcp project file to launch this project with CodeWarrior. The IDE should open with the project files on the left side of the window.

4. Click Make from the Project menu to rebuild the project. The project should build without errors. You may receive a dead assignment warning if for example some defines are set to a zero value.

5. **Install the PE Micro USB Multilink Interface cable per the instructions.**

6. Plug the USB Multilink 6-pin debug cable into the J9 debug connector and power up the board with 3.3V.

7. Download the program by clicking Debug from the Project menu. The first time you download you may need to configure the debugger for the USB Multilink cable. After downloading is complete the debugger window should be displayed with the first line in main.c highlighted. Press the green arrow button to run the program. Since the program has been loaded automatically you can power down the board and then power up, and the program should run automatically without the debugger.

Holt HI-8436 project loaded with CodeWarrior 5.9.0
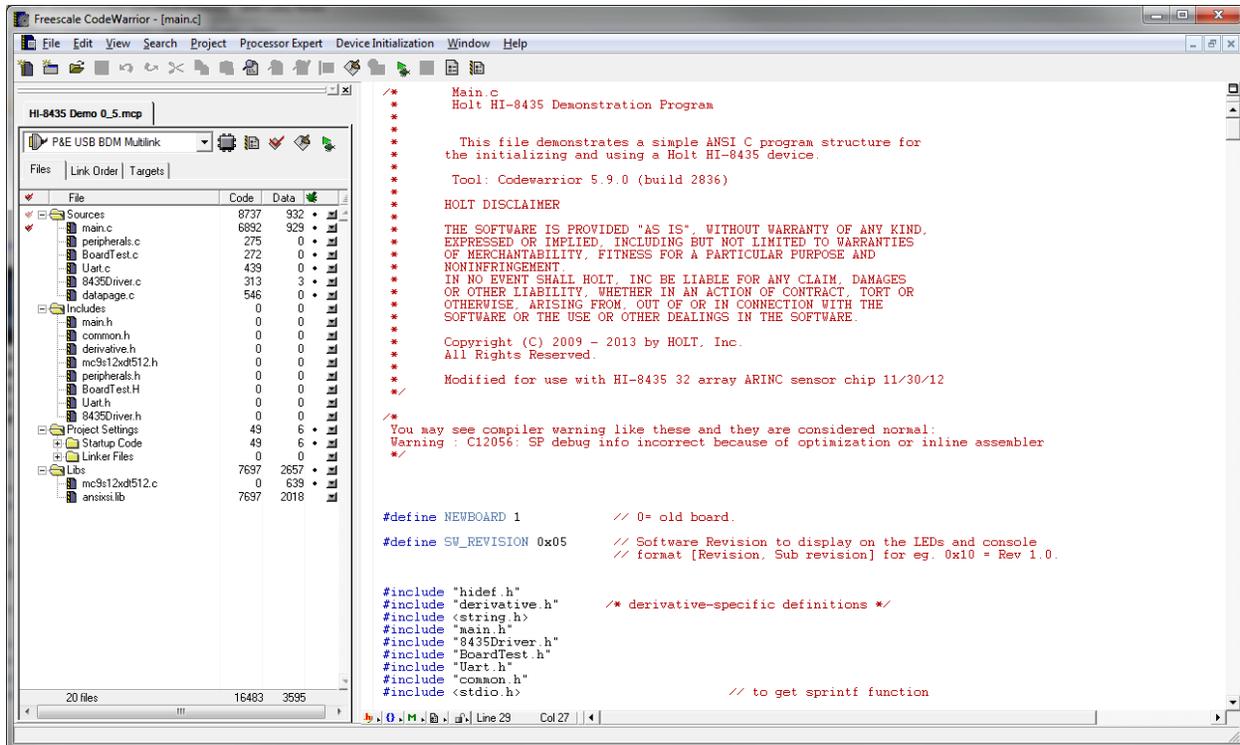
Freescale MC9S12XDT512xxx Development Tools

The Freescale microcontroller data sheet and other documentation can be found at this link:

http://www.freescale.com/webapp/sps/site/prod_summary.jsp?code=S12XD&tid=16bhp

If these links become out of date go to: http://www.freescale.com/ , then search for information on "S12XD: 16-Bit Automotive Microcontroller".

A free 32K limited program limited version of the Code Warrior IDE from Freescale is available:

http://www.freescale.com/webapp/sps/site/prod_summary.jsp?code=CW-HCS12X&tid=CWH#

The US Multilink debugger cable used for this project is:

http://www.freescale.com/webapp/sps/site/prod_summary.jsp?code=USBMULTILINKBDM&parentCode=S12XD&fpsp=1

http://search.digikey.com/scripts/DkSearch/dksus.dll?Detail&name=USBMULTILINKBDME-ND

References:

http://www.holtic.com/

REVISION HISTORY

Revision	Date	Description of Change
AN-8436, Rev. New	9-12-13	New

3