

# ZL38090 Preliminary Data Sheet

## Designed for USB Headsets and Microphones

### Description

The ZL38090 is part of Microsemi's Timberwolf audio processor family of products that features Microsemi's innovative *AcuEdge™* firmware, which uses a set of highly-complex and integrated algorithms designed for audio enhancement. These algorithms are incorporated into a powerful DSP platform that allows the user to extract intelligible information from adverse audio environments.

The Microsemi *AcuEdge* Firmware for the ZL38090 device is specifically designed for USB headset and USB microphones. The ZLS38090 *AcuEdge* firmware is royalty-free and provides an advanced audio feature set including beam forming (BF), noise reduction (NR), equalizers (EQ), and a compressor, limiter and expander (CLE) to improve both the intelligibility and subjective quality of voice in harsh acoustic environments.

Microsemi offers additional tools to speed up the product development cycle. The *MiTuner™* ZLS38508 or ZLS38508LITE GUI software packages allow a user to interactively configure the ZL38090 device. The optional ZLE38470BADA Automatic Tuning Kit provides automatic tuning and easy control for manual fine tuning adjustments.

### Ordering Information

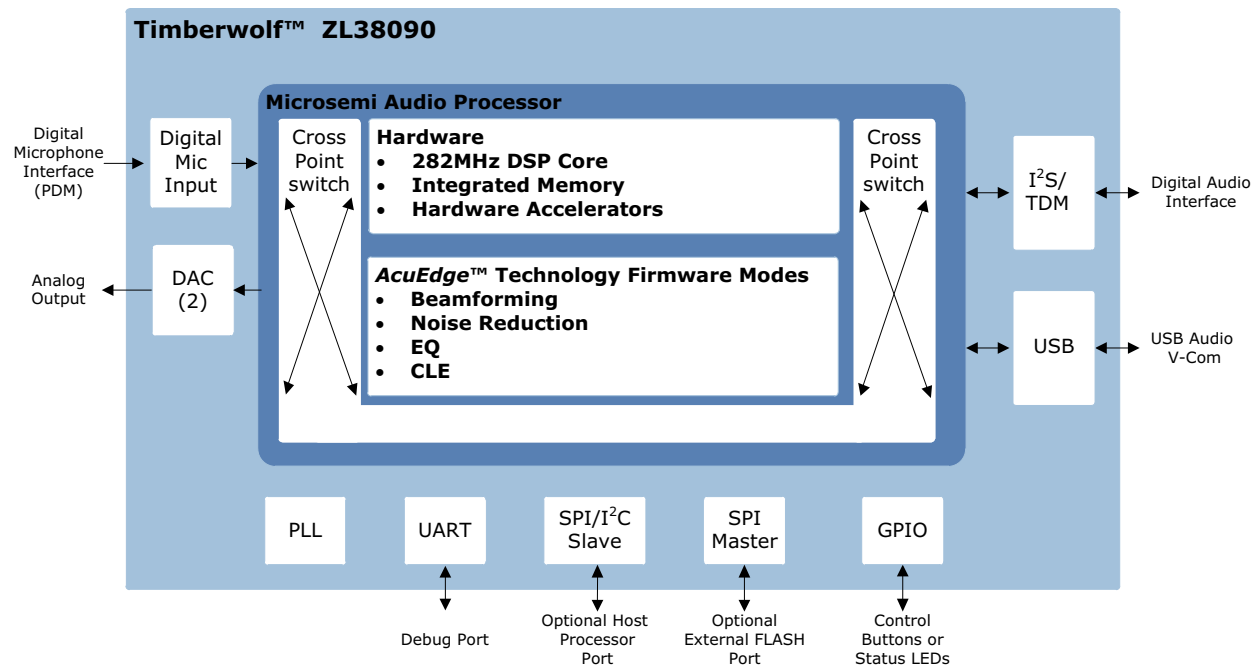
- ZL38090LDF1: 64-pin QFN (9×9) Package (Tape & Reel)
- ZL38090LDG1: 64-pin QFN (9×9) Package (Tray)
- ZL38090UGB2: 56-ball WLCSP (3.1×3.1) Package (Tape & Reel)

**Note:** These packages meet RoHS 2 Directive 2011/65/EU of the European Council to minimize the environmental impact of electrical equipment.

### Applications

- USB Beamforming Microphones
- USB to analog bridge/ USB to I<sup>2</sup>S bridge
- USB Headsets/headset dongles
- USB Speakerphones
- USB Speakers

Figure 1 • ZL38090 Block Diagram



## Microsemi *AcuEdge*™ Technology ZL38090 Firmware

- Supports 1 stereo headset with play and record or playback-only functions
- Microphone Beamforming (2 microphones)
- Advanced Microphone noise reduction
- Standard Dynamic Range Compressor
- Limiter
- Expander
- Send and receive path 8-band parametric equalizers
- 8 kHz/16 kHz/24 kHz/48 kHz audio streaming
- 4 Defined Function GPIOs for Volume Up/Down, Mute Mic, and Hook-Switch On/Off
- 4 Defined Function PWM outputs for LED control
- 4 additional GPIOs capable of key input and PWM LED control
- USB Audio Class Device v1.0 compliant
- Adaptive mode for playback, Asynchronous mode for record
- USB Audio Class clock modes
- Common HID controls for volume, hookswitch control and mute
- USB port that enumerates with:
  - EP0 (Control)
  - 2 endpoints for Microphones and Speakers (both stereo)
  - 1 interrupt endpoint (for HID Status Reporting)
  - 2 optional endpoints for Virtual Com support
- Skype/Lync Compatible
- Standalone USB device (additional host processor not required for headphone applications)

## Hardware Features

- DSP with Voice Hardware Accelerators
- Dual  $\Delta\Sigma$  16-bit digital-to-analog converters (DAC)
  - Sampling up to 48 kHz and internal output drivers
  - Headphone amplifiers capable of 32mW output drive power into 16 ohms
- 2 Digital Microphone input supporting up to 4 Microphones
- 1 TDM / Inter-IC Sound (I<sup>2</sup>S) port
- SPI or I<sup>2</sup>C Slave port for host processor interface
- Master SPI port for optional serial Flash interface
  - Device boots from either Flash or SPI
- General Purpose Input/Output pins (GPIOs)
- General purpose UART port for debug

## The *MiTuner*™ Automatic Tuning Kit and ZLS38508 *MiTuner* GUI

Microsemi's Automatic Tuning Kit option includes:

- Audio Interface Box hardware
- Microphone and Speaker
- ZLS38508 *MiTuner* GUI software
  - Allows tuning of Microsemi's *AcuEdge* Technology Audio Processor

The ZLS38508 software features:

- Auto Tuning and Subjective Tuning support
- Provides visual representations of the audio paths with drop-down menus to program parameters, allowing:
  - Control of the audio routing configuration
  - Programming of key blocks in the transmit (Tx) and receive (Rx) audio paths
  - Setting analog and digital gains
- Configuration parameters allow users to “fine tune” the overall performance



## Tools

- ZLK38000 Evaluation Kit
- *MiTuner*™ ZLS38508 and ZLS38508LITE GUI
- *MiTuner*™ ZLE38470BADA Automatic Tuning Kit



# Contents

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|          |   |           |
|----------|---|-----------|
| <b>1</b> | <b>Revision History</b> .....                     | <b>1</b>  |
| 1.1      | Revision 2.0 .....                                | 1         |
| <b>2</b> | <b>Overview</b> .....                             | <b>2</b>  |
| 2.1      | Introduction .....                                | 2         |
| 2.2      | Applications .....                                | 2         |
| 2.3      | Hardware Peripherals .....                        | 2         |
| 2.4      | Audio Design Considerations .....                 | 3         |
| <b>3</b> | <b>AcuEdge Firmware</b> .....                     | <b>4</b>  |
| 3.1      | Main Application Configurations .....             | 5         |
| 3.1.1    | Headset Configuration .....                       | 5         |
| 3.1.2    | USB Bridge Configuration .....                    | 5         |
| <b>4</b> | <b>Audio Interfaces</b> .....                     | <b>6</b>  |
| 4.1      | Digital Microphone Interface .....                | 6         |
| 4.1.1    | Analog Microphone Use .....                       | 7         |
| 4.2      | DAC Output .....                                  | 7         |
| 4.2.1    | Output Driver Configurations .....                | 8         |
| 4.2.2    | DAC Bias Circuit .....                            | 9         |
| 4.3      | TDM Interface .....                               | 10        |
| 4.3.1    | I <sup>2</sup> S Mode .....                       | 10        |
| 4.3.2    | PCM Mode .....                                    | 12        |
| 4.3.3    | GCI Mode .....                                    | 14        |
| 4.4      | USB Interface .....                               | 15        |
| <b>5</b> | <b>Control Interfaces</b> .....                   | <b>16</b> |
| 5.1      | Host Bus Interface .....                          | 16        |
| 5.1.1    | SPI Slave .....                                   | 16        |
| 5.1.2    | I <sup>2</sup> C Slave .....                      | 18        |
| 5.1.3    | Host Interrupt Pin .....                          | 18        |
| 5.2      | UART .....  | 18        |
| 5.3      | Master SPI .....                                  | 18        |
| 5.3.1    | Flash Interface .....                             | 18        |
| 5.4      | GPIO .....  | 20        |
| 5.5      | USB Interface .....                               | 21        |
| 5.5.1    | USB Audio Function Topology .....                 | 21        |
| <b>6</b> | <b>Reset</b> .....                                | <b>22</b> |
| <b>7</b> | <b>Power Supply</b> .....                         | <b>23</b> |
| 7.1      | Power Supply Sequencing/Power up .....            | 23        |
| 7.1.1    | Power Supply Considerations .....                 | 23        |
| <b>8</b> | <b>Device Booting and Firmware Swapping</b> ..... | <b>26</b> |
| 8.1      | Bootloader .....                                  | 26        |
| 8.2      | Bootstrap Modes .....                             | 26        |
| 8.3      | Loadable Device Code .....                        | 26        |
| 8.3.1    | Boot Speed .....                                  | 26        |

|           |  |           |
|-----------|--|-----------|
| 8.4       | Bootup Procedure                                   | 27        |
| <b>9</b>  | <b>Device Pinouts</b>                              | <b>28</b> |
| 9.1       | 64-Pin QFN   | 28        |
| 9.2       | 56-Ball WLCSP                                      | 29        |
| <b>10</b> | <b>Pin Descriptions</b>                            | <b>30</b> |
| 10.1      | Reset Pin  | 30        |
| 10.2      | DAC Pins   | 30        |
| 10.3      | Microphone Pins                                    | 31        |
| 10.4      | TDM and I <sup>2</sup> S Port Pins                 | 31        |
| 10.5      | Headset Control/Indicator Pins                     | 32        |
| 10.6      | USB Pins   | 33        |
| 10.7      | HBI – SPI Slave Port Pins                          | 33        |
| 10.8      | Master SPI Port Pins                               | 34        |
| 10.9      | Oscillator Pins                                    | 34        |
| 10.10     | UART Pins  | 34        |
| 10.11     | GPIO Pins  | 35        |
| 10.12     | Supply and Ground Pins                             | 35        |
| 10.13     | No Connect Pins                                    | 36        |
| 10.14     | IN0 Pins   | 36        |
| <b>11</b> | <b>Electrical Characteristics</b>                  | <b>37</b> |
| 11.1      | Absolute Maximum Ratings                           | 37        |
| 11.2      | Thermal Resistance                                 | 37        |
| 11.3      | Operating Ranges                                   | 37        |
| 11.4      | Device Power States                                | 38        |
| 11.4.1    | Working State                                      | 38        |
| 11.4.2    | USB Suspend State                                  | 38        |
| 11.4.3    | Reset State  | 38        |
| 11.4.4    | Current Consumption                                | 39        |
| 11.5      | DC Specifications                                  | 39        |
| 11.6      | AC Specifications                                  | 40        |
| 11.6.1    | Microphone Interface                               | 40        |
| 11.6.2    | DAC  | 40        |
| 11.7      | External Clock Requirements                        | 42        |
| 11.7.1    | Crystal Application                                | 42        |
| 11.7.2    | Clock Oscillator Application                       | 43        |
| 11.7.3    | AC Specifications - External Clocking Requirements | 44        |
| <b>12</b> | <b>Timing Characteristics</b>                      | <b>45</b> |
| 12.1      | TDM Interface Timing Parameters                    | 45        |
| 12.1.1    | GCI and PCM Timing Parameters                      | 45        |
| 12.1.2    | I <sup>2</sup> S Timing Parameters                 | 47        |
| 12.2      | Host Bus Interface Timing Parameters               | 49        |
| 12.2.1    | SPI Slave Port Timing Parameters                   | 49        |
| 12.2.2    | I <sup>2</sup> C Slave Interface Timing Parameters | 50        |
| 12.3      | UART Timing Parameters                             | 51        |
| 12.4      | Master SPI Timing Parameters                       | 52        |
| <b>13</b> | <b>Package Outline Drawings</b>                    | <b>53</b> |
| 13.1      | Package Drawings                                   | 53        |

# Figures

|           |  |    |
|-----------|--|----|
| Figure 1  | ZL38090 Block Diagram  | i  |
| Figure 2  | USB Headset  | 2  |
| Figure 3  | ZL38090 <i>AcuEdge</i> Firmware Typical Interfaces               | 4  |
| Figure 4  | Single Mono Digital Microphone Interface                         | 6  |
| Figure 5  | Dual Microphone or Stereo Digital Microphone Interface           | 6  |
| Figure 6  | Four Digital Microphone Interfaces                               | 7  |
| Figure 7  | ECM Circuit  | 7  |
| Figure 8  | Audio Output Configurations                                      | 9  |
| Figure 9  | ZL38090 Bias Circuit   | 10 |
| Figure 10 | I <sup>2</sup> S Mode  | 11 |
| Figure 11 | Left Justified Mode  | 11 |
| Figure 12 | Dual Codec Configuration   | 12 |
| Figure 13 | TDM – PCM Slave Functional Timing Diagram (8-bit, xeDX = 0)      | 13 |
| Figure 14 | TDM – PCM Slave Functional Timing Diagram (8-bit, xeDX = 1)      | 13 |
| Figure 15 | TDM – PCM Master Functional Timing Diagram (8-bit, xeDX = 0)     | 13 |
| Figure 16 | TDM – PCM Master Functional Timing Diagram (8-bit, xeDX = 1)     | 14 |
| Figure 17 | TDM – GCI Slave Functional Timing Diagram                        | 14 |
| Figure 18 | TDM – GCI Master Functional Timing Diagram                       | 14 |
| Figure 19 | USB Interface Circuit  | 15 |
| Figure 20 | SPI Slave Byte Framing Mode – Write                              | 16 |
| Figure 21 | SPI Slave Byte Framing Mode – Read                               | 17 |
| Figure 22 | SPI Slave Word Framing Mode – Write, Multiple Data Words         | 17 |
| Figure 23 | SPI Slave Word Framing Mode – Read, Multiple Data Words          | 17 |
| Figure 24 | SPI Slave Command Framing Mode – Write                           | 17 |
| Figure 25 | SPI Slave Command Framing Mode – Read                            | 18 |
| Figure 26 | Flash Interface Circuit  | 19 |
| Figure 27 | Typical Power Supply Configuration                               | 24 |
| Figure 28 | Internal +1.2V Power Supply Configuration                        | 25 |
| Figure 29 | ZL38090 64-Pin QFN – Top View                                    | 28 |
| Figure 30 | ZL38090 56-Ball WLCSP – Top View                                 | 29 |
| Figure 31 | THD+N Ratio versus Output Power – Driving Low Impedance          | 41 |
| Figure 32 | THD+N Ratio versus V <sub>RMS</sub> – Driving High Impedance     | 42 |
| Figure 33 | Crystal Application Circuit                                      | 43 |
| Figure 34 | Clock Oscillator Application Circuit                             | 43 |
| Figure 35 | Timing Parameter Measurement Digital Voltage Levels              | 45 |
| Figure 36 | GCI Timing, 8-bit  | 46 |
| Figure 37 | PCM Timing, 8-bit with xeDX = 0 (Transmit on Negative PCLK Edge) | 46 |
| Figure 38 | PCM Timing, 8-bit with xeDX = 1 (Transmit on Positive PCLK Edge) | 47 |
| Figure 39 | Slave I <sup>2</sup> S Timing                                    | 48 |
| Figure 40 | Master I <sup>2</sup> S Timing                                   | 48 |
| Figure 41 | SPI Slave Timing   | 50 |
| Figure 42 | I <sup>2</sup> C Timing Parameter Definitions                    | 51 |
| Figure 43 | UART_RX Timing   | 51 |
| Figure 44 | UART_TX Timing   | 51 |
| Figure 45 | Master SPI Timing  | 52 |
| Figure 46 | 64-Pin QFN   | 53 |
| Figure 47 | Recommended 64-Pin QFN Land Pattern – Top View                   | 54 |
| Figure 48 | 56-Ball WLCSP  | 55 |
| Figure 49 | 56-Ball WLCSP Staggered Balls Expanded Bottom View               | 56 |

# Tables

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|          |   |    |
|----------|---|----|
| Table 1  | HBI Slave Interface Selection . . . . .                     | 16 |
| Table 2  | Flash Devices Tested with the ZL38090 . . . . .             | 19 |
| Table 3  | Supported Flash Types . . . . .                             | 20 |
| Table 4  | Q1 Component Options . . . . .                              | 24 |
| Table 5  | Bootstrap Modes . . . . .                                   | 26 |
| Table 6  | Reset Pin Description . . . . .                             | 30 |
| Table 7  | DAC Pin Description . . . . .                               | 30 |
| Table 8  | Microphone Pin Description . . . . .                        | 31 |
| Table 9  | TDM and I <sup>2</sup> S Ports Pin Descriptions . . . . .   | 31 |
| Table 10 | Headset Control/Indicator Pin Descriptions . . . . .        | 32 |
| Table 11 | USB Pin Descriptions . . . . .                              | 33 |
| Table 12 | HBI – SPI Slave Port Pin Descriptions . . . . .             | 33 |
| Table 13 | Master SPI Port Pin Descriptions . . . . .                  | 34 |
| Table 14 | Oscillator Pin Descriptions . . . . .                       | 34 |
| Table 15 | UART Pin Descriptions . . . . .                             | 34 |
| Table 16 | GPIO Pin Descriptions . . . . .                             | 35 |
| Table 17 | Supply and Ground Pin Descriptions . . . . .                | 35 |
| Table 18 | No Connect Pin Description . . . . .                        | 36 |
| Table 19 | IN0 Pin Descriptions . . . . .                              | 36 |
| Table 20 | Absolute Maximum Ratings . . . . .                          | 37 |
| Table 21 | Thermal Resistance . . . . .                                | 37 |
| Table 22 | Operating Ranges . . . . .                                  | 37 |
| Table 23 | Current Consumption . . . . .                               | 39 |
| Table 24 | DC Specifications . . . . .                                 | 39 |
| Table 25 | Microphone Interface . . . . .                              | 40 |
| Table 26 | DAC . . . . .   | 40 |
| Table 27 | AC Specifications – External Clocking Requirement . . . . . | 44 |
| Table 28 | GCI and PCM Timing Parameters . . . . .                     | 45 |
| Table 29 | I <sup>2</sup> S Slave Timing Specifications . . . . .      | 47 |
| Table 30 | I <sup>2</sup> S Master Timing Specifications . . . . .     | 48 |
| Table 31 | SPI Slave Port Timing Parameters . . . . .                  | 49 |
| Table 32 | I <sup>2</sup> S Slave Timing Specifications . . . . .      | 50 |
| Table 33 | UART Timing Specifications . . . . .                        | 51 |
| Table 34 | Master SPI Timing Specifications . . . . .                  | 52 |

# 1 Revision History

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The revision history describes the changes that were implemented in the document. The changes are listed by revision, starting with the most current publication.

## 1.1 Revision 2.0

The following is a summary of the changes in revision 2 of this document.

- Migration to new document format; no other changes to technical details or content besides those listed here
- Added USB interface schematic and recommendation for protection device
- Added second digital microphone input pin
- Removed reference to second TDM port
- Updated verbiage on front page to better delineate and describe features
- Minor text corrections
- Headers applied to aid in documentation navigation
- Updated typical power consumption numbers and updated descriptions of operating power states
- Added more detailed block diagram on front page
- Section 2 [Overview](#), page 2 and Section 3 [AcuEdge Firmware](#), page 4 rewritten to provide clarification on applications and firmware operational modes: no changes to technical details or specification
- Type 3 and Type 4 flash devices are supported, but not recommended; specific devices previously recommended have been removed from [Table 3](#), page 20
- Removed remote wake up bullet from firmware feature highlights



## 2 Overview

### 2.1 Introduction

The Microsemi ZL38090 Audio Processor powered by ZLS38090 *AcuEdge™* Firmware is ideal for providing high definition audio for USB headsets, USB Microphones and for USB audio bridging devices (USB to I<sup>2</sup>S/TDM).

The ZL38090 provides Two-way Audio Communication using sophisticated audio processing. This includes beam forming (BF), noise reduction (NR), equalizers (EQ), and a compressor, limiter and expander (CLE) to improve both the intelligibility and subjective quality of voice in harsh acoustic environments.

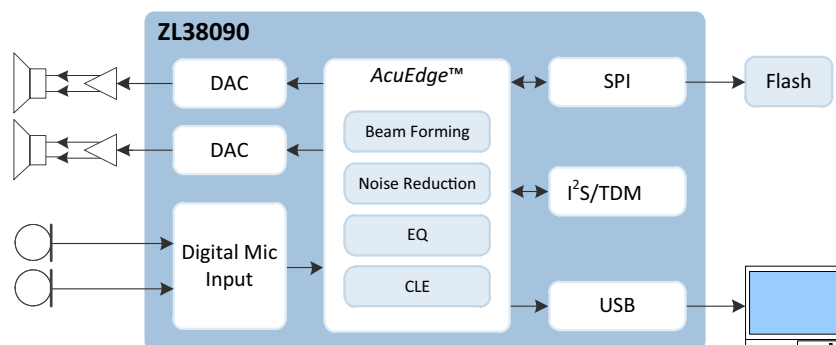
### 2.2 Applications

Applications for the ZL38090 device include any design that requires USB to analog or USB to I<sup>2</sup>S/TDM bridging. In addition to this basic function, the ZL38090 also offers audio enhancement for audio recording and two-way audio. Typical applications include:

- USB Beamforming Microphones
- USB to analog bridge/ USB to I<sup>2</sup>S bridge
- USB Headsets/ headset dongles
- USB Speakerphone
- USB Speakers

The following application block diagram shows the ZL38090 used in an USB headset utilizing the 2-microphone beam forming to remove interfering noise. The USB headset does not need a host processor to control the device. The ZL38090 is a self-contained processor that provide basic functions for 2-way audio communications, including GPIO functions for Volume Up/Down, Mute Mic, and Hook-Switch On/Off. The ZL38090 is Skype/Lync compatible allowing the user to control Skype/Lync through the GPIO. The ZL38090 incorporates a virtual com port to allow the developer/user to modify various audio processing settings. An external FLASH is used to hold the PID and VID of the end device.

**Figure 1 • USB Headset**



### 2.3 Hardware Peripherals

The main peripherals of the ZL38090 device are shown in Figure 1, page i, and a description of each follows.

The ZL38090 device provides the following peripheral interfaces:

- USB Audio Class Device v1.0 compliant
  - Adaptive mode for playback, Asynchronous mode for record
  - USB Audio Class clock modes
  - Remote wake-up via fixed function GPIO
  - Common HID controls for volume, hookswitch control and mute

- USB port that enumerates with EP0 (Control), 2 endpoints for Microphones and Speakers, (both stereo), and 1 interrupt endpoint (for Status Reporting)
- Skype/Lync Compatible
- Standalone USB device (additional host processor not required for headphone applications)
- 1 digital Microphone interface allowing sampling of 1 or 2 digital microphones
- 2 independent headphone drivers
  - Dual 16-bit digital-to-analog converters (DACs)
  - 16 ohms single-ended or differential drive capability
  - 32 mW output drive power into 16 ohms
- 2 Time-Division Multiplexing (TDM) buses
  - The ports can be configured for Inter-IC Sound (I<sup>2</sup>S) or Pulse-Code Modulation (PCM) operation
  - PCM operation supports PCM and GCI timing, I<sup>2</sup>S operation supports normal and left justified transmission
  - Each port can be a clock master or a slave
  - Each port supports up to four bi-directional streams when configured in PCM mode or two bi-directional streams when configured for I<sup>2</sup>S mode at data rates from 128 kb/s to 8 Mb/s
  - Sample rate conversions are automatically done when data is sent/received at different rates than is processed internally. Only integer conversions are allowed.
- SPI – The device provides two Serial Peripheral Interface (SPI) ports
  - The SPI Slave port is recommended as the main communication port with a host processor. The port provides the fastest means to Host Boot and configures the device's firmware and configuration record<sup>1</sup>.
  - The Master SPI port is used to load the device's firmware and configuration record from external Flash memory (Auto Boot).
- I<sup>2</sup>C - The device provides one Inter-Integrated Circuit (I<sup>2</sup>C) port. (Pins are shared with the SPI Slave port)
  - The I<sup>2</sup>C port can be used as the main communication port with a host processor, and can be used to Host Boot and configure the device's firmware and configuration record.
- UART – The device provides one Universal Asynchronous Receiver/Transmitter (UART) port
  - The UART port can be used as a debug tool and is used for tuning purposes.
- GPIO – The device provides 14 General Purpose Input/Output (GPIO) ports.
  - GPIO ports can be used for interrupt and event reporting, fixed function control, bootstrap options, as well as being used for general purpose I/O for communication and controlling external devices.
  - The 56 pin WLCSP package is limited to 11 GPIOs.

