DIGITAL COMPASS REFERENCE DESIGN KIT USER'S GUIDE

1. Kit Contents

The Digital Compass Reference Design Kit contains the following items:

- C8051F350 Digital Compass Reference Design Board
- Silicon Laboratories Reference Design CD-ROM. CD content includes the following:
  - PC Compass GUI
  - Driver installation utility
  - Documentation
  - Digital Compass Reference Design Kit User's Guide (this document)
- USB Cable
- Two AAA alkaline batteries

2. Introduction

The Digital Compass Reference Design Kit combines the performance of Silicon Laboratories MCUs and the latest sensors in magnetic and tilt measuring. This reference design, in addition to offering a high-performance and reliable compass solution, demonstrates the ability to interface sensors directly to an MCU.

3. Getting Started

The Digital Compass Reference Design Board is a fully functional tilt-compensated digital compass. It can be powered via batteries for stand-alone operation or via the USB cable when used in conjunction with the GUI. Before you use your compass, it **must be calibrated**.

- Install the two AAA alkaline batteries (noting the polarity markings)
- Press the ENTER button
- Perform the calibration procedure described in "6.6. Calibration" on page 7.

The compass will display a traditional direction heading (e.g., N, S, E, W) with absolute information displayed in degrees minutes format. In addition, an arrow and a corresponding 'N' will always point north.

4. General Description

A compass is a navigational instrument for finding direction. It consists of a magnetized pointer, free to align itself accurately with Earth's magnetic field. It is the oldest instrument for navigation and still is a vital tool even in present times when GPS exists. Here are the definitions of some terms you will see throughout this user manual:

- **Azimuth** is the angle between magnetic north and the heading direction.
- **Ddeclination** is the angle between geographic or true north and magnetic north.

5. Reference Design Board

The following is a general description of the Digital Compass Reference Design board:

- Dimensions: 55 x 85 x 16 mm
- Weight: 60 grams
- Function buttons: SW1 (MENU), SW2 (ENTER), and SW3 (RESET)
- LCD display
- USB connector
- Debug connector
- USB and POWER LEDS
- Power connector
- Slot for 2 x AAA batteries

Note: The USB and power jack are under the LCD display.

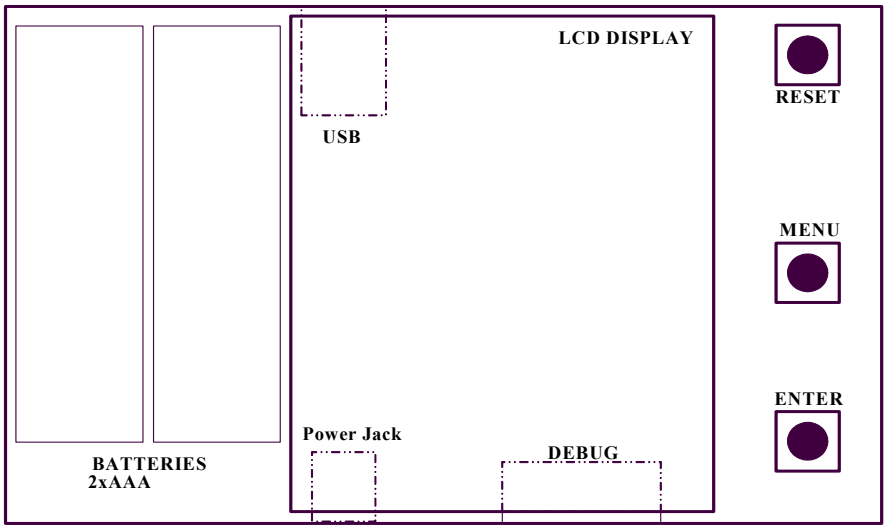

Figure 1. Digital Compass Reference Design Board

5.1. USB

The compass can easily be connected to a PC using the USB port. Software is provided to communicate with the compass through USB. This software displays the same information provided by the compass using a friendly interface. See Section 8 for details on installing the provided software. Additionally, the USB connection provides power to the board when connected to a PC. While the USB connector is plugged in, the USB icon will be displayed on the LCD.

