

## AC'97 Audio and Touchpanel CODEC

### DESCRIPTION

The WM9712L is a highly integrated input / output device designed for mobile computing and communications. The device can connect directly to a 4-wire or 5-wire touchpanel, mono or stereo microphones, stereo headphones and a mono speaker, reducing total component count in the system. Additionally, phone input and output pins are provided for seamless integration with wireless communication devices.

The WM9712L also offers up to four auxiliary ADC inputs for analogue measurements such as temperature or light, and five GPIO pins for interfacing to buttons or other digital devices. To monitor the battery voltage in portable systems, the WM9712L has two uncommitted comparator inputs.

All device functions are accessed and controlled through a single AC-Link interface compliant with the AC'97 standard. Additionally, the WM9712L can generate interrupts to indicate pen down, pen up, availability of touchpanel data, low battery, dead battery, and GPIO conditions.

The WM9712L operates at supply voltages from 1.8 to 3.6 Volts. Each section of the chip can be powered down under software control to save power. The device is available in a small leadless 7x7mm QFN package, ideal for use in hand-held portable systems.

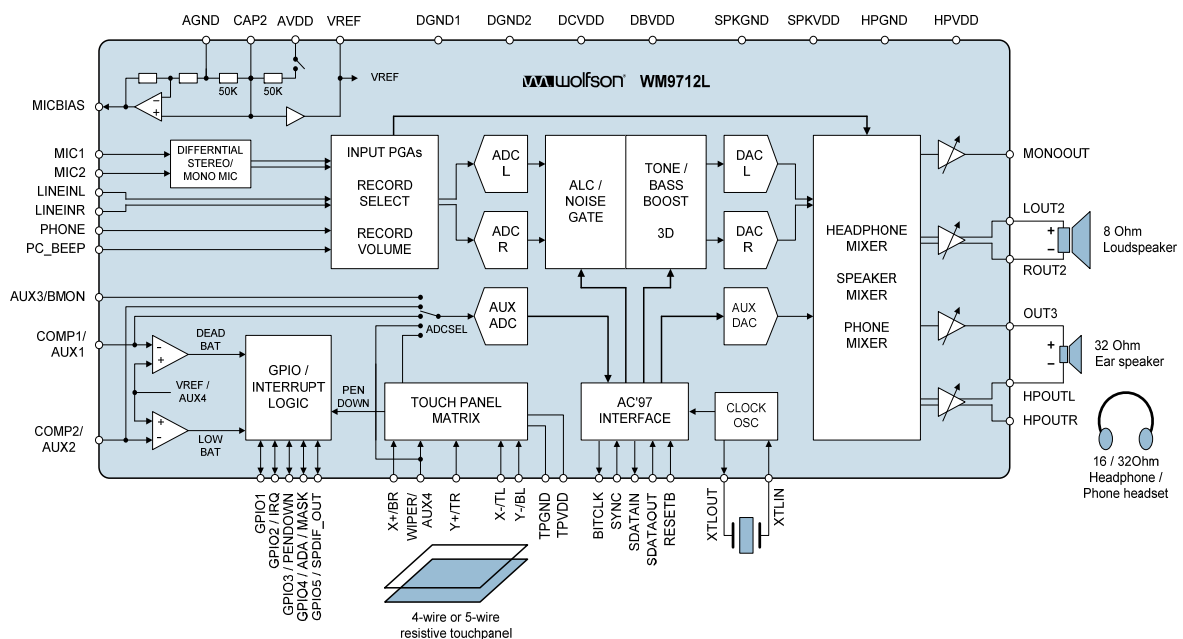
### FEATURES

- AC'97 Rev 2.2 compatible stereo CODEC
  - DAC SNR 94dB, THD -87dB
  - ADC SNR 92dB, THD -87dB
  - Variable Rate Audio, supports all WinCE sample rates
  - Tone Control, Bass Boost and 3D Enhancement
- On-chip 45mW headphone driver
- On-chip 400mW mono speaker driver
- Stereo, mono or differential microphone input
  - Automatic Level Control (ALC)
- Auxiliary mono DAC (ring tone or DC level generation)
- Seamless interface to wireless chipset
- Resistive touchpanel interface
  - Supports 4-wire and 5-wire panels
  - 12-bit resolution, INL  $\pm 2$  LSBs (<0.5 pixels)
  - X, Y and touch-pressure (Z) measurement
  - Pen-down detection supported in Sleep Mode
- Up to 5 GPIO pins
- 2 comparator inputs for battery monitoring
- Up to 4 auxiliary ADC inputs
- 1.8V to 3.6V supplies
- 7x7mm QFN

### APPLICATIONS

- Personal Digital Assistants (PDA)
- Smartphones
- Handheld and Tablet Computers

### BLOCK DIAGRAM



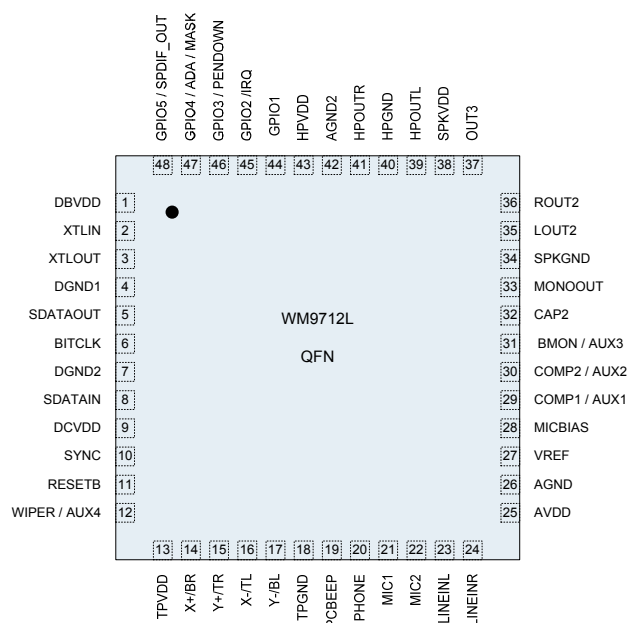
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## PIN CONFIGURATION



## ORDERING INFORMATION

| DEVICE          | TEMP. RANGE  | PACKAGE                              | MOISTURE LEVEL SENSITIVITY | PEAK SOLDERING TEMP |
|-----------------|--------------|--------------------------------------|----------------------------|---------------------|
| WM9712CLGEFL/V  | -25 to +85°C | 48-lead QFN (Pb-free)                | MSL3                       | 260°C               |
| WM9712CLGEFL/RV | -25 to +85°C | 48-lead QFN (pb-free, tape and reel) | MSL3                       | 260°C               |

**Note:**

Reel quantity = 2,200

**PIN DESCRIPTION**

| PIN | NAME               | TYPE              | DESCRIPTION                                                                                                                                                                         |
|-----|--------------------|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1   | DBVDD              | Supply            | Digital I/O Buffer Supply                                                                                                                                                           |
| 2   | XTLIN              | Digital Input     | Clock Crystal Connection 1 / External Clock Input                                                                                                                                   |
| 3   | XTLOUT             | Digital Output    | Clock Crystal Connection 2                                                                                                                                                          |
| 4   | DGND1              | Supply            | Digital Ground (return path for both DCVDD and DBVDD)                                                                                                                               |
| 5   | SDATAOUT           | Digital Input     | Serial Data Output from Controller / Input to WM9712L                                                                                                                               |
| 6   | BITCLK             | Digital Output    | Serial Interface Clock Output to Controller                                                                                                                                         |
| 7   | DGND2              | Supply            | Digital Ground (return path for both DCVDD and DBVDD)                                                                                                                               |
| 8   | SDATAIN            | Digital Output    | Serial Data Input to Controller / Output from WM9712L                                                                                                                               |
| 9   | DCVDD              | Supply            | Digital Core Supply                                                                                                                                                                 |
| 10  | SYNC               | Digital Input     | Serial Interface Synchronisation Pulse from Controller                                                                                                                              |
| 11  | RESETB             | Digital Input     | Reset (asynchronous, active Low, resets all registers to their default)                                                                                                             |
| 12  | WIPER / AUX4       | Analogue Input    | Top Sheet Connection for 5-wire Touchpanels / Auxiliary ADC Input                                                                                                                   |
| 13  | TPVDD              | Supply            | Touchpanel Driver Supply                                                                                                                                                            |
| 14  | X+/BR              | Analogue Input    | Touchpanel Connection: X+ (Right) for 4-wire / bottom right for 5-wire                                                                                                              |
| 15  | Y+/TR              | Analogue Input    | Touchpanel Connection: Y+ (Top) for 4-wire / top right for 5-wire                                                                                                                   |
| 16  | X-/TL              | Analogue Input    | Touchpanel Connection: X- (Left) for 4-wire / top left for 5-wire                                                                                                                   |
| 17  | Y-/BL              | Analogue Input    | Touchpanel Connection: Y- (Bottom) for 4-wire / bottom left for 5-wire                                                                                                              |
| 18  | TPGND              | Supply            | Touchpanel Driver Ground                                                                                                                                                            |
| 19  | PCBEEP             | Analogue Input    | Line Input to analogue audio mixers, typically used for beeps                                                                                                                       |
| 20  | PHONE              | Analogue Input    | Phone Input (RX)                                                                                                                                                                    |
| 21  | MIC1               | Analogue Input    | Left Microphone or Microphone 1 Input                                                                                                                                               |
| 22  | MIC2               | Analogue Input    | Right Microphone or Microphone 2 Input                                                                                                                                              |
| 23  | LINEINL            | Analogue Input    | Left Line Input                                                                                                                                                                     |
| 24  | LINEINR            | Analogue Input    | Right Line Input                                                                                                                                                                    |
| 25  | AVDD               | Supply            | Analogue Supply (feeds audio DACs, ADCs, PGAs, mic boost, mixers)                                                                                                                   |
| 26  | AGND               | Supply            | Analogue Ground                                                                                                                                                                     |
| 27  | VREF               | Analogue Output   | Internal Reference Voltage (buffered CAP2)                                                                                                                                          |
| 28  | MICBIAS            | Analogue Output   | Bias Voltage for Microphones (buffered CAP2 $\times$ 1.8)                                                                                                                           |
| 29  | COMP1 / AUX1       | Analogue Input    | Comparator 1 (dead battery alarm) / Auxiliary ADC Input 1                                                                                                                           |
| 30  | COMP2 / AUX2       | Analogue Input    | Comparator 2 (low battery alarm) / Auxiliary ADC Input 2                                                                                                                            |
| 31  | BMON / AUX3        | Analogue Input    | Battery Monitor Input / Auxiliary ADC Input 3                                                                                                                                       |
| 32  | CAP2               | Analogue In / Out | Internal Reference Voltage (normally AVDD/2, if not overdriven)                                                                                                                     |
| 33  | MONOOUT            | Analogue Output   | Mono Output, intended for Phone TX signal                                                                                                                                           |
| 34  | SPKGND             | Supply            | Speaker Ground (feeds output buffers on pins 35 and 36)                                                                                                                             |
| 35  | LOUT2              | Analogue Output   | Left Output 2 (Speaker, Line or Headphone)                                                                                                                                          |
| 36  | ROUT2              | Analogue Output   | Right Output 2 (Speaker, Line or Headphone)                                                                                                                                         |
| 37  | OUT3               | Analogue Output   | Analogue Output 3 (from AUXDAC or headphone pseudo-ground)                                                                                                                          |
| 38  | SPKVDD             | Supply            | Speaker Supply (feeds output buffers on pins 35 and 36)                                                                                                                             |
| 39  | HPOUTL             | Analogue Output   | Headphone Left Output                                                                                                                                                               |
| 40  | HPGND              | Supply            | Headphone Ground (feeds output buffers on pins 37, 39, 41)                                                                                                                          |
| 41  | HPOUTR             | Analogue Output   | Headphone Right Output                                                                                                                                                              |
| 42  | AGND2              | Supply            | Analogue Ground, Chip Substrate                                                                                                                                                     |
| 43  | HPVDD              | Supply            | Headphone Supply (feeds output buffers on pins 37, 39, 41)                                                                                                                          |
| 44  | GPIO1              | Digital In / Out  | GPIO Pin 1                                                                                                                                                                          |
| 45  | GPIO2 / IRQ        | Digital In / Out  | GPIO Pin 2 or IRQ (Interrupt Request) Output                                                                                                                                        |
| 46  | GPIO3 / PENDOWN    | Digital In / Out  | GPIO Pin 3 or Pen Down Output                                                                                                                                                       |
| 47  | GPIO4 / ADA / MASK | Digital In / Out  | GPIO Pin 4 or ADA (ADC Data Available) Output or Mask input (On reset, pin level configures device power up status. See Applications section for external components configuration) |
| 48  | GPIO5 / SPDIF_OUT  | Digital In / Out  | GPIO Pin 5 or SPDIF Digital Audio Output                                                                                                                                            |

**Note:** It is recommended that the QFN ground paddle should be connected to analogue ground on the application PCB.

## ABSOLUTE MAXIMUM RATINGS

Absolute Maximum Ratings are stress ratings only. Permanent damage to the device may be caused by continuously operating at or beyond these limits. Device functional operating limits and guaranteed performance specifications are given under Electrical Characteristics at the test conditions specified.



ESD Sensitive Device. This device is manufactured on a CMOS process. It is therefore generically susceptible to damage from excessive static voltages. Proper ESD precautions must be taken during handling and storage of this device.

Wolfson tests its package types according to IPC/JEDEC J-STD-020B for Moisture Sensitivity to determine acceptable storage conditions prior to surface mount assembly. These levels are:

MSL1 = unlimited floor life at <30°C / 85% Relative Humidity. Not normally stored in moisture barrier bag.

MSL2 = out of bag storage for 1 year at <30°C / 60% Relative Humidity. Supplied in moisture barrier bag.

MSL3 = out of bag storage for 168 hours at <30°C / 60% Relative Humidity. Supplied in moisture barrier bag.

The Moisture Sensitivity Level for each package type is specified in Ordering Information.

| CONDITION                                             | MIN        | MAX         |
|-------------------------------------------------------|------------|-------------|
| Digital supply voltages (DCVDD, DBVDD)                | -0.3V      | +3.63V      |
| Analogue supply voltages (AVDD, HPVDD, SPKVDD, TPVDD) | -0.3V      | +3.63V      |
| Touchpanel supply voltage (TPVDD)                     | AVDD -0.3V | AVDD +0.3V  |
| Voltage range digital inputs                          | DGND -0.3V | DBVDD +0.3V |
| Voltage range analogue inputs                         | AGND -0.3V | AVDD +0.3V  |
| Voltage range touchpanel Inputs X+, X-, Y+ and Y-     |            | TPVDD +0.3V |
| Voltage range touchpanel Inputs X+, X-, Y+ and Y-     |            | AVDD +0.3V  |
| Voltage range, BMON/AUX3 (pin31)                      |            | +5V         |
| Operating temperature range, T <sub>A</sub>           | -25°C      | +85°C       |

## RECOMMENDED OPERATING CONDITIONS

| PARAMETER                                | SYMBOL                     | TEST CONDITIONS | MIN  | TYP | MAX             | UNIT |
|------------------------------------------|----------------------------|-----------------|------|-----|-----------------|------|
| Digital input/output buffer supply range | DBVDD                      | Notes 1, 2      | 1.8  |     | 3.6 or AVDD+0.3 | V    |
| Digital core supply range                | DCVDD                      | Notes 1, 2      | 1.8  |     | 3.6 or AVDD+0.3 | V    |
| Analogue supply range                    | AVDD, HPVDD, SPKVDD, TPVDD |                 | 1.8  |     | 3.6             | V    |
| Digital ground                           | DCGND, DBGND               |                 |      | 0   |                 | V    |
| Analogue ground                          | AGND, HPGND, SPKGND, TPGND |                 |      | 0   |                 | V    |
| Difference AGND to DGND                  |                            | Note 3          | -0.3 | 0   | +0.3            | V    |

### Notes:

1. AVDD, DCVDD and DBVDD can all be different
2. Digital supplies (DCVDD, DBVDD) must not exceed analogue supplies (AVDD, HPVDD, SPKVDD, TPVDD) by more than 0.3V
3. AGND is normally the same as DGND

## ELECTRICAL CHARACTERISTICS

### AUDIO OUTPUTS

#### Test Conditions

DBVDD=3.3V, DCVDD = 3.3V, AVDD=HPVDD=SPKVDD =3.3V,  $T_A$  = +25°C, 1kHz signal,  $f_s$  = 48kHz, 18-bit audio data unless otherwise stated.

| PARAMETER                                                                                                        | SYMBOL     | TEST CONDITIONS                                              | MIN | TYP         | MAX | UNIT    |
|------------------------------------------------------------------------------------------------------------------|------------|--------------------------------------------------------------|-----|-------------|-----|---------|
| <b>DAC to Line-Out (HPOUTL/R or MONOOUT with 10k<math>\Omega</math> / 50pF load)</b>                             |            |                                                              |     |             |     |         |
| Full-scale output                                                                                                |            | AVDD = 3.3V, PGA gains set to 0dB                            |     | 1           |     | V rms   |
| Signal to Noise Ratio (A-weighted)                                                                               | SNR        |                                                              | 85  | 94          |     | dB      |
| Total Harmonic Distortion                                                                                        | THD        | -3dB output                                                  |     | -87         | -80 | dB      |
| Power Supply Rejection                                                                                           | PSRR       | 100mV, 20Hz to 20kHz signal on AVDD                          |     | 50          |     | dB      |
| <b>Speaker Output (LOUT2/ROUT2 with 8<math>\Omega</math> bridge tied load, INV=1)</b>                            |            |                                                              |     |             |     |         |
| Output Power                                                                                                     | $P_O$      | Output power is very closely correlated with THD; see below. |     |             |     |         |
| Output Power at 1% THD                                                                                           | $P_O$      |                                                              |     | 400         |     | mW      |
| Abs. Max Output Power                                                                                            | $P_{Omax}$ |                                                              |     | 500         |     | mW      |
| Total Harmonic Distortion                                                                                        | THD        | $P_O=200mW$                                                  |     | -66<br>0.05 |     | dB<br>% |
| Signal to Noise Ratio (A-weighted)                                                                               | SNR        |                                                              | 90  | 100         |     | dB      |
| <b>Headphone Output (HPOUTL/R, OUT3 or LOUT2/ROUT2 with 16<math>\Omega</math> or 32<math>\Omega</math> load)</b> |            |                                                              |     |             |     |         |
| Output Power per channel                                                                                         | $P_O$      | Output power is very closely correlated with THD; see below. |     |             |     |         |
| Total Harmonic Distortion                                                                                        | THD        | $P_O=10mW, R_L=16\Omega$                                     |     | -76         |     | dB      |
|                                                                                                                  |            | $P_O=10mW, R_L=32\Omega$                                     |     | -73         |     |         |
|                                                                                                                  |            | $P_O=20mW, R_L=16\Omega$                                     |     | -75         | -70 |         |
|                                                                                                                  |            | $P_O=20mW, R_L=32\Omega$                                     |     | -78         |     |         |
| Signal to Noise Ratio (A-weighted)                                                                               | SNR        |                                                              | 90  | 95          |     | dB      |

#### Note:

- All THD values are valid for the output power level quoted above – for example, at HPVDD=3.3V and  $R_L=16\Omega$ , THD is -76dB when output power is 10mW. Higher output power is possible, but will result in a deterioration in THD.

**AUDIO INPUTS****Test Conditions**

DBVDD=3.3V, DCVDD = 3.3V, AVDD = 3.3V, T<sub>A</sub> = +25°C, 1kHz signal, f<sub>s</sub> = 48kHz, 18-bit audio data unless otherwise stated.

| PARAMETER                                                        | SYMBOL            | TEST CONDITIONS                      | MIN                            | TYP   | MAX | UNIT             |
|------------------------------------------------------------------|-------------------|--------------------------------------|--------------------------------|-------|-----|------------------|
| LINEINL/R, MICL/R and PHONE pins                                 |                   |                                      |                                |       |     |                  |
| Full Scale Input Signal Level<br>(for ADC 0dB Input at 0dB Gain) | V <sub>INFS</sub> | AVDD = 3.3V                          |                                | 1.0   |     | V <sub>rms</sub> |
|                                                                  |                   | AVDD = 1.8V                          |                                | 0.545 |     |                  |
|                                                                  |                   | differential input mode<br>(MS = 01) | half of the value listed above |       |     |                  |
| Input Resistance                                                 | R <sub>IN</sub>   | 0dB PGA gain                         |                                | 34    |     | kΩ               |
|                                                                  |                   | 12dB PGA gain                        | 10                             | 16    | 22  |                  |
| Input Capacitance                                                |                   |                                      |                                | 5     |     | pF               |
| Line input to ADC (LINEINL, LINEINR, PHONE)                      |                   |                                      |                                |       |     |                  |
| Signal to Noise Ratio<br>(A-weighted)                            | SNR               |                                      | 85                             | 92    |     | dB               |
| Total Harmonic Distortion                                        | THD               | -6dBFS                               |                                | -87   | -80 | dB               |
| Power Supply Rejection                                           | PSRR              | 20Hz to 20kHz                        |                                | 50    |     | dB               |
| Microphone input to ADC (MIC1/2 pins)                            |                   |                                      |                                |       |     |                  |
| Signal to Noise Ratio<br>(A-weighted)                            | SNR               | 20dB boost enabled                   |                                | 80    |     | dB               |
| Total Harmonic Distortion                                        | THD               | 20dB boost enabled                   |                                | -80   |     | dB               |
| Power Supply Rejection Ratio                                     | PSRR              |                                      |                                | 50    |     | dB               |
| Common Mode Rejection Ratio                                      | CMRR              | Differential mic mode                |                                | TBD   |     | dB               |

**AUXILIARY MONO DAC (AUXDAC)****Test Conditions**

AVDD = 3.3V, T<sub>A</sub> = +25°C, unless otherwise stated.

| PARAMETER                             | SYMBOL | TEST CONDITIONS | MIN | TYP | MAX | UNIT             |
|---------------------------------------|--------|-----------------|-----|-----|-----|------------------|
| Resolution                            |        |                 |     | 12  |     | bits             |
| Full scale output voltage             |        | AVDD=3.3V       |     | 1   |     | V <sub>rms</sub> |
| Signal to Noise Ratio<br>(A-weighted) | SNR    |                 | 65  | 70  |     | dB               |
| Total Harmonic Distortion             | THD    |                 |     | -62 | -50 | dB               |

## TOUCHPANEL AND AUXILIARY ADC

## Test Conditions

DBVDD=3.3V, DCVDD = 3.3V, AVDD = TPVDD = 3.3V, T<sub>A</sub> = +25°C, MCLK = 24.576 MHz, unless otherwise stated.

| PARAMETER                                                                   | SYMBOL          | TEST CONDITIONS                                                 | MIN  | TYP                | MAX  | UNIT |
|-----------------------------------------------------------------------------|-----------------|-----------------------------------------------------------------|------|--------------------|------|------|
| Input Pins X+, X-, Y+, Y-, WIPER/AUX4, COMP1/AUX1, COMP2/AUX2 and BMON/AUX3 |                 |                                                                 |      |                    |      |      |
| Input Voltage                                                               |                 |                                                                 | AGND |                    | AVDD | V    |
| Input leakage current                                                       |                 | AUX pin not selected as<br>AUX ADC input                        |      | <10                |      | nA   |
| ADC Resolution                                                              |                 |                                                                 |      | 12                 |      | bits |
| Differential Non-Linearity Error                                            | DNL             |                                                                 |      | ±0.25              | ±1   | LSB  |
| Integral Non-Linearity Error                                                | INL             |                                                                 |      |                    | ±2   | LSB  |
| Offset Error                                                                |                 |                                                                 |      |                    | ±4   | LSB  |
| Gain Error                                                                  |                 |                                                                 |      |                    | ±6   | LSB  |
| Power Supply Rejection                                                      | PSRR            |                                                                 |      | 50                 |      | dB   |
| Throughput Rate                                                             |                 | DEL = 1111<br>(zero settling time)                              |      |                    | 48   | kHz  |
| Settling Time (programmable)                                                |                 | MCLK = 24.576MHz                                                | 0    |                    | 6    | ms   |
| Conversion Time                                                             |                 | Note: touch pressure<br>measurements require two<br>conversions |      | 20.8               |      | µs   |
| Switch matrix resistance                                                    |                 |                                                                 |      | 12                 |      | Ω    |
| Programmable Pull-up resistor                                               | R <sub>PU</sub> | RPU = 000001                                                    | 55   | 63                 | 70   | kΩ   |
| Pen down detector threshold                                                 |                 |                                                                 |      | VDD/2              |      | V    |
| Pressure measurement current                                                | I <sub>P</sub>  | PIL = 1                                                         |      | 400                |      | µA   |
|                                                                             |                 | PIL = 0                                                         |      | 200                |      |      |
| BMON/AUX3 (pin 31 only)                                                     |                 |                                                                 |      |                    |      |      |
| Input Range                                                                 |                 | AVDD = 3.3V                                                     | AGND |                    | 5    | V    |
|                                                                             |                 | AVDD = 1.8V                                                     | AGND |                    | 3.3  | V    |
| Scaling                                                                     |                 |                                                                 | -3%  | 1/3                | +3%  |      |
| Input Resistance (Note 1)                                                   |                 | during measurement                                              |      | 30                 |      | kΩ   |
|                                                                             |                 | average over time                                               |      | 30 /<br>duty cycle |      |      |

## Note:

- Current only flows into pin 31 during a measurement. At all other times, BMON/AUX3 is effectively an open circuit.

## COMPARATORS

## Test Conditions

AVDD = 3.3V, T<sub>A</sub> = +25°C, unless otherwise stated.

| PARAMETER                                      | SYMBOL | TEST CONDITIONS                   | MIN  | TYP | MAX  | UNIT |
|------------------------------------------------|--------|-----------------------------------|------|-----|------|------|
| <b>COMP1/AUX1 and COMP2/AUX2 (pins 29, 30)</b> |        |                                   |      |     |      |      |
| Input Voltage                                  |        |                                   | AGND |     | AVDD | V    |
| Input leakage current                          |        | pin not selected as AUX ADC input |      | <10 |      | nA   |
| Comparator Input Offset<br>(COMP1, COMP2 only) |        |                                   | -50  |     | +50  | mV   |
| COMP2 delay (COMP2 only)                       |        | 24.576MHz crystal                 | 0    |     | 10.9 | s    |

## REFERENCE VOLTAGES

## Test Conditions

DBVDD=3.3V, DCVDD = 3.3V, AVDD = 3.3V,  $T_A = +25^{\circ}\text{C}$ , 1kHz signal,  $f_s = 48\text{kHz}$ , 18-bit audio data unless otherwise stated.

| PARAMETER                       | SYMBOL               | TEST CONDITIONS | MIN  | TYP  | MAX  | UNIT                   |
|---------------------------------|----------------------|-----------------|------|------|------|------------------------|
| <b>Audio ADCs, DACs, Mixers</b> |                      |                 |      |      |      |                        |
| Reference Input/Output          | CAP2 pin             |                 | 1.6  | 1.65 | 1.7  | V                      |
| Buffered Reference Output       | VREF pin             |                 | 1.6  | 1.65 | 1.7  | V                      |
| <b>Microphone Bias</b>          |                      |                 |      |      |      |                        |
| Bias Voltage                    | $V_{\text{MICBIAS}}$ |                 | 2.88 | 2.97 | 3.06 | V                      |
| Bias Current Source             | $I_{\text{MICBIAS}}$ |                 |      |      | 3    | mA                     |
| Output Noise Voltage            | $V_n$                | 1K to 20kHz     |      | 15   |      | nV/ $\sqrt{\text{Hz}}$ |

## DIGITAL INTERFACE CHARACTERISTICS

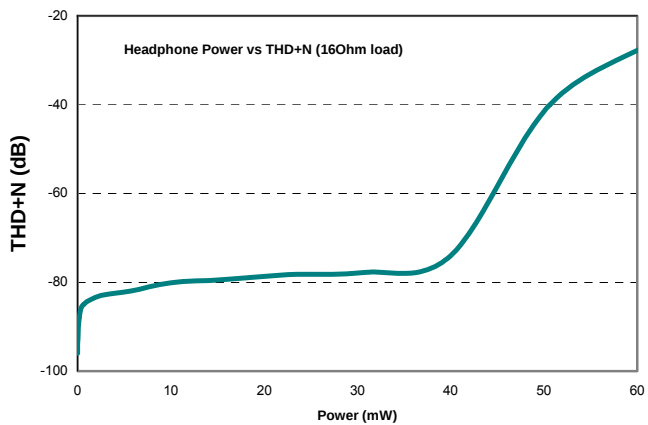
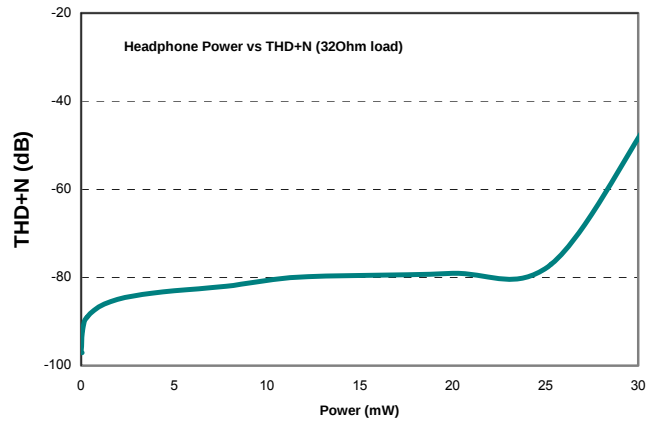
## Test Conditions

DBVDD = 3.3V, DCVDD = 3.3V,  $T_A = +25^{\circ}\text{C}$ , unless otherwise stated.

| PARAMETER                                                                    | SYMBOL          | TEST CONDITIONS      | MIN                | TYP    | MAX                | UNIT |
|------------------------------------------------------------------------------|-----------------|----------------------|--------------------|--------|--------------------|------|
| <b>Digital Logic Levels (all digital input or output pins) – CMOS Levels</b> |                 |                      |                    |        |                    |      |
| Input HIGH level                                                             | $V_{\text{IH}}$ |                      | DBVDD $\times 0.7$ |        |                    | V    |
| Input LOW level                                                              | $V_{\text{IL}}$ |                      |                    |        | DBVDD $\times 0.3$ | V    |
| Output HIGH level                                                            | $V_{\text{OH}}$ | source current = 2mA | DBVDD $\times 0.9$ |        |                    |      |
| Output LOW level                                                             | $V_{\text{OL}}$ | sink current = 2mA   |                    |        | DBVDD $\times 0.1$ |      |
| <b>Clock Frequency</b>                                                       |                 |                      |                    |        |                    |      |
| Master clock (XTLIN pin)                                                     |                 |                      |                    | 24.576 |                    | MHz  |
| AC'97 bit clock (BIT_CLK pin)                                                |                 |                      |                    | 12.288 |                    | MHz  |
| AC'97 sync pulse (SYNC pin)                                                  |                 |                      |                    | 48     |                    | kHz  |

## Note:

1. All audio and non-audio sample rates and other timing scales proportionately with the master clock.
2. For signal timing on the AC-Link, please refer to the AC'97 specification (Revision 2.2)

**HEADPHONE / SPEAKER OUTPUT THD VERSUS POWER**

## POWER CONSUMPTION

The power consumption of the WM9712L depends on the following factors.