## 2.4 Audio Design Considerations

The acoustic design consists of the microphone, speaker, speaker driver and the industrial design of the enclosure. For optimal performance, care must be taken with the device speaker, speaker driver, microphone selection, and the industrial design to insure maximum acoustic isolation and minimize distortion.

Microsemi offers various tools and guides to assist in developing the end system. Consult the *Microsemi AcuEdge™ Firmware Manual* and the *Microphone Speaker and Amplifier Design Note* for more information.

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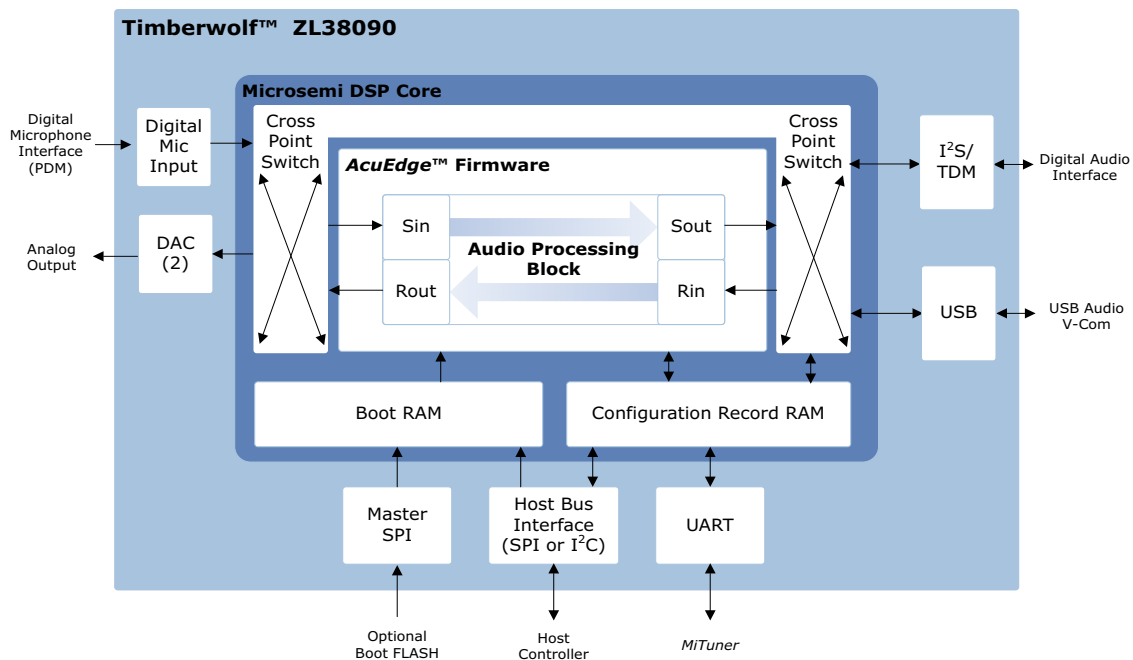
1. The configuration record is a set of register values that are customizable by the application developer to configure and tune the ZL38090 for a particular design. Refer to the *Microsemi AcuEdge™ Firmware Manual* for firmware and configuration record information

## 3 AcuEdge Firmware

Firmware-implemented algorithms, configuration options, and performance can vary based on the loaded firmware image. The description here of firmware modes and features represents a summary of the options available at the time of publication, and should not be considered part of the hardware datasheet specification. The *Microsemi AcuEdge™ Firmware Manual* for the appropriate firmware image should be referenced for more detailed information and specification about each of the firmware modes.

Figure 1 depicts many of the typical interfaces available in an *AcuEdge* firmware image. The desired firmware image may be loaded at startup or swapped during runtime via the host processor or via an optional external flash device (see [Device Booting and Firmware Swapping](#), page 26, for more information). Once running, the *AcuEdge* firmware and Cross Point Switch share configuration registers, which may be accessed via the Host Bus Interface. The *MiTuner* GUI Application can be used during development to tune the various registers via the UART debug interface. *MiTuner* can save the complete set of configuration registers to a file, called the Configuration Record. The set and definition of configuration registers is defined by the firmware, and can vary based on the loaded image. The specification of these registers is documented in the *Microsemi AcuEdge™ Firmware Manual*.

Figure 2 • ZL38090 *AcuEdge* Firmware Typical Interfaces



The Microsemi *AcuEdge* Firmware implements various signal processing algorithms, such as Equalization, Noise Reduction, beam forming and CLE. These algorithms execute in the Audio Processing Block. The send path is processed at 16 kHz sampling rate while the receive path is processed at full band. All audio is presented at the USB at full band sampling rates. The Audio Processing Block has between one and four audio IO (input/output) ports which can be routed to/from the various audio interfaces via the Cross Point Switch. The firmware automatically decimates audio inputs down to the Audio Processing sampling rate (16 kHz), and interpolates audio outputs up to the rate appropriate for the given output peripheral. Refer to the corresponding Audio Interface-specific documentation in [Audio Interfaces](#), page 6, for details and audio rates for each audio peripheral.

The following section highlights some key features of the firmware. Consult the *Microsemi AcuEdge™ Firmware Manual* for more details.

## 3.1 Main Application Configurations

The configuration of the ZL38090 is determined depending on which firmware block is enabled. The firmware image and configuration is initially loaded at power-on-reset, either from external serial Flash or from a host controller (see [Device Booting and Firmware Swapping](#), page 26).

There are two main configurations, headset configuration and USB/I<sup>2</sup>S bridge configuration. The sections that follow highlight the primary features and operation of the various configurations.

### 3.1.1 Headset Configuration

In this configuration, the ZL38090 can use either a single mic or dual microphones. In both configurations, the following features are available:

- Noise Reduction – Analyses the spectral density of the background noise. This information is used to remove noise while minimizing signal distortion.
- CLE – A sophisticated audio compressor/limiter/expander with adjustable attack and decay time. This feature along with Beamforming and advanced Noise Reduction allows for Far Field Microphone pick-up.
- 8 band parametric equalizer – Equalizers are available on the Rin/Rout path, and the Sin/Sout path. Each path contains eight programmable equalization filters. These equalization filters allow the application developer to adjust and tune the audio signal to meet certain design requirements

When using dual microphones, Beam Forming (BF) can be implemented to form a steerable beam in from of the 2-microphone array. The beamformer accepts those sources that it determines are in the direction of interest and attenuates those that are deemed to be coming from other directions. The beam former setting can be programmed to allow the beam angle and aggressiveness of the off-beam attenuation to be modified. This can allow multiple setting corresponding to a "low/med/high" setting for noise reduction and beamforming. If a single mic is used, beamforming is not available but all other functions are available.

### 3.1.2 USB Bridge Configuration

In this configuration, the ZL38090 is used as a simple I<sup>2</sup>S/TDM/Audio to USB bridge. All audio processes are bypassed.

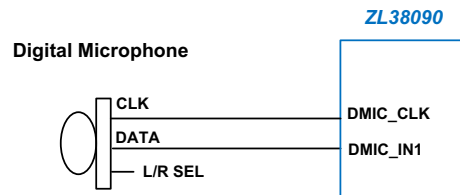
## 4 Audio Interfaces

### 4.1 Digital Microphone Interface

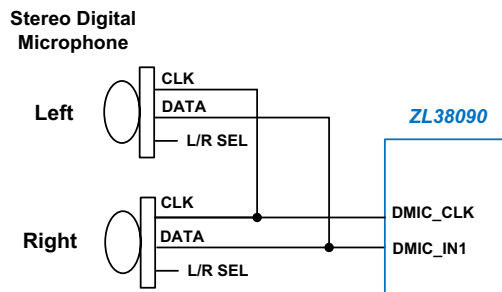
The ZL38090 supports up to four digital microphones using the DMIC\_CLK, DMIC\_IN1, and DMIC\_IN2 interface pins. The ZL38090 digital microphone clock output (DMIC\_CLK) is either 1.024 MHz or 3.072 MHz depending on the selected TDM-A sample rate. Selecting an 8 kHz or 16 kHz TDM-A sample rate corresponds to a 1.024 MHz digital microphone clock and selecting a 48 kHz sample rate corresponds to a 3.072 MHz digital microphone clock. Microphone data is decimated and filtered to operate at the 16 kHz sampling rate of the Audio Processing block. When there is no TDM-A bus to set the sample rate, the ZL38090 will operate from the crystal and will pass digital audio from the microphones operating at a 48 kHz sampling rate.

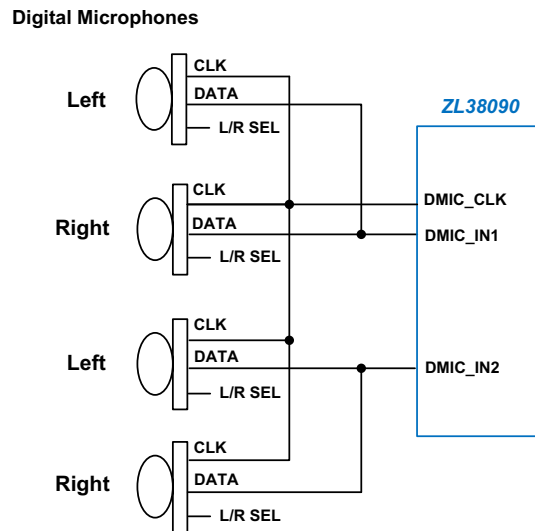
A stereo digital microphone, or two separate mono digital microphones, send two microphone channels on one pin by sending the data for one channel on the rising edge and one channel on the falling edge. The selection as to which clock edge is used to clock in the microphone data (rising/falling) is done via a firmware configuration record register. Various digital microphone interfaces are presented in Figures 3–5.

**Figure 3 • Single Mono Digital Microphone Interface**



**Figure 4 • Dual Microphone or Stereo Digital Microphone Interface**

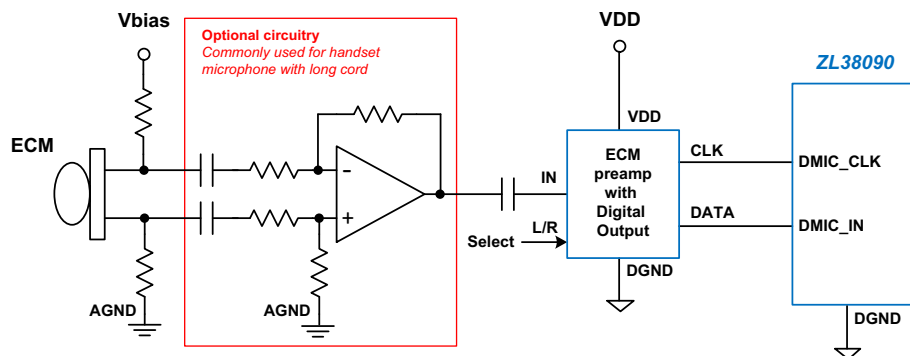


**Figure 5 • Four Digital Microphone Interfaces**


### 4.1.1 Analog Microphone Use

Electret condenser microphones (ECM) can be used with the digital microphone interface by using a Digital Electret Microphone Pre-Amplifier device as shown in [Figure 6](#). External Codecs can also be used to connect to analog microphones. The external Codecs would interface to the ZL38090 via the TDM buses.

The analog microphone is wired to an optional differential amplifier which can provide filtering and gain and converts the microphone signal to single-ended. The microphone signals are then further amplified and digitized through the Digital Electret Microphone Pre-Amplifiers and applied to the ZL38090 digital microphone input. The ZL38090 provides the clock to activate the Digital Electret Microphone Pre-Amplifier.

**Figure 6 • ECM Circuit**


When using an analog microphone, operation in the Low Power state is not recommended. For more information, see [Device Power States](#), page 38.

## 4.2 DAC Output

The ZL38090 supports two 16-bit fully differential delta-sigma digital-to-analog converters. The two output DACs independently drive an analog output subsystem. Each subsystem is able to drive two output pins, representing four independent single-ended headphone outputs that can be driven by two independent data streams. The pins can be independently configured. Four analog gains on each headphone output are provided and can be set to: 1x, 0.5x, 0.333x, or 0.25x.

**Note:** Only the positive DAC outputs are available with the 56-ball WLCSP package. The 56-ball WLCSP package provides two independent single-ended headphone outputs that can be driven by two independent data streams.

The headphone amplifiers are self-protecting so that a direct short from the output to ground or a direct short across the terminals does not damage the device.

The ZL38090 provides audible pop suppression which reduces pop noise in the headphone earpiece when the device is powered on/off or when the device channel configurations are changed. This is especially important when driving a headphone single-ended through an external capacitor (see [Output Driver Configurations](#), page 8, configuration C).

The DACs and headphone amplifiers can be powered down if they are not required for a given application. To fully power down the DACs, disable both the positive and negative outputs.

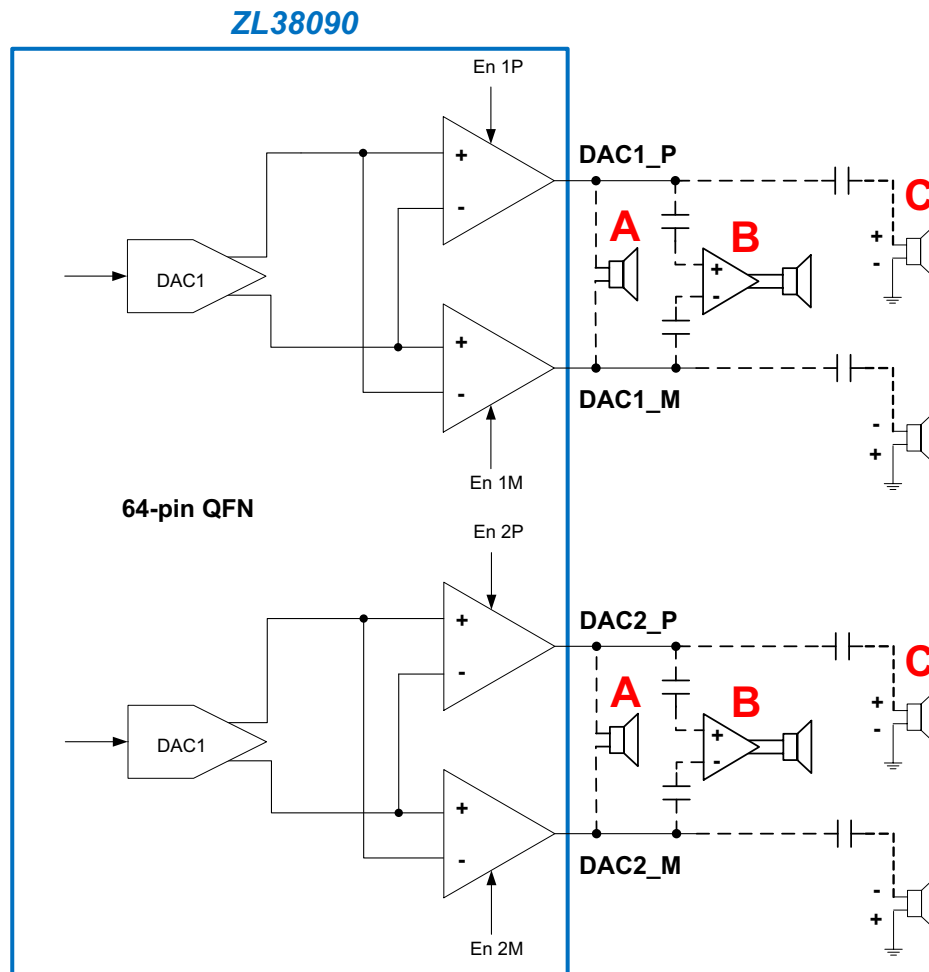
## 4.2.1 Output Driver Configurations

Figure 7, page 9 shows the different possible output driver configurations for the 64-pin QFN package. When using the 56-ball WLCSP package, only the positive single ended outputs DAC1\_P and DAC2\_P are provided.

The two output DACs independently drive positive and negative headphone driver amplifiers. The output pins can be independently configured in the following ways:

- A. Direct differential drive of a speaker as low as 32 ohms. For this configuration an analog gain of 1x is commonly used. (Differentially driving a 16 ohm speaker is possible, but only with the same amount of power as in the single-ended case. The signal level must be reduced to not exceed ½ scale in this case.) This configuration is not available in the 56-ball WLCSP package.
- B. Direct differential drive of a high impedance power amplifier. A Class D amplifier is recommended for this speaker driver. A 1  $\mu$ F coupling capacitor is generally used with the Class D amplifier. The analog gain setting depends on the gain of the Class D amplifier, analog gain settings of 0.25x or 0.5x are commonly used. This configuration is not available in the 56-ball WLCSP package.
- C. Driving either a high impedance or a capacitively coupled speaker as low as 16 ohms single-ended. For this configuration an analog gain of 1x is commonly used. The coupling capacitor value can vary from 10  $\mu$ F to 100  $\mu$ F depending on the type of earpiece used and the frequency response desired.

Figure 7 • Audio Output Configurations



## 4.2.2 DAC Bias Circuit

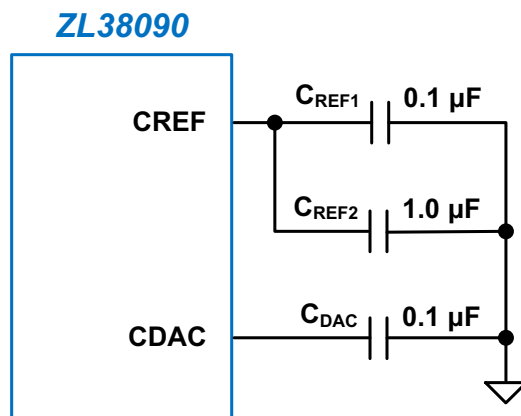
The common mode bias voltage output signal (CREF) must be decoupled through a  $0.1\ \mu\text{F}$  ( $C_{\text{REF1}}$ ) and a  $1.0\ \mu\text{F}$  ( $C_{\text{REF2}}$ ) ceramic capacitor to VSS.

The positive DAC reference voltage output (CDAC) must be decoupled through a  $0.1\ \mu\text{F}$  ( $C_{\text{DAC}}$ ) ceramic capacitor to VSS as shown in [Figure 8](#).

All capacitors can have a 20% tolerance and should have a minimum voltage rating of 6.3 V.



Figure 8 • ZL38090 Bias Circuit



## 4.3 TDM Interface

The ZL38090 supports a generic TDM interface that consists of four signals:

- Data clock (PCLK/I<sup>2</sup>S\_SCK)
- Data rate sync (FS/I<sup>2</sup>S\_WS)
- Serial data input (DR/I<sup>2</sup>S\_SDI)
- Serial data output (DX/I<sup>2</sup>S\_SDO)

The TDM port can be configured for Inter-IC Sound (I<sup>2</sup>S) or Pulse-Code Modulation (PCM) operation.

The TDM block is capable of being a master or a slave.

While a TDM bus configuration may carry many encoded audio streams, the ZL38090 device Cross Point Switch can only address a maximum of 4 bi-directional audio streams per TDM bus. These four audio streams are referred to as channels #1 through #4, and each of these channels can be independently configured to decode any of the TDM bus's audio streams.

Once the TDM bus is configured for a data sample rate and encoding, all data rates and encoding on that bus will be the same. 16-bit linear data will be sent on consecutive 8-bit timeslots (e.g., if timeslot N is programmed in the timeslot registers, the consecutive timeslot is N+1).

The TDM interface supports bit reversal (LSB first <- -> MSB first) and loopbacks within the TDM interface and from one interface to another.

The generic TDM interface supports the following mode and timing options.

### 4.3.1 I<sup>2</sup>S Mode

In I<sup>2</sup>S mode, the 4-wire TDM port conforms to the I<sup>2</sup>S protocol and the port pins become I2S\_SCK, I2S\_WS, I2S\_SDI, and I2S\_SDO (refer to [Table 9](#), page 31 for pin definitions).

An I<sup>2</sup>S bus supports two bi-directional data streams with left and right channels, by using the send and receive data pins utilizing the common clock and word signals. The send data is transmitted on the I2S\_SDO line and the receive data is received on the I2S\_SDI line.

The I<sup>2</sup>S port can be used to connect external analog-to-digital converters or Codecs. The port can operate in master mode where the ZL38090 is the source of the port clocks, or slave mode where the word select and serial clocks are inputs to the ZL38090.

The word select (I2S\_WS) defines the I<sup>2</sup>S data rate and sets the frame period when data is transmitted for the left and right channels. A frame consists of one left and one right audio channel. The I<sup>2</sup>S ports operate at 8, 16, and 48 kHz data rates as slave or master. Per the I<sup>2</sup>S standard, the word select is output using a 50% duty cycle.

The serial clock (I2S\_SCK) rate sets the number of bits per word select frame period and defines the frequency of I2S\_CLK. I<sup>2</sup>S data is input and output at the serial clock rate. Input data bits are received on I2S\_SDI and output data bits are transmitted on I2S\_SDO. Data bits are always MSB first. The number

of clock and data bits per frame can be programmed as 8, 16, 32, 64, 96, 128, 192, 256, 384, 512, or 1024. Any input data bits that are received after the LSB are ignored.

The I<sup>2</sup>S port operates in two frame alignment modes (I<sup>2</sup>S and Left justified) which determine the data start in relation to the word select.

Figure 9 illustrates the I<sup>2</sup>S mode, which is left channel first with I2S\_WS (Left/Right Clock signal) low, followed by the right channel with I2S\_WS high. The MSB of the data is clocked out starting on the second falling edge of I2S\_SCK following the I2S\_WS transition and clocked in starting on the second rising edge of I2S\_SCK following the I2S\_WS transition. Figure 9 shows I<sup>2</sup>S operation with 32 bits per frame.

**Figure 9 • I<sup>2</sup>S Mode**

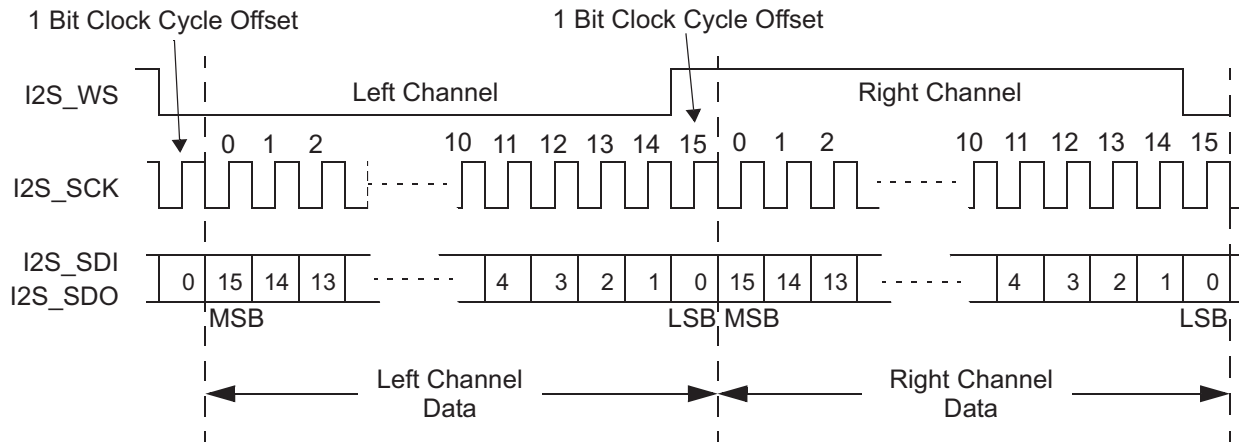
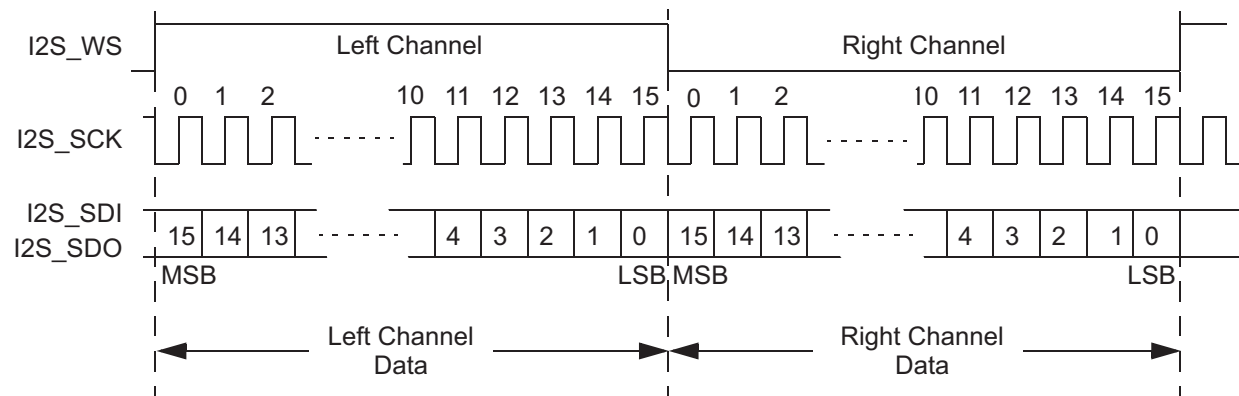


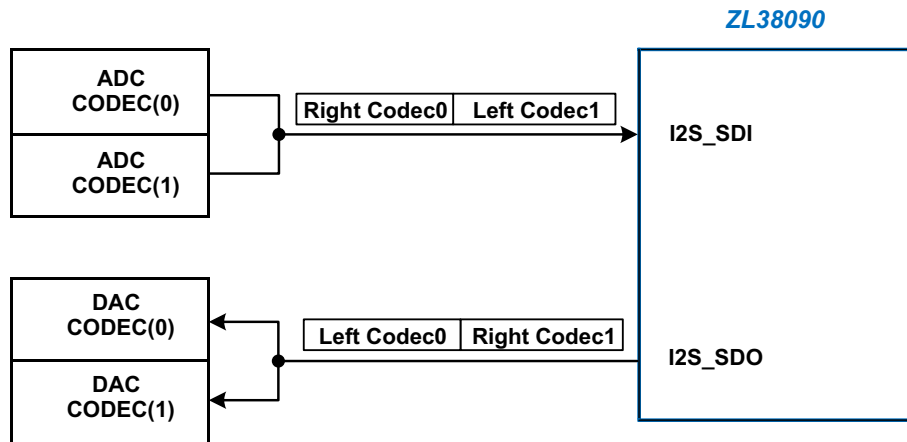
Figure 10 illustrates the left justified mode, which is left channel first associated with I2S\_WS (Left/Right Clock signal) high, followed by the right channel associated with I2S\_WS low. The MSB of the data is clocked out starting on the falling edge of I2S\_SCK associated with the I2S\_WS transition, and clocked in starting on the first rising edge of I2S\_SCK following the I2S\_WS transition.

