PoE-VOICE-RD

PoE Voice Transmission Reference Design Kit User's Guide

1. Kit Contents

The Power Over Ethernet Voice Transmission Reference Design Kit includes the following items:

- PoE-VOICE-EB Reference Design Board
- Universal (100–240 V, 50–60 Hz) AC to DC Power Adapter
- Cat5E Ethernet Cable (blue)
- Cat5E Ethernet Crossover Cable (orange)
- Reference Design CD containing the following items:
  - PoE Voice Transmission Reference Design Kit User's Guide (this document)
  - PoE Voice Transmission Reference Design (AN312) and associated software
  - Keil Software 8051 Development Tools (evaluation assembler, 2 kB limited compiler, and linker)
  - All related documentation (Data Sheets, Application Notes, User's Guides, etc.) in PDF format

2. Power Over Ethernet Voice Transmission Board Overview

The PoE-VOICE-EB Reference Design Board contains an IEEE 802.3af compliant Power over Ethernet circuit, 8 kHz voice/speech sampling system, and an IEEE 802.3 Embedded Ethernet connection. The reference design board provides a hardware platform for evaluating and developing software for embedded systems that use the C8051F340 as the main controller, the CP2201 as the Ethernet controller, and the Si3400 as the PoE controller. The PoE-VOICE-EB Reference Design Board is shown in Figure 1.

The Power Over Ethernet Voice Transmission Reference Design (available on the CD) includes the following:

- Discussion on how to add PoE to your embedded system.
- Software implementation notes for voice transmission over an IP network.
- Remote temperature and light sensing from a web browser.
- Software implementation notes for the web server interface.
- Full C source code for the MCU firmware including TFTP bootloader. The software is also available for download from the Reference Design Kit CD and on the Silicon Laboratories website.

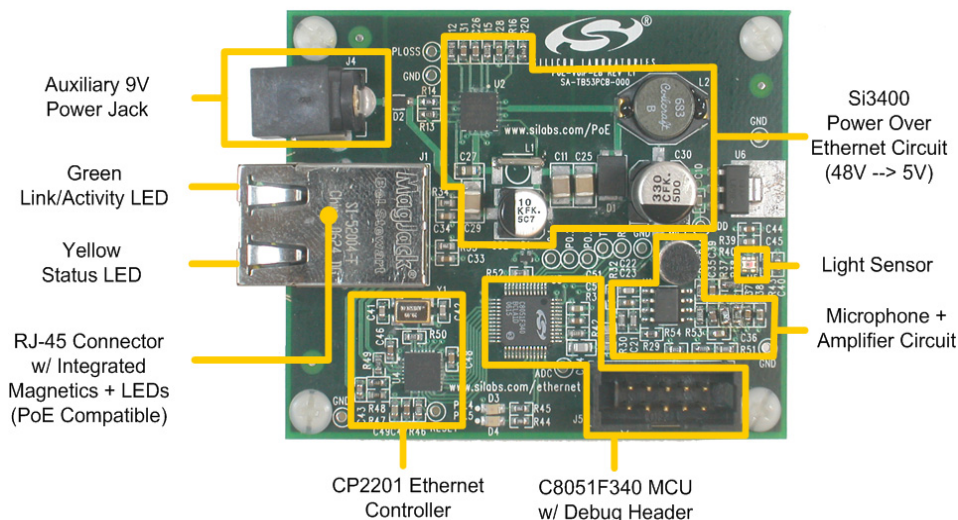**Figure 1. Power over Ethernet Voice Transmission Reference Design Board**

2.1. Power Section

The PoE-VoIP-EB Reference Design Board contains a Power Over Ethernet circuit based on the Si3400. In addition to performing all the functions required by the IEEE 802.3af specification, the Si3400 contains a switching regulator capable of regulating many voltages including 5 or 3.3 V. Since the Si3400 output will be passed through an LDO (used for the auxiliary 9 V supply), a 5 V output was chosen.

For this application the Si3400 is configured to put out approximately 5.2 V and diodes D1 and D2 are connected to "diode OR" the 9 V adapter power. A linear post regulator is used to produce the 3.3 V output. While the Si3400 can be configured to supply about 10 W of output power, the output from the linear regulator is limited to about 500 mA average for thermal reasons.

See www.silabs.com/PoE for more information about the Si3400.

2.2. MCU, Ethernet Controller, and Microphone Section

The MCU and Ethernet controller section of the board contain a C8051F340 MCU and a CP2201 Ethernet Controller. The MCU is pre-programmed with the reference design software and the CP2201 is pre-programmed with several web pages that are accessible from a web browser. The on-chip ADC is shared between the embedded temperature and light sensors and the microphone. When the light and temperature sensors are being sampled, the ADC sampling rate is 300 Hz. When the microphone is being sampled, the ADC is oversampled at 32 kHz for a resulting output word rate of 8 kHz.

The microphone section of the PoE-VoIP-EB Reference Design Board contains an electret condenser microphone with a dual-stage amplifier circuit. The amplifier gain has been tuned to provide optimal reception at distances of 1 to 3 meters. As the person speaking moves further away, a digital gain of up to 4x is applied to the sound stream. The digital gain is automatically applied and the automatic gain control state is displayed on the red LED (D4). The red LED is shown at the bottom of Figure 1 and the various automatic gain control states are listed in Table 1.

Table 1. Automatic Gain Control States

State	Description	Red LED
Not Connected	The PC application is not running and the microphone is not currently being sampled. ADC is sampling the light and temperature sensors.	Solid Off
Silence Detected	Digital gain is turned off.	Solid On
Normal Speech	Digital gain is turned off.	Blinking Slow (once per second)
2x Sensitivity Boost	Digital gain is set to 2.	Blinking Fast (4 times per second)
4x Sensitivity Boost	Digital gain is set to 4.	Blinking Very Fast (15 times per second)

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3. Hardware Setup

The only external hardware connections required by the PoE-VOICE-EB are power and a connection to a network. All required system configuration is performed over the network, saving the board space and cost of an LCD screen or dedicated UART interface. The board may be powered directly from the Ethernet cable using PoE or from a separate universal power adapter.

1. Connect the PoE-VOICE-EB to an unused Ethernet jack using the **blue** straight-through cable. This can be a wall outlet or an empty port on a network router or switch. If an Ethernet outlet is not available, the PoE-VOICE-EB can be directly connected to a PC using the **yellow** crossover cable.
   See "Appendix—Using a Crossover Cable" on page 18 for additional setup instructions if using a crossover cable.
2. Power the PoE-VOICE-EB using the universal power adapter supplied with the kit or by injecting power into the Ethernet cable as shown in the procedure below.
3. Wait until the yellow LED on the Ethernet connector stops blinking (always on), or starts to blink intermittently (blink twice then pause). The green LED (D3) on the board will follow the same pattern as the yellow LED and is provided for clarity and viewing ease from multiple angles.

Injecting power into an Ethernet Cable:

Power can be injected into an Ethernet cable using an IEEE 802.3af compliant power injector such as the PHIHONG PSA16U-480. This power injector is widely available for approximately $25 from distributors such as Mouser Electronics at www.mouser.com or directly from PHIHONG at www.phihong.com.