- Supply voltages: Reducing the supply voltages also reduces digital supply currents, and therefore results in significant power savings especially in the digital sections of the WM9712L.
- Operating mode: Significant power savings can be achieved by always disabling parts of the WM9712L that are not used (e.g. audio ADC, DAC, touchpanel digitiser).

| Mode Description                                                                                | 26h 14:8 | 24h 15:0         | Other Settings                     | AVDD              |                            | DCVDD             |                         | DBVDD             |                      | Total Power (mW)              |
|-------------------------------------------------------------------------------------------------|----------|------------------|------------------------------------|-------------------|----------------------------|-------------------|-------------------------|-------------------|----------------------|-------------------------------|
|                                                                                                 |          |                  |                                    | V                 | I (mA)                     | V                 | I (mA)                  | V                 | I (mA)               |                               |
| OFF (lowest possible power)<br>Clocks stopped                                                   | 1111111  | 0111111111111111 | 58h, SVD = 1                       | 3.3<br>2.5<br>1.8 | 0.0005<br>0.0004<br>0.0003 | 3.3<br>2.5<br>1.8 | 0<br>0<br>0             | 3.3<br>2.5<br>1.8 | 0<br>0<br>0          | 0.00165<br>0.001<br>0.00054   |
| LPS (Low Power Standby)<br>VREF maintained using 1MΩ string                                     | 1111111  | 0111111111111111 |                                    | 3.3<br>2.5<br>1.8 | 0.005<br>0.004<br>0.003    | 3.3<br>2.5<br>1.8 | 0<br>0<br>0             | 3.3<br>2.5<br>1.8 | 0<br>0<br>0          | 0.0165<br>0.01<br>0.0054      |
| Standby Mode (ready to playback)<br>VREF maintained using 50kΩ string                           | 1110111  | 0111111111111111 |                                    | 3.3<br>2.5<br>1.8 | 0.56<br>0.37<br>0.241      | 3.3<br>2.5<br>1.8 | 0<br>0<br>0             | 3.3<br>2.5<br>1.8 | 0<br>0<br>0          | 1.848<br>0.925<br>0.4338      |
| "Idle" Mode<br>VREF maintained using 50kΩ string<br>use LPS mode instead, if possible           | 1100111  | 0111111111111111 |                                    | 3.3<br>2.5<br>1.8 | 1.1<br>0.76<br>0.508       | 3.3<br>2.5<br>1.8 | 0<br>0<br>0             | 3.3<br>2.5<br>1.8 | 0<br>0<br>0          | 3.63<br>1.9<br>0.9144         |
| Touchpanel only (waiting for pen-down)<br>AC-Link running                                       | 1101111  | 0111111111111111 | 76h = 0C00h<br>78h = 0001h         | 3.3<br>2.5<br>1.8 | 0.05<br>0.02<br>0.009      | 3.3<br>2.5<br>1.8 | 1.301<br>0.883<br>0.571 | 3.3<br>2.5<br>1.8 | 3.26<br>2.1<br>1.41  | 15.2163<br>7.5075<br>3.582    |
| Touchpanel only (continuous conversion)<br>93.75 points per second                              | 1001111  | 0111111111111111 | 76h = 0C00h<br>78h = C001h         | 3.3<br>2.5<br>1.8 | 0.08<br>0.04<br>0.027      | 3.3<br>2.5<br>1.8 | 5.85<br>3.922<br>2.87   | 3.3<br>2.5<br>1.8 | 2.67<br>2.1<br>1.41  | 28.38<br>15.155<br>7.7526     |
| Phone Call - using headphone / ear speaker<br>HPOUTL, HPOUTR and OUT3 active<br>AC-Link stopped | 0110011  | 0111100010101100 | 0Eh, bit 7 = 1<br>(mic gain boost) | 3.3<br>2.5<br>1.8 | 2.36<br>1.838<br>1.218     | 3.3<br>2.5<br>1.8 | 0<br>0<br>0             | 3.3<br>2.5<br>1.8 | 0<br>0<br>0          | 7.788<br>4.595<br>2.1924      |
| Phone Call - using loudspeaker<br>AC-Link stopped                                               | 1110011  | 0111101100110100 | 0Eh, bit 7 = 1<br>(mic gain boost) | 3.3<br>2.5<br>1.8 | 2.385<br>1.837<br>1.218    | 3.3<br>2.5<br>1.8 | 0<br>0<br>0             | 3.3<br>2.5<br>1.8 | 0<br>0<br>0          | 7.8705<br>4.5925<br>2.1924    |
| Record from mono microphone<br>with MICBIAS<br>all analogue outputs disabled                    | 1000110  | 0110101111111111 | 0Eh, bit 7 = 1<br>(mic gain boost) | 3.3<br>2.5<br>1.8 | 3.27<br>2.66<br>1.838      | 3.3<br>2.5<br>1.8 | 11.21<br>7.78<br>5.21   | 3.3<br>2.5<br>1.8 | 2.6<br>2.13<br>1.41  | 56.364<br>31.425<br>15.2244   |
| Record phone call<br>both sides mixed to mono<br>call using headphone / ear speaker             | 0000000  | 0000000010001000 | 0Eh, bit 7 = 1<br>(mic gain boost) | 3.3<br>2.5<br>1.8 | 9.461<br>7.46<br>5.318     | 3.3<br>2.5<br>1.8 | 12.22<br>8.552<br>5.799 | 3.3<br>2.5<br>1.8 | 2.62<br>2.1<br>1.48  | 80.1933<br>45.28<br>22.6746   |
| DAC Playback - using loudspeaker                                                                | 1000001  | 0001111101110111 |                                    | 3.3<br>2.5<br>1.8 | 3.45<br>2.549<br>1.738     | 3.3<br>2.5<br>1.8 | 9.884<br>6.755<br>4.606 | 3.3<br>2.5<br>1.8 | 2.6<br>2.1<br>1.41   | 52.5822<br>28.51<br>13.9572   |
| DAC Playback - using headphone                                                                  | 0000001  | 0001110011101111 |                                    | 3.3<br>2.5<br>1.8 | 3.62<br>2.71<br>1.748      | 3.3<br>2.5<br>1.8 | 9.8<br>6.78<br>4.606    | 3.3<br>2.5<br>1.8 | 2.6<br>2.1<br>1.47   | 52.866<br>28.975<br>14.0832   |
| DAC Playback - to Line-out                                                                      | 0000001  | 0001110011101111 |                                    | 3.3<br>2.5<br>1.8 | 3.62<br>2.71<br>1.748      | 3.3<br>2.5<br>1.8 | 9.8<br>6.78<br>4.606    | 3.3<br>2.5<br>1.8 | 2.6<br>2.1<br>1.41   | 52.866<br>28.975<br>13.9752   |
| Maximum Power (everything on)                                                                   | 0000000  | 0000000000000000 | 0Eh, bit 7 = 1<br>(mic gain boost) | 3.3<br>2.5<br>1.8 | 9.593<br>7.37<br>5.388     | 3.3<br>2.5<br>1.8 | 12.26<br>8.563<br>5.8   | 3.3<br>2.5<br>1.8 | 2.62<br>2.12<br>1.48 | 80.7609<br>45.1325<br>22.8024 |

**Table 1 Supply Current Consumption**

**Notes:**

1. All figures are at  $T_A = +25^\circ\text{C}$ , audio sample rate  $f_s = 48\text{kHz}$ , with zero signal (quiescent).
2. The power dissipated in the headphone, speaker and touchpanel is not included in the above table.

## DEVICE DESCRIPTION

### INTRODUCTION

The WM9712L is designed to meet the mixed-signal requirements of portable and wireless computer systems. It includes audio recording and playback, touchpanel digitisation, battery monitoring, auxiliary ADC and GPIO functions, all controlled through a single 5-wire AC-Link interface.

### SOFTWARE SUPPORT

The basic audio features of the WM9712L are software compatible with standard AC'97 device drivers. However, to better support the touchpanel and other additional functions, Wolfson Microelectronics supplies custom device drivers for selected CPUs and operating systems. Please contact your local Wolfson Sales Office for more information.

### AC'97 COMPATIBILITY

The WM9712L uses an AC'97 interface to communicate with a microprocessor or controller. The audio and GPIO functions are largely compliant with AC'97 Revision 2.2. The following **differences** from the AC'97 standard are noted:

- Pinout: The function of some pins has been changed to support device specific features. The PHONE and PCBEEP pins have been moved to different locations on the device package.
- Package: The package for the WM9712L is a 7×7mm leadless QFN package.
- Audio mixing: The WM9712L handles all the audio functions of a smartphone, including audio playback, voice recording, phone calls, phone call recording, ring tones, as well as simultaneous use of these features. The AC'97 mixer architecture does not fully support this. The WM9712L therefore uses a modified AC'97 mixer architecture with three separate mixers.
- Tone Control, Bass Boost and 3D Enhancement: These functions are implemented in the digital domain and therefore affect only signals being played through the audio DACs, not all output signals as stipulated in AC'97.

Some other functions are **additional** to AC'97:

- On-chip BTL loudspeaker driver
- On-chip BTL driver for ear speaker (phone receiver)
- Auxiliary mono DAC for ring tones, system alerts etc.
- Touchpanel controller
- Auxiliary ADC Inputs
- 2 Analogue Comparators for Battery Alarm
- Programmable Filter Characteristics for Tone Control and 3D Enhancement

## AUDIO PATHS OVERVIEW

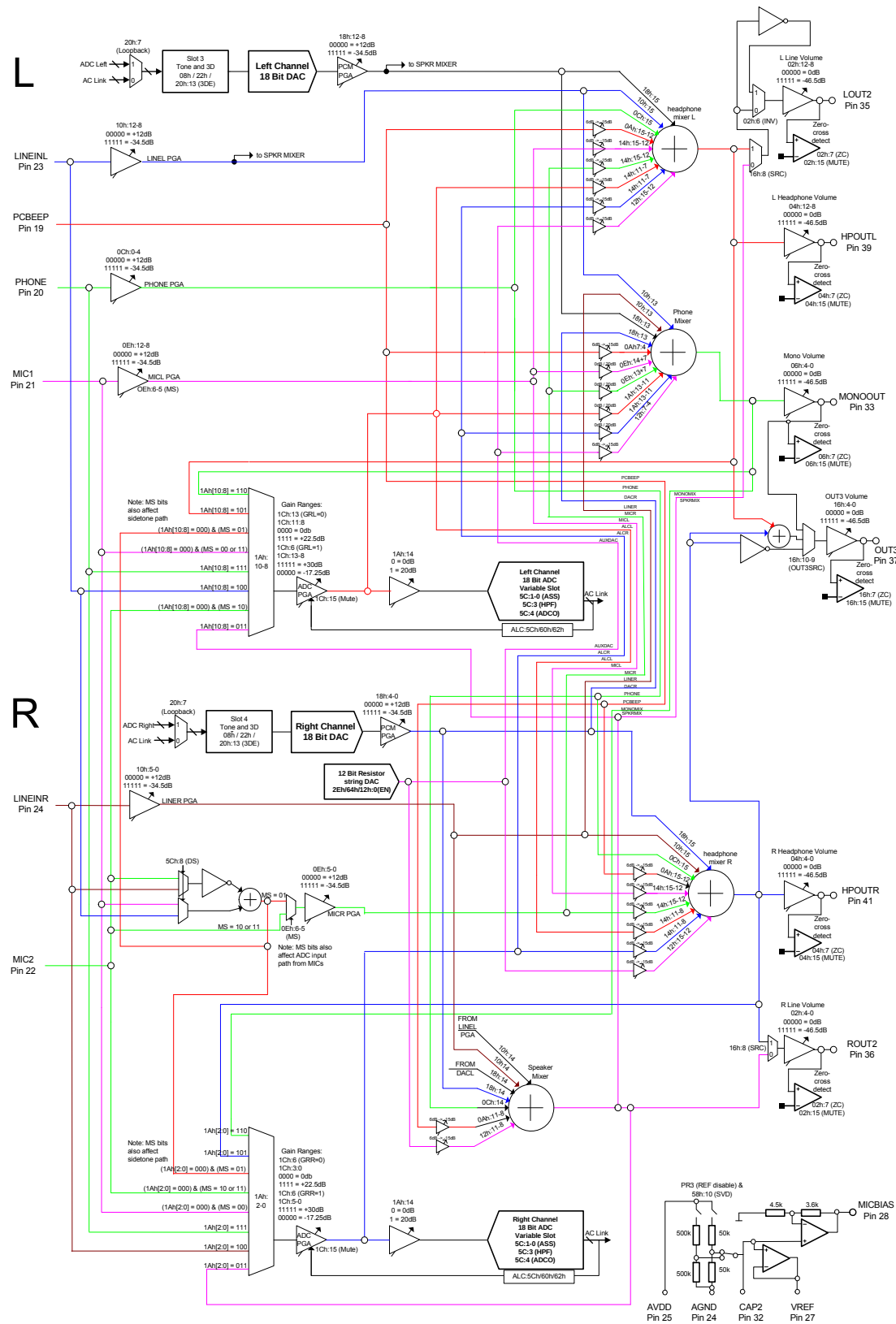


Figure 1 Audio Paths Overview

## AUDIO INPUTS

The following sections give an overview of the analogue audio input pins and their function. For more information on recommended external components, please refer to the “Applications Information” section.

### LINE INPUT

The LINEINL and LINEINR inputs are designed to record line level signals, and/or to mix into one of the analogue outputs.

Both pins are directly connected to the record selector. The record PGA adjusts the recording volume, controlled by register 1Ch or by the ALC function.

For analogue mixing, the line input signals pass through a separate PGA, controlled by register 10h. The signals can be routed into all three output mixers (headphone, speaker and phone). Each LINEIN-to-mixer path has an independent mute bit. When the line inputs are not used, the line-in PGA can be switched off to save power (see “Power Management” section).

LINEINL and LINEINR are biased internally to the reference voltage VREF. Whenever the inputs are muted or the device placed into standby mode, the inputs remain biased to VREF using special anti-thump circuitry to suppress any audible clicks when changing inputs.

| REGISTER ADDRESS | BIT  | LABEL       | DEFAULT     | DESCRIPTION                                                               |
|------------------|------|-------------|-------------|---------------------------------------------------------------------------|
| 10h              | 12:8 | LINEINL VOL | 01000 (0dB) | LINEINL input gain<br>00000: +12dB<br>... (1.5dB steps)<br>11111: -34.5dB |
|                  | 4:0  | LINEINR VOL | 01000 (0dB) | LINEINR input gain<br>similar to LINEINL VOL                              |
|                  | 15   | L2H         | 1           | Mute LINEIN path to headphone mixer<br>1: Mute, 0: No mute (ON)           |
|                  | 14   | L2S         | 1           | Mute LINEIN path to speaker mixer<br>1: Mute, 0: No mute (ON)             |
|                  | 13   | L2P         | 1           | Mute LINEIN path to phone mixer<br>1: Mute, 0: No mute (ON)               |

**Table 2** Line Input Control

### MICROPHONE INPUT

The MIC1 and MIC2 inputs are designed for direct connection to single-ended mono, stereo or differential mono microphone. If the microphone is mono, the same signal appears on both left and right channels. In stereo mode, MIC1 is routed to the left and MIC2 to the right channel.

For voice recording, the microphone signal is directly connected to the record selector. The record PGA adjusts the recording volume, controlled by register 1Ch or by the ALC function.

For analogue mixing, the signal passes through a separate PGA, controlled by register 0Eh. The microphone signal can be routed into the phone mixer (for normal phone call operation) and/or the headphone mixer (using register 14h, see “Audio Mixers / Sidetone Control” section), but not into the speaker mixer (to prevent acoustic feedback from the speaker into the microphone). When the microphone inputs are not used, the microphone PGA can be switched off to save power (see “Power Management” section).

MIC1 and MIC2 are biased internally to the reference voltage VREF. Whenever the inputs are muted or the device placed into standby mode, the inputs remain biased to VREF using special anti-thump circuitry to suppress any audible clicks when changing inputs.

It is also possible to use the LINEINL and LINEINR pins as a second differential microphone input. This is achieved by setting the DS bit (register 5Ch, bit 11) to '1'. This disables the line-in audio paths and routes the signal from LINEINL and LINEINR through the differential mic path, as if it came from the MIC1 and MIC2 pins. Only one differential microphone be used at a time. The DS bit only has an effect when MS = 01 (differential mode).

| REGISTER ADDRESS                           | BIT  | LABEL   | DEFAULT        | DESCRIPTION                                                                                                           |
|--------------------------------------------|------|---------|----------------|-----------------------------------------------------------------------------------------------------------------------|
| 0Eh<br>Mic Volume                          | 14   | M12P    | 1              | Mute MIC1 path to phone mixer<br>1: Mute, 0: No mute (ON)                                                             |
|                                            | 13   | M22P    | 1              | Mute MIC2 path to phone mixer<br>1: Mute, 0: No mute (ON)                                                             |
|                                            | 12:8 | LMICVOL | 01000<br>(0dB) | Left microphone volume<br>Only used when MS = 11<br>Similar to MICVOL                                                 |
|                                            | 7    | 20dB    | 0              | Microphone gain boost (Note 1)<br>1: 20dB boost ON<br>0: No boost (0dB gain)                                          |
|                                            | 6:5  | MS      | 00             | Microphone mode select                                                                                                |
|                                            |      |         |                | 00 Single-ended mono (left)<br>left = right = MIC1 (pin 21)<br>Volume controlled by MICVOL                            |
|                                            |      |         |                | 01 Differential mono mode<br>left = right = MIC1 – MIC2<br>Volume controlled by MICVOL                                |
|                                            |      |         |                | 10 Single-ended mono (right)<br>left = right = MIC2 (pin 22)<br>Volume controlled by MICVOL                           |
|                                            |      |         |                | 11 Stereo mode<br>MIC1 = left, MIC2 = right<br>Left Volume controlled by LMICVOL<br>Right volume controlled by MICVOL |
|                                            | 4:0  | MICVOL  | 01000<br>(0dB) | Microphone volume to mixers<br>00000: +12dB<br>... (1.5dB steps)<br>11111: -34.5dB                                    |
| 5Ch<br>Additional<br>Analogue<br>Functions | 8    | DS      | 0              | Differential Microphone Select<br>0 : Use MIC1 and MIC2<br>1: Use LINEL and LINER (Note 2)                            |

**Table 3 Microphone Input Control**

**Note:**

1. The 20dB gain boost acts on the input to the phone mixer only. A separate microphone boost for recording can be enabled using the BOOST bit in register 1Ah.
2. When the LINEL and LINER are selected for differential microphone select then the MIC1 and MIC2 input pins become disabled, these signals can therefore not be routed internally to the device.

**MICROPHONE BIAS**

The MICBIAS output (pin 28) provides a low noise reference voltage suitable for biasing electret type microphones and the associated external resistor biasing network. The internal MICBIAS circuitry is shown below. Note that the maximum source current capability for MICBIAS is 3mA. The external biasing resistors and microphone cartridge therefore must limit the MICBIAS current to 3mA.

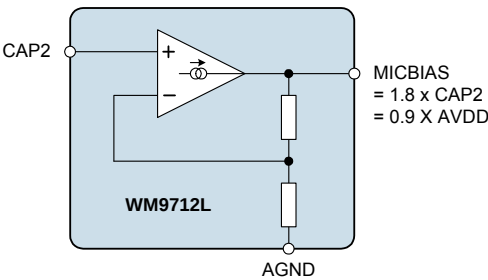


Figure 2 Microphone Bias Schematic

PHONE INPUT

Pin 20 (PHONE) is a mono, line level input designed to connect to the receive path of a telephony device.

The pin connects directly to the record selector for phone call recording (Note: to record both sides of a phone call, one ADC channel should record the PHONE signal while the other channel records the MIC signal). The RECVOL PGA adjusts the recording volume, controlled by register 1Ch or by the ALC function.

To listen to the PHONE signal, the signal passes through a separate PGA, controlled by register 0Ch. The signal can be routed into the headphone mixer (for normal phone call operation) and/or the speaker mixer (for speakerphone operation), but not into the phone mixer (to prevent forming a feedback loop). When the phone input is not used, the phone-in PGA can be switched off to save power (see “Power Management” section).

PHONE is biased internally to the reference voltage VREF. Whenever the input is muted or the device placed into standby mode, the input remains biased to VREF using special anti-thump circuitry to suppress any audible clicks when changing inputs.

| REGISTER ADDRESS   | BIT | LABEL     | DEFAULT     | DESCRIPTION                                                             |
|--------------------|-----|-----------|-------------|-------------------------------------------------------------------------|
| 0Ch<br>Phone Input | 15  | P2H       | 1           | Mute PHONE path to headphone mixer<br>1: Mute, 0: No mute (ON)          |
|                    | 14  | P2S       | 1           | Mute PHONE path to speaker mixer<br>1: Mute, 0: No mute (ON)            |
|                    | 4:0 | PHONE VOL | 01000 (0dB) | PHONE input gain<br>00000: +12dB<br>... (1.5dB steps)<br>11111: -34.5dB |

Table 4 Phone Input Control

**PCBEEP INPUT**

Pin 19 (PCBEEP) is a mono, line level input intended for externally generated signal or warning tones. It is routed directly to the record selector and all three output mixers, without an input amplifier. The signal gain into each mixer can be independently controlled, with a separate mute bit for each signal path.

| REGISTER ADDRESS    | BIT   | LABEL  | DEFAULT      | DESCRIPTION                                                                  |
|---------------------|-------|--------|--------------|------------------------------------------------------------------------------|
| 0Ah<br>PCBEEP input | 15    | B2H    | 1            | Mute PCBEEP path to headphone mixer<br>1: Mute, 0: No mute (ON)              |
|                     | 14:12 | B2HVOL | 010<br>(0dB) | PCBEEP to headphone mixer gain<br>000: +6dB<br>... (3dB steps)<br>111: -15dB |
|                     | 11    | B2S    | 1            | Mute PCBEEP path to speaker mixer<br>1: Mute, 0: No mute (ON)                |
|                     | 10:8  | B2SVOL | 010<br>(0dB) | PCBEEP to speaker mixer gain<br>000: +6dB<br>... (3dB steps)<br>111: -15dB   |
|                     | 7     | B2P    | 1            | Mute PCBEEP path to phone mixer<br>1: Mute, 0: No mute (ON)                  |
|                     | 6:4   | B2PVOL | 010<br>(0dB) | PCBEEP to phone mixer gain<br>000: +6dB<br>... (3dB steps)<br>111: -15dB     |

**Table 5 PCBEEP Control**

## AUDIO ADC

The WM9712L has a stereo sigma-delta ADC to digitize audio signals. The ADC achieves high quality audio recording at low power consumption. The ADC sample rate can be controlled by writing to a control register (see "Variable Rate Audio"). It is independent of the DAC sample rate.

To save power, the left and right ADCs can be separately switched off using the PD11 and PD12 bits, whereas PR0 disables both ADCs (see "Power Management" section). If only one ADC is running, the same ADC data appears on both the left and right AC-Link slots.

### HIGH PASS FILTER

The WM9712L audio ADC incorporates a digital high-pass filter that eliminates any DC bias from the ADC output data. The filter is enabled by default. For DC measurements, it can be disabled by writing a '1' to the HPF bit (register 5Ch, bit 3).

### ADC SLOT MAPPING

By default, the output of the left audio ADC appears on slot 3 of the SDATAIN signal (pin 8), and the right ADC data appears on slot 4. However, the ADC output data can also be sent to other slots, by setting the ASS (ADC slot select) control bits as shown below.

| REGISTER ADDRESS                         | BIT | LABEL | DEFAULT | DESCRIPTION                                                                                                                                                                         |
|------------------------------------------|-----|-------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 5Ch<br>Additional<br>Function<br>Control | 1:0 | ASS   | 00      | ADC to slot mapping<br>00: Left = Slot 3, Right = Slot 4 (default)<br>01: Left = Slot 7, Right = Slot 8<br>10: Left = Slot 6, Right = Slot 9<br>11: Left = Slot 10, Right = Slot 11 |
|                                          | 3   | HPF   | 0       | High-pass filter disable<br>0: Filter enabled (for audio)<br>1: Filter disabled (for DC measurements)                                                                               |

**Table 6** ADC Control

**RECORD SELECTOR**

The record selector determines which input signals are routed into the audio ADC. The left and right channels can be selected independently. This is useful for recording a phone call: one channel can be used for the RX signal and the other for the TX signal, so that both sides of the conversation are digitized.

| REGISTER ADDRESS     | BIT   | LABEL    | DEFAULT | DESCRIPTION                                                                                                                                                                                                         |
|----------------------|-------|----------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1Ah<br>Record Select | 14    | BOOST    | 0       | 20dB Boost<br>1: Boost ADC input signal by 20dB<br>0 :No boost                                                                                                                                                      |
|                      | 13:12 | R2P      | 11      | Record to phone path enable<br>00: Left ADC and Right ADC to phone mixer<br>01 : Left ADC to phone mixer<br>10: Right ADC to phone imixer<br>11 : Muted                                                             |
|                      | 11    | R2PBOOST | 0       | 20dB Boost for ADC to phone signal<br>1: Boost signal by 20dB<br>0 :No boost                                                                                                                                        |
|                      | 10:8  | RECSL    | 000     | Left ADC signal source<br>000: MIC* (pre-PGA)<br>001-010: Reserved (do not use this setting)<br>011: Speaker mix<br>100: LINEINL (pre-PGA)<br>101: Headphone Mix (left)<br>110: Phone Mix<br>111: PHONE (pre-PGA)   |
|                      | 2:0   | RECSR    | 000     | Right ADC signal source<br>000: MIC* (pre-PGA)<br>001-010: Reserved (do not use this setting)<br>011: Speaker mix<br>100: LINEINR (pre-PGA)<br>101: Headphone Mix (right)<br>110: Phone Mix<br>111: PHONE (pre-PGA) |

**Table 7 Audio Record Selector**

**Note:**

\*In stereo mic mode, MIC1 is routed to the left ADC and MIC2 to the right ADC. In all mono mic modes, the same signal (MIC1, MIC2 or MIC1-MIC2) is routed to both the left and right ADCs. See "Microphone Input" section for details.

## RECORD GAIN

The amplitude of the signal that enters the audio ADC is controlled by the Record PGA (Programmable Gain Amplifier). The PGA gain can be programmed either by writing to the Record Gain register, or by the Automatic Level Control (ALC) circuit (see next section). When the ALC is enabled, any writes to the Record Gain register have no effect.

Two different gain ranges can be implemented: the standard gain range defined in the AC'97 standard, or an extended gain range with smaller gain steps. The ALC circuit always uses the extended gain range, as this has been found to result in better sound quality.

