VOICE-RECORD-RD

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VOICE RECORDER REFERENCE DESIGN KIT USER'S GUIDE

1. Kit Contents

The Voice Recorder (VOICE-RECORD-RD) Reference Design Kit contains the following items:

- C8051F411-GM Voice Recorder board (1)
- Headphones (1)
- Universal Power Supply (1)
- 9 V battery (1)
- Voice Recorder Quick-Start Guide (1)
- Voice Recorder Reference Design Kit CD-ROM. CD contents include the following:
  - Voice Recorder Reference Design Kit User's Guide (this document)
  - Reference Design Documentation (AN278)
  - Voice Recorder Reference Design Source Code (AN278)
  - C8051F41x Device Data Sheet

Note: The Silicon Labs USB Debug Adapter is not included in this kit and is required to reprogram the board.

2. Kit Overview

Voice applications require a microcontroller to sample the audio channel, compress and decompress the signal, store and retrieve the samples, and interpret user input. With its available feature set (12-bit ADC, 12-bit DAC, 50 MIPS peak CPU, low-power SUSPEND mode, and extremely small size in a 28-pin QFN package), the C8051F411-GM is uniquely suited for this purpose. This reference design illustrates how to use a C8051F411-GM for voice applications.

Figure 1. Voice Recorder Reference Design Board

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3. Using the Voice Recorder

The voice recorder can record up to 87 seconds of audio. The following steps describe how to use the voice recorder:

1. Connect the headphones to the speaker jack (labeled SPKR).
2. Connect the Universal Power Supply or 9 V battery to the board. The red power LED (PWR LED) will turn on. The red record LED (REC) and green play LED (PLAY) may also turn on briefly.
3. **Once only the red power LED is on**, the record, playback, and erase features may be used:

   ■ **RECORD: Press and hold** the record/play (O / >) button to **record**. The **button must remain pressed** during the recording session.

     Once the red LED is lit, the voice recorder is recording. The microphone is sensitive enough that you do not need to speak directly into the microphone in order to be heard.

   ■ **PLAY: Tap** (press and immediately release) the record/play (O / >) button **once** to **play back**.

     While the green LED is lit, the voice record is playing the recording. The playback may be stopped at any time by tapping the button, or it may be allowed to continue until the end of the recording.

   ■ **ERASE**: Tap (press and immediately release) the ERASE button once to erase the current contents of the voice recorder.

     The PLAY and REC LEDs will turn on while the voice recorder is busy erasing the contents of the memory. When the LEDs turn off, the voice recorder has finished erasing.

   ■ **VOLUME:**

     The volume of the voice recorder may be changed at any time by turning the dial labeled VOL. Moving the dial counter-clockwise (up) will increase the volume, and moving the dial clockwise (down) will decrease the volume.

4. After several idle seconds, the voice recorder will go into **Suspend** mode to conserve battery life and the **red power LED will turn off**. Press the record/play (O / >), ERASE, or RESET button at any time to wake from Suspend. **The record/play (O / >) or ERASE button must be released** before the record, playback, or erase features are available.

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4. Major Components

This section describes each of the major components found on the Voice Recorder board.
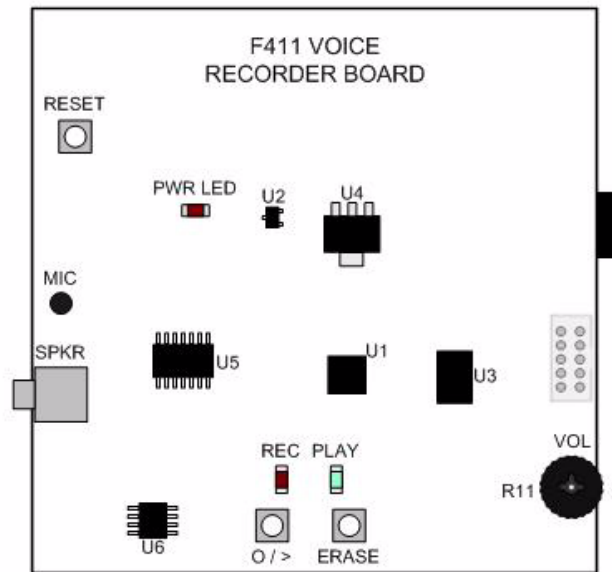

Figure 2. Voice Recorder Reference Design Components

- **U1**—C8051F411:

    The C8051F411 controls the sampling, sample storing and retrieving, sample output, and user interaction for the voice recorder.