**Figure 10 • Left Justified Mode**



Each I<sup>2</sup>S interface can support one dual channel Codec (Figure 11) through the Codec's I<sup>2</sup>S interface. The four 16-bit channel processing capacity of the DSP is spread across the two input channels from the ADCs of Codec(0) and Codec(1), and the two output channels to the DACs of Codec(0) and Codec(1).

**Figure 11 • Dual Codec Configuration**



Both I<sup>2</sup>S bus modes can support full bi-directional stereo communication. The device supports I<sup>2</sup>S loopback.

See the *Microsemi AcuEdge™ Firmware Manual* for I<sup>2</sup>S port registers.

### 4.3.2 PCM Mode

Each of the PCM channels can be assigned an independent timeslot. The timeslots can be any 8-bit timeslot up to the maximum supported by the PCLK being used.

The PCM ports can be configured for Narrowband G.711 A-law/ $\mu$ -Law or Linear PCM or Wideband G.722 encoding. For a given TDM bus, once it is configured for a data sample rate and encoding, all data rates and encoding on that bus will be the same. 16-bit linear PCM will be sent on consecutive 8-bit timeslots (e.g., if timeslot N is programmed in the timeslot registers, the consecutive timeslot is N+1). The PCM interface can transmit/receive 8-bit compressed or 16-bit linear data with 8 kHz sampling (Narrowband), or 16-bit linear data with 16 kHz sampling (Wideband). Although the firmware allows it, 44.1 and 48 kHz sampling are not commonly used with PCM.

Wideband audio usually means that the TDM bus is operating at a 16 kHz FS, but there are two other operating modes that support wideband audio using an 8 kHz FS:

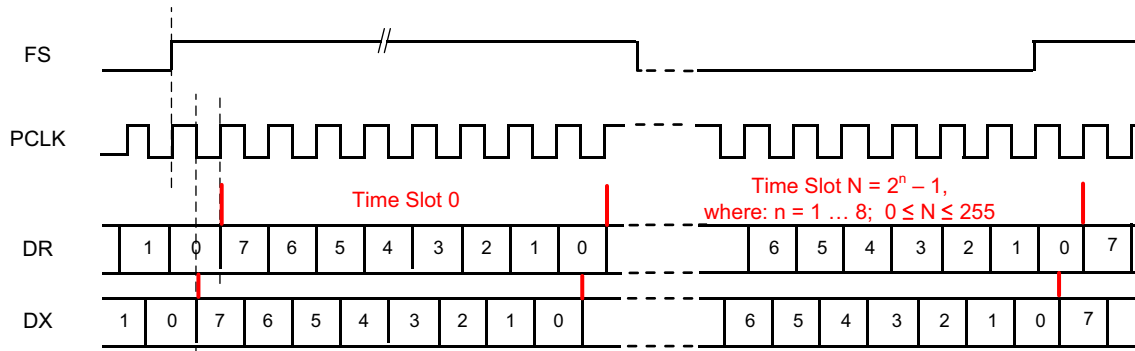
- G.722 supports wideband audio with an 8 kHz FS. This uses a single 8-bit timeslot on the TDM bus.
- “Half-FS Mode” supports wideband audio with an 8 kHz FS signal. In this mode, 16-bit linear audio is received on two timeslot pairs; the first at the specified timeslot (N, N+1) and the second a half-frame later. In total, four 8-bit timeslots are used per frame, timeslots (N, N+1) and ((N + ((bits\_per\_frame)/16)), (N + 1 + ((bits\_per\_frame)/16))). The user programs the first timeslot and the second grouping is generated automatically 125/2  $\mu$ s from the first timeslot.

The PCM voice/data bytes can occupy any of the available timeslots, except for PCM clock rates that have extra clocks in the last timeslot. If there is more than one extra clock in the last timeslot, the timeslot data will be corrupted, do not use the last timeslot for these clock frequencies (e.g., 3.088 MHz etc.).

The PCM block can be configured as a master or a slave and is compatible with the Texas Instruments Inc. McBSP mode timing format.

Figure 12 and Figure 13 illustrate the PCM format with slave timing, FS and PCLK are provided by the host. Slave mode accommodates frame sync pulses with various widths (see [GCI and PCM Timing Parameters](#), page 45).

**Figure 12 • TDM – PCM Slave Functional Timing Diagram (8-bit, xeDX = 0)**



**Figure 13 • TDM – PCM Slave Functional Timing Diagram (8-bit, xeDX = 1)**

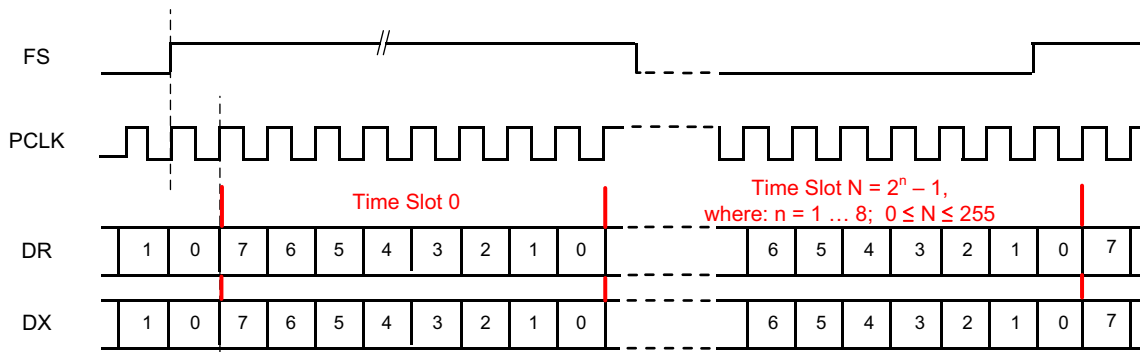
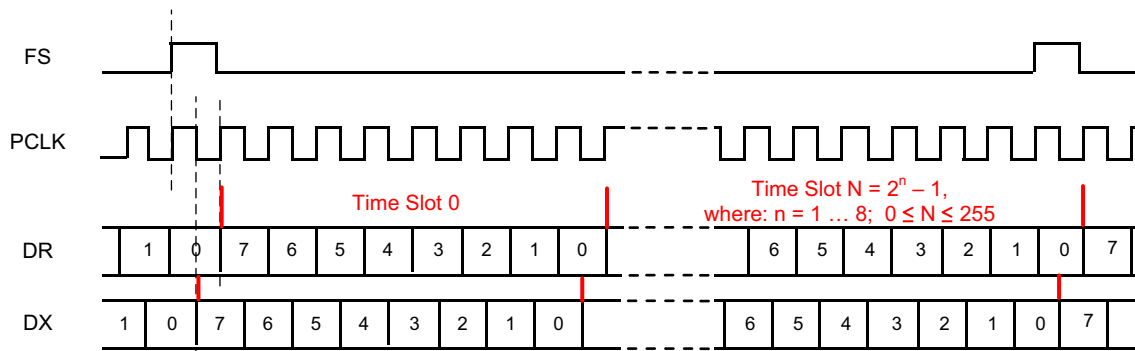


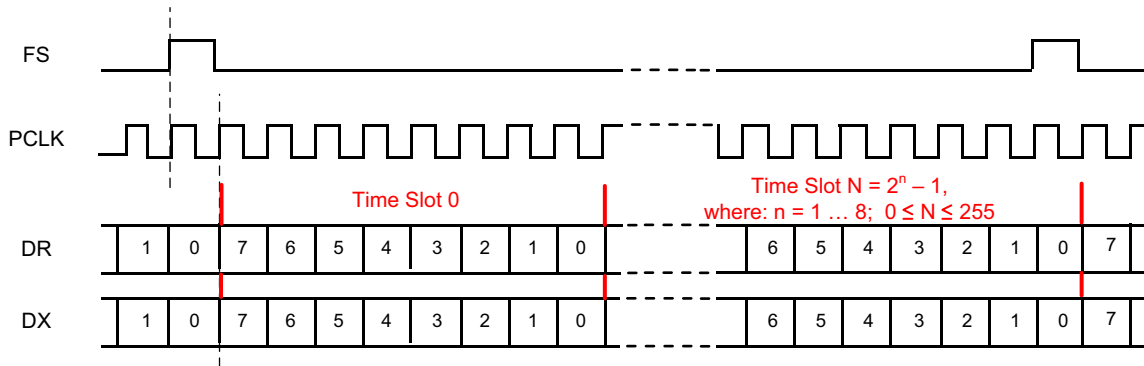
Figure 14 and Figure 15 illustrate the PCM format with master timing, FS and PCLK are provided by the ZL38090. Master mode outputs a frame sync pulse equal to one PCLK cycle.

Diagrams for PCM transmit on negative edge (xeDX = 0) and PCM transmit on positive edge (xeDX = 1) are shown for both slave and master timing.

**Figure 14 • TDM – PCM Master Functional Timing Diagram (8-bit, xeDX = 0)**



**Figure 15 • TDM – PCM Master Functional Timing Diagram (8-bit, xeDX = 1)**



### 4.3.3 GCI Mode

The GCI voice/data bytes can occupy any of the available timeslots. The GCI block can be configured as a master or a slave and supports a clock that has the same frequency as the data rate.

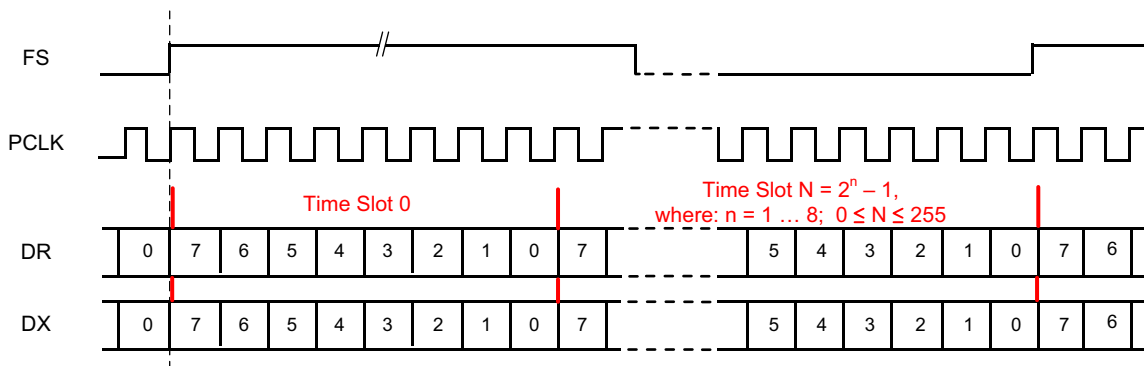
**Note:** Traditional GCI Monitor, Signaling, and Control channel bytes and double data rate are not supported.

Figure 16 illustrates the GCI format with slave timing, FS and PCLK are provided by the host. Slave mode accommodates frame sync pulses with various widths (see [GCI and PCM Timing Parameters](#), page 45).

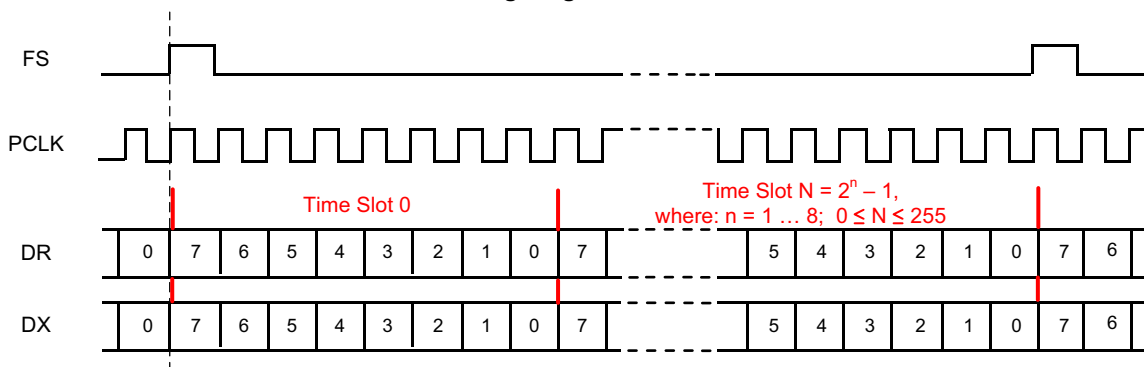
Figure 17 illustrates the GCI format with master timing, FS and PCLK are provided by the ZL38090. Master mode outputs a frame sync pulse equal to one PCLK cycle.

For both, first data bits are aligned with the rising edge of the frame sync pulse.

**Figure 16 • TDM – GCI Slave Functional Timing Diagram**



**Figure 17 • TDM – GCI Master Functional Timing Diagram**

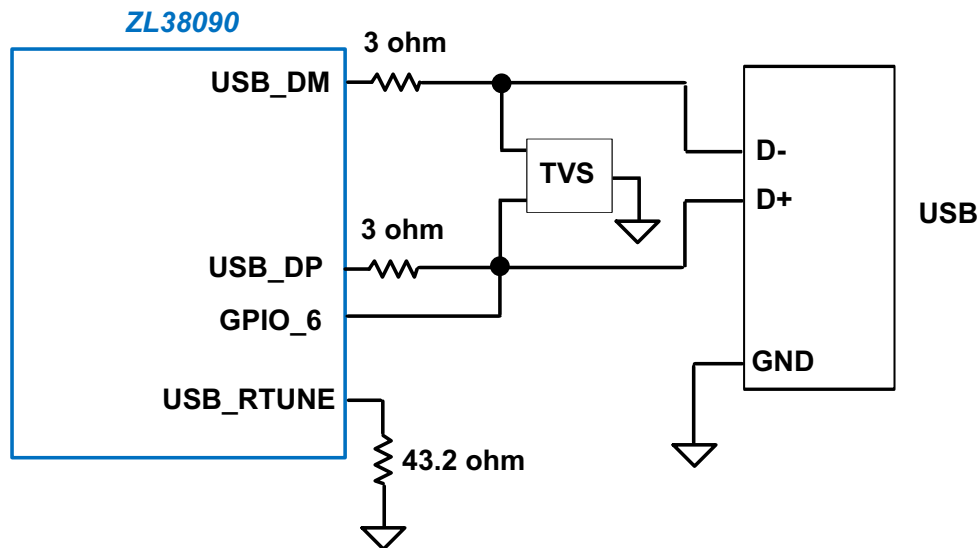


## 4.4 USB Interface

The ZL38090 will enumerate as a USB Audio Class v1.0 Device. Windows, Macintosh, and Linux PCs will all identify the ZL38090 as an audio class device without requiring additional driver installation. The ZL38090 is USB 2.0 compliant. It will send and receive at the full speed rate of 12 Mbps. The device will enumerate with one control endpoint, and two endpoints for Microphone input and Speaker output (both are Stereo) with one interrupt endpoint for Status Reporting. Configuration settings allows for either stereo play/record or just stereo playback.

Figure 18 illustrates the connection of the USB interface to the ZL38090. A USB protection device (transient voltage suppressor) is recommended. The ZL38090 uses GPIO\_6 for USB Resume.

**Figure 18 • USB Interface Circuit**



## 5 Control Interfaces

### 5.1 Host Bus Interface

The host bus interface (HBI) is the main communication port from a host processor to the ZL38090. It can be configured to be either a SPI Slave or an I<sup>2</sup>C Slave port, either of which can be used to program or query the device.

The ZL38090 allows for automatic configuration between SPI and I<sup>2</sup>C operation. For the HBI port, if the HCLK toggles for two cycles, the HBI will default to the SPI Slave, otherwise it will remain configured as I<sup>2</sup>C (see Table 1, page 16). The HBI comes up listening in both SPI and I<sup>2</sup>C modes, but with I<sup>2</sup>C inputs selected. If HCLK is present, it switches the data selection before the first byte is complete so that no bits are lost. Once the port is determined to be SPI, a hardware reset is needed to change back to I<sup>2</sup>C.

This port can read and write all of the memory and registers on the ZL38090. The port can also be used to boot the device, refer to [Device Booting and Firmware Swapping](#), page 26.

**Table 1 • HBI Slave Interface Selection**

| Description                    | Condition           | Operating Mode  | Notes        |
|--------------------------------|---------------------|---|--------------|
| HBI Slave interface selection. | HCLK toggling       | Host SPI bus  |              |
|                                | HDIN tied to VSS    | Host I <sup>2</sup> C bus. Slave address 45h (7-bit). | <sup>1</sup> |
|                                | HDIN tied to DVDD33 | Host I <sup>2</sup> C bus. Slave address 52h (7-bit). |              |

- By default, the HBI comes up as an I<sup>2</sup>C interface. Toggling the HCLK pin will cause the host interface to switch to a SPI interface. If an I<sup>2</sup>C interface is desired, HCLK needs to be tied to ground.

#### 5.1.1 SPI Slave

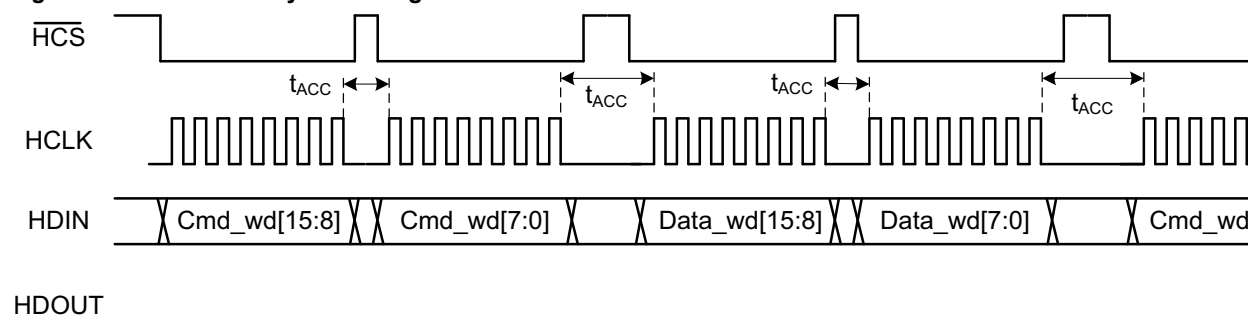
The physical layer is a 4-wire SPI interface. Chip select and clock are both inputs.

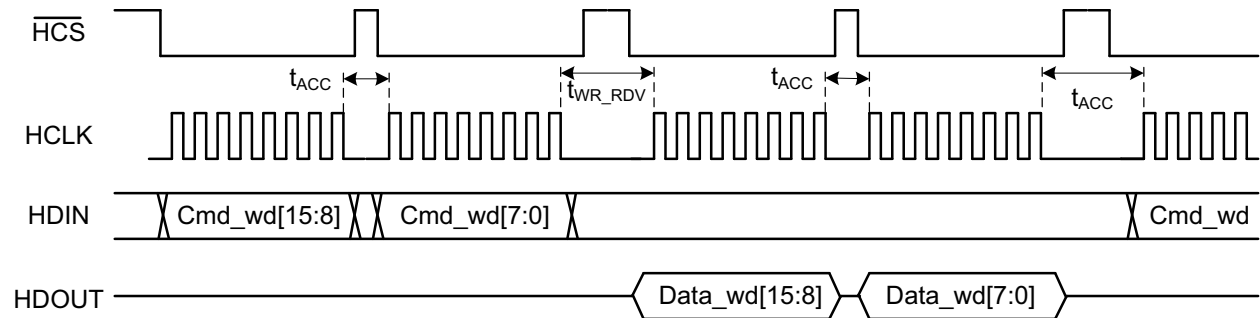
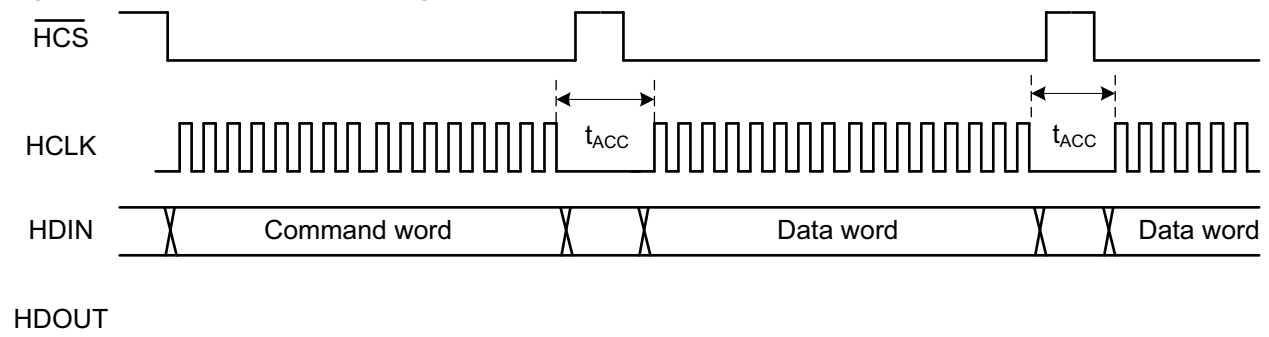
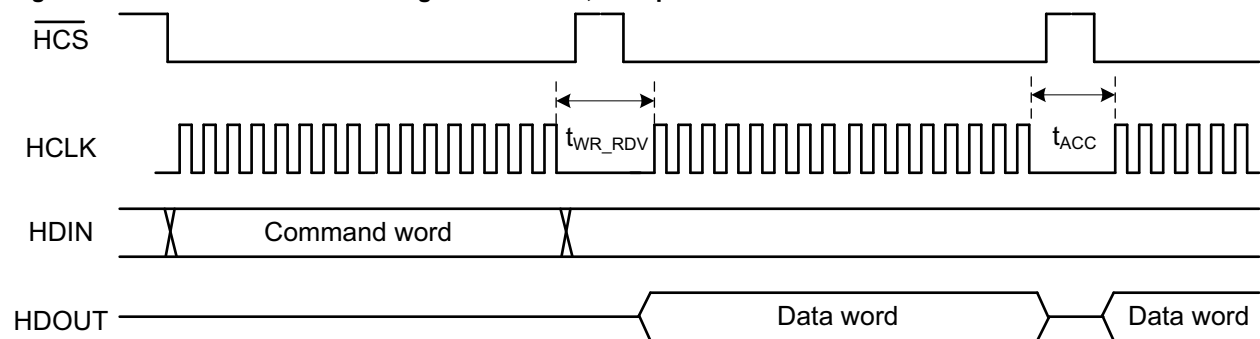
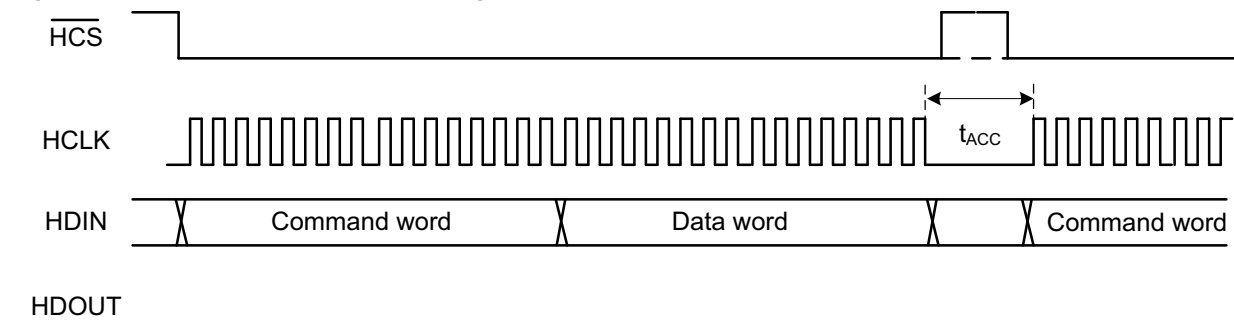
The SPI Slave port can support byte, word, or command framing. Write and read diagrams for these framing modes are shown in [Figures 19 – 24](#). The SPI Slave chip select polarity, clock polarity, and sampling phase are fixed.