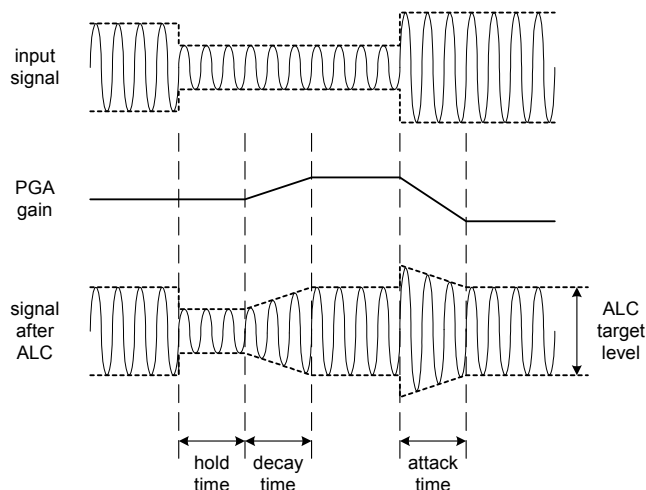
The output of the Record PGA can also be mixed into the phone and/or headphone outputs (see "Audio Mixers"). This makes it possible to use the ALC function for the microphone signal in a smartphone application.

| REGISTER ADDRESS   | BIT  | LABEL   | DEFAULT | DESCRIPTION                                                                                                             |
|--------------------|------|---------|---------|-------------------------------------------------------------------------------------------------------------------------|
| 1Ch<br>Record Gain | 15   | RMU     | 1       | Mute Audio ADC (both channels)<br>1: Mute (OFF)<br>0: No Mute (ON)                                                      |
|                    | 14   | GRL     | 0       | Gain range select (left)<br>0: Standard (0 to 22.5dB, 1.5dB step size)<br>1: Extended (-17.25 to +30dB, 0.75dB steps)   |
|                    | 13:8 | RECVOLL | 000000  | Record Volume (left)                                                                                                    |
|                    |      |         |         | Standard (GRL=0)                                                                                                        |
|                    |      |         |         | Extended (GRL=1)                                                                                                        |
|                    |      |         |         | XX0000: 0dB<br>XX0001: +1.5dB<br>... (1.5dB steps)<br>XX1111: +22.5dB                                                   |
|                    |      |         |         | 000000: -17.25dB<br>000001: -16.5dB<br>... (0.75dB steps)<br>111111: +30dB                                              |
|                    | 7    | ZC      | 0       | Zero Cross Enable<br>0: Record Gain changes immediately<br>1: Record Gain changes when signal is zero or after time-out |
|                    | 6    | GRR     | 0       | Gain range select (right)<br>Similar to GRL                                                                             |
|                    | 5:0  | RECVOLR | 000000  | Record Volume (right)<br>Similar to RECVOLL                                                                             |

**Table 8 Record Gain Register**

## AUTOMATIC LEVEL CONTROL

The WM9712L has an automatic level control that aims to keep a constant recording volume irrespective of the input signal level. This is achieved by continuously adjusting the PGA gain so that the signal level at the ADC input remains constant. A digital peak detector monitors the ADC output and changes the PGA gain if necessary.



**Figure 3 ALC Operation**

The ALC function is enabled using the ALCSEL control bits. When enabled, the recording volume can be programmed between  $-6\text{dB}$  and  $-28.5\text{dB}$  (relative to ADC full scale) using the ALCL register bits.

HLD, DCY and ATK control the hold, decay and attack times, respectively:

**Hold** time is the time delay between the peak level detected being below target and the PGA gain beginning to ramp up. It can be programmed in power-of-two ( $2^n$ ) steps, e.g. 2.67ms, 5.33ms, 10.67ms etc. up to 43.7s. Alternatively, the hold time can also be set to zero. The hold time only applies to gain ramp-up, there is no delay before ramping the gain down when the signal level is above target.

**Decay** (Gain Ramp-Up) Time is the time that it takes for the PGA gain to ramp up across 90% of its range (e.g. from  $-15\text{B}$  up to  $27.75\text{dB}$ ). The time it takes for the recording level to return to its target value therefore depends on both the decay time and on the gain adjustment required. If the gain adjustment is small, it will be shorter than the decay time. The decay time can be programmed in power-of-two ( $2^n$ ) steps, from 24ms, 48ms, 96ms, etc. to 24.58s.

**Attack** (Gain Ramp-Down) Time is the time that it takes for the PGA gain to ramp down across 90% of its range (e.g. from  $27.75\text{dB}$  down to  $-15\text{B}$  gain). The time it takes for the recording level to return to its target value therefore depends on both the attack time and on the gain adjustment required. If the gain adjustment is small, it will be shorter than the attack time. The attack time can be programmed in power-of-two ( $2^n$ ) steps, from 6ms, 12ms, 24ms, etc. to 6.14s.

When operating in stereo, the peak detector takes the maximum of left and right channel peak values, and any new gain setting is applied to both left and right PGAs, so that the stereo image is preserved. However, the ALC function can also be enabled on one channel only. In this case, only one PGA is controlled by the ALC mechanism, while the other channel runs independently with its PGA gain set through the control register.

| REGISTER ADDRESS                | BIT   | LABEL      | DEFAULT         | DESCRIPTION                                                                                                                                                                                                                                                   |
|---------------------------------|-------|------------|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 62h<br>ALC / Noise Gate Control | 15:14 | ALCSEL     | 00<br>(OFF)     | ALC function select<br>00 = ALC off (PGA gain set by register)<br>01 = Right channel only<br>10 = Left channel only<br>11 = Stereo (PGA registers unused)<br>Note: Ensure that RECVOLL and RECVOLR settings (reg. 1Ch) are the same before entering this mode |
|                                 | 13:11 | MAXGAIN    | 111<br>(+30dB)  | PGA gain limit for ALC<br>111 = +30dB<br>110 = +24dB<br>....(6dB steps)<br>001 = -6dB<br>000 = -12dB                                                                                                                                                          |
|                                 | 8     | ALCZC      | 0               | ALC Zero Cross enable (overrides ZC bit in register 1Ch)<br>0: PGA Gain changes immediately<br>1: PGA Gain changes when signal is zero or after time-out                                                                                                      |
|                                 | 9:10  | ZC TIMEOUT | 11              | Programmable zero cross timeout<br>11 $2^{17}$ x MCLK period<br>10 $2^{16}$ x MCLK period<br>01 $2^{15}$ x MCLK period<br>00 $2^{14}$ x MCLK period                                                                                                           |
| 60h<br>ALC Control              | 15:12 | ALCL       | 1011<br>(-12dB) | ALC target – sets signal level at ADC input<br>0000 = -28.5dB FS<br>0001 = -27.0dB FS<br>... (1.5dB steps)<br>1110 = -7.5dB FS<br>1111 = -6dB FS                                                                                                              |
|                                 | 11:8  | HLD        | 0000<br>(0ms)   | ALC hold time before gain is increased.<br>0000 = 0ms<br>0001 = 2.67ms<br>0010 = 5.33ms<br>... (time doubles with every step)<br>1111 = 43.691s                                                                                                               |
|                                 | 7:4   | DCY        | 0011<br>(192ms) | ALC decay (gain ramp-up) time<br>0000 = 24ms<br>0001 = 48ms<br>0010 = 96ms<br>... (time doubles with every step)<br>1010 or higher = 24.58s                                                                                                                   |
|                                 | 3:0   | ATK        | 0010<br>(24ms)  | ALC attack (gain ramp-down) time<br>0000 = 6ms<br>0001 = 12ms<br>0010 = 24ms<br>... (time doubles with every step)<br>1010 or higher = 6.14s                                                                                                                  |

Table 9 ALC Control

**MAXIMUM GAIN**

The MAXGAIN register sets the maximum gain value that the PGA can be set to whilst under the control of the ALC. This has no effect on the PGA when ALC is not enabled.

**PEAK LIMITER**

To prevent clipping when a large signal occurs just after a period of quiet, the ALC circuit includes a limiter function. If the ADC input signal exceeds 87.5% of full scale ( $-1.16\text{dB}$ ), the PGA gain is ramped down at the maximum attack rate (as when  $\text{ATK} = 0000$ ), until the signal level falls below 87.5% of full scale. This function is automatically enabled whenever the ALC is enabled.

(Note: If  $\text{ATK} = 0000$ , then the limiter makes no difference to the operation of the ALC. It is designed to prevent clipping when long attack times are used).

**NOISE GATE**

When the signal is very quiet and consists mainly of noise, the ALC function may cause “noise pumping”, i.e. loud hissing noise during silence periods. The WM9712L has a noise gate function that prevents noise pumping by comparing the signal level at the input pins (i.e. before the record PGA) against a noise gate threshold, NGTH. Provided that the noise gate function is enabled ( $\text{NGAT} = 1$ ), the noise gate cuts in when:

- Signal level at ADC [dB] < NGTH [dB] + PGA gain [dB] + Mic Boost gain [dB]

This is equivalent to:

- Signal level at input pin [dB] < NGTH [dB]

The PGA gain is then held constant (preventing it from ramping up as it normally would when the signal is quiet). If the NGG bit is set, the ADC output is also muted when the noise gate cuts in.

The table below summarises the noise gate control register. The NGTH control bits set the noise gate threshold with respect to the ADC full-scale range. The threshold is adjusted in 1.5dB steps. Levels at the extremes of the range may cause inappropriate operation, so care should be taken with set-up of the function. Note that the noise gate only works in conjunction with the ALC function, and always operates on the same channel(s) as the ALC (left, right, both, or none).

| REGISTER ADDRESS                | BIT | LABEL     | DEFAULT | DESCRIPTION                                                                                                                                              |
|---------------------------------|-----|-----------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| 62h<br>ALC / Noise Gate Control | 7   | NGAT      | 0       | Noise gate function enable<br>1 = enable<br>0 = disable                                                                                                  |
|                                 | 5   | NGG       | 0       | Noise gate type<br>0 = PGA gain held constant<br>1 = mute ADC output                                                                                     |
|                                 | 4:0 | NGTH(4:0) | 00000   | Noise gate threshold<br>00000: $-76.5\text{dBFS}$<br>00001: $-75\text{dBFS}$<br>... 1.5 dB steps<br>11110: $-31.5\text{dBFS}$<br>11111: $-30\text{dBFS}$ |

**Table 10 Noise Gate Control**

## AUDIO DACS

### STEREO DAC

The WM9712L has a stereo sigma-delta DAC that achieves high quality audio playback at low power consumption. Digital tone control, adaptive bass boost and 3-D enhancement functions operate on the digital audio data before it is passed to the stereo DAC. (Contrary to the AC'97 specification, they have no effect on analogue input signals or signals played through the auxiliary DAC. Nevertheless, the ID2 and ID5 bits in the reset register, 00h, are set to '1' to indicate that the WM9712L supports tone control and bass boost.)

The DAC output has a PGA for volume control. The DAC sample rate can be controlled by writing to a control register (see "Variable Rate Audio"). It is independent of the ADC sample rate. The left and right DACs can be separately powered down using the PD13 and PD14 control bits, whereas the PR1 bit disables both DACs (see "Power Management" section).

#### STEREO DAC VOLUME

The volume of the DAC output signal is controlled by a PGA (Programmable Gain Amplifier). It can be mixed into the headphone, speaker and phone output paths (see "Audio Mixers").

| REGISTER ADDRESS                      | BIT  | LABEL       | DEFAULT        | DESCRIPTION                                                                                                                  |
|---------------------------------------|------|-------------|----------------|------------------------------------------------------------------------------------------------------------------------------|
| 18h<br>DAC<br>Volume                  | 15   | D2H         | 1              | Mute DAC path to headphone mixer<br>1: Mute, 0: No mute (ON)                                                                 |
|                                       | 14   | D2S         | 1              | Mute DAC path to speaker mixer<br>1: Mute, 0: No mute (ON)                                                                   |
|                                       | 13   | D2P         | 1              | Mute DAC path to phone mixer<br>1: Mute, 0: No mute (ON)                                                                     |
|                                       | 12:8 | DACL<br>VOL | 01000<br>(0dB) | Left DAC Volume<br>00000: +12dB<br>... (1.5dB steps)<br>11111: -34.5dB                                                       |
|                                       | 4:0  | DACR<br>VOL | 01000<br>(0dB) | Right DAC Volume<br>similar to DACLVOL                                                                                       |
| 5Ch<br>Additional<br>Functions<br>(1) | 15   | AMUTE       | 0              | Read-only bit to indicate auto-muting<br>1: DAC auto-muted<br>0: DAC not muted                                               |
|                                       | 7    | AMEN        | 0              | DAC Auto-Mute Enable<br>1: Automatically mutes analogue output of<br>stereo DAC if digital input is zero<br>0: Auto-mute OFF |

Table 11 Stereo DAC Volume Control

**TONE CONTROL / BASS BOOST**

The WM9712L provides separate controls for bass and treble with programmable gains and filter characteristics. This function operates on digital audio data before it is passed to the audio DACs.

Bass control can take two different forms:

- Linear bass control: bass signals are amplified or attenuated by a user programmable gain. This is independent of signal volume, and very high bass gains on loud signals may lead to signal clipping.
- Adaptive bass boost: The bass volume is amplified by a variable gain. When the bass volume is low, it is boosted more than when the bass volume is high. This method is recommended because it prevents clipping, and usually sounds more pleasant to the human ear.

Treble control applies a user programmable gain, without any adaptive boost function.

Treble, linear bass and 3D enhancement can all produce signals that exceed full-scale. In order to avoid limiting under these conditions, it is recommended to set the DAT bit to attenuate the digital input signal by 6dB. The gain at the outputs should be increased by 6dB to compensate for the attenuation. Cut-only tone adjustment and adaptive bass boost cannot produce signals above full-scale and therefore do not require the DAT bit to be set.

| REGISTER ADDRESS        | BIT  | LABEL | DEFAULT            | DESCRIPTION                                                                                                                            |
|-------------------------|------|-------|--------------------|----------------------------------------------------------------------------------------------------------------------------------------|
| 08h<br>DAC Tone Control | 15   | BB    | 0                  | Bass Mode<br>0 = Linear bass control<br>1 = Adaptive bass boost                                                                        |
|                         | 12   | BC    | 0                  | Bass Cut-off Frequency<br>0 = Low (130Hz at 48kHz sampling)<br>1 = High (200Hz at 48kHz sampling)                                      |
|                         | 11:8 | BASS  | 1111<br>(OFF)      | Bass Intensity                                                                                                                         |
|                         |      |       |                    | Code      BB=0      BB=1                                                                                                               |
|                         |      |       |                    | 0000      +9dB      15 (max)                                                                                                           |
|                         |      |       |                    | 0001      +9dB      14                                                                                                                 |
|                         |      |       |                    | 0010      +7.5dB      13                                                                                                               |
|                         |      |       |                    | ...      (1.5dB steps)      ...                                                                                                        |
|                         |      |       |                    | 0111      0dB      8                                                                                                                   |
|                         |      |       |                    | ...      (1.5dB steps)      ...                                                                                                        |
|                         |      |       |                    | 1011-1101      -6dB      4-2                                                                                                           |
|                         |      |       |                    | 1110      -6dB      1 (min)                                                                                                            |
|                         |      |       |                    | 1111      Bypass (OFF)                                                                                                                 |
|                         | 6    | DAT   | 0                  | -6dB attenuation<br>0 = Off<br>1 = On                                                                                                  |
|                         | 4    | TC    | 0                  | Treble Cut-off Frequency<br>0 = High (8kHz at 48kHz sampling)<br>1 = Low (4kHz at 48kHz sampling)                                      |
|                         | 3:0  | TRBL  | 1111<br>(Disabled) | Treble Intensity<br>0000 or 0001 = +9dB<br>0010 = +7.5dB<br>... (1.5dB steps)<br>1011 to 1110 = -6dB<br>1111 = Treble Control Disabled |

**Table 12 DAC Tone Control**

**Note:**

1. All cut-off frequencies change proportionally with the DAC sample rate.

**3D STEREO ENHANCEMENT**

The 3D stereo enhancement function artificially increases the separation between the left and right channels by amplifying the (L-R) difference signal in the frequency range where the human ear is sensitive to directionality. The programmable 3D depth setting controls the degree of stereo expansion introduced by the function. Additionally, the upper and lower limits of the frequency range used for 3D enhancement can be selected using the 3DFILT control bits.

| REGISTER ADDRESS       | BIT | LABEL   | DEFAULT         | DESCRIPTION                                                                                           |
|------------------------|-----|---------|-----------------|-------------------------------------------------------------------------------------------------------|
| 20h<br>General Purpose | 13  | 3DE     | 0<br>(disabled) | 3D enhancement enable                                                                                 |
| 22h<br>DAC 3D Control  | 5   | 3DLC    | 0               | Lower Cut-off Frequency<br>0 = Low (200Hz at 48kHz sampling)<br>1 = High (500Hz at 48kHz sampling)    |
|                        | 4   | 3DUC    | 0               | Upper Cut-off Frequency<br>0 = High (2.2kHz at 48kHz sampling)<br>1 = Low (1.5kHz at 48kHz sampling)  |
|                        | 3:0 | 3DDEPTH | 0000            | 3D Depth<br>0000: 0% (minimum 3D effect)<br>0001: 6.67%<br>...<br>1110: 93.3%<br>1111: 100% (maximum) |

**Table 13 Stereo Enhancement Control****Note:**

1. All cut-off frequencies change proportionally with the DAC sample rate.

## AUXILIARY DAC

AUXDAC is a simple 12-bit mono DAC. It can be used to generate DC signals (with the numeric input written into a control register), or AC signals such as telephone-quality ring tones or system beeps (with the input signal supplied through an AC-Link slot). In AC mode (XSLE = 1), the input data is binary offset coded; in DC mode (XSLE = 0), there is no offset.

The analogue output of AUXDAC is routed directly into the output mixers. The signal gain into each mixer can be adjusted at the mixer inputs using control register 12h. In slot mode (XSLE = 1), the AUXDAC also supports variable sample rates (See "Variable Rate Audio" section).

When the auxiliary DAC is not used, it can be powered down by setting AXE = 0. This is also the default setting.

| REGISTER ADDRESS             | BIT   | LABEL      | DEFAULT   | DESCRIPTION                                                                                                                                                                                                                                                                                                                                            |
|------------------------------|-------|------------|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 64h<br>AUXDAC Input Control  | 15    | XSLE       | 0         | AUXDAC input selection<br>0: from AUXDACVAL (for DC signals)<br>1: from AC-Link slot selected by AUXDACSLT (for AC signals)                                                                                                                                                                                                                            |
|                              | 14:12 | AUXDAC SLT | 000       | AUXDAC Input Selection<br>000 – Slot 5, bits 8-19 (with XSLE=1)<br>001 – Slot 6, bits 8-19 (with XSLE=1)<br>010 – Slot 7, bits 8-19 (with XSLE=1)<br>011 – Slot 8, bits 8-19 (with XSLE=1)<br>100 – Slot 9, bits 8-19 (with XSLE=1)<br>101 – Slot 10, bits 8-19 (with XSLE=1)<br>110 – Slot 11, bits 8-19 (with XSLE=1)<br>111 – RESERVED (do not use) |
|                              | 11:0  | AUXDAC VAL | 000h      | AUXDAC Digital Input (with XSLE=0)<br>000h: minimum<br>FFFh: full-scale                                                                                                                                                                                                                                                                                |
| 12h<br>AUXDAC Output Control | 15    | A2H        | 1         | Mute AUXDAC path to headphone mixer<br>1: Mute, 0: No mute (ON)                                                                                                                                                                                                                                                                                        |
|                              | 14:12 | A2HVOL     | 010 (0dB) | AUXDAC to headphone mixer gain<br>000: +6dB<br>... (3dB steps)<br>111: -15dB                                                                                                                                                                                                                                                                           |
|                              | 11    | A2S        | 1         | Mute AUXDAC path to speaker mixer<br>1: Mute, 0: No mute (ON)                                                                                                                                                                                                                                                                                          |
|                              | 10:8  | A2SVOL     | 010 (0dB) | AUXDAC to speaker mixer gain<br>000: +6dB<br>... (3dB steps)<br>111: -15dB                                                                                                                                                                                                                                                                             |
|                              | 7     | A2P        | 1         | Mute AUXDAC path to phone mixer<br>1: Mute, 0: No mute (ON)                                                                                                                                                                                                                                                                                            |
|                              | 6:4   | A2PVOL     | 010 (0dB) | AUXDAC to phone mixer gain<br>000: +6dB<br>... (3dB steps)<br>111: -15dB                                                                                                                                                                                                                                                                               |
|                              | 0     | AXE        | 0         | 0: AUXDAC off<br>1: AUXDAC enabled                                                                                                                                                                                                                                                                                                                     |

Table 14 AUXDAC Control

## ANALOGUE AUDIO OUTPUTS

The following sections give an overview of the analogue audio output pins. For more information on recommended external components, please refer to the “Applications Information” section.

### HEADPHONE OUTPUTS – HPOUTL AND HPOUTR

The HPOUTL and HPOUTR (pins 39 and 41) are designed to drive a 16Ω or 32Ω headphone or a line output. They can also be used as line-out pins. The output signal is produced by the headphone mixer.

The signal volume on HPOUTL and HPOUTR can be independently adjusted under software control by writing to register 04h. When HPOUTL and HPOUTR are not used, the output drivers can be disabled to save power (see “Power Management” section). Both pins remain at the same DC level (the reference voltage VREF) when they are disabled, so that no click noise is produced.

| REGISTER ADDRESS                    | BIT  | LABEL     | DEFAULT         | DESCRIPTION                                                                                                         |
|-------------------------------------|------|-----------|-----------------|---------------------------------------------------------------------------------------------------------------------|
| 04h<br>HPOUTL /<br>HPOUTR<br>Volume | 15   | MUTE      | 1               | Mute HPOUTL and HPOUTR<br>1: Mute (OFF)<br>0: No Mute (ON)                                                          |
|                                     | 13:8 | HPOUTLVOL | 000000<br>(0dB) | HPOUTL Volume<br>000000: 0dB (maximum)<br>000001: -1.5dB<br>... (1.5dB steps)<br>011111: -46.5dB<br>1xxxxx: -46.5dB |
|                                     | 7    | ZC        | 0               | Zero Cross Enable<br>0: Change gain immediately<br>1: Change gain only on zero crossings,<br>or after time-out      |
|                                     | 5:0  | HPOUTRVOL | 00000<br>(0dB)  | HPOUTR Volume<br>Similar to HPOUTLVOL                                                                               |

Table 15 HPOUTL / HPOUTR Control

**EAR SPEAKER OUTPUT – OUT3**

Pin 37 (OUT3) has a buffer that can drive load impedances down to 16Ω. It can be used to:

- Drive an ear speaker (phone receiver). The speaker can be connected differentially between OUT3 and HPOUTL, or in single-ended configuration (OUT3 to HPGND). The ear speaker output is produced by the headphone mixer. The right signal must be inverted (OUT3INV = 1), so that the left and right channel are mixed to mono in the speaker  $[L - (-R) = L + R]$ .
- Eliminate the DC blocking capacitors on HPOUTL and HPOUTR. In this configuration, OUT3 produces a buffered midrail voltage (AVDD/2) and is connected to the headphone socket's ground pin (see "Applications Information")
- Produce the inverse of the MONOOUT signal, for a differential mono output.

Note: OUT3 can only handle one of the above functions at any given time.

| REGISTER ADDRESS       | BIT  | LABEL       | DEFAULT         | DESCRIPTION                                                                                                       |
|------------------------|------|-------------|-----------------|-------------------------------------------------------------------------------------------------------------------|
| 16h<br>OUT3<br>Control | 15   | MUTE        | 1               | Mute OUT3<br>1: Mute (Buffer OFF)<br>0: No Mute (Buffer ON)                                                       |
|                        | 10:9 | OUT3<br>SRC | 00              | Source of OUT3 signal                                                                                             |
|                        |      |             |                 | 00 inverse of HPOUTR<br>(for BTL ear speaker)                                                                     |
|                        |      |             |                 | 01 VREF (for capless headphone drive)                                                                             |
|                        |      |             |                 | 10 mono mix of both headphone channels<br>(for single-ended ear speaker)                                          |
|                        |      |             |                 | 11 inverse of MONOOUT<br>(for differential mono output)                                                           |
|                        | 7    | ZC          | 0               | Zero Cross Enable<br>0: Change gain immediately<br>1: Change gain only on zero crossings, or after<br>time-out    |
|                        | 5:0  | OUT3<br>VOL | 000000<br>(0dB) | OUT3 Volume<br>000000: 0dB (maximum)<br>000001: -1.5dB<br>... (1.5dB steps)<br>011111: -46.5dB<br>1xxxxx: -46.5dB |

**Table 16 OUT3 Control**

## LOUDSPEAKER OUTPUTS – LOUT2 AND ROUT2

The LOUT2 and ROUT2 outputs are designed to differentially drive an 8Ω mono speaker. They can also be used as a stereo line-out or headphone output.

For speaker drive, the LOUT2 signal must be inverted (INV = 1), so that the left and right channel are added up in the speaker  $[R - (-L) = R + L]$ .

| REGISTER ADDRESS             | BIT  | LABEL    | DEFAULT        | DESCRIPTION                                                                                                        |
|------------------------------|------|----------|----------------|--------------------------------------------------------------------------------------------------------------------|
| 02h<br>LOUT2/ROUT2<br>Volume | 15   | MUTE     | 1              | Mute LOUT2 and ROUT2<br>1: Mute (OFF)<br>0: No Mute (ON)                                                           |
|                              | 13:8 | LOUT2VOL | 00000<br>(0dB) | LOUT2 Volume<br>000000: 0dB (maximum)<br>000001: -1.5dB<br>... (1.5dB steps)<br>011111: -46.5dB<br>1xxxxx: -46.5dB |
|                              | 7    | ZC       | 0              | Zero Cross Enable<br>0: Change gain immediately<br>1: Change gain only on zero crossings,<br>or after time-out     |
|                              | 6    | INV      | 0              | LOUT2 Invert<br>0 = No Inversion (0° phase shift)<br>1 = Signal inverted (180° phase shift)                        |
|                              | 5:0  | ROUT2VOL | 00000<br>(0dB) | ROUT2 Volume<br>Similar to LOUT2VOL                                                                                |
| 16h                          | 8    | SRC      | 0              | Source of LOUT2/ROUT2 signals<br>0: speaker mixer (for BTL speaker)<br>1: headphone mixer (for stereo output)      |

**Table 17 LOUT2 / ROUT2 Control**

**Note:**

- For BTL speaker drive, it is recommended that LOUT2VOL = ROUT2VOL.

## PHONE OUTPUT (MONOOUT)

The MONOOUT output (pin 33) is intended for connection to the TX side of a wireless chipset. The signal is generated in a dedicated mono mixer; it is not necessarily a mono mix of the stereo outputs HPOUTL/R or LOUT2/ROUT2 (see “Audio Mixers” section).

The MONOOUT volume can be controlled by writing to register 06h. When MONOOUT is not used, the output buffer can be disabled to save power (see “Power Management” section). The MONOOUT pin remains at the same DC level (the reference voltage on the VREF pin), so that no click noise is produced when muting or un-muting.

| REGISTER ADDRESS         | BIT | LABEL       | DEFAULT     | DESCRIPTION                                                                                                 |
|--------------------------|-----|-------------|-------------|-------------------------------------------------------------------------------------------------------------|
| 06h<br>MONOOUT<br>Volume | 15  | MUTE        | 1           | Mute MONOOUT<br>1: Mute<br>0: No Mute                                                                       |
|                          | 7   | ZC          | 0           | Zero Cross Enable<br>0: Change gain immediately<br>1: Change gain only on zero crossings, or after time-out |
|                          | 4:0 | MONOOUT VOL | 00000 (0dB) | MONOOUT Volume<br>00000: 0dB (maximum)<br>00001: -1.5dB<br>... (1.5dB steps)<br>11111: -46.5dB              |

Table 18 MONOOUT Control

## THERMAL SENSOR

The speaker and headphone outputs can drive very large currents. To protect the WM9712L from becoming too hot, a thermal sensor has been built in. If the chip temperature reaches approximately 150°C, and the ENT bit is set, the WM9712L asserts GPIO bit 11 in register 54h, a virtual GPIO that can be set up to generate an interrupt to the CPU (see “GPIO and Interrupt Control” section).

| REGISTER ADDRESS | BIT | LABEL | DEFAULT | DESCRIPTION                                                                                                                                 |
|------------------|-----|-------|---------|---------------------------------------------------------------------------------------------------------------------------------------------|
| 5Ch              | 2   | ENT   | 0       | Enable thermal sensor<br>0: Disabled<br>1: Enabled                                                                                          |
| 54h              | 11  | TI    | 1       | Thermal sensor (virtual GPIO)<br>1: Temperature below 150°C<br>0: Temperature above 150°C<br>See also “GPIO and Interrupt Control” section. |

Table 19 Thermal Cutout Control

## JACK INSERTION AND AUTO-SWITCHING

In a phone application, a BTL ear speaker may be connected across OUT3 and HPOUTL, and a stereo headphone on HPOUTL and HPOUTR. Typically, only one of these two output devices is used at any given time: when no headphone is plugged in, the BTL ear speaker is active, otherwise the headphone is used.

The presence of a headphone can be detected using GPIO1 (pin 44) and an external pull-up resistor (see “Applications Information” section for a circuit diagram). When the jack is inserted GPIO1 is pulled low by a switch on the socket. When the jack is removed GPIO1 is pulled high by a resistor. If the JIEN bit is set, the WM9712L automatically switches between headphone and ear speaker, as shown below.

| REGISTER ADDRESS                     | BIT | LABEL | DEFAULT | DESCRIPTION                                      |
|--------------------------------------|-----|-------|---------|--------------------------------------------------|
| 58h<br>Additional Functional Control | 12  | JIEN  | 0       | Jack Insert Enable – Takes output of GPIO1 logic |
|                                      | 11  | FRC   | 0       | Force Ear Speaker Mode<br>See table below        |

Table 20 Jack Insertion / Auto-Switching (1)

| JIEN | FRC | GPIO1 | MODE DESCRIPTION                                                                        | OUT3 STATE              | HPOUTL VOLUME   | HPOUTR VOLUME   | OUT3 VOLUME     | HPOUTL/HPOUTR STATE     |
|------|-----|-------|-----------------------------------------------------------------------------------------|-------------------------|-----------------|-----------------|-----------------|-------------------------|
| 0    | 0   | X     | Jack insert detection disabled (headphone and ear speaker can be used at the same time) | Set by reg. 24h and 26h | Set by reg. 04h |                 |                 |                         |
| 1    | 0   | 0     | Jack insert detection enabled, headphone plugged in                                     | Disabled                |                 |                 |                 |                         |
| 1    | X   | 1     | Jack insert detection enabled, headphone not plugged in                                 | Set by reg. 24h and 26h | Set by reg. 16h | Set by reg. 04h | Set by reg. 16h | Set by reg. 24h and 26h |
| 0    | 1   | X     | Force Ear Speaker Mode                                                                  |                         |                 |                 |                 |                         |
| 1    | 1   | X     | Invalid; do not use this setting                                                        |                         |                 |                 |                 |                         |

Table 21 Jack Insertion / Auto-Switching (2)

## DIGITAL AUDIO (SPDIF) OUTPUT

The WM9712L supports the SPDIF standard using pin 47 as its output. Note that pin 47 can also be used as a GPIO pin. The GE5 bit (register 56h, bit 5) selects between GPIO and SPDIF functionality (see "GPIO and Interrupt control" section).