5.2. LCD

The following is a list of indicators that could be shown on the LCD display. See Figure 2 for a diagram of the LCD display with all the segments on:

1. Symbols that are used during the calibration process:
   - CALIBRATION - calibration routine is in progress
   - ERROR - error encountered during calibration process
   - TURN - the compass must be turned a full circle
2. Digits and symbols used for azimuth, temperature, or inclination display:
   - Five digits
   - Degree (°) and minute (') symbols used in azimuth display
   - X and Y symbols used in inclination display
   - Decimal point used for temperature display
3. Indications that either temperature, inclination, or azimuth is displayed:
   - When neither of them is on, the azimuth is displayed.
   - When temperature is on, the environment temperature is displayed.
   - When inclination is on, the tilt angles on both X and Y axes is displayed.
4. Sixteen arrows that indicate the North direction relative to the reference point.
5. Silicon Laboratories logo.
6. Three digits that indicate the heading or the menu of the compass.
7. USB, battery low icons.

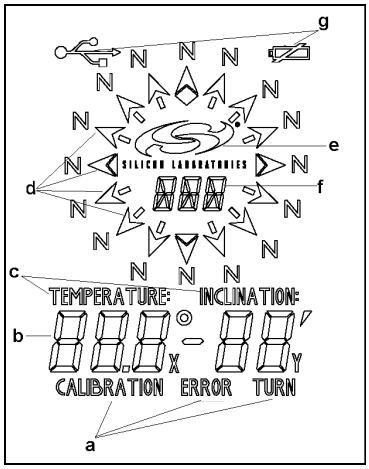

Figure 2. LCD Indicators

5.3. Buttons

The MENU and ENTER buttons are located on the board to provide access to the compass menu. The following is a short description of these button functions. See Section 6 for a more detailed description of the operation of the compass.

1) Press MENU (SW1) to enter the compass menu. Options in menu are:

   a) A - displays azimuth information

   b) t - displays temperature information

   c) I - displays inclination information

   d) Ct - calibration of tilt sensor

   e) C - calibration of magnetic sensors

Note: During the calibration process, the MENU button is used to input angle of declination. See "6.6. Calibration" on page 7 for further details on the calibration process.

2) ENTER (SW2) has the following functions:

   a) Enables the option selected in the menu.

   b) If temperature is displayed, toggles between Celsius and Fahrenheit degrees.

   c) During calibration process it is used to save angle of declination.

Pressing the RESET button will send a reset signal to the C8051F350 device on the board. When this occurs, all the segments of the LCD display will be active for a short period of time. After reset, the compass will display the azimuth mode.

5.4. Power

The compass solution is a low power device. The following are power specifications for the board:

1. Supply voltage: two AAA batteries, USB or AC-DC adapter (max voltage 12 V)
2. Supply current: average of 18 mA, stand-by 4 uA

6. Modes Of Operation

6.1. Power Up

When powered from USB, battery, or AC-DC adaptor, at power up, all the segments of the LCD display will turn on. This is an indicator that a normal power up has occurred. After power-up, the compass will display the azimuth mode.

6.2. Azimuth

The default information that is displayed after each reset, power-up, or calibration is the azimuth. If you choose another mode to be displayed and want to return to the azimuth mode, choose menu option "A" and press the ENTER button to select this option.

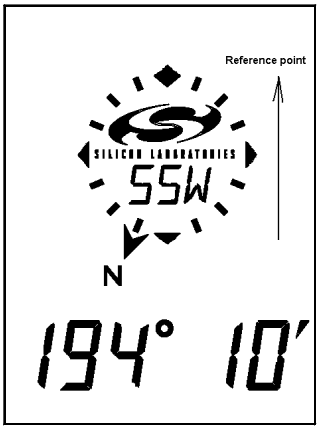

Figure 3. LCD Azimuth Mode Display

6.3. Temperature

Another feature of the Digital Compass Reference Design board is measuring and displaying the ambient temperature using the on-chip temperature sensor of the MCU. Choose menu option "t" and press the ENTER button to select this option. Temperature can be displayed either in Celsius degrees or Fahrenheit degrees, as shown in Figure 4. Press the ENTER button to toggle between temperature displays. Temperature is displayed by default using Fahrenheit degrees.

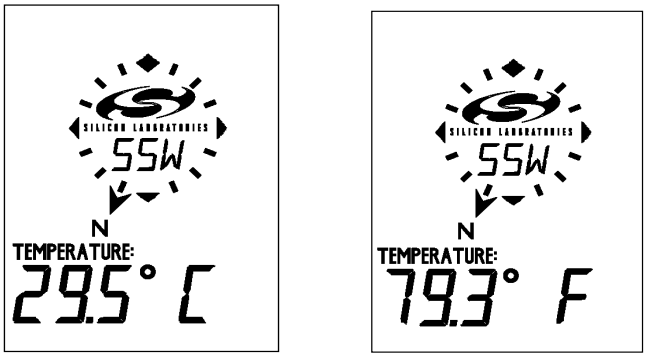

Figure 4. LCD Temperature Mode Display

6.4. Inclination

Choose menu option "I" and press the ENTER button to select this option. Angles of tilt on both X and Y axes will be displayed on the LCD. Inclination angles can be measured correctly up to 70 degrees on both axes. Beyond this value the degree displayed will be 70.