Figure 2 shows an overview of Power Injection.
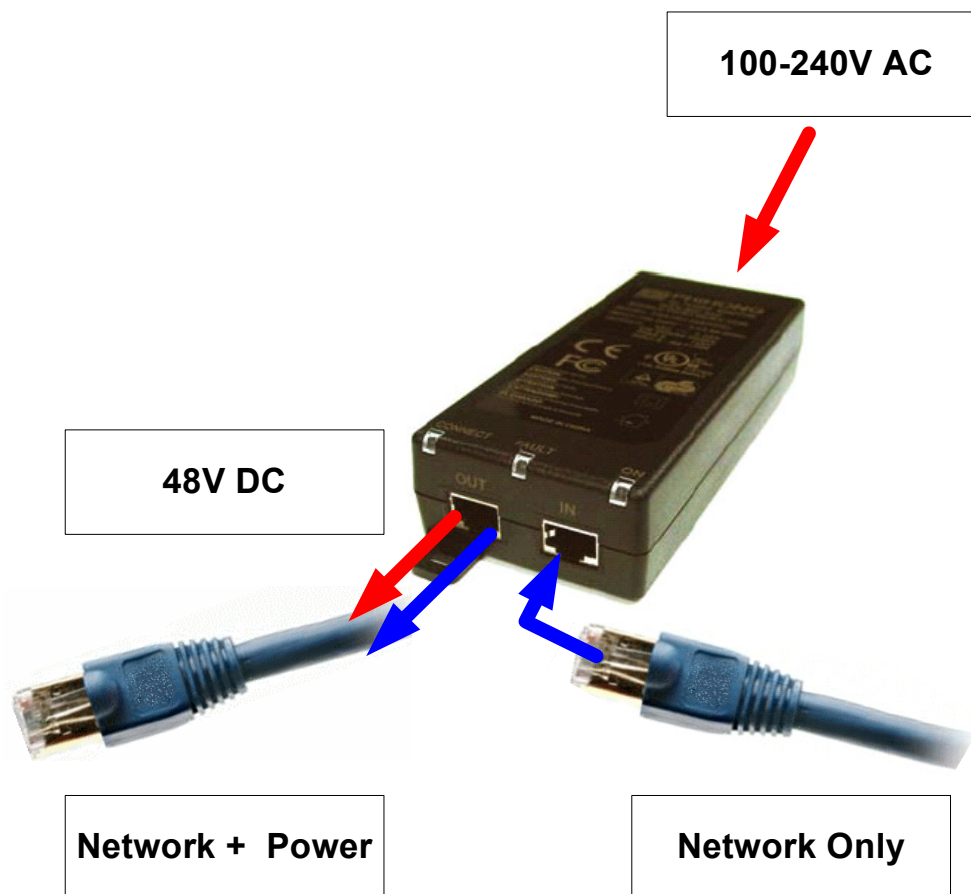
Figure 2. Power Injection using PHIHONG PSA16U-480

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4. Software Setup

To get started, insert the CD-ROM into your PC's CD-ROM drive. Follow the on-screen instructions when the blue dialog automatically launches. If the dialog does not automatically appear on the screen when you insert the CD-ROM, run *autorun.exe* found in the root directory of the CD-ROM. Select the installation for the Power Over Ethernet Voice Transmission Reference Design.

5. Network Setup

The Power Over Ethernet Voice Transmission Reference Design PC application uses the Netfinder protocol to find all PoE-VOICE-EB boards connected to the network. If the network has a DHCP server, then each device will automatically acquire an IP address once it detects that it has been plugged into a live network. If there are multiple PoE-VOICE-EB boards on the network, the Netfinder utility allows the user to identify the desired device based on the time powered, time plugged into network, MAC address, or IP address.

1. Start the "Power Over Ethernet Voice Demo" application and press the **Search** button as shown in Figure 3.
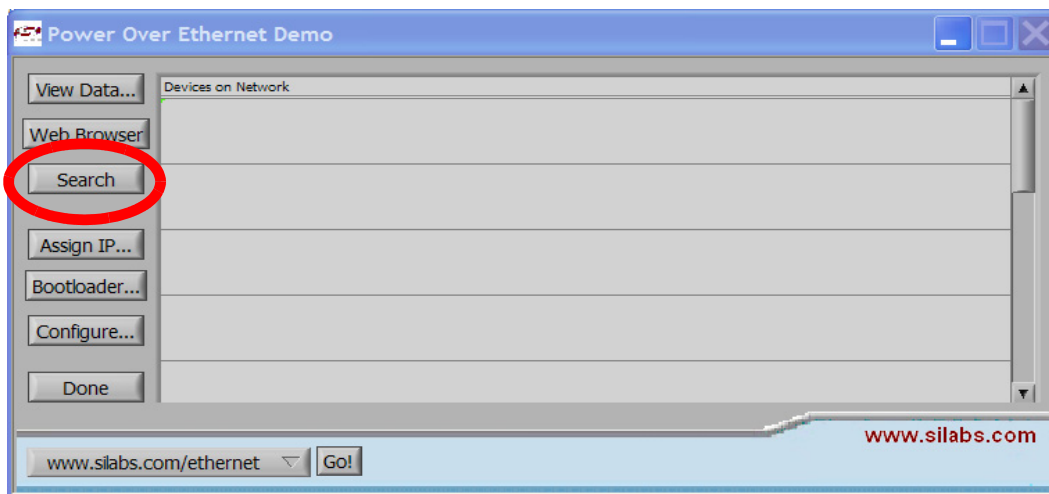

Figure 3. Search Button

2. Click on the device. The background color will turn **green** or **yellow**.
   a. If the background turns **green**, press the **View Data...** Button, then **skip to Section 6. "Power Over Ethernet Voice Transmission Demonstration" on page 6.**
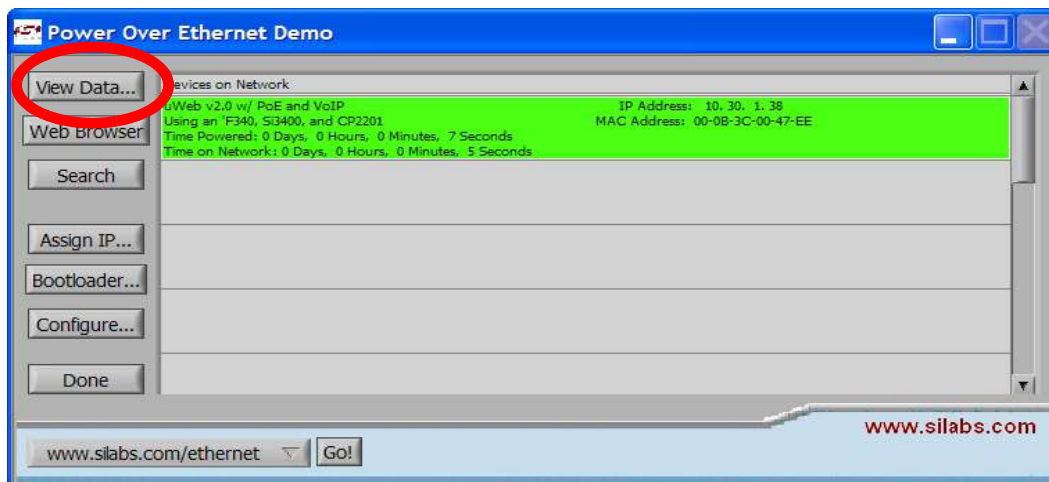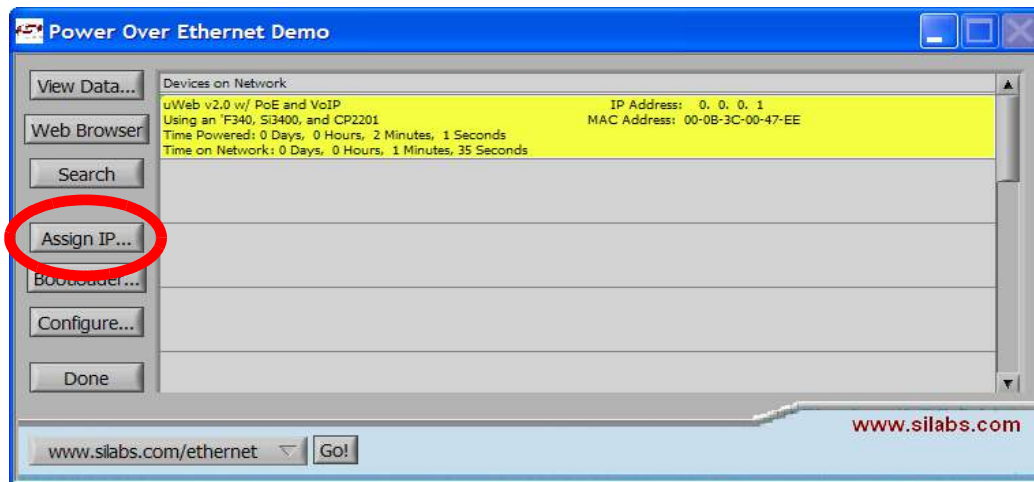   b. If the background turns **yellow**, then **go to step 3**.