Register 3Ah is a read/write register that controls SPDIF functionality and manages bit fields propagated as channel status (or sub-frame in the V case). With the exception of V, this register should only be written to when the SPDIF transmitter is disabled (SPDIF bit in register 2Ah is '0'). Once the desired values have been written to this register, the contents should be read back to ensure that the sample rate in particular is supported, then SPDIF validity bit SPCV in register 2Ah should be read to ensure the desired configuration is valid. Only then should the SPDIF enable bit in register 2Ah be set. This ensures that control and status information start up correctly at the beginning of SPDIF transmission.

| REGISTER ADDRESS                   | BIT   | LABEL | DEFAULT | DESCRIPTION                                                                                                                    |
|------------------------------------|-------|-------|---------|--------------------------------------------------------------------------------------------------------------------------------|
| 2Ah<br>Extended Audio              | 10    | SPCV  | 0       | SPDIF validity bit (read-only)                                                                                                 |
|                                    | 5:4   | SPSA  | 01      | SPDIF slot assignment (ADCO = 0)<br>00: Slots 3, 4<br>01: Slots 6, 9<br>10: Slots 7, 8<br>11: Slots 10, 11                     |
|                                    | 2     | SEN   | 0       | SPDIF output enable<br>1 = enabled, 0 = disabled                                                                               |
| 3Ah<br>SPDIF Control Register      | 15    | V     | 0       | Validity bit; '0' indicates frame valid, '1' indicates frame not valid                                                         |
|                                    | 14    | DRS   | 0       | Indicates that the WM9712L does not support double rate SPDIF output (read-only)                                               |
|                                    | 13:12 | SPSR  | 10      | Indicates that the WM9712L only supports 48kHz sampling on the SPDIF output (read-only)                                        |
|                                    | 11    | L     | 0       | Generation level; programmed as required by user                                                                               |
|                                    | 10:4  | CC    | 0000000 | Category code; programmed as required by user                                                                                  |
|                                    | 3     | PRE   | 0       | Pre-emphasis; '0' indicates no pre-emphasis, '1' indicates 50/15us pre-emphasis                                                |
|                                    | 2     | COPY  | 0       | Copyright; '0' indicates copyright is not asserted, '1' indicates copyright                                                    |
|                                    | 1     | AUDIB | 0       | Non-audio; '0' indicates data is PCM, '1' indicates non-PCM format (e.g. DD or DTS)                                            |
|                                    | 0     | PRO   | 0       | Professional; '0' indicates consumer, '1' indicates professional                                                               |
| 5Ch<br>Additional Function Control | 4     | ADCO  | 0       | Source of SPDIF data<br>0: SPDIF data comes from SDATAOUT (pin 5), slot selected by SPSA<br>1: SPDIF data comes from audio ADC |

Table 22 SPDIF Output Control

## AUDIO MIXERS

### MIXER OVERVIEW

The WM9712L has three separate low-power audio mixers to cover all audio functions required by smartphones, PDAs and handheld computers. The diagram below shows the routing of the analogue audio signals into the mixers. The numbers at the mixer inputs refer to the control register bits that control the volume and muting for that particular signal.

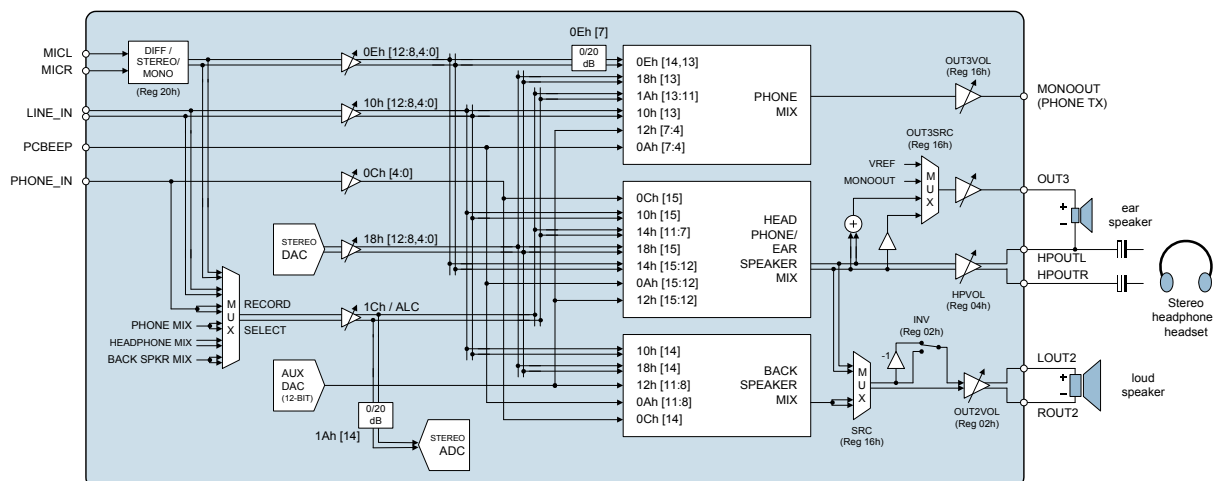


Figure 4 Audio Mixer Overview

### HEADPHONE MIXER

The headphone mixer drives the HPOUTL and HPOUTR outputs. It also drives OUT3, if this pin is connected to an ear speaker (phone receiver). The following signals can be mixed into the headphone path:

- PHONE (controlled by register 0Ch, see "Audio Inputs")
- LINE\_IN (controlled by register 10h, see "Audio Inputs")
- the output of the Record PGA (see "Audio ADC", "Record Gain")
- the stereo DAC signal (controlled by register 18h, see "Audio DACs")
- the MIC signal (controlled by register 0Eh, see "Audio Inputs")
- PC\_BEEP (controlled by register 0Ah, see "Audio Inputs")
- the AUXDAC signal (controlled by register 12h, see "Auxiliary DAC")

In a typical smartphone application, the headphone signal is a mix of PHONE and sidetone (for phone calls) and the stereo DAC signal (for music playback).

## SPEAKER MIXER

The speaker mixer drives the LOUT2 and ROUT2 output. The following signals can be mixed into the speaker path:

- PHONE (controlled by register 0Ch, see "Audio Inputs")
- LINE\_IN (controlled by register 10h, see "Audio Inputs")
- the stereo DAC signal (controlled by register 18h, see "Audio DACs")
- PC\_BEEP (controlled by register 0Ah, see "Audio Inputs")
- the AUXDAC signal (controlled by register 12h, see "Auxiliary DAC")

In a typical smartphone application, the speaker signal is a mix of AUXDAC (for system alerts or ring tone playback), PHONE (for speakerphone function), and PC\_BEEP (for externally generated ring tones).

## MONO MIXER

The mono mixer drives the MONOOUT pin. The following signals can be mixed into MONOOUT:

- LINE\_IN (controlled by register 10h, see "Audio Inputs")
- the output of the Record PGA (see "Audio ADC", "Record Gain")
- the stereo DAC signal (controlled by register 18h, see "Audio DACs")
- the MIC signal (controlled by register 10h, see "Audio Inputs")
- PC\_BEEP (controlled by register 0Ah, see "Audio Inputs")
- the AUXDAC signal (controlled by register 12h, see "Auxiliary DAC")

In a typical smartphone application, the MONOOUT signal is a mix of the amplified microphone signal (possibly with Automatic Gain Control) and (if enabled) an audio playback signal from the stereo DAC or the auxiliary DAC.

## SIDE TONE CONTROL

The side tone path is into the headphone mixer and is either from the MIC or ALC path (with no 20dB boost)

| REGISTER ADDRESS        | BIT   | LABEL  | DEFAULT      | DESCRIPTION                                                                                    |
|-------------------------|-------|--------|--------------|------------------------------------------------------------------------------------------------|
| 14h<br>Sidetone Control | 15    | STM    | 1            | MIC side tone select<br>0: selected<br>1 : not selected (path muted)                           |
|                         | 14:12 | STVOL  | 010<br>(0dB) | MIC Sidetone volume<br>000 : +6dB (max.)<br>001: +3dB<br>... (3dB steps)<br>111 : -15dB (min.) |
|                         | 11:10 | ALCM   | 11           | ALC side tone select<br>11: mute<br>10: mono – left<br>01: mono – right<br>00: stereo          |
|                         | 9:7   | ALCVOL | 010<br>(0dB) | ALC Sidetone volume<br>Similar to STVOL                                                        |

Table 23 Side Tone Control

## VARIABLE RATE AUDIO / SAMPLE RATE CONVERSION

By using an AC'97 Rev2.2 compliant audio interface, the WM9712L can record and playback at all commonly used audio sample rates, and offer full split-rate support (i.e. the DAC, ADC and AUXDAC sample rates are completely independent of each other – any combination is possible).

The default sample rate is 48kHz. If the VRA bit in register 2Ah is set and the appropriate block is enabled, then other sample rates can be selected by writing to registers 2Ch, 32h and 2Eh. The AC-Link continues to run at 48k frames per second irrespective of the sample rate selected. However, if the sample rate is less than 48kHz, then some frames do not carry an audio sample.

| REGISTER ADDRESS                | BIT  | LABEL     | DEFAULT       | DESCRIPTION                                                                                                                                                                                                                                    |
|---------------------------------|------|-----------|---------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2Ah<br>Extended Audio Stat/Ctrl | 0    | VRA       | 0 (OFF)       | Variable Rate Audio<br>0: OFF (DAC and ADC run at 48kHz)<br>1: ON (sample rates determined by registers 2Ch, 2Eh and 32h)                                                                                                                      |
| 2Ch<br>Audio DAC Sample Rate    | 15:0 | DACSR     | BB80h (48kHz) | Audio DAC sample rate<br>1F40h: 8kHz<br>2B11h: 11.025kHz<br>2EE0h: 12kHz<br>3E80h: 16kHz<br>5622h: 22.05kHz<br>5DC0h: 24kHz<br>7D00h: 32kHz<br>AC44h: 44.1kHz<br>BB80h: 48kHz<br>Any other value defaults to the nearest supported sample rate |
| 32h<br>Audio ADC Sample Rate    | 15:0 | ADCSR     | BB80h (48kHz) | Audio ADC sample rate similar to DACSR                                                                                                                                                                                                         |
| 2Eh<br>AUXDAC Sample Rate       | 15:0 | AUXDA CSR | BB80h (48kHz) | AUXDAC sample rate similar to DACSR                                                                                                                                                                                                            |

**Table 24 Audio Sample Rate Control**

## TOUCHPANEL INTERFACE

The WM9712L includes a touchpanel driver and digitiser circuit for use with 4-wire or 5-wire resistive touchpanels. The following functions are implemented:

- X co-ordinate measurement
- Y co-ordinate measurement
- Pen down detection, with programmable sensitivity
- Touch pressure measurement (4-wire touchpanel only)
- Auxiliary measurement from COMP1/AUX1 (pin 29), COMP2/AUX2 (pin 30), BMON/AUX3 (pin 31), or WIPER/AUX4 (pin 12)

The touchpanel digitiser uses a very low power, 12-bit successive approximation type ADC. The same ADC can also be used for battery and auxiliary measurements (see the "Battery Alarm and Battery Measurement" and "Auxiliary ADC Inputs" sections).

An on-chip switch matrix connects each touchpanel terminal to the supply voltage TPVDD, to ground (TPGND), or to the ADC input, as required.

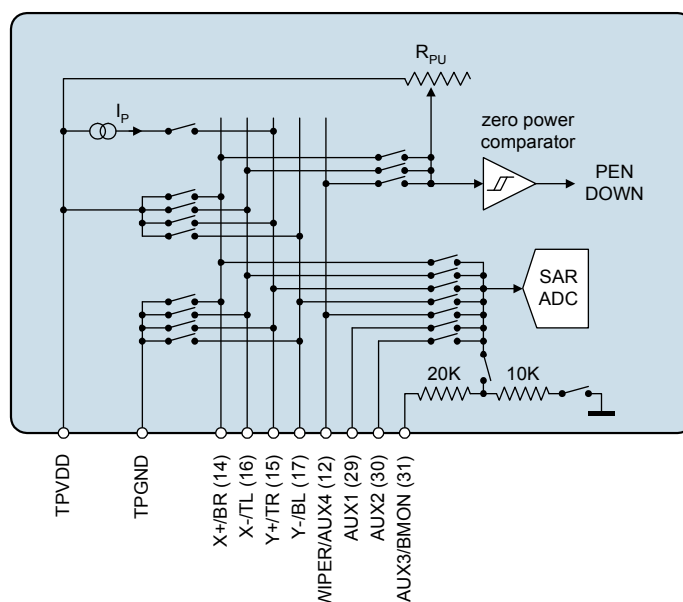


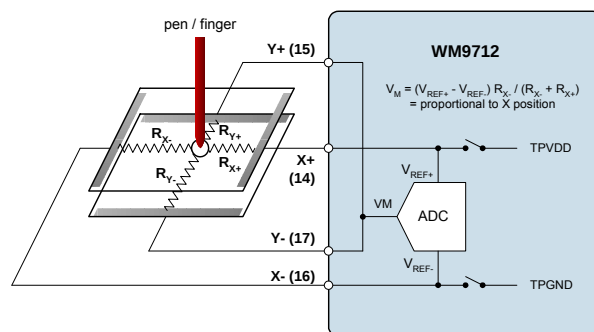
Figure 5 Touchpanel Switch Matrix

### PRINCIPLE OF OPERATION - FOUR-WIRE TOUCHPANEL

Four-wire touchpanels are connected to the WM9712L as follows:

- Right side contact = X+ (pin 14)
- Left side contact = X- (pin 16)
- Top side contact = Y+ (pin 15)
- Bottom side contact = Y- (pin 17)

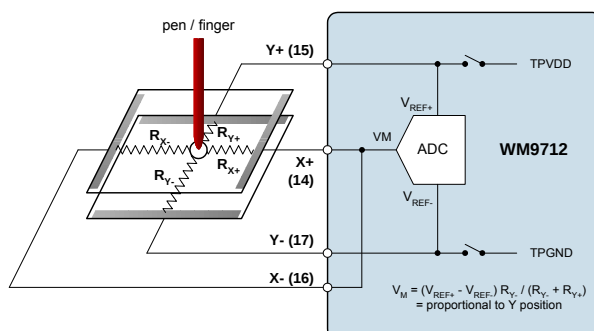
The principle of operation is illustrated below (Note: the illustrations assume that the top plate is used for X and the bottom plate for Y measurements, although the reverse is also possible).



**Figure 6 X Co-ordinate Measurement on 4-wire Touchpanel**

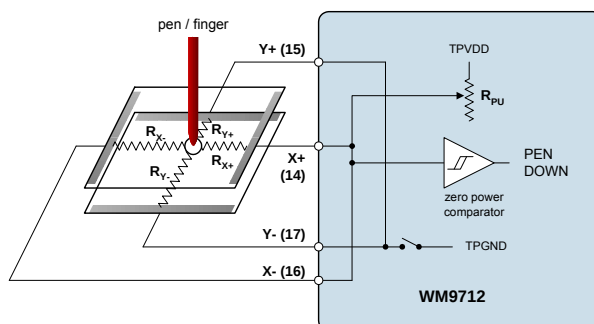
For an X co-ordinate measurement, the X+ pin is internally switched to VDD and X- to GND. The X plate becomes a potential divider, and the voltage at the point of contact is proportional to its X co-ordinate. This voltage is measured on the Y+ and Y- pins, which carry no current (hence there is no voltage drop in  $R_{Y+}$  or  $R_{Y-}$ ).

Due to the ratiometric measurement method, the supply voltage does not affect measurement accuracy. The voltage references  $V_{REF+}$  and  $V_{REF-}$  are taken from after the matrix switches, so that any voltage drop in these switches has no effect on the ADC measurement.



**Figure 7 Y Co-ordinate Measurement on 4-wire Touchpanel**

Y co-ordinate measurements are similar to X co-ordinate measurements, with the X and Y plates interchanged.

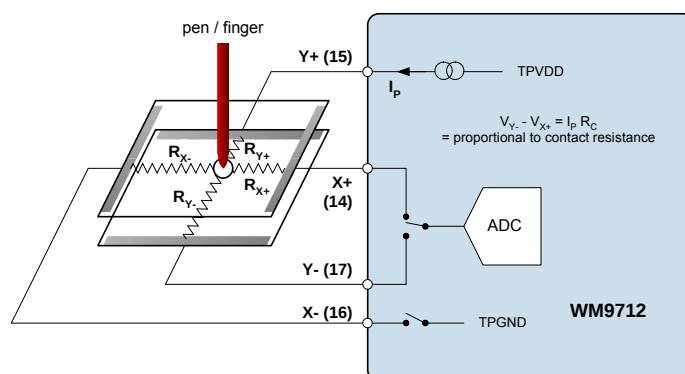


**Figure 8 Pen Down Detection on 4-wire Touchpanel**

Pen down detection uses a zero power comparator (effectively a CMOS logic gate) with an internal, programmable pull-up resistor  $R_{PU}$  that controls pen-down sensitivity. Increasing  $R_{PU}$  makes the touchpanel less sensitive to touch, while lowering  $R_{PU}$  makes it more sensitive.

When the touchpanel is not being touched, no current flows in the circuit, and the PENDOWN signal is low. When the panel is touched with a pen or finger, current flows through  $R_{PU}$  and the panel, and the comparator output goes high.

The PENDOWN signal can be read from bit 15 in register 7Ah (labeled PNDN). It can also be observed on pin 46 (GPIO3 / PENDOWN), if the pin is not used for GPIO (GE3=0). Additionally, PENDOWN is passed to the GPIO logic block (register 54h, bit 13), where it can generate CPU interrupts, and / or to wake up the WM9712L from sleep mode (see "GPIO and Interrupt Control" section).



**Figure 9 Touch Pressure Measurement on 4-wire Touchpanel**

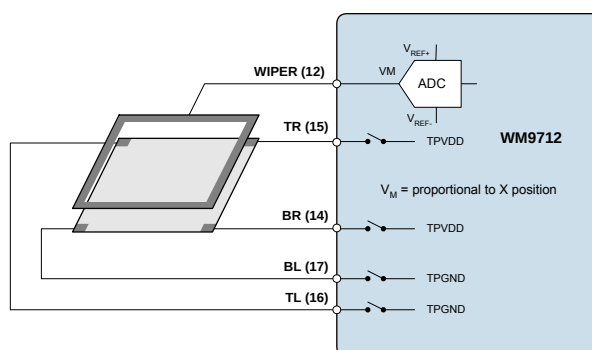
Touch pressure can be determined indirectly by measuring the contact resistance  $R_C$  between the top and bottom plates.  $R_C$  decreases as the touch pressure on the panel increases. The WM9712L measures  $R_C$  by sending a constant current  $I_P$  through the touchpanel and measuring the potential on each plate. The two values are subtracted in the digital domain to obtain the potential difference, which is proportional to  $R_C$ .

To suit different types of touchpanels, the magnitude of  $I_P$  can be set to either 400 $\mu$ A or 200 $\mu$ A using the PIL control bit.

## PRINCIPLE OF OPERATION - FIVE-WIRE TOUCHPANEL

Five-wire touchpanels are connected to the WM9712L as follows:

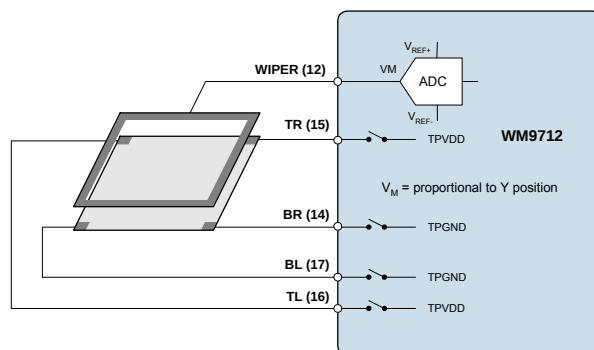
- Top sheet contact = WIPER/AUX4 (pin 12)
- Top left corner of bottom sheet = TL (pin 16)
- Top right corner of bottom sheet = TR (pin 15)
- Bottom left corner of bottom sheet = BL (pin 17)
- Bottom right corner of bottom sheet = BR (pin 14)



**Figure 10 X Co-ordinate Measurement on 5-wire Touchpanel**

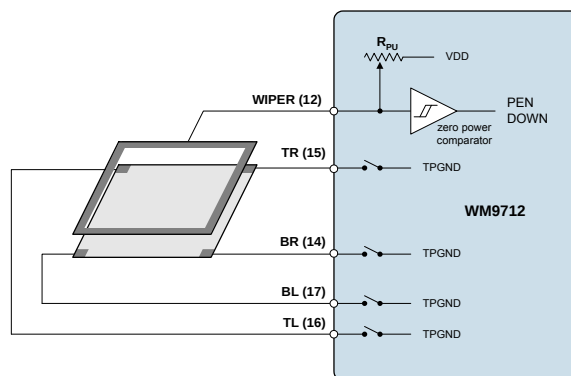
For an X co-ordinate measurement, the top left and bottom left corners of the touchpanel are grounded internally to the WM9712, while the top right and bottom right contacts are connected to TPVDD. The bottom plate becomes a potential divider with a voltage gradient in the X direction. The voltage at the point of contact is proportional to its X co-ordinate. This voltage is measured on the TOP pin and converted to a digital value by the ADC.

Due to the ratiometric measurement method, the supply voltage does not affect measurement accuracy. The voltage references VREF+ and VREF- are taken from after the matrix switches, so that any voltage drop in these switches has no effect on the ADC measurement.



**Figure 11 Y Co-ordinate Measurement on 5-wire Touchpanel**

Y co-ordinate measurements are similar to Y co-ordinate measurements. However, the voltage gradient on the bottom plate is in the Y direction instead of the X direction. This is achieved by grounding the bottom left and bottom right corners of the touchpanel, and connecting the top left and top right contacts to TPVDD.



**Figure 12 Pen Down Detection on 5-wire Touchpanel**

Pen down detection works in a similar fashion for both 4-wire and 5-wire touchpanels (see Four-Wire Touchpanel Operation). On a 5-wire touchpanel, all four contacts of the bottom plate are grounded, and the top plate contact is connected to the internal programmable pull-up resistor,  $R_{PU}$ .

## CONTROLLING THE TOUCHPANEL DIGITISER

All touchpanel functions are accessed and controlled through the AC-Link interface.

### PHYSICAL CHARACTERISTICS

The physical characteristics of the touchpanel interface are controlled through register 78, as shown below.

| REGISTER ADDRESS | BIT | LABEL | DEFAULT                   | DESCRIPTION                                                                                                                                                                                                                                                                                                                    |
|------------------|-----|-------|---------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 78h              | 12  | 45W   | 0 (4-wire)                | Touchpanel Type Selection<br>0: 4-wire<br>1: 5-wire                                                                                                                                                                                                                                                                            |
|                  | 0:5 | RPU   | 000001<br>(64k $\Omega$ ) | Internal Pull-up resistor for Pen Detection<br>000000: RESERVED (do not use this setting)<br>000001: $R_{PU}/1 = \text{TYP } 64\text{k}\Omega$ (most sensitive)<br>000010: $R_{PU}/2 = \text{TYP } 32\text{k}\Omega$<br>... (pull-up = $R_{PU} / \text{binary value of RPU}$ )<br>(Refer to page 9 for $R_{PU}$ specification) |
|                  | 8   | PIL   | 0 (200 $\mu\text{A}$ )    | Current used for pressure measurement<br>0: $I_P = 200\mu\text{A}$<br>1: $I_P = 400\mu\text{A}$                                                                                                                                                                                                                                |

**Table 25 Touchpanel Digitiser Control (Physical Characteristics)**

### POWER MANAGEMENT

To save power, the touchpanel digitiser and the pen-down detector can be independently disabled when they are not used. The power consumption of the pen-down detector is normally negligible, except when the pen is down.

The state of the digitiser and pen down detector is controlled by the following bits.

| REGISTER ADDRESS | BIT   | LABEL | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                                                  |
|------------------|-------|-------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 78h              | 15:14 | PRP   | 00      | Pen ADC/AUX ADC enable<br>00 – Pen digitiser off, pen detect off, no wake-up on pen down (default)<br>01 – Pen digitiser powered off, pen detect enabled, touchpanel digitiser wakes up (changes to state 11) on pen-down<br>10 – Pen digitiser off, pen detect enabled, no wake-up on pen down<br>11 – Pen digitiser and pen detect enabled |
|                  | 13    | RPR   | 0       | Wake-up on pen-down mode<br>0: Wake-up the AC-Link only (hold SDATAIN high until controller sends warm reset or cold reset)<br>1: Wake-up the WM9712L without waiting for a reset signal from the controller                                                                                                                                 |

**Table 26 Touchpanel Digitiser Control (Power Management)**

## INITIATION OF MEASUREMENTS

The WM9712L touchpanel interface supports both polling routines and DMA (direct memory access) to control the flow of data from the touchpanel ADC to the host CPU.

In a polling routine, the CPU starts each measurement individually by writing to the POLL bit (register 76h, bit 15). This bit automatically resets itself when the measurement is completed.

| REGISTER ADDRESS | BIT | LABEL | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                                                                                                                 |
|------------------|-----|-------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 76h              | 10  | CTC   | 0       | 0: Polling mode<br>1: Continuous mode (for DMA)                                                                                                                                                                                                                                                                                                                                                             |
|                  | 15  | POLL  | 0       | Writing "1" initiates a measurement                                                                                                                                                                                                                                                                                                                                                                         |
|                  | 9:8 | CR    | 00      | Continuous mode rate (DEL ≠ 1111)<br>00: 93.75 Hz (every 512 AC-Link frames)<br>01: 187.5 Hz (every 256 AC-Link frames)<br>10: 375Hz (every 128 AC-Link frames)<br>11: 750Hz (every 64 AC-Link frames)<br>Continuous mode rate (DEL = 1111)<br>00: 8 kHz (every six AC-Link frames)<br>01: 12 kHz (every four AC-Link frames)<br>10: 24 kHz (every other AC-Link frame)<br>11: 48 kHz (every AC-Link frame) |
| 78h              | 11  | PDEN  | 0       | 0: measure regardless of pen status<br>1: measure only when pen is down (when CTC=0 and POLL=1, measurement is delayed until pen-down; when CTC=1, measurements are stopped on pen-up)                                                                                                                                                                                                                      |

**Table 27 Touchpanel Digitiser Control (Initiation of Measurements)**

In continuous mode (CTC = 1), the WM9712L autonomously initiates measurements at the rate set by CR, and supplies the measured data to the CPU on one of the unused AC'97 time slots. DMA-enabled CPUs can write the data directly into a FIFO without any intervention by the CPU core. This reduces CPU loading and speeds up the execution of user programs in handheld systems.

Note that the measurement frequency in continuous mode is also affected by the DEL bits (see "Touchpanel Settling Time"). The faster rates achieved when DEL = 1111 may be useful when the ADC is used for auxiliary measurements.

## MEASUREMENT TYPES

The ADCSEL control bits determine which type of measurement is performed (see below).

| REGISTER ADDRESS | BIT   | LABEL  | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                                  |
|------------------|-------|--------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 76h              | 14:12 | ADCSEL | 000     | Measurement Type (ADC Input Selector)<br>000: No measurement<br>001: X co-ordinate measurement<br>010: Y co-ordinate measurement<br>011: Pressure measurement<br>100: COMP1/AUX1 measurement (pin 29)<br>101: COMP2/AUX2 measurement (pin 30)<br>110: BMON/AUX3 measurement (pin 31)<br>111: WIPER/AUX4 measurement (pin 12) |
|                  | 11    | COO    | 0       | Enable co-ordinate mode<br>0: Single measurement according to ADCSEL<br>1: X, then Y, then additional measurement indicated by ADCSEL                                                                                                                                                                                        |

**Table 28 Touchpanel Digitiser Control (Measurement Types)**

When COO is '0', the WM9712L performs one type of measurement once (in polling mode) or continuously (in continuous mode).

The co-ordinate mode (COO = '1') makes it easier to obtain co-ordinate pairs rather than single co-ordinates. In polling-coordinate mode (CTC = '0', COO = '1'), the WM9712L performs an X measurement, followed by a Y measurement, followed by an additional measurement determined by ADCSEL, then stops. In continuous-coordinate mode (CTC = '1', COO = '1'), the WM9712L continuously repeats a sequence consisting of an X-co-ordinate measurement, followed by a Y co-ordinate measurement, followed by an additional measurement determined by ADCSEL (if ADCSEL = 000, the sequence is XYXYXY... only).

### DATA READBACK

The output data word of the touchpanel interface consists of three parts:

- Pen Status (1 bit) – this is also passed to the GPIO logic block, which can be programmed to generate an interrupt and/or wake up the WM9712L on pen down (see GPIO and Interrupt Control).
- Output data from the touchpanel ADC (12 bits)
- ADCSRC: 3 additional bits that indicate the source of the ADC data. With COO = '0', ADCSRC echoes ADCSEL. However, in co-ordinate mode (COO = '1'), the WM9712L schedules different types of measurements autonomously and sets the ADCSRC bits accordingly (see "Measurement Types").