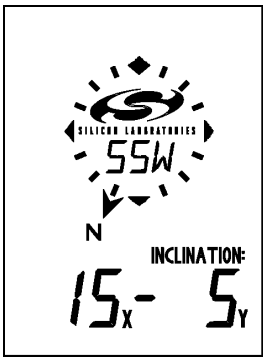

Figure 5. LCD Inclination Mode Display

6.5. Tilt Calibration

To calibrate the tilt of the compass, put the board in a horizontal position. Choose menu option "Ct" and press the ENTER button to select this option. "CALIBRATION" and "INCLINATION" segments will appear during the calibration process as shown in Figure 6. Do not tilt or move compass during tilt sensor calibration. After tilt calibration the compass will display the inclination angles. Tilt calibration should be performed after every compass calibration procedure.

Figure 6. LCD Tilt Calibration Mode Display

6.6. Calibration

To calibrate the compass, put the board in a horizontal position. Choose menu option "C" and press the ENTER button to select this option. Use the following steps to perform a calibration of the magnetic compass:

1. Hold the compass in a perfectly horizontal position. The symbols "CALIBRATION" and "TURN" will be displayed on the LCD as shown in Figure 7.

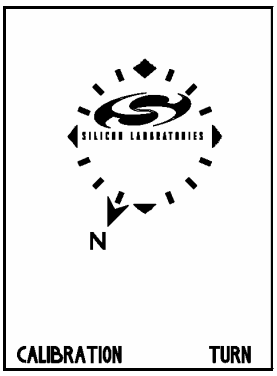

Figure 7. LCD Calibration Mode Display

2. Start rotating the compass and keep it as horizontal as possible (Figure 8). Any tilt of the compass during the rotation will introduce errors in the calibration values. The arrow will make one complete turn during this step of the calibration procedure. While the arrow makes a complete turn, it is recommended that the compass be rotated approximately four complete turns.

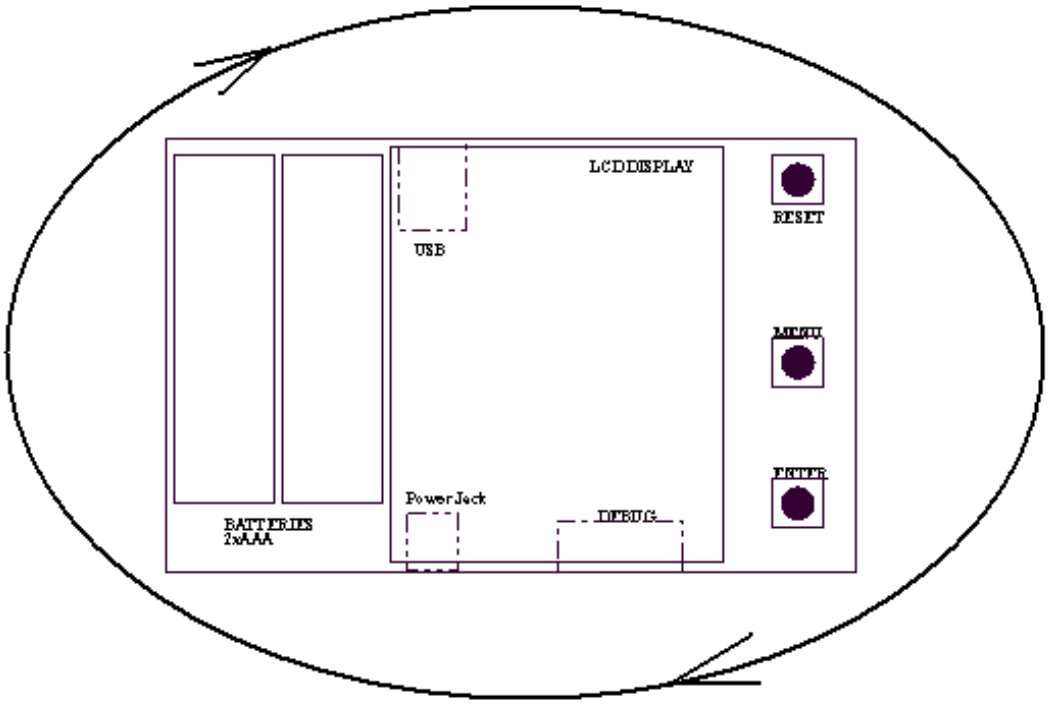

Figure 8. Compass Rotation during Calibration

3. Turn the compass upside down, again as horizontal as possible, and allow it to remain stable for several seconds.
4. Turn the compass back over to introduce the degree value of the declination angle. Use the MENU button to increment the value. The display will appear as shown in Figure 9. After the correct value of the declination angle for your region has been set, press the ENTER button. See “7. Declination Angle” for an overview of the declination angle.

