

Multi-Channel High Definition Audio CODEC

DESCRIPTION

The WM8860 is a high performance multi-channel audio CODEC designed for high performance portable PC audio systems. The device offers full compatibility with the Intel High Definition Audio (HDA) specification revision 1.0, allowing seamless integration with industry-standard HDA controllers.

The WM8860 has two high performance stereo DACs to enable four channels of high definition audio. A high-performance ground-referenced stereo headphone amplifier utilises advanced charge pump and DC servo technology to minimise system cost and space without compromise on audio quality. A balanced line output, which can provide a differential connection to an external speaker amplifier, is also provided and enables common mode noise rejection when these traces are routed across a PCB.

The WM8860 also has two high performance stereo ADCs to provide Hi-Fi quality analogue line-in and microphone input digitisation. A low noise microphone bias with programmable output voltage is provided. Additionally, the CODEC contains a digital microphone interface capable of supporting up to four independent digital microphones. One differential stereo input is provided for line level signals, while one pseudo-differential stereo input with integrated microphone preamplifier is provided.

The WM8860 also contains a S/PDIF transmitter which is fully compatible with IEC-60958-3. Two dedicated GPIO pins are provided, enabling control of external amplifiers or other additional system components.

The WM8860 is supplied in a small 48-pin QFN package.

FEATURES

- Multi-channel High Definition Audio CODEC
- Fully compatible with Intel High Definition Audio Revision 1.0
- 4-Channel DAC, 4-channel ADC
- DAC sampling frequency 8kHz - 192kHz
- ADC sampling frequency 8kHz - 96kHz
- DAC Performance:
 - SNR 108dB ('A' weighted)
 - SNR 105dB (non weighted)
 - THD -96dB (at 0dBFS)
- ADC Performance:
 - SNR 105dB ('A' weighted)
 - SNR 102dB (non weighted)
 - THD -95dB (at -1dBFS)
- Ground-referenced stereo headphone driver
- Differential line inputs/outputs
- Stereo microphone interface with integrated pre-amp
- Multi-channel digital microphone interface
- IEC-60958-3 compatible S/PDIF transmitter
- Jack detect and load impedance sensing
- Beep generator
- GPIO functionality
- IEEE-754 Single precision 32-bit floating point support
- Power supplies
 - Digital core: 1.62V – 1.98V
 - Digital buffer: 2.97V – 3.63V
 - Analogue: 4.5V – 5.25V
 - Charge pump: 4.5V – 5.25V
- 48-pin 7mm x 7mm QFN package

APPLICATIONS

- High performance PC audio
- All-in-one desktop PC
- Notebook PC

BLOCK DIAGRAM

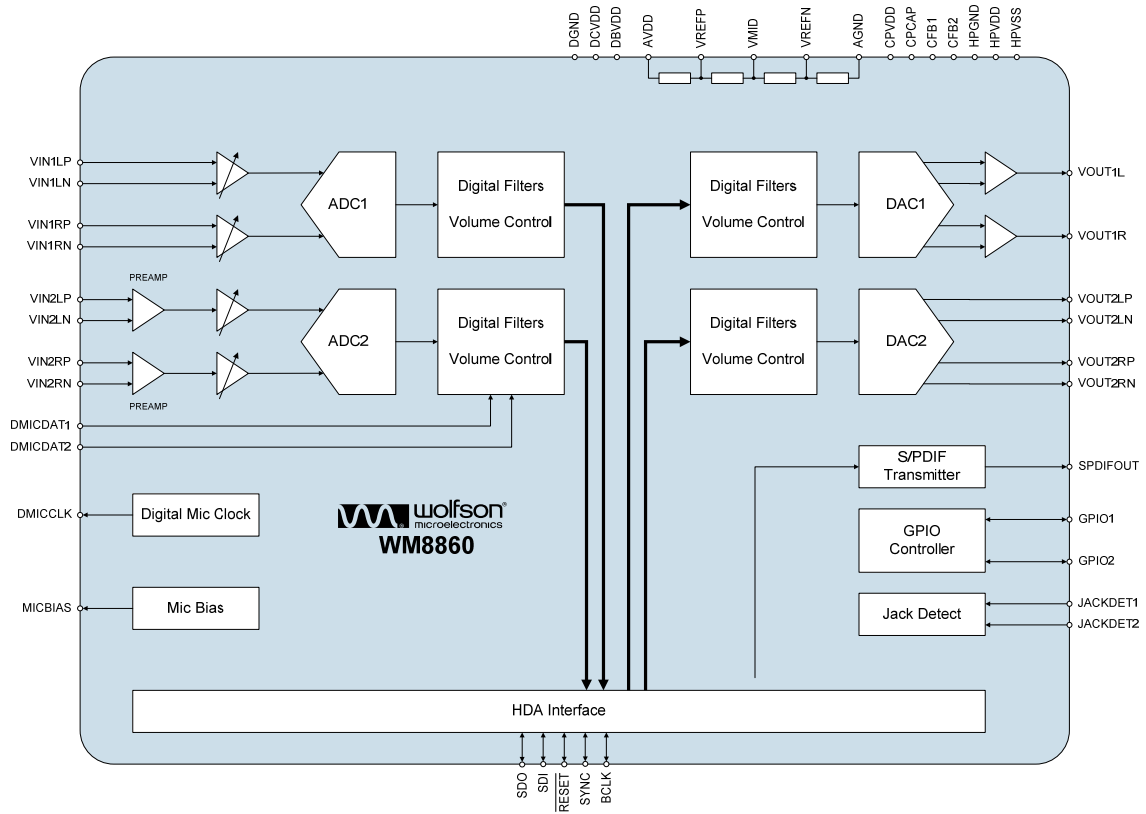


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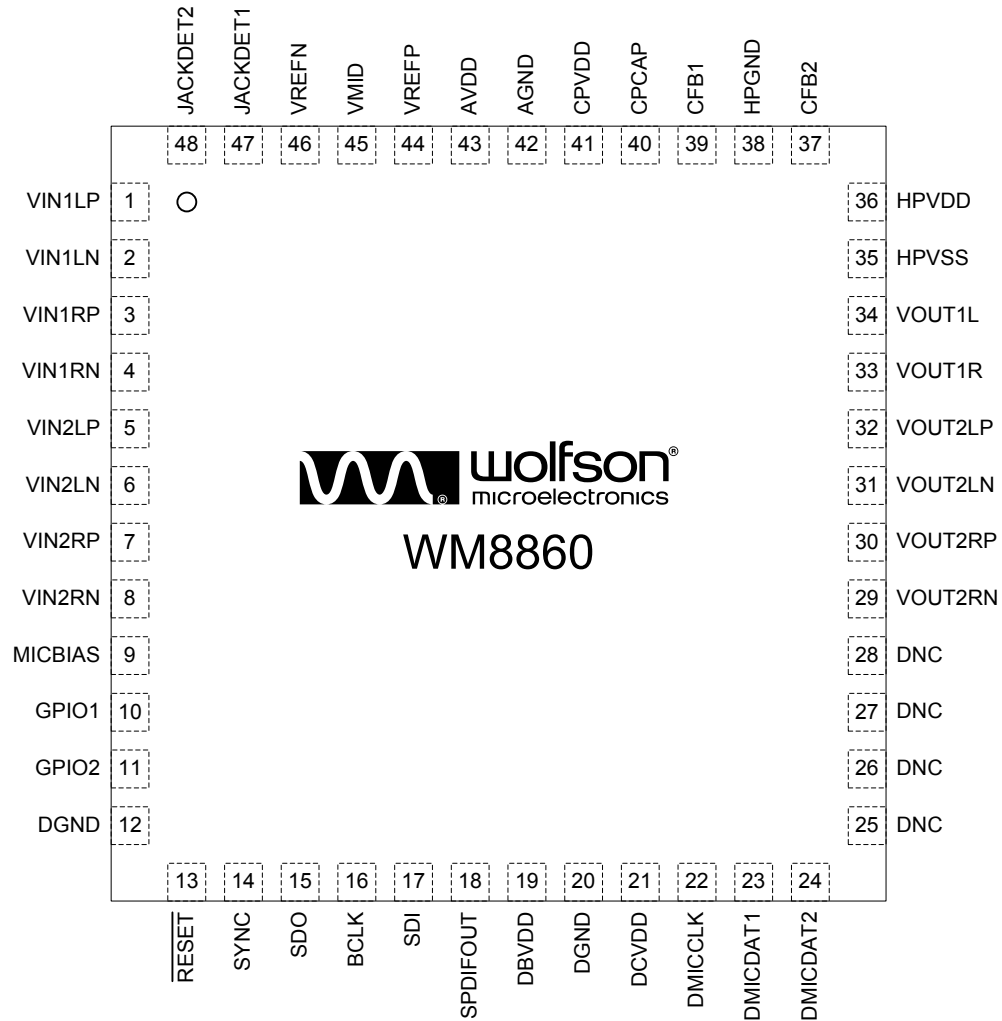
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PIN CONFIGURATION



ORDERING INFORMATION

| ORDER CODE | TEMPERATURE RANGE | PACKAGE | MOISTURE SENSITIVITY LEVEL | PEAK SOLDERING TEMPERATURE |
|---------------|-------------------|-------------------------------------|----------------------------|----------------------------|
| WM8860GEFL/V | -40°C to +85°C | 48-pin QFN (Pb-free) | MSL3 | 260°C |
| WM8860GEFL/RV | -40°C to +85°C | 48-pin QFN (Pb-free, tape and reel) | MSL3 | 260°C |

Note:

Reel quantity = 2200

PIN DESCRIPTION

| PIN NO | NAME | TYPE | DESCRIPTION |
|--------|----------|------------------------|--|
| 1 | VIN1LP | Analogue input | Left channel 1 positive input |
| 2 | VIN1LN | Analogue input | Left channel 1 negative input |
| 3 | VIN1RP | Analogue input | Right channel 1 positive input |
| 4 | VIN1RN | Analogue input | Right channel 1 negative input |
| 5 | VIN2LP | Analogue input | Left channel 2 positive input |
| 6 | VIN2LN | Analogue input | Left channel 2 negative input |
| 7 | VIN2RP | Analogue input | Right channel 2 positive input |
| 8 | VIN2RN | Analogue input | Right channel 2 negative input |
| 9 | MICBIAS | Analogue output | Microphone bias output |
| 10 | GPIO1 | Digital input / output | General purpose digital input/output 1 |
| 11 | GPIO2 | Digital input / output | General purpose digital input/output 2 |
| 12 | DGND | Supply input | Digital ground (return for DBVDD and DCVDD) |
| 13 | /RESET | Digital input | Global reset (active low) |
| 14 | SYNC | Digital input | HDA frame sync, 48kHz |
| 15 | SDO | Digital input | Serial data output from HDA controller |
| 16 | BCLK | Digital input | HDA Link bit clock, 24MHz |
| 17 | SDI | Digital input / output | Serial data input to HDA controller |
| 18 | SPDIFOUT | Digital output | S/PDIF output |
| 19 | DBVDD | Supply input | Digital buffer supply input |
| 20 | DGND | Supply input | Digital ground (return for DBVDD and DCVDD) |
| 21 | DCVDD | Supply input | Digital core supply input |
| 22 | DMICCLK | Digital output | Digital microphone clock output |
| 23 | DMICDAT1 | Digital input | Digital microphone data input 1 |
| 24 | DMICDAT2 | Digital input / output | Digital microphone data input 2 |
| 25 | DNC | | Reserved - Do not connect |
| 26 | DNC | | Reserved - Do not connect |
| 27 | DNC | | Reserved - Do not connect |
| 28 | DNC | | Reserved - Do not connect |
| 29 | VOOUT2RN | Analogue output | Right channel 2 negative output |
| 30 | VOOUT2RP | Analogue output | Right channel 2 positive output |
| 31 | VOOUT2LN | Analogue output | Left channel 2 negative output |
| 32 | VOOUT2LP | Analogue output | Left channel 2 positive output |
| 33 | VOOUT1R | Analogue output | Right channel 1 output |
| 34 | VOOUT1L | Analogue output | Left channel 1 output |
| 35 | HPVSS | Supply output | Charge pump negative supply decoupling point |
| 36 | HPVDD | Supply output | Charge pump positive supply decoupling point |
| 37 | CFB2 | Analogue output | Charge pump flyback capacitor pin 2 |
| 38 | HPGND | Supply input | Charge pump ground (return path for HPVDD and HPVSS) |
| 39 | CFB1 | Analogue output | Charge pump flyback capacitor pin 1 |
| 40 | CPCAP | Supply output | Internally generated regulated charge pump supply decoupling point |
| 41 | CPVDD | Supply input | Charge pump supply input |
| 42 | AGND | Supply input | Analogue ground (return path for AVDD and CPVDD) |
| 43 | AVDD | Supply input | Analogue supply input |
| 44 | VREFP | Analogue output | Analogue positive reference decoupling point |
| 45 | VMID | Analogue output | Midrail voltage decoupling point |
| 46 | VREFN | Analogue output | Analogue negative reference decoupling point |
| 47 | JACKDET1 | Analogue output | Jack detect sense 1 |
| 48 | JACKDET2 | Analogue output | Jack detect sense 2 |

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 |
|---|------------|-------------|
| Analogue supply voltage (AVDD) | -0.3V | +7V |
| Charge pump supply voltage (CPVDD) | -0.3V | +7V |
| Digital core supply voltage (DCVDD) | -0.3V | +2.5V |
| Digital buffer supply voltage (DBVDD) | -0.3V | +7V |
| Voltage range digital inputs | DGND -0.3V | DBVDD +0.3V |
| Voltage range analogue inputs | AGND -0.3V | AVDD +0.3V |
| Operating temperature range, T _A | -40°C | +85°C |
| Junction temperature, T _{JMAX} | -40°C | +150°C |
| Storage temperature after soldering | -65°C | +150°C |

RECOMMENDED OPERATING CONDITIONS

| PARAMETER | SYMBOL | MIN | TYP | MAX | UNIT |
|-----------------------------|-------------------|------|-----|------|------|
| CODEC Power Supplies | | | | | |
| Digital core supply range | DCVDD | 1.62 | 1.8 | 1.98 | V |
| Digital buffer supply range | DBVDD | 2.97 | 3.3 | 3.63 | V |
| Analogue supply range | AVDD | 4.5 | 5.0 | 5.25 | V |
| Charge pump supply range | CPVDD | 4.5 | 5.0 | 5.25 | V |
| Ground | DGND, AGND, HPGND | | 0 | | V |

Notes:

- Analogue and digital grounds must always be within 0.3V of each other.
- All digital and analogue supplies are completely independent from each other (i.e. not internally connected).

THERMAL PERFORMANCE

Thermal analysis should be performed in the intended application to prevent the WM8860 from exceeding maximum junction temperature. Several contributing factors affect thermal performance most notably the physical properties of the mechanical enclosure, location of the device on the PCB in relation to surrounding components and the number of PCB layers. Connecting the GND paddle through thermal vias and into a large ground plane will aid heat extraction.

Three main heat transfer paths exist to surrounding air as illustrated below in Figure 1:

- Package top to air (radiation).
- Package bottom to PCB (radiation).
- Package leads & paddle to PCB (conduction).

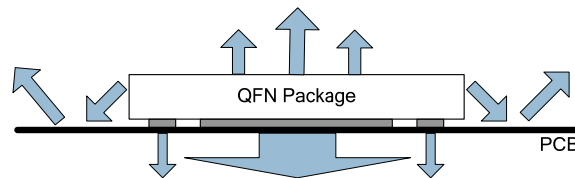


Figure 1 Heat Transfer Paths

The temperature rise T_R is given by $T_R = P_D * \Theta_{JA}$

- P_D is the power dissipated in the device.
- Θ_{JA} is the thermal resistance from the junction of the die to the ambient temperature and is therefore a measure of heat transfer from the die to surrounding air. Θ_{JA} is determined with reference to JEDEC standard JESD51-9.

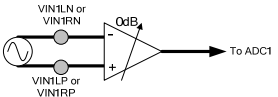
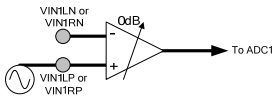
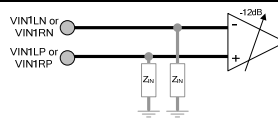
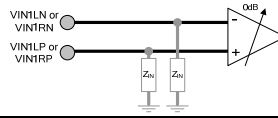
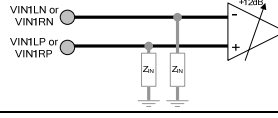
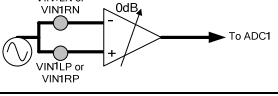
The junction temperature T_J is given by $T_J = T_A + T_R$, where T_A is the ambient temperature.

| PARAMETER | SYMBOL | MIN | TYP | MAX | UNIT |
|--------------------------------|---------------|-----|-----|-----|------|
| Operating temperature range | T_A | -40 | | 85 | °C |
| Operating junction temperature | T_J | -40 | | 125 | °C |
| Thermal Resistance | Θ_{JA} | | 29 | | °C/W |

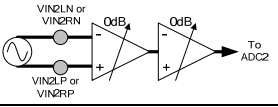
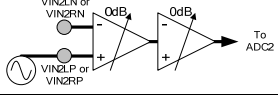
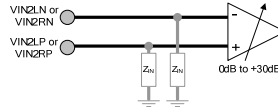
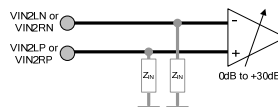
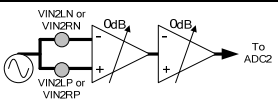
ELECTRICAL CHARACTERISTICS

Test Conditions

AVDD = CPVDD = 5V, DBVDD = 3.3V, DCVDD = 1.8V, T_A = +25°C, 1kHz signal, f_s = 48kHz, 24-bit data unless otherwise stated.

| PARAMETER | SYMBOL | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|--|--------------------------|---|-----|---------------|-----|------------------|
| Analogue Input 1 (VIN1LP, VIN1LN, VIN1RP, VIN1RN) | | | | | | |
| Maximum Differential Input Signal Level | V _{INDIFF(max)} | 0dB gain  | | 2.25 x AVDD/5 | | V _{RMS} |
| Maximum Single-ended Input Signal Level | V _{INSE(max)} | 0dB gain  | | 1.6 x AVDD/5 | | V _{RMS} |
| Input impedance | Z _{IN} | -12dB gain  | | 42 | | kΩ |
| | | 0dB gain  | | 27 | | kΩ |
| | | +12dB gain  | | 9 | | kΩ |
| Common Mode Rejection Ratio | CMRR | 20Hz to 20kHz  | | 55 | | dB |
| Minimum PGA Gain Setting | | | | -12 | | dB |
| Maximum PGA Gain Setting | | | | +12 | | dB |
| PGA Gain Step Size | | Guaranteed monotonic | | 0.5 | | dB |

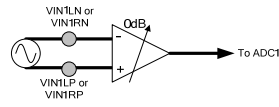
Test ConditionsAVDD = CPVDD = 5V, DBVDD = 3.3V, DCVDD = 1.8V, $T_A = +25^\circ\text{C}$, 1kHz signal, $f_s = 48\text{kHz}$, 24-bit data unless otherwise stated.

| PARAMETER | SYMBOL | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|--|--------------------------|---|-----|-----------------------------|-----|------------------|
| Analogue Input 2 (VIN2LP, VIN2LN, VIN2RP, VIN2RN) | | | | | | |
| Maximum Differential Input Signal Level | $V_{\text{INDIFF(max)}}$ | 0dB gain  | | $2.25 \times \text{AVDD}/5$ | | V_{RMS} |
| Maximum Single-ended Input Signal Level | $V_{\text{INSE(max)}}$ | 0dB gain  | | $1.1 \times \text{AVDD}/5$ | | V_{RMS} |
| Input impedance | Z_{IN} | Single-ended or Differential (Inverting)  | | 10 | | $\text{k}\Omega$ |
| | | Differential (Non-inverting)  | | 120 | | $\text{k}\Omega$ |
| Common Mode Rejection Ratio | CMRR | 20Hz to 20kHz  | | 65 | | dB |
| Microphone Preamp Gain Options | | | | 0 10 20 30 | | dB |
| Minimum PGA Gain Setting | | | | -12 | | dB |
| Maximum PGA Gain Setting | | | | +12 | | dB |
| PGA Gain Step Size | | Guaranteed monotonic | | 0.5 | | dB |

Test Conditions

AVDD = CPVDD = 5V, DBVDD = 3.3V, DCVDD = 1.8V, T_A = +25°C, 1kHz signal, f_s = 48kHz, 24-bit data unless otherwise stated.