This data is stored in register 7Ah, and can be retrieved by reading the register in the usual manner (see AC-Link Interface section). Additionally, the data can also be passed to the controller on one of the AC-Link time slots not used for audio functions.

If the data is being read back using the polling method, there are several ways to determine when a measurement has finished:

- Reading back the POLL bit. If it has been reset to '0', then the measurement has finished.
- By monitoring the ADA signal, see GPIO and interrupt section
- Reading back 7Ah until the new data appears

| REGISTER ADDRESS                                | BIT   | LABEL  | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                                               |
|-------------------------------------------------|-------|--------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7Ah<br>or<br>AC-Link slot<br>selected by<br>SLT | 15    | PNDN   | 0       | Pen status (read-only)<br>0: Pen Up<br>1: Pen Down                                                                                                                                                                                                                                                                                        |
|                                                 | 14:12 | ADCSRC | 000     | Touchpanel ADC Source<br>000: No measurement<br>001: X co-ordinate measurement<br>010: Y co-ordinate measurement<br>011: Pressure measurement<br>(4-wire touchpanels only)<br>100: COMP1/AUX1 measurement (pin 29)<br>101: COMP2/AUX2 measurement (pin 30)<br>110: BMON/AUX3 measurement (pin 31)<br>111: WIPER/AUX4 measurement (pin 12) |
|                                                 | 11:0  | ADCD   | 000h    | Touchpanel ADC Data (read-only)<br>Bit 11 = MSB<br>Bit 0 = LSB                                                                                                                                                                                                                                                                            |
| 78h                                             | 9     | WAIT   | 0       | 0: No effect (new ADC data overwrites unread data in register 7Ah)<br>1: New data is held back, and measurements delayed, until register 7Ah is read                                                                                                                                                                                      |

**Table 29 Touchpanel Digitiser Data**

To avoid losing data that has not yet been read, the WM9712L can delay overwriting register 7Ah with new data until the old data has been read. This function is enabled using the WAIT bit.

If the SLEN bit is set to '1', then the touchpanel data appears on the AC-Link slot selected by the SLT control bits, as shown below. The Slot 0 'tag' bit corresponding to the selected time slot is asserted whenever there is new data on that slot.

| REGISTER ADDRESS | BIT | LABEL | DEFAULT | DESCRIPTION                                                                                                                    |
|------------------|-----|-------|---------|--------------------------------------------------------------------------------------------------------------------------------|
| 76h              | 3   | SLEN  | 0       | Slot Readback Enable<br>0: Disabled (readback through register only)<br>1: Enable (readback slot selected by SLT)              |
|                  | 2:0 | SLT   | 110     | AC'97 Slot Selection for Touchpanel Data<br>000: Slot 5<br>001: Slot 6<br>...<br>101: Slot 10<br>110: Slot 11<br>111: RESERVED |

**Table 30 Returning Touchpanel Data through an AC-Link Time Slot**

### TOUCHPANEL SETTLING TIME

For accurate touchpanel measurements, some settling time may be required between the switch matrix applying a voltage across the touchpanel plate and the ADC sampling the signal. This time delay function is built into the WM9712L and can be programmed as shown below.

| REGISTER ADDRESS | BIT | LABEL | DEFAULT           | DESCRIPTION                  |
|------------------|-----|-------|-------------------|------------------------------|
| 76h              | 7:4 | DEL   | 0000<br>(1 frame) | Touchpanel ADC Settling Time |

**Table 31 Touchpanel Settling Time Control (1)**

| DEL  | DELAY<br>(AC-LINK FRAMES)         | DELAY<br>(TIME) |
|------|-----------------------------------|-----------------|
| 0000 | 1                                 | 20.8µs          |
| 0001 | 2                                 | 41.7µs          |
| 0010 | 4                                 | 83.3µs          |
| 0011 | 8                                 | 167µs           |
| 0100 | 16                                | 333µs           |
| 0101 | 32                                | 667µs           |
| 0110 | 48                                | 1ms             |
| 0111 | 64                                | 1.33ms          |
| 1000 | 96                                | 2ms             |
| 1001 | 128                               | 2.67ms          |
| 1010 | 160                               | 3.33ms          |
| 1011 | 192                               | 4ms             |
| 1100 | 224                               | 4.67ms          |
| 1101 | 256                               | 5.33ms          |
| 1110 | 288                               | 6ms             |
| 1111 | No delay, switch matrix always on |                 |

**Table 32 Touchpanel Settling Time Control (2)**

The total time for co-ordinate or auxiliary measurements to complete is the delay time DEL, plus one AC-Link frame (20.8µs). For a pressure measurement, the time taken is DEL plus two AC-Link frames (41.6µs).

Setting DEL to '1111' reduces the settling time to zero, i.e. measurements begin immediately. This mode is intended for fast sampling on AUX inputs. It is NOT intended for touchpanel digitisation. There are several side-effects when DEL is set to '1111':

- Co-ordinate mode does not work, i.e. the WM9712L behaves as if COO = 0, even if COO = 1 (see "Measurement Types")
- If X / Y co-ordinate or touch pressure measurements are selected (ADCSEL = 001, 010 or 011), then the switch matrix is constantly on, and current constantly flows in the touchpanel. This increases power consumption in the system, and is therefore not recommended for battery powered systems
- In continuous mode (CTC = 1), setting DEL = 1111 increases the sampling rate of the touchpanel ADC (see "Initiation of Measurements")

### MASK INPUT CONTROL

Sources of glitch noise, such as the signals driving an LCD display, may feed through to the touchscreen plates and affect measurement accuracy. In order to minimise this effect, a signal may be applied to MASK (pin 47) to delay or synchronise the sampling of any input to the ADC. The effect of the MASK signal depends on the the MSK[1-0] bits of register 78h, as described below.

| MSK[1-0] | EFFECT OF SIGNAL ON MASK PIN                                                                                                                                                                                          |
|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 00       | Mask has no effect on conversions GPIO input disabled (default)                                                                                                                                                       |
| 01       | Static; 'hi' on MASK pin stops conversions, 'lo' has no effect.                                                                                                                                                       |
| 10       | Edge triggered; rising or falling edge on MASK pin delays conversions by an amount set in the DEL[3-0] register. Conversions are asynchronous to the MASK signal.                                                     |
| 11       | Synchronous mode; conversions wait until rising or falling edge on MASK initiates cycle; screen starts to be driven when the edge arrives, the conversion sample being taken a period set by DEL[3-0] after the edge. |

**Table 33 Controlling the MASK Feature**

Note that pin 47 can also be used as a GPIO(see "GPIO and Interrupt Control" section), or to output the ADA signal (see below).

### THE ADA SIGNAL

Whenever data becomes available from the touchpanel ADC, the internal ADA (ADC Data Available) signal goes high and remains high until the data has been read from register 7Ah (if SLEN = 0) or until it has been sent out on an AC-Link slot (if SLEN = 1).

ADA can be used to generate an interrupt, if the AW bit (register 52h, bit 12) is set (see "GPIO and interrupt control" section)

It is also possible to output the ADA signal on pin 47, if this pin is not used as a GPIO. The GE4 bit (register 56h, bit 12) must be set to '0' to achieve this (see "GPIO and interrupt control" section).

Alternatively, ADA can be read from bit 12 in register 54h.

## AUXILIARY ADC INPUTS

The ADC used for touchpanel digitisation can also be used for auxiliary measurements, provided that it is enabled (register 78h, PRP = 11). The WM9712L has four pins that can be used as auxiliary ADC inputs:

- COMP1 / AUX1 (pin 29)
- COMP2 / AUX2 (pin 30)
- BMON / AUX3 (pin 31)
- WIPER / AUX4 (pin 12)

Note that pin 12 connects to the wiper of a 5-wire touchpanel wiper function. Auxiliary measurements taken on pin 12 are only meaningful when it is not connected to a touchpanel (i.e. a 4-wire touchpanel, or no touchpanel at all, is used). Pins 29 and 30 are also used as comparator inputs (see Battery Alarm and Battery Measurement), but auxiliary measurements can still be taken on these pins at any time. For the use of pin 31 see the “Battery Alarm And Battery Measurement” section, note that the measured value from the BMON/AUX3 pin will be 1/3 of the actual value due to the potential divider on this pin. The ADCSEL control bits select between different ADC inputs, as shown below.

| REGISTER ADDRESS                    | BIT   | LABEL  | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                  |
|-------------------------------------|-------|--------|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 76h<br>Touchpanel Digitiser Control | 14:12 | ADCSEL | 000     | Touchpanel ADC Input Selector<br>000: No measurement<br>001-011: Touchpanel measurement (please refer to Touchpanel Digitiser section)<br>100: COMP1 / AUX1 measurement (pin 29)<br>101: COMP2 AUX2 measurement (pin 30)<br>110: BMON / AUX3 measurement (pin 31)<br>111: WIPER / AUX 4 measurement (pin 12) |

**Table 34 Auxiliary ADC Measurements**

Auxiliary ADC measurements are initiated in the same way as touchpanel measurements, and the data is returned in the same manner. Please refer to the “Controlling the Touchpanel Interface” section.

## BATTERY MEASUREMENT USING THE BMON/AUX3 PIN

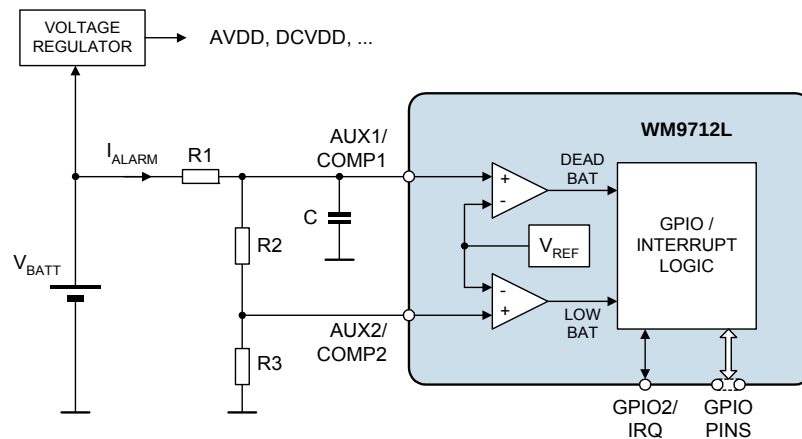
BMON/AUX3 (pin 31) has the capability to take inputs up to 5 volts (Assuming AVDD=3.3V) by dividing down the input signal. The internal potential divider has a total resistance of 30kΩ. However, it is only connected to the pin when an AUX3 measurement is requested, and remains connected for the duration of one AC-Link frame (20.83μs, assuming a 24.576MHz clock crystal is used). The effective input impedance of BMON/AUX3 is therefore given by:

$$R_{\text{BMON}} = 30\text{k}\Omega \times 48\text{kHz} / [\text{BMON sampling rate}]$$

For example, if BMON is sampled ten times per second, the effective input resistance is  $30\text{k}\Omega \times 48\text{kHz} / 10\text{Hz} = 144\text{M}\Omega$ .

## BATTERY ALARM AND ANALOGUE COMPARATORS

The battery alarm function differs from battery measurement in that it does not actually measure the battery voltage. Battery alarm only indicates “OK”, “Low” or “Dead”. The advantage of the battery alarm function is that it does not require a clock and can therefore be used in low-power sleep or standby modes.



**Figure 13 Battery Alarm Example Schematic**

The typical schematic for a dual threshold battery alarm is shown above. This alarm has two thresholds, “dead battery” (COMP1) and “low battery” (COMP2). R1, R2 and R3 set the threshold voltages. Their values can be up to about 1MΩ in order to keep the battery current [ $I_{ALARM} = V_{BATT} / (R1+R2+R3)$ ] to a minimum (higher resistor values may affect the accuracy of the system as leakage currents into the input pins become significant).

- Dead battery alarm: COMP1 triggers when  $V_{BATT} < V_{REF} \times (R1+R2+R3) / (R2+R3)$

A dead battery alarm is the highest priority of interrupt in the system. It should immediately save all unsaved data and shut down the system. The GP15, GS15 and GW15 bits must be set to generate this interrupt.

- Low battery alarm: COMP2 triggers when  $V_{BATT} < V_{REF} \times (R1+R2+R3) / R3$

A low battery alarm has a lower priority than a dead battery alarm. Since the threshold voltage is higher than for a dead battery alarm, there is enough power left in the battery to give the user a warning and/or shut down “gracefully”. When  $V_{BATT}$  gets close to the low battery threshold, spurious alarms are filtered out by the COMP2 delay function.

The purpose of the capacitor C is to remove from the comparator inputs any high frequency noise or glitches that may be present on the battery (for example, noise generated by a charge pump). It forms a low pass filter with R1, R2 and R3.

- Low pass cutoff  $f_c$  [Hz] =  $1 / (2\pi \times C \times (R1 \parallel (R2+R3)))$

Provided that the cutoff frequency is several orders of magnitude lower than the noise frequency  $f_n$ , this simple circuit can achieve excellent noise rejection.

- Noise rejection [dB] =  $20 \log (f_n / f_c)$

The circuit shown above also allows for measuring the battery voltage  $V_{BATT}$ . This is achieved simply by setting the touchpanel ADC input to be either COMP1 (ADCSEL = 100) or COMP2 (ADCSEL = 101) (see also Auxiliary ADC Inputs).

The WM9712L has two on-chip comparators that can be used to implement a battery alarm function, or other functions such as a window comparator. Each comparator has one of its inputs tied to any one of three device pins and the other tied to a voltage reference. The voltage reference can be either internally generated ( $V_{REF} = AVDD/2$ ) or externally connected on AUX4 (pin 12).

The comparator output signals are passed to the GPIO logic block (see “GPIO and Interrupt Control” section), where they can be used to send an interrupt to the CPU via the AC-Link or via the IRQ pin, and / or to wake up the WM9712L from sleep mode. COMP1/AUX1 (pin 29) corresponds to GPIO bit 15 and COMP2/AUX2 (pin30) to bit 14.

| REGISTER ADDRESS | BIT   | LABEL     | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                                                                                                    |
|------------------|-------|-----------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 4Eh              | 15    | CP1       | 1       | COMP1 Polarity (see also “GPIO and Interrupt Control”)<br>0: Alarm when COMP1 voltage is below $V_{REF}$<br>1: Alarm when COMP1 voltage is above $V_{REF}$                                                                                                                                                                                                                                     |
|                  | 14    | CP2       | 1       | COMP2 Polarity (see also “GPIO and Interrupt Control”)<br>0: Alarm when COMP2 voltage is below $V_{REF}$<br>1: Alarm when COMP2 voltage is above $V_{REF}$                                                                                                                                                                                                                                     |
| 58h              | 15:13 | COMP2 DEL | 0       | Low Battery Alarm Delay<br>000: No delay<br>001: 0.17s ( $2^{13} = 8192$ AC-Link frames)<br>010: 0.34s ( $2^{14} = 16384$ AC-Link frames)<br>011: 0.68s ( $2^{15} = 32768$ AC-Link frames)<br>100: 1.4s ( $2^{16} = 65536$ AC-Link frames)<br>101: 2.7s ( $2^{17} = 131072$ AC-Link frames)<br>110: 5.5s ( $2^{18} = 262144$ AC-Link frames)<br>111: 10.9s ( $2^{19} = 524288$ AC-Link frames) |

Table 35 Comparator Control

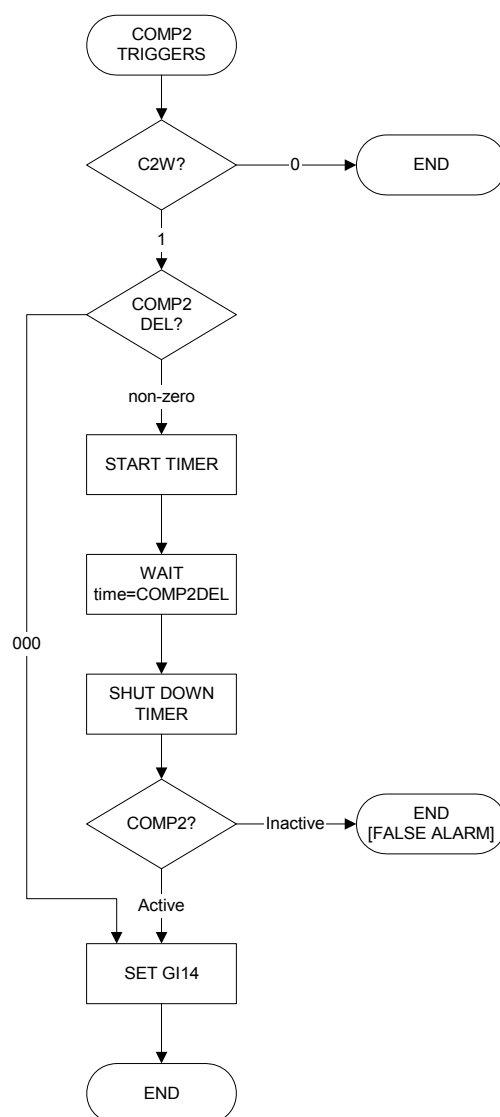
| REGISTER ADDRESS                           | BIT   | LABEL | DEFAULT | DESCRIPTION                                                        |
|--------------------------------------------|-------|-------|---------|--------------------------------------------------------------------|
| 5Ch<br>Additional<br>Analogue<br>Functions | 14    | C1REF | 0       | Comparator 1 Reference Voltage                                     |
|                                            |       |       |         | 0 $V_{REF} = AVDD/2$                                               |
|                                            |       |       |         | 1 WIPER/AUX4 (pin 12)                                              |
|                                            | 13:12 | C1SRC | 00      | Comparator 1 Signal Source                                         |
|                                            |       |       |         | 00 $AVDD/2$ when C1REF='1'. Otherwise comparator 1 is powered down |
|                                            |       |       |         | 01 COMP1/AUX1 (pin 29)                                             |
|                                            |       |       |         | 10 COMP2/AUX2 (pin 30)                                             |
|                                            |       |       |         | 11 BMON/AUX3 (pin 31)                                              |
|                                            | 11    | C2REF | 0       | Comparator 2 Reference Voltage                                     |
|                                            |       |       |         | 0 $V_{REF} = AVDD/2$                                               |
|                                            |       |       |         | 1 WIPER/AUX4 (pin 12)                                              |
|                                            | 10:9  | C2SRC | 00      | Comparator 2 Signal Source                                         |
|                                            |       |       |         | 00 $AVDD/2$ when C2REF='1'. Otherwise comparator 2 is powered down |
|                                            |       |       |         | 01 COMP1/AUX1 (pin 29)                                             |
|                                            |       |       |         | 10 COMP2/AUX2 (pin 30)                                             |
|                                            |       |       |         | 11 BMON/AUX3 (pin 31)                                              |

Table 36 Comparator Reference and Source Control

**COMP2 DELAY FUNCTION**

COMP2 has an optional delay function for use when the input signal is noisy. When COMP2 triggers and the delay is enabled (i.e. COMP2DEL is non-zero), then GPIO bit 14 does not change state immediately, and no interrupt is generated. Instead, the WM9712L starts a delay timer and checks COMP2 again after the delay time has passed. If COMP2 is still active, then the GPIO bit is set and an interrupt may be generated (depending on the state of the GW14 bit). If COMP2 is no longer active, the GPIO bit is not set, i.e. all register bits are as if COMP2 had never triggered.

Note: If COMP2 triggers while the WM9712L is in sleep mode, and the delay is enabled, then the device starts the on-chip crystal oscillator in order to count the time delay.



**Figure 14 COMP2 Delay Flow Chart**

## GPIO AND INTERRUPT CONTROL

The WM9712L has five GPIO pins that operate as defined in the AC'97 Revision 2.2 specification. Each GPIO pin can be set up as an input or as an output, and has corresponding bits in register 54h and in slot 12. The state of a GPIO output is determined by sending data through slot 12 of outgoing frames (SDATAOUT). Data can be returned from a GPIO input by reading the register bit, or examining slot 12 of incoming frames (SDATAIN). GPIO inputs can be made sticky, and can be programmed to generate and interrupt, transmitted either through the AC-Link or through a dedicated, level-mode interrupt pin (GPIO2/IRQ, pin 45).

GPIO pins 2 to 5 are multi-purpose pins that can also be used for other (non-GPIO) purposes, e.g. as a SPDIF output or to signal pen-down. This is controlled by register 56h.

Independently of the GPIO pins, the WM9712L also has five virtual GPIOs. These are signals from inside the WM9712L, which are treated as if they were GPIO input signals. From a software perspective, virtual GPIOs are the same as GPIO pins, but they cannot be set up as outputs, and are not tied to an actual pin. This allows for simple, uniform processing of different types of signals that may generate interrupts (e.g. pen down, battery warnings, jack insertion, high-temperature warning, or GPIO signals).

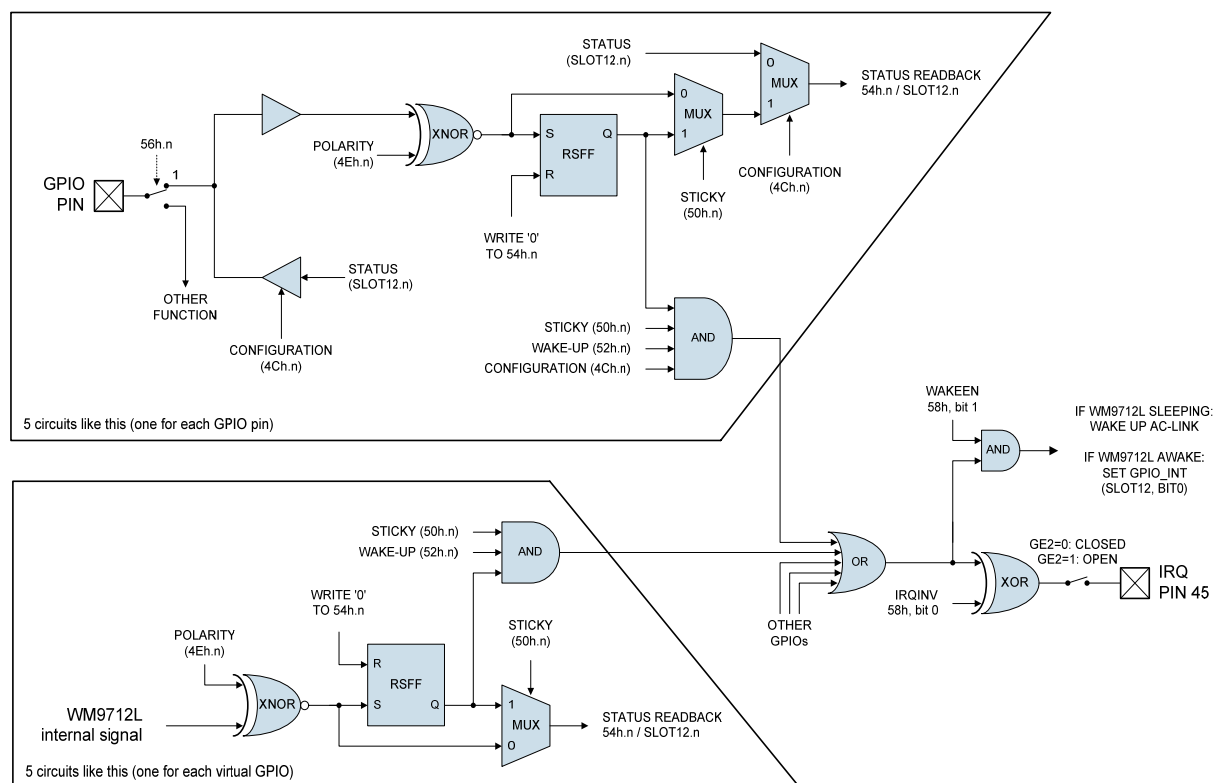


Figure 15 GPIO Logic

| GPIO BIT | SLOT12 BIT | TYPE         | PIN NO.               | DESCRIPTION                                                                                                            |
|----------|------------|--------------|-----------------------|------------------------------------------------------------------------------------------------------------------------|
| 1        | 5          | GPIO Pin     | 44                    | GPIO1                                                                                                                  |
| 2        | 6          | GPIO Pin     | 45                    | GPIO2 / IRQ<br>enabled only when pin not used as IRQ                                                                   |
| 3        | 7          | GPIO Pin     | 46                    | GPIO3 / PENDOWN<br>enabled only when pin not used as PENDOWN                                                           |
| 4        | 8          | GPIO Pin     | 47                    | GPIO4 / ADA / MASK<br>enabled only when pin not used as ADA                                                            |
| 5        | 9          | GPIO Pin     | 48                    | GPIO5 / SPDIF_OUT<br>enabled only when pin not used as SPDIF_OUT                                                       |
| 6-10     | N/A        | Unused       | -                     | GPIO Logic not implemented for these bits                                                                              |
| 11       | 15         | Virtual GPIO | -<br>[Thermal Cutout] | Internal thermal cutout signal, indicates when internal temperature reaches approximately 150°C (see "Thermal Sensor") |
| 12       | 16         | virtual GPIO | -<br>[ADA]            | Internal ADA (ADC Data Available) Signal<br>enabled only when auxiliary ADC is active                                  |
| 13       | 17         | Virtual GPIO | -<br>[PEN DOWN]       | Internal PENDOWN Signal<br>enabled only when pen-down detection is active                                              |
| 14       | 18         | Virtual GPIO | -<br>[COMP2]          | Internal COMP2 output (Low Battery Alarm)<br>enabled only when COMP2 is on                                             |
| 15       | 19         | Virtual GPIO | -<br>[COMP1]          | Internal COMP1 output (Dead Battery Alarm)<br>enabled only when COMP1 is on                                            |

Table 37 GPIO Bits and Pins

The properties of the GPIOs are controlled through registers 4Ch to 52h, as shown below.

| REGISTER ADDRESS | BIT | LABEL | DEFAULT | DESCRIPTION                                                                                                                                          |
|------------------|-----|-------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| 4Ch              | n   | GCn   | 1       | GPIO Pin Configuration<br>0: Output<br>1: Input<br>GC11-15 are always '1'<br>Unused bits GC6-GC10 are always '0'                                     |
| 4Eh              | n   | GPn   | 1       | GPIO Pin Polarity / Type<br>0: Active Low<br>1: Active High<br>[GIn = pin level XNOR GPn]<br>Unused bits GP6-GP10 are always '1'                     |
| 50h              | n   | GSn   | 0       | GPIO Pin Sticky<br>1: Sticky<br>0: Not Sticky<br>Unused bits GS6-GS10 are always '0'                                                                 |
| 52h              | n   | GWn   | 0       | GPIO Pin Wake-up<br>1: Wake Up (generate interrupts from this pin)<br>0: No wake-up (no interrupts generated)<br>Unused bits GW6-GW10 are always '0' |
| 54h              | n   | GIn   | N/A     | GPIO Pin Status<br>Read: Returns status of each GPIO pin<br>Write: Writing '0' clears sticky bit<br>Unused bits GI6-GI10 are always '0'              |

**Table 38 GPIO Control**

The following procedure is recommended for handling interrupts:

When the controller receives an interrupt, check register 54h. For each GPIO bit in descending order of priority, check if the bit is '1'. If yes, execute corresponding interrupt routine, then write '0' to corresponding bit in 54h. If no, continue to next lower priority GPIO. After all GPIOs have been checked, check if the interrupt still present or no. If yes, repeat procedure. If no, then jump back to process that ran before the interrupt.