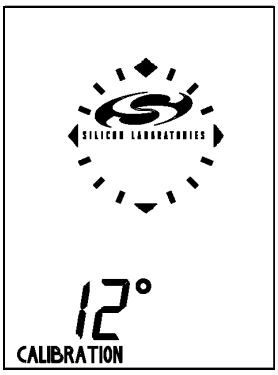

Figure 9. LCD Declination Angle Degree Display

5. Use the MENU button to increment the minute value of the declination angle. The display will appear as shown in Figure 10. After you have finished, press the ENTER button.
6. Perform tilt calibration (See "6.5. Tilt Calibration" on page 6).

Figure 10. LCD Declination Angle Minute Display

The calibration procedure is now finished, and the compass will display the azimuth and the direction. If the calibration procedure was not successfully completed (e.g., the compass was not rotated 360°), the ERROR symbol will be displayed on the LCD, meaning that the calibration procedure should be repeated for the compass to work properly.

7. Declination Angle

The compass is calibrated at the Silicon Laboratories factory in Austin, Texas, but because the angle of declination varies with respect to geographic position, the compass must be calibrated again for the specific location of use to achieve maximum accuracy. Table 1 provides this information for several major cities around the world.

Table 1. Angles of Declination for Selected Cities - February 2005

Location	Declination Angle (E)
Austin, Texas	5º 20’
San Francisco, CA	14º 51’
Nuremberg, Germany	1º 23’
London, England	4º 11’
Paris, France	–1º 13’
Tokyo, Japan	–6º 54’

There are a number of resources available on the World Wide Web that compute angles of declination for any location in the world. A "World Magnetic Model Calculator" is available from both the National Geophysical Data Center and the British Geological Survey:

- http://www.ngdc.noaa.gov/seg/geomag/jsp/struts/calcDeclination
- http://www.geomag.bgs.ac.uk/gifs/wmm_calc.html

8. Compass Software

The included CD-ROM contains the Silicon Laboratories Compass Software and additional documentation. This software allows the user to connect to the compass board and display the information on a PC. The following sections detail the software installation process and connection options.

8.1. Installation

Install the compass application software and USB drivers according to the instructions below.

1. Place the Reference Design Kit CD-ROM into the PC.
2. An installation dialogue box will appear. Click the “Install Reference Design Kit Tools” button.
3. The Kit Selection window will open, showing the available Reference Design Kits. To install the application, select the "Digital Compass Reference Design Kit" option. Click the "Install" button.
4. The "Confirm Installations" window will open, showing the available installation options. Only the "Digital Compass Reference Design Kit Demo" and "Install CP210x Drivers" need to be selected to run the demo.
5. Follow the installation prompts to install the demo application. By default, the software will be installed in the *C:\SiLabs\MCU\Digital_Compass_RD* directory. In addition, a shortcut to the application will be placed in the Start > Programs menu.
6. Next, the CP210x Driver "unpacker" utility will run. Follow the steps to copy the driver files to the desired location. The default directory is *C:\SiLabs\MCU\CP210x*.
7. The final window will give an option to install the driver on the target system. Select the “Launch the CP210x VCP Driver Installer” option if you are ready to install the driver.
8. If selected, the driver installer will now launch, providing an option to specify the driver installation location. After pressing the “Install” button, the installer will search your system for copies of previously installed CP210x Virtual COM Port drivers. It will let you know when your system is up to date. The driver files included in this installation have been certified by Microsoft.
9. If the “Launch the CP210x VCP Driver Installer” option was not selected in step 7, the installer can be found in the location specified in step 6. The default location is *C:\SiLabs\MCU\CP210x\Windows_2K_XP_S2K3_Vista*. At this location, run *CP210xVCPInstaller.exe.*
10. To complete the installation process, connect the included USB cable between the host computer and the USB connector on the compass board. Windows will automatically finish the driver installation. Information windows will pop up from the taskbar to show the installation progress.
11. If needed, the driver files can be uninstalled by selecting “Silicon Laboratories CP210x USB to UART Bridge (Driver Removal)” option in the “Add or Remove Programs” window.