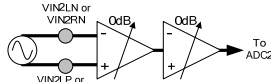
| PARAMETER | SYMBOL | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|------------------------------|--------|-------------------------------------|-----|------|-----|------|
| ADC1 Performance | | | | | | |
| Signal to Noise Ratio | SNR | Unweighted | | 102 | | dB |
| | | A-weighted | 100 | 105 | | dB |
| | | A-weighted f _s =96kHz | | 105 | | dB |
| Dynamic Range | DNR | A-weighted -60dBFS | | 105 | | dB |
| Total Harmonic Distortion | THD | -1dBFS | | -95 | -90 | dB |
| | | -1dBFS f _s =96kHz | | -95 | | dB |
| Channel Separation | | 1kHz | | 86 | | dB |
| | | 20Hz to 20kHz | | 86 | | dB |
| Channel Level Matching | | 0dBFS | | 0.1 | | dB |
| Channel Phase Deviation | | | | 0.01 | | ° |
| Power Supply Rejection Ratio | PSRR | 1kHz, 100mVpp on AVDD | | 90 | | dB |
| | | 20Hz to 20kHz, 100mVpp on AVDD | | 70 | | dB |



Test Conditions

AVDD = CPVDD = 5V, DBVDD = 3.3V, DCVDD = 1.8V, $T_A = +25^\circ\text{C}$, 1kHz signal, $f_s = 48\text{kHz}$, 24-bit data unless otherwise stated.

| PARAMETER | SYMBOL | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|------------------------------|--------|----------------------------------|-----|------|-----|------|
| ADC2 Performance | | | | | | |
| Signal to Noise Ratio | SNR | Unweighted | | 100 | | dB |
| | | A-weighted | | 95 | 103 | dB |
| | | A-weighted $f_s=96\text{kHz}$ | | | 103 | dB |
| Dynamic Range | DNR | A-weighted -60dBFS | | 103 | | dB |
| Total Harmonic Distortion | THD | -1dBFS | | -95 | -90 | dB |
| Channel Separation | | 1kHz | | 87 | | dB |
| | | 20Hz to 20kHz | | 84 | | dB |
| Channel Level Matching | | 0dBFS | | 0.1 | | dB |
| Channel Phase Deviation | | | | 0.01 | | ° |
| Power Supply Rejection Ratio | PSRR | 1kHz, 100mVpp on AVDD | | 90 | | dB |
| | | 20Hz to 20kHz, 100mVpp on AVDD | | 70 | | dB |

**Test Conditions**

AVDD = CPVDD = 5V, DBVDD = 3.3V, DCVDD = 1.8V, $T_A = +25^\circ\text{C}$, 1kHz signal, $f_s = 48\text{kHz}$, 24-bit data unless otherwise stated.

| PARAMETER | SYMBOL | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|----------------------------------|--------|--------------------------------|-----|--------------|-----|------|
| Microphone Bias Generator | | | | | | |
| Output Voltage | | $V_{\text{RefEn}[2:0]} = 001$ | | 0.5x AVDD | | V |
| | | $V_{\text{RefEn}[2:0]} = 100$ | | 0.8x AVDD | | V |
| Current Source Capability | | | | | 2.5 | mA |
| Power Supply Rejection Ratio | PSRR | 1kHz, 100mVpp on AVDD | | 100 | | dB |
| | | 20Hz to 20kHz, 100mVpp on AVDD | | 88 | | dB |

Test Conditions

AVDD = CPVDD = 5V, DBVDD = 3.3V, DCVDD = 1.8V, T_A = +25°C, 1kHz signal, fs = 48kHz, 24-bit data unless otherwise stated.

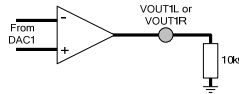
| PARAMETER | SYMBOL | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|--------------------------------------|--------|-----------------|-----|---|-----|------|
| Digital Microphone Interface | | | | | | |
| Digital Microphone Clock Frequencies | | | | 1.024 1.4112 2.048 2.8224 3.072 | | MHz |
| Signal to Noise Ratio | SNR | | | 96 | | dB |
| Minimum Digital Gain Setting | | | | -12 | | dB |
| Maximum Digital Gain Setting | | | | +32 | | dB |
| Digital Gain Step Size | | | | 0.5 | | dB |

Test ConditionsAVDD = CPVDD = 5V, DBVDD = 3.3V, DCVDD = 1.8V, $T_A = +25^\circ\text{C}$, 1kHz signal, $f_s = 48\text{kHz}$, 24-bit data unless otherwise stated.

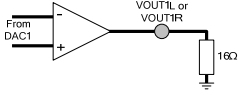
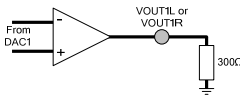
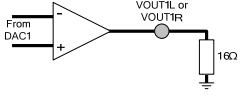
| PARAMETER | SYMBOL | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|--|-----------------------|--|-----|-----|------------------------|------------------|
| Analogue Output 1 (VOUT1L, VOUT1R) | | | | | | |
| Full Scale Output Signal Level | V_{OUT} | $R_L = 1\text{k}\Omega$ to $47\text{k}\Omega$ H-Phn Enable = 0 | | | $2 \times$ AVDD/5 | V_{RMS} |
| | | $R_L = 16\Omega$ to $1\text{k}\Omega$ H-Phn Enable = 1 | | | $0.8 \times$ AVDD/5 | V_{RMS} |
| Maximum Rated Output Power | $P_{\text{OUT(max)}}$ | $R_L = 16\Omega$ | | | 40 | mW |
| Load Impedance | R_L | | 16 | | 47k | Ω |
| Load Capacitance | C_L | | | | 1 | nF |
| DC Offset | | Measured between VOUT1L/R and AGND with path fully enabled but no signal playing | -1 | 0 | +1 | mV |
| Analogue Output 2 (VOUT2L, VOUT2LN, VOUT2RP, VOUT2RN) | | | | | | |
| Differential Full Scale Output Signal Level | V_{OUT} | $R_L = 5\text{k}\Omega$ to $47\text{k}\Omega$ | | | $2 \times$ AVDD/5 | V_{RMS} |
| Single-ended Full Scale Output Signal Level | V_{OUT} | $R_L = 5\text{k}\Omega$ to $47\text{k}\Omega$ | | | $1 \times$ AVDD/5 | V_{RMS} |
| Load Impedance | R_L | | 5 | | 47 | k Ω |
| Load Capacitance | C_L | | | | 1 | nF |

Test ConditionsAVDD = CPVDD = 5V, DBVDD = 3.3V, DCVDD = 1.8V, $T_A = +25^\circ\text{C}$, 1kHz signal, $f_s = 48\text{kHz}$, 24-bit data unless otherwise stated.

| PARAMETER | SYMBOL | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|--|------------|----------------------------------|-----|------|-----|------|
| DAC1 Path Performance (VOUT1L and VOUT1R into 10kΩ Line Load) | | | | | | |
| Signal to Noise Ratio | SNR | Unweighted | | 105 | | dB |
| | | A-weighted | 100 | 108 | | dB |
| | | A-weighted $f_s=96\text{kHz}$ | | 108 | | dB |
| Out of Band Signal to Noise Ratio (0.6fs to 150kHz) | OBSNR | $F_s > 11.025\text{kHz}$ | | 80 | | dB |
| | | $F_s \leq 11.025\text{kHz}$ | | 75 | | dB |
| Dynamic Range | DNR | A-weighted -60dBFS | | 108 | | dB |
| Total Harmonic Distortion | THD | 0dBFS | | -96 | -85 | dB |
| | | 0dBFS $f_s=96\text{kHz}$ | | -96 | -85 | dB |
| Channel Separation | | 1kHz | | 115 | | dB |
| | | 20Hz to 20kHz | | 110 | | dB |
| Channel Level Matching | | 0dBFS | | 0.1 | | dB |
| Channel Phase Deviation | | | | 0.01 | | ° |
| AVDD Power Supply Rejection Ratio | AVDD PSRR | 1kHz, 100mVpp on AVDD | | 51 | | dB |
| | | 20Hz to 20kHz, 100mVpp on AVDD | | 50 | | dB |
| CPVDD Power Supply Rejection Ratio | CPVDD PSRR | 1kHz, 100mVpp on CPVDD | | 86 | | dB |
| | | 20Hz to 20kHz, 100mVpp on CPVDD | | 75 | | dB |



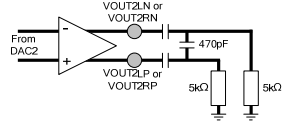
Test ConditionsAVDD = CPVDD = 5V, DBVDD = 3.3V, DCVDD = 1.8V, T_A = +25°C, 1kHz signal, f_s = 48kHz, 24-bit data unless otherwise stated.

| PARAMETER | SYMBOL | TEST CONDITIONS | MIN | TYP | MAX | UNIT | |
|--|--------|--|---|-----|------|-------|-----|
| DAC1 Path Performance (VOUT1L and VOUT1R into 16Ω Headphone Load) | | | | | | | |
| Total Harmonic Distortion | THD | P _{OUT} = 30mW R _L = 16Ω |  | | -80 | -73 | dB |
| | | | | | 0.01 | | % |
| | | P _{OUT} = 10mW R _L = 300Ω |  | | -80 | | dB |
| | | | | | 0.01 | | % |
| Idle Channel Noise | | R _L = 16Ω A-weighted |  | 90 | 98 | | dBV |
| | | | | | | 12.26 | |
| Channel Separation | | R _L = 16Ω 1kHz | | 85 | | dB | |
| | | R _L = 16Ω 20Hz to 20kHz | | 72 | | dB | |

Test Conditions

AVDD = CPVDD = 5V, DBVDD = 3.3V, DCVDD = 1.8V, T_A = +25°C, 1kHz signal, f_s = 48kHz, 24-bit data unless otherwise stated.

| PARAMETER | SYMBOL | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|-----------|-------------------------------------|-----|------|-----|------|
| DAC2 Path Performance (VOUT2LP, VOUT2LN, VOUT2RP and VOUT2N into 10kΩ Line Load) | | | | | | |
| Signal to Noise Ratio | SNR | Unweighted | | 103 | | dB |
| | | A-weighted | 100 | 106 | | dB |
| | | A-weighted f _s =96kHz | | 106 | | dB |
| Out of Band Signal to Noise Ratio (0.6f _s to 150kHz) | OBSNR | F _s > 11.025kHz | | 80 | | dB |
| | | F _s ≤ 11.025kHz | | 75 | | dB |
| Dynamic Range | DNR | A-weighted -60dBFS | | 106 | | dB |
| | | 0dBFS | | -92 | | dB |
| | | 0dBFS f _s =96kHz | | -92 | | dB |
| Channel Separation | | 20Hz to 20kHz | | 102 | | dB |
| Channel Level Matching | | 0dBFS | | 0.1 | | dB |
| Channel Phase Deviation | | | | 0.01 | | ° |
| AVDD Power Supply Rejection Ratio | AVDD PSRR | 1kHz, 100mVpp on AVDD | | 75 | | dB |
| | | 20Hz to 20kHz, 100mVpp on AVDD | 55 | | | dB |



Test ConditionsAVDD = CPVDD = 5V, DBVDD = 3.3V, DCVDD = 1.8V, T_A = +25°C, 1kHz signal, fs = 48kHz, 24-bit data unless otherwise stated.

| PARAMETER | SYMBOL | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|--|-------------------------|--|----------------|--|----------------|------|
| S/PDIF Transmitter Specification | | | | | | |
| Output Signal Logic High | V _{OH(S/PDIF)} | | 0.9 * DBVDD | | | V |
| Output Signal Logic Low | V _{OL(S/PDIF)} | | | | 0.1 * DBVDD | V |
| Output Current Source/Sink Capability | | DBVDD = 1.8V | 7 | | | mA |
| | | DBVDD = 3.63V | 15 | | | mA |
| Output Sample Rate Tolerance | | Includes maximum reference clock error of ±0.025% as allowed by HDA Specification | | | 1000 | ppm |
| | | | -0.1 | | +0.1 | % |
| Output Sample Rate Support | | | | 32 44.1 48 88.2 96 176.4 192 | | kHz |

Test ConditionsAVDD = CPVDD = 5V, DBVDD = 3.3V, DCVDD = 1.8V, T_A = +25°C, 1kHz signal, f_s = 48kHz, 24-bit data unless otherwise stated.