If the system CPU cannot execute such an interrupt routine, it may be preferable to switch internal signals (such as PENDOWN) directly onto the GPIO pins. However, in this case the interrupt signals cannot be made sticky, and more GPIO pins are tied up both on the WM9712L and on the CPU.

| REGISTER ADDRESS                       | BIT | LABEL | DEFAULT | DESCRIPTION                                                                                                                                                                                                 |
|----------------------------------------|-----|-------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 56h<br>GPIO pins<br>function<br>select | 2   | GE2   | 1       | GPIO2 / IRQ output select<br>0: Pin 45 disconnected from GPIO logic<br>set 4Ch, bit 2 to '0' to output IRQ signal<br>1: Pin 45 connected to GPIO logic (IRQ disabled)                                       |
|                                        | 3   | GE3   | 1       | GPIO3 / PENDOWN output select<br>0: Pin 46 disconnected from GPIO logic<br>set 4Ch, bit 3 to '0' to output PENDOWN signal<br>1: Pin 46 connected to GPIO logic                                              |
|                                        | 4   | GE4   | 1       | GPIO4 / ADA / MASK output select<br>0: Pin 47 disconnected from GPIO logic<br>set 4Ch, bit 4 to '0' to output ADA signal<br>set 4Ch, bit 4 to '1' to input MASK signal<br>1: Pin 47 connected to GPIO logic |
|                                        | 5   | GE5   | 1       | GPIO5 / SPDIF output select<br>0: Pin 48 = SPDIF (disconnected from GPIO logic)<br>set 4Ch, bit 5 to '0' to output SPDIF signal<br>1: Pin 48 connected to GPIO logic (SPDIF disabled)                       |

Table 39 Using GPIO Pins for Non-GPIO Functions

| REGISTER ADDRESS                           | BIT | LABEL   | DEFAULT | DESCRIPTION                                                                             |
|--------------------------------------------|-----|---------|---------|-----------------------------------------------------------------------------------------|
| 58h<br>Additional<br>Functional<br>Control | 0   | IRQ INV | 0       | Inverts the IRQ signal (pin 45)<br>0: IRQ signal not inverted<br>1: IRQ signal inverted |
|                                            | 1   | WAKEEN  | 0       | Enables GPIO wake-up<br>0: Disabled<br>1: Enabled                                       |

Table 40 Additional Functionality for GPIO Pins

**POWER MANAGEMENT**

The WM9712L includes the standard power down control register defined by the AC'97 specification (register 26h). Additionally, it also allows more specific control over the individual blocks of the device through register 24h. Each particular circuit block is active when both the relevant bit in register 26h AND the relevant bit in register 24h are set to '0'.

| REGISTER ADDRESS                        | BIT | LABEL | DEFAULT |                          | DESCRIPTION                                                         |
|-----------------------------------------|-----|-------|---------|--------------------------|---------------------------------------------------------------------|
|                                         |     |       | NORMAL  | PIN 47 'HI' DURING RESET |                                                                     |
| 26h<br>Powerdown/<br>Status<br>register | 14  | PR6   | 0 (ON)  | 1 (OFF)                  | Disables HPOUTL, HPOUTR and OUT3 Buffer                             |
|                                         | 13  | PR5   | 0 (ON)  | 1 (OFF)                  | Disables internal clock                                             |
|                                         | 12  | PR4   | 0 (ON)  | 1 (OFF)                  | Disables AC-link interface (external clock off)                     |
|                                         | 11  | PR3   | 0 (ON)  | 1 (OFF)                  | Disables VREF, analogue mixers and outputs                          |
|                                         | 10  | PR2   | 0 (ON)  | 1 (OFF)                  | Disables analogue mixers, LOUT2, ROUT2 (but not VREF)               |
|                                         | 9   | PR1   | 0 (ON)  | 1 (OFF)                  | Disables stereo DAC                                                 |
|                                         | 8   | PR0   | 0 (ON)  | 1 (OFF)                  | Disables audio ADCs and input Mux                                   |
|                                         | 3   | REF   | 1       | 0                        | Read-only bit, indicates VREF is ready (inverse of PR2)             |
|                                         | 2   | ANL   | 1       | 0                        | Read-only bit, indicates analogue mixers are ready (inverse of PR3) |
|                                         | 1   | DAC   | 1       | 0                        | Read-only bit, indicates audio DACs are ready (inverse of PR1)      |
|                                         | 0   | ADC   | 1       | 0                        | Read-only bit, indicates audio ADCs are ready (inverse of PR0)      |

**Table 41 Powerdown and Status Register (Conforms to AC'97 Rev 2.2)**

As can be seen from the table above, most blocks are 'ON' by default. However, if pin 47 (GPIO4/ADA/MASK) is held high during reset, the WM9712L starts up with all blocks powered down by default, saving power. This is achieved by connecting a pull-up resistor (e.g. 100k $\Omega$ ) from pin 47 to DBVDD. Note that the state of pin 47 during reset only affects register 26h.

| REGISTER ADDRESS                                                                                                                                                                                                                                                                             | BIT | LABEL | DEFAULT | DESCRIPTION                                       |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|-------|---------|---------------------------------------------------|
| 24h<br>Additional power down control                                                                                                                                                                                                                                                         | 15  | PD15  | 0 (ON)  | Disables Crystal Oscillator                       |
|                                                                                                                                                                                                                                                                                              | 14  | PD14  | 0 (ON)  | Disables left audio DAC                           |
|                                                                                                                                                                                                                                                                                              | 13  | PD13  | 0 (ON)  | Disables right audio DAC                          |
|                                                                                                                                                                                                                                                                                              | 12  | PD12  | 0 (ON)  | Disables left audio ADC                           |
|                                                                                                                                                                                                                                                                                              | 11  | PD11  | 0 (ON)  | Disables right audio ADC                          |
|                                                                                                                                                                                                                                                                                              | 10  | PD10  | 0 (ON)  | Disables MICBIAS                                  |
|                                                                                                                                                                                                                                                                                              | 9   | PD9   | 0 (ON)  | Disables left headphone mixer                     |
|                                                                                                                                                                                                                                                                                              | 8   | PD8   | 0 (ON)  | Disables right headphone mixer                    |
|                                                                                                                                                                                                                                                                                              | 7   | PD7   | 0 (ON)  | Disables speaker mixer                            |
|                                                                                                                                                                                                                                                                                              | 6   | PD6   | 0 (ON)  | Disables MONO_OUT buffer (pin 33) and phone mixer |
|                                                                                                                                                                                                                                                                                              | 5   | PD5   | 0 (ON)  | Disables OUT3 buffer (pin 37)                     |
|                                                                                                                                                                                                                                                                                              | 4   | PD4   | 0 (ON)  | Disables headphone buffers (HPOUTL/R)             |
|                                                                                                                                                                                                                                                                                              | 3   | PD3   | 0 (ON)  | Disables speaker outputs (LOUT2, ROUT2)           |
|                                                                                                                                                                                                                                                                                              | 2   | PD2   | 0 (ON)  | Disables Line Input PGA (left and right) *        |
|                                                                                                                                                                                                                                                                                              | 1   | PD1   | 0 (ON)  | Disables Phone Input PGA *                        |
|                                                                                                                                                                                                                                                                                              | 0   | PD0   | 0 (ON)  | Disables Mic Input PGA (left and right) *         |
| Note: When analogue inputs or outputs are disabled, they are internally connected to VREF through a large resistor ( $V_{REF}=AVDD/2$ except in OFF mode, when VREF itself is disabled). This maintains the potential at that node and helps to eliminate pops when the pins are re-enabled. |     |       |         |                                                   |

Table 42 Extended Power Down Register (Additional to AC'97 Rev 2.2)

**Note:**

\*When disabling a PGA, always ensure that it is muted first.

**ADDITIONAL POWER MANAGEMENT:**

- AUXDAC: see "Auxiliary DAC" section. AUXDAC is OFF by default.
- Touchpanel Interface: see "Controlling the Touchpanel Digitiser / Power Management". The touchpanel digitiser is OFF by default.

**SLEEP MODE**

Whenever the PR4 bit (reg. 26h) is set, the AC-Link interface is disabled, and the WM9712L is in sleep mode. There is in fact a very large number of different sleep modes, depending on the other control bits. For example, the low-power standby mode described below is a sleep mode. It is desirable to use sleep modes whenever possible, as this will save power. The following functions do not require a clock and can therefore operate in sleep mode:

- Analogue-to-analogue audio (DACs and ADCs unused), e.g. phone call mode
- Pen-down detection
- GPIO and interrupts
- Battery alarm / analogue comparators (but not battery measurement)

The WM9712L can awake from sleep mode as a result of

- A warm reset on the AC-Link (according to the AC'97 specification)
- A signal on a GPIO pin (if the pin is configured as an input, with wake-up enabled – see "GPIO and Interrupt Control" section)
- A virtual GPIO event such as pen-down, battery alarm, etc. (see "GPIO and Interrupt Control" section)

**LOW POWER STANDBY MODE**

If all the bits in registers 26h and 24h are set, then the WM9712L is in low-power standby mode and consumes very little current. A 1M $\Omega$  resistor string remains connected across AVDD to generate VREF. This is necessary if the on-chip analogue comparators are used (see “Battery Alarm and Battery Measurement” section), and helps shorten the delay between wake-up and playback readiness. If VREF is not required, the 1M $\Omega$  resistor string can be disabled by setting the SVD bit, reducing current consumption further.

| REGISTER ADDRESS | BIT | LABEL | DEFAULT | DESCRIPTION                                                                                                                                        |
|------------------|-----|-------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------|
| 58h              | 10  | SVD   | 0       | VREF Disable<br>0: VREF enabled using 1M $\Omega$ string (low-power standby mode)<br>1 : VREF disabled, 1M $\Omega$ string disconnected (OFF mode) |

**Table 43 Disabling VREF (for lowest possible power consumption)****SAVING POWER AT LOW SUPPLY VOLTAGES**

The analogue supplies to the WM9712L can run from 1.8V to 3.6V. By default, all analogue circuitry on the IC is optimized to run at 3.3V. This set-up is also good for all other supply voltages down to 1.8V. However, at lower voltages, it is possible to save power by reducing the internal bias currents used in the analogue circuitry. This is controlled as shown below.

| REGISTER ADDRESS | BIT | LABEL | DEFAULT | DESCRIPTION                                                                                                                                                                  |
|------------------|-----|-------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 5Ch              | 6:5 | VBIAS | 00      | Analogue Bias optimization<br>11 : Lowest bias current, optimized for 1.8V<br>10 : Low bias current, optimized for 2.5V<br>01, 00 : Default bias current, optimized for 3.3V |

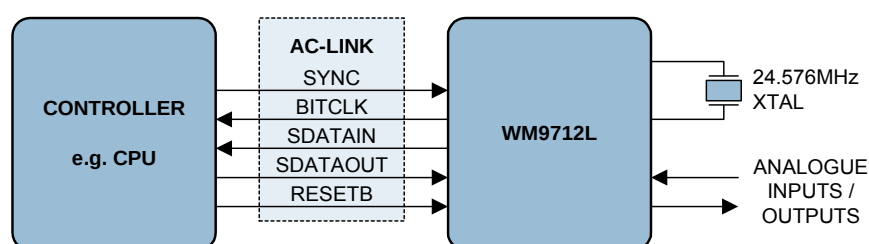
**Table 44 Analogue Bias Selection**

## AC97 DATA AND CONTROL INTERFACE

### INTERFACE PROTOCOL

The WM9712L has a single AC'97 interface for both data transfer and control. The AC-Link uses 5 wires:

- SDATAIN (pin 8) carries data from the WM9712L to the controller
- SDATAOUT (pin 5) carries data from the controller to the WM9712L
- BITCLK (pin 6) is a clock, normally generated by the WM9712L crystal oscillator and supplied to the controller. However, BITCLK can also be passed to the WM9712L from an off-chip generator.
- SYNC is a synchronization signal generated by the controller and passed to the WM9712L
- RESETB resets the WM9712L to its default state



**Figure 16 AC-Link Interface (typical case with BITCLK generated by the AC97 CODEC)**

The SDATAIN and SDATAOUT signals each carry 13 time-division multiplexed data streams (slots 0 to 12). A complete sequence of slots 0 to 12 is referred to as an AC-Link frame, and contains a total of 256 bits. The frame rate is 48kHz. This makes it possible to simultaneously transmit and receive multiple data streams (e.g. audio, touchpanel, AUXDAC, control) at sample rates up to 48kHz.

Detailed information can be found in the AC'97 (Revision 2.2) specification, which can be obtained at [www.intel.com/labs/media/audio/](http://www.intel.com/labs/media/audio/)

**Note:**

SDATAOUT and SYNC must be held low for when RESETB is applied. These signals must be held low for the entire duration of the RESETB pulse and especially during the low-to-high transition of RESETB. If either is set high during reset the AC'97 device may enter test modes. Information relating to this operation is available in the AC'97 specification or in Wolfson applications note WAN-0104 available at [www.wolfsonmicro.com](http://www.wolfsonmicro.com).

## INTERFACE TIMING

### Test Characteristics:

DBVDD = 3.3V, DCVDD = 3.3V, DGND1 = DGND2 = 0V,  $T_A$  = -25°C to +85°C, unless otherwise stated.

### CLOCK SPECIFICATIONS

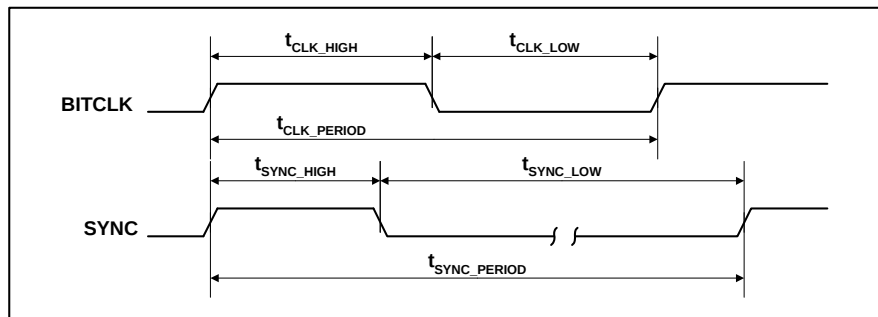


Figure 17 Clock Specifications (50pF External Load)

| PARAMETER                        | SYMBOL             | MIN | TYP    | MAX | UNIT |
|----------------------------------|--------------------|-----|--------|-----|------|
| BITCLK frequency                 |                    |     | 12.288 |     | MHz  |
| BITCLK period                    | $t_{CLK\_PERIOD}$  |     | 81.4   |     | ns   |
| BITCLK output jitter             |                    |     |        | 750 | ps   |
| BITCLK high pulse width (Note 1) | $t_{CLK\_HIGH}$    | 36  | 40.7   | 45  | ns   |
| BITCLK low pulse width (Note 1)  | $t_{CLK\_LOW}$     | 36  | 40.7   | 45  | ns   |
| SYNC frequency                   |                    |     | 48     |     | kHz  |
| SYNC period                      | $t_{SYNC\_PERIOD}$ |     | 20.8   |     | μs   |
| SYNC high pulse width            | $t_{SYNC\_HIGH}$   |     | 1.3    |     | μs   |
| SYNC low pulse width             | $t_{SYNC\_LOW}$    |     | 19.5   |     | μs   |

#### Note:

1. Worst case duty cycle restricted to 45/55

### DATA SETUP AND HOLD

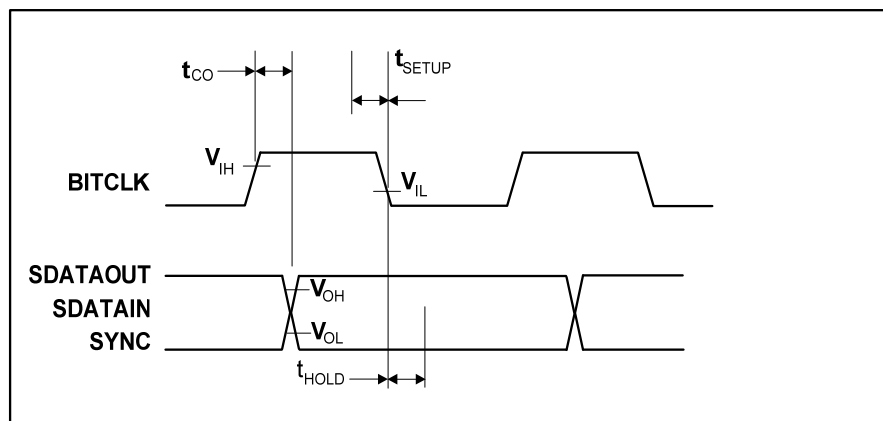


Figure 18 Data Setup and Hold (50pF External Load)

#### Note:

Setup and hold times for SDATAIN are with respect to the AC'97 controller, not the WM9712L.

| PARAMETER                                     | SYMBOL      | MIN | TYP | MAX | UNIT |
|-----------------------------------------------|-------------|-----|-----|-----|------|
| Setup to falling edge of BITCLK               | $t_{SETUP}$ | 10  |     |     | ns   |
| Hold from falling edge of BITCLK              | $t_{HOLD}$  | 10  |     |     | ns   |
| Output valid delay from rising edge of BITCLK | $t_{CO}$    |     |     | 15  | ns   |

## SIGNAL RISE AND FALL TIMES

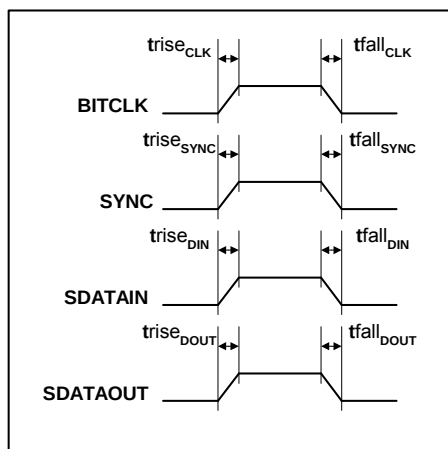


Figure 19 Signal Rise and Fall Times (50pF External Load)

| PARAMETER                                                          | SYMBOL         | MIN | TYP | MAX | UNIT |
|--------------------------------------------------------------------|----------------|-----|-----|-----|------|
| <b>Incoming signals (from the AC'97 controller to the WM9712L)</b> |                |     |     |     |      |
| SDATAOUT rise time                                                 | $trise_{DOUT}$ |     |     | 6   | ns   |
| SDATAOUT fall time                                                 | $tfall_{DOUT}$ |     |     | 6   | ns   |
| SYNC rise time                                                     | $trise_{SYNC}$ |     |     | 6   | ns   |
| SYNC fall time                                                     | $tfall_{SYNC}$ |     |     | 6   | ns   |
| <b>Outgoing signals (from the WM9712L to the AC'97 controller)</b> |                |     |     |     |      |
| BITCLK rise time                                                   | $trise_{CLK}$  | 2   |     | 6   | ns   |
| BITCLK fall time                                                   | $tfall_{CLK}$  | 2   |     | 6   | ns   |
| SDATAIN rise time                                                  | $trise_{DIN}$  | 2   |     | 6   | ns   |
| SDATAIN fall time                                                  | $tfall_{DIN}$  | 2   |     | 6   | ns   |

## AC-LINK POWERDOWN

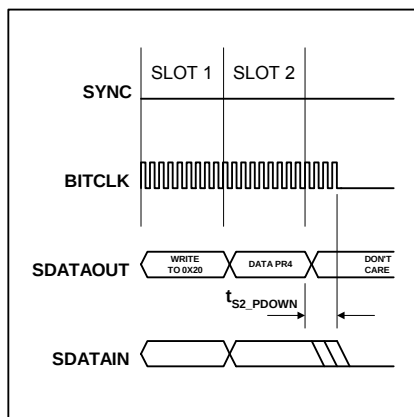
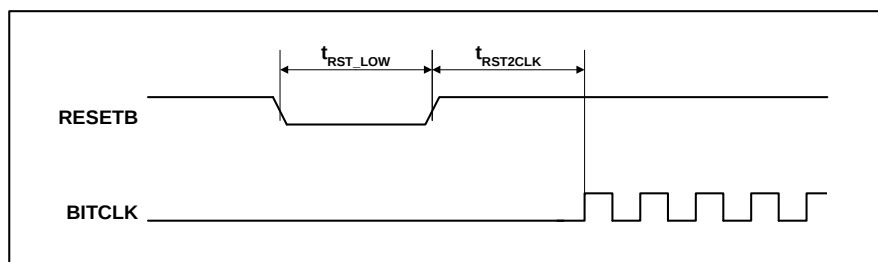


Figure 20 AC-Link Powerdown Timing

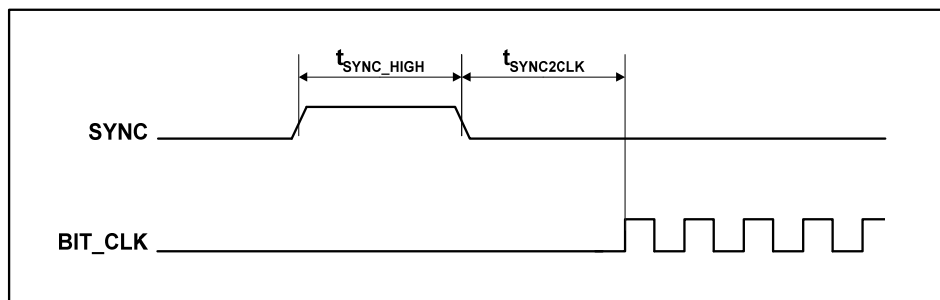
AC-Link powerdown occurs when PR4 (register 26h, bit 12) is set (see "Power Management" section).

| PARAMETER                               | SYMBOL          | MIN | TYP | MAX | UNIT    |
|-----------------------------------------|-----------------|-----|-----|-----|---------|
| End of Slot 2 to BITCLK and SDATAIN low | $t_{S2\_PDOWN}$ |     |     | 1.0 | $\mu s$ |

**COLD RESET (ASYNCHRONOUS, RESETS REGISTER SETTINGS)****Figure 21 Cold Reset Timing****Note:**

For correct operation SDATAOUT and SYNC must be held LOW for entire RESETB active low period otherwise the device may enter test mode. See AC'97 specification or Wolfson applications note WAN104 for more details.

| PARAMETER                               | SYMBOL         | MIN   | TYP | MAX | UNIT          |
|-----------------------------------------|----------------|-------|-----|-----|---------------|
| RESETB active low pulse width           | $t_{RST\_LOW}$ | 1.0   |     |     | $\mu\text{s}$ |
| RESETB inactive to BITCLK startup delay | $t_{RST2CLK}$  | 162.8 |     |     | ns            |

**WARM RESET (ASYNCHRONOUS, PRESERVES REGISTER SETTINGS)****Figure 22 Warm Reset Timing**

| PARAMETER                             | SYMBOL           | MIN   | TYP | MAX | UNIT          |
|---------------------------------------|------------------|-------|-----|-----|---------------|
| SYNC active high pulse width          | $t_{SYNC\_HIGH}$ |       | 1.3 |     | $\mu\text{s}$ |
| SYNC inactive to BITCLK startup delay | $t_{RST2CLK}$    | 162.4 |     |     | ns            |

## REGISTER MAP

**Note:** Highlighted bits differ from the AC'97 specification (newly added for non-AC'97 function, or same bit used in a different way, or for another function)

| Reg     | Name                                                                             | 15                                        | 14        | 13            | 12                  | 11                         | 10                 | 9          | 8    | 7                                   | 6      | 5             | 4                    | 3                 | 2      | 1       | 0       | Default   |
|---------|----------------------------------------------------------------------------------|-------------------------------------------|-----------|---------------|---------------------|----------------------------|--------------------|------------|------|-------------------------------------|--------|---------------|----------------------|-------------------|--------|---------|---------|-----------|
| 00h     | Reset                                                                            | 0                                         | SE4       | SE3           | SE2                 | SE1                        | SE0                | ID9        | ID8  | ID7                                 | ID6    | ID5           | ID4                  | ID3               | ID2    | ID1     | ID0     | 6174h     |
| 02h     | LOUT2/ROUT2 Volume                                                               | MU                                        | 0         | LOUT2 Volume  |                     |                            |                    |            |      | ZC                                  | INV    | ROUT2 Volume  |                      |                   |        |         |         | 8000h     |
| 04h     | Headphone Volume                                                                 | MU                                        | 0         | HPOUTL Volume |                     |                            |                    |            |      | ZC                                  | 0      | HPOUTR Volume |                      |                   |        |         |         | 8000h     |
| 06h     | MONOOUT Volume                                                                   | MU                                        | 0         | 0             | 0                   | 0                          | 0                  | 0          | 0    | ZC                                  | 0      | 0             | MONOOUT Volume       |                   |        |         |         | 8000h     |
| 08h     | DAC Tone Control                                                                 | BB                                        | 0         | 0             | BC                  | BASS                       |                    |            |      | 0                                   | DAT    | 0             | TC                   | TRBL              |        |         |         | 0F0Fh     |
| 0Ah     | PCBEEP Input                                                                     | B2H                                       | B2HVOL    |               |                     | B2S                        | B2SVOL             |            |      | B2P                                 | B2PVOL |               |                      | 0                 | 0      | 0       | 0       | AAA0h     |
| 0Ch     | PHONE Volume                                                                     | P2H                                       | P2S       | 0             | 0                   | 0                          | 0                  | 0          | 0    | 0                                   | 0      | 0             | PHONEIN Volume       |                   |        |         |         | C008h     |
| 0Eh     | MIC Volume                                                                       | 0                                         | M12P      | M22P          | LMICVOL (Left Only) |                            |                    |            |      | 20dB                                | MS     |               | MICVOL (Mono /Right) |                   |        |         |         | 6808h     |
| 10h     | LINEIN Volume                                                                    | L2H                                       | L2S       | L2P           | LINEINLVOL          |                            |                    |            |      | 0                                   | 0      | 0             | LINEINRVOL           |                   |        |         |         | E808h     |
| 12h     | AUXDAC Volume / Routing                                                          | A2H                                       | A2HVOL    |               |                     | A2S                        | A2SVOL             |            |      | A2P                                 | A2PVOL |               |                      | 0                 | 0      | 0       | AXE     | AAA0h     |
| 14h     | Sidetone Volume                                                                  | STM                                       | STVOL     |               |                     | ALCM                       |                    | ALCVOL     |      |                                     | 0      | 0             | 0                    | 0                 | 0      | 0       | 0       | AD00h     |
| 16h     | OUT3 Volume                                                                      | MU                                        | 0         | 0             | 0                   | 0                          | OUT3SRC            |            | SRC  | ZC                                  | 0      | OUT3 Volume   |                      |                   |        |         |         | 8000h     |
| 18h     | DAC Volume                                                                       | D2H                                       | D2S       | D2P           | Left DAC Volume     |                            |                    |            |      | 0                                   | 0      | 0             | Right DAC Volume     |                   |        |         |         | E808h     |
| 1Ah     | Record Select                                                                    | 0                                         | BOOST     | R2P           | R2P                 | BST                        | RECSL              |            |      | 0                                   | 0      | 0             | 0                    | 0                 | RECSR  |         |         | 3000h     |
| 1Ch     | Record Gain                                                                      | RMU                                       | GRL       | (Extended)    |                     | RECVOLL                    |                    |            |      | ZC                                  | GRR    | (Extended)    |                      | RECVOLR           |        |         |         | 8000h     |
| 20h     | General Purpose                                                                  | 0                                         | 0         | 3DE           | 0                   | 0                          | 0                  | 0          | 0    | LB                                  | 0      | 0             | 0                    | 0                 | 0      | 0       | 0       | 0000h     |
| 22h     | DAC 3D Control                                                                   | 0                                         | 0         | 0             | 0                   | 0                          | 0                  | 0          | 0    | 0                                   | 0      | 3DLC          | 3DUC                 | 3DDEPTH           |        |         |         | 0000h     |
| 24h     | Powerdown                                                                        | PD15                                      | PD14      | PD13          | PD12                | PD11                       | PD10               | PD9        | PD8  | PD7                                 | PD6    | PD5           | PD4                  | PD3               | PD2    | PD1     | PD0     | 0000h     |
| 26h     | Powerdown Ctrl/Stat                                                              | 0                                         | PR6       | PR5           | PR4                 | PR3                        | PR2                | PR1        | PR0  | 0                                   | 0      | 0             | 0                    | REF               | ANL    | DAC     | ADC     |           |
|         | Default for reg. 26h - pin 47 "low"                                              |                                           |           |               |                     |                            |                    |            |      |                                     |        |               |                      |                   |        |         |         | 000Fh     |
|         | Default for reg. 26h - pin 47 "high" during reset (recommended for lowest power) |                                           |           |               |                     |                            |                    |            |      |                                     |        |               |                      |                   |        |         |         | FF00h     |
| 28h     | Extended Audio ID                                                                | ID1                                       | ID0       | 0             | 0                   | REV1                       | REV0               | AMAP       | LDAC | SDAC                                | CDAC   | 0             | 0                    | VRM               | SPDIF  | DRA     | VRA     | 0405h     |
| 2Ah     | Ext'd Audio stst/ctrl                                                            | 0                                         | 0         | 0             | 0                   | 0                          | SPCV               | 0          | 0    | 0                                   | 0      | SPSA          |                      | 0                 | SEN    | 0       | VRA     | 0410h     |
| 2Ch     | Audio DACs Sample Rate                                                           | DACSR (Audio DACs Sample Rate)            |           |               |                     |                            |                    |            |      |                                     |        |               |                      |                   |        |         |         | BB80h     |
| 2Eh     | AUXDAC Sample Rate                                                               | AUXDACSR (Auxiliary DAC Sample Rate)      |           |               |                     |                            |                    |            |      |                                     |        |               |                      |                   |        |         |         | BB80h     |
| 32h     | Audio ADCs Sample Rate                                                           | ADCSR (Audio ADCs Sample Rate)            |           |               |                     |                            |                    |            |      |                                     |        |               |                      |                   |        |         |         | BB80h     |
| 3Ah     | SPDIF control                                                                    | V                                         | DRS       | SPSR          |                     | L                          | CC (Category Code) |            |      |                                     |        |               | PRE                  | COPY              | AUD IB | PRO     | 2000h   |           |
| 4Ch     | GPIO Pin Configuration                                                           | 1                                         | 1         | 1             | 1                   | 1                          | 0                  | 0          | 0    | 0                                   | 0      | GC5           | GC4                  | GC3               | GC2    | GC1     | 0       | F83Eh     |
| 4Eh     | GPIO Pin Polarity / Type                                                         | C1P                                       | C2P       | PP            | AP                  | TP                         | 1                  | 1          | 1    | 1                                   | 1      | GP5           | GP4                  | GP3               | GP2    | GP1     | 1       | FFFFh     |
| 50h     | GPIO Pin Sticky                                                                  | C1S                                       | C2S       | PS            | AS                  | TS                         | 0                  | 0          | 0    | 0                                   | 0      | GS5           | GS4                  | GS3               | GS2    | GS1     | 0       | 0000h     |
| 52h     | GPIO Pin Wake-Up                                                                 | C1W                                       | C2W       | PW            | AW                  | TW                         | 0                  | 0          | 0    | 0                                   | 0      | GW5           | GW4                  | GW3               | GW2    | GW1     | 0       | 0000h     |
| 54h     | GPIO Pin Status                                                                  | C1I                                       | C2I       | PI            | AI                  | TI                         | 0                  | 0          | 0    | 0                                   | 0      | GI5           | GI4                  | GI3               | GI2    | GI1     | 0       | GPIO pins |
| 56h     | GPIO Pin Sharing                                                                 | 1                                         | 1         | 1             | 1                   | 1                          | 0                  | 0          | 0    | 0                                   | 0      | GE5           | GE4                  | GE3               | GE2    | 1       | 0       | F83Eh     |
| 58h     | Additional Functions (1)                                                         | COMP2DEL                                  |           |               | J1EN                | FRC                        | SVD                | 0          | 0    | 0                                   | 0      | 0             | 0                    | Die Revision      |        | WAKE EN | IRQ INV | 0008h     |
| 5Ah     | Vendor Reserved                                                                  | RESERVED FOR TEST                         |           |               |                     |                            |                    |            |      |                                     |        |               |                      |                   |        |         |         |           |
| 5Ch     | Add. Functions (2)                                                               | AMUTE                                     | C1 REF    | C1SRC         |                     | C2 REF                     | C2SRC              |            | DS   | AMEN                                | VBIAS  |               | ADCO                 | HPF               | ENT    | ASS     |         | 0000h     |
| 5Eh     | Vendor Reserved                                                                  | RESERVED FOR TEST                         |           |               |                     |                            |                    |            |      |                                     |        |               |                      |                   |        |         |         |           |
| 60h     | ALC Control                                                                      | ALCL (target level)                       |           |               |                     | HLD (hold time)            |                    |            |      | DCY (decay time)                    |        |               |                      | ATK (attack time) |        |         |         | B032h     |
| 62h     | ALC / Noise Gate Control                                                         | ALCSEL                                    |           |               | MAXGAIN             |                            |                    | ZC TIMEOUT |      | ALC ZC                              | NG AT  | 0             | NGG                  | NGTH (threshold)  |        |         |         | 3E00h     |
| 64h     | AUXDAC input control                                                             | XSLE                                      | AUXDACSLT |               |                     | AUXDAC VAL                 |                    |            |      |                                     |        |               |                      |                   |        |         |         | 0000h     |
| 66h-74h | Vendor Reserved                                                                  | RESERVED. DO NOT WRITE TO THESE REGISTERS |           |               |                     |                            |                    |            |      |                                     |        |               |                      |                   |        |         |         |           |
| 76h     | Digitiser Reg 1                                                                  | POLL                                      | ADCSEL    |               |                     | COO                        | CTC                | CR         |      |                                     | DEL    |               |                      | SLEN              | SLT    |         |         | 0006h     |
| 78h     | Digitiser Reg 2                                                                  | PRP                                       |           | RPR           | 45W                 | PDEN                       | 0                  | WAIT       | PIL  | MSK                                 |        |               | RPU                  |                   |        |         |         | 0001h     |
| 7Ah     | Digitiser Read Back                                                              | PNDN                                      | ADCSRC    |               |                     | ADCD (TOUCHPANEL ADC DATA) |                    |            |      |                                     |        |               |                      |                   |        |         |         | 0000h     |
| 7Ch     | Vendor ID1                                                                       | ASCII character "W"                       |           |               |                     |                            |                    |            |      | ASCII character "M"                 |        |               |                      |                   |        |         |         | 574Dh     |
| 7Eh     | Vendor ID2                                                                       | ASCII character "L"                       |           |               |                     |                            |                    |            |      | "12" (indicates part number WM9712) |        |               |                      |                   |        |         |         | 4C12h     |

