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TWO-CHANNEL HD AUDIO CODEC WITH MODEM & DUAL DIGITAL MICROPHONE INTERFACES

STAC9250/9251

DESCRIPTION

The STAC9250/9251 are high fidelity, 2-channel audio CODECs compliant with the High Definition Audio (HD Audio) specification defined by Intel. The STAC9250/9251 enables a two-chip audio and modem implementation by integrating the “System Side” functionality of Silicon Labs’ modem solution. The STAC9250/9251 provides a direct interface to Silicon Labs’ “Line Side” integrated circuit. This integration results in cost savings without sacrificing audio fidelity or modem functionality. The STAC9251 also implements a direct interface to two digital microphones, supporting advanced beam forming applications and resulting in increased quality of voice applications.

FEATURES

- **High-integration HD Audio Product**
 - 2-channel PC Audio CODEC
 - Modem “System-side” functionality¹
 - Dual Digital Microphone interface(STAC9251)
- **Two-Channel DACs and ADCs with 24-bit sample resolution**
 - High performance $\Sigma\Delta$ technology
 - Sample rates up to 192 KHz
 - 100dB DAC SNR

1. Modem functionality can only be used with a “Line Side” DAA integrated circuit, Si3080 or similar, available from Silicon Labs (www.silabs.com).

- **Integrated modem functionality from Silicon Labs¹ supports reduced BOM costs**
 - Interfaces directly to Line Side integrated circuit from Silicon Labs
 - Supports two-chip audio plus modem functionality
 - Supports Software modem implementations from Motorola and others compatible with the Silicon Labs chipset
 - Supports Motherboard implementations eliminating MDC card and connector costs
 - Reduced board space
 - Reduced external component count
- **Integrated Headphone Amps**
- **Stereo Analog Microphone**
 - Supports Stereo Microphone
 - Microphone Boost 0, 10, 20, 30, 40dB
- **S/PDIF In and Out**
- **Universal Jacks™ Functionality for jack retasking**
- **Adjustable VREF Out**
- **Digital PC Beep to all outputs**
- **48-pin LQFP Environmental Package**
- **Two-Channel High Definition Audio CODEC with Modem and Dual Digital Microphone Interfaces**

Table of Contents

1. DESCRIPTION	9
1.1. Overview	9
1.2. Features	9
1.3. Description	10
2. CHARACTERISTICS	11
2.1. Audio Fidelity	11
2.2. Electrical Specifications	11
2.3. STAC9250/9251 5V Analog Performance Characteristics	13
2.4. STAC9250/9251 4V Analog Performance Characteristics	14
2.5. STAC9250/9251 3.3V Analog Performance Characteristics	14
2.6. Power Consumption	15
3. DETAILED DESCRIPTION	16
3.1. SPDIF Input	16
3.2. SPDIF Output	16
3.3. Digital Microphone Support (STAC9251 only)	16
3.4. SiLabs System Side Modem	16
3.5. Mono Out	16
3.6. Headphone Drivers (Restrictions)	17
3.7. Universal Jacks™	17
4. FUNCTIONAL BLOCK DIAGRAMS	18
4.1. STAC9250	18
4.2. STAC9251	19
5. WIDGET INFORMATION	20
5.1. Widget Diagram - STAC9250	20
5.2. Widget Diagram - STAC9251	21
5.3. Widget List - STAC9250/9251	22
5.4. Root Node (NID = 0x00)	23
5.5. AFG Node (NID = 0x01)	24
5.6. DAC0Cnvtr Node (NID = 0x02)	39
5.7. ADC0Cnvtr Node (NID = 0x03)	43
5.8. SPDIFinCnvtr Node (NID = 0x04)	48
5.9. SPDIFoutCnvtr Node (NID = 0x05)	54
5.10. DAC0Mux Node (NID = 0x06)	59
5.11. DigInPin Node (NID = 0x07)	62
5.12. DigOutPin Node (NID = 0x08)	68
5.13. ADC0VolMux Node (NID = 0x09)	73
5.14. MasterVol Node (NID = 0x0E)	77
5.15. InPortMux Node (NID = 0x0F)	80
5.16. PortAPin Node (NID = 0x0A)	84
5.17. PortDPin Node (NID = 0x0D)	89
5.18. PortCPin Node (NID = 0x0C)	95
5.19. PortBPin Node (NID = 0x0B)	101
5.20. MonoOutPin Node (NID = 0x10)	107
5.21. CDPin Node (NID = 0x11)	112
5.22. MonoOutMix Node (NID = 0x12)	115
5.23. PCBeep Node (NID = 0x13)	117
5.24. ADC0InMux Node (NID = 0x14)	120
5.25. DigMicPin Node (NID = 0x15) (STAC9251 only)	125
6. ORDERING INFORMATION	129
6.1. STAC9250/9251 Family Options and Part Order Numbers	129
6.2. STAC9250/9251 Pin Diagram	130
6.3. Pin Table for STAC9250/9251	131
7. PACKAGE DRAWINGS	133

7.1. 48-Pin LQFP	133
8. SOLDER REFLOW PROFILE	134
8.1. Standard Reflow Profile Data	134
8.2. Pb Free Process - Package Classification Reflow Temperatures	135
9. REVISION HISTORY	136

List of Figures

Figure 1. STAC9250 Functional Block Diagram	18
Figure 2. STAC9250 Functional Block Diagram	19
Figure 3. STAC9250 Widget Diagram	20
Figure 4. STAC9251 Widget Diagram	21
Figure 5. STAC9250/9251 Pin Diagram	130
Figure 6. 48-Pin LQFP Package Outline and Package Dimensions	133
Figure 7. Solder Reflow Profile	134

List of Tables

Table 1. Digital Power Consumption	15
Table 2. 5V Analog Power Consumption	15
Table 3. High Definition Audio Widget	22
Table 4. Root PnpID Command Verb Format	23
Table 5. Root PnpID Command Response Format	23
Table 6. Root RevID Command Verb Format	23
Table 7. Root RevID Command Response Format	23
Table 8. Root NodeInfo Command Verb Format	24
Table 9. Root NodeInfo Command Response Format	24
Table 10. AFG Reset Command Verb Format	24
Table 11. AFG Reset Command Response Format	25
Table 12. AFG NodeInfo Command Verb Format	25
Table 13. AFG NodeInfo Command Response Format	25
Table 14. AFG Type Command Verb Format	26
Table 15. AFG Type Command Response Format	26
Table 16. AFG GrpCap Command Verb Format	26
Table 17. AFG GrpCap Command Response Format	26
Table 18. AFG FrmtCap Command Verb Format	27
Table 19. AFG FrmtCap Command Response Format	27
Table 20. AFG StreamCap Command Verb Format	28
Table 21. AFG StreamCap Command Response Format	28
Table 22. AFG PwrCap Command Verb Format	28
Table 23. AFG PwrCap Command Response Format	29
Table 24. AFG GPIOCap Command Verb Format	29
Table 25. AFG GPIOCap Command Response Format	30
Table 26. AFG OutAmpCap Command Verb Format	30
Table 27. AFG OutAmpCap Command Response Format	30
Table 28. AFG PwrState Command Verb Format	31
Table 29. AFG PwrState Command Response Format	31
Table 30. AFG UnsolResp Command Verb Format	31
Table 31. AFG UnsolResp Command Response Format	32
Table 32. AFG GPIO Command Verb Format	32