- **U2**—Transistor:

    The transistor turns off all power to the Flash, op-amps, LEDs, and speaker driver when the 'F411 goes into Suspend mode to conserve as much power as possible.

- **U3**—External Flash:

    The external Flash communicates with the 'F411 through the serial interface (SPI) and allows up to 87 seconds of recording (512 kB with 12-bit samples compressed to 6 bits at an effective 8 kHz sampling rate).

- **U4**—External Voltage Regulator

    For ease of use in a development environment, the 'F411 runs off an external voltage regulator that regulates the 9V battery or power supply input to 3.3 V. All components except the 'F411 use the 3.3 V output, and the internal 'F411 regulator regulates the 3.3 V down to 2.5 V for the 'F411 core.

- **U5**—Op-Amps:

    The signal input from the microphone and the output to the speaker driver require some filtering by op-amp filters to remove any components caused by frequencies outside the signal bandwidth (up to 4 kHz). Additionally, the op-amp filters smooth the output of the IDAC.

- **U6**—Speaker Driver:

    The speaker driver provides the power to the speaker and takes the single-ended output of the IDAC and turns it into a differential speaker output, which requires less power for the same output amplitude.

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5. Summary of Demonstrated C8051F411-GM Features

The voice recorder samples the output of a microphone through op-amp based filters using the ADC. The C8051F411 then compresses the samples and sends them to the external SST Flash memory over the SPI. To play back, the C8051F411 retrieves the samples from the external Flash, decompresses them, and outputs the sample using the on-chip IDAC. The on-chip PCA (Programmable Counter Array) controls brightness of the LEDs.
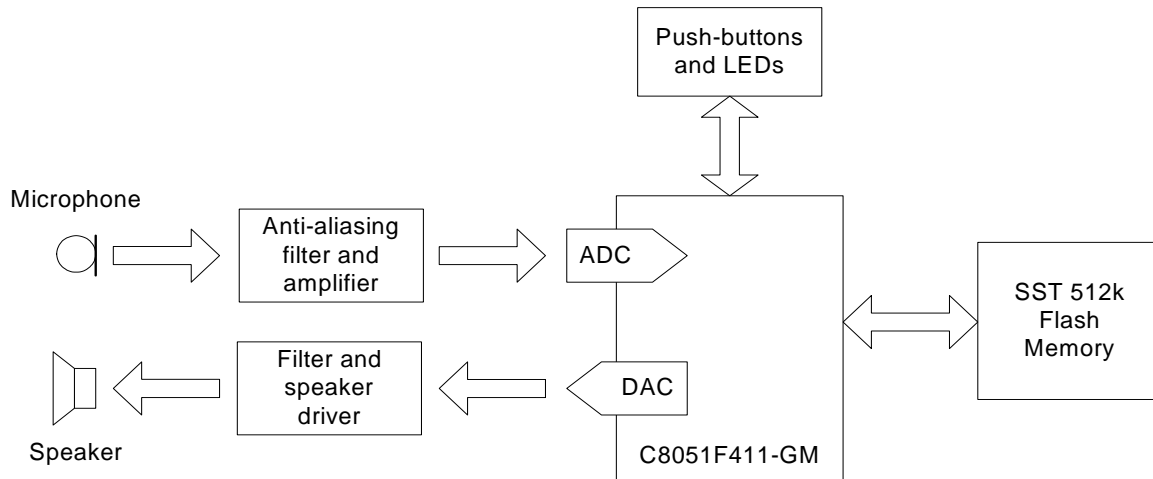
Figure 3. Voice Recorder Functional Block Diagram

The C8051F411-GM on the voice recorder uses the internal voltage regulator to run off of the output of the external regulator (9 V down to 3.3 V) and the VDD monitor to check whether the input battery or power supply voltage is high enough to guarantee proper functionality.