Table 45 WM9712L Register Map

## REGISTER BITS BY ADDRESS

**Register 00h** is a read-only register. Writing any value to this register resets all registers to their default, but does not change the contents of reg. 00h. Reading the register reveals information about the CODEC to the driver, as required by the AC'97 Specification, Revision 2.2

| REG ADDR | BIT   | LABEL    | DEFAULT | DESCRIPTION                                                         | REFER TO                                                     |
|----------|-------|----------|---------|---------------------------------------------------------------------|--------------------------------------------------------------|
| 00h      | 14:10 | SE [4:0] | 11000   | Indicates a CODEC from Wolfson Microelectronics                     | Intel's AC'97 Component Specification, Revision 2.2, page 50 |
|          | 9:6   | ID9:6    | 0101    | Indicates 18 bits resolution for ADCs and DACs                      |                                                              |
|          | 5     | ID5      | 1       | Indicates that the WM9712L supports bass boost                      |                                                              |
|          | 4     | ID4      | 1       | Indicates that the WM9712L has a headphone output                   |                                                              |
|          | 3     | ID3      | 0       | Indicates that the WM9712L does not support simulated stereo        |                                                              |
|          | 2     | ID2      | 1       | Indicates that the WM9712L supports bass and treble control         |                                                              |
|          | 1     | ID1      | 0       | Indicates that the WM9712L does not support modem functions         |                                                              |
|          | 0     | ID0      | 0       | Indicates that the WM9712L does not have a dedicated microphone ADC |                                                              |

**Register 02h** controls the output pins LOUT2 and ROUT2.

| REG ADDR | BIT  | LABEL     | DEFAULT          | DESCRIPTION                               | REFER TO               |
|----------|------|-----------|------------------|-------------------------------------------|------------------------|
| 02h      | 15   | MU        | 1 (mute)         | Mutes LOUT2 and ROUT2.                    | Analogue Audio Outputs |
|          | 13:8 | LOUT2 VOL | 000000 (0dB)     | LOUT2 volume                              |                        |
|          | 7    | ZC        | 0 (OFF)          | Enables zero-cross detector               |                        |
|          | 6    | INV       | 0 (not inverted) | Inverts LOUT2 (for BTL speaker operation) |                        |
|          | 5:0  | ROUT2 VOL | 000000 (0dB)     | ROUT2 volume                              |                        |

**Register 04h** controls the headphone output pins, HPOUTL and HPOUTR.

| REG ADDR | BIT  | LABEL      | DEFAULT      | DESCRIPTION                 | REFER TO               |
|----------|------|------------|--------------|-----------------------------|------------------------|
| 04h      | 15   | MU         | 1 (mute)     | Mutes HPOUTL and HPOUTR.    | Analogue Audio Outputs |
|          | 13:8 | HPOUTL VOL | 000000 (0dB) | HPOUTL volume               |                        |
|          | 7    | ZC         | 0 (OFF)      | Enables zero-cross detector |                        |
|          | 5:0  | HPOUTR VOL | 000000 (0dB) | HPOUTR volume               |                        |

**Register 06h** controls the analogue output pin MONOOUT.

| REG ADDR | BIT | LABEL       | DEFAULT      | DESCRIPTION                 | REFER TO               |
|----------|-----|-------------|--------------|-----------------------------|------------------------|
| 06h      | 15  | MU          | 1 (mute)     | Mutes MONOOUT.              | Analogue Audio Outputs |
|          | 7   | ZC          | 0 (OFF)      | Enables zero-cross detector |                        |
|          | 5:0 | MONOOUT VOL | 000000 (0dB) | MONOOUT volume              |                        |

**Register 08h** controls the bass and treble response of the left and right audio DAC (but not AUXDAC).

| REG ADDR | BIT  | LABEL | DEFAULT    | DESCRIPTION                                        | REFER TO                                    |
|----------|------|-------|------------|----------------------------------------------------|---------------------------------------------|
| 08h      | 15   | BB    | 0 (linear) | Selects linear bass control or adaptive bass boost | Audio DACs,<br>Tone Control /<br>Bass Boost |
|          | 12   | BC    | 0 (low)    | Selects bass cut-off frequency                     |                                             |
|          | 11:8 | BASS  | 1111 (OFF) | Controls bass intensity                            |                                             |
|          | 6    | DAT   | 0 (OFF)    | Enables 6dB pre-DAC attenuation                    |                                             |
|          | 4    | TC    | 0 (high)   | Selects treble cut-off frequency                   |                                             |
|          | 3:0  | TRBL  | 1111 (OFF) | Controls treble intensity                          |                                             |

**Register 0Ah** controls the analogue input pin PCBEEP.

| REG ADDR | BIT   | LABEL  | DEFAULT   | DESCRIPTION                                     | REFER TO                            |
|----------|-------|--------|-----------|-------------------------------------------------|-------------------------------------|
| 0Ah      | 15    | B2H    | 1 (mute)  | Mutes PCBEEP to headphone mixer path            | Analogue<br>Inputs,<br>PCBEEP Input |
|          | 14:12 | B2HVOL | 010 (0dB) | Controls gain of PCBEEP to headphone mixer path |                                     |
|          | 11    | B2S    | 1 (mute)  | Mutes PCBEEP to speaker mixer path              |                                     |
|          | 10:8  | B2SVOL | 010 (0dB) | Controls gain of PCBEEP to speaker mixer path   |                                     |
|          | 7     | B2P    | 1 (mute)  | Mutes PCBEEP to phone mixer path                |                                     |
|          | 6:4   | B2PVOL | 010 (0dB) | Controls gain of PCBEEP to phone mixer path     |                                     |

**Register 0Ch** controls the analogue input pin PHONE.

| REG ADDR | BIT | LABEL    | DEFAULT     | DESCRIPTION                                              | REFER TO                           |
|----------|-----|----------|-------------|----------------------------------------------------------|------------------------------------|
| 0Ch      | 15  | P2H      | 1 (mute)    | Mutes PHONE to headphone mixer path                      | Analogue<br>Inputs,<br>PHONE Input |
|          | 14  | P2S      | 1 (mute)    | Mutes PHONE to speaker mixer path                        |                                    |
|          | 4:0 | PHONEVOL | 01000 (0dB) | Controls PHONE input gain to all mixers (but not to ADC) |                                    |

**Register 0Eh** controls the analogue input pins MIC1 and MIC2.

| REG ADDR | BIT  | LABEL   | DEFAULT        | DESCRIPTION                                                                     | REFER TO                                   |
|----------|------|---------|----------------|---------------------------------------------------------------------------------|--------------------------------------------|
| 0Eh      | 14   | M12P    | 1 (mute)       | Mutes MIC1 to phone mixer path                                                  | Analogue<br>Inputs,<br>Microphone<br>Input |
|          | 13   | M22P    | 1 (mute)       | Mutes MIC2 to phone mixer path                                                  |                                            |
|          | 12:8 | LMICVOL | 01000 (0dB)    | Controls volume of MIC1 (left), in stereo mode only                             |                                            |
|          | 7    | 20dB    | 0 (OFF)        | Enables 20dB gain boost                                                         |                                            |
|          | 6:5  | MS      | 00 (MIC1 only) | Selects microphone mode. 00=MIC1 only, 01=differential, 10=MIC2 only, 11=stereo |                                            |
|          | 4:0  | MICVOL  | 01000 (0dB)    | Controls mic volume (except MIC1 in stereo mode)                                |                                            |

**Register 10h** controls the analogue input pins LINEINL and LINEINR.

| REG ADDR | BIT  | LABEL      | DEFAULT     | DESCRIPTION                                                | REFER TO                          |
|----------|------|------------|-------------|------------------------------------------------------------|-----------------------------------|
| 10h      | 15   | L2H        | 1 (mute)    | Mutes LINEIN to headphone mixer path                       | Analogue<br>Inputs, Line<br>Input |
|          | 14   | L2S        | 1 (mute)    | Mutes LINEIN to speaker mixer path                         |                                   |
|          | 13   | L2P        | 1 (mute)    | Mutes LINEIN to phone mixer path                           |                                   |
|          | 12:8 | LINEINLVOL | 01000 (0dB) | Controls LINEINL input gain to all mixers (but not to ADC) |                                   |
|          | 4:0  | LINEINRVOL | 01000 (0dB) | Controls LINEINR input gain to all mixers (but not to ADC) |                                   |

**Register 12h** controls the output signal of the auxiliary DAC.

| REG ADDR | BIT   | LABEL  | DEFAULT   | DESCRIPTION                                     | REFER TO      |
|----------|-------|--------|-----------|-------------------------------------------------|---------------|
| 12h      | 15    | A2H    | 1 (mute)  | Mutes AUXDAC to headphone mixer path            | Auxiliary DAC |
|          | 14:12 | A2HVOL | 010 (0dB) | Controls gain of AUXDAC to headphone mixer path |               |
|          | 11    | A2S    | 1 (mute)  | Mutes AUXDAC to speaker mixer path              |               |
|          | 10:8  | A2SVOL | 010 (0dB) | Controls gain of AUXDAC to speaker mixer path   |               |
|          | 7     | A2P    | 1 (mute)  | Mutes AUXDAC to phone mixer path                |               |
|          | 6:4   | A2PVOL | 010 (0dB) | Controls gain of AUXDAC to phone mixer path     |               |
|          | 0     | AXE    | 0 (OFF)   | Enables AUXDAC                                  |               |

**Register 14h** controls the side tone paths.

| REG ADDR | BIT   | LABEL  | DEFAULT        | DESCRIPTION                                                                                              | REFER TO                              |
|----------|-------|--------|----------------|----------------------------------------------------------------------------------------------------------|---------------------------------------|
| 14h      | 15    | STM    | 1 (mute)       | Mutes microphone to headphone mixer path                                                                 | Audio Mixers,<br>Side Tone<br>Control |
|          | 14:12 | STVOL  | 010 (0dB)      | Controls gain of microphone to headphone mixer path                                                      |                                       |
|          | 11:10 | ALCM   | 11 (mute both) | Selects ALC to headphone mixer path. 00=stereo, 01=right only, 10=left only, 11=mute both left and right |                                       |
|          | 9:7   | ALCVOL | 010 (0dB)      | Controls gain of ALC to headphone mixer path                                                             |                                       |

**Register 16h** controls the analogue output pin OUT3, and also contains one control bit that affects LOUT2 and ROUT2.

| REG ADDR | BIT  | LABEL   | DEFAULT      | DESCRIPTION                                                                             | REFER TO                  |
|----------|------|---------|--------------|-----------------------------------------------------------------------------------------|---------------------------|
| 16h      | 15   | MU      | 1 (mute)     | Mutes OUT3.                                                                             | Analogue<br>Audio Outputs |
|          | 10:9 | OUT3SRC | 00 (-HPOUTL) | Selects source of OUT3 signal. 00=-HPOUTL, 01=VREF, 10=HPOUTL+HPOUTR, 11=-MONOOUT       |                           |
|          | 8    | SRC     | 0 (spkr mix) | Selects source of LOUT2 and ROUT2 signals. 0=from speaker mixer, 1=from headphone mixer |                           |
|          | 7    | ZC      | 0 (disabled) | Zero-cross enable                                                                       |                           |
|          | 5:0  | OUT3VOL | 000000 (0dB) | OUT3 volume                                                                             |                           |

**Register 18h** controls the audio DACs (but not AUXDAC).

| REG ADDR | BIT  | LABEL   | DEFAULT     | DESCRIPTION                                 | REFER TO   |
|----------|------|---------|-------------|---------------------------------------------|------------|
| 18h      | 15   | D2H     | 1 (mute)    | Mutes DAC to headphone mixer path           | Audio DACs |
|          | 14   | D2S     | 1 (mute)    | Mutes DAC to speaker mixer path             |            |
|          | 13   | D2P     | 1 (mute)    | Mutes DAC to phone mixer path               |            |
|          | 12:8 | LDACVOL | 01000 (0dB) | Controls left DAC input gain to all mixers  |            |
|          | 4:0  | RDACVOL | 01000 (0dB) | Controls right DAC input gain to all mixers |            |

**Register 1Ah** controls the record selector and the ADC to phone mixer path.

| REG ADDR | BIT   | LABEL  | DEFAULT   | DESCRIPTION                                                                                              | REFER TO                         |
|----------|-------|--------|-----------|----------------------------------------------------------------------------------------------------------|----------------------------------|
| 1Ah      | 14    | BOOST  | 0 (OFF)   | Enables 20dB gain boost for recording                                                                    | Audio ADC,<br>Record<br>Selector |
|          | 13:12 | R2P    | 11 (mute) | Controls ADC to phone mixer path. 00=stereo, 01=left ADC only, 10=right ADC only, 11=mute left and right |                                  |
|          | 11    | R2PBST | 0 (OFF)   | Enables 20dB gain boost for ADC to phone mixer path                                                      |                                  |
|          | 10:8  | RECSL  | 000 (mic) | Selects left ADC signal source                                                                           |                                  |
|          | 2:0   | RECSR  | 000 (mic) | Selects right ADC signal source                                                                          |                                  |

Register 1Ch controls the recording gain.

| REG ADDR | BIT  | LABEL   | DEFAULT      | DESCRIPTION                                                                                            | REFER TO               |
|----------|------|---------|--------------|--------------------------------------------------------------------------------------------------------|------------------------|
| 1Ch      | 15   | RMU     | 1 (mute)     | Mutes audio ADC input                                                                                  | Audio ADC, Record Gain |
|          | 14   | GRL     | 0 (standard) | Selects gain range for PGA of left ADC. 0=0...+22.5dB in 1.5dB steps, 1=-17.25...+30dB in 0.75dB steps |                        |
|          | 13:8 | RECVOLL | 000000 (0dB) | Controls left ADC recording volume                                                                     |                        |
|          | 7    | ZC      | 0 (OFF)      | Enables zero-cross detector                                                                            |                        |
|          | 6    | GRR     | 0 (standard) | Selects gain range for PGA of left ADC. 0=0...+22.5dB in 1.5dB steps, 1=-17.25...+30dB in 0.75dB steps |                        |
|          | 5:0  | RECVOLR | 000000 (0dB) | Controls right ADC recording volume                                                                    |                        |

Register 20h is a “general purpose” register as defined by the AC’97 specification. Only two bits are implemented in the WM9712L.

| REG ADDR | BIT | LABEL | DEFAULT | DESCRIPTION                                                    | REFER TO                                                     |
|----------|-----|-------|---------|----------------------------------------------------------------|--------------------------------------------------------------|
| 20h      | 13  | 3DE   | 0 (OFF) | Enables 3D enhancement                                         | Audio DACs, 3D Stereo Enhancement                            |
|          | 7   | LB    | 0 (OFF) | Enables loopback (i.e. feed ADC output data directly into DAC) | Intel’s AC’97 Component Specification, Revision 2.2, page 55 |

Register 22h controls 3D stereo enhancement for the audio DACs.

| REG ADDR | BIT | LABEL   | DEFAULT   | DESCRIPTION                     | REFER TO                          |
|----------|-----|---------|-----------|---------------------------------|-----------------------------------|
| 22h      | 5   | 3DLC    | 0 (low)   | Selects lower cut-off frequency | Audio DACs, 3D Stereo Enhancement |
|          | 4   | 3DUC    | 0 (high)  | Selects upper cut-off frequency |                                   |
|          | 3:0 | 3DDEPTH | 0000 (0%) | Controls depth of 3D effect     |                                   |

Register 24h is for power management additional to the AC’97 specification. Note that the actual state of each circuit block depends on both register 24h AND register 26h.

| REG ADDR | BIT | LABEL | DEFAULT | DESCRIPTION                                       | REFER TO         |
|----------|-----|-------|---------|---------------------------------------------------|------------------|
| 24h      | 15  | PD15  | 0 *     | Disables Crystal Oscillator                       | Power Management |
|          | 14  | PD14  | 0 *     | Disables left audio DAC                           |                  |
|          | 13  | PD13  | 0 *     | Disables right audio DAC                          |                  |
|          | 12  | PD12  | 0 *     | Disables left audio ADC                           |                  |
|          | 11  | PD11  | 0 *     | Disables right audio ADC                          |                  |
|          | 10  | PD10  | 0 *     | Disables MICBIAS                                  |                  |
|          | 9   | PD9   | 0 *     | Disables left headphone mixer                     |                  |
|          | 8   | PD8   | 0 *     | Disables right headphone mixer                    |                  |
|          | 7   | PD7   | 0 *     | Disables speaker mixer                            |                  |
|          | 6   | PD6   | 0 *     | Disables MONO_OUT buffer (pin 33) and phone mixer |                  |
|          | 5   | PD5   | 0 *     | Disables OUT3 buffer (pin 37)                     |                  |
|          | 4   | PD4   | 0 *     | Disables headphone buffers (HPOUTL/R)             |                  |
|          | 3   | PD3   | 0 *     | Disables speaker outputs (LOUT2, ROUT2)           |                  |
|          | 2   | PD2   | 0 *     | Disables Line Input PGA (left and right)          |                  |
|          | 1   | PD1   | 0 *     | Disables Phone Input PGA                          |                  |
|          | 0   | PD0   | 0 *     | Disables Mic Input PGA (left and right)           |                  |

\* “0” corresponds to “ON”, if and only if the corresponding bit in register 26h is also 0.

**Register 26h** is for power management according to the AC'97 specification. Note that the actual state of many circuit blocks depends on both register 24h AND register 26h.

| REG ADDR | BIT | LABEL | DEFAULT        | DESCRIPTION                                           | REFER TO         |
|----------|-----|-------|----------------|-------------------------------------------------------|------------------|
|          | 14  | PR6   | see note       | Disables HPOUTL, HPOUTR and OUT3 Buffer               | Power Management |
|          | 13  | PR5   |                | Disables Internal Clock                               |                  |
|          | 12  | PR4   |                | Disables AC-link interface (external clock off)       |                  |
|          | 11  | PR3   |                | Disables VREF, analogue mixers and outputs            |                  |
|          | 10  | PR2   |                | Disables analogue mixers, LOUT2, ROUT2 (but not VREF) |                  |
|          | 9   | PR1   |                | Disables Stereo DAC and AUXDAC                        |                  |
|          | 8   | PR0   |                | Disables audio ADCs and input Mux                     |                  |
|          | 3   | REF   | inverse of PR2 | Read-only bit, Indicates VREF is ready                |                  |
|          | 2   | ANL   | inverse of PR3 | Read-only bit, indicates analogue mixers are ready    |                  |
|          | 1   | DAC   | inverse of PR1 | Read-only bit, indicates audio DACs are ready         |                  |
|          | 0   | ADC   | inverse of PR0 | Read-only bit, indicates audio ADCs are ready         |                  |

**Note:** PR6 to PR0 default to 1 if pin 47 is held high during reset, otherwise they default to 0.

**Register 28h** is a read-only register that indicates to the driver which advanced AC'97 features the WM9712L supports.

| REG ADDR | BIT   | LABEL | DEFAULT | DESCRIPTION                                                                        | REFER TO                                                     |
|----------|-------|-------|---------|------------------------------------------------------------------------------------|--------------------------------------------------------------|
| 28h      | 15:14 | ID    | 00      | Indicates that the WM9712L is configured as the primary CODEC in the system.       | Intel's AC'97 Component Specification, Revision 2.2, page 59 |
|          | 11:10 | REV   | 01      | Indicates that the WM9712L conforms to AC'97 Rev2.2                                |                                                              |
|          | 9     | AMAP  | 0       | Indicates that the WM9712L does not support slot mapping                           |                                                              |
|          | 8     | LDAC  | 0       | Indicates that the WM9712L does not have an LFE DAC                                |                                                              |
|          | 7     | SDAC  | 0       | Indicates that the WM9712L does not have Surround DACs                             |                                                              |
|          | 6     | CDAC  | 0       | Indicates that the WM9712L does not have a Centre DAC                              |                                                              |
|          | 3     | VRM   | 0       | Indicates that the WM9712L does not have a dedicated, variable rate microphone ADC |                                                              |
|          | 2     | SPDIF | 1       | Indicates that the WM9712L supports SPDIF output                                   |                                                              |
|          | 1     | DRA   | 0       | Indicates that the WM9712L does not support double rate audio                      |                                                              |
|          | 0     | VRA   | 1       | Indicates that the WM9712L supports variable rate audio                            |                                                              |

**Register 2Ah** controls the SPDIF output and variable rate audio.

| REG ADDR | BIT | LABEL | DEFAULT         | DESCRIPTION                                                                | REFER TO                     |
|----------|-----|-------|-----------------|----------------------------------------------------------------------------|------------------------------|
| 2Ah      | 10  | SPCV  | 1 (valid)       | SPDIF validity bit (read-only)                                             | Digital Audio (SPDIF) Output |
|          | 5:4 | SPSA  | 01 (slots 6, 9) | Controls SPDIF slot assignment. 00=slots 3 and 4, 01=6/9, 10=7/8, 11=10/11 |                              |
|          | 2   | SEN   | 0 (OFF)         | Enables SPDIF output enable                                                |                              |
|          | 0   | VRA   | 0 (OFF)         | Enables variable rate audio                                                |                              |

**Registers 2Ch, 2Eh 32h** and control the sample rates for the stereo DAC, auxiliary DAC and audio ADC, respectively.

| REG ADDR | BIT | LABEL    | DEFAULT | DESCRIPTION                        | REFER TO                                     |
|----------|-----|----------|---------|------------------------------------|----------------------------------------------|
| 2Ch      | all | DACSR    | BB80h   | Controls stereo DAC sample rate    | Variable Rate Audio / Sample Rate Conversion |
| 2Eh      | all | AUXDACSR | BB80h   | Controls auxiliary DAC sample rate |                                              |
| 32h      | all | ADCSR    | BB80h   | Controls audio ADC sample rate     |                                              |

**Note:** The VRA bit in register 2Ah must be set first to obtain sample rates other than 48kHz

Register 3Ah controls the SPDIF output.

| REG ADDR | BIT   | LABEL | DEFAULT | DESCRIPTION                                                                             | REFER TO                     |
|----------|-------|-------|---------|-----------------------------------------------------------------------------------------|------------------------------|
| 3Ah      | 15    | V     | 0       | Validity bit; '0' indicates frame valid, '1' indicates frame not valid                  | Digital Audio (SPDIF) Output |
|          | 14    | DRS   | 0       | Indicates that the WM9712L does not support double rate SPDIF output (read-only)        |                              |
|          | 13:12 | SPSR  | 10      | Indicates that the WM9712L only supports 48kHz sampling on the SPDIF output (read-only) |                              |
|          | 11    | L     | 0       | Generation level; programmed as required by user                                        |                              |
|          | 10:4  | CC    | 0000000 | Category code; programmed as required by user                                           |                              |
|          | 3     | PRE   | 0       | Pre-emphasis; '0' indicates no pre-emphasis, '1' indicates 50/15us pre-emphasis         |                              |
|          | 2     | COPY  | 0       | Copyright; '0' indicates copyright is not asserted, '1' indicates copyright             |                              |
|          | 1     | AUDIB | 0       | Non-audio; '0' indicates data is PCM, '1' indicates non-PCM format (e.g. DD or DTS)     |                              |
|          | 0     | PRO   | 0       | Professional; '0' indicates consumer, '1' indicates professional                        |                              |

Register 4Ch to 54h control the GPIO pins and virtual GPIO signals.

| REG ADDR | BIT  | LABEL                            | DEFAULT                               | DESCRIPTION                                                                                  | REFER TO                   |
|----------|------|----------------------------------|---------------------------------------|----------------------------------------------------------------------------------------------|----------------------------|
| 4Ch      |      |                                  | all 1 (all inputs) except unused bits | Controls GPIO configuration as inputs or as outputs (note: virtual GPIOs can only be inputs) | GPIO and Interrupt Control |
| 4Eh      |      |                                  | all 1                                 | Controls GPIO polarity (actual polarity depends on register 4Ch AND register 4Eh)            |                            |
| 50h      |      |                                  | all 0 (not sticky)                    | Makes GPIO signals sticky                                                                    |                            |
| 52h      |      |                                  | all 0 (OFF)                           | Enables wake-up for each GPIO signal                                                         |                            |
| 54h      |      |                                  | = status of GPIO inputs               | GPIO pin status (read from inputs, write '0' to clear sticky bits)                           |                            |
|          | 15   | please refer to the register map |                                       | Controls Comparator 1 signal (virtual GPIO)                                                  |                            |
|          | 14   |                                  |                                       | Controls Comparator 2 signal (virtual GPIO)                                                  |                            |
|          | 13   |                                  |                                       | Controls Pen-Down Detector signal (virtual GPIO)                                             |                            |
|          | 12   |                                  |                                       | Controls ADA signal (virtual GPIO)                                                           |                            |
|          | 11   |                                  |                                       | Controls Thermal sensor signal (virtual GPIO)                                                |                            |
|          | 10-6 |                                  |                                       | Unused                                                                                       |                            |
|          | 5    |                                  |                                       | Controls GPIO5 (pin 48)                                                                      |                            |
|          | 4    |                                  |                                       | Controls GPIO4 (pin 47)                                                                      |                            |
|          | 3    |                                  |                                       | Controls GPIO3 (pin 46)                                                                      |                            |
|          | 2    |                                  |                                       | Controls GPIO2 (pin 45)                                                                      |                            |
|          | 1    |                                  |                                       | Controls GPIO1 (pin 44)                                                                      |                            |

Register 56h controls the use of GPIO pins for non-GPIO functions.

| REG ADDR | BIT | LABEL | DEFAULT  | DESCRIPTION                                             | REFER TO                   |
|----------|-----|-------|----------|---------------------------------------------------------|----------------------------|
| 56h      | 5   | GE5   | 1 (GPIO) | Selects between GPIO5 and SPDIF_OUT function for pin 48 | GPIO and Interrupt Control |
|          | 4   | GE4   | 1 (GPIO) | Selects between GPIO4 and ADA/MASK functionS for pin 47 |                            |
|          | 3   | GE3   | 1 (GPIO) | Selects between GPIO3 and PENDOWN function for pin 46   |                            |
|          | 2   | GE2   | 1 (GPIO) | Selects between GPIO2 and IRQ function for pin 45       |                            |

**Register 58h** controls several additional functions.

| REG ADDR | BIT   | LABEL    | DEFAULT                                                 | DESCRIPTION                                         | REFER TO                                                  |
|----------|-------|----------|---------------------------------------------------------|-----------------------------------------------------|-----------------------------------------------------------|
| 58h      | 15:13 | COMP2DEL | 000 (no delay)                                          | Selects Comparator 2 delay                          | Battery Alarm                                             |
|          | 12    | JIEN     | 0                                                       | Enables Jack Insert Detection                       | Analogue Audio Outputs, Jack Insertion and Auto-Switching |
|          | 11    | FRC      | 0                                                       | Forces Jack Insert Detection                        |                                                           |
|          | 10    | SVD      | 0 (enabled)                                             | Disables VREF for lowest possible power consumption | Power Management                                          |
|          | 3:2   | DIE REV  | Indicates device revision. 00=Rev.A, 01=Rev.B, 10=Rev.C |                                                     | N/A                                                       |
|          | 1     | WAKEEN   | 0 (no wake-up)                                          | Enables GPIO wake-up                                | GPIO and Interrupt Control                                |
|          | 0     | IRQ INV  | 0 (not inverted)                                        | Inverts the IRQ signal (pin 45)                     |                                                           |