8.2. Connection Options

Use the following steps to run the compass software and connect to the board.

1. Start the compass application by running Compass.exe located by default at "*C:\SiLabs\MCU\Digital_Compass_RD\4.PC Software*". The application is shown in Figure 11.

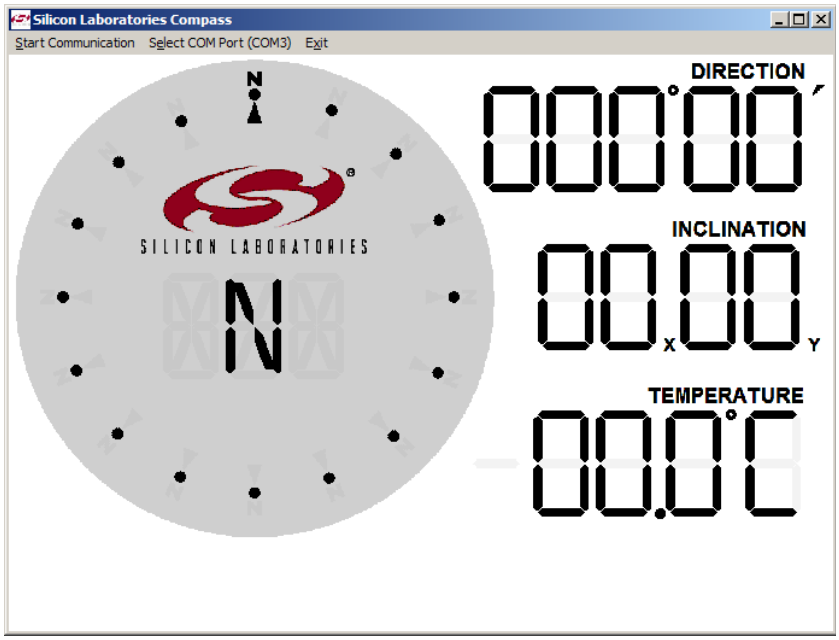

Figure 11. Compass Software Startup

2. To connect to the board, the COM port designated to the compass device must be specified. To find the correct COM port, open the PC's "Device Manager" window. Expand the "Ports (COM & LPT)" section. Find the COM port assigned to "Silicon Labs CP210x USB to UART Bridge." An example is shown in Figure 12.

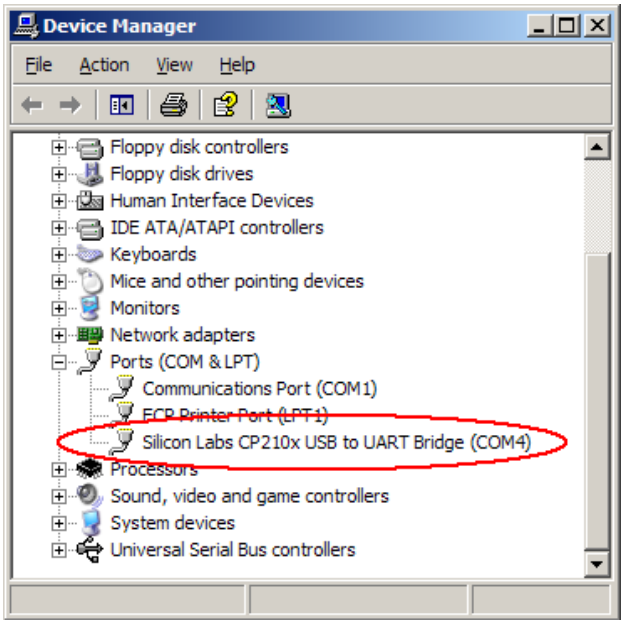

Figure 12. COM Port in Device Manager

3. Once the COM port has been determined, press the "Select COM Port (COM_)" option in the compass application. Enter the correct COM port into the "COM Port Selection" window shown in Figure 13.

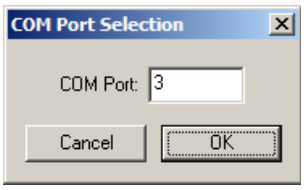

Figure 13. COM Port Selection

4. Press the "Start Communication" button in the compass application. If the connection is successful, the application will begin displaying the Direction, Inclination, and Temperature calculated by the compass board. The display is shown in Figure 14.