Table 33. AFG GPIO Command Response Format	32
Table 34. AFG GPIOEn Command Verb Format	33
Table 35. AFG GPIOEn Command Response Format	33
Table 36. AFG GPIODir Command Verb Format	34
Table 37. AFG GPIODir Command Response Format	34
Table 38. AFG GPIOWake Command Verb Format	35
Table 39. AFG GPIOWake Command Response Format	35
Table 40. AFG GPIOUnsolEn Command Verb Format	35
Table 41. AFG GPIOUnsolEn Command Response Format	36
Table 42. AFG GPIOSticky Command Verb Format	36
Table 43. AFG GPIOSticky Command Response Format	37
Table 44. AFG SysID Command Verb Format	37
Table 45. AFG SysID Command Response Format	38
Table 46. AFG DigMic (for STAC9251 only) Command Verb Format	38
Table 47. AFG DigMic (for STAC9251 only) Command Response Format	38
Table 48. DAC0Cnvtr Frmt Command Verb Format	39
Table 49. DAC0Cnvtr Frmt Command Response Format	39
Table 50. DAC0Cnvtr WCap Command Verb Format	40
Table 51. DAC0Cnvtr WCap Command Response Format	40
Table 52. DAC0Cnvtr PwrState Command Verb Format	41
Table 53. DAC0Cnvtr PwrState Command Response Format	41
Table 54. DAC0Cnvtr Stream Command Verb Format	42
Table 55. DAC0Cnvtr Stream Command Response Format	42
Table 56. ADC0Cnvtr Frmt Command Verb Format	43
Table 57. ADC0Cnvtr Frmt Command Response Format	43
Table 58. ADC0Cnvtr WCap Command Verb Format	44
Table 59. ADC0Cnvtr WCap Command Response Format	44
Table 60. ADC0Cnvtr ConnLen Command Verb Format	45
Table 61. ADC0Cnvtr ConnLen Command Response Format	45
Table 62. ADC0Cnvtr ConnLst Command Verb Format	46
Table 63. ADC0Cnvtr ConnLst Command Response Format	46
Table 64. ADC0Cnvtr ProcState Command Verb Format	46
Table 65. ADC0Cnvtr ProcState Command Response Format	46
Table 66. ADC0Cnvtr PwrState Command Verb Format	47
Table 67. ADC0Cnvtr PwrState Command Response Format	47
Table 68. ADC0Cnvtr Stream Command Verb Format	47
Table 69. ADC0Cnvtr Stream Command Response Format	47
Table 70. SPDIFinCnvtr Frmt Command Verb Format	48
Table 71. SPDIFinCnvtr Frmt Command Response Format	48
Table 72. SPDIFinCnvtr WCap Command Verb Format	49
Table 73. SPDIFinCnvtr WCap Command Response Format	49
Table 74. SPDIFinCnvtr FrmtCap Command Verb Format	50
Table 75. SPDIFinCnvtr FrmtCap Command Response Format	50
Table 76. SPDIFinCnvtr StreamCap Command Verb Format	51
Table 77. SPDIFinCnvtr StreamCap Command Response Format	52
Table 78. SPDIFinCnvtr ConnLen Command Verb Format	52
Table 79. SPDIFinCnvtr ConnLen Command Response Format	52
Table 80. SPDIFinCnvtr ConnLst Command Verb Format	52
Table 81. SPDIFinCnvtr ConnLst Command Response Format	53
Table 82. SPDIFinCnvtr Stream Command Verb Format	53
Table 83. SPDIFinCnvtr Stream Command Response Format	53
Table 84. SPDIFinCnvtr DigCtl Command Verb Format	53
Table 85. SPDIFinCnvtr DigCtl Command Response Format	54
Table 86. SPDIFoutCnvtr Frmt Command Verb Format	54
Table 87. SPDIFoutCnvtr Frmt Command Response Format	55

Table 88. SPDIFoutCnvtr WCap Command Verb Format	56
Table 89. SPDIFoutCnvtr WCap Command Response Format	56
Table 90. SPDIFoutCnvtr FrmtCap Command Verb Format	57
Table 91. SPDIFoutCnvtr FrmtCap Command Response Format	57
Table 92. SPDIFoutCnvtr StreamCap Command Verb Format	58
Table 93. SPDIFoutCnvtr StreamCap Command Response Format	58
Table 94. SPDIFoutCnvtr Stream Command Verb Format	58
Table 95. SPDIFoutCnvtr Stream Command Response Format	58
Table 96. SPDIFoutCnvtr DigCtl Command Verb Format	59
Table 97. SPDIFoutCnvtr DigCtl Command Response Format	59
Table 98. DAC0Mux WCap Command Verb Format	59
Table 99. DAC0Mux WCap Command Response Format	60
Table 100. DAC0Mux ConnLen Command Verb Format	60
Table 101. DAC0Mux ConnLen Command Response Format	61
Table 102. DAC0Mux ConnSel Command Verb Format	61
Table 103. DAC0Mux ConnSel Command Response Format	61
Table 104. DAC0Mux ConnLst Command Verb Format	61
Table 105. DAC0Mux ConnLst Command Response Format	61
Table 106. DAC0Mux LR Command Verb Format	62
Table 107. DAC0Mux LR Command Response Format	62
Table 108. DigInPin WCap Command Verb Format	62
Table 109. DigInPin WCap Command Response Format	63
Table 110. DigInPin Cap Command Verb Format	63
Table 111. DigInPin Cap Command Response Format	64
Table 112. DigInPin PwrState Command Verb Format	64
Table 113. DigInPin PwrState Command Response Format	64
Table 114. DigInPin Ctl Command Verb Format	65
Table 115. DigInPin Ctl Command Response Format	65
Table 116. DigInPin UnsolResp Command Verb Format	65
Table 117. DigInPin UnsolResp Command Response Format	66
Table 118. DigInPin Sense Command Verb Format	66
Table 119. DigInPin Sense Command Response Format	66
Table 120. DigInPin EAPD Command Verb Format	67
Table 121. DigInPin EAPD Command Response Format	67
Table 122. DigInPin Config Command Verb Format	67
Table 123. DigInPin Config Command Response Format	68
Table 124. DigOutPin WCap Command Verb Format	68
Table 125. DigOutPin WCap Command Response Format	68
Table 126. DigOutPin Cap Command Verb Format	69
Table 127. DigOutPin Cap Command Response Format	69
Table 128. DigOutPin ConnLen Command Verb Format	70
Table 129. DigOutPin ConnLen Command Response Format	70
Table 130. DigOutPin ConnSel Command Verb Format	71
Table 131. DigOutPin ConnSel Command Response Format	71
Table 132. DigOutPin ConnLst Command Verb Format	71
Table 133. DigOutPin ConnLst Command Response Format	71
Table 134. DigOutPin Ctl Command Verb Format	72
Table 135. DigOutPin Ctl Command Response Format	72
Table 136. DigOutPin Config Command Verb Format	72
Table 137. DigOutPin Config Command Response Format	72
Table 138. ADC0VolMux VolRight Command Verb Format	73
Table 139. ADC0VolMux VolRight Command Response Format	73
Table 140. ADC0VolMux VolLeft Command Verb Format	74
Table 141. ADC0VolMux VolLeft Command Response Format	74
Table 142. ADC0VolMux WCap Command Verb Format	74