The ZL38090 command protocol is half duplex, allowing the serial in and serial out to be shorted together for a 3-wire connection. The chip select is active low. The data is output on the falling edge of the clock and sampled on the rising edge of the clock.

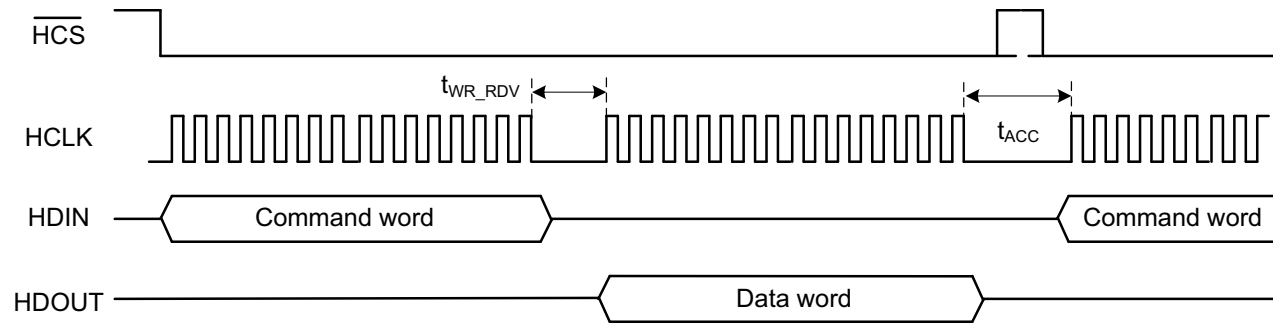
The SPI Slave supports access rates up to 25 MHz. The outbound interrupt is always active low.

**Figure 19 • SPI Slave Byte Framing Mode – Write**



**Figure 20 • SPI Slave Byte Framing Mode – Read****Figure 21 • SPI Slave Word Framing Mode – Write, Multiple Data Words****Figure 22 • SPI Slave Word Framing Mode – Read, Multiple Data Words****Figure 23 • SPI Slave Command Framing Mode – Write**



**Figure 24 • SPI Slave Command Framing Mode – Read**

### 5.1.2 I<sup>2</sup>C Slave

The I<sup>2</sup>C bus is similar to the Philips Semiconductor (NXP) 1998 Version 2.0, I<sup>2</sup>C standard. The ZL38090 I<sup>2</sup>C bus supports 7-bit addressing and transfer rates up to 400 kHz. External pull-up resistors are required on the I<sup>2</sup>C serial clock input (HCS) and the I<sup>2</sup>C serial data input/output (HDOUT) when operating in this mode (note, the I<sup>2</sup>C slave pins are 3.3 V pins and are not 5 V tolerant).

The selection of the I<sup>2</sup>C slave address is performed at bootup by the strapping of the HDIN and HCLK pins, see [Table 1](#), page 16.

### 5.1.3 Host Interrupt Pin

An internal host interrupt controller controls the active low interrupt pin which is part of the host bus interface. Associated with the interrupt controller is an event queue which reports status information about which event caused the interrupts.

Upon sensing the interrupt, the host can read the event queue to determine which event caused the interrupt. Specific events are enabled by the host processor, and are typically not used with a standalone (controllerless) design.

Refer to Events in the *Microsemi AcuEdge™ Firmware Manual* for Event ID Enumerations.

## 5.2 UART

The ZL38090 device incorporates a two-wire UART (Universal Asynchronous Receiver Transmitter) interface with a fixed 115.2 K baud transfer rate, 8 data bits, 1 stop and no parity. TX and RX pins allow bi-directional communication with a host PC. The UART pins must be made accessible on the PCB for debug and tuning purposes.

## 5.3 Master SPI

Like the HBI SPI Slave, the physical layer of the Master SPI is a 4-wire SPI interface supporting half duplex communication. It supports only one chip select which is multiplexed with GPIO\_9.

The Master SPI is only used by the built-in boot ROM to bootload from an external serial Flash. The ZL38090 can automatically read the Flash data (program code and configuration record) through this interface upon the release of reset (Auto Boot), depending on the value of the bootstrap options.

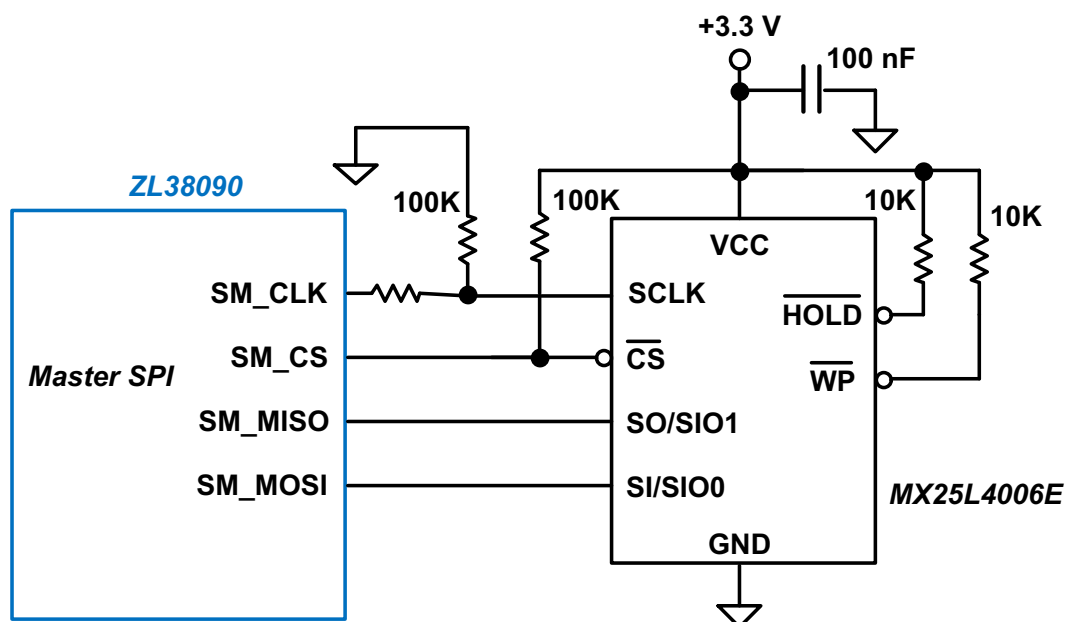
**Note:** An alternative to Auto Boot is to perform a Host Boot through the HBI port. Refer to [Device Booting and Firmware Swapping](#), page 26.

### 5.3.1 Flash Interface

After power-up the ZL38090 will run its resident boot code, which establishes the initial setup of the Master SPI port and then downloads the firmware from external Flash memory when configured for auto boot mode. This Flash firmware establishes the resident application and sets the configuration of all the ZL38090 ports.

[Figure 25](#) illustrates the connection of Flash memory to the ZL38090 Master SPI port. [Figure 25](#) and the ZLE38000 demonstration hardware uses the Macronix™ MX25L4006E 4 Mbit CMOS Serial Flash device.

Figure 25 • Flash Interface Circuit



### 5.3.1.1 Flash Selection

The ZL38090 Boot ROM is designed to work with a wide variety of Flash devices. There are numerous Flash devices that the ZL38090 Boot ROM can recognize and program without host intervention other than a command to initialize the Flash. Other unrecognized devices may be utilized if they conform to certain characteristics of known devices and the host informs the ZL38090 Boot ROM of their type and size.

The ZL38090 identifies Flash devices (with a single binary image) with the ZL38090 boot ROM auto-sensing the Flash type. The ZL38090 complies with *JEDEC Manufacturer and Device ID Read Methodology for SPI Compatible Serial Interface Memory Devices*. The ZL38090 is compatible with the *Serial Flash Discoverable Parameters JEDEC standard JESD216B* and the *Common Flash Interface JESD68.01 JEDEC standard*. The ZL38090 can identify devices by their JEDEC standard *JEP106-K Standard Manufacturer's Identification Code*.

Select a Flash size that is adequate to store all the firmware images required of the application. The image sizes can be obtained from the specific firmware releases.

A list of Flash devices that are identifiable by the ZL38090 Boot ROM are shown in [Table 2](#). The size of these devices are all 2 Mbit or 4 Mbit, the Boot ROM will also recognize the size of 8 Mbit parts that are Type 1 or Type 2 devices (as defined in [Table 3](#)).

**Table 2 • Flash Devices Tested with the ZL38090**

| Manufacturer | Part Number       | Description   |
|--------------|-------------------|---|
| Macronix™    | MX25V4006EM1I-13G | 4 Mbit Flash.   |
| Winbond™     | W25X40CLSNIG-ND   | 4 Mbit Flash.   |
|              | W25X20CLSNIG-ND   | 2 Mbit Flash.   |
| Micron®      | M25P20-VMN6PB     | Large 512 Kbit sectors limit the usefulness of this device. Holds only 1 application image.                     |
|              | M25P40-VMN6PB     | 4 Mbit Flash. Large 512 Kbit sectors limit the usefulness of this device. Holds only 2 or 3 application images. |
| Spansion™    | S25FL204K0TMF1010 | 4 Mbit Flash.   |

**Table 2 • Flash Devices Tested with the ZL38090**

| Manufacturer    | Part Number | Description   |
|-----------------|-------------|---------------|
| AMIC Technology | A25L020O-F  | 2 Mbit Flash. |

Flash devices whose JEDEC ID or size (usually a size of 16 Mbit or larger) that are not recognized by the ZL38090 Boot ROM can be made to work if they fit the characteristics of one of the four Flash types listed in Table 3. By writing the type (1, 2, 3, or 4) to ZL38090 address 0x118 and the number of sectors to ZL38090 address 0x116 prior to initializing the Flash device, the Boot ROM will treat it as a known device of known size even though the manufacturer ID or size field are not recognized.

**Table 3 • Supported Flash Types**

| Characteristic               | Type 1   | Type 2   | Type 3 <sup>1</sup>   | Type 4 <sup>1</sup>                    |
|------------------------------|--|--|---|--|
| <b>Sector Size</b>           | 512 Kbit (64 KB)                                 | 32 Kbit (4 KB)   | 32 Kbit (4 KB)  | 16 Kbit (2 KB)                         |
| <b>Read Status Reg Cmd</b>   | 0x05   | 0x05   | 0x05  | 0xD7                                   |
| <b>Status Reg</b>            | Busy bit = 0x01                                  | Busy bit = 0x01  | Busy bit = 0x01   | Done bit = 0x80                        |
| <b>Data Read Cmd</b>         | 0x03   | 0x03   | 0x03  | 0x03                                   |
| <b>Write Enable Cmd</b>      | 0x06   | 0x06   | 0x06  | N/A                                    |
| <b>Page Write Cmd</b>        | 0x02   | 0x02   | N/A<br>Uses AAI to program word or byte. Uses Write Disable command to terminate AAI. | N/A<br>Uses write from buffer command. |
| <b>4-Byte Bulk Erase Cmd</b> | N/A  | N/A  | N/A   | 0xC794809A                             |
| <b>Examples</b>              | <b>Micron®</b><br>M25P20-VMN6PB<br>M25P40-VMN6PB | <b>Winbond™</b><br>W25X40CLSNIG-ND<br>W25X20CLSNIG-ND<br><b>Macronix™</b><br>MX25V4006EM1I-13G<br><b>AMIC Technology</b><br>A25L020O-F<br><b>Spansion™</b><br>S25FL204K0TMF1010<br><b>Atmel®</b><br>AT25DF041A |   |  |

1. While Type 3 and Type 4 flash devices are supported, they are not recommended due to the time and complexity required to program these devices.

## 5.4 GPIO

The ZL38090 64-pin QFN package has 14 GPIO (General Purpose Input/Output) pins; the ZL38090 56-ball WLCSP package has 11 GPIO pins.

The GPIO pins can be individually configured as either inputs or outputs, and have associated maskable interrupts reported to the host processor through the interrupt controller and event queue. The GPIO pins are intended for low frequency signaling.

When a GPIO pin is defined as an input, the state of that pin is sampled and latched into the GPIO Read Register. A transition on a GPIO input can cause an interrupt and event to be passed to the host processor.

GPIO pins 7, 8, and 10–13 have special predefined functions, such as volume up/down, associated with these pins. This functionality is designed to support the features of a headset designed for Skype, Lync,

or other VoIP communication system. See Fixed Function I/O in the *Microsemi AcuEdge™ Firmware Manual*.

Immediately after any power-on or hardware reset the GPIO pins are defined as inputs and their state is captured in the GPIO Configuration Register. The state of this register is used to determine which options are selected for the device. The GPIO pin status is then redefined as specified in the configuration record that is loaded from the Flash or host.

In addition to the predefined fixed functions and the general functionality of the GPIO pins, the GPIO pins also support the bootstrap functions listed in [Table 5](#), page 26.

## 5.5 USB Interface

In addition to the USB Audio outlined in [USB Interface](#), page 15, the ZL38090 has the option of enumerating 2 endpoints for bi-directional Virtual Com support over USB. This optional USB Virtual Com interface can be used for code load and debug control from any connected PC. This Virtual Com interface is available over the same USB connection that carries audio and can be enabled or disabled via the configuration record. See USB Endpoints in the *Microsemi AcuEdge™ Firmware Manual*.

### 5.5.1 USB Audio Function Topology

The USB Audio Class Descriptors allow the host to discover and control the USB devices' audio controls, commonly called the Audio Function. See USB Audio Function in the *Microsemi AcuEdge™ Firmware Manual*.

## 6 Reset

---

The device has a hardware reset pin ( $\overline{\text{RESET}}$ ) that places the entire device into a known low power state. When the reset pin is brought low for a duration of at least 10 $\mu\text{s}$ , both a digital and analog reset will occur. The digital reset will reset all device states and registers. The analog reset will deactivate the internal PLL and drive the VDD12\_CTRL pin low, disabling the +1.2V supply.

When the reset pin is driven high, the device will go through its boot process and the firmware will be reloaded. GPIO pins will be re-sensed when the reset pin is brought high.

A 10 K $\Omega$  pull-up resistor is required on the  $\overline{\text{RESET}}$  pin to DVDD33 if this pin is not continuously driven.

## 7 Power Supply

---

### 7.1 Power Supply Sequencing/Power up

No special power supply sequencing is required. The +3.3 V or +1.2 V power rails can be applied in either order.

Upon power-up, the ZL38090 begins to boot and senses the external resistors on the GPIO to determine the bootstrap settings. After 3 ms, the boot process begins and the ZL38090 takes less than 1 second to become fully operational (for Auto Boot from Flash, including the time it takes to load the firmware).

In order to properly boot, the clocks (and power supplies) to the device must be stable. This requires either the 12.000 MHz crystal or clock oscillator to be active and stable before the ZL38090's reset is released.

#### 7.1.1 Power Supply Considerations

The 5V USB supply is typically used to power the ZL38090.

The ZL38090 requires +1.2 V to power its core DSP power supply (DVDD12). To achieve optimum noise and power performance, supply DVDD12 from an external source. Use a DC-DC switching power converter like the Microsemi LX7186A to achieve high efficiency and load regulation. The ZL38090 is designed to minimize power in its active states when DVDD12 is supplied externally.

Figure 26, page 24 shows DVDD33 and DVDD12 powered from the +5V USB supply. The Microsemi LX8213-33ISE 300mA Low Drop Out Voltage Regulator is shown supplying DVDD33. The Microsemi LX7186A 1.4MHz fixed frequency, current mode, synchronous PWM buck (step-down) DC-DC converter is shown supplying DVDD12.

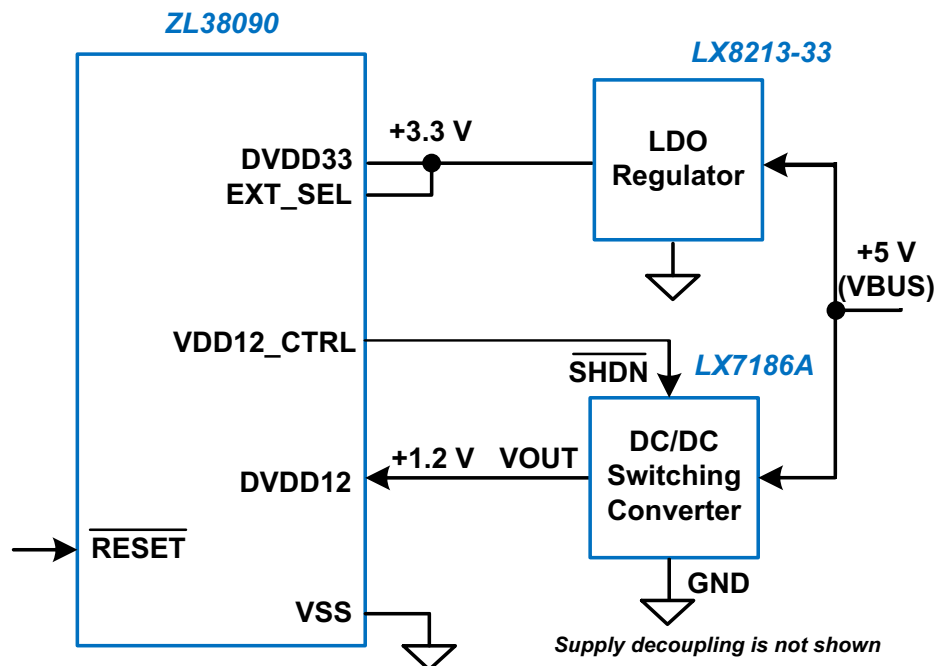
External +1.2 V supply use is selected when the EXT\_SEL pin is tied to +3.3 V. The EXT\_SEL pin can be pulled high or simply hard-wired to DVDD33. This is the typical use case.

VDD12\_CTRL is a CMOS output which can be used to control the shutdown of the external +1.2 V supply. VDD12\_CTRL will provide a steady +3.3 V output (with up to 4 mA of source current) for the external supply to be enabled and 0 V for the supply to be disabled.

For power savings when the ZL38090 does not need to be operational, the external voltage regulator can be turned off by pulling the  $\overline{\text{RESET}}$  pin low for longer than 10  $\mu\text{s}$  (Reset mode). This action will force the VDD12\_CTRL pin low, shutting off the external LDO and allowing the +1.2 V supply to collapse to 0 V.

If shutdown of the external +1.2 V supply is not desired, simply leave the VDD12\_CTRL output pin floating.

Figure 26 • Typical Power Supply Configuration



### 7.1.1.1 Internal +1.2V Power

**Note:** The internal +1.2V power option is only available with the 64-pin QFN package. The VDD12\_CTRL pin is not available on the 56-ball WLCSP package.

An alternative supply configuration takes advantage of the ZL38090 built-in voltage regulator as the DVDD12 source. The internal voltage regulator requires an external N-channel FET device and a parallel 470 ohm resistor. Figure 27, page 25 shows DVDD12 powered from the internal supply. Power dissipation is higher with internal regulator use due to the internal control circuitry and functional blocks being active.

**Note:** When using the internal regulator, the ZL38090 will not meet the 12.5 mW USB suspend power specification.

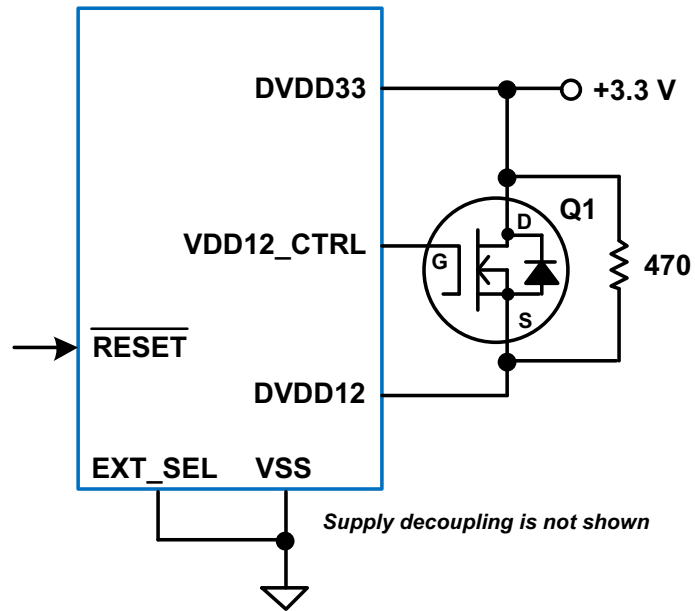
Internal supply use is selected when the EXT\_SEL pin is tied to VSS. With the built-in voltage regulator enabled, VDD12\_CTRL will drive Q1 and generate +1.2V at DVDD12. The parallel 470 ohm resistor is required to ensure supply start-up. Q1 can be any of the high power FETs shown in Table 4, page 24, or an equivalent.

Table 4 • Q1 Component Options

| Manufacturer            | Part Number |
|-------------------------|-------------|
| Vishay®                 | Si1422DH    |
| International Rectifier | IRLMS2002   |
| Diodes Inc.®            | ZXMN2B03E6  |

For power savings when the ZL38090 does not need to be operational, the internal voltage regulator can be turned off by pulling the RESET pin low for longer than 10  $\mu$ S (Reset mode). This action will force the VDD12\_CTRL pin low, shutting off the FET and allowing the +1.2V supply to collapse to 0V.

Figure 27 • Internal +1.2 V Power Supply Configuration  
ZL38090





## 8 Device Booting and Firmware Swapping

### 8.1 Bootloader

The ZL38090 device contains a built-in bootloader that gets executed after a hardware reset, when power is initially applied to the part, and during the firmware Swap process. The bootloader performs the following actions:

- Reads the GPIO bootstrap information and stores it in the Boot Sense registers
- Determinant on the bootstrap setting, it loads external serial Flash device contents (firmware and configuration record) into Program RAM (Auto Boot), or waits for the host to load Program RAM (Host Boot and Firmware Swap)
- If Auto Boot is selected, the bootloader then programs the ZL38090 configuration registers to their proper default values, and jumps to Program RAM to execute the firmware

### 8.2 Bootstrap Modes

Table 5 lists the different boot options that can be selected by using an external resistor. GPIOs have internal pull-down resistors, thereby defaulting to a 0 setting. A resistor to DVDD33 is required to select a 1 option. An external pull-up resistor must have a value of 3.3 K $\Omega$ . A GPIO with a bootstrap pull-up can be used for other functionality following the power-up boot sense process.

**Table 5 • Bootstrap Modes**

| GPIO_2 | GPIO_1 | GPIO_0 | Operating Mode                                       | Description            | Notes |
|--------|--------|--------|--|------------------------|-------|
| X      | 0      | 0      | 12.000 MHz Crystal (default)                         | Clock source selection |       |
| X      | 1      | 1      | Reserved   |                        |       |
| 0      | X      | X      | Host Boot over HBI or USB Virtual Com Port (default) | Boot source selection  |       |
| 1      | X      | X      | Auto Boot from external Flash                        |                        | 1     |

1. Apply a 3.3 K $\Omega$  resistor from GPIO\_2 to DVDD33. Note, when external Flash is selected, GPIO\_9 = SM\_CS.

### 8.3 Loadable Device Code

In order for the ZL38090 to operate, it must be loaded with code that resides externally. This code can be Auto Booted from an external Flash memory through the Master SPI, loaded into the ZL38090 by the host processor through the HBI port, or loaded from the USB host over the USB Virtual Com port. An external resistor pull-up or an internal resistor pull-down determines which boot mode will be used (see Table 5).

The external code consists of two logical segments, the firmware code itself and the configuration record. The firmware is a binary image which contains all of the executable code allowing the ZL38090 to perform voice processing and establishes the user command set. The configuration record contains settings for all of the user registers and defines the power-up operation of the device.

The configuration record is set up so that the registers are initialized to their desired values for normal operation.

A GUI development tool (*MiTuner*™ ZLS38508) is provided to create and modify a configuration record and create a bootable Flash image which can then be duplicated for production of the end product. This tool requires access to the UART for tuning.

#### 8.3.1 Boot Speed

When performing an Auto Boot from a Flash device, the boot sequence lasts <1 second (for a typical firmware image and configuration record of size 400 kB).

## 8.4 Bootup Procedure

Valid clocks (crystal or clock oscillator) must be present before the ZL38090 device can exit its reset state. After the reset line is released, the ZL38090's internal voltage regulator will be enabled (if the EXT\_SEL pin is strapped low). Once the +1.2V supply is established, the PLL will be also be enabled. Based on the GPIO bootstrap options, the ZL38090 will select the system parameters and the PLL will lock to the desired operating frequency.