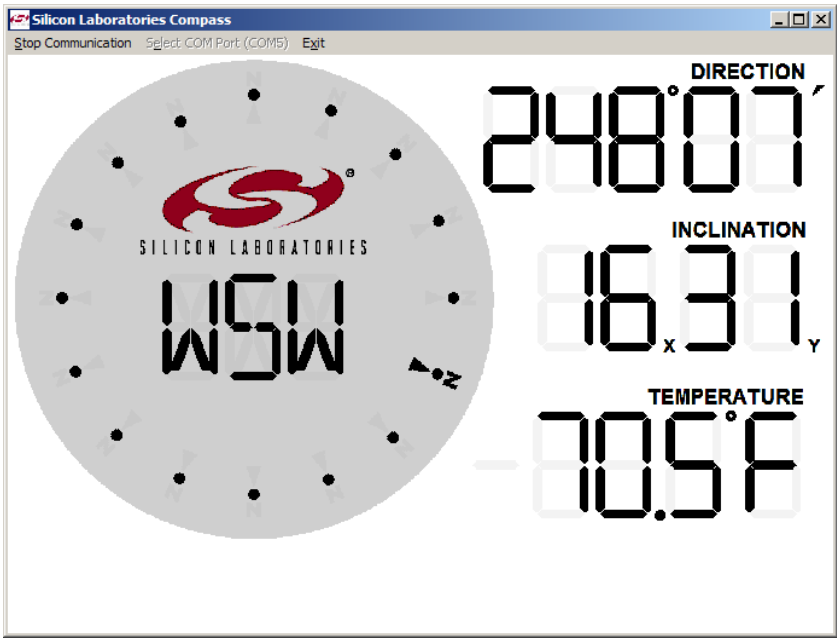

Figure 14. Compass Software Display

5. To disconnect from the compass board, press the "Stop Communication" button.

9. Schematics