Table 143. ADC0VolMux WCap Command Response Format	74
Table 144. ADC0VolMux OutAmpCap Command Verb Format	75
Table 145. ADC0VolMux OutAmpCap Command Response Format	75
Table 146. ADC0VolMux ConnLen Command Verb Format	76
Table 147. ADC0VolMux ConnLen Command Response Format	76
Table 148. ADC0VolMux ConnLst Command Verb Format	76
Table 149. ADC0VolMux ConnLst Command Response Format	76
Table 150. MasterVol Right Command Verb Format	77
Table 151. MasterVol Right Command Response Format	77
Table 152. MasterVol Left Command Verb Format	77
Table 153. MasterVol Left Command Response Format	77
Table 154. MasterVol WCap Command Verb Format	78
Table 155. MasterVol WCap Command Response Format	78
Table 156. MasterVol ConnLen Command Verb Format	79
Table 157. MasterVol ConnLen Command Response Format	79
Table 158. MasterVol ConnLst Command Verb Format	79
Table 159. MasterVol ConnLst Command Response Format	79
Table 160. InPortMux VolRight Command Verb Format	80
Table 161. InPortMux VolRight Command Response Format	80
Table 162. InPortMux VolLeft Command Verb Format	80
Table 163. InPortMux VolLeft Command Response Format	80
Table 164. InPortMux WCap Command Verb Format	80
Table 165. InPortMux WCap Command Response Format	81
Table 166. InPortMux ConnLen Command Verb Format	81
Table 167. InPortMux ConnLen Command Response Format	82
Table 168. InPortMux AmpCap Command Verb Format	82
Table 169. InPortMux AmpCap Command Response Format	82
Table 170. InPortMux ConnSel Command Verb Format	83
Table 171. InPortMux ConnSel Command Response Format	83
Table 172. InPortMux ConnLst0 Command Verb Format	83
Table 173. InPortMux ConnLst0 Command Response Format	83
Table 174. InPortMux ConnLst4 Command Verb Format	83
Table 175. InPortMux ConnLst4 Command Response Format	84
Table 176. PortAPin WCap Command Verb Format	84
Table 177. PortAPin WCap Command Response Format	84
Table 178. PortAPin Cap Command Verb Format	85
Table 179. PortAPin Cap Command Response Format	85
Table 180. PortAPin ConnLen Command Verb Format	86
Table 181. PortAPin ConnLen Command Response Format	86
Table 182. PortAPin ConnLst Command Verb Format	86
Table 183. PortAPin ConnLst Command Response Format	86
Table 184. PortAPin Ctl Command Verb Format	87
Table 185. PortAPin Ctl Command Response Format	87
Table 186. PortAPin UnsolResp Command Verb Format	87
Table 187. PortAPin UnsolResp Command Response Format	87
Table 188. PortAPin Sense Command Verb Format	88
Table 189. PortAPin Sense Command Response Format	88
Table 190. PortAPin Config Command Verb Format	89
Table 191. PortAPin Config Command Response Format	89
Table 192. PortDPin WCap Command Verb Format	90
Table 193. PortDPin WCap Command Response Format	90
Table 194. PortDPin Cap Command Verb Format	91
Table 195. PortDPin Cap Command Response Format	91
Table 196. PortDPin ConnLen Command Verb Format	91
Table 197. PortDPin ConnLen Command Response Format	92

Table 198. PortDPin ConnLst Command Verb Format	92
Table 199. PortDPin ConnLst Command Response Format	92
Table 200. PortDPin Ctl Command Verb Format	92
Table 201. PortDPin Ctl Command Response Format	93
Table 202. PortDPin UnsolResp Command Verb Format	93
Table 203. PortDPin UnsolResp Command Response Format	93
Table 204. PortDPin Sense Command Verb Format	94
Table 205. PortDPin Sense Command Response Format	94
Table 206. PortDPin Config Command Verb Format	94
Table 207. PortDPin Config Command Response Format	95
Table 208. PortCPin WCap Command Verb Format	95
Table 209. PortCPin WCap Command Response Format	95
Table 210. PortCPin Cap Command Verb Format	96
Table 211. PortCPin Cap Command Response Format	96
Table 212. PortCPin ConnLen Command Verb Format	97
Table 213. PortCPin ConnLen Command Response Format	97
Table 214. PortCPin ConnLst Command Verb Format	98
Table 215. PortCPin ConnLst Command Response Format	98
Table 216. PortCPin Ctl Command Verb Format	98
Table 217. PortCPin Ctl Command Response Format	98
Table 218. PortCPin UnsolResp Command Verb Format	99
Table 219. PortCPin UnsolResp Command Response Format	99
Table 220. PortCPin Sense Command Verb Format	100
Table 221. PortCPin Sense Command Response Format	100
Table 222. PortCPin Config Command Verb Format	100
Table 223. PortCPin Config Command Response Format	101
Table 224. PortBPin WCap Command Verb Format	101
Table 225. PortBPin WCap Command Response Format	101
Table 226. PortBPin Cap Command Verb Format	102
Table 227. PortBPin Cap Command Response Format	102
Table 228. PortBPin ConnLen Command Verb Format	103
Table 229. PortBPin ConnLen Command Response Format	103
Table 230. PortBPin ConnLst Command Verb Format	104
Table 231. PortBPin ConnLst Command Response Format	104
Table 232. PortBPin Ctl Command Verb Format	104
Table 233. PortBPin Ctl Command Response Format	104
Table 234. PortBPin UnsolResp Command Verb Format	105
Table 235. PortBPin UnsolResp Command Response Format	105
Table 236. PortBPin Sense Command Verb Format	106
Table 237. PortBPin Sense Command Response Format	106
Table 238. PortBPin Config Command Verb Format	106
Table 239. PortBPin Config Command Response Format	107
Table 240. MonoOutPin Vol Command Verb Format	107
Table 241. MonoOutPin Vol Command Response Format	107
Table 242. MonoOutPin WCap Command Verb Format	108
Table 243. MonoOutPin WCap Command Response Format	108
Table 244. MonoOutPin Cap Command Verb Format	109
Table 245. MonoOutPin Cap Command Response Format	109
Table 246. MonoOutPin ConnLen Command Verb Format	110
Table 247. MonoOutPin ConnLen Command Response Format	110
Table 248. MonoOutPin ConnLst Command Verb Format	110
Table 249. MonoOutPin ConnLst Command Response Format	110
Table 250. MonoOutPin Ctl Command Verb Format	111
Table 251. MonoOutPin Ctl Command Response Format	111
Table 252. MonoOutPin Config Command Verb Format	111