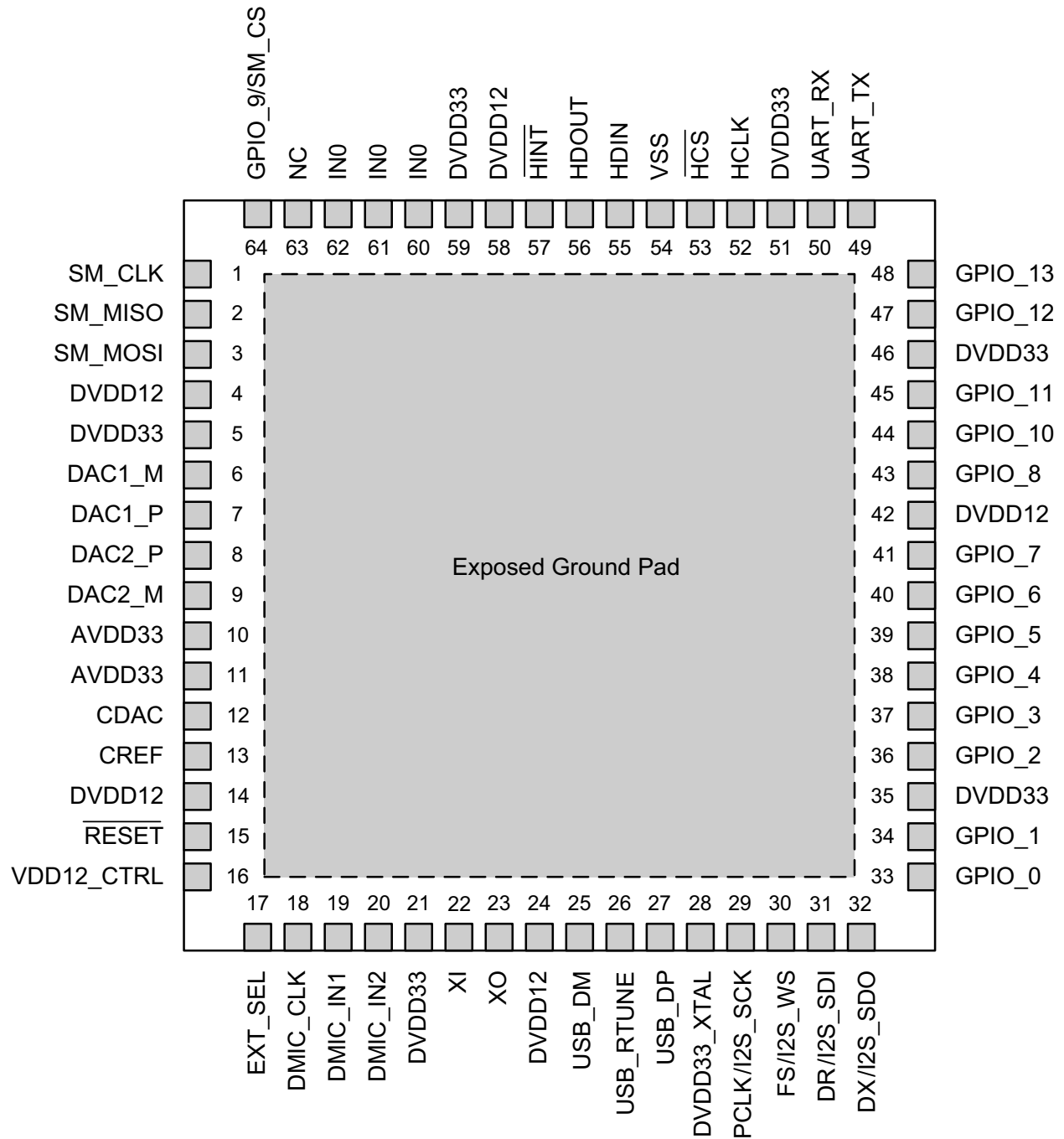
Next, if the GPIO strapping pins indicate that the ZL38090 will Auto Boot, it will begin reading data from the external Flash. Refer to the *Microsemi AcuEdge™ Firmware Manual* for a listing of the complete Boot Sequence.

If the GPIO strapping pins indicate that the ZL38090 will Host Boot, the SPI or I<sup>2</sup>C port that initiates the loading process becomes the boot master. The ZL38090 allows for automatic configuration between SPI and I<sup>2</sup>C operation.

# 9 Device Pinouts

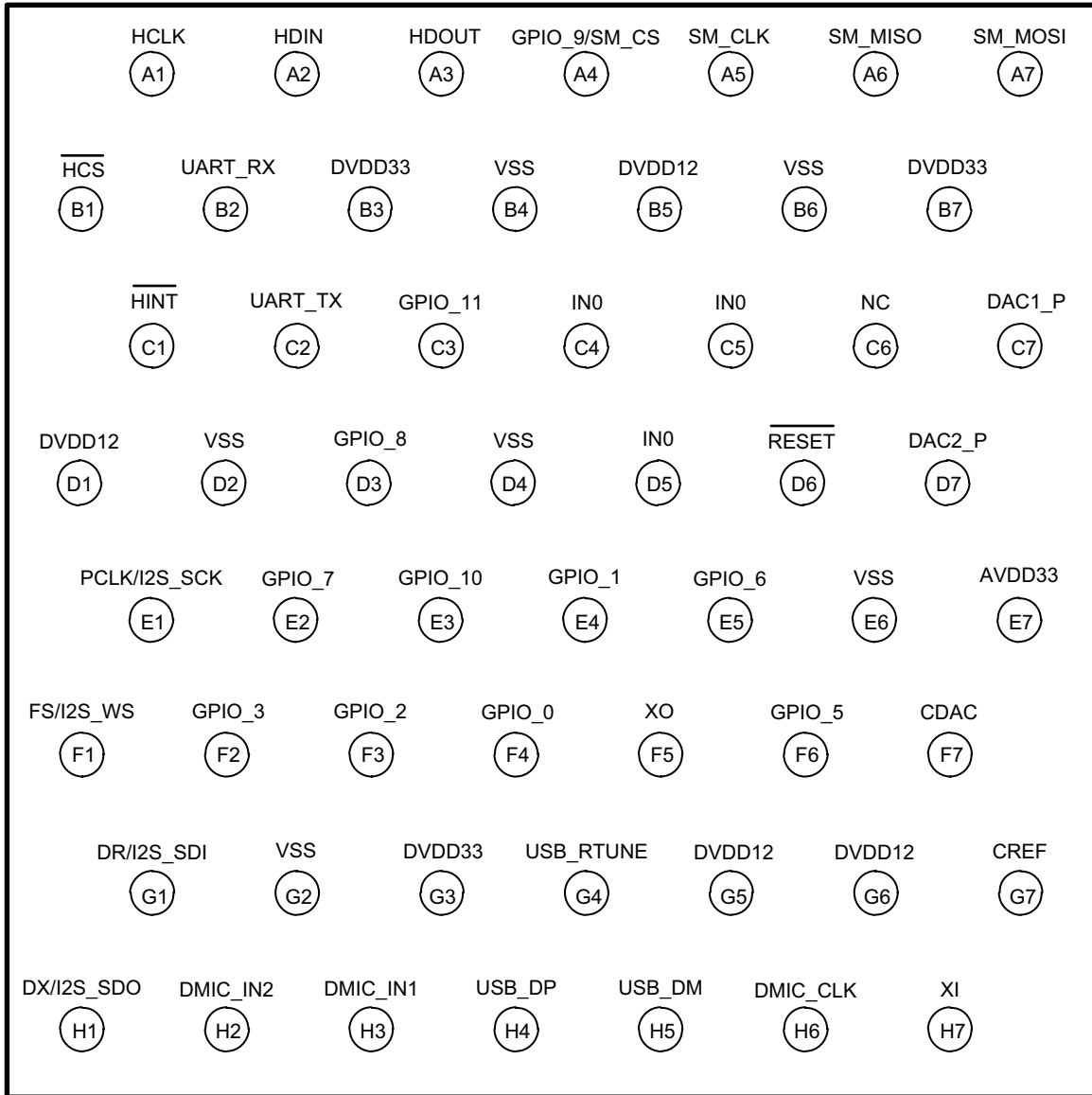
## 9.1 64-Pin QFN

Figure 28 • ZL38090 64-Pin QFN – Top View



## 9.2 56-Ball WLCSP

Figure 29 • ZL38090 56-Ball WLCSP – Top View



# 10 Pin Descriptions

## 10.1 Reset Pin

**Table 6 • Reset Pin Description**

| QFN Pin # | WLCSP Ball | Name  | Type  | Description  |
|-----------|------------|-------|-------|--|
| 15        | D6         | RESET | Input | <p><b>Reset.</b> When low the device is in its reset state and all tristate outputs will be in a high impedance state. This input must be high for normal device operation.</p> <p><i>A 10 K<math>\Omega</math> pull-up resistor is required on this pin to DVDD33 if this pin is not continuously driven.</i></p> <p>Refer to <a href="#">Reset</a>, page 22 for an explanation of the various reset states and their timing.</p> |

## 10.2 DAC Pins

**Table 7 • DAC Pin Description**

| QFN Pin # | WLCSP Ball | Name   | Type   | Description   |
|-----------|------------|--------|--------|---|
| 6         | –          | DAC1_M | Output | <p><b>DAC 1 Minus Output.</b> This is the negative output signal of the differential amplifier of DAC 1. Pin functionality is firmware dependent.</p> <p><i>Not available on the WLCSP package.</i></p> |
| 7         | C7         | DAC1_P | Output | <p><b>DAC 1 Plus Output.</b> This is the positive output signal of the differential amplifier of DAC 1. Pin functionality is firmware dependent.</p>  |
| 9         | –          | DAC2_M | Output | <p><b>DAC 2 Minus Output.</b> This is the negative output signal of the differential amplifier of DAC 2. Pin functionality is firmware dependent.</p> <p><i>Not available on the WLCSP package.</i></p> |
| 8         | D7         | DAC2_P | Output | <p><b>DAC 2 Plus Output.</b> This is the positive output signal of the differential amplifier of DAC 2. Pin functionality is firmware dependent.</p>  |
| 12        | F7         | CDAC   | Output | <p><b>DAC Reference.</b> This pin may require capacitive decoupling. Refer to <a href="#">DAC Output</a>, page 7.</p>   |
| 13        | G7         | CREF   | Output | <p><b>Common Mode Reference.</b> This pin requires capacitive decoupling. Refer to <a href="#">DAC Output</a>, page 7.</p>  |

## 10.3 Microphone Pins

**Table 8 • Microphone Pin Description**

| QFN Pin # | WLCSP Ball | Name     | Type   | Description   |
|-----------|------------|----------|--------|---|
| 18        | H6         | DMIC_CLK | Output | <b>Digital Microphone Clock Output.</b> Clock output for digital microphones and digital electret microphone pre-amplifier devices. |
| 19        | H3         | DMIC_IN1 | Input  | <b>Digital Microphone Input 1.</b> Stereo or mono digital microphone input.<br><i>Tie to VSS if unused.</i>                         |
| 20        | H2         | DMIC_IN2 | Input  | <b>Digital Microphone Input 2.</b> Stereo or mono digital microphone input.<br><i>Tie to VSS if unused.</i>                         |

## 10.4 TDM and I<sup>2</sup>S Port Pins

The firmware supports a single TDM interface. The TDM block is capable of being a master or a slave. The ports can be configured for Pulse-Code Modulation (PCM) or Inter-IC Sound (I<sup>2</sup>S) operation. The ports conform to PCM, GCI, and I<sup>2</sup>S timing protocols.

**Table 9 • TDM and I<sup>2</sup>S Ports Pin Descriptions**

| QFN Pin # | WLCSP Ball | Name             | Type             | Description   |
|-----------|------------|------------------|------------------|---|
| 29        | E1         | PCLK/<br>I2S_SCK | Input/<br>Output | <p><b>PCM Clock (Input/Tristate Output).</b> PCLK is equal to the bit rate of signals DR/DX. In TDM master mode this clock is an output and in TDM slave mode this clock is an input.</p> <p><b>I<sup>2</sup>S Serial Clock (Input/Tristate Output).</b> This is the I<sup>2</sup>S bit clock. In I<sup>2</sup>S master mode this clock is an output and drives the bit clock input of the external slave device's peripheral converters. In I<sup>2</sup>S slave mode this clock is an input and is driven from a converter operating in master mode.</p> <p>After power-up, this signal defaults to be an input in I<sup>2</sup>S slave mode.</p> <p><i>A 100 KΩ pull-down resistor is required on this pin to VSS. If this pin is unused, tie the pin to VSS.</i></p> <p><i>When driving PCLK/I2S_SCK from a host, one of the following conditions must be satisfied:</i></p> <ol style="list-style-type: none"> <li>1. Host drives PCLK low during reset, or</li> <li>2. Host tri-states PCLK during reset (the 100 KΩ resistor will keep PCLK low), or</li> <li>3. Host drives PCLK at its normal frequency</li> </ol> |

**Table 9 • TDM and I<sup>2</sup>S Ports Pin Descriptions (continued)**

| QFN Pin # | WLCSP Ball | Name       | Type         | Description   |
|-----------|------------|------------|--------------|---|
| 30        | F1         | FS/I2S_WS  | Input/Output | <p><b>PCM Frame Sync (Input/Tristate Output).</b> This is the TDM frame alignment reference. This signal is an input for applications where the PCM bus is frame aligned to an external frame signal (slave mode). In master mode this signal is a frame pulse output.</p> <p><b>I<sup>2</sup>S Word Select (Left/Right) (Input/Tristate Output).</b> This is the I<sup>2</sup>S left or right word select. In I<sup>2</sup>S master mode word select is an output which drives the left/right input of the external slave device's peripheral converters. In I<sup>2</sup>S slave mode this pin is an input which is driven from a converter operating in master mode.</p> <p>After power-up, this signal defaults to be an input in I<sup>2</sup>S slave mode.</p> <p><i>Tie this pin to VSS if unused.</i></p> |
| 31        | G1         | DR/I2S_SDI | Input        | <p><b>PCM Serial Data Stream Input.</b> This serial data stream operates at PCLK data rates.</p> <p><b>I<sup>2</sup>S Serial Data Input.</b> This is the I<sup>2</sup>S port serial data input.</p> <p><i>Tie this pin to VSS if unused.</i></p>  |
| 32        | H1         | DX/I2S_SDO | Output       | <p><b>PCM Serial Data Stream Output.</b> This serial data stream operates at PCLK data rates.</p> <p><b>I<sup>2</sup>S Serial Data Output.</b> This is the I<sup>2</sup>S port serial data output.</p>  |

## 10.5 Headset Control/Indicator Pins

These pins are used for headset control functions and LED indicators.

**Table 10 • Headset Control/Indicator Pin Descriptions**

| QFN Pin # | WLCSP Ball | Name    | Type         | Description   |
|-----------|------------|---------|--------------|---|
| 41        | E2         | GPIO_7  | Input/Output | <b>Hook Switch/Volume Down.</b> Fixed function used to control the hook state and volume down with GPIO[10:13].   |
| 43        | D3         | GPIO_8  | Input/Output | <b>Microphone/Volume Up.</b> Fixed function used to control the hook state and volume down with GPIO[10:13].  |
| 44        | E3         | GPIO_10 | Input/Output | <b>Volume Control/Call State.</b> Fixed function used to control the volume and indicate the call state with GPIO[7:8].   |
| 45        | C3         | GPIO_11 | Input/Output | <b>Call Control/Volume State 1.</b> Fixed function used to control the hook switch (on/off) and control multicolor LEDs for volume indication with GPIO[7:8].                   |
| 47        | –          | GPIO_12 | Input/Output | <p><b>Volume State 2.</b> Fixed function used to control multicolor LEDs for volume indication with GPIO[7:8].</p> <p><i>GPIO_12 is not available on the WLCSP package.</i></p> |
| 48        | –          | GPIO_13 | Input/Output | <p><b>Volume State 3.</b> Fixed function used to control multicolor LEDs for volume indication with GPIO[7:8].</p> <p><i>GPIO_13 is not available on the WLCSP package.</i></p> |

## 10.6 USB Pins

These pins are used for USB functions.

**Table 11 • USB Pin Descriptions**

| QFN Pin # | WLCSP Ball | Name      | Type         | Description   |
|-----------|------------|-----------|--------------|---|
| 25        | H5         | USB_DM    | Input/Output | <b>USB Data D- Signal.</b> Carries USB data to/from USB 2.0.  |
| 26        | G4         | USB_RTUNE | Input/Output | <b>Tx Resistor Tune.</b> Connect to external 43.2 $\Omega$ resistor to VSS.   |
| 27        | H4         | USB_DP    | Input/Output | <b>USB Data D+ Signal.</b> Carries USB data to/from USB 2.0.  |
| 40        | E5         | GPIO_6    | Input/Output | <b>USB Resume.</b> This pin is used to sense activity on USB Data D+ to resume from sleep or perform a USB reset. It can be configured as an input or output and is intended for low-frequency signaling. |

## 10.7 HBI – SPI Slave Port Pins

This port functions as a peripheral interface for an external controller, and supports access to the internal registers and memory of the device.

**Table 12 • HBI – SPI Slave Port Pin Descriptions**

| QFN Pin # | WLCSP Ball | Name                     | Type         | Description   |
|-----------|------------|--------------------------|--------------|---|
| 52        | A1         | HCLK                     | Input        | <b>HBI SPI Slave Port Clock Input.</b> Clock input for the SPI Slave port. Maximum frequency = 25 MHz. This input should be tied to VSS in I <sup>2</sup> C mode, refer to <a href="#">Table 1</a> , page 16<br><i>Tie this pin to VSS if unused.</i>   |
| 53        | B1         | $\overline{\text{HCS}}$  | Input        | <b>HBI SPI Slave Chip Select Input.</b> This active low chip select signal activates the SPI Slave port.<br><b>HBI I<sup>2</sup>C Serial Clock Input.</b> This pin functions as the I <sup>2</sup> C_SCLK input in I <sup>2</sup> C mode. <i>A pull-up resistor is required on this node for I<sup>2</sup>C operation.</i><br><i>Tie this pin to VSS if unused.</i> |
| 55        | A2         | HDIN                     | Input        | <b>HBI SPI Slave Port Data Input.</b> Data input signal for the SPI Slave port. This input selects the slave address in I <sup>2</sup> C mode, refer to <a href="#">Table 1</a> , page 16<br><i>Tie this pin to VSS if unused.</i>  |
| 56        | A3         | HDOUT                    | Input/Output | <b>HBI SPI Slave Port Data Output (Tristate Output).</b> Data output signal for the SPI Slave port.<br><b>HBI I<sup>2</sup>C Serial Data (Input/Output).</b> This pin functions as the I <sup>2</sup> C_SDA I/O in I <sup>2</sup> C mode. <i>A pull-up resistor is required on this node for I<sup>2</sup>C operation.</i>  |
| 57        | C1         | $\overline{\text{HINT}}$ | Output       | <b>HBI Interrupt Output.</b> This output can be configured as either CMOS or open drain by the host.  |



## 10.8 Master SPI Port Pins

This port functions as the interface to an external Flash device used to optionally Auto Boot and load the device's firmware and configuration record from external Flash memory.

**Table 13 • Master SPI Port Pin Descriptions**

| QFN Pin # | WLCSP Ball | Name             | Type             | Description   |
|-----------|------------|------------------|------------------|---|
| 1         | A5         | SM_CLK           | Output           | <b>Master SPI Port Clock (Tristate Output).</b> Clock output for the Master SPI port. Maximum frequency = 8 MHz.  |
| 2         | A6         | SM_MISO          | Input            | <b>Master SPI Port Data Input.</b> Data input signal for the Master SPI port.   |
| 3         | A7         | SM_MOSI          | Output           | <b>Master SPI Port Data Output (Tristate Output).</b> Data output signal for the Master SPI port.   |
| 64        | A4         | GPIO_9/<br>SM_CS | Input/<br>Output | <b>Master SPI Port Chip Select (Input Internal Pull-Up/Tristate Output).</b> Chip select output for the Master SPI port.<br><br>Shared with GPIO_9, see <a href="#">Table 16</a> , page 35. |

## 10.9 Oscillator Pins

These pins are connected to a 12.000 MHz crystal or clock oscillator which drives the device's internal PLL.

**Table 14 • Oscillator Pin Descriptions**

| QFN Pin # | WLCSP Ball | Name | Type   | Description   |
|-----------|------------|------|--------|---|
| 22        | H7         | XI   | Input  | <b>Crystal Oscillator Input.</b> Refer to <a href="#">External Clock Requirements</a> , page 42.  |
| 23        | F5         | XO   | Output | <b>Crystal Oscillator Output.</b> Refer to <a href="#">External Clock Requirements</a> , page 42. |

## 10.10 UART Pins

The ZL38090 device incorporates a two-wire UART (Universal Asynchronous Receiver Transmitter) interface with a fixed 115.2 K baud transfer rate, 8 data bits, 1 stop and no parity. The UART port can be used as a debug tool and is used for tuning purposes.

**Table 15 • UART Pin Descriptions**

| QFN Pin # | WLCSP Ball | Name    | Type   | Description   |
|-----------|------------|---------|--------|---|
| 50        | B2         | UART_RX | Input  | <b>UART (Input).</b> Receive serial data in. This port functions as a peripheral interface for an external controller and supports access to the internal registers and memory of the device.             |
| 49        | C2         | UART_TX | Output | <b>UART (Tristate Output).</b> Transmit serial data out. This port functions as a peripheral interface for an external controller and supports access to the internal registers and memory of the device. |

## 10.11 GPIO Pins

GPIO ports can be used for interrupt and event reporting, fixed function control, bootstrap options, as well as being used for general purpose I/O for communication and controlling external devices. Pin functionality is firmware dependent.

**Table 16 • GPIO Pin Descriptions**

| QFN Pin #  | WLCSP Ball | Name             | Type         | Description   |
|------------|------------|------------------|--------------|---|
| 33, 34, 36 | F4, E4, F3 | GPIO_[0:2]       | Input/Output | <b>General Purpose I/O (Input Internal Pull-Down/Tristate Output).</b> These pins can be configured as an input or output and are intended for low-frequency signaling. Refer to <a href="#">Table 5</a> , page 26 for bootstrap functionality.         |
| 37, 38, 39 | F2, –, F6  | GPIO_[3:5]       | Input/Output | <b>General Purpose I/O (Input Internal Pull-Down/Tristate Output).</b> These pins can be configured as an input or output and are intended for low-frequency signaling.<br><i>GPIO_4 is not available on the WLCSP package.</i>                         |
| 64         | A4         | GPIO_9/<br>SM_CS | Input/Output | <b>General Purpose I/O (Input Internal Pull-Down/Tristate Output).</b> This pin can be configured as an input or output and is intended for low-frequency signaling.<br><br>Alternate functionality with SM_CS, see <a href="#">Table 13</a> , page 34. |

## 10.12 Supply and Ground Pins

**Table 17 • Supply and Ground Pin Descriptions**

| QFN Pin #             | WLCSP Ball     | Name        | Type   | Description  |
|-----------------------|----------------|-------------|--------|--|
| 17                    | –              | EXT_SEL     | Input  | <b>VDD +1.2 V Select.</b> Select external +1.2 V supply. Tie to DVDD33 if the +1.2 V supply is to be provided externally. Tie to VSS (0 V) if the +1.2 V supply is to be generated internally.<br>Refer to <a href="#">Power Supply Considerations</a> , page 23 for more information.<br><i>Not available on the WLCSP package.</i>   |
| 16                    | –              | VDD12_CTRL  | Output | <b>VDD +1.2 V Control.</b> Analog control line for the voltage regulator external FET when EXT_SEL is tied to VSS. When EXT_SEL is tied to DVDD33, the VDD12_CTRL pin becomes a CMOS output which can drive the shutdown input of an external LDO.<br>Refer to <a href="#">Power Supply Considerations</a> , page 23 for more information.<br><i>Not available on the WLCSP package.</i> |
| 4, 14, 24, 42, 58     | B5, D1, G5, G6 | DVDD12      | Power  | <b>Core Supply.</b> Connect to a +1.2 V ±5% supply.<br><i>Place a 100 nF, 20%, 10 V, ceramic capacitor on each pin decoupled to the VSS plane.</i><br>Refer to <a href="#">Power Supply Considerations</a> , page 23 for more information.   |
| 5, 21, 35, 46, 51, 59 | B3, B7, G3     | DVDD33      | Power  | <b>Digital Supply.</b> Connect to a +3.3 V ±5% supply.<br><i>Place a 100 nF, 20%, 10 V, ceramic capacitor on each pin decoupled to the VSS plane.</i>  |
| 28                    | –              | DVDD33_XTAL | Power  | <b>Crystal Digital Supply.</b> This pin must be connected to a +3.3 V supply source capable of delivering 10 mA.<br><i>Not available on the WLCSP package.</i>   |

**Table 17 • Supply and Ground Pin Descriptions (continued)**

| QFN Pin # | WLCSP Ball             | Name               | Type   | Description   |
|-----------|------------------------|--------------------|--------|---|
| 10, 11    | E7                     | AVDD33             | Power  | <b>Analog Supply.</b> Connect to a +3.3 V $\pm$ 5% supply. Place a 100 nF, 20%, 10 V, ceramic capacitor on each pin decoupled to the VSS plane.   |
| 54        | B4, B6, D2, D4, E6, G2 | VSS                | Ground | <b>Ground.</b> Connect to digital ground plane.   |
| –         | –                      | Exposed Ground Pad | Ground | <b>Exposed Pad Substrate Connection.</b> Connect to VSS. This pad is at ground potential and must be soldered to the printed circuit board and connected via multiple vias to a heatsink area on the bottom of the board and to the internal ground plane. <i>Not available on the WLCSP package.</i> |

## 10.13 No Connect Pins

**Table 18 • No Connect Pin Description**

| QFN Pin # | WLCSP Ball | Name | Type | Description   |
|-----------|------------|------|------|---|
| 63        | C6         |      |      | <b>No Connection.</b> This pins is to be left unconnected, do not use as a tie point. |

## 10.14 IN0 Pins

These pins are to be tied to Ground only.