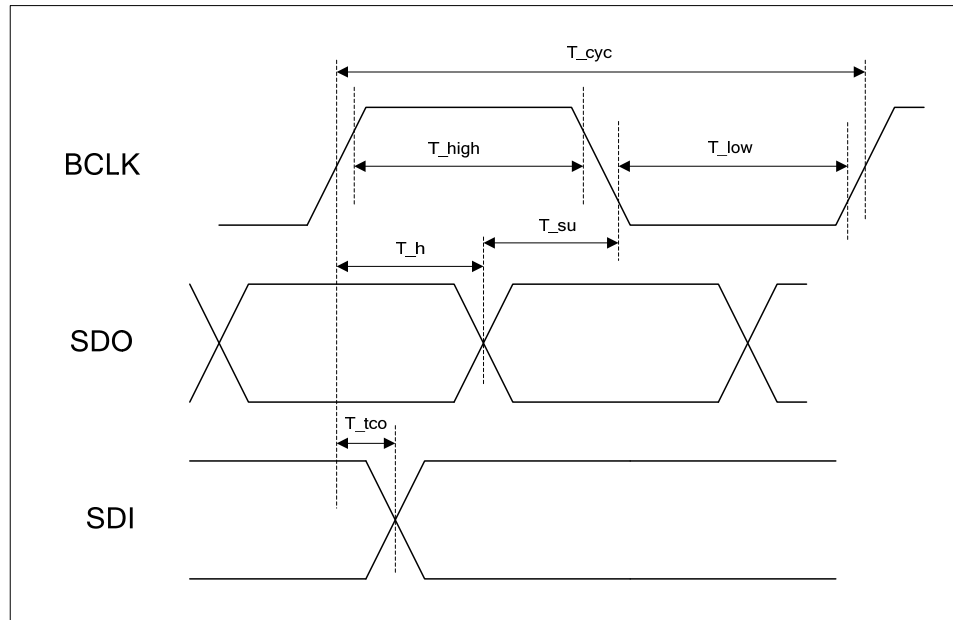
| PARAMETER | SYMBOL | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|-------------------------------|-------------------|--|-----------------|---------------|-----------------|------|
| Analogue References | | | | | | |
| Positive Voltage Reference | VREFP | | | 0.9 * AVDD | | V |
| Negative Voltage Reference | VREFN | | | 0.1 * AVDD | | V |
| Midrail Voltage Reference | VMID | | | 0.5 * AVDD | | V |
| Charge Pump Cap Level | CPCAP | | | 3.15 | | V |
| Midrail Voltage Resistance | R _{VMID} | AVDD to VMID or VMID to AGND VMID_SEL[1:0]=00 | | 12.5 | | kΩ |
| | | AVDD to VMID or VMID to AGND VMID_SEL[1:0]=01 | | 75 | | kΩ |
| | | AVDD to VMID or VMID to AGND VMID_SEL[1:0]=10 | | 37.5 | | kΩ |
| | | AVDD to VMID or VMID to AGND VMID_SEL[1:0]=11 | | 375 | | kΩ |
| Digital Input / Output | | | | | | |
| Input High Level | V _{IH} | | 0.65 * DBVDD | | | V |
| Input Low Level | V _{IL} | | | | 0.35 * DBVDD | V |
| Output High Level | V _{OH} | | 0.9 * DBVDD | | | V |
| Output Low Level | V _{OL} | | | | 0.1 * DBVDD | V |
| Input Capacitance | | | | | 7.5 | pF |
| Input Leakage | | | -0.1 | | +0.1 | μA |

TERMINOLOGY

1. Signal-to-Noise Ratio (dB) – SNR is a measure of the difference in level between the full scale output signal and the output with no input signal applied.
2. Total Harmonic Distortion (dB) – THD is the level of the rms value of the sum of harmonic distortion products relative to the amplitude of the applied input signal.
3. Total Harmonic Distortion plus Noise (dB) – THD+N is the level of the rms value of the sum of harmonic distortion products plus noise in the specified bandwidth relative to the amplitude of the applied input signal.
4. Crosstalk (L/R) (dB) – left-to-right and right-to-left channel crosstalk is the measured signal level in the idle channel at the test signal frequency relative to the signal level at the output of the active channel. The active channel is configured and supplied with an appropriate input signal to drive a full scale output, with signal measured at the output of the associated idle channel. For example, measured signal level on the output of the idle right channel with a full scale signal level at the output of the active left channel.
5. Multi-Path Channel Separation (dB) – is the measured signal level in the idle path at the test signal frequency relative to the signal level at the output of the active path. The active path is configured and supplied with an appropriate input signal to drive a full scale output, with signal measured at the output of the specified idle path.
6. All performance measurements carried out with 20kHz low pass filter, and where noted an A-weighted filter. Failure to use such a filter will result in higher THD and lower SNR readings than are found in the Electrical Characteristics. The low pass filter removes out of band noise; although it is not audible it may affect dynamic specification values.
7. Mute Attenuation – This is a measure of the difference in level between the full scale output signal and the output with mute applied.
8. Channel Level Matching (dB) – the difference in output level between channels in a stereo pair.
9. Channel Phase Deviation (Degrees) – the difference in phase between channels in a stereo pair.
10. Idle Channel Noise (dBV) – absolute rms measurement of the noise floor over the 20Hz to 20kHz band.

SIGNAL TIMING REQUIREMENTS

Signal timing requirements are as defined in the High Definition Audio Specification Revision 1.0, section 6.2.3.1. This section of the specification is repeated here for completeness.



Test Conditions

DBVDD=3.3V, AVDD=CPVDD=5V, DCVDD=1.8V, $T_A=+25^\circ\text{C}$

| PARAMETER | SYMBOL | MIN | TYP | MAX | UNIT |
|---|------------|--------|-------|--------|------|
| Period of BCLK including jitter | T_{cyc} | 41.163 | 41.67 | 42.171 | ns |
| High phase of BCLK | T_{high} | 17.5 | | | ns |
| Low phase of BCLK | T_{low} | 17.5 | | | ns |
| BCLK jitter | | | 150 | 500 | ps |
| Time after rising edge of BCLK that SDI becomes valid | T_{tco} | 3 | | 11 | ns |
| Setup for SDO at both rising and falling edge of BCLK | T_{su} | 5 | | | ns |
| Hold for SDO at both rising and falling edge of BCLK | T_h | 5 | | | ns |

Table 1 High Definition Audio Link I/O Signal Timing

Notes:

1. Measurement points are as defined in the High Definition Audio Specification Revision 1.0 at either $0.35 \cdot \text{DBVDD}$, $0.5 \cdot \text{DBVDD}$ or $0.65 \cdot \text{DBVDD}$ as appropriate
2. Period specification for BCLK is the long term average frequency measured over 1ms. BCLK has a 100ppm tolerance in the High Definition Audio Architecture
3. 42/58% is the worst case BCLK duty cycle at the WM8860
4. The WM8860 meets the timing requirements with the slew rate of the inputs in the range of 1V/ns to 3V/ns

INTERNAL POWER ON RESET CIRCUIT

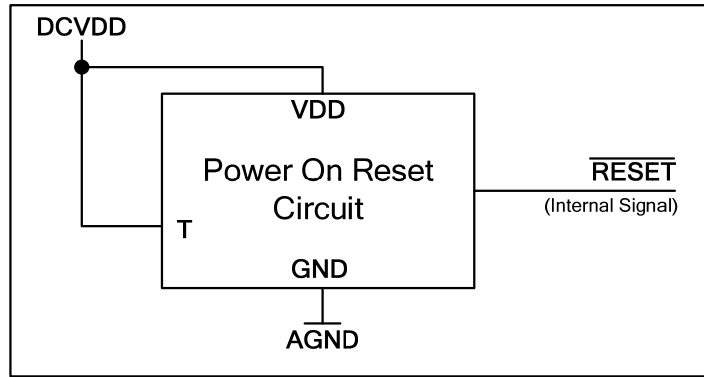


Figure 2 Internal Power on Reset Circuit Schematic

The WM8860 includes an internal Power-On-Reset Circuit, as shown in Figure 2, which is used to reset the digital logic into a default state after power up. The POR circuit is both powered from and monitors DCVDD. It asserts the internal $\overline{\text{RESET}}$ low if DCVDD is below a minimum threshold.

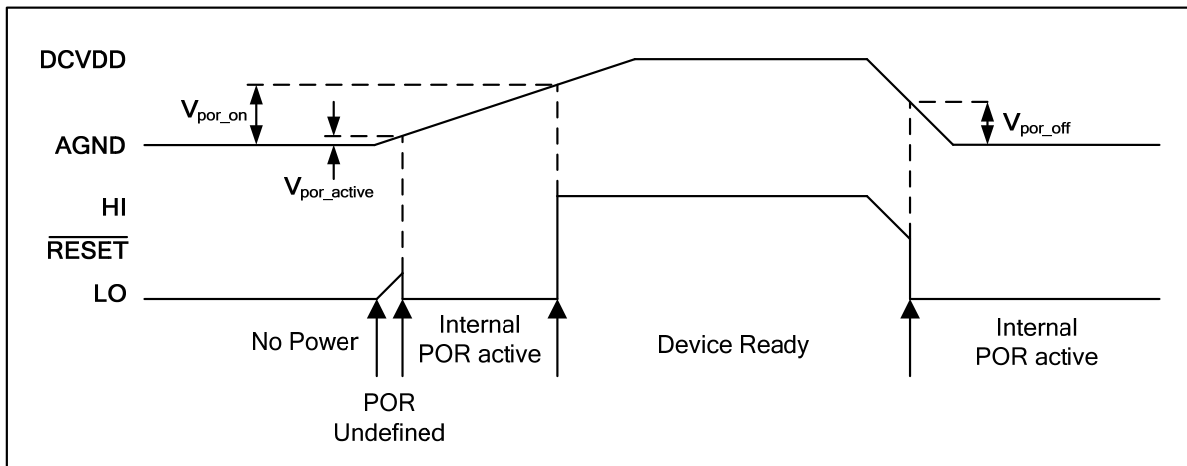


Figure 3 Typical Power up Sequence

Figure 3 shows a typical power-up sequence. The $\overline{\text{RESET}}$ signal is undefined until DCVDD has exceeded the minimum threshold, $V_{\text{por_active}}$. Once this threshold has been exceeded, $\overline{\text{RESET}}$ is asserted low and the chip is held in reset. In this condition, all stimulus to the WM8860 is ignored. Once DCVDD has reached $V_{\text{por_on}}$, $\overline{\text{RESET}}$ is released high, all registers are in their default state and access to the WM8860 via the HDA Interface may take place.