Figure 4. View Data Button

Rev. 0.2

3. Click the **Assign IP...** button.
Note:"0.0.0.1" is an invalid placeholder address that indicates that the device needs to be assigned a valid IP address.

Figure 5. Assign IP Button

Important Note: If the network does not have a DHCP server, then the PoE-VOICE-EB will search for approximately **35 seconds** before going into static IP address mode. **While searching, the yellow and greed LEDs will be blinking fast and the device will not respond to Netfinder requests, therefore, will not be found by the PC application.** After going into static IP address mode, the PC application will be able to display information about the device.

4. Enter the IP address, subnet mask, and default gateway (if known) into the 'Assign IP Address' dialog and press **Assign Address**. See "Appendix—Using a Crossover Cable" on page 18 for information on how to configure the PC with a static IP address and how to select a static IP address for the embedded system. Programming is successful when the status box displays the message "**Succeeded!**".
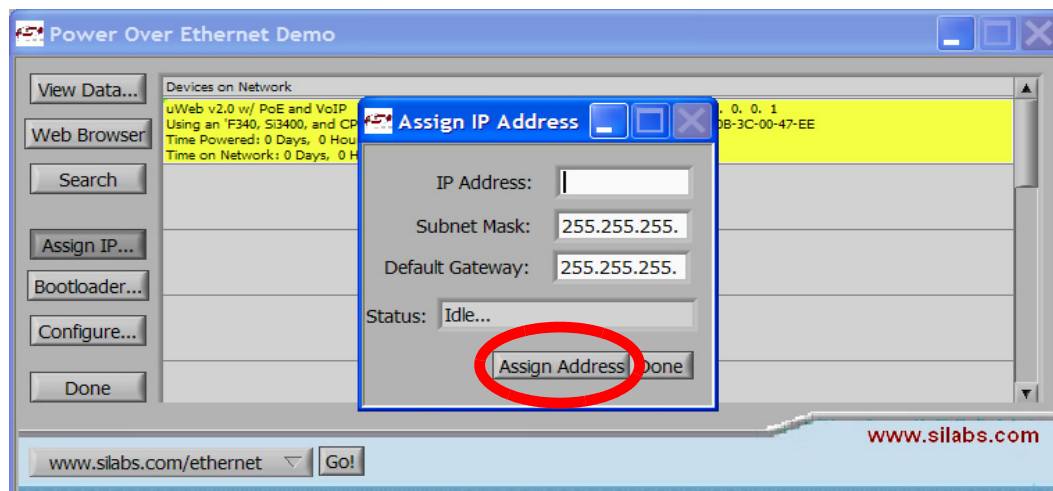
Figure 6. Assign IP Button

5. Press **Done** when the assignment is complete. Then click **View Data...** on the main panel as shown in Figure 4.

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6. Power Over Ethernet Voice Transmission Demonstration

The demonstration includes:

- Voice Transmission from the embedded system.
- Detecting PoE power vs. Auxiliary power.
- Monitoring real-time sensor data using a web browser.
- Controlling the state of the yellow and green LEDs from a web browser.
- Sending an e-mail from the embedded system containing the latest sensor data.
- Remotely updating firmware using the bootloader.

6.1. Voice Transmission From the Embedded System

Once the **View Data...** button is pressed, the sound from the PoE-VOICE-EB will be transmitted to the PC application. The time-domain representation of the signal is shown in the bottom graph and an FFT of the sound showing its various frequency components is shown in the top graph. There are two options for listening to the sound transmitted from the embedded system.

a. Record to WAV file -- Pressing the Start Record button will begin recording. When finished speaking, press the Stop Record button and specify a location to save the WAV file. You can listen to the recording using the Play Wave File... button or by playing the WAV file in your favorite media player.

b. Live Playback -- If the embedded system is located in a different room than the PC, or you are using headphones, then the Live Playback button may be pressed to allow real-time listening to the sound picked up by the embedded system's microphone. When live playback is enabled, sound is buffered/delayed for 5 seconds to remove network-generated jitter.
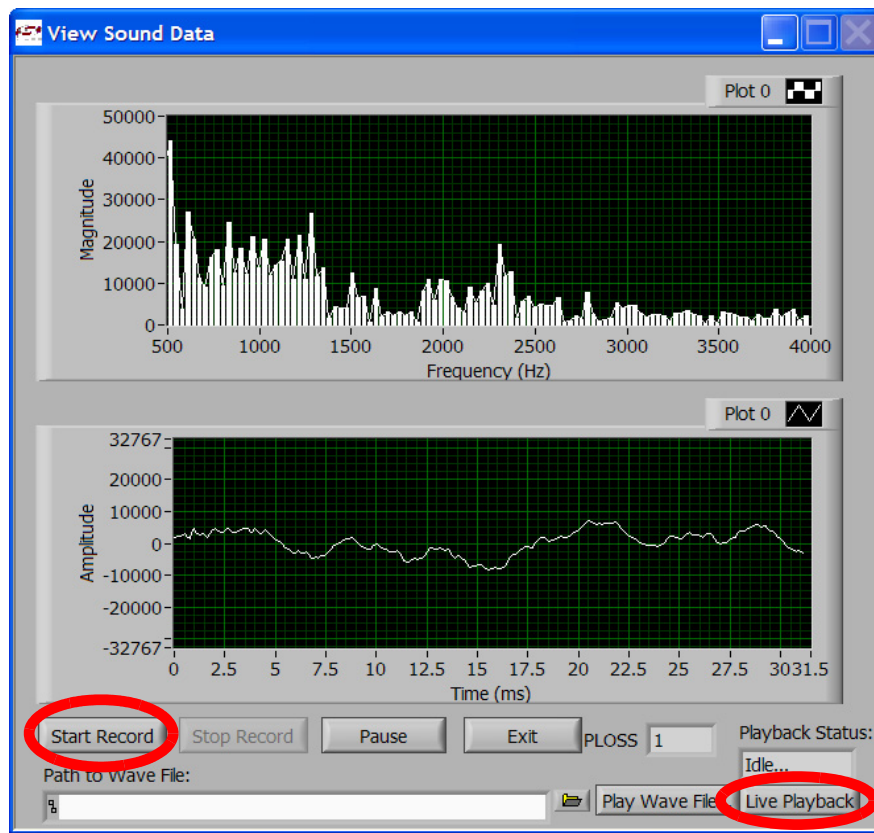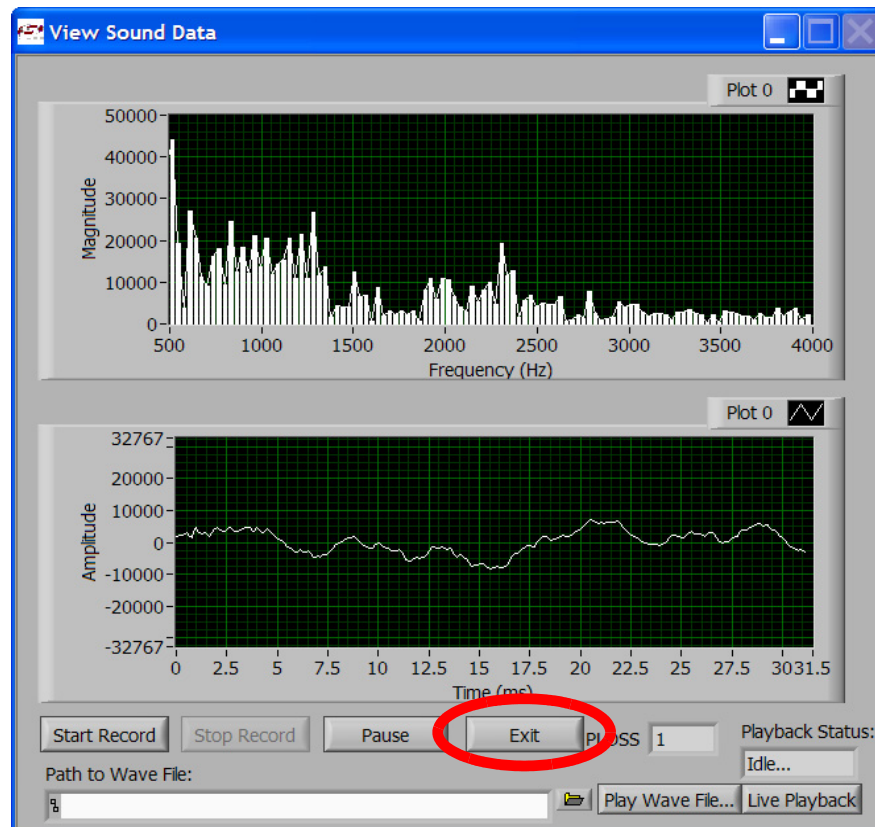
Figure 7. Listening to sound from the Embedded System