**Table 19 • IN0 Pin Descriptions**

| QFN Pin #  | WLCSP Ball | Name | Type  | Description                           |
|------------|------------|------|-------|---------------------------------------|
| 60, 61, 62 | C4, C5, D5 | IN0  | Input | <b>IN0.</b> Tie these pins to Ground. |

# 11 Electrical Characteristics

## 11.1 Absolute Maximum Ratings

Stresses above those listed under *Absolute Maximum Ratings* can cause permanent device failure. Functionality at or above these limits is not implied. Exposure to absolute maximum ratings for extended periods may affect device reliability.

**Table 20 • Absolute Maximum Ratings**

|  |                                |
|--|--------------------------------|
| Supply voltage (DVDD33, AVDD33)                        | -0.5 to +4.0 V                 |
| Core supply voltage (DVDD12)                           | -0.5 to +1.32 V                |
| Input voltage  | -0.5 to +4.0 V                 |
| Continuous current at digital outputs                  | 15 mA                          |
| Reflow temperature, 10 sec., MSL3, per JEDEC J-STD-020 | 260 °C                         |
| Storage temperature                                    | -55 to +125 °C                 |
| ESD immunity (Human Body Model)                        | JS-001-2014 Class 1C compliant |

## 11.2 Thermal Resistance

**Table 21 • Thermal Resistance**

|  |               |           |
|--|---------------|-----------|
| Junction to ambient thermal resistance <sup>1</sup> , $\theta_{JA}$          | 64-pin QFN    | 22.1 °C/W |
|  | 56-ball WLCSP | 33.8 °C/W |
| Junction to board thermal resistance <sup>1</sup> , <Footnote> $\theta_{JB}$ | 64-pin QFN    | 6.1 °C/W  |
|  | 56-ball WLCSP | 3.9 °C/W  |
| Junction to exposed pad thermal resistance <sup>1</sup> , $\theta_{JC}$      | 64-pin QFN    | 2.0 °C/W  |
| Junction to case thermal resistance <sup>1</sup> , $\theta_{JC}$             | 56-ball WLCSP | 5.2 °C/W  |
| Junction to top characterization parameter, $\Psi_{JT}$                      | 64-pin QFN    | 0.1 °C/W  |
|  | 56-ball WLCSP | 0.3 °C/W  |

1. The thermal specifications assume that the device is mounted on an effective thermal conductivity test board (4 layers, 2s2p) per JEDEC JESD51-7 and JESD51-5

## 11.3 Operating Ranges

Microsemi guarantees the performance of this device over the industrial (-40 °C to 85 °C) temperature range by conducting electrical characterization over each range and by conducting a production test with single insertion coupled to periodic sampling. These characterization and test procedures comply with the *Telcordia GR-357-CORE Generic Requirements for Assuring the Reliability of Components Used in Telecommunications Equipment*.

**Table 22 • Operating Ranges**

| Parameter           | Symbol | Min. | Typ. | Max. | Units |
|---------------------|--------|------|------|------|-------|
| Ambient temperature | $T_A$  | -40  |      | +85  | °C    |

**Table 22 • Operating Ranges (continued)**

| Parameter                      | Symbol                   | Min.  | Typ. | Max.  | Units |
|--------------------------------|--------------------------|-------|------|-------|-------|
| Analog supply voltage          | V <sub>AVDD33</sub>      | 3.135 | 3.3  | 3.465 | V     |
| Digital supply voltage         | V <sub>AVDD33</sub>      |       |      |       |       |
| Crystal Digital supply voltage | V <sub>DVDD33_XTAL</sub> |       |      |       |       |
| Crystal I/O voltage            | V <sub>XI</sub>          |       | 2.5  | 2.625 | V     |
| Core supply voltage            | V <sub>DVDD12</sub>      | 1.14  | 1.2  | 1.26  | V     |

## 11.4 Device Power States

The ZL38090 operates in one of four hardware power states. These power states are defined as Working, Sleep, Reset, and USB Suspend. The current consumed by the ZL38090 is dependent upon the power state and the active firmware mode. Typical current consumption for all firmware modes and hardware states are shown in [Table 23](#), page 39. Refer to the *Microsemi AcuEdge™ Firmware Manual* for programming and additional information on the firmware modes.

### 11.4.1 Working State

In the Working state, the ZL38090 is awake and running. In simple terms, the device is “on”. Device features are enabled and supported depending on the firmware and configuration settings.

There are two modes of operation in the ZLS38090 firmware Normal Mode and Power Saving Mode. Both modes support the full complement of firmware audio processing features.

Normal Mode is recommended for applications that use the internal voltage regulator with analog microphones. Normal Mode keeps the Audio Processor always on, thereby minimizing +1.2V power supply noise that could be injected into sensitive analog microphone circuitry via the board layout.

Power Saving Mode can be enabled by setting register 0x206 (System Control Flags) bit 0, or it can be selected from the ZLS38508 *MiTuner™* GUI in the AEC Control window (Enable Power Saving Mode). This mode disables the audio processor block when idle, reducing the average current drawn from the +1.2V power supply. The resulting trade-off is switching noise on this supply. Because of this, Power Saving Mode is not recommended for applications that use the internal voltage regulator with analog microphones.

### 11.4.2 USB Suspend State

USB Suspend is used to conserve power when a quick response is required. The Audio Processor is made inactive and the internal clocks are shut down. The ZL38090 will respond to no other inputs until it awakens from USB Suspend mode. In accordance with the USB specification, the ZL38090 will respond to activity on the USB bus to wake from USB Suspend state. The firmware and configuration records loaded into the device RAM are retained and no re-boot is required.

### 11.4.3 Reset State

Reset is a hardware state used to further conserve power. The +1.2V supply can be removed. The firmware and configuration records loaded into the device RAM are not retained in Reset and must be reloaded when the device is brought out of Reset. See [Reset](#), page 22 for more information and refer to [Power Supply](#), page 23 for information on +1.2V removal.

## 11.4.4 Current Consumption

Device current consumption can vary with the firmware load. Common values are listed here using an external +1.2 V supply for the core power supply with a 12.000 MHz crystal and a 3.3 K $\Omega$  resistor from GPIO\_2 to DVDD33 (external Flash selected), unless otherwise noted.

**Table 23 • Current Consumption**

| Device Power State               | +3.3 V <sup>1</sup> |      | +1.2 V <sup>2</sup> |      | Units   | Notes / Conditions  |
|----------------------------------|---------------------|------|---------------------|------|---------|---|
|                                  | Typ.                | Max. | Typ.                | Max. |         |   |
| Working state, Normal Mode       | 21                  |      | 115                 |      | mA      | Firmware active, Power Saving off, 1 DAC active <sup>3</sup> , 2 MICs active <sup>4</sup> .         |
| Working state, Power Saving Mode | 21                  |      | 85                  |      |         | Firmware active, Power Saving on, 1 DAC active <sup>3</sup> , 2 MICs active <sup>4</sup> .          |
| USB Suspend state                | 0.68                |      | 3.4                 |      |         | Firmware inactive (firmware and configuration record are retained), DACs and MICs are powered down. |
| Reset state                      | 100                 |      | 0                   |      | $\mu$ A | Device in reset (reset > 10 $\mu$ S), DVDD12 removed <sup>5</sup> .                                 |

1. Table values include all current entering DVDD33, AVDD33, and DVDD33\_XTAL pins. Add 1.0 mA to Normal, Power Saving, and USB Suspend modes if the internal voltage regulator is used (EXT\_SEL = VSS).
2. Core supply voltage. Table values include all current entering DVDD12 pins.
3. DAC in differential mode, for 2 DACs active in differential mode, add 3.6 mA to +3.3 V current.
4. DMIC\_IN active.
5. DVDD12 is removed if the internal regulator is used for +1.2 V generation or if the VDD12\_CTRL pin is used to shutdown an external +1.2 V LDO that provides DVDD12 to the ZL38090.

## 11.5 DC Specifications

Typical values are for  $T_A = 25^\circ\text{C}$  and nominal supply voltage. Minimum and maximum values are over the industrial  $-40^\circ\text{C}$  to  $85^\circ\text{C}$  temperature range and supply voltage range as shown in [Operating Ranges](#), page 37, except as noted. A 12.000 MHz clock oscillator is active.

**Table 24 • DC Specifications**

| Parameter                                      | Symbol    | Min.                    | Typ. | Max.                    | Units   | Notes / Conditions |
|--|-----------|-------------------------|------|-------------------------|---------|--------------------|
| Input high voltage                             | $V_{IH}$  | $0.7 \times V_{DVDD33}$ |      | $V_{DVDD33} + 0.3$      | V       | All digital inputs |
| Input low voltage                              | $V_{IL}$  | $V_{VSS} - 0.3$         |      | $0.3 \times V_{DVDD33}$ | V       | All digital inputs |
| Input hysteresis voltage                       | $V_{HYS}$ | 0.4                     |      |                         | V       |                    |
| Input leakage (input pins)                     | $I_{IL}$  |                         |      | 5                       | $\mu$ A | 0 to +3.3 V        |
| Input leakage (bi-directional pins)            | $I_{BL}$  |                         |      | 5                       | $\mu$ A | 0 to +3.3 V        |
| Weak pull-up current                           | $I_{PU}$  | 38                      | 63   | 101                     | $\mu$ A | Input at 0 V       |
| Weak pull-down current                         | $I_{PD}$  | 19                      | 41   | 158                     | $\mu$ A | Input at +3.3 V    |
| Input pin capacitance                          | $C_I$     |                         | 5    |                         | pF      |                    |
| Output high voltage                            | $V_{OH}$  | 2.4                     |      |                         | V       | At 12 mA           |
| Output low voltage                             | $V_{OL}$  |                         |      | 0.4                     | V       | At 12 mA           |
| Output high impedance leakage                  | $I_{OZ}$  |                         |      | 5                       | $\mu$ A | 0 to +3.3 V        |
| Pin capacitance (output & input/tristate pins) | $C_O$     |                         | 5    |                         | pF      |                    |

**Table 24 • DC Specifications (continued)**

| Parameter        | Symbol   | Min. | Typ. | Max. | Units | Notes / Conditions                |
|------------------|----------|------|------|------|-------|-----------------------------------|
| Output rise time | $t_{RT}$ |      | 1.25 |      | ns    | 10% to 90%,<br>$C_{LOAD} = 20$ pF |
| Output fall time | $t_{FT}$ |      | 1.25 |      | ns    | 90% to 10%,<br>$C_{LOAD} = 20$ pF |

## 11.6 AC Specifications

For all AC specifications, typical values are for  $T_A = 25$  °C and nominal supply voltage. Minimum and maximum values are over the industrial  $-40$  °C to  $85$  °C temperature range and supply voltage ranges as shown in [Operating Ranges](#), page 37, except as noted. A 12.000 MHz clock oscillator is active with Two-Way Voice Communication firmware in Normal, Wideband operational mode.

### 11.6.1 Microphone Interface

AC specifications for microphone interface.

**Table 25 • Microphone Interface**

| Parameter  | Symbol     | Min. | Typ.  | Max. | Units | Notes / Conditions           |
|--|------------|------|-------|------|-------|------------------------------|
| Microphone clock output (DMIC_CLK),<br>8 kHz, 16 kHz sample rate |            |      | 1.024 |      | MHz   |                              |
| 48 kHz sample rate   |            |      | 3.072 |      | MHz   |                              |
| DMIC_CLK, Output high current                                    | $I_{OH}$   |      | 20    |      | mA    | $V_{OH} = D_{VDD33} - 0.4$ V |
| DMIC_CLK, Output low current                                     | $I_{OL}$   |      | 30    |      | mA    | $V_{OL} = 0.4$ V             |
| DMIC_CLK, Output rise and fall time                              | $t_R, t_F$ |      | 5     |      | nS    | $C_{LOAD} = 100$ pF          |

### 11.6.2 DAC

Measurements taken using PCM mode. THD+N versus output power for speaker drive applications presented in [Figure 30](#), page 41; THD+N versus output voltage for amplifier drive applications presented in [Figure 31](#), page 42.

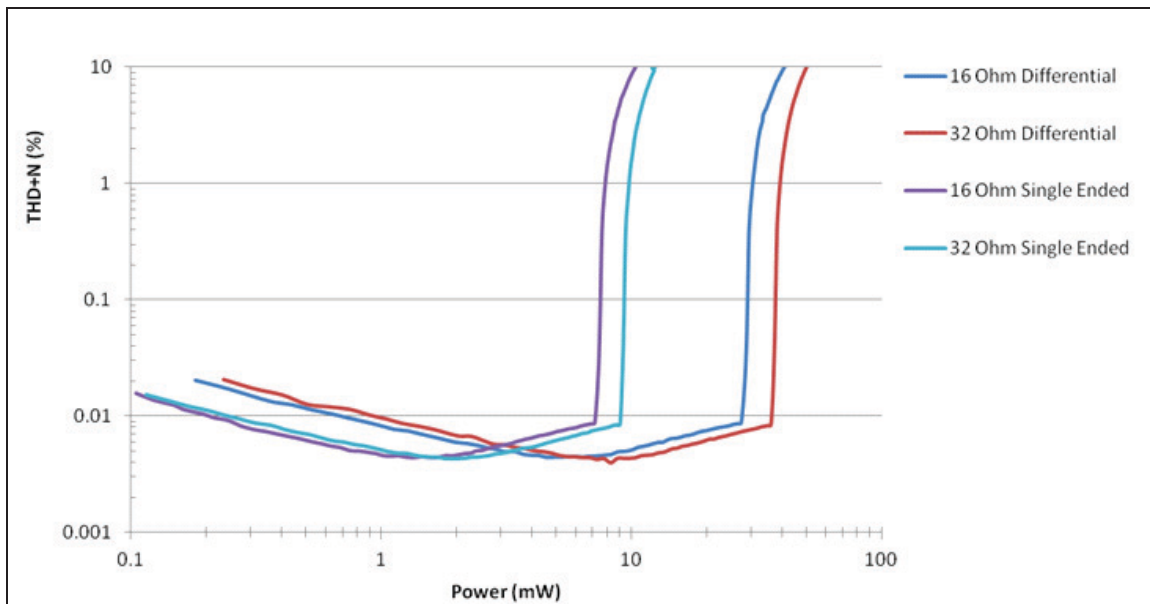
**Table 26 • DAC**

| Parameter                               | Symbol      | Min. | Typ. | Max. | Units    | Notes / Conditions                                     |
|---|-------------|------|------|------|----------|--|
| DAC output level:                       |             |      |      |      |          | DAC gain = 1, 1 K $\Omega$ load.                       |
| Full scale: Differential                | $V_{DACFS}$ |      | 4.8  |      | $V_{PP}$ |  |
| Single-ended                            |             |      | 2.4  |      |          |  |
| 0 dBm0: Differential                    |             |      | 2.8  |      |          |  |
| Single-ended                            |             |      | 1.4  |      |          |  |
| PCM full scale level ( $V_{ppd}$ value) |             |      | 9    |      | dBm0     | DAC gain = 1, 600 $\Omega$ load                        |
| DAC output power:                       |             |      |      |      |          | 1,<br>Single-ended loads driven capacitively to ground |
| Single-ended, 32 ohm load               |             |      | 20.6 | 24   | mW       |  |
| Single-ended, 16 ohm load               |             |      | 37.5 | 47   |          |  |
| Differential, 32 ohm load               |             |      | 86.0 | 94   |          |  |

**Table 26 • DAC (continued)**

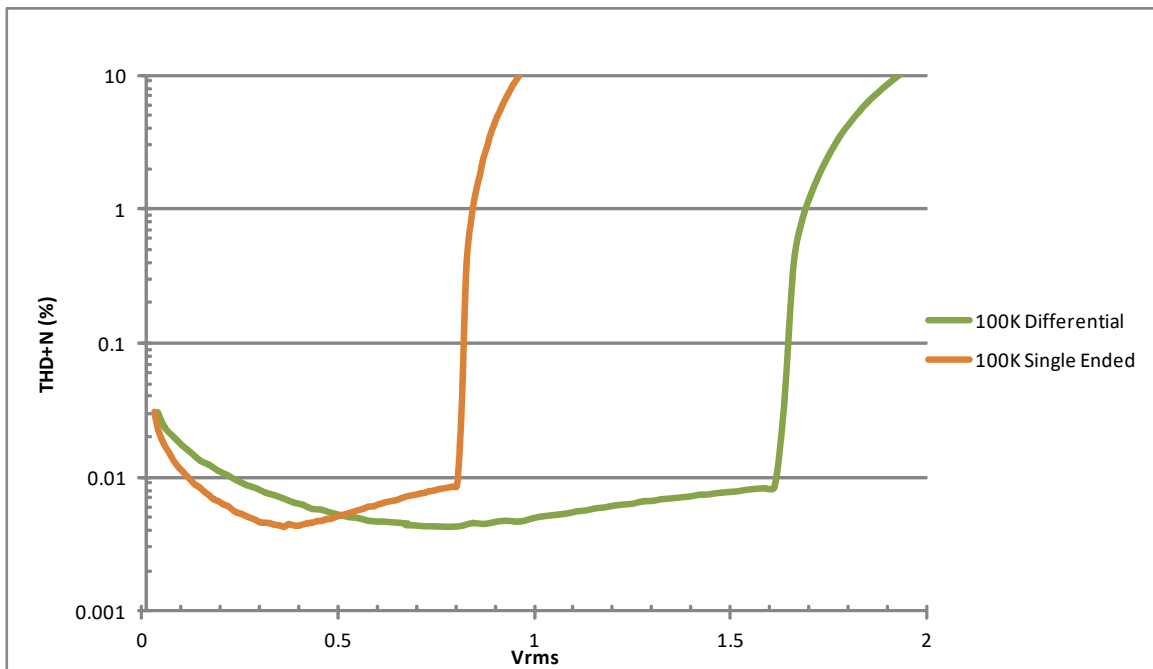
| Parameter                                    | Symbol  | Min. | Typ. | Max.  | Units | Notes / Conditions  |
|--|---------|------|------|-------|-------|---|
| Frequency response:<br>Sample rate = 48 kS/s | $f_R$   | 20   |      | 20000 | Hz    | <sup>1,3</sup> dB cutoff includes external AC coupling, without AC coupling the response is low pass. |
| Dynamic range:<br>Sample rate = 48 kS/s      |         |      | 92   |       | dBFS  | 20 Hz – 20 kHz  |
| Total harmonic distortion plus noise         | THD + N |      | -82  |       | dBFS  | <sup>2</sup> , Input = -3 dBFS.   |
| Signal to Noise Ratio                        | SNR     |      | 85   |       | dB    | <sup>2</sup> , 1004 Hz, C-message weighted  |
| Allowable capacitive load to ground          | $C_L$   |      |      | 100   | pF    | <sup>1</sup> , At each DAC output.  |
| Power supply rejection ratio                 | PSRR    |      | 70   |       | dB    | <sup>1</sup> , 20 Hz - 100 kHz, 100 mVpp supply noise.  |
| Crosstalk                                    |         |      | -85  | -70   | dB    | <sup>1</sup> , Between DAC outputs.   |

1. Guaranteed by design, not tested in production.
2. Single-ended or differential output.

**Figure 30 • THD+N Ratio versus Output Power – Driving Low Impedance**



**Figure 31 • THD+N Ratio versus  $V_{RMS}$  – Driving High Impedance**



## 11.7 External Clock Requirements

In all modes of operation the ZL38090 requires an external clock source. The external clock drives the device's internal PLL which is the source for the internal timing signals.

The external clock source can either be:

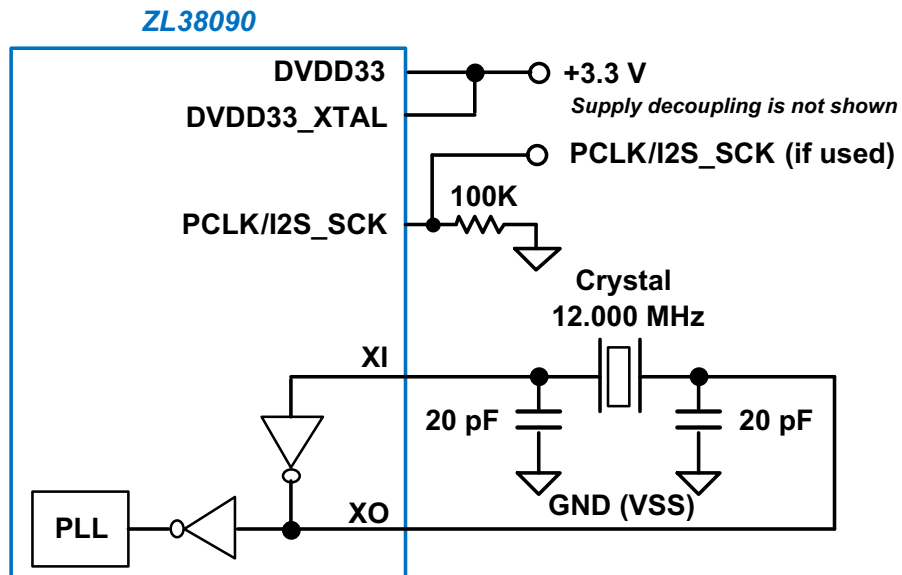
- 12.000 MHz crystal, or
- 12.000 MHz clock oscillator with a 2.5 V output

The following sections discuss these options.

### 11.7.1 Crystal Application

The oscillator circuit that is created across pins XI and XO requires an external fundamental mode crystal that has a specified parallel resonance ( $f_p$ ) at 12.000 MHz.

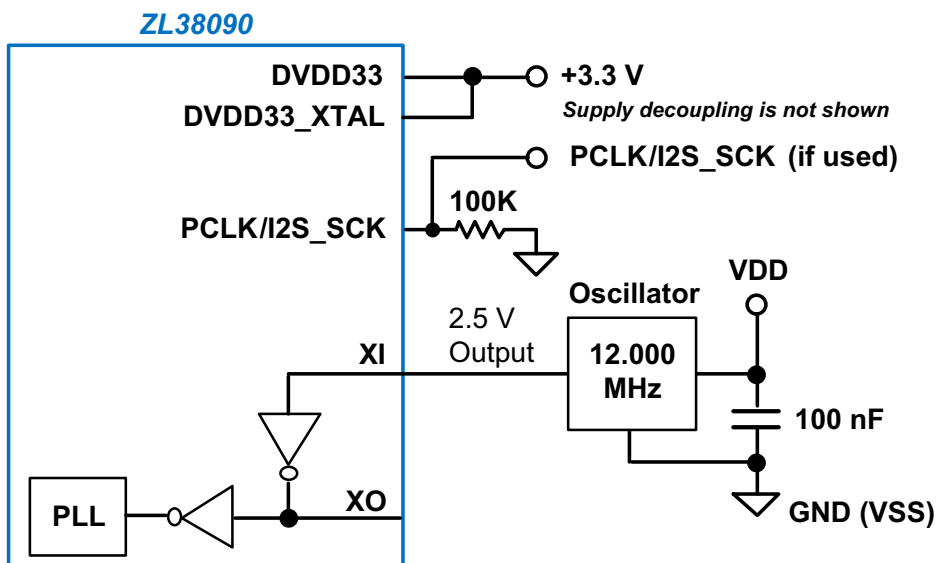
Figure 32 • Crystal Application Circuit



## 11.7.2 Clock Oscillator Application

Figure 33, page 43 illustrates the circuit that is used when the ZL38090 external clock source is a clock oscillator. The oscillator pins are 2.5V compliant and should not be driven from 3.3V CMOS without a level shifter or voltage attenuator.

Figure 33 • Clock Oscillator Application Circuit



### 11.7.3 AC Specifications - External Clocking Requirements

These specifications apply to crystal and clock oscillator external clocking.

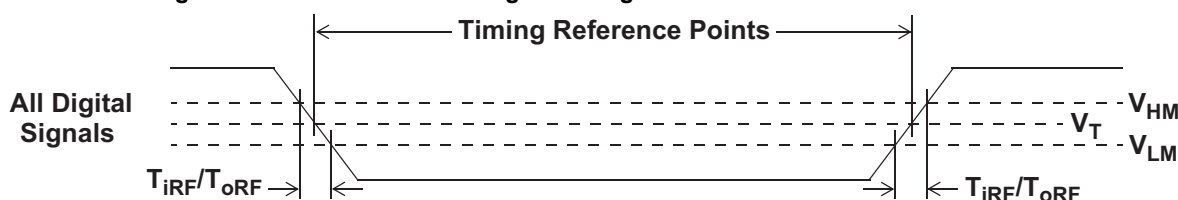
**Table 27 • AC Specifications – External Clocking Requirement**

| Parameter                            | Symbol     | Min. | Typ. | Max. | Units            | Notes / Conditions        |
|--------------------------------------|------------|------|------|------|------------------|---------------------------|
| External clocking frequency accuracy | $A_{OSC}$  | -50  |      | 50   | ppm              | Not tested in production. |
| External clocking duty cycle         | $DC_{OSC}$ | 40   |      | 60   | %                |                           |
| PCLK input jitter                    |            |      |      | 1    | ns <sub>pp</sub> |                           |
| PCLK output jitter (master mode)     |            |      |      | 0.75 | ns <sub>pp</sub> |                           |
| PCLK input jitter                    |            |      | 200  |      | μs               |                           |
| Holdover accuracy                    |            |      |      | 50   | ppm              |                           |

## 12 Timing Characteristics

Figure 34 depicts the timing reference points that apply to the timing diagrams shown in this section. For all timing characteristics, typical values are for  $T_A = 25^\circ\text{C}$  and nominal supply voltage. Minimum and maximum values are over the industrial  $-40^\circ\text{C}$  to  $85^\circ\text{C}$  temperature range and supply voltage ranges as shown in [Operating Ranges](#), page 37, except as noted.