The voice recorder uses DPCM (Differential Pulse Code Modulated) compression to convert the 12-bit samples of the ADC and IDAC to 6 bits at an effective sampling rate of 8 kHz. This compression allows for an extended recording time without audibly losing sound quality. Additionally, the firmware utilizes the **Burst Mode** and **Repeat Count** features of the 'F411 ADC. **Burst Mode** saves power between conversions by allowing the ADC to stay in shutdown mode, wake up on a convert start signal, rapidly take samples, and return to shutdown mode, all automatically. The **Repeat Count** feature allows the ADC to take multiple samples (16) with one convert start signal and automatically accumulate the samples in the ADC data register, which allows the firmware to easily average a set of samples to provide enhanced recording quality.

Since most functions are done in hardware (SPI, ADC Burst Mode and hardware accumulation), the 'F411 samples, compresses or decompresses the sample, and interacts with the external Flash on SPI while running on a 6 MHz internal oscillator.

When no activity occurs for a few seconds, the voice recorder automatically enters **Suspend mode** and turns off the power to all the other components by controlling a transistor with a port pin. **Suspend mode** causes the internal oscillator to stop until a waking event occurs, which allows the voice recorder to save power while not in use. When a button (record/play (O / >) or ERASE) is pressed, the 'F411 recognizes a waking event and resumes activity without requiring a hardware reset.

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6. Reference Design Documentation and Source Code

The architecture of the Voice Recorder Reference Design is described in detail in the application note AN278, which is included on the Kit's CD-ROM. AN278 includes the Voice Recorder board schematic, bill of materials (BOM), and C-language firmware source code.

To debug and download code to the Voice Recorder, the Keil C51 tools (compiler, linker, and assembler) and Silicon Labs USB Debug Adapter are required. These can be purchased separately from the Silicon Laboratories website or as part of the C8051F410DK Development Kit (which includes the evaluation version of the Keil C51 tools). For more information, please visit the "Development Tools" webpage or contact the local Silicon Laboratories distributor.

■ http://www.silabs.com/products/microcontroller/devtools.asp

The Silicon Laboratories Integrated Development Environment (IDE) can be used with the USB Debug Adapter to program and develop on the reference design boards. The Silicon Labs IDE and other software tools can be downloaded from the following link:

■ http://www.silabs.com/mcudownloads

7. Debugging with the Voice Recorder

To debug and run the Voice Recorder firmware in the Silicon Labs IDE, first disconnect the power to the Voice Recorder board. Then, connect the USB Debug Adapter (not included in the Voice Recorder kit) and reconnect the power, as shown in Figure 4.
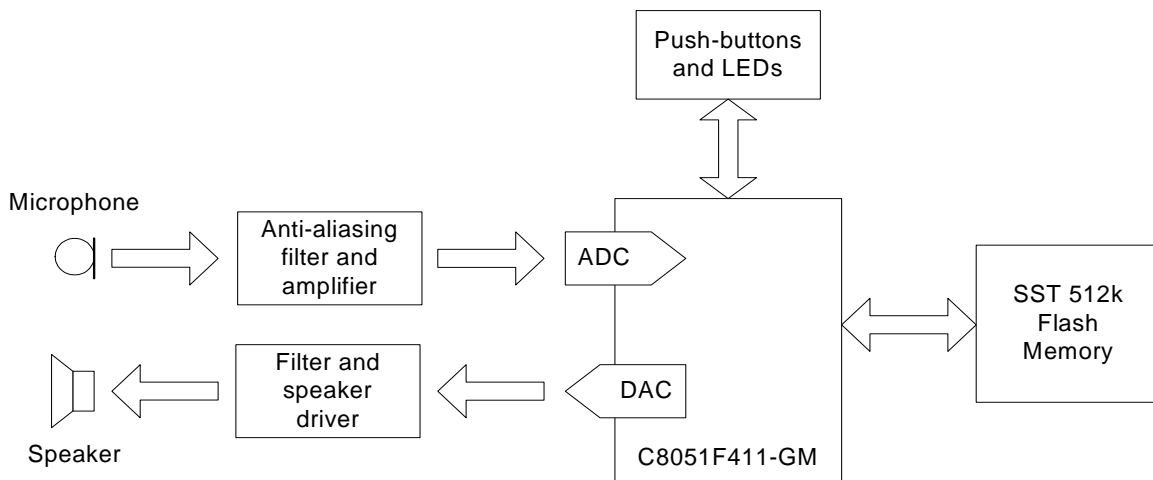