Table 253. MonoOutPin Config Command Response Format	111
Table 254. CDPin WCap Command Verb Format	112
Table 255. CDPin WCap Command Response Format	112
Table 256. CDPin Cap Command Verb Format	113
Table 257. CDPin Cap Command Response Format	113
Table 258. CDPin Ctl Command Verb Format	114
Table 259. CDPin Ctl Command Response Format	114
Table 260. CDPin Config Command Verb Format	114
Table 261. CDPin Config Command Response Format	115
Table 262. MonoOutMix WCap Command Verb Format	115
Table 263. MonoOutMix WCap Command Response Format	116
Table 264. MonoOutMix ConnLen Command Verb Format	116
Table 265. MonoOutMix ConnLen Command Response Format	117
Table 266. MonoOutMix ConnLst Command Verb Format	117
Table 267. MonoOutMix ConnLst Command Response Format	117
Table 268. PCBeep Vol Command Verb Format	117
Table 269. PCBeep Vol Command Response Format	118
Table 270. PCBeep WCap Command Verb Format	118
Table 271. PCBeep WCap Command Response Format	118
Table 272. PCBeep OutAmpCap Command Verb Format	119
Table 273. PCBeep OutAmpCap Command Response Format	119
Table 274. PCBeep Gen Command Verb Format	119
Table 275. PCBeep Gen Command Response Format	120
Table 276. ADC0InMux WCap Command Verb Format	120
Table 277. ADC0InMux WCap Command Response Format	120
Table 278. ADC0InMux ConnLen Command Verb Format	121
Table 279. ADC0InMux ConnLen Command Response Format	121
Table 280. ADC0InMux ConnSel Command Verb Format	122
Table 281. ADC0InMux ConnSel Command Response Format	122
Table 282. ADC0InMux ConnLst Command Verb Format	122
Table 283. ADC0InMux ConnLst Command Response Format	122
Table 284. ADC0InMux LR Command Verb Format	123
Table 285. ADC0InMux LR Command Response Format	123
Table 286. ADC0InMux OutAmpCap Command Verb Format	123
Table 287. ADC0InMux OutAmpCap Command Response Format	123
Table 288. ADC0InMux VolRight Command Verb Format	124
Table 289. ADC0InMux VolRight Command Response Format	124
Table 290. ADC0InMux VolLeft Command Verb Format	124
Table 291. ADC0InMux VolLeft Command Response Format	124
Table 292. DigMicPin WCap (for STAC9251 only) Command Verb Format	125
Table 293. DigMicPin WCap (for STAC9251 only) Command Response Format	125
Table 294. DigMicPin Cap (for STAC9251 only) Command Verb Format	126
Table 295. DigMicPin Cap (for STAC9251 only) Command Response Format	126
Table 296. DigMicPin Ctl (for STAC9251 only) Command Verb Format	127
Table 297. DigMicPin Ctl (for STAC9251 only) Command Response Format	127
Table 298. DigMicPin Config (for STAC9251 only) Command Verb Format	127
Table 299. DigMicPin Config (for STAC9251 only) Command Response Format	127
Table 300. STAC9250/9251 Ordering Information	129

1. DESCRIPTION

1.1. Overview

The STAC9250/9251 are high fidelity, 2-channel audio CODECs compliant with the High Definition Audio (HD Audio) specification defined by Intel. The STAC9250/9251 enables a two-chip audio and modem implementation by integrating the “System Side” functionality of Silicon Labs’ modem solution. The STAC9250/9251 provides a direct interface to Silicon Labs’ “Line Side” integrated circuit. This integration results in cost savings without sacrificing audio fidelity or modem functionality. The STAC9251 also implements a direct interface to two digital microphones supporting advanced beam forming applications resulting in increased quality of voice applications.

1.2. Features

- High-integration HD Audio Product
 - 2-channel PC Audio CODEC
 - Modem “System-side” functionality¹
 - Dual Digital Microphone interface (STAC9251)
- Two-Channel DACs and ADCs with 24-bit sample resolution
 - High performance $\Sigma\Delta$ technology
 - Sample rates up to 192 KHz
 - 100dB DAC SNR
- Integrated modem functionality from Silicon Labs¹ supports reduced BOM costs
 - Interfaces directly to Line Side integrated circuit from Silicon Labs
 - Supports two-chip audio plus modem functionality
 - Supports software modem implementations from Motorola and others compatible with the Silicon Labs chipset
 - Supports motherboard implementations eliminating MDC card and connector costs
 - Reduced board space
 - Reduced external component count
- Integrated Headphone Amps
- Stereo Analog Microphone
 - Supports Stereo Microphone
 - Microphone Boost 0, 10, 20, 30, 40dB
- Dual Digital Microphone Interface optimized for use with Akustica Digital Microphones. (STAC9251 only)
- S/PDIF In and Out
- Universal Jacks™ Functionality for jack retasking
- Adjustable VREF Out
- Digital PC BEEP to all outputs
- 48-pin LQFP Environmental Package

1. Modem functionality can only be used with a “Line Side” DAA integrated circuit, Si3080 or similar, available from Silicon Labs (www.silabs.com).

1.3. Description

The STAC9250/9251 are high fidelity, 2-channel audio CODECs compatible with the Intel High Definition (HD) Audio Interface. The STAC9250/9251 provide high quality, HD Audio capability to notebook and cost sensitive desktop PC applications.

The STAC9250/9251 incorporate IDT's proprietary $\Sigma\Delta$ technology to achieve a DAC SNR of 100dB. The higher performance and quality of IDT's audio solutions brings consumer electronics level performance to the notebook, desktop and media center PC.

The STAC9250/9251 provide stereo 24-bit, full duplex resolution supporting sample rates up to 192 KHz by the DAC and ADC. The STAC9250/9251 SPDIF In/Out support sample rates of 96 KHz, 48 KHz and 44.1 KHz plus SPDIF_OUT supports 88.2 KHz. Additional sample rates are supported by the driver software.

The STAC9250/9251 supports flexible configurations including switchable Headphone Out and Universal Jacks™ functionality for jack detection and re-tasking. The SPDIF interface provides connectivity to Consumer Electronic equipment like Dolby Digital decoders, powered speakers, mini-disk drives or to a home entertainment system. All analog I/O pairs support LINE_IN, LINE_OUT and MIC.

MIC inputs can be programmed with 0/10/20/30/40dB boost. For more advanced configurations, the STAC9250/9251 have four General Purpose I/O (GPIO) pins. The STAC9250/9251 also provide a single ended CD input for compatibility with DRM solutions and to support legacy OS issues.

The STAC9250/9251 integrate a headphone amplifier, which is available on Ports A and D. The headphone amplifier is switchable between these two outputs for increased flexibility, enhanced user experience, and reduced implementation costs.

The Universal Jack capabilities allow the CODECs to detect when audio devices are connected, and allow the CODECs to be reconfigured to support these devices regardless of which port they are connected to. SPDIF input sensing is also supported. The fully parametric IDT SoftEQ can be initiated upon headphone jack insertion and removal for protection of notebook speakers.

Note: The Jack Detect circuit and component selection are critical for accurate detection of audio jacks on individual ports. Please see the IDT STAC9250/9251 reference design for circuit implementation details.

The STAC9250/9251 operate with a 3.3 V digital supply and a 3.3 V, 4 V, and 5 V analog supply.

The STAC9250/9251 are available in a 48-pin LQFP Environmental (ROHS) package.

2. CHARACTERISTICS

2.1. Audio Fidelity

DAC SNR: 100dB

ADC SNR: 90dB

2.2. Electrical Specifications

2.2.1. Absolute Maximum Ratings

Stresses above the ratings listed below can cause permanent damage to the STAC9250/9251. These ratings, which are standard values for IDT commercially rated parts, are stress ratings only. Functional operation of the device at these or any other conditions above those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods can affect product reliability. Electrical parameters are guaranteed only over the recommended operating temperature range.

Item	Pin	Maximum Rating
Analog maximum supply voltage	AVdd	6 Volts
Digital maximum supply voltage	DVdd	5.5 Volts
VREFOUT output current		5 mA
Voltage on any pin relative to ground		Vss - 0.3 V to Vdd + 0.3 V
Operating temperature		0°C to +70°C
Storage temperature		-55 °C to +125 °C
Soldering temperature		260 °C for 10 seconds * Soldering temperature information for all available packages begins on page 134.

2.2.2. Recommended Operation Conditions

Parameter		Min.	Typ.	Max.	Units
Power Supply Voltage	Digital - 3.3 V	3.135	3.3	3.465	V
	Analog - 3.3 V	3.135	3.3	3.465	V
(Note: The +4 V Analog voltage is supported by the +5 V version of the STAC9250/9251.)	Analog - 4 V	3.8	4	4.2	V
	Analog - 5 V	4.75	5	5.25	V
Ambient Operating Temperature		0		+70	°C
Case Temperature	T _{case} (48-LQFP)			+90	°C

ESD: The STAC9250/9251 is an ESD (electrostatic discharge) sensitive device. The human body and test equipment can accumulate and discharge electrostatic charges up to 4000 Volts without detection. Even though the STAC9250/9251 implements internal ESD protection circuitry, proper ESD precautions should be followed to avoid damaging the functionality or performance.