On power down, $\overline{\text{RESET}}$ is asserted low whenever DCVDD drops below the minimum threshold $V_{\text{por_off}}$.

Typical Power-On Reset parameters for the WM8860 are defined in Table 2.

| SYMBOL | MIN | TYP | MAX | UNIT |
|-------------|-----|------|-----|------|
| Vpor_active | | 0.1 | | V |
| Vpor_on | | 1.23 | | V |
| Vpor_off | | 1.16 | | V |

Table 2 Typical Power-On Reset parameters

INTRODUCTION

The WM8860 is a high performance multi-channel audio CODEC designed for high performance portable PC audio systems. The device offers full compatibility with the Intel High Definition Audio (HDA) specification revision 1.0, allowing seamless integration with industry-standard HDA controllers.

The WM8860 has two high performance stereo DACs to enable four channels of high definition audio. A high-performance ground-referenced stereo headphone amplifier utilises advanced charge pump and DC servo technology to minimise system cost and space without compromise on audio quality. A stereo balanced line output is also provided. These line outputs may be used connected to external speaker drivers in a notebook or netbook application.

The WM8860 also has two high performance stereo ADCs to provide Hi-Fi quality analogue line-in and microphone input digitisation. A low noise microphone bias with programmable output voltage is provided, ideally suited as a bias current source for ECM microphones. Additionally, the CODEC contains a digital microphone interface capable of supporting up to four independent digital microphones, allowing high quality microphone array implementations to be realised. One differential stereo input is provided for line level signals, while one pseudo-differential stereo input with integrated microphone preamplifier is provided.

The WM8860 also contains a S/PDIF transmitter which is fully compatible with IEC-60958-3.

The WM8860 includes an integrated beep generator allowing system beeps to be played back through the output paths.

This datasheet assumes familiarity with the High Definition Audio Specification Revision 1.0, available from <http://www.intel.com/standards/hdaudio/>. For those verbs implemented in the WM8860 which are as defined in the High Definition Audio Specification Revision 1.0 there is no detailed text describing their use in this datasheet. However, detailed text describing the function of of vendor-specific verbs is provided. Additionally, a full list of each node and each verb implemented in the WM8860 is provided at the rear of the document.

WOLFSON INTERPRETATION OF HDA SPECIFICATION

DOLBY AC3 (IEC-61937)

The AFG node and Converter Widget nodes have a parameter called *AC3* within the *Supported Stream Formats Parameter*. The Intel High Definition Audio specification states that *AC3* should be set to 1 if the node supports Dolby AC3 (IEC-61937) encoded data.

There is some ambiguity as to what is meant by "supports Dolby AC3 (IEC-61937)". The WM8860 does not support processing of Dolby AC3 (IEC-61937) encoded data but it does support the passing of AC3 data through the S/PDIF Converter Widgets.

Wolfson interpret the Intel specification to mean that the *AC3* parameter should be set if a node supports the encoding/decoding of AC3 data, and so we set the WM8860 *AC3* parameters to 0.

When the S/PDIF Converters are passing AC3 (IEC-61937) data, the *Stream Format Verb* for the widget node should have *Bits* = 1 (for 16-bit formatting) and *Type* = 1 to indicate that non-PCM data is being passed. Note that setting *Type* is for controller purposes only, and the WM8860 performs the same operation regardless of what *Type* is set to.

The user should ensure that Sample Rate Converters (SRCs) are bypassed when S/PDIF contains AC3 data.

FLOAT32

The WM8860 performs a Fixed-point/Floating-point conversion. Fixed point format is <1,23>, while floating point format is IEEE-754, single precision 32-bit, full scale between -1.0 and 1.0 with silence at 0.0.

Floating point conversion is implemented in all Converter widgets. The conversion is enabled when the *Stream Format Verb* for the widget node has *Bits* set to 4 (for 32-bit formatting).

AUDIO WIDGETS CAPABILITIES PARAMETER: DIGITAL

The MIC1 audio path can begin at either Port-B (Analogue Microphone) or Port-D (Digital Microphone). This leads to some confusion when setting the *Widget Capability Parameter*. Bit [9] of this parameter is called *Digital* and is used to indicate if the widget acts on an analogue stream or on a digital stream.

In the cases of the MIC1 Converter (NID = 03h) and the MIC1 Mux (NID = 09h), these can act on both analogue or digital streams, depending on which microphone interface is being used. For these two nodes, *Digital* = 0 to indicate that the nodes act on analogue data, but the user should be aware that these nodes can also act on digital data when the digital microphone is being used.

The Port-D node has its *Digital* parameter set to 1 to indicate that it acts on digital data.

LATENCY

The group delay or latency for an audio path varies based on sample rate and processing steps (e.g. SRC). As variable reporting is not supported as part of the Intel HDA Specification, the *Delay* parameter in the *Audio Widgets Capabilities Parameter* is set to 0 to indicate that latency is not reported.

POWER STATES

Within the AFG, all power states are supported. These are interpreted as follows:

- D0: Fully on
- D1: Link active, Jack detection logic on, analogue references enabled, but converters and DSP logic still disabled.
- D2: Link active, Jack detection logic on, register read/write access possible but all modules in an audio path are disabled.
- D3: Link disabled (i.e. BCLK stopped), responses not possible but Jack detection logic on and capable of issuing a wake.
- D4: Power applied, and settings maintained. Jack detection logic off, and wake disabled.

The AFG node supports the *Power State* verb. Widget nodes also offer power control, but their settings are restricted to select only power states below that of the AFG power state setting. For example, if the AFG node is set at D1, widget nodes can be set to D1, D2, D3, but not D0.

The default power state of the AFG is D2 so as to allow the PLLs to lock during CODEC initialisation. The default power state of the widget nodes is D3 so as to minimise power consumption. Widget nodes do not support D4 as the D3 state is identical to D4 at the widget node level.

Power state transitions are done in sequence. For example, if a node is in power state D3, and the power state is set to D0, the transitions steps are D3-D2-D1-D0. If a *Get Power State* command is issued during the state transitions, the actual power state returned, will be the power state at the end of the frame that the *Power State* command was issued in.

It is possible that the actual power state returned is D3, D2 or D0 while the set power state returned is D0.

For low power operation, the link should be in the Link Reset state and the WM8860 AFG should be in D3 or D4. If the link is in the Link Reset state, and the WM8860 AFG was left in states D0, D1 or D2, the WM8860 cannot issue a power state changes request (i.e. wake).

The only settings that can be changed in the D4 state is the AFG Power State or AFG reset settings – any other changes will be ignored.

In D3, BCLK may be stopped after the WM8860 asserts the *PS-ClkStopOK* register in the AFG's *Power State* verb. The *PS-ClkStopOK* bit will remain asserted in power state D3 until the power state is modified to D0, D1 or D2. If the power state is changed to D4 while in power state D3 when the *PS-ClkStopOK* bit is set, software must poll the AFG *PS-Act* bits to determine when the WM8860 reports transition to power state D4 complete (and hence reports *PS-Act* as D4) before stopping the BCLK.

In D3, if the link is not in the Link Reset state and BCLK is running, the WM8860 will issue an unsolicited response rather than a wake.

In D3 (with the link in the Link Reset state), the WM8860 is capable of generating a wake (i.e. a power state change request). The Controller will respond to the wake by putting the WM8860 through an initialisation sequence. The initialisation sequence will not change the register settings, so the WM8860 will still report a power state of D3 but the WM8860 will be able to send responses, including any unsolicited response(s) that caused a wake to be issued.

As register settings are maintained in the D3/D4 states, the user should be aware that if the WM8860 is brought from D3/D4 to D0 and stream IDs had been previously assigned, data rendering and capture will commence. If this behaviour is not desired, the user should bring the WM8860 to state D3 and set the stream IDs to 0, or ensure that stream IDs are set to 0 prior to entering the D3/D4 state.

STREAM START/STOP

Sections 4.5.3 and 4.5.4 of the Intel HD Audio specification describe the starting and stopping of streams. While the descriptions are sufficient from a controller perspective, there are ambiguities from a CODEC perspective.

For each stream that goes through the HDA Link, there is a 'Stream Manager' module within the WM8860 whose function is to assemble/disassemble the stream packets within the link frame. The Stream Manager is disabled while the *Stream* value in the *Converter Stream, Channel Verb* is set to 0h. When disabled, the captured data will not be sent on the link, and data from the link will not be decoded for rendering.

For audio path configuration, it is assumed that the Stream ID is the last register to be set in the configuration sequence. When Stream ID is set to a non-zero value it has the effect of starting the stream. On starting the stream, Stream Managers associated with input converters begin transmitting data on the link, and Stream Managers associated with output converters begin to decode data with the corresponding stream tag.

Note: Audio paths with mute capabilities may have 'un-mute' as the final configuration step. For these paths, the stream will have started but the audio data will be zeroed until mute has been disabled.

There are test paths within the WM8860 that do not use the HDA Link. These paths can still be used when the Stream Manager is disabled.

The Stream Manager is also disabled when the associated converter widget is in power state D1, D2 or D3. Digital converters (i.e. S/PDIF) have a *DigEn* register bit. When this is set to 0, the associated stream manager is disabled.

It is assumed that the settings of the *Stream Format Verb* and *Converter Stream, Channel Verb* will not change when a stream is active (with the exception of changing the Stream ID to 0 to terminate the stream). Changing stream settings while a stream is active is an erroneous action, and may result in audio corruption.

SDI STREAM ORDER

The order of stream transmission on the SDI link is governed by the CODEC. The WM8860 will transmit streams with the lowest stream ID value first.

If a stream is started with a stream ID lower than an existing stream, then the new stream is transmitted earlier in the frame than the existing stream (i.e. the WM8860 auto-shuffles the stream placement within the frame). This moves the existing stream to further on in the frame than it was prior to the starting of the new stream. It is assumed that moving streams within a frame is acceptable to the Controller.

BANDWIDTH CONFLICTS

Sections 5.3.2.2 and 5.3.3.3 of the HD Audio spec describe the scenario of over-subscription of SDO and SDI bandwidths. It indicates that the final stream on the link is terminated prior to completion, and further behaviour is undefined.