Figure 4. Voice Recorder Debugging Setup

Connect the USB Debug Adapter (UDA) to the PC and open the Silicon Laboratories IDE. The Voice Recorder project can be opened by going to **Project→Open Project** and selecting "F411_VR.wsp" after navigating to the proper directory.
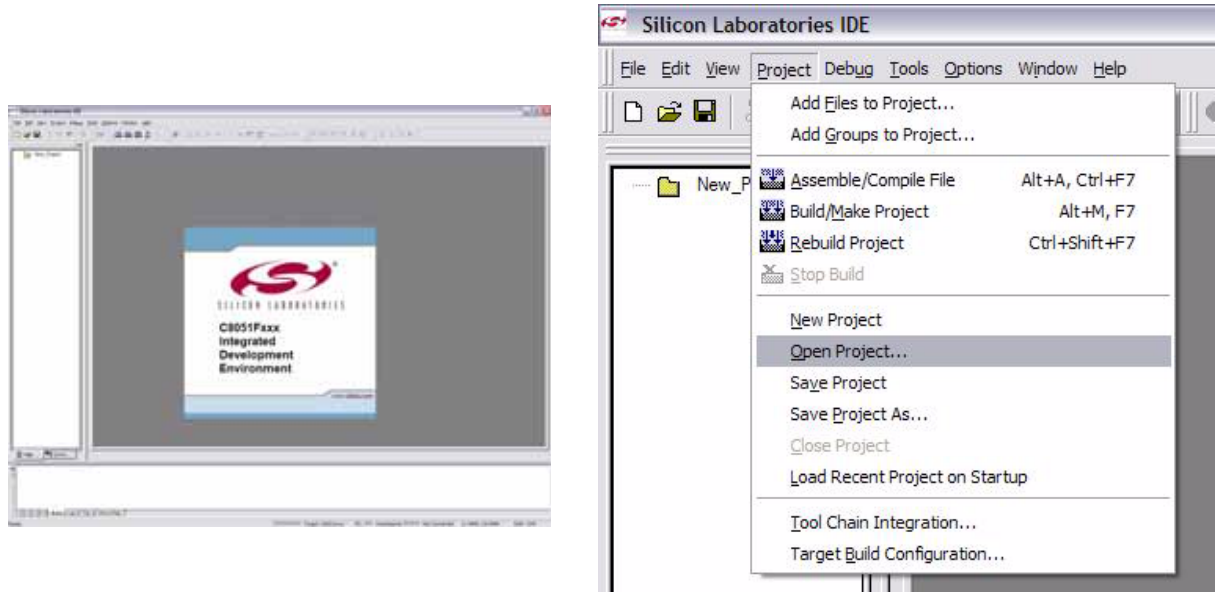
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Figure 5. Debugging in the Silicon Laboratories IDE

Once the Voice Recorder project is open:

1. Build the project by using the **Build/Make Project** button in the Build toolbar or selecting **Project->Build/Make Project** from the menu.

Figure 6. Build and Debug Toolbars in the Silicon Labs IDE

> **Note:** After the project has been built the first time, the **Build/Make Project** command will only build the files that have been changed since the previous build. To rebuild all files and project dependencies, click on the **Rebuild All** button in the toolbar or select **Project→Rebuild All** from the menu.

2. Before connecting to the target device, several connection options may need to be set. Open the **Connection Options** window by selecting **Options→Connection Options...** in the IDE menu. To connect to the Voice Recorder, verify that the USB Debug Adapter and Silicon Labs 2-wire (C2) debug interface are selected. Once the proper selections are made, click the OK button to close the window.

3. Click the **Connect** button in the toolbar or select **Debug→Connect** from the menu to connect to the Voice Recorder board.

4. Download the project to the board by clicking the **Download Code** button in the Build toolbar.

> **Note:** To enable automatic downloading if the program build is successful, select **Enable automatic connect/download after build** in the **Project→Target Build Configuration** dialog. If errors occur during the build process, the IDE will not attempt the download.

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5. Save the project when finished with the debug session to preserve the current target build configuration, editor settings and the location of all open debug views. To save the project, select **Project→Save Project** from the menu.