2.3. STAC9250/9251 5V Analog Performance Characteristics

($T_{\text{ambient}} = 25\text{ }^{\circ}\text{C}$, $AV_{\text{dd}} = 5.0\text{ V} \pm 5\%$, $DV_{\text{dd}} = 3.3\text{ V} \pm 5\%$, $AV_{\text{ss}} = DV_{\text{ss}} = 0\text{ V}$; 1 KHz input sine wave; Sample Frequency = 48 KHz; 0dB = 1 VRMS, 10 K Ω / 50 pF load, Testbench Characterization BW: 20 Hz – 20 KHz, 0dB settings on all gain stages)

Min and Max performance targets are not included here, as specific system characteristics, such as layout, routing and external CODEC component selection, influence the performance of the CODEC. To receive min/max levels for your system, please send us a unit and IDT will perform a full audio test suite and provide you with the results. Contact IDT for more information.

Parameter	Min	Typ	Max	Unit
Full Scale Input Voltage:				
All Analog Inputs with out boost	-	1.00	-	Vrms
All Analog Inputs with boost (Note 1)	-	0.03	-	Vrms
Full Scale Output:				
PCM (DAC) to All Analog Outputs	-	1.00	-	Vrms
HEADPHONE_OUT (32 Ω load) per channel (peak)	-	50	-	mW
Dynamic Range: -60dB signal level (Note 2)				
PCM to All Analog Outputs	-	99	-	dB
All Analog Inputs to A/D (1 VRMS Input Referenced)	-	88	-	dB
Analog Frequency Response (Note 3)	10	-	30,000	Hz
Total Harmonic Distortion + Noise (-3dB): (Note 4)				
PCM to All Analog Outputs	-	-90	-	dB
All Analog Inputs to A/D (-3dBV input Level)	-	-87	-	dB
HEADPHONE_OUT (32 Ω load)	-	-87	-	dB
HEADPHONE_OUT (10 K Ω load)	-	-90	-	dB
SNR (idle channel) (Note 5)				
DAC to All Analog Outputs	-	100	-	dB
All Analog Inputs to A/D with High Pass Filter enabled	-	89	-	dB
A/D & D/A Digital Filter Pass Band (Note 6)	20	-	19,200	Hz
A/D & D/A Digital Filter Transition Band	19,200	-	28,800	Hz
A/D & D/A Digital Filter Stop Band	28,800	-	-	Hz
A/D & D/A Digital Filter Stop Band Rejection (Note 7)	-100	-	-	dB
DAC Out-of-Band Rejection (Note 8)	-55	-	-	dB
Group Delay (48 KHz sample rate)	-	-	1	ms
Power Supply Rejection Ratio (1 KHz)	-	-70	-	dB
Power Supply Rejection Ratio (20 KHz)	-	-40	-	dB
Any Analog Input to ADC (10 KHz Signal Frequency) Crosstalk	-	-90	-	dB
Any Analog Input to ADC (1 KHz Signal Frequency) Crosstalk	-	-90	-	dB
Spurious Tone Rejection	-	-100	-	dB

Parameter	Min	Typ	Max	Unit
Attenuation, Gain Step Size ANALOG	-	1.5	-	dB
Attenuation, Gain Step Size DIGITAL	-	0.75	-	dB
Input Impedance	-	50	-	K Ω
Input Capacitance	-	15	-	pF
VREFout	-	0.5 X AVdd	-	V
VREF	-	0.45 X AVdd	0.5	V
Interchannel Gain Mismatch ADC	-	-	0.5	dB
Interchannel Gain Mismatch DAC	-	-	-	dB
Gain Drift	-	100	-	ppm/ $^{\circ}$ C
DAC Offset Voltage	-	5	10	mV
Deviation from Linear Phase	-	10	1	deg.
All Analog Outputs Load Resistance	-	10	-	K Ω
All Analog Outputs Load Capacitance	-	-	50	pF
HEADPHONE_OUT Load Resistance	-	32	-	Ω
HEADPHONE_OUT Load Capacitance	-	100	-	pF
Mute Attenuation	-	-	-	dB
PLL lock time	-	96	200	μ sec
PLL (or HD Audio Bit CLK) 24.576 MHz clock jitter	-	100	300	psec

1. With +30dB Boost on, 1.00 Vrms with Boost off.
2. Ratio of Full Scale signal to noise output with -60dB signal, measured "A weighted" over a 20 Hz to a 20 KHz bandwidth.
3. \pm 1dB limits for Line Output & 0dB gain, at -20dBV
4. Amplitude of THD+N, measured with A-weighting filter, over 20 Hz to 20 KHz bandwidth.
5. Ratio of Full Scale signal to idle channel noise output is measured "A weighted" over a 20 Hz to a 20 KHz bandwidth. (AES17-1991 Idle Channel Noise or EIAJ CP-307 Signal-to-noise Ratio).
6. Peak-to-Peak Ripple over Passband meets \pm 0.25dB limits, 48 KHz Sample Frequency.
7. Stop Band rejection determines filter requirements. Out-of-Band rejection determines audible noise.
8. The integrated Out-of-Band noise generated by the DAC process, during normal PCM audio playback, over a bandwidth 28.8 to 100 KHz, with respect to a 1 Vrms DAC output.

2.4. STAC9250/9251 4V Analog Performance Characteristics

If you are interested in using the STAC9250/9251 at 4V Analog, please contact IDT for more information.

2.5. STAC9250/9251 3.3V Analog Performance Characteristics

If you are interested in using the STAC9250/9251 at 3.3V Analog, please contact IDT for more information.

2.6. Power Consumption

2.6.1. Digital

Audio Power State	Modem Power State	Typical	Max	units
D0	D0 INIT	41	43	mA
D1	D0 UN INIT	28	29	mA
D2	D3 HOT	34	36	mA
D3	D3 COLD	27	28	mA

Table 1. Digital Power Consumption

2.6.2. 5V Analog

Audio Power State	Modem Power State	Typical	Max	units
D0	D0 INIT	30	36	mA
D1	D0 UN INIT	12	26	mA
D2	D3 HOT	12	26	mA
D3	D3 COLD	11	26	mA

Table 2. 5V Analog Power Consumption

3. DETAILED DESCRIPTION

3.1. SPDIF Input

SPDIF IN can operate at 44.1 KHz or 96 KHz, and implements internal Jack Sensing. A sophisticated digital PLL allows automatic rate detection and accurate data recovery. The ability to directly accept consumer SPDIF voltage levels eliminates the need for costly external receiver ICs. Advanced features such as record slot select and SPDIF_IN routing to the DAC allows for simultaneous record and play.

3.2. SPDIF Output

SPDIF OUT can operate at 44.1 KHz, 48 KHz, 88.2 KHz, and 96 KHz, as defined in the Intel High Definition Audio Specification, with resolutions up to 24 bits. This insures compatibility with all consumer audio gear and allows for convenient integration into home theater systems and media center PCs.

3.3. Digital Microphone Support (STAC9251 only)

The STAC9251 has a three-pin digital microphone interface that accepts high-rate, single-bit data streams from two digital microphones. Each microphone requires only one data line. Both microphones share a single clock line. This robust digital interface gives designers the flexibility to place the microphones in the optimum location on a system (such as along the top of the screen bezel) and use a simple, 3-wire ribbon cable to directly connect the microphones to the STAC9251 CODEC.