SDO

It is possible that the SDO line could be oversubscribed, if all streams are active at their maximum sample rate, and word length. It is the responsibility of the Controller to handle this situation, and determine what is put on the SDO line during oversubscription. The WM8860 will produce unsolicited responses from the converter nodes that have not received the stream packets that they have been configured for.

SDI

The WM8860 invokes a protection mechanism, should a bandwidth over-subscription situation arise. The mechanism monitors the sample rate, and sample-size settings of a stream to detect oversubscription.

If the SDI line is over-subscribed, due to software configuration or configuration from the recovered S/PDIF sample-rate, the stream (or streams) assigned the highest Stream ID tag value, will be dropped, and an unsolicited response issued from the stream converter whose stream has been dropped.

A stream will be restarted on a re-issue of a non-zero stream ID. However, should the bandwidth problem still be present, the stream won't start and an unsolicited response will be re-sent.

Although there is a protection mechanism in the WM8860, it is the responsibility of the user to identify and rectify bandwidth problems.

SOFTWARE FORMATTED (RAW) S/PDIF

An S/PDIF sub-frame consists of a preamble, 24-bits of audio data, and four control bits. In Software Formatted (Raw) S/PDIF mode, all 24-bits of the audio data, plus the 4 bits of control information, plus a 4-bit encoding of the preamble (taking the last 4-bits of the 8-bit bi-phase encoded preamble) are transported across the link. Software Formatted S/PDIF mode is selected by setting the *Bits* register in the *Stream Format Verb* to 4h (i.e. 32-bits) and setting the *Type* register to 1.

S/PDIF TX VALIDITY FLAG

The validity flag is bit [28] of an S/PDIF sub-frame. It is configured using *V-bit* in the *Digital Converter Control Verb*.

When the *V-bit* is set to 1, the validity flag for both sub-frames is set to 1.

When the *V-bit* is set to 0, the validity flag for both sub-frames is set to 0, unless an invalid sample is being transmitted for that sub-frame - in which case the validity flag is set to 1 for that sub-frame.

An invalid sample may occur under the following conditions:

- The Stream ID is set to 0
- SRC2 is enabled but is unlocked
- There has been a FIFO overrun/under-run condition in the S/PDIF Tx Stream Manager (i.e. a Stream Error).

Note: A Stream Error problem would only be present due to a problem upstream of the WM8860. A Stream Error triggers an unsolicited response with the *EF_STREAM_ERR* flag set. If an invalid sample is detected, it will be overwritten with all-zeros if *VCFG* in the *Digital Converter Control Verb* is set to 1.

CHANNEL NUMBERING

Multi-Channel Streams

Channels 0, 2, 4, etc will be assigned to the Left Channel of a stereo converter. Channels 1, 3, 5, etc will be assigned to the Right Channel of a stereo converter.

Channel synchronisation between channels is only guaranteed where stream packets are received by the WM8860 after all converters in a multi-channel stream have had their stream ID assigned.

Mono Streams

All converters are stereo. Where an input converter (eg. ADC1) is associated with a mono stream, only the left channel (channel 0) will be sent on the HDA Link.

In mono mode, right channel modules in the ADC will be disabled to save power.

Where an output converter (eg. DAC1, S/PDIF Tx) is associated with a mono stream, both left and right channels render the same samples. If both left and right DAC outputs are not desired, the unwanted channel can be muted.

A stream is assumed to be mono when its *Chan* control in the *Stream Format Verb* is set to 0. The *Channel* control in the *Converter Stream, Channel Verb* should be set to 0, although any setting of this register gives the same behaviour in mono mode.

ILLEGAL REGISTER VALUES

Should the user set verb registers to illegal, unsupported or reserved values, WM8860 behaviour is undefined.

Writing to Reserved registers has no effect.

RESPONSE FIELD

Valid Bit

Bit [35] of the Response Field is defined as the Valid Bit. Section 7.3.1 of the HDA specification states: "A 1 in the Valid bit position indicates the Response Filed contains a valid response, which the controller will place in the RIRB; a 0 indicates there is no response."

The WM8860 will set the Valid Bit for all responses, except null responses.

We define a null response as a response to a command that contains an invalid verb (a command where NID=0h, and Verb=0h), or a response to a command with a CODEC address (CAd) that does not match the WM8860 CAd. Either of these commands can be considered as a null command.

We define a non-defined command as a command that has no meaning (i.e. a NID that is not within the WM8860, or a Verb ID that is not supported for the given node). The WM8860 will set the Valid Bit for non-defined commands.

CHIP HIERARCHY

WIDGET DIAGRAM

Figure 4 below shows the widgets for the WM8860 CODEC, showing available audio routing options. The Node ID (NID) values are shown in the top right corner of each widget. Dotted lines indicate paths that are controlled by vendor-specific verbs.

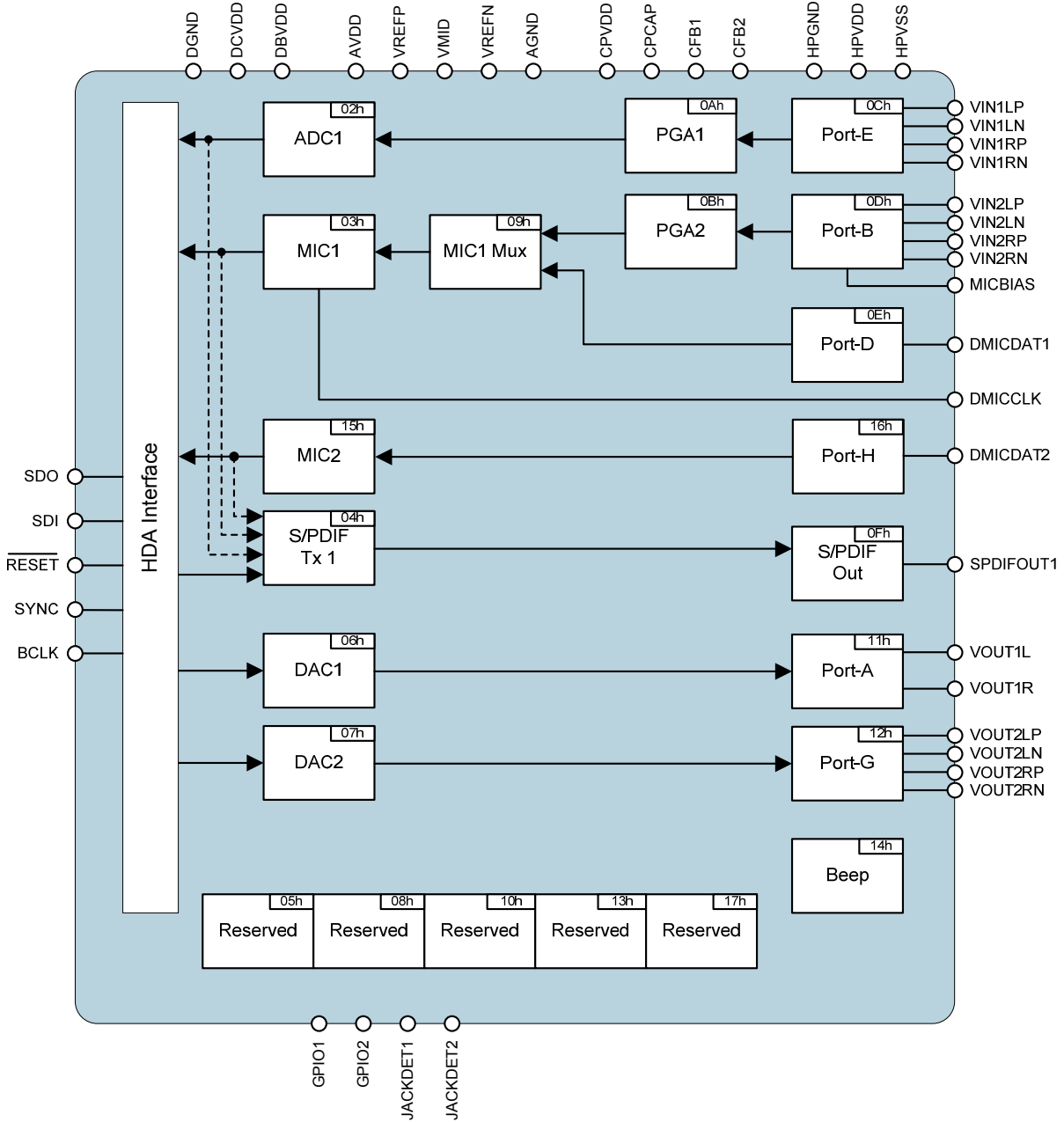


Figure 4 Widget Diagram Showing Valid Audio Paths

NODE LIST

A summary of the capabilities of each node is given in Table 3 below:

| NID | NAME | WIDGET TYPE | DESCRIPTION |
|-----|-------------|------------------------|---|
| 00h | Root | Root | Provides Vendor ID, Device ID, and NID of the AFG. |
| 01h | AFG | Audio Function Group | Provides the number of Widget Nodes, and NID of first Widget Node. Describes CODEC Audio capabilities. |
| 02h | ADC1 | Audio Input Converter | Supports sample rates from 8kHz to 96kHz, and sample sizes from 16-bits to 24-bits. |
| 03h | MIC1 | Audio Input Converter | Supports sample rates from 8kHz to 48kHz, and sample sizes from 16-bits to 24-bits. |
| 04h | S/PDIF Tx 1 | Audio Output Converter | Supports sample rates from 32kHz to 192kHz, and sample sizes from 16-bits to 32-bits. Includes a fully asynchronous SRC. |
| 05h | | | Reserved |
| 06h | DAC1 | Audio Output Converter | Supports sample rates from 8kHz to 192kHz, and sample sizes from 16-bits to 24-bits. Supports digital attenuation from 0dB to -63.5 dB in 0.5 dB steps. |
| 07h | DAC2 | Audio Output Converter | As DAC1. |
| 08h | | | Reserved |
| 09h | MIC1 Mux | Audio Selector | Selects between Digital Mic (Port-D), and Analogue Mic (Port-B). |
| 0Ah | PGA1 | Audio Selector | Supports a gain range of -12dB to +12 dB in 0.5dB steps. |
| 0Bh | PGA2 | Selector | As PGA1. |
| 0Ch | Port-E | Pin Complex | Line Input (VIN1) with presence detection. |
| 0Dh | Port-B | Pin Complex | Analogue Mic Input (VIN2) with pre-amplifier (0dB, +10dB, +20dB, +30dB), configurable V_{REF} , presence detection and custom impedance sensing scheme. |
| 0Eh | Port-D | Pin Complex | Digital Mic Input (DMIC1) with gain (-12dB to +32dB in 0.5dB steps). |
| 0Fh | S/PDIF Out | Pin Complex | S/PDIF Output with presence detection. |
| 10h | | | Reserved |
| 11h | Port-A | Pin Complex | Ground-referenced headphone/line out (VOUT1) with presence detection. |
| 12h | Port-G | Pin Complex | Differential line out (VOUT2) with presence detection. |
| 13h | | | Reserved |
| 14h | Beep | Beep Generator | Generates a configurable tone that can be muxed into DAC audio paths. Supports a gain range 0dB to -24dB in 6dB steps. |
| 15h | MIC2 | Audio Input Converter | Supports sample rates from 8kHz to 48kHz, and sample sizes from 16-bits to 24-bits. |
| 16h | Port-H | Pin Complex | Digital Mic Input (DMIC2) with gain (-12 dB to 32dB in 0.5 dB steps). Output port for S/PDIF Tx 2. |
| 17h | | | Reserved |