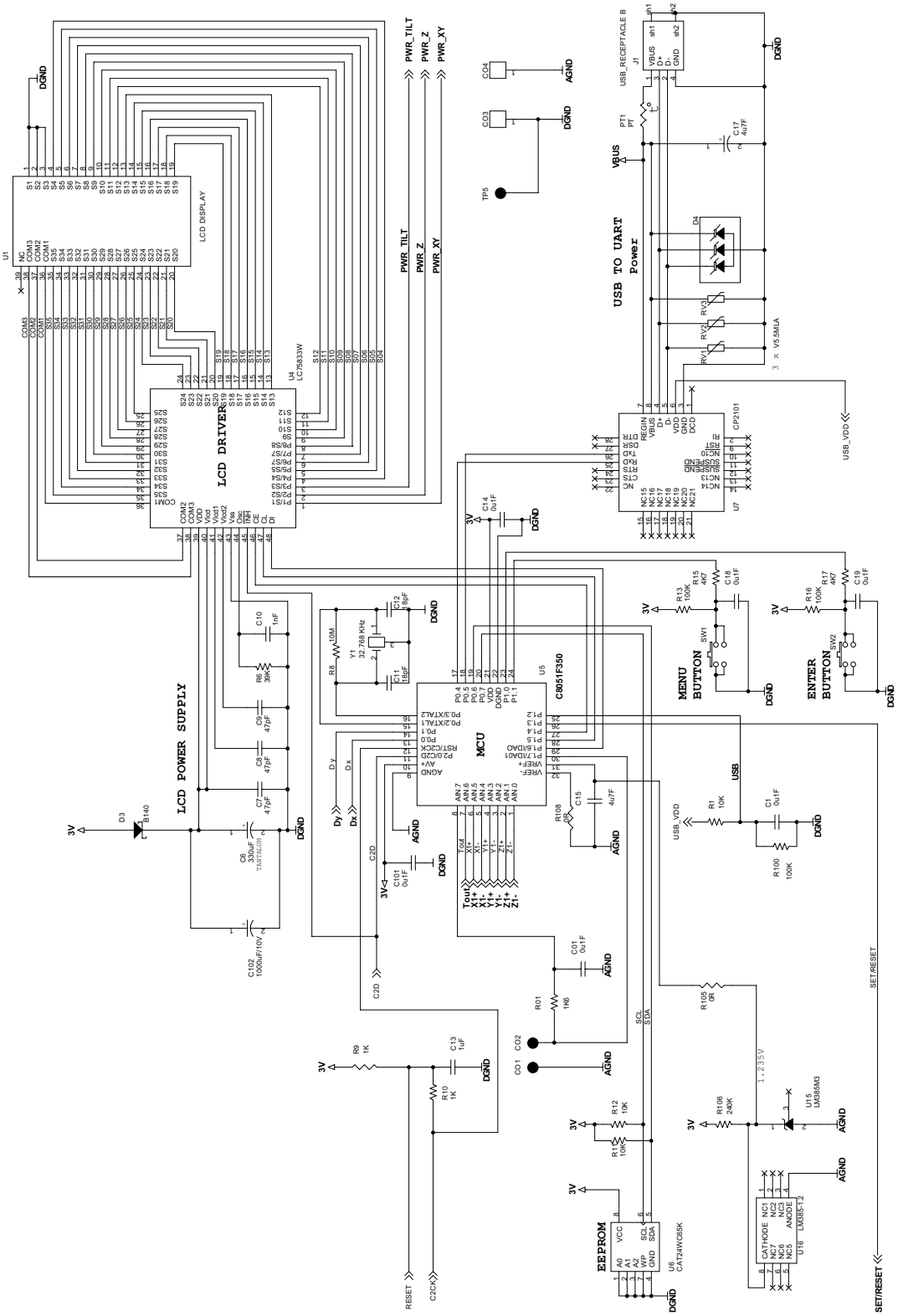

Figure 15. C8051F350-COMPASS Evaluation Board Schematic (Page 1)

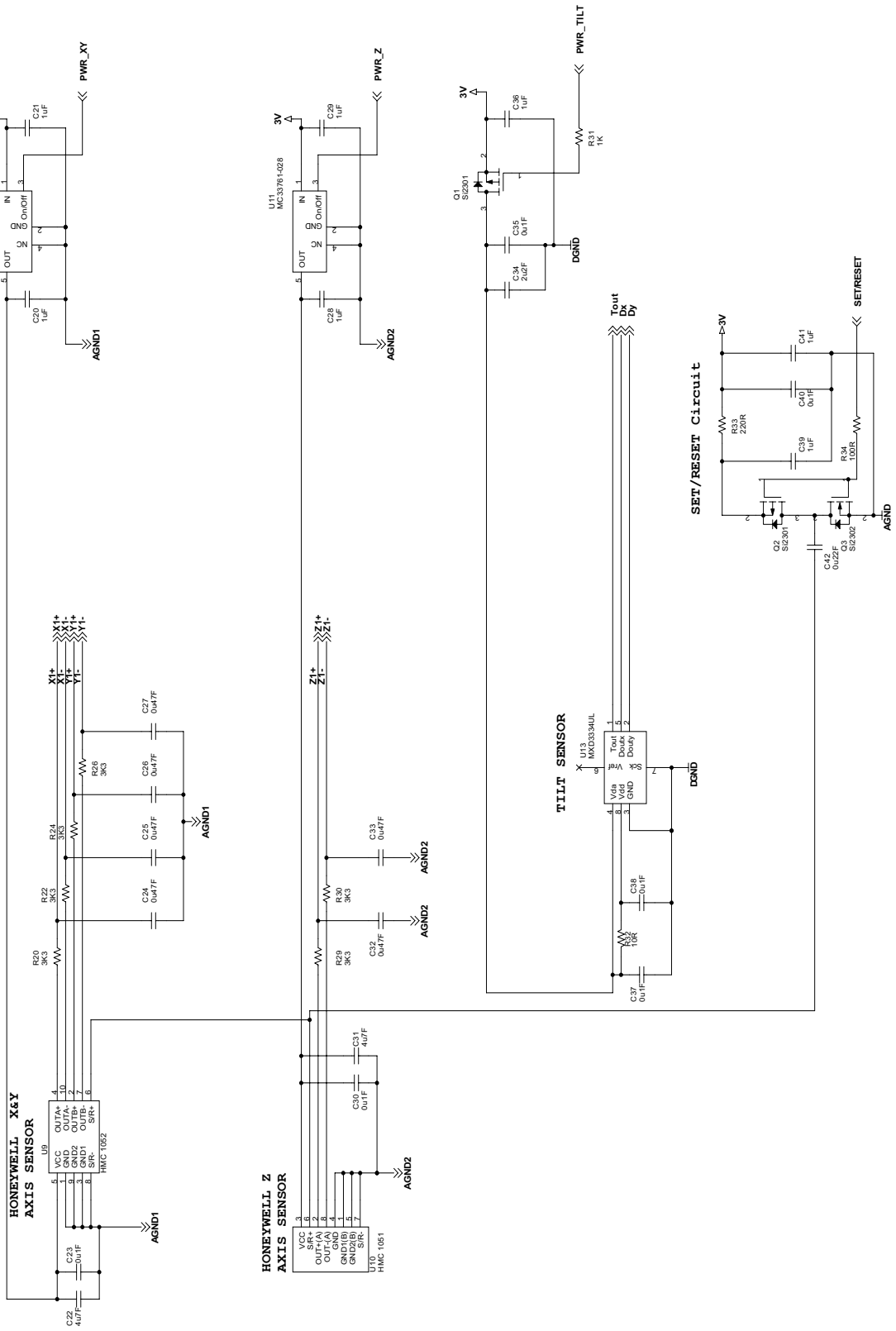

Figure 16. C8051F350-COMPASS Evaluation Board Schematic (Page 2)