3.4. SiLabs System Side Modem

A licensed Silicon Labs System Side modem based on the Si3054 architecture is integrated into STAC9250/9251. Combined with a Silicon Labs Line Side IC (Si3080 or similar), the STAC9250/9251 allows designers to implement a two-chip HD Audio and HD Modem solution for significant cost and board space savings.

3.5. Mono Out

The MONO Output is connected to pin 37 and has independent volume and mute control (see the Widget listing for details). The MONO Output derives its input from the output of the summing node that drives PORT A and PORT D. The following analog signals feed the summing amplifier that feeds the MONO Out summing amplifier:

- DAC Output: When enabled, both DAC Outputs are summed together.
- Analog PC Beep: Source from Pin 12
- ADC Input: Stereo analog feed into the stereo ADC input.

The combination of the stereo channels from DAC are combined into a single analog signal with a -6dB degradation in signal strength.

3.6. Headphone Drivers (Restrictions)

It is not recommended that users operate both Port A and Port D as headphone drivers simultaneously. Using both ports as headphone drivers degrades the signal quality of both outputs.¹

Note: 1) Headphone capabilities are on Port A (pins 39/41) and Port D (pins 35/36). Do NOT put headphone loads on both sets of pins at the same time.

3.7. Universal Jacks™

IDT's Universal Jacks™ technology allows for flexibility in board design and implementation.

On the STAC9250/9251, only one function can be selected at a time. A set of pins cannot be set as input and output at the same time. However, the selected function can be changed at any time.

For the STAC9250/9251, the Universal Jacks capabilities are as follows

- All of the STAC9250/9251 ports support:
 - Line Out
 - Line In
 - Mic with 0/10/20/30/40² dB Mic Boost
- Ports A and D also support:
 - Headphone Out¹

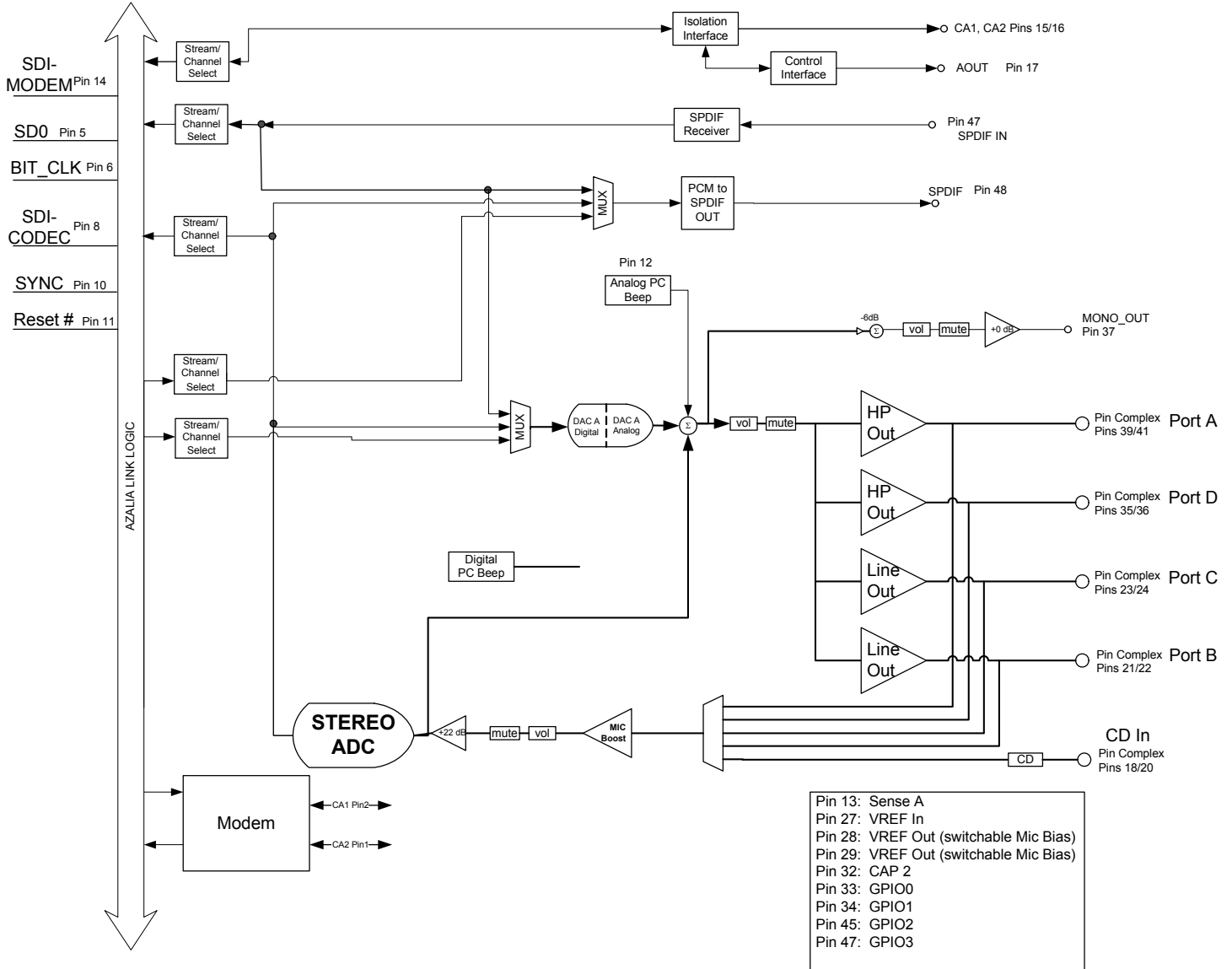
Note: 1) Headphone capabilities are on Port A (pins 39/41) and Port D (pins 35/36). Do NOT put headphone loads on both sets of pins at the same time.

Note: 2) When the 40dB mic boost feature is enabled, additional gain increases greater than 6dB may result in significant audio quality degradation of the microphone audio input. In particular, when the 40dB MIC boost is active, the SNR, THD+N and DC offset will significantly degrade regardless of the input signal level.