6.2. Detecting PoE power vs. Auxiliary power

The Si3400 provides a signal named "PLOSS" which indicates the presence of PoE power. This signal is level-shifted and routed from the Si3400 into a digital input on the MCU.

The PLOSS Indicator, shown in Figure 8, will be cleared to "0" if PoE power is available. The indicator is set to "1" if PoE power is lost and the embedded system is running from the auxiliary power supply.

Click the **Exit** button once you have finished listening to sound from the embedded system.

Figure 8. Listening to sound from the Embedded System

Usage Note 1: If running on PoE power, plugging in the 9 V AC adapter will override the PoE power. Once the power injector detects that the PoE load current has dropped, it will stop supplying power and the PLOSS will change to "1" to indicate a PoE power failure. Operation will not be interrupted.

Usage Note 2: If the 9 V auxiliary power adapter is removed while the system is running, PoE power will not resume instantaneously. Rather, the Si3400 must perform "Detection, Classification, and Power Sequencing" in order to receive power from the IEEE802.3af Power Source. While this procedure typically lasts less than 100 ms, it will cause a supply voltage dip large enough to trigger the built-in V_{DD} Monitors on both the 8051F340 and CP2201. To provide seamless switching between power sources, a large valued capacitor may be used to keep the supply voltage constant during the switchover.

7. Power Over Ethernet Web Browser Demonstration

Click on the **Web Browser** button. A web browser window should open and display a web page served from the embedded web server. This web page contains links to web server content stored in both the C8051F340 Main Flash and in the CP220x Flash Memory. Storing web server content in the CP220x Flash allows the MCU to utilize more of its executable Flash allowing more space for application firmware.
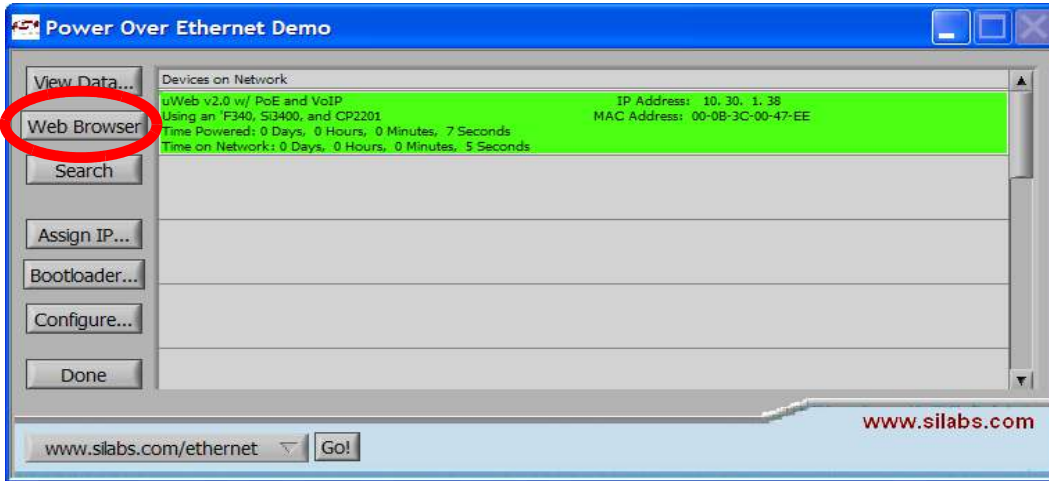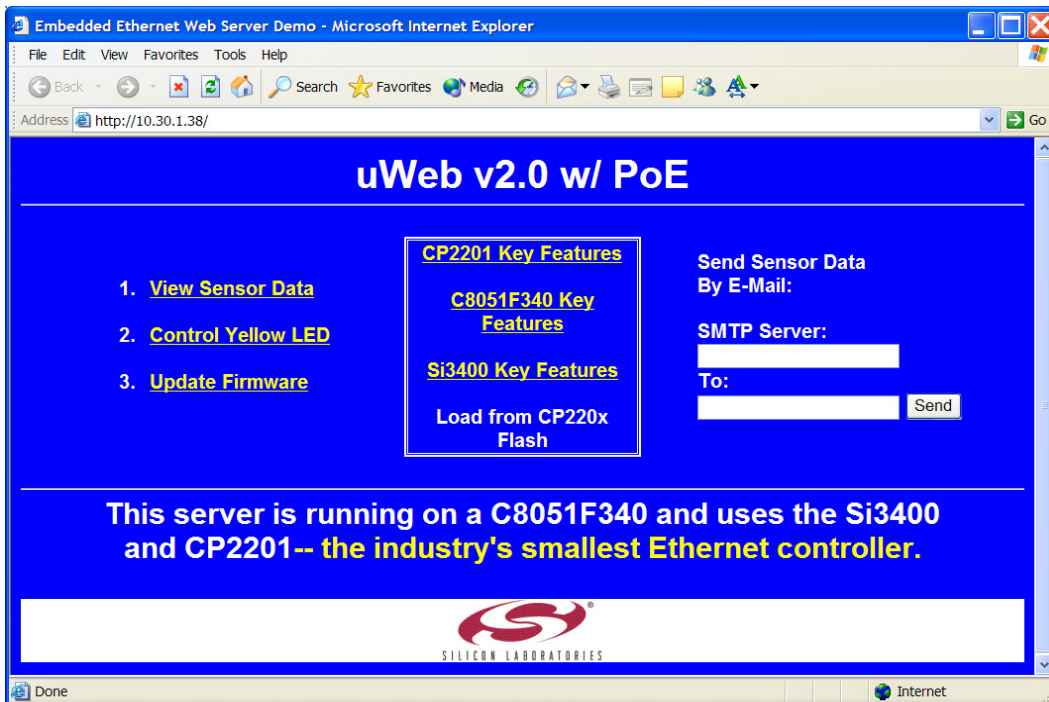