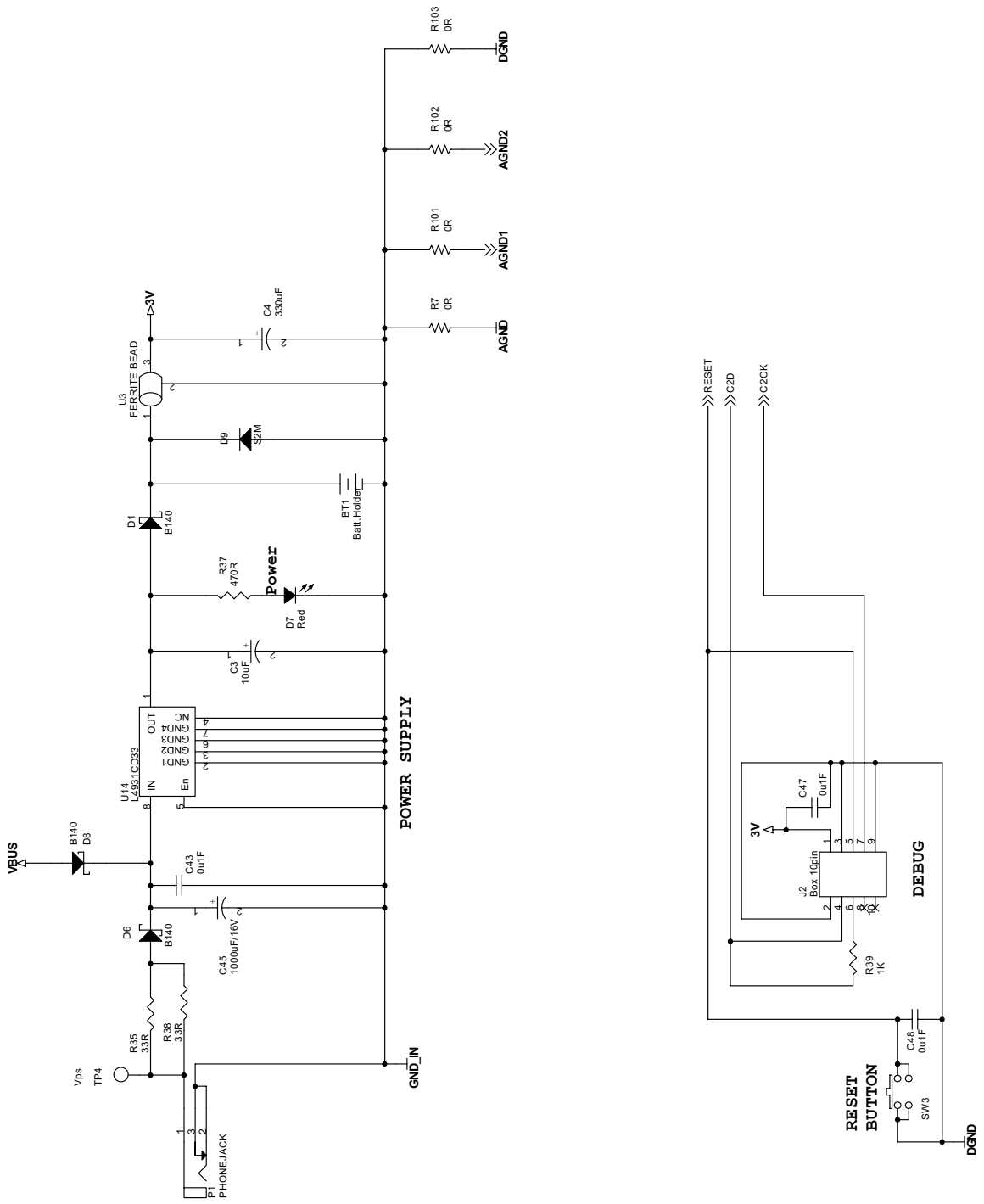

Figure 17. C8051F350-COMPASS Evaluation Board Schematic (Page 3)

NOTES:

DOCUMENT CHANGE LIST

- Updated section 8 to include latest VCP driver installation instructions.

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