4. FUNCTIONAL BLOCK DIAGRAMS

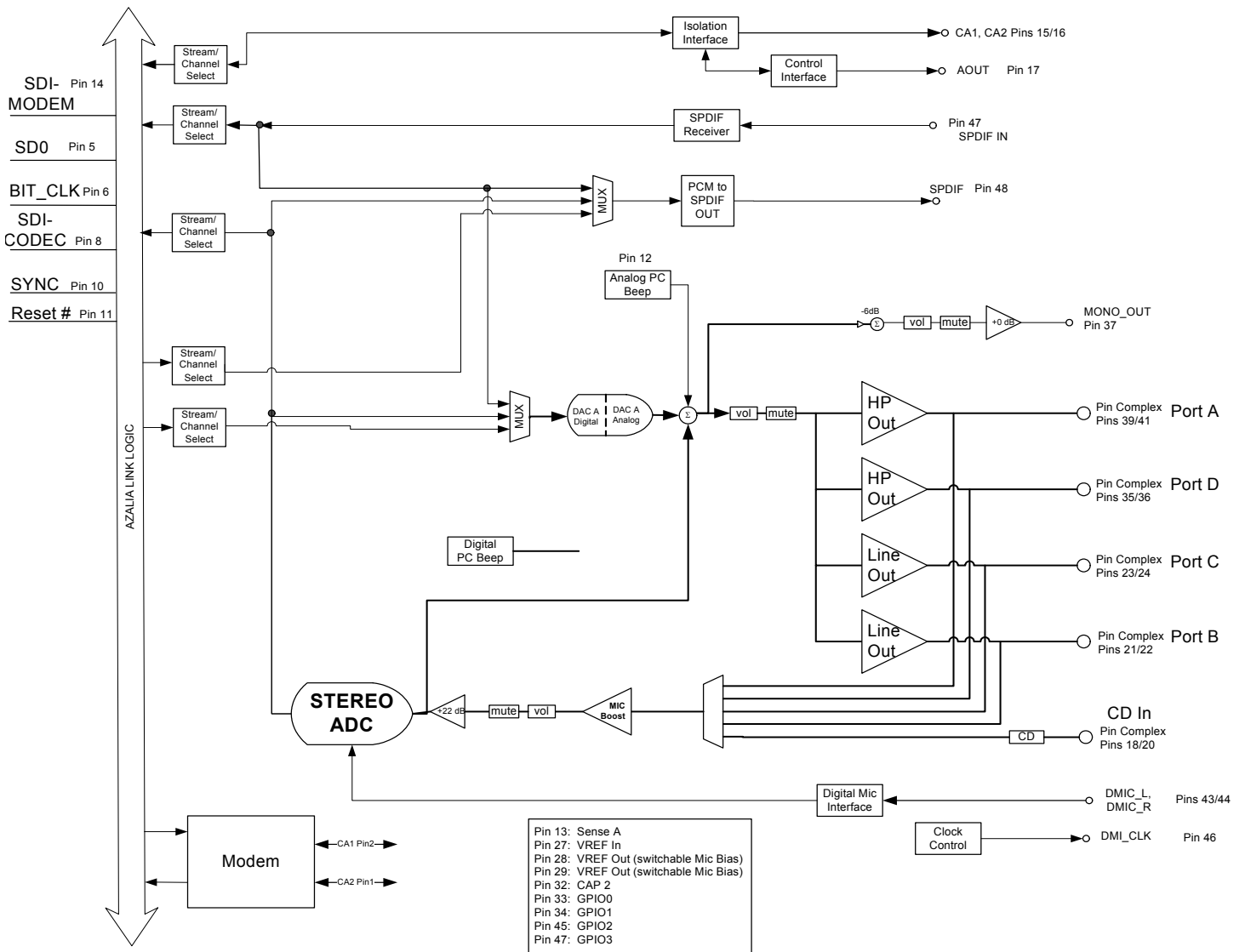
4.1. STAC9250

Figure 1. STAC9250 Functional Block Diagram



4.2. STAC9251

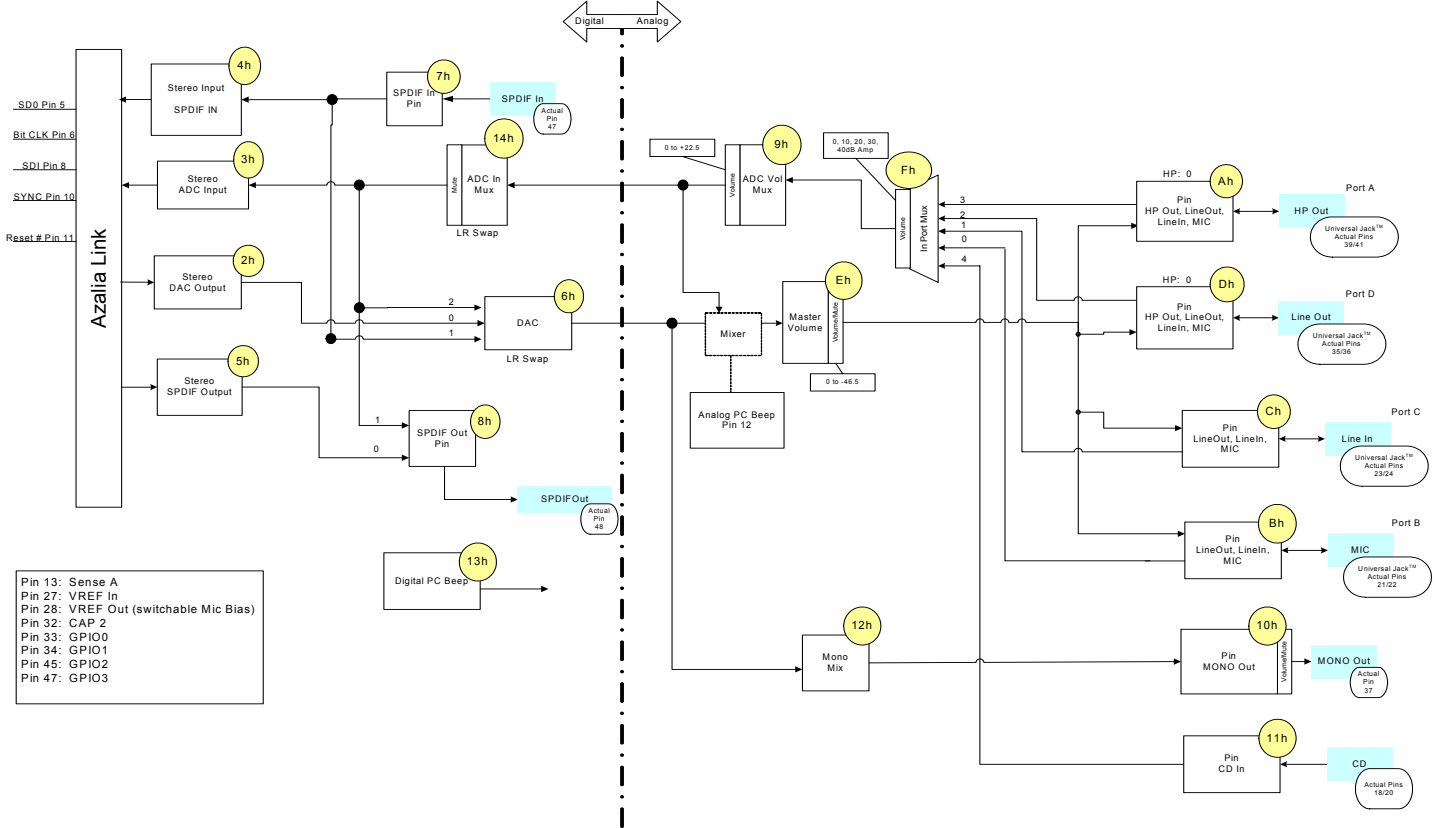
Figure 2. STAC9250 Functional Block Diagram