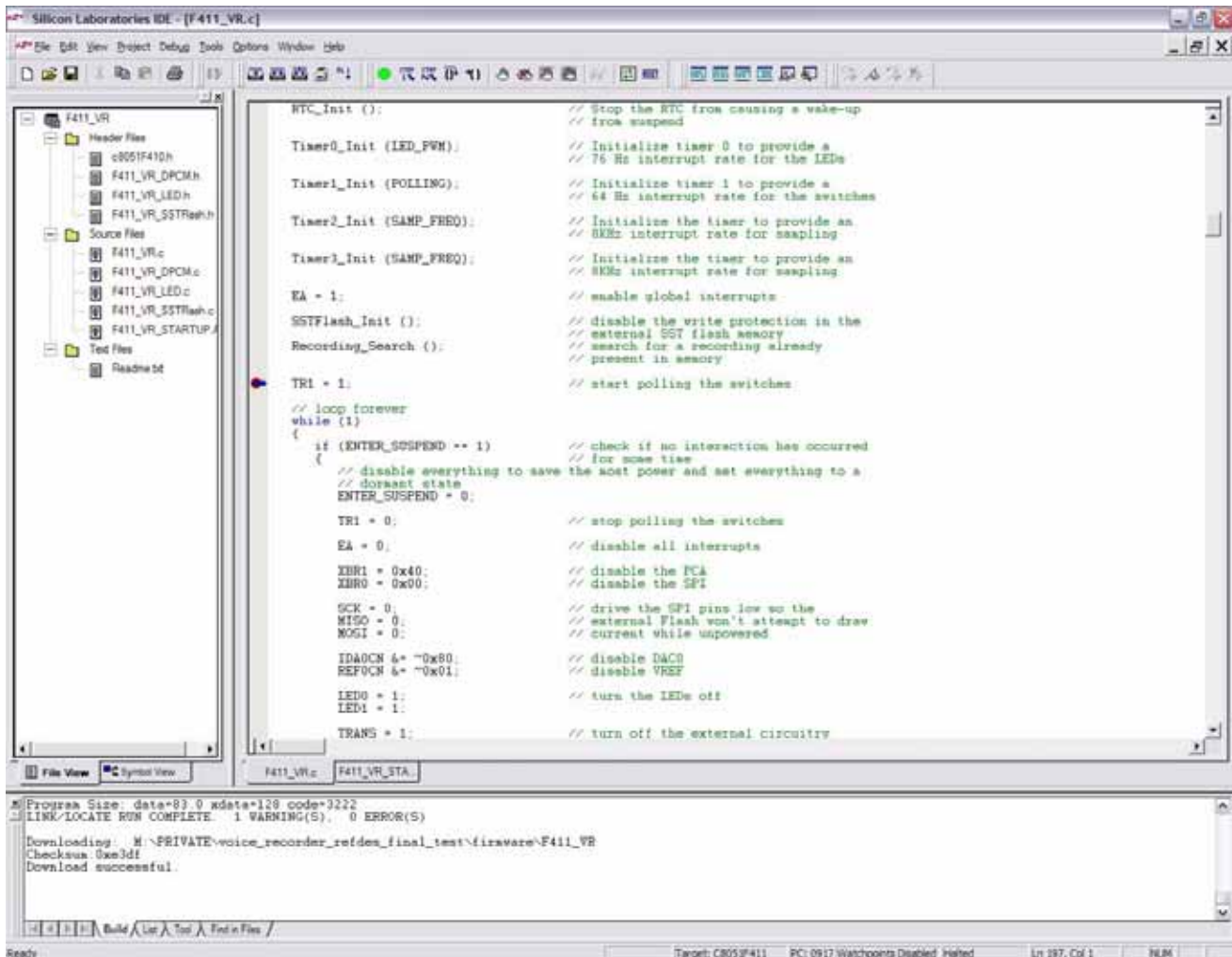6. Run, Step, and Reset the firmware using the Debug toolbar

Figure 7. Debugging the Voice Recorder Firmware

The AN278 Voice Recorder Reference Design document contains a detailed firmware description. This document can be found on the Voice Recorder Reference Design Kit CD-ROM or downloaded from the Silicon Laboratories Reference Designs website.

■ http://www.silabs.com/products/microcontroller/designs.asp

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