Figure 9. Web Browser Button

Figure 10. Main Web Page

7.1. Monitoring Real-Time Sensor Data Using a Web Browser

Clicking the first link on the main web page '**1. View sensor data**' will load the embedded sensor data web page shown in Figure 11. This page alternates between refreshing the temperature and the light sensor data every two seconds. The temperature measurements are taken from the C8051F340's on-chip temperature sensor and the ambient light reading is taken from the light sensor in the right hand side of the board next to the microphone.
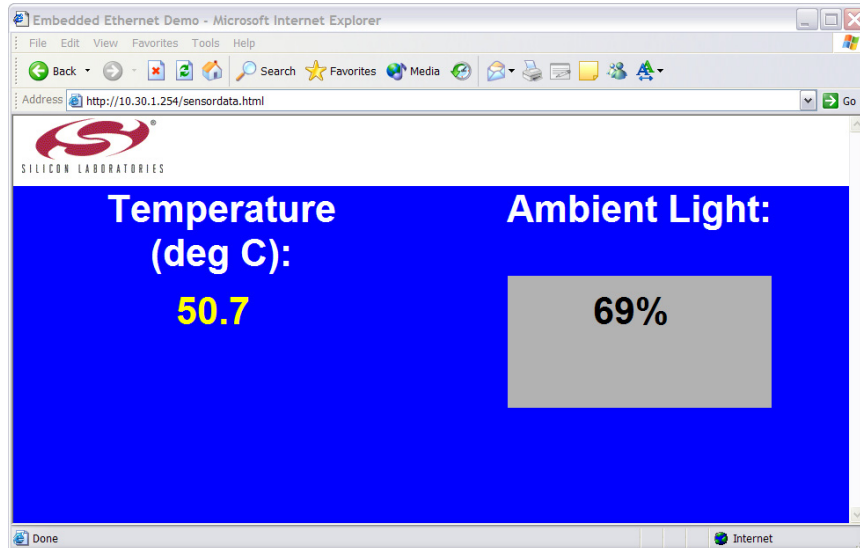
Figure 11. Viewing Sensor Data

7.2. Simulating Yellow and Green (System Status LEDs) From a Web Browser

The yellow LED on the Ethernet connector and the green LED on the board are used to indicate system status when first connecting the PoE-VoIP-EB to a network. Table 2 describes the various system states indicated by the yellow and green LEDs.

Table 2. Yellow LED States

LED State	System State
Blinking (slow)	The MCU is waiting for a network connection. The Ethernet cable is not connected.
Blinking (fast)	The MCU is connected to a network and is trying to acquire an IP address using DHCP.
On (continuous)	The system has obtained an IP address and is properly configured.
Blinking (intermittent)	The system has entered static IP address mode. Please use Netfinder to assign a static IP address or cycle power to continue searching for a DHCP server.
Off (continuous)	A hardware error has occurred. Please cycle power.

Clicking the second link on the main web page '**2. Control Yellow LED**' will load the yellow LED control page shown in Figure 12. Each of the links numbered 1 through 4 on this page borrow the yellow and green LEDs for 10 seconds and force them to the state described in the text. The LED states are restored after 10 seconds or if the 5th link '**5. Restore LED State**' is pressed.
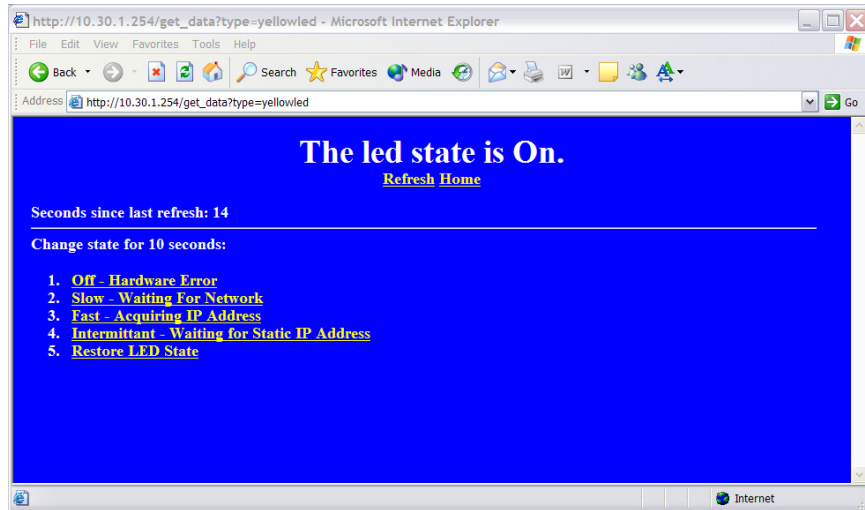When finished cycling through the various LED states, click the '**Home'** link to return to the main page.

Figure 12. Yellow and Green LED Control Page

7.3. Sending an E-mail Containing the Latest Sensor Data

To send an e-mail, the two pieces of information needed are the **address of an SMTP server** and the **destination e-mail address**. This information can be entered in the HTML form on the main web page as shown in Figure 13.

On most networks, the SMTP server can be located by typing "ping mail" at the command prompt or asking a system administrator. If the SMTP server address is unknown, a free software SMTP server that turns any Windows PC into an outgoing mail server is available for download from http://www.postcastserver.com. Once the software SMTP is running, use the PC's IP address as the SMTP server address. The SMTP server address cannot contain any letters—only numbers are permitted. The destination e-mail address must be less than 50 characters.
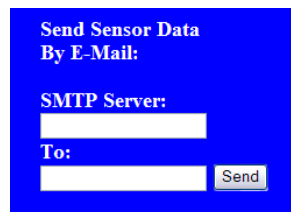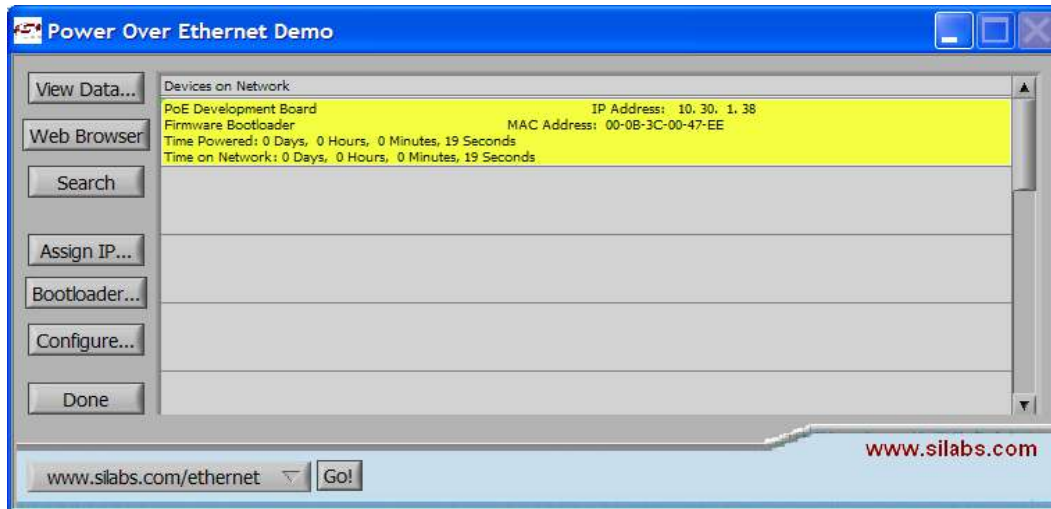

Figure 13. HTML Form Used For Sending E-Mail

8. Bill of Materials

Table 3. PoE Voice Transmission Reference Design Bill of Materials

Item	Qty	Reference	Value	Rating	Tol	Dielectric	PCB Footprint	Manufacturer Part Number	Manufacturer
1	1	U4	CP2201				MLP28	CP2201	Silicon Labs
2	5	C10,C38,C45,C49,C51	10 u	6.3 V	20%	X5R	603	C0603X5R6R3-106M	Venkel
	1	C36	0.33 u		5%		603		
3	3	C11,C25,C29	0.68 u	100 V	10%	X7R	1210	ECJ-4YB2A684K	Panasonic
4	1	C21	1.2 n	50 V	10%	NPO	603	C0603C0G500-122K	Venkel
5	1	C22	2.7 n	50 V	10%	NPO	603	C0603C0G500-272K	Venkel
6	12	C26,C28,C31,C33,C37,C40,C44,C46,C47,C48,C50,C34	0.1 u	50 V	10%	X7R	603	C0603X7R500-104K	Venkel
	1	C36	0.022 u		5%		603		
6a	1	C39	0.01 u		5%		603		
7	1	C27	0.1 u	100 V	10%	X7R	805	C0805X7R101-104K	Venkel
8	1	C24	8.2 n	50 V	10%	NPO	805	C0805C0G500-822K	Venkel
10	1	C30	330 u	16 V		Al Elec	8x10.2mm	EEEFK1C331P	Panasonic
11	1	C32	10 u	80 V		Al Elec	8x6.2mm	EEEFK1K100XP	Panasonic
13	1	C35	82 p	50 V	5%	NPO	603	511-1136-1-ND	Digikey
14	2	C41,C42	22 p	50 V	10%	NPO	603	C0603C0G500-220K	Venkel
15	1	C43	560 p	50 V	10%	NPO	603	C0603C0G500-561K	Venkel
17	1	U3	F340				QFP48	C8051F340	Silicon Labs
18	1	D1	PDS5100				PDI5	PDS5100-13	Diodes Inc
19	1	D2	MBR0520L	20 V			SOD123	MBR0520L	IR
20	1	D3	Green				805	SML-LXT0805GW-TR	Lumex
21	1	D4	Red				805	SML-LXT0805IW-TR	Lumex
22	1	U5	EL7900ILCZ					EL7900ILCZ	Intersil
23	1	MIC1	MICRO-PHONE					EM6050P-443-G	Horn