5. WIDGET INFORMATION

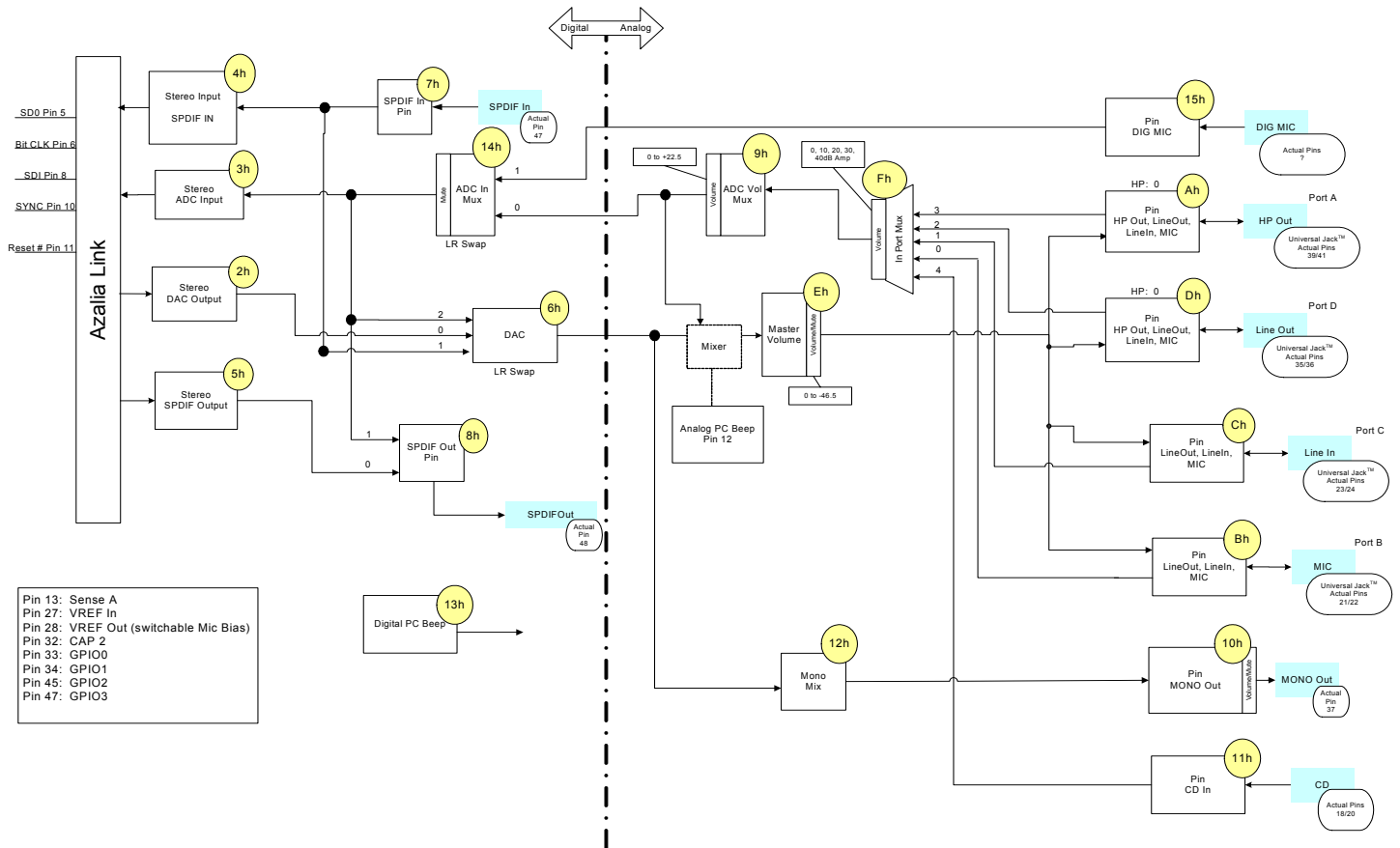
5.1. Widget Diagram - STAC9250

Figure 3. STAC9250 Widget Diagram



5.2. Widget Diagram - STAC9251

Figure 4. STAC9251 Widget Diagram



5.3. Widget List - STAC9250/9251

Table 3. High Definition Audio Widget

ID	Widget Name	Description
00h	Root	Root Node
01h	Audio Function Group	Audio Function Group (AFG)
02h	DAC0	Stereo Output to DAC
03h	ADC0	Stereo Input from ADC
04h	SPDIF_IN	Stereo Input for SPDIF_In
05h	SPDIF_OUT	Stereo Output for SPDIF_Out
06h	DAC0Mux	DAC Mux and Boost for outputs for DAC
07h	DigPin1	Pin Widget for SPDIF_In (pin 47)
08h	DigPin0	Pin Widget for SPDIF_Out (pin 48)
09h	ADC0VolMux	ADC0 Volume
0Eh	MasterVolume	Master Volume Controls
0Fh	InPortMux	Port Mux for ADC0
0Ah	Port A	Port A Pin Widget (Pins 39/41, configurable as HP, Line In, Line Out, Mic)
0Dh	Port D	Port D Pin Widget (Pins 35/36, configurable as HP, Line In, Line Out, Mic)
0Ch	Port C	Port C Pin Widget (Pins 23/24, configurable as Line Out, Mic)
0Bh	Port B	Port B Pin Widget (Pins 21/22, configurable as Line Out, Mic)
10h	MonoOut	Mono Output from DAC
11h	CD	CD Pin Widget pins 18/19/20
12h	MonoOutMix	Mixer for Mono Output
13h	Digital PC Beep	Digital PC Beep
14h	ADC0InMux	Input Mux for ADC converter
15h	DigMicPin	Pin Widget for Digital Microphone (Pins 43/44/46 configurable as a Mic) (STAC9251 only)

5.4. Root Node (NID = 0x00)

5.4.1. Root PnpID

Table 4. Root PnpID Command Verb Format

	Verb ID	Payload	Response
Get	F00	00	See bitfield table

Table 5. Root PnpID Command Response Format

Bit	Bitfield Name	RW	Reset	Description
[31:16]	Vendor	R	0x8384	Vendor ID = 8384h
[15:0]	Device	R	0x7630	Device ID for: STAC9250 = 7634 STAC9251 = 7636

5.4.2. Root RevID

Table 6. Root RevID Command Verb Format

	Verb ID	Payload	Response
Get	F00	02	See bitfield table

Table 7. Root RevID Command Response Format

Bit	Bitfield Name	RW	Reset	Description
[31:24]	Rsvd	R	0x00	Reserved
[23:20]	Major	R	0x1	Major rev number of compliant HD Audio specification
[19:16]	Minor	R	0x0	Minor rev number of compliant HD Audio specification
[15:8]	Vendor	R	0x01	Vendor rev number for this device ID
[7:0]	Stepping	R	0x01	Vendor stepping number within the given Vendor RevID

5.4.3. Root NodeInfo

Table 8. Root NodeInfo Command Verb Format

	Verb ID	Payload	Response
Get	F00	04	See bitfield table

Table 9. Root NodeInfo Command Response Format

Bit	Bitfield Name	RW	Reset	Description
[31:24]	Rsvd2	R	0x00	Reserved
[23:16]	StartNID	R	0x01	Starting node number (NID) of first function group
[15:8]	Rsvd1	R	0x00	Reserved
[7:0]	TotalNodes	R	0x01	Total number of nodes

5.5. AFG Node (NID = 0x01)

5.5.1. AFG Reset

Table 10. AFG Reset Command Verb Format

	Verb ID	Payload	Response
Get	7FF	00	See bitfield table
Set1	7FF	See bits [7:0] of bitfield table	0000_0000h

Table 11. AFG Reset Command Response Format

Bit	Bitfield Name	RW	Reset	Description
[31:0]	Response	R	0x0	Reserved. Overlaps Execute.
[0]	Execute	W	0x0	Function Reset. Function Group reset is executed when the Set verb 7FF is written with 8-bit payload of 00h. The CODEC should issue a response to acknowledge receipt of the verb, and then reset the affected Function Group and all associated widgets to their power-on reset values. Some controls such as Configuration Default controls should not be reset. Overlaps Response.

5.5.2. AFG NodeInfo

Table 12. AFG NodeInfo Command Verb Format

	Verb ID	Payload	Response
Get	F00	04	See bitfield table

Table 13. AFG NodeInfo Command Response Format

Bit	Bitfield Name	RW	Reset	Description
[31:24]	Rsvd2	R	0x0	Reserved
[23:16]	StartNID	R	0x02	Starting node number for function group subordinate nodes.
[15:8]	Rsvd1	R	0x0	Reserved
[7:0]	TotalNodes	R	0x14	Total number of nodes. 13h for STAC9250 14h for STAC9251