Table 3 Node List

Notes:

1. All Widget Nodes are as defined in the HDA specification; there are no vendor defined widgets.

NODE/VERB SUMMARY

Table 4 gives a summary of the verbs available for each node in the WM8860. Shaded cells show vendor-specific verbs:

| | Root Node | AFG Node | ADC1 | MIC1 | S/PDIF TX 1 | Reserved | DAC1 | DAC2 | Reserved | MIC1 Mux | PGA1 | PGA2 | Port-E | Port-B | Port-D | S/PDIF Out | Reserved | Port-A | Port-G | Reserved | Beep | MIC2 | Port-H | Reserved |
|--|-----------|----------|------|------|-------------|----------|------|------|----------|----------|------|------|--------|--------|--------|------------|----------|--------|--------|----------|------|------|--------|----------|
| | 00h | 01h | 02h | 03h | 04h | 05h | 06h | 07h | 08h | 09h | 0Ah | 0Bh | 0Ch | 0Dh | 0Eh | 0Fh | 10h | 11h | 12h | 13h | 14h | 15h | 16h | 17h |
| Reset Get: – Execute: 7FFh | | X | | | | | | | | | | | | | | | | | | | | | | |
| Stream Format Get: Ah Set: 2h | | | X | X | X | | X | X | | | | | | | | | | | | | | 1 | | |
| Amplifier Gain/Mute Get: Bh Set: 3h | | | | | | | X | X | | | X | X | | X | X | | | | | | X | | X | |
| Get Parameter Get: F00h Set: – | X | X | X | X | X | | X | X | | X | X | X | X | X | X | X | | X | X | | X | X | X | |
| Connection Select Control Get: F01h Set: 701h | | | | | | | | | | X | | | | | | | | | | | | | | |
| Get Connection List Entry Get: F02h Set: – | | | X | X | | | | | | X | X | X | | | | X | | X | X | | | X | X | |
| Processing State Get: F03h Set: 703h | | | X | X | | | | | | | | | | | | | | | | | | X | | |
| Power State Get: F05h Set: 705h | | X | X | X | | | X | X | | | | | | | | | | | | | | | | |
| Converter Stream, Channel Verb Get: F06h Set: 706h | | | X | X | X | | X | X | | | | | | | | | | | | | | X | | |
| Pin Widget Control Get: F07h Set: 707h | | | | | | | | | | | | | X | X | X | X | | X | X | | | | X | |
| Unsolicited Response Get: F08h Set: 708h | | X | X | X | X | | X | X | | | | | X | X | | X | | X | X | | | X | | |
| Pin Sense Get: F09h Execute: 709h | | | | | | | | | | | | | 2 | X | | 2 | | 2 | 2 | | | | | |
| Beep Generation Get: F0Ah Set: 70Ah | | | | | | | | | | | | | | | | | | | | | X | | | |
| EAPD/BTL Enable Get: F0Ch Set: 70Ch | | | | | | | | | | | | | X | X | | | | | | | | | | |
| Digital Converter Control Get: F0Dh Set: 70Dh, 70Eh | | | | | X | | | | | | | | | | | | | | | | | | | |
| GPIO Data Get: F15h Set: 715h | | X | | | | | | | | | | | | | | | | | | | | | | |
| GPIO Enable Get: F16h Set: 716h | | X | | | | | | | | | | | | | | | | | | | | | | |
| GPIO Direction Get: F17h Set: 717h | | X | | | | | | | | | | | | | | | | | | | | | | |
| GPIO Wake Enable Get: F18h Set: 718h | | X | | | | | | | | | | | | | | | | | | | | | | |
| GPIO Unsolicited Enable Mask Get: F19h Set: 719h | | X | | | | | | | | | | | | | | | | | | | | | | |
| GPIO Sticky Mask Get: F1Ah Set: 71Ah | | X | | | | | | | | | | | | | | | | | | | | | | |
| Configuration Default Get: F1Ch Set: 71Ch, 71Dh, 71Eh, 71Fh | | | | | | | | | | | | | X | X | X | X | 3 | X | X | 3 | | | X | |
| Implementation Identification/Subsystem ID Get: F20h Set: 720h, 721h, 722h, 723h | | X | | | | | | | | | | | | | | | | | | | | | | |
| VMID Control Get: F71h Set: 771h | | X | | | | | | | | | | | | | | | | | | | | | | |
| Beep Mask Selection Get: F72h Set: 772h | | | | | | | | | | | | | | | | | | | | | X | | | |
| Internal Path Get: F73h Set: 773h | | | | | X | | | | | | | | | | | | | | | | | | X | |
| S/PDIF Get: F80h Set: 780h | | | | | | | | | | | | | | | | | | | | | | | | |
| Tx Channel Status Control Get: F81h Set: 781h, 782h, 783h, 784h | | | | | X | | | | | | | | | | | | | | | | | | | |
| Channel Status Data Packing Configuration Get: F85h Set: 785h | | | | | X | | | | | | | | | | | | | | | | | | | |

| | Root Node | AFG Node | ADC1 | MIC1 | S/PDIF Tx 1 | Reserved | DAC1 | DAC2 | Reserved | MIC1 Mux | PGA1 | PGA2 | Port-E | Port-B | Port-D | S/PDIF Out | Reserved | Port-A | Port-G | Reserved | Beep | MIC2 | Port-H | Reserved |
|---|-----------|----------|------|------|-------------|----------|------|------|----------|----------|------|------|--------|--------|--------|------------|----------|--------|--------|----------|------|------|--------|----------|
| | 00h | 01h | 02h | 03h | 04h | 05h | 06h | 07h | 08h | 09h | 0Ah | 0Bh | 0Ch | 0Dh | 0Eh | 0Fh | 10h | 11h | 12h | 13h | 14h | 15h | 16h | 17h |
| GPIO Automatic Control Get: F86h Set: 786h | | X | | | | | | | | | | | | | | | | | | | | | | |
| Unsolicited Response Priority Control Get: F8Eh Set: 78Eh | | X | X | X | X | | X | X | | | | | X | X | | X | | X | X | | | X | | |
| Differential Get: FA3h Set: 7A3h | | | | | | | | | | | | | | X | | | | | | | | | | |
| Auto-Mute Control Get: FB0h Set: 7B0h | | | | | | | | | | | | | X | X | | | | | | | | | | |
| Channel Copy Get: FB1h Set: 7B1h | | | X | X | | | | | | | | | | | | | | | | | | X | | |
| PGA Control Get: FB2h Set: 7B2h, 7B3h | | | | | | | | | | | X | X | | | | | | | | | | | | |

Table 4 Node/Verb Summary

Note:

1. Set Verbs are not supported in this case.
2. Execute Verbs are not supported in these cases
3. Node IDs 10h and 13h are Reserved, but the Host Processor must issue a Configuration Default Verb to these nodes as described in the "Detailed Verb Descriptions" section.

DEVICE DESCRIPTION

This section of the datasheet provides detailed information on all the major paths through the device, along with the nodes used and the vendor-specific verbs. For those verbs implemented in the WM8860 which are as defined in the High Definition Audio Specification Revision 1.0 there is no detailed text describing their use in this datasheet.

The functions covered in this section of the datasheet, and the WM8860 nodes associated with each, are listed in Table 5.

| FUNCTION | NODE NAME | NODE ID (NID) |
|---|-------------|---------------|
| Stereo Analogue Line Record | Port-E | 0Ch |
| | PGA1 | 0Ah |
| | ADC1 | 02h |
| Stereo Analogue Microphone Record | Port-B | 0Dh |
| | PGA2 | 0Bh |
| | MIC1 Mux | 09h |
| | MIC1 | 03h |
| Digital Microphone Record | Port-D | 0Eh |
| | MIC1 Mux | 09h |
| | MIC1 | 03h |
| | Port-H | 16h |
| | MIC2 | 15h |
| Stereo Headphone Playback | DAC1 | 06h |
| | Port-A | 11h |
| Stereo Line Playback | DAC2 | 07h |
| | Port-G | 12h |
| S/PDIF Transmit | S/PDIF Tx 1 | 04h |
| | S/PDIF Out | 0Fh |
| Ancillary Functions (Beep generator, VMID control, GPIO2 automatic control mode, Unsolicited response priority control) | Beep | 14h |
| | AFG | 01h |

Table 5 WM8860 Device Functions

STEREO ANALOGUE LINE RECORD

Stereo analogue line input is supported using the VIN1LP, VIN1LN, VIN1RP and VIN1RN pins; these are available for high-quality stereo digitisation through the ADC1 node.

The WM8860 nodes associated with this function are shown in Figure 5.

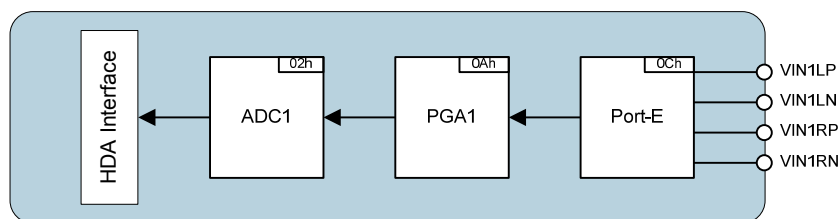


Figure 5 Stereo Analogue Line Record Path

This section provides a summary of the Port-E, PGA1 and ADC1 nodes, and describes the vendor-specific verb functions associated with each.

PORT-E (NID = 0CH)

Table 6 gives a summary of the Port-E node:

| NODE SUMMARY INFORMATION | |
|------------------------------|--|
| NID | 0Ch |
| Widget Type | Pin Complex |
| Supported Get Verbs | F00h, F07h, F08h, F09h, F0Ch, F1Ch, F8Eh, FB0h |
| Supported Set Verbs | 707h, 708h, 70Ch, 71Ch, 71Dh, 71Eh, 71Fh, 78Eh, 7B0h |
| Unsolicited Responses | Presence Detect Status Change |
| Vendor-Specific Verbs | F8Eh, 78Eh : Unsolicited Response Priority Control Verb FB0h, 7B0h : Auto-Mute Control Verb |

Table 6 Port-E Node Summary Information

Port-E supports two different input configurations, controlled by the *EAPD/BTL Verb*.

| SET VERB | BIT | BITFIELD NAME | DEFAULT | DESCRIPTION |
|----------|-----|---------------|---------|---|
| 70Ch | 0 | BTL | 1h | Controls the configuration of the input pins on Port-E: 0 = Single-ended mode 1 = BTL (balanced) mode |

In single-ended input mode, VIN1LP and VIN1RP are used as the Port-E input pins VIN1LN and VIN1RN must be left floating in this mode. Note that the full-scale input signal level is reduced in single-ended mode, as shown in the "Electrical Characteristics" section.