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Table 3. PoE Voice Transmission Reference Design Bill of Materials (Continued)

Item	Qty	Reference	Value	Rating	Tol	Dielectric	PCB Footprint	Manufacturer Part Number	Manufacturer
24	1	J4	CONN JACK PWR					RAPC722	Switchcraft
25	1	U6	LDO	3.3 V			SOT223	LM2937IMP-3.3	National
27	1	L2	68 uH					DO3308P-683MKL	Coilcraft
28	2	R32, R42	100 K		1%		603	CR0603-16W-1003F	Venkel
28a	1	R12	20 K		1%		603	CR0603-16W-2002F	Venkel
28b	1	R52	4.99 K		1%		603	CR0603-16W-4991F	Venkel
29	1	R13	48.7		1%		603	CR0603-16W-48R7F	Venkel
30	1	R14	25.5 K		1%		603	CR0603-16W-2552F	Venkel
31	1	R15	1.00 K		1%		603	CR0603-16W-1001F	Venkel
32	1	R16	2.67 K		1%		603	CR0603-16W-2671F	Venkel
33	1	R20	7.32 K		1%		603	CR0603-16W-7321F	Venkel
34	2	R29	4.99 K		1%		603	CR0603-16W-4991F	Venkel
35	2	R30, R33	9.76 K		1%		603	CR0603-16W-9761F	Venkel
37	4	R34,R35,R44,R45	249		1%		603	CR0603-16W-2490F	Venkel
38	1	R36	511 K		1%		603	CR0603-16W-5113F	Venkel
	1	R37	475		1%		603		
39	1	R38	750		1%		603	311-750HRCT-ND	Digikey
40	1	R39	2.2 K		1%		603		
41	2	R40,R41	154 K		1%		603	CR0603-16W-1543F	Venkel
42	1	R43	2.21 K		1%		603	CR0603-16W-2211F	Venkel
43	2	R46,R51	4.75 K		1%		603	CR0603-16W-4751F	Venkel
44	2	R47,R48	8.25		1%		603	CR0603-16W-8R25F	Venkel
45	1	R49	100		1%		603	CR0603-16W-1000F	Venkel
46	1	R50	10 Meg		1%		603	CR0603-16W-1005F	Venkel
46a	1	R53,R54	1 K		1%		603	CR0603-16W-1001F	Venkel
47	1	J1	MagJack				RJ45	SI-52004-F	BelFuse

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Table 3. PoE Voice Transmission Reference Design Bill of Materials (Continued)

Item	Qty	Reference	Value	Rating	Tol	Dielectric	PCB Footprint	Manufacturer Part Number	Manufacturer
48	1	U1	MC33202				SO8	MC33202DG	On semiconductor
49	1	U2	Si3400				5x5 QFN		Silicon Labs
50	1	Y1	ABM3-20 MHz					ABM3B-20.000MHZ-B2-T	Abracon
51	1	Q1	2N3904				SOT-523	MMBT3904T	Diodes Inc or equiv
52	1	J5	2x5 header						
53	1	ESD bag							
54	4	Rubber feet							
55	1	L1	0 Ohm Resistor				2010	RK73Z2HLTE	
Do Not Populate									
27a	1	L1	10 uH					DO1608C-103ML	Coilcraft