**Register 5Ch** controls several additional functions.

| REG ADDR | BIT   | LABEL | DEFAULT    | DESCRIPTION                                                                                 | REFER TO                               |
|----------|-------|-------|------------|---------------------------------------------------------------------------------------------|----------------------------------------|
| 5Ch      | 15    | AMUTE | 0          | Read-only bit to indicate DAC auto-muting                                                   | Audio DACs, Stereo DACs                |
|          | 14    | C1REF | 0 (AVDD/2) | Selects Comparator 1 Reference Voltage                                                      | Battery Alarm                          |
|          | 13:12 | C1SRC | 00 (OFF)   | Selects Comparator 1 Signal Source                                                          |                                        |
|          | 11    | C2REF | 0 (AVDD/2) | Selects Comparator 1 Reference Voltage                                                      |                                        |
|          | 10:9  | C2SRC | 00 (OFF)   | Selects Comparator 1 Signal Source                                                          |                                        |
|          | 8     | DS    | 0          | Selects differential microphone input pins. 0=MIC1 and MIC2, 1=LINEL and LINER              | Analogue Inputs, Microphone Input      |
|          | 7     | AMEN  | 0 (OFF)    | Enables DAC Auto-Mute                                                                       |                                        |
|          | 6:5   | VBIAS | 00         | Selects analogue bias for lowest power, depending on AVDD supply. 0X=3.3V, 10=2.5V, 11=1.8V | Power Management                       |
|          | 4     | ADCO  | 0          | Selects source of SPDIF data. 0=from SDATAOUT, 1= from audio ADC                            | Digital Audio (SPDIF) Output           |
|          | 3     | HPF   | 0          | Disables ADC high-pass filter                                                               | Audio ADC                              |
|          | 2     | ENT   | 0          | Enables thermal sensor                                                                      | Analogue Audio Outputs, Thermal Sensor |
|          | 1:0   | ASS   | 00         | Selects time slots for stereo ADC data. 00=slots 3 and 4, 01=7/8, 10=6/9, 11=10/11          | Audio ADC, ADC Slot Mapping            |

**Registers 60h and 62h** control the ALC and Noise Gate functions.

| REG ADDR | BIT   | LABEL      | DEFAULT         | DESCRIPTION                                                                           | REFER TO                           |
|----------|-------|------------|-----------------|---------------------------------------------------------------------------------------|------------------------------------|
| 60h      | 15:12 | ALCL       | 1011 (-12dB)    | Controls ALC threshold                                                                | Audio ADC, Automatic Level Control |
|          | 11:8  | HLD        | 0000 (0 ms)     | Controls ALC hold time                                                                |                                    |
|          | 7:4   | DCY        | 0011 (192 ms)   | Controls ALC decay time                                                               |                                    |
|          | 3:0   | ATK        | 0010 (24 ms)    | Controls ALC attack time                                                              |                                    |
| 62h      | 15:14 | ALCSEL     | 00 (OFF)        | Controls which channel ALC operates on. 00=none, 01=right only, 10=left only, 11=both |                                    |
|          | 13:11 | MAXGAIN    | 111 (+30dB)     | Controls upper gain limit for ALC                                                     |                                    |
|          | 10:9  | ZC TIMEOUT | 11 (slowest)    | Controls time-out for zero-cross detection                                            |                                    |
|          | 8     | ALCZC      | 0 (OFF)         | Enables zero-cross detection for ALC                                                  |                                    |
|          | 7     | NGAT       | 0 (OFF)         | Enables noise gate function                                                           |                                    |
|          | 5     | NGG        | 0 (hold gain)   | Selects noise gate type. 0=hold gain, 1=mute                                          |                                    |
|          | 4:0   | NGTH       | 00000 (-76.5dB) | Controls noise gate threshold                                                         |                                    |

Register 64h controls the input signal of the auxiliary DAC.

| REG ADDR | BIT   | LABEL     | DEFAULT      | DESCRIPTION                                                                                       | REFER TO      |
|----------|-------|-----------|--------------|---------------------------------------------------------------------------------------------------|---------------|
| 64h      | 15    | XSLE      | 0            | Selects input for AUXDAC. 0=from AUXDACVAL (for DC signals), 1=from AC-Link slot (for AC signals) | Auxiliary DAC |
|          | 14:12 | AUXDACSLT | 000 (Slot 5) | Selects input slot for AUXDAC (with XSLE=1)                                                       |               |
|          | 11:0  | AUXDACVAL | 000000000    | AUXDAC Digital Input for AUXDAC (with XSLE=0). 000h=minimum, FFFh=full-scale                      |               |

Registers 76h, 78h and 7Ah control the touchpanel interface.

| REG ADDR      | BIT   | LABEL   | DEFAULT       | DESCRIPTION                                                                                                  | REFER TO             |
|---------------|-------|---------|---------------|--------------------------------------------------------------------------------------------------------------|----------------------|
| 76h           | 15    | POLL    | 0             | Writing "1" starts a measurement (this bit resets itself)                                                    | Touchpanel Interface |
|               | 14:12 | ADCSEL  | 000 (none)    | Selects measurement type                                                                                     |                      |
|               | 11    | COO     | 0 (OFF)       | Enables co-ordinate mode                                                                                     |                      |
|               | 10    | CTC     | 0 (polling)   | Enables continuous conversions                                                                               |                      |
|               | 9:8   | CR      | 00 (93.75Hz)  | Controls conversion rate in continuous mode                                                                  |                      |
|               | 7:4   | DEL     | 0000 (20.8μs) | Controls touchpanel settling time                                                                            |                      |
|               | 3     | SLEN    | 1             | Enables slot readback of touchpanel data                                                                     |                      |
|               | 2:0   | SLT     | 10            | Selects time slot for readback of touchpanel data                                                            |                      |
| 78h           | 15:14 | PRP     | 00            | Selects mode of operation. 00=OFF, 01=pen detect with wake-up, 10=pen detect without wake-up, 11=running     |                      |
|               | 13    | RPR     | 0             | Selects wake-up mode. 0=AC-Link only, 1=AC-Link and WM9712L auto-wake-up                                     |                      |
|               | 12    | 45W     | 0 (4-wire)    | Selects 4-wire or 5-wire touchpanel                                                                          |                      |
|               | 11    | PDEN    | 0 (always)    | Selects when touchpanel measurements take place. 0=always, 1=only when pen is down                           |                      |
|               | 9     | WAIT    | 0             | Controls data readback from register 7Ah. 0=overwrite old data with new, 1=wait until old data has been read |                      |
|               | 8     | PIL     | 0 (200μA)     | Controls current used for pressure measurement. 1=400μA                                                      |                      |
|               | 7:6   | MSK     | 00 (OFF)      | Controls MASK feature                                                                                        |                      |
|               | 5:0   | RPU     | 000001 (64kΩ) | Controls internal pull-up resistor for pen-down detection                                                    |                      |
| 7Ah read only | 15    | PNDN    | 0 (pen up)    | Indicates pen status.                                                                                        |                      |
|               | 14:12 | ADC SRC | 000 (none)    | Indicates measurement type                                                                                   |                      |
|               | 11:0  | ADCD    | 000h          | Returns data from touchpanel / AUXADC                                                                        |                      |

Register 7Ch and 7Eh are read-only registers that indicate to the driver that the CODEC is a WM9712L.

| REG ADDR | BIT  | LABEL  | DEFAULT | DESCRIPTION                     | REFER TO                                                     |
|----------|------|--------|---------|---------------------------------|--------------------------------------------------------------|
| 7Ch      | 15:8 | F7:0   | 57h     | ASCII character "W" for Wolfson | Intel's AC'97 Component Specification, Revision 2.2, page 50 |
|          | 7:0  | S7:0   | 4Dh     | ASCII character "M"             |                                                              |
| 7Eh      | 15:8 | T7:0   | 4Ch     | ASCII character "L"             |                                                              |
|          | 7:0  | REV7:0 | 12h     | 12 for WM9712L                  |                                                              |

## APPLICATIONS INFORMATION

## RECOMMENDED EXTERNAL COMPONENTS

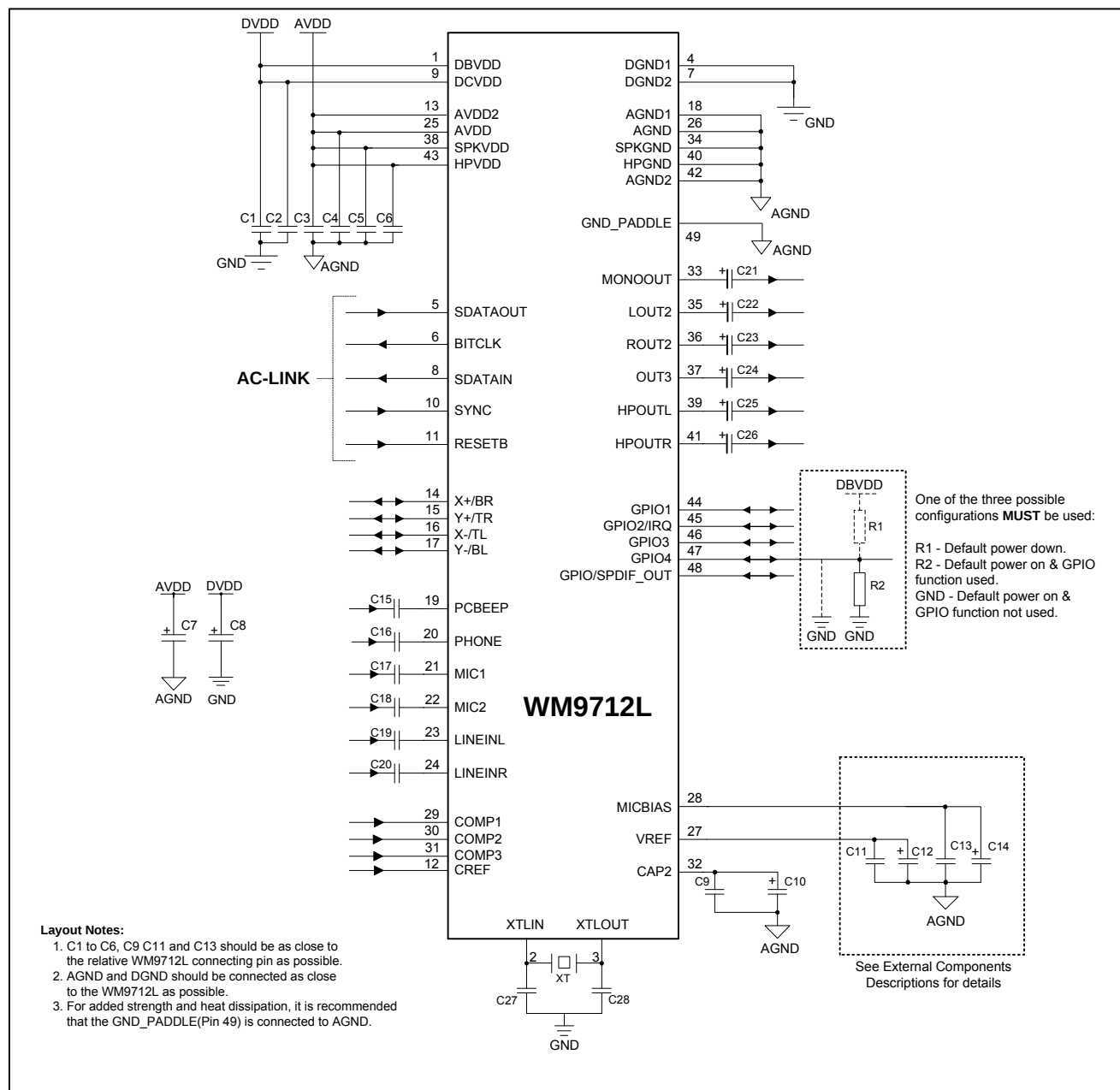


Figure 23 External Components Diagram

## RECOMMENDED COMPONENTS VALUES

| COMPONENT REFERENCE | SUGGESTED VALUE | DESCRIPTION                                                                                                                                         |
|---------------------|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| C1 - C6             | 100nF           | De-coupling for DBVDD,DCVDD,TPVDD,AVDD,SPKVDD,HPVDD                                                                                                 |
| C7 - C8             | 10uF            | Reservoir capacitor for DVDD, AVDD. Should the supplies use separate sources then additional capacitors will be required of each additional source. |
| C9                  | 100nF           | De-coupling for CAP2.                                                                                                                               |
| C10                 | 10uF            | Reservoir capacitor for CAP2                                                                                                                        |
| C11                 | 100nF           | De-coupling for VREF                                                                                                                                |
| C12                 | 10uF            | Reservoir capacitor for VREF                                                                                                                        |
| C13                 | 100nF           | De-coupling for MICBIAS - Not required if MICBIAS output is not used                                                                                |
| C14                 | 10uF            | Reservoir capacitor for MICBIAS - Not required if MICBIAS output is not used                                                                        |
| C27 & C28           | 22pF            | Required when used with a parallel resonant crystal.                                                                                                |
| C15 - C20           | 1uF             | AC coupling capacitors                                                                                                                              |
| C21 - C23           | 2.2uF           | Output AC coupling capacitors to remove VREF DC level from outputs                                                                                  |
| C24 - C26           | 220μF           | Output AC coupling capacitors to remove VREF DC level from outputs.                                                                                 |
| R1                  | 100kΩ           | Pull-up resistor, ensures that all circuit blocks are OFF by default                                                                                |
| R2                  | 100kΩ           | Pull down resistor, ensures that all circuit blocks are ON by default                                                                               |
| XT                  | 24.576MHz       | AC'97 master clock frequency. A bias resistor is not required but if connected will not affect operation if the value is large (above 1MΩ)          |

Table 46 External Components Descriptions

## Note:

- For Capacitors C7, C8, C10, C12 and C14 it is recommended that very low ESR components are used.

## LINE OUTPUT

The headphone outputs, HPOUTL and HPOUTR, can be used as stereo line outputs. The speaker outputs, LOUT2 and ROUT2, can also be used as line outputs, if LOUT2 is not inverted for BTL operation (INV = 0). Recommended external components are shown below.

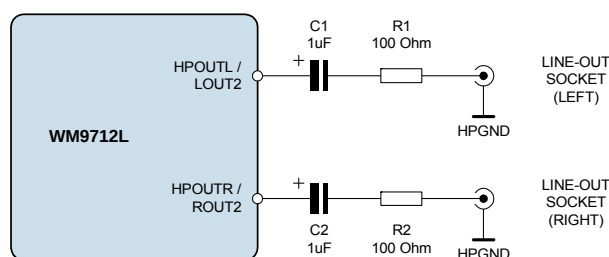


Figure 24 Recommended Circuit for Line Output

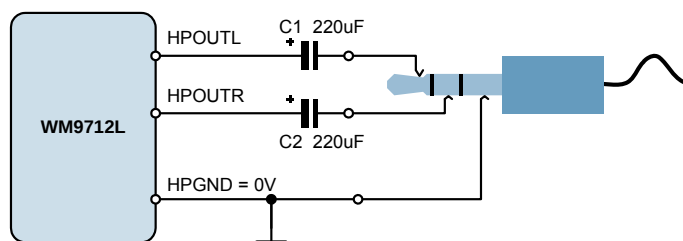
The DC blocking capacitors and the load resistance together determine the lower cut-off frequency,  $f_c$ . Assuming a 10 kΩ load and  $C_1, C_2 = 10\mu\text{F}$ :

$$f_c = 1 / 2\pi (R_L + R_i) \quad C_1 = 1 / (2\pi \times 10.1\text{k}\Omega \times 1\mu\text{F}) = 16 \text{ Hz}$$

Increasing the capacitance lowers  $f_c$ , improving the bass response. Smaller values of  $C_1$  and  $C_2$  will diminish the bass response. The function of  $R_1$  and  $R_2$  is to protect the line outputs from damage when used improperly.

## AC-COUPLED HEADPHONE OUTPUT

The circuit diagram below shows how to connect a stereo headphone to the WM9712L.



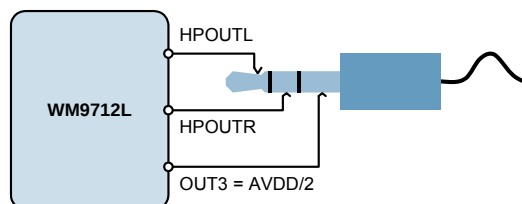
**Figure 25 Simple Headphone Output Circuit Diagram**

The DC blocking capacitors C1 and C2 together with the load resistance determine the lower cut-off frequency,  $f_c$ . Increasing the capacitance lowers  $f_c$ , improving the bass response. Smaller capacitance values will diminish the bass response. For example, with a  $16\Omega$  load and  $C_1 = 220\mu\text{F}$ :

$$f_c = 1 / 2\pi R_L C_1 = 1 / (2\pi \times 16\Omega \times 220\mu\text{F}) = 45 \text{ Hz}$$

## DC COUPLED (CAPLESS) HEADPHONE OUTPUT

In the interest of saving board space and cost, it may be desirable to eliminate the  $220\mu\text{F}$  DC blocking capacitors. This can be achieved by using OUT3 as a headphone pseudo-ground, as shown below.



**Figure 26 Capless Headphone Output Circuit Diagram (OUT3SRC = 10)**

As the OUT3 pin produces a DC voltage of  $AVDD/2$ , there is no DC offset between HPOUTL/HPOUTR and OUT3, and therefore no DC blocking capacitors are required. However, this configuration has some drawbacks:

- The power consumption of the WM9712L is increased, due to the additional power consumed in the OUT3 output buffer.
- If the DC coupled output is connected to the line-in of a grounded piece of equipment, then OUT3 becomes short-circuited. Although the built-in short circuit protection will prevent any damage to the WM9712L, the audio signal will not be transmitted properly.
- OUT3 cannot be used for another purpose

## BTL LOUDSPEAKER OUTPUT

LOUT2 and ROUT2 can differentially drive a mono 8Ω loudspeaker as shown below.

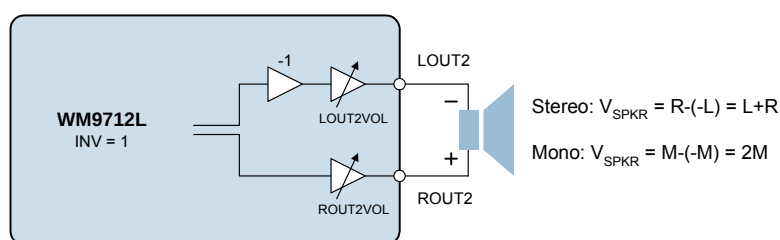


Figure 27 Speaker Output Connection (INV = 1)

The right channel is inverted by setting the INV bit, so that the signal across the loudspeaker is the sum of left and right channels.

## COMBINED HEADSET / BTL EAR SPEAKER

In smartphone applications with a loudspeaker and separate ear speaker (receiver), a BTL ear speaker can be connected at the OUT3 pin, as shown below.

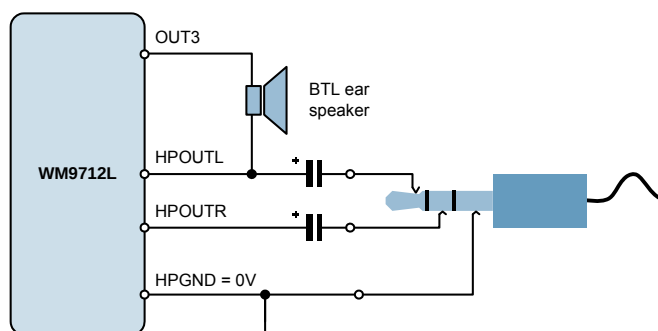


Figure 28 Combined Headset / BTL Ear Speaker (OUT3SRC = 00)

The ear speaker and the headset play the same signal. Whenever the headset is plugged in, the headphone outputs are enabled and OUT3 disabled. When the headset is not plugged in, OUT3 is enabled (see "Jack Insertion and Auto-Switching")

## COMBINED HEADSET / SINGLE-ENDED EAR SPEAKER

Instead of a BTL ear speaker, a single-ended ear speaker can also be used, as shown below.

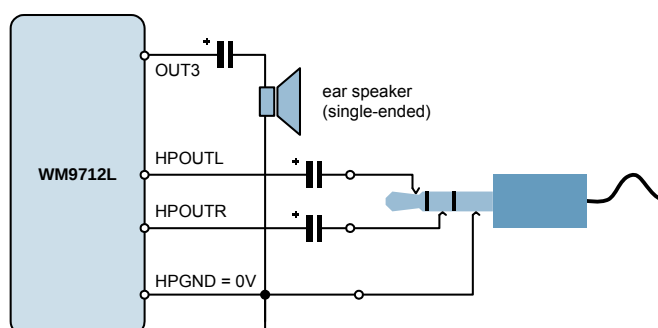
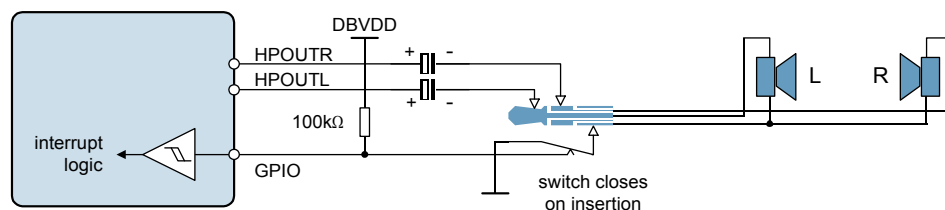


Figure 29 Combined Headset / Single-ended Ear Speaker (OUT3SRC = 01)

## JACK INSERT DETECTION

The circuit diagram below shows how to detect when a headphone or headset has been plugged into the headphone socket. It generates an interrupt, instructing the controller to enable HPOUTL and HPOUTR and disable OUT3.

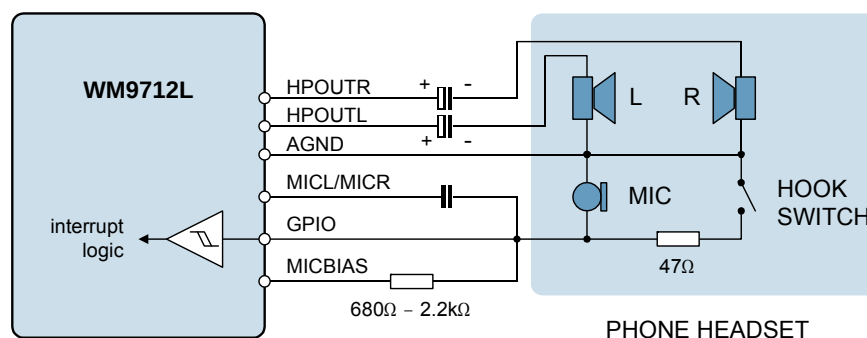


**Figure 30 Jack Insert Detection Circuit**

The circuit requires a headphone socket with a switch that closes on insertion. It detects both headphones and phone headsets. Any GPIO pin can be used, provided that it is configured as an input.

## HOOKSWITCH DETECTION

The circuit diagram below shows how to detect when the “hookswitch” of a phone headset is pressed (pressing the hookswitch is equivalent to lifting the receiver in a stationary telephone).



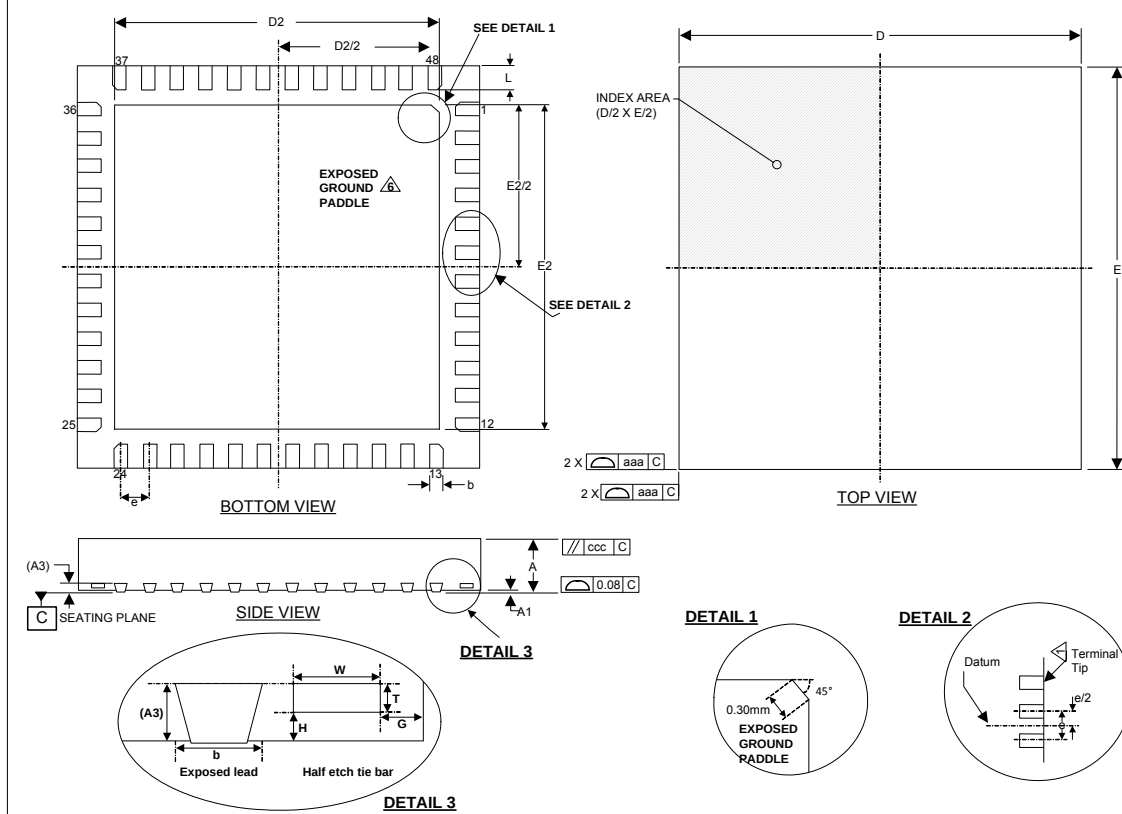
**Figure 31 Hookswitch Detection Circuit**

The circuit uses a GPIO pin as a sense input. The impedance of the microphone and the resistor in the MICBIAS path must be such that the potential at the GPIO pin is above  $0.7 \times \text{DBVDD}$  when the hookswitch is open, and below  $0.3 \times \text{DBVDD}$  when it is closed.

## PACKAGE DRAWING

FL: 48 PIN QFN PLASTIC PACKAGE 7 x 7 x 0.9 mm BODY, 0.50 mm LEAD PITCH

DM103.A



| Symbols                                | Dimensions (mm)                 |          |      |      |
|----------------------------------------|---------------------------------|----------|------|------|
|                                        | MIN                             | NOM      | MAX  | NOTE |
| A                                      | 0.80                            | 0.90     | 1.00 |      |
| A1                                     | 0                               | 0.02     | 0.05 |      |
| A3                                     |                                 | 0.20 REF |      |      |
| b                                      | 0.18                            | 0.25     | 0.30 | 1    |
| D                                      |                                 | 7.00 BSC |      |      |
| D2                                     | 5.55                            | 5.65     | 5.75 |      |
| E                                      |                                 | 7.00 BSC |      |      |
| E2                                     | 5.55                            | 5.65     | 5.75 |      |
| e                                      |                                 | 0.5 BSC  |      |      |
| G                                      |                                 | 0.20     |      |      |
| H                                      |                                 | 0.10     |      |      |
| L                                      | 0.30                            | 0.4      | 0.50 |      |
| T                                      |                                 | 0.103    |      |      |
| W                                      |                                 | 0.15     |      |      |
| <b>Tolerances of Form and Position</b> |                                 |          |      |      |
| aaa                                    |                                 | 0.15     |      |      |
| bbb                                    |                                 | 0.10     |      |      |
| ccc                                    |                                 | 0.10     |      |      |
| REF                                    | JEDEC, MO-220, VARIATION VKKD-4 |          |      |      |

## NOTES:

1. DIMENSION b APPLIED TO METALLIZED TERMINAL AND IS MEASURED BETWEEN 0.15 mm AND 0.30 mm FROM TERMINAL TIP.
2. ALL DIMENSIONS ARE IN MILLIMETRES
3. THE TERMINAL #1 IDENTIFIER AND TERMINAL NUMBERING CONVENTION SHALL CONFORM TO JEDEC 95-1 SPP-002.
4. COPLANARITY APPLIES TO THE EXPOSED HEAT SINK SLUG AS WELL AS THE TERMINALS.
5. THIS DRAWING IS SUBJECT TO CHANGE WITHOUT NOTICE.
6. REFER TO APPLICATION NOTE WAN\_0118 FOR FURTHER INFORMATION REGARDING PCB FOOTPRINTS AND QFN PACKAGE SOLDERING.

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**REVISION HISTORY**

| DATE     | REV | ORIGINATOR | CHANGES                                                                                                                                   |
|----------|-----|------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| 10/10/11 | 4.6 | JMacD      | Order codes updated from WM9712LGEFL/V and WM9712LGEFL/RV to WM9712CLGEFL/V and WM9712CLGEFL/RV to reflect change to copper wire bonding. |
| 10/10/11 | 4.6 | JMacD      | Package Diagram updated to DM103.A                                                                                                        |

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