In differential input mode, VIN1LP, VIN1LN, VIN1RP and VIN1RN are used as the Port-E input pins.

See Figure 6 for examples of the external connections required in each of the supported input configurations.

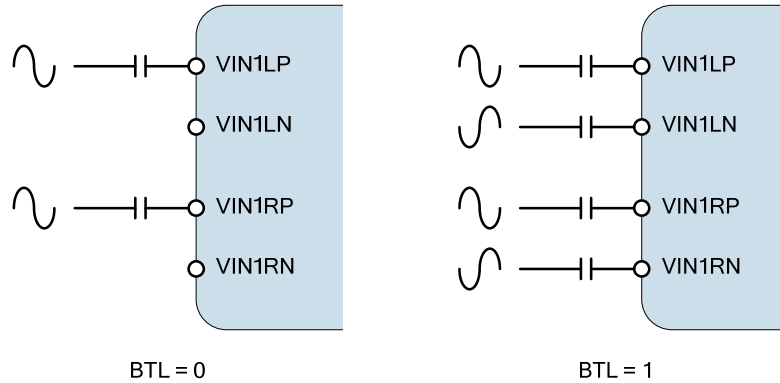


Figure 6 Single Ended (Left) and Differential (Right) External Connections

Port-E supports presence detect. This can be read directly from the *Pin Sense Verb*.

If nothing is plugged into Port-E it is possible to use an automute function which will automatically replace the samples in the stream with zeros, thus avoiding any noise being transmitted when there is no input. This function can be enabled using the vendor-specific *Auto-Mute Control Verb*.

| SET VERB | BIT | BITFIELD NAME | DEFAULT | DESCRIPTION |
|----------|-----|---------------|---------|---|
| 7B0h | 0 | PD_ AUTOMUTE | 0h | Auto-Mute Control: 0 = Automute disabled 1 = Automute enabled Note: When PD_AUTOMUTE=1 and Presence Detect (bit 31 in verb F09h)=1 the WM8860 will replace the samples in the stream with zeros |

PGA1 (NID = 0Ah)

Table 7 gives a summary of the PGA1 node:

| NODE SUMMARY INFORMATION | |
|------------------------------|--------------------------------|
| NID | 0Ch |
| Widget Type | Audio Selector |
| Supported Get Verbs | Bh, F00h, F02h, FB2h |
| Supported Set Verbs | 3h, 7B2h, 7B3h |
| Unsolicited Responses | None |
| Vendor-Specific Verbs | FB2h, 7B2h, 7B3h : PGA Control |

Table 7 PGA1 Node Summary Information

PGA1 provides analogue gain for the inputs to Port-E, allowing the signal level to be adjusted by up to +/-12dB in 0.5dB steps. Gain can be applied to left and right channels independently if required. Additionally, a mute function is available – again this can be applied to separate channels as required. The gain of PGA1 is controlled using the *Amplifier Gain/Mute Verb*.

Note: When Port-E is configured in single-ended mode the actual gain settings applied to the signal will be adjusted by a further -3.0dB. This changes the effective gain range to -15dB to +9dB.

PGA1 uses an internal zero cross detect circuit to ensure that all gain changes occur while the signal passes through the zero point. This function eliminates any potential DC steps that can occur if gain changes are applied at other times, and therefore the potential for zipper noise is removed. If no zero cross occurs within a specified time after the gain change is requested via a register write a timeout period will elapse and the gain will be changed regardless. This timeout period can be changed using the vendor-specific *PGA Control Verb*:

| SET VERB | BIT | BITFIELD NAME | DEFAULT | DESCRIPTION |
|--------------|------|----------------|---------|---|
| 7B2h 7B3h | 13:0 | Terminal Count | 1FFFh | <p>Set the period of the zero detect timeout clock: 0000h = Timeout disabled 0001h to 03FFh = Reserved 0400h = 1025 x 20.833µs (21.3ms) 0401h = 1026 x 20.833µs (21.4ms) ... 1FFFh = 8192 x 20.833µs (171ms) ... 3FFFh = 16384 x 20.833µs (341ms)</p> <p>Note: The timeout clock uses the SYNC signal from the HDA interface, so the absolute value of the timeout period will depend on the absolute accuracy of the SYNC signal.</p> |

ADC1 (NID = 02h)

Table 8 gives a summary of the ADC1 node:

| NODE SUMMARY INFORMATION | |
|------------------------------|---|
| NID | 02h |
| Widget Type | Audio Input Converter |
| Supported Get Verbs | Ah, F00h, F02h, F03h, F05h, F06h, F08h, F8Eh, FB1h |
| Supported Set Verbs | 2h, 703h, 705h, 706h, 708h, 78Eh, 7B1h |
| Unsolicited Responses | Stream Drop |
| Vendor-Specific Verbs | F8Eh, 78Eh : Unsolicited Response Priority Control Verb FB1h, 7B1h : Channel Copy Verb |

Table 8 ADC1 Node Summary Information

ADC1 supports all common sample rates from 8kHz to 96kHz and data widths of 16, 20, 24 and 32-bit (Float-32).

The sample rate and word length of the data captured by the ADC1 node is set using the *Stream Format Verb*. Table 9 below shows the required settings for *Base*, *Mult* and *Div* as part of the *Stream Format Verb* to obtain the required sample rate.

| Sample Rate | Base | Mult | Div |
|-------------|------|------|-----|
| 8kHz | 0h | 0h | 5h |
| 11.025kHz | 1h | 0h | 3h |
| 16kHz | 0h | 0h | 2h |
| 22.05kHz | 1h | 0h | 1h |
| 24kHz | 0h | 0h | 1h |
| 32kHz | 0h | 1h | 2h |
| 44.1kHz | 1h | 0h | 0h |
| 48kHz | 0h | 0h | 0h |
| 88.2kHz | 1h | 1h | 0h |
| 96kHz | 0h | 1h | 0h |

Table 9 ADC1 Supported Sample Rate Settings

Note: Other settings of *Base*, *Mult* and *Div* are reserved and should not be set.

The ADC1 output data is by default set to provide the captured waveform from the left channel in Channel 0, and the right channel in Channel 1. It is possible to adjust this mapping using the vendor-specific *Channel Copy Verb*.

| SET VERB | BIT | BITFIELD NAME | DEFAULT | DESCRIPTION |
|----------|-----|---------------|---------|---|
| 7B1h | 1 | CHAN1_SEL | 1 | Channel 1 (right) Mapping Control: 0 = Channel 1 takes data from left audio channel 1 = Channel 1 takes data from right audio channel |
| | 0 | CHAN0_SEL | 0 | Channel 0 (left) Mapping Control: 0 = Channel 0 takes data from left audio channel 1 = Channel 0 takes data from right audio channel |

STEREO ANALOGUE MICROPHONE RECORD

Stereo analogue microphone input is supported using the VIN2LP, VIN2LN, VIN2RP and VIN2RN pins; these are available for analogue microphone digitisation through the MIC1 node. The MICBIAS output, controlled via the Port-B node, provides a low noise voltage output suitable for use as a power supply for analogue or digital microphones.

The WM8860 nodes associated with this function are shown in Figure 7.

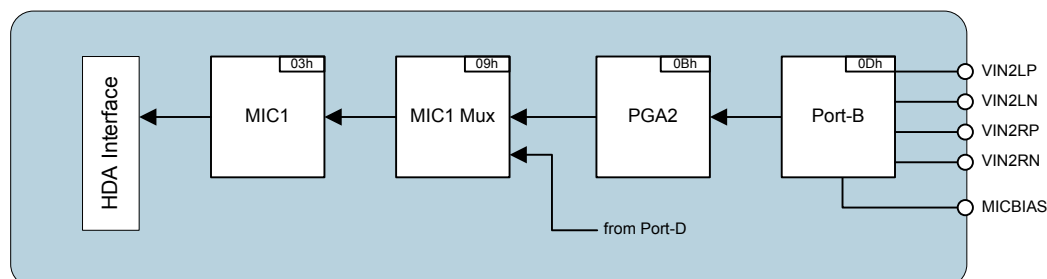


Figure 7 Stereo Analogue Microphone Record Path

This section provides a summary of the Port-B, PGA2, MIC1 Mux and MIC1 nodes, and describes the vendor-specific functions associated with each.

PORT-B (NID = 0DH)

Table 10 gives a summary of the Port-B node:

| NODE SUMMARY INFORMATION | |
|------------------------------|--|
| NID | 0Dh |
| Widget Type | Pin Complex |
| Supported Get Verbs | Bh, F00h, F07h, F08h, F09h, F0Ch, F1Ch, F8Eh, FA3h, FB0h |
| Supported Set Verbs | 3h, 707h, 708h, 70Ch, 71Ch, 71Dh, 71Eh, 71Fh, 78Eh, 7A3h, 7B0h |
| Unsolicited Responses | Presence Detect Status Change Impedance Measurement Ready |
| Vendor-Specific Verbs | F8Eh, 78Eh : Unsolicited Response Priority Control Verb FA3h, 7A3h : Differential Verb FB0h, 7B0h : Auto-Mute Control Verb |

Table 10 Port-B Node Summary Information

Port-B supports three different input configurations, controlled by the *EAPD/BTL Verb* and the vendor-specific *Differential Verb*.

| SET VERB | BIT | BITFIELD NAME | DEFAULT | DESCRIPTION |
|----------|-----|-------------------|---------|---|
| 70Ch | 0 | BTL | 1h | Controls the configuration of the input pins on Port-E: 0 = Single-ended mode 1 = BTL (balanced) mode |
| 7A3h | 0 | Differential Mode | 0h | Differential mode: 0 = Differential (microphone) 1 = Pseudo-differential |

The supported input configurations are described in Table 11 below:

| BTL | DIFFERENTIAL MODE | MODE | ACTIVE PINS | NOTES |
|-----|-------------------|---------------------------|--------------------------------------|---|
| 0 | X | Single Ended | VIN2LP VIN2RP | Input impedance varies with gain setting – minimum 10kΩ Suitable for microphone or line level signals |
| 1 | 0 | Differential (Microphone) | VIN2LP VIN2LN VIN2RP VIN2RN | Input impedance does