9. Schematics
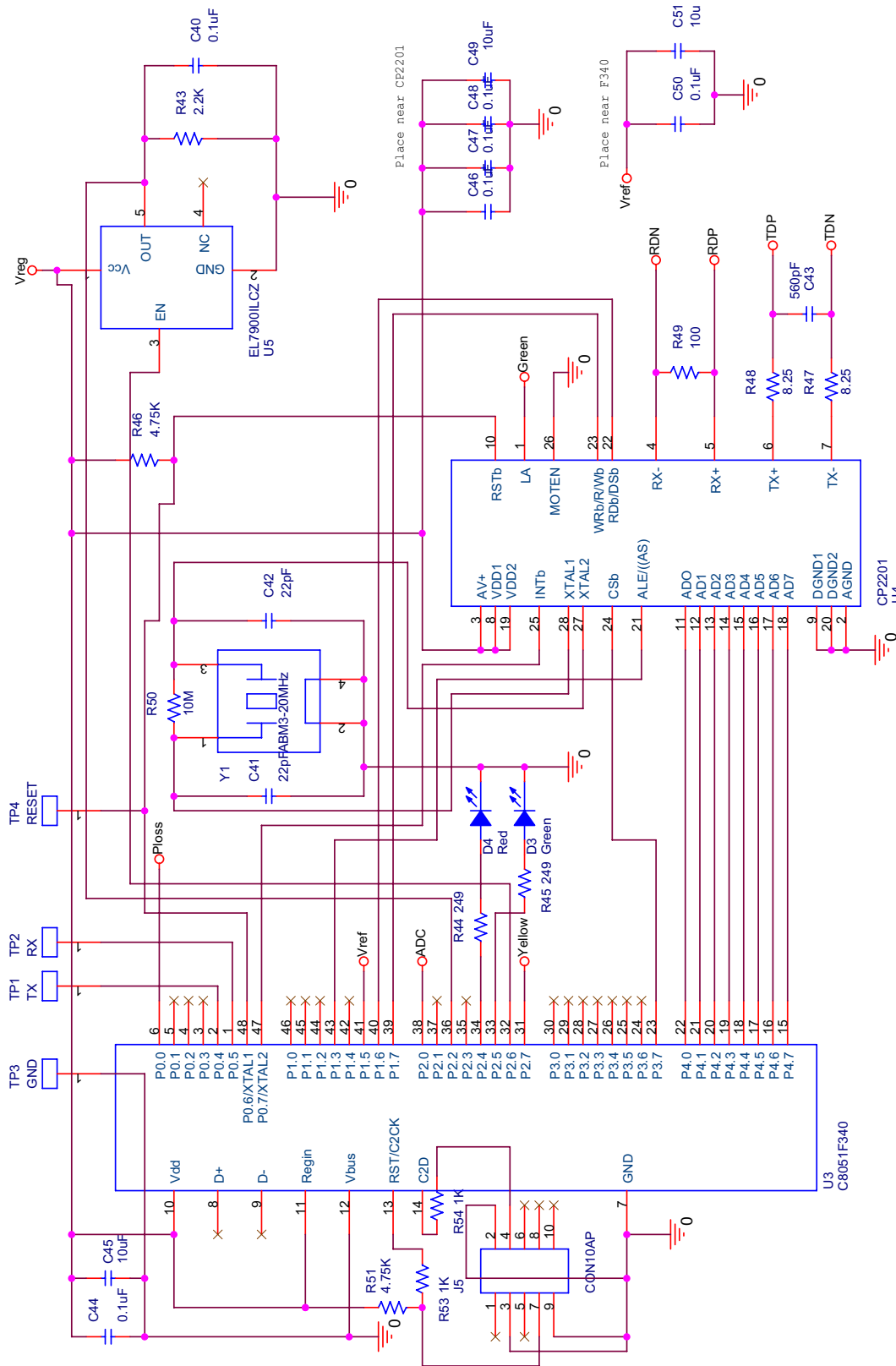
Figure 16. PoE Voice Transmission Reference Design Schematic (1 of 3)
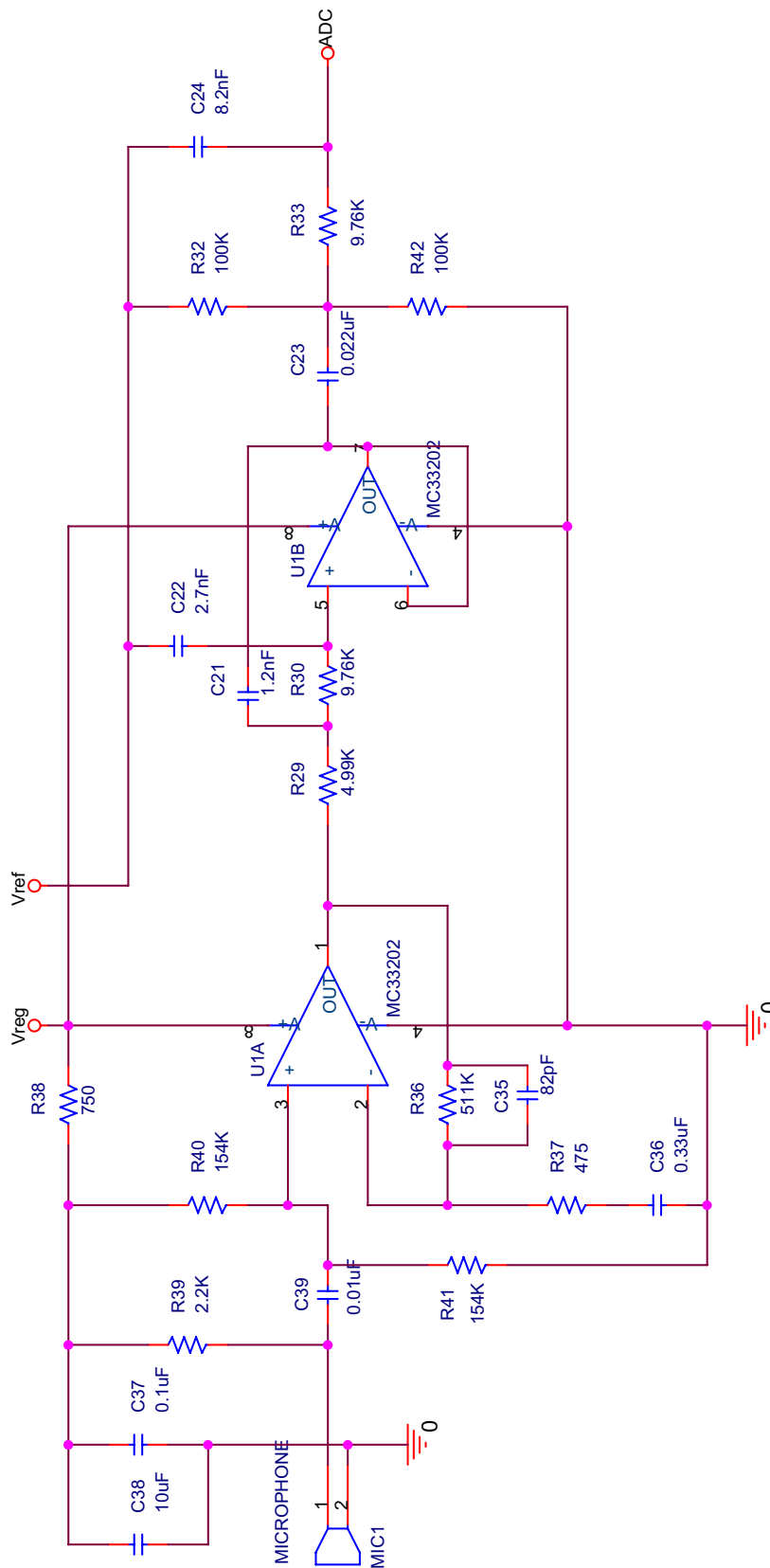
Figure 17. PoE Voice Transmission Reference Design Schematic (2 of 3)
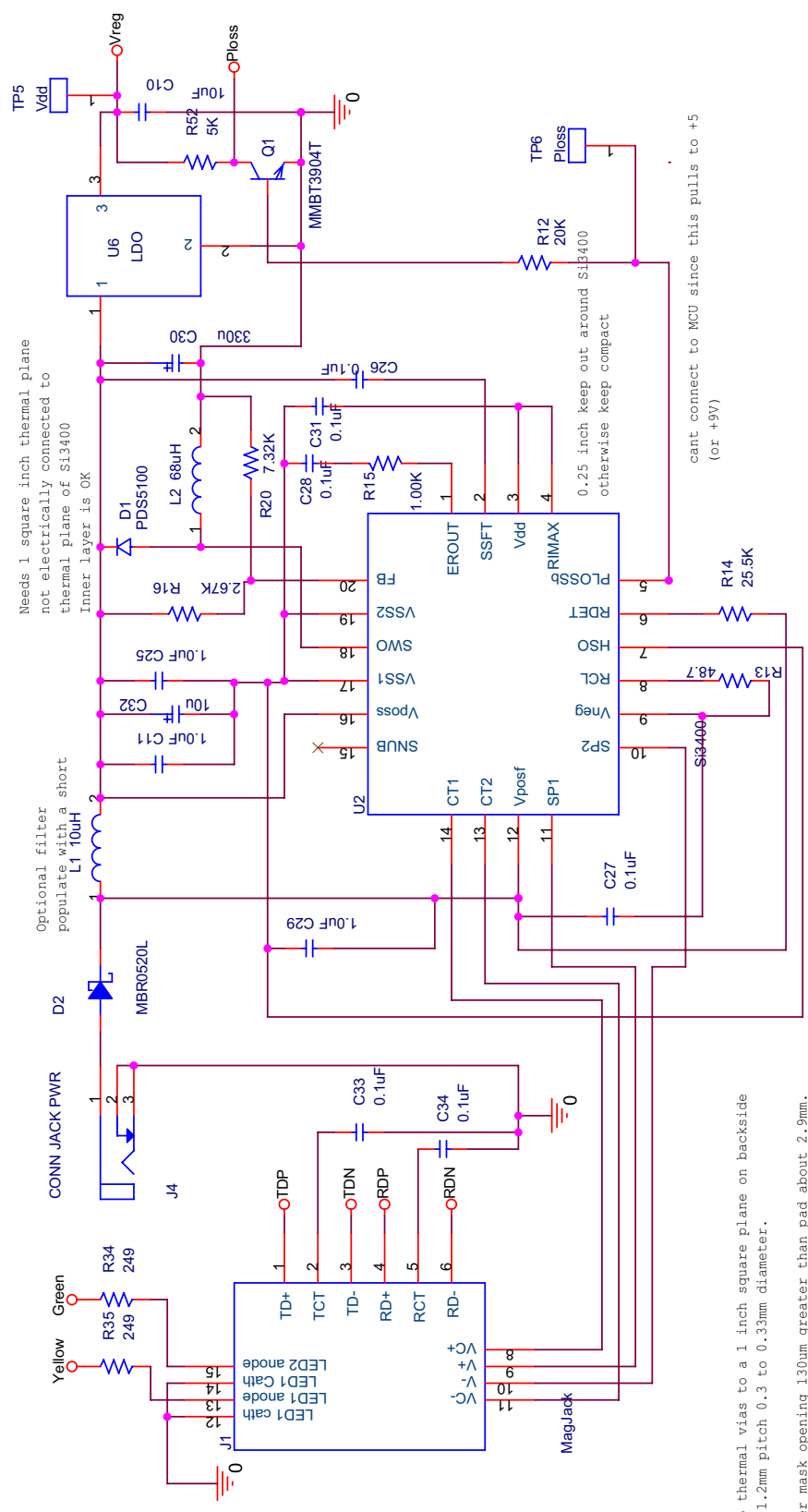
Figure 18. PoE Voice Transmission Reference Design Schematic (3 of 3)

## APPENDIX—USING A CROSSOVER CABLE

Introduction

The PoE-VOICE-EB can be connected to an Ethernet network using a standard Ethernet cable (see Figure 19) or directly to a PC using a crossover cable (see Figure 20). Table 4 describes the benefits of using each of the connection methods. A standard Ethernet cable is included in the kit and crossover cables are available for order from the Silicon Laboratories website, at www.silabs.com. Both cable types are included in the reference design kit.