**Figure 34 • Timing Parameter Measurement Digital Voltage Levels**



### 12.1 TDM Interface Timing Parameters

#### 12.1.1 GCI and PCM Timing Parameters

Specifications for GCI and PCM timing modes are presented in the following table. The specifications apply to both port A and port B in slave operation.

A timing diagram that applies to GCI timing of the TDM interface is illustrated in [Figure 35](#), page 46.

Timing diagrams that apply to PCM timing of the TDM interface are illustrated in [Figure 36](#), page 46 and [Figure 37](#), page 47.

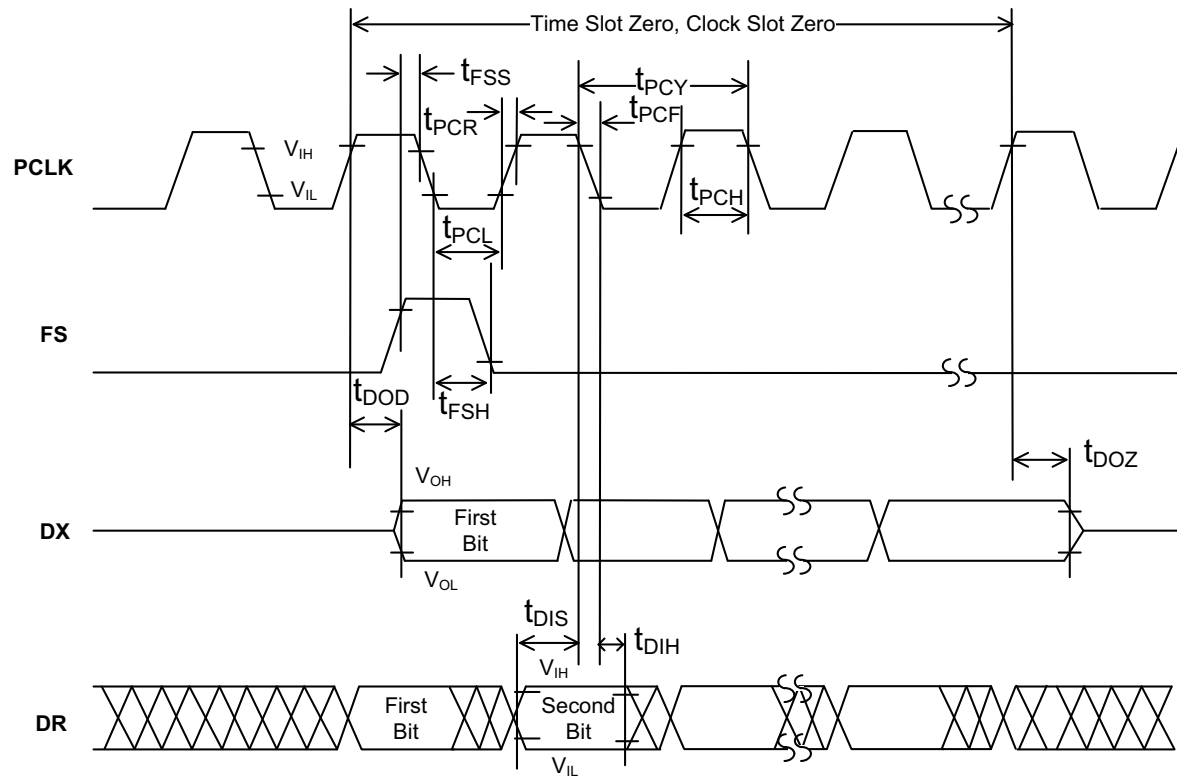
**Table 28 • GCI and PCM Timing Parameters**

| Parameter                           | Symbol    | Min. | Typ. | Max.                | Units | Notes / Conditions |
|-------------------------------------|-----------|------|------|---------------------|-------|--------------------|
| PCLK period                         | $t_{PCY}$ | 122  |      | 7812.5              | ns    | 1, 2               |
| PCLK High pulse width               | $t_{PCH}$ | 48   |      |                     |       | 2                  |
| PCLK Low pulse width                | $t_{PCL}$ | 48   |      |                     |       | 2                  |
| Fall time of clock                  | $t_{PCF}$ |      |      | 8                   |       |                    |
| Rise time of clock                  | $t_{PCR}$ |      |      | 8                   |       |                    |
| FS delay (output rising or falling) | $t_{FSD}$ | 2    |      | 15                  |       | 2                  |
|                                     |           | 2    |      | 25                  |       | 3                  |
| FS setup time (input)               | $t_{FSS}$ | 5    |      |                     |       | 4                  |
| FS hold time (input)                | $t_{FSH}$ | 0.5  |      | $125000 - 2t_{PCY}$ |       | 4                  |
| Data output delay                   | $t_{DOD}$ | 2    |      | 15                  |       | 2                  |
|                                     |           | 2    |      | 25                  |       | 5                  |
| Data output delay to High-Z         | $t_{DOZ}$ | 0    |      | 10                  |       | 5                  |
| Data input setup time               | $t_{DIS}$ | 5    |      |                     |       | 4                  |
| Data input hold time                | $t_{DIH}$ | 0    |      |                     |       | 4                  |
| Allowed PCLK jitter time            | $t_{PCT}$ |      |      | 20                  |       | Peak-to-peak       |
| Allowed Frame Sync jitter time      | $t_{FST}$ |      |      | 20                  |       | Peak-to-peak       |

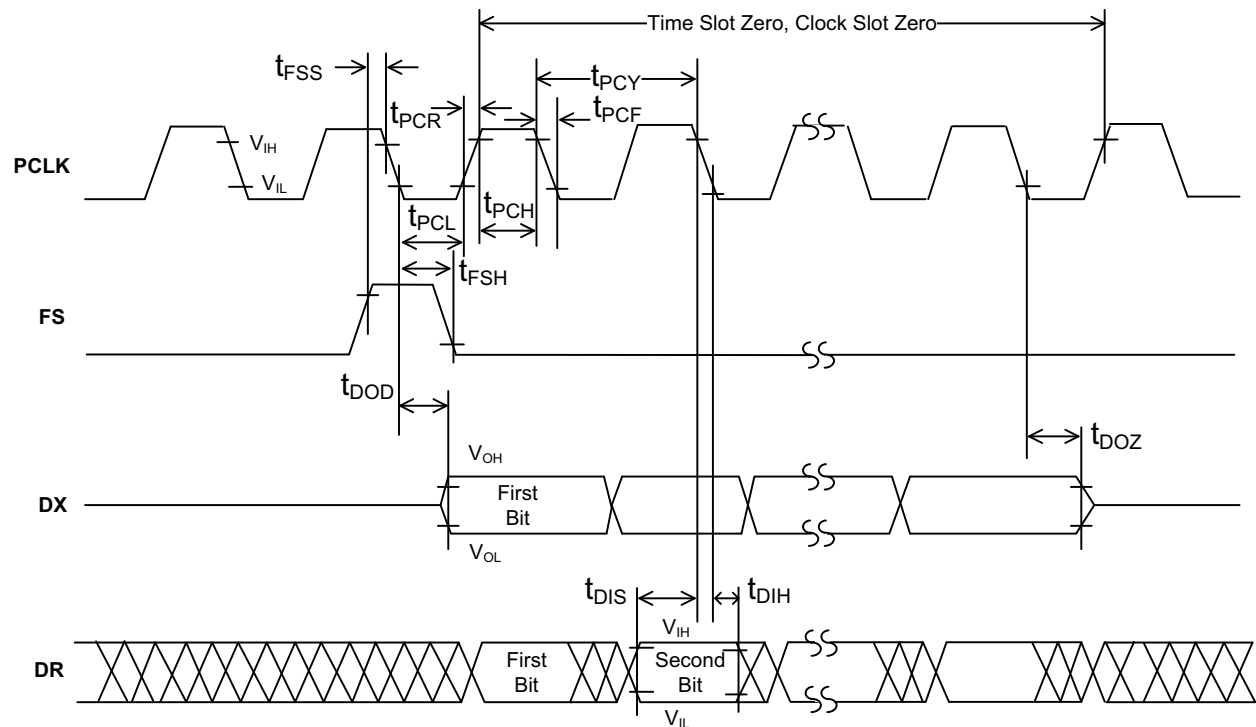
1. PCLK frequency must be within 100 ppm.
2.  $C_{LOAD} = 40\text{ pF}$

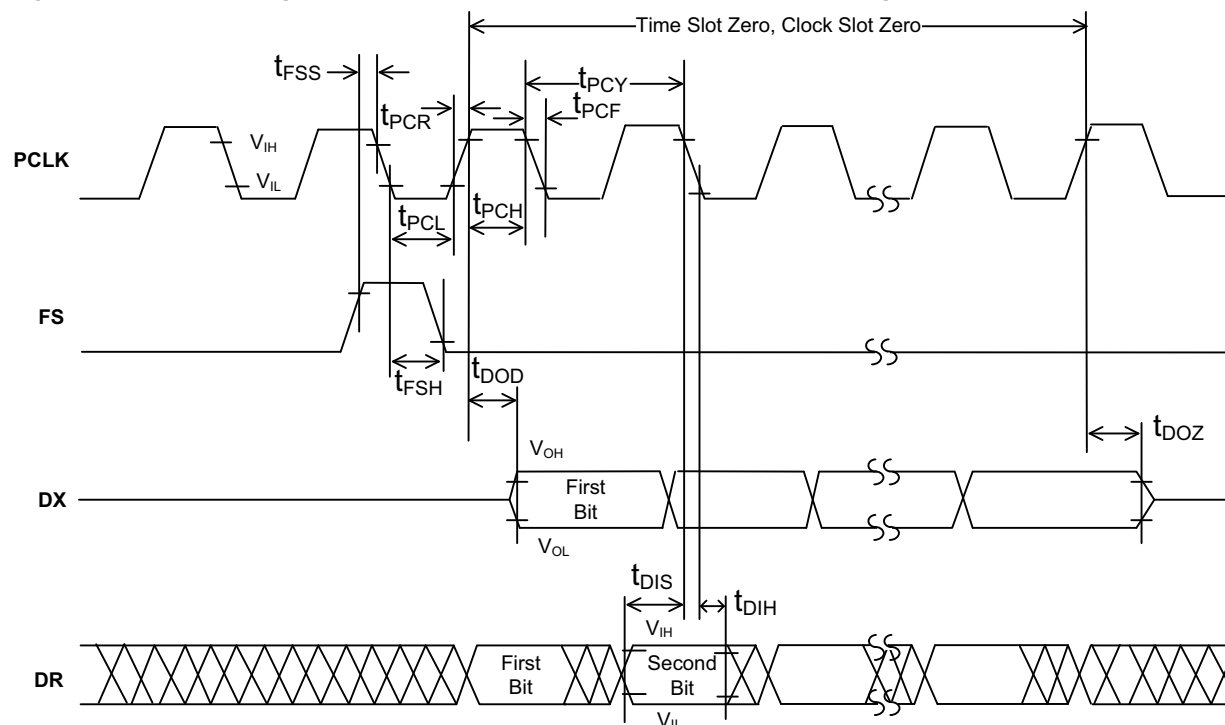
3.  $C_{LOAD} = 150\text{ pF}$
4. Setup times based on 2 ns PCLK rise and fall times; hold times based on 0 ns PCLK rise and fall times.
5. Guaranteed by design, not tested in production.

**Figure 35 • GCI Timing, 8-bit**



**Figure 36 • PCM Timing, 8-bit with xeDX = 0 (Transmit on Negative PCLK Edge)**



**Figure 37 • PCM Timing, 8-bit with xeDX = 1 (Transmit on Positive PCLK Edge)**


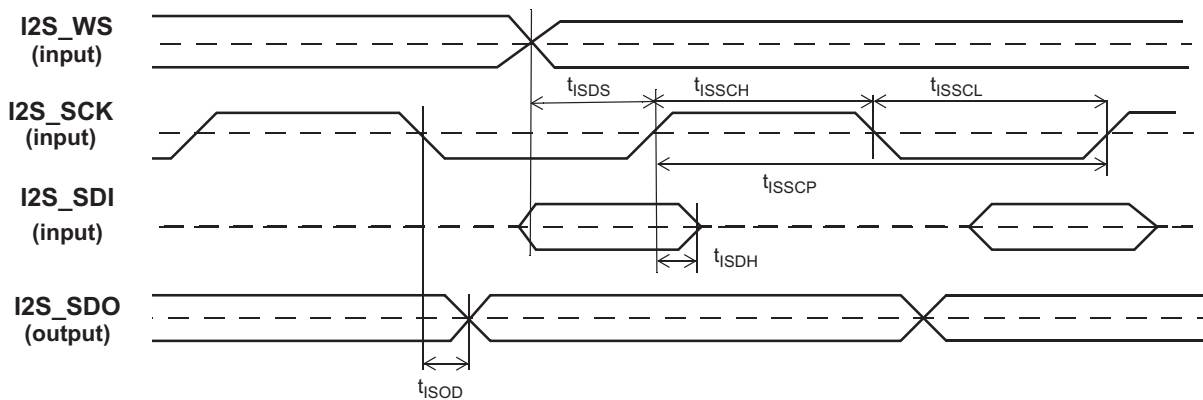
## 12.1.2 I<sup>2</sup>S Timing Parameters

### 12.1.2.1 I<sup>2</sup>S Slave

Specifications for I<sup>2</sup>S Slave timing are presented in the following table. The specifications apply to both port A and port B. A timing diagram for the I<sup>2</sup>S Slave timing parameters is illustrated in [Figure 38](#), page 48.

**Table 29 • I<sup>2</sup>S Slave Timing Specifications**

| Parameter                             | Symbol      | Min.   | Typ.   | Max.   | Units         | Notes / Conditions         |
|---------------------------------------|-------------|--------|--------|--------|---------------|----------------------------|
| I2S_SCK Clock Period                  |             |        |        |        |               |                            |
| $f_s = 48 \text{ kHz}$                | $t_{ISSCP}$ |        | 651.04 |        | ns            |                            |
| $f_s = 8 \text{ kHz}$                 |             |        | 3.91   |        | $\mu\text{s}$ |                            |
| I2S_SCK Pulse Width High              |             |        |        |        |               |                            |
| $f_s = 48 \text{ kHz}$                | $t_{ISSCH}$ | 292.97 |        | 358.07 | ns            |                            |
| $f_s = 8 \text{ kHz}$                 |             | 1.76   |        | 2.15   | $\mu\text{s}$ |                            |
| I2S_SCK Pulse Width Low               |             |        |        |        |               |                            |
| $f_s = 48 \text{ kHz}$                | $t_{ISSCL}$ | 292.97 |        | 358.07 | ns            |                            |
| $f_s = 8 \text{ kHz}$                 |             | 1.76   |        | 2.15   | $\mu\text{s}$ |                            |
| I2S_SDI Setup Time                    | $t_{ISDS}$  | 5      |        |        | ns            |                            |
| I2S_WS Setup Time                     | $t_{ISDS}$  | 5      |        |        | ns            |                            |
| I2S_SDI Hold Time                     | $t_{ISDH}$  | 0      |        |        | ns            |                            |
| I2S_WS Hold Time                      | $t_{ISDH}$  | 0.5    |        |        | ns            |                            |
| I2S_SCK Falling Edge to I2S_SDO Valid | $t_{ISOD}$  | 2      |        | 15     | ns            | $C_{LOAD} = 40 \text{ pF}$ |

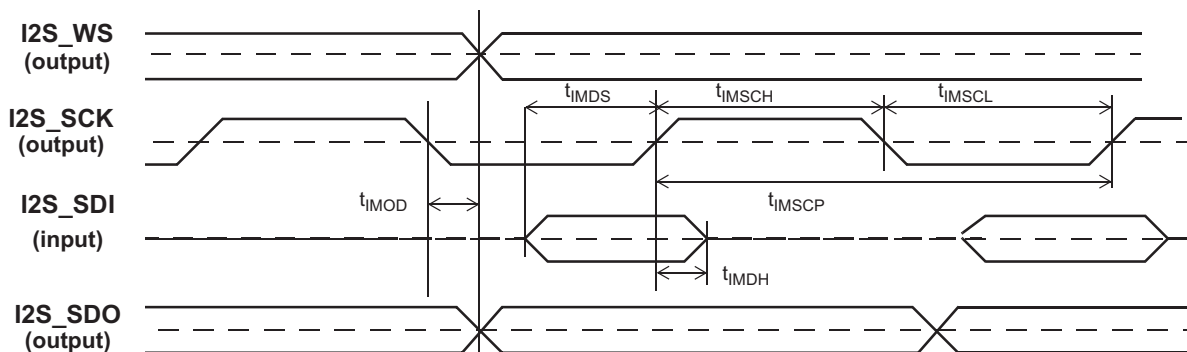
**Figure 38 • Slave I<sup>2</sup>S Timing**

### 12.1.2.2 I<sup>2</sup>S Master

Specifications for I<sup>2</sup>S Master timing are presented in the following table. The specifications apply to both port A and port B. A timing diagram for the I<sup>2</sup>S Master timing parameters is illustrated in [Figure 39](#).

**Table 30 • I<sup>2</sup>S Master Timing Specifications**

| Parameter                             | Symbol      | Min.  | Typ.   | Max.  | Units         | Notes / Conditions         |
|---------------------------------------|-------------|-------|--------|-------|---------------|----------------------------|
| I2S_SCK Clock Period                  |             |       |        |       |               |                            |
| $f_s = 48 \text{ kHz}$                | $t_{IMSCP}$ |       | 651.04 |       | ns            |                            |
| $f_s = 8 \text{ kHz}$                 |             |       | 3.91   |       | $\mu\text{s}$ |                            |
| I2S_SCK Pulse Width High              |             |       |        |       |               |                            |
| $f_s = 48 \text{ kHz}$                | $t_{IMSCH}$ | 318.0 |        | 333.0 | ns            |                            |
| $f_s = 8 \text{ kHz}$                 |             | 1.95  |        | 1.96  | $\mu\text{s}$ |                            |
| I2S_SCK Pulse Width Low               |             |       |        |       |               |                            |
| $f_s = 48 \text{ kHz}$                | $t_{IMSCL}$ | 318.0 |        | 333.0 | ns            |                            |
| $f_s = 8 \text{ kHz}$                 |             | 1.95  |        | 1.96  | $\mu\text{s}$ |                            |
| I2S_SDI Setup Time                    | $t_{IMDS}$  | 5     |        |       | ns            |                            |
| I2S_SDI Hold Time                     | $t_{IMDH}$  | 0     |        |       | ns            |                            |
| I2S_SCK Falling Edge to I2S_WS        | $t_{IMOD}$  | 2     |        | 15    | ns            | $C_{LOAD} = 40 \text{ pF}$ |
| I2S_SCK Falling Edge to I2S_SDO Valid | $t_{IMOD}$  | 2     |        | 15    | ns            | $C_{LOAD} = 40 \text{ pF}$ |

**Figure 39 • Master I<sup>2</sup>S Timing**

## 12.2 Host Bus Interface Timing Parameters

The HBI is the main communication port from the host processor to the , this port can read and write all of the memory and registers on the . The port can be configured as SPI Slave or I<sup>2</sup>C Slave.

For fastest command and control operation, use the SPI Slave configuration. The SPI Slave can be operated with HCLK speeds up to 25 MHz; the I<sup>2</sup>C Slave will operate with HCLK speeds up to 400 kHz.

### 12.2.1 SPI Slave Port Timing Parameters

The following table describes timing specific to the device. A timing diagram for the SPI Slave timing parameters is illustrated in Figure 40, page 50.

For seamless control operation, both the SPI Slave timing and the system timing need to be considered when operating the SPI Slave at high speeds. System timing includes host set-up and delay times and board delay times.

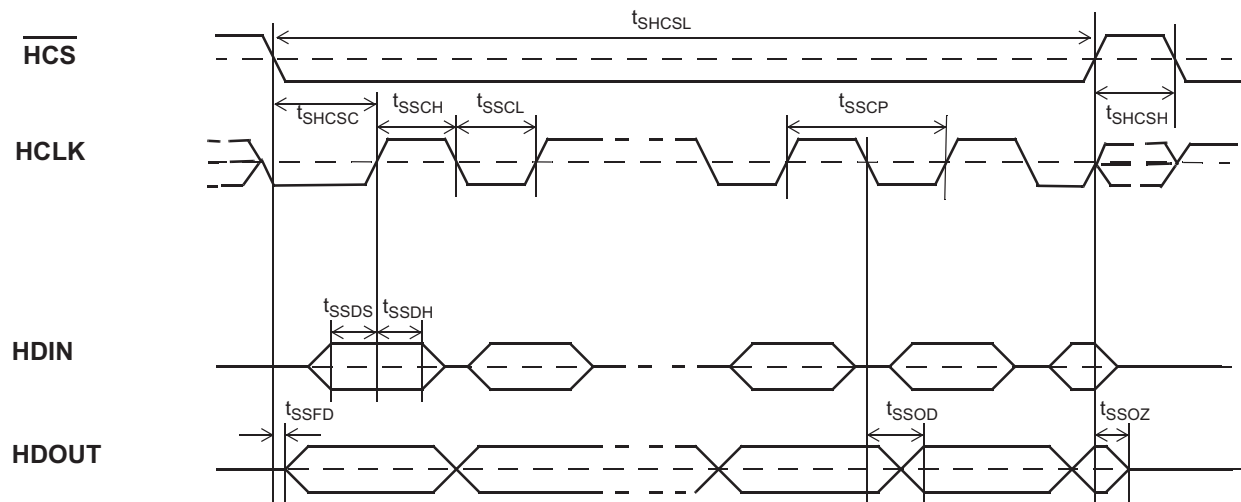
**Table 31 • SPI Slave Port Timing Parameters**

| Parameter   | Symbol      | Min.   | Typ.                         | Max. | Units | Notes / Conditions                        |
|---|-------------|--|------------------------------|------|-------|---|
| HCLK Clock Period                                     | $t_{SSCP}$  | 40   |                              |      | ns    |   |
| HCLK Pulse Width High                                 | $t_{SSCH}$  | 16   | $t_{SSCP}/2$                 |      |       | 1   |
| HCLK Pulse Width Low                                  | $t_{SSCL}$  | 16   | $t_{SSCP}/2$                 |      |       | 1   |
| HDIN Setup Time                                       | $t_{SSDS}$  | 5  |                              |      |       |   |
| HDIN Hold Time  | $t_{SSDH}$  | 0  |                              |      |       |   |
| $\overline{\text{HCS}}$ Asserted to HCLK Rising Edge: |             |  |                              |      |       |   |
| Write   | $t_{SHCSC}$ | 5  | $t_{SSCP}/2$                 |      |       |   |
| Read if host samples on falling edge                  |             | 5  | $t_{SSCP}/2$                 |      |       |   |
| Read if host samples on rising edge                   |             | $t_{SSFD} +$<br>host<br>HDOUT<br>setup time<br>to HCLK | $t_{SSFD} +$<br>$t_{SSCP}/2$ |      |       |   |
| HCLK Driving Edge to HDOUT Valid                      | $t_{SSOD}$  | 2  |                              | 15   |       | $C_{LOAD} = 40 \text{ pF}$                |
| $\overline{\text{HCS}}$ Falling Edge to HDOUT Valid   | $t_{SSFD}$  | 0  |                              | 15   |       | <sup>2</sup> , $C_{LOAD} = 40 \text{ pF}$ |
| $\overline{\text{HCS}}$ De-asserted to HDOUT Tristate | $t_{SSOZ}$  | 0  |                              | 10   |       | <sup>5</sup> , $C_{LOAD} = 40 \text{ pF}$ |
| $\overline{\text{HCS}}$ Pulse High                    | $t_{SHCSH}$ | 20   | $t_{SSCP}/2$                 |      |       | <sup>1, 3</sup>                           |
| $\overline{\text{HCS}}$ Pulse low                     | $t_{SHCSL}$ |  |                              |      |       | <sup>4</sup>                              |

- HCLK may be stopped in the high or low state indefinitely without loss of information. When  $\overline{\text{HCS}}$  is at low state, every 16 HCLK cycles, the 16-bit received data will be interpreted by the SPI interface logic.
- The first data bit is enabled on the falling edge of  $\overline{\text{HCS}}$  or on the falling edge of HCLK, whichever occurs last.
- The SPI Slave requires 61 ns  $\overline{\text{HCS}}$  off time just to make the transition of HCS synchronized with HCLK clock. In the command framing mode, there is no  $\overline{\text{HCS}}$  off time between each 16-bit command/data, and  $\overline{\text{HCS}}$  is held low until the end of command.
- If  $\overline{\text{HCS}}$  is not held low for 8 or 16 HCLK cycles exactly, the SPI Slave will reset. During byte or word framing mode,  $\overline{\text{HCS}}$  is held low for the whole duration of the command. Multiple commands can be transferred with  $\overline{\text{HCS}}$  low for the whole duration of the multiple commands. The rising edge of the  $\overline{\text{HCS}}$  indicates the end of the command sequence and resets the SPI Slave.
- Guaranteed by design, not tested in production.



Figure 40 • SPI Slave Timing



## 12.2.2 I<sup>2</sup>C Slave Interface Timing Parameters

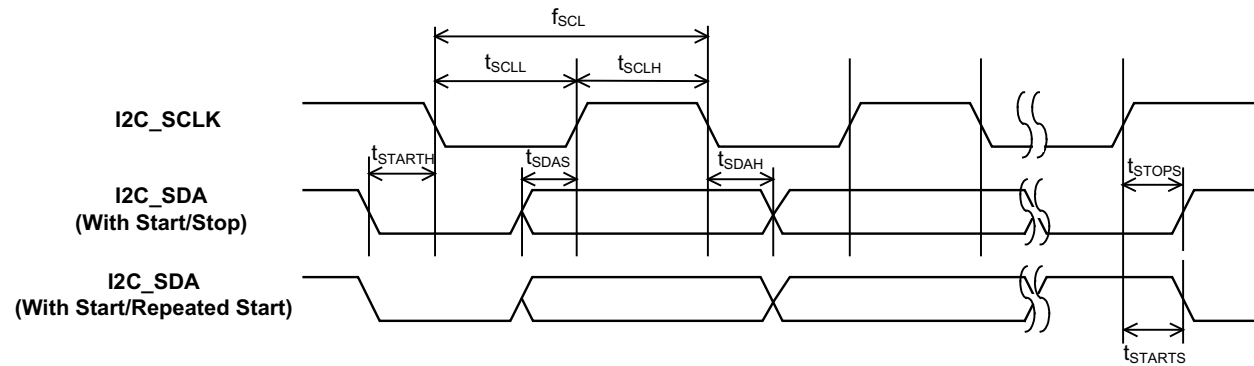
The I<sup>2</sup>C interface uses the SPI Slave interface pins.

Specifications for I<sup>2</sup>C interface timing are presented in the following table. A timing diagram for the I<sup>2</sup>C timing parameters is illustrated in Figure 41, page 51.

Table 32 • I<sup>2</sup>S Slave Timing Specifications

| Parameter   | Symbol       | Min. | Typ. | Max. | Units   | Notes / Conditions |
|---|--------------|------|------|------|---------|--------------------|
| SCLK Clock Frequency  | $f_{SCL}$    | 0    |      | 400  | kHz     |                    |
| START Condition Hold Time                                       | $t_{STARTH}$ | 0.6  |      |      | $\mu$ s |                    |
| SDA data setup time   | $t_{SDAS}$   | 100  |      |      | ns      |                    |
| SDA Hold Time Input   | $t_{SDAH}$   | 100  |      |      | ns      |                    |
| SDA Hold Time Output  | $t_{SDAH}$   | 300  |      |      | ns      |                    |
| High period of SCLK   | $t_{SCLH}$   | 0.6  |      |      | $\mu$ s |                    |
| Low period of SCLK  | $t_{SCLL}$   | 1.3  |      |      | $\mu$ s |                    |
| STOP Condition Setup Time                                       | $t_{STOPS}$  | 0.6  |      |      | $\mu$ s |                    |
| Repeated Start Condition Setup Time                             | $t_{STARTS}$ | 0.6  |      |      | $\mu$ s |                    |
| Pulse Width Spike Suppression, glitches ignored by input filter | $t_{SP}$     | 50   |      |      | ns      |                    |

**Figure 41 • I<sup>2</sup>C Timing Parameter Definitions**



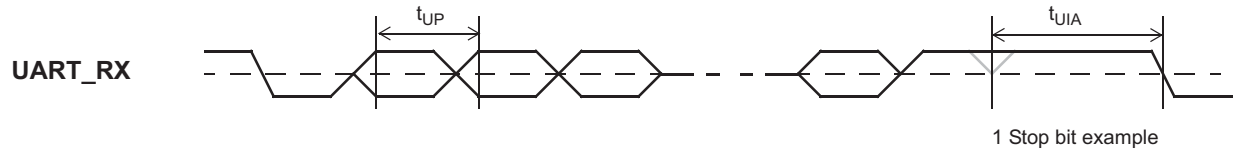
## 12.3 UART Timing Parameters

Specifications for UART timing are presented in the following table. Timing diagrams for the UART timing parameters are illustrated in [Figure 42](#) and [Figure 43](#).

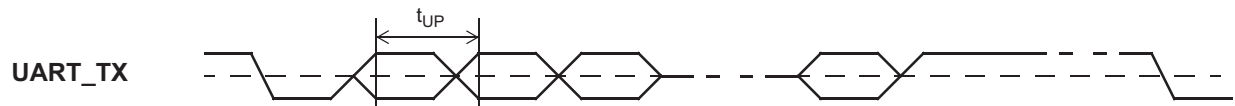
**Table 33 • UART Timing Specifications**

| Parameter  | Symbol   | Min. | Typ. | Max. | Units   | Notes / Conditions                              |
|--|----------|------|------|------|---------|---|
| UART_RX and UART_TX bit width Baud rate = 115.2 kbps | $t_{UP}$ |      | 8.68 |      | $\mu$ s |   |
| Allowed baud rate deviation 8 bits with no parity    |          |      |      | 4.86 | %       | Guaranteed by design, not tested in production. |

**Figure 42 • UART\_RX Timing**



**Figure 43 • UART\_TX Timing**



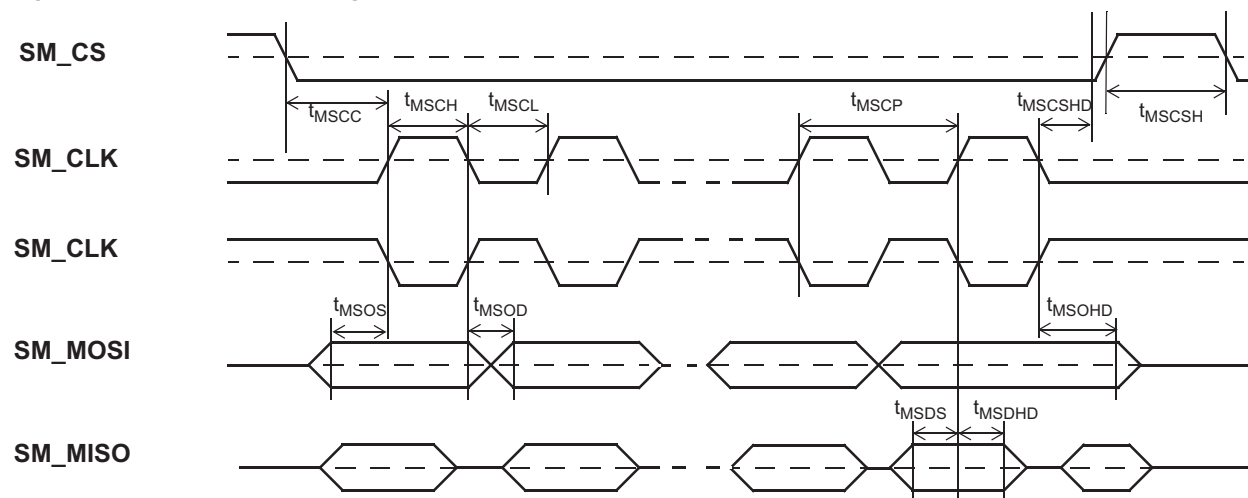
## 12.4 Master SPI Timing Parameters

Specifications for Master SPI timing are presented in the following table. A timing diagram for the Master SPI timing parameters is illustrated in Figure 44.

**Table 34 • Master SPI Timing Specifications**

| Parameter                                       | Symbol       | Min.               | Typ. | Max. | Units | Notes / Conditions        |
|---|--------------|--------------------|------|------|-------|---------------------------|
| SM_CLK Clock Period                             | $t_{MSCP}$   | 40                 |      | 320  | ns    | Max. 25.0 MHz             |
| SM_CLK Pulse Width High                         | $t_{MSCH}$   | $(t_{MSCP}/2) - 2$ |      | 160  |       |                           |
| SM_CLK Pulse Width Low                          | $t_{MSCL}$   | $(t_{MSCP}/2) - 2$ |      | 160  |       |                           |
| SM_MISO Setup Time                              | $t_{MSDS}$   | 3                  |      |      |       |                           |
| SM_MISO Hold Time                               | $t_{MSDHD}$  | 0                  |      |      |       |                           |
| SM_CS Asserted to SM_CLK Sampling Edge          | $t_{MSCC}$   | $(t_{MSCP}/2) - 4$ |      |      |       |                           |
| SM_CLK Driving Edge to SM_MOSI Valid            | $t_{MSOD}$   | -1                 |      | 2    |       | $C_{LOAD} = 40\text{ pF}$ |
| SM_MOSI Setup to SM_CLK Sampling Edge           | $t_{MSOS}$   | $(t_{MSCP}/2) - 4$ |      |      |       | $C_{LOAD} = 40\text{ pF}$ |
| SM_MOSI Hold Time to SM_CLK Sampling Edge       | $t_{MSOHD}$  | $(t_{MSCP}/2) - 4$ |      |      |       | $C_{LOAD} = 40\text{ pF}$ |
| SM_CS Hold Time after last SM_CLK Sampling Edge | $t_{MSCSHD}$ | $(t_{MSCP}/2) - 4$ |      |      |       |                           |
| SM_CS Pulse High                                | $t_{MSCSH}$  | $(t_{MSCP}/2) - 2$ |      |      |       |                           |

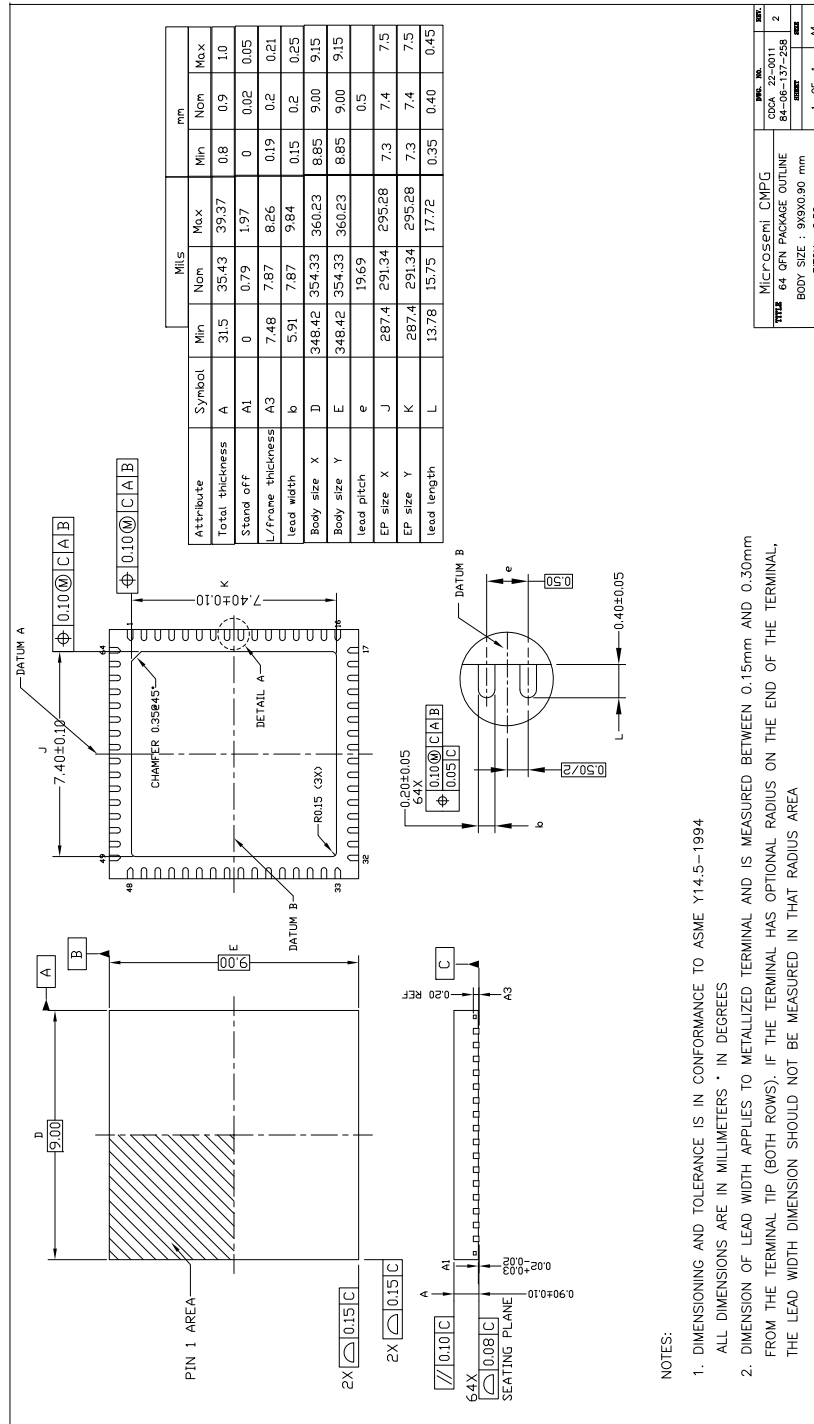
**Figure 44 • Master SPI Timing**



# 13 Package Outline Drawings

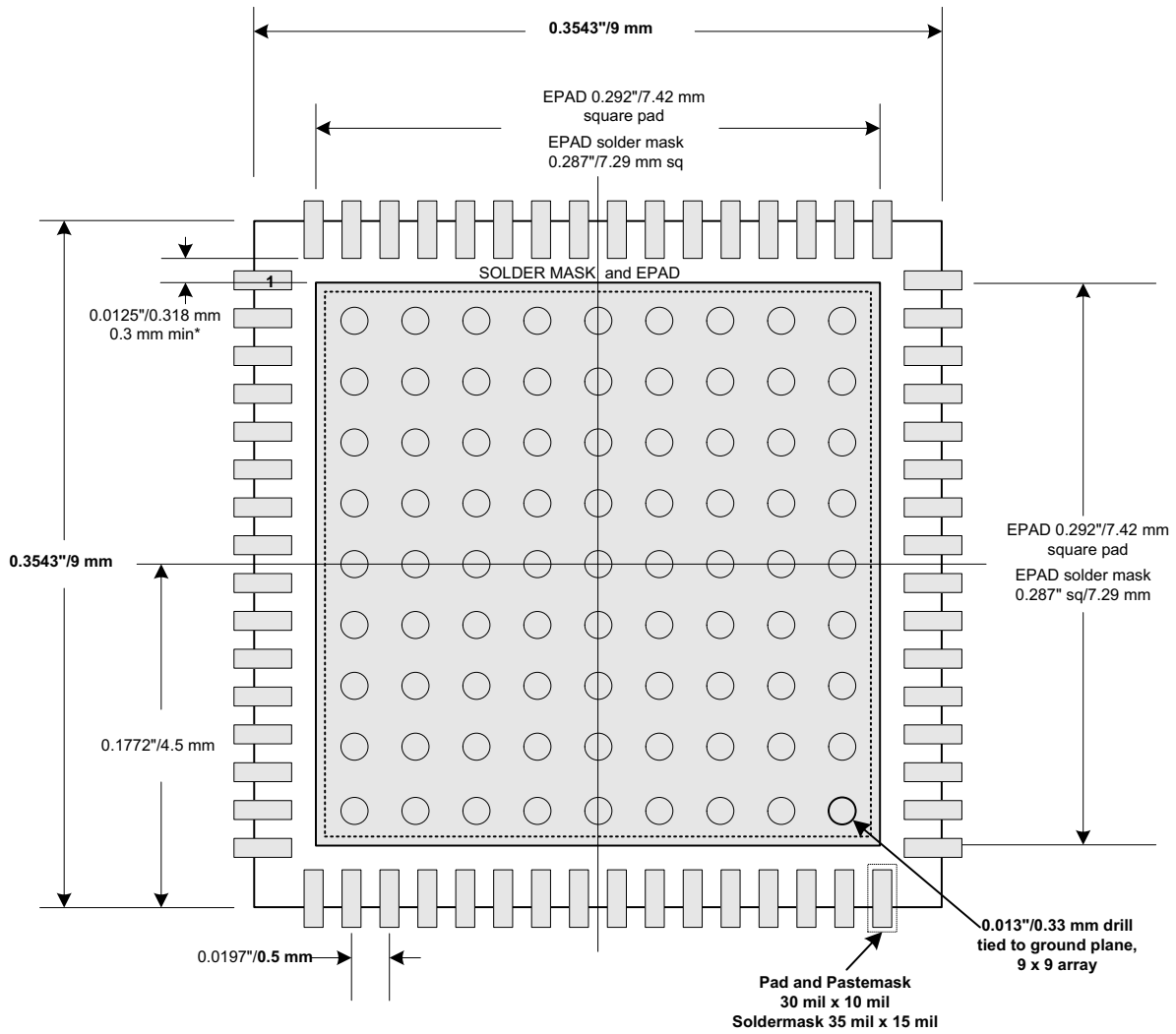
## 13.1 Package Drawings

Figure 45 • 64-Pin QFN



|                         |                        |        |      |
|-------------------------|------------------------|--------|------|
| MICROSEMI CMPG          |                        | REV.   | DATE |
| TITLE                   | 64 QFN PACKAGE OUTLINE | REV.   | DATE |
| BODY SIZE : 9x9x0.90 mm |                        | 1 OF 1 | AM   |
| PITCH : 0.50mm          |                        |        |      |

**Figure 46 • Recommended 64-Pin QFN Land Pattern – Top View**



**64-QFN  
9 mm x 9 mm, 0.5 mm pitch**

\* Minimum spacing between pins and epad must be 0.3 mm

Recommended EPAD configuration uses 0.292"/7.42 mm square pad tied to a ground plane with a 9 x 9 array of 0.013"/0.33 mm vias. This is necessary for good thermal performance.

Figure 47 • 56-Ball WLCSP

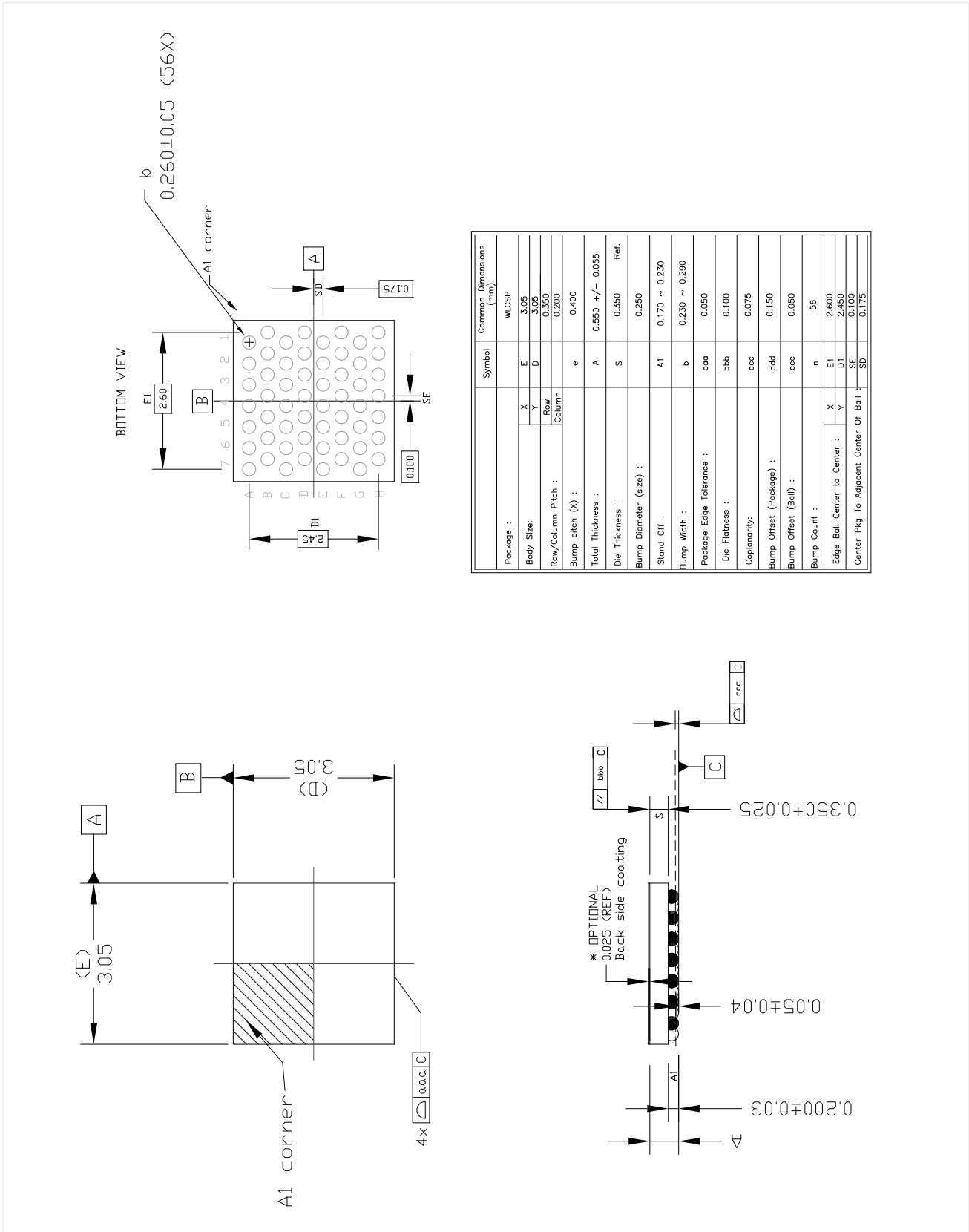
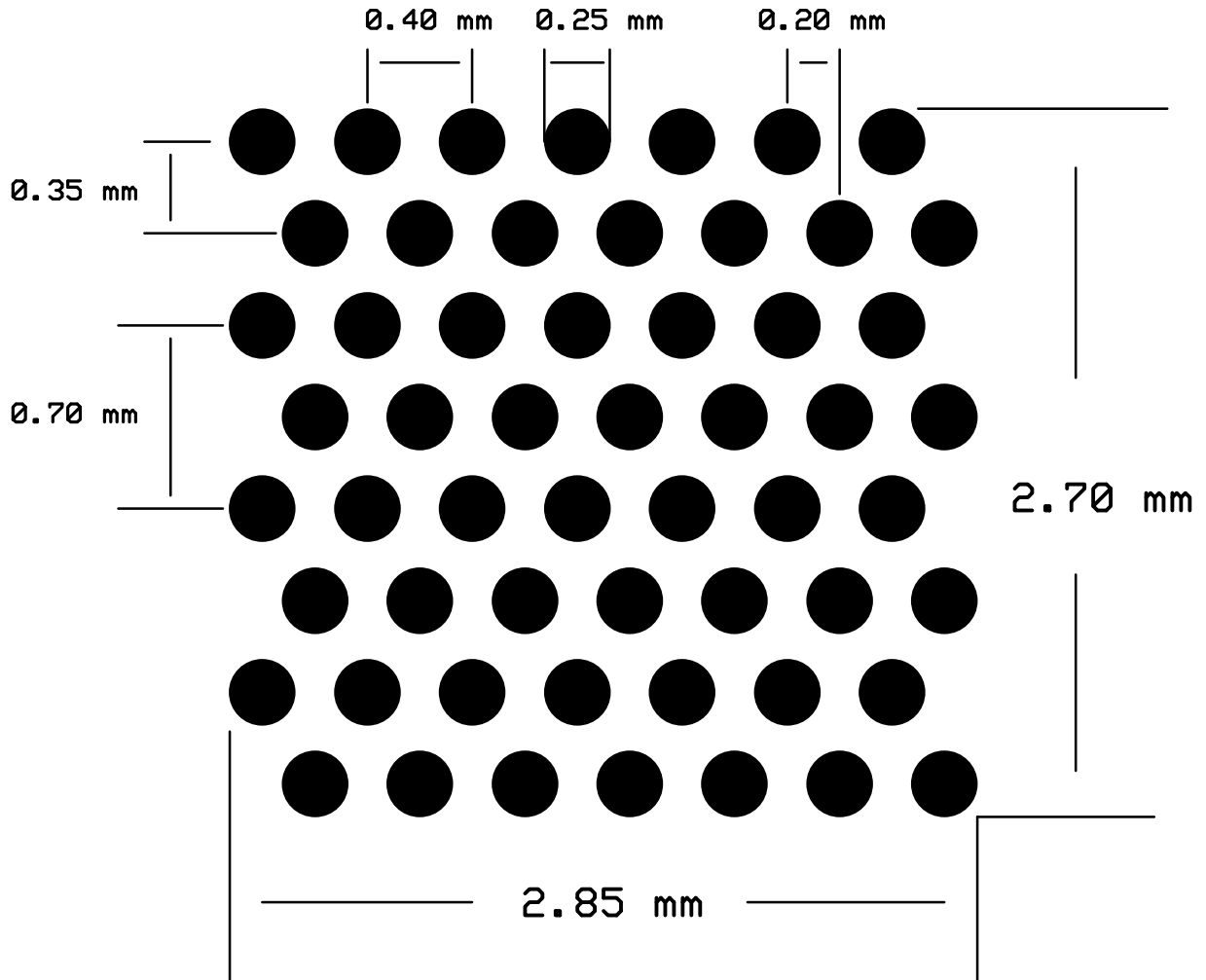


Figure 48 • 56-Ball WLCSP Staggered Balls Expanded Bottom View



Ball Diameter -- 0.25 mm

Pitch:

Horizontal -- 0.40 mm

Vertical -- 0.35 mm