Table 4. Ethernet Cable Comparison

Standard Cable	Crossover Cable
Remote access to embedded system.	Distance from PC to embedded system is limited by the length of the cable.
Multiple embedded systems may be networked and accessed from the same (or multiple) PC(s).	Only a single embedded system may be accessed from a single PC.
Shared communication medium. System may experience packet delays under heavy network traffic. This effect is greatly reduced if using a switched network.	Dedicated channel bandwidth. Good for achieving consistent data throughput measurements.
An existing network with wall outlet or a router/switch is required.	No additional hardware required.
PC does not require any additional IP address configuration.	PC must be configured with a static IP address in order to recognize embedded system.
Standard cable is included in evaluation kit.	Crossover cable is included in evaluation kit.
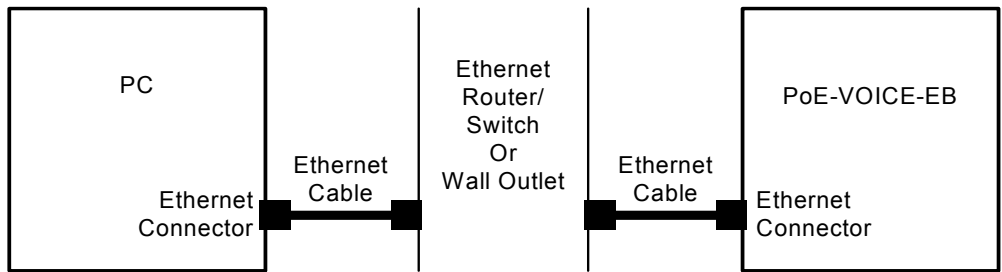
**Figure 19. Embedded Ethernet Network Connection (Standard Cable)**
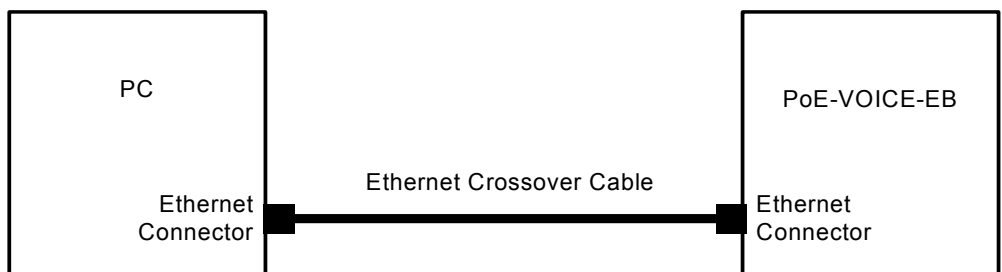
Figure 20. Embedded Ethernet Network Connection (Crossover Cable)

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PC Configuration

The steps below show how to configure a Windows 2000/XP PC to use a static IP address. The SET_STATIC.bat and SET_DHCP.bat batch files included in the reference design software directory may be used to automate this process.

1. Open the *Network Connections* Folder. This is accessible from the control panel or from the start menu by right-clicking on *My Network Places* and selecting *Properties*.
2. Right-click on the *Local Area Connection* and select *Properties*.
3. Select *Internet Protocol (TCP/IP)* and click *Properties*. Optionally, if the *Show icon in notification area when connected* is checked, right-clicking the system tray icon will provide a quick shortcut to the *LAN properties* dialog and can be used as an indicator that the network is functioning properly.
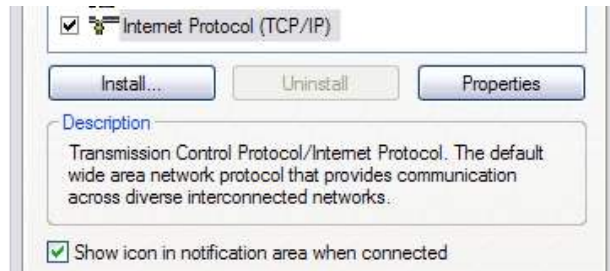
Figure 21. Internet Protocol Properties Window

4. Select *Use the following IP address* and specify an IP address and subnet mask for the PC. For a subnet mask of 255.255.255.0, the embedded system's IP address must match the first three octets of the PC's IP address for the PC to recognize the embedded system. See Section **Selecting an IP Address for the Embedded System** on the next page for additional information about choosing the embedded system's IP address.
    Note: When entering an IP or subnet address into the dialog box, the cursor will automatically advance to the next field for a three digit octet. If entering a one or two digit octet, the spacebar, right arrow key, or '.' can be pressed to advance to the next field.
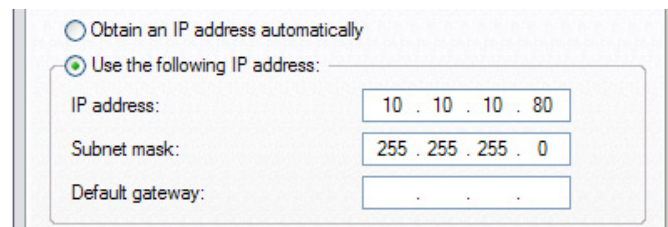
Figure 22. IP Address and Subnet Mask Window

5. Click *OK* after the static IP address and subnet mask have been configured. The PC will now be able to access the embedded system using a crossover cable.

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Selecting an IP Address for the Embedded System

For a PC to recognize an embedded system on a network, its IP address and subnet mask need to be configured. Below are a few guidelines to follow when choosing an IP address for the embedded system. Figure 23 shows an example of a compatible PC and embedded system IP address combination.

1. Find the IP address and Subnet mask for the PC. If a Default Gateway is specified, then save this address for later use. If you are using a crossover cable, you may choose any IP address for your PC as long as the Subnet mask allows it to recognize the embedded system.
2. The IP address chosen for the embedded system must match the PC's IP address in all bit locations where the Subnet mask is a 1 in order for the PC to recognize the embedded system. Otherwise, the PC will send it's request outside the local network.
3. Do not duplicate IP addresses or select a broadcast address. An IP address is considered a broadcast address if all bits which are 0 in the Subnet mask are 1 in the IP address. Broadcast addresses with additional 1s such as 10.10.255.255 (Figure 23) can be broadcast to nodes outside the local network.
4. The address 255.255.255.255 is known as the Ethernet broadcast address and is used when the Subnet mask for the network is not known. Any packet transmitted to this address will reach all nodes on the local network but cannot go further than the nearest router.

IP Address Selection Example

The example in Figure 23 shows the IP address and subnet mask of the PC we want to connect to the embedded system. Since the first 24 bits of the subnet mask are 1, the first 24 bits of the embedded web server's IP address (shown in bold) must match the PC's IP address. Only the least significant 8 bits may vary making the valid range of IP addresses for the embedded web server 10.10.10.0 to 10.10.10.254 with the exception of 10.10.10.80 since this address is already taken by the PC. 10.10.10.255 is reserved because it is the broadcast address for this network.

PC IP Address

10	10	10	80	(decimal)
0000 1010	0000 1010	0000 1010	0101 0000	(binary)

PC Subnet Mask

255	255	255	0	(decimal)
1111 1111	1111 1111	1111 1111	0000 0000	(binary)

Embedded Web Server IP Address

10	**10**	**10**	163	(decimal)
0000 1010	**0000 1010**	**0000 1010**	1010 0011	(binary)

Figure 23. IP Address Selection Example

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NOTES:

PoE-VOICE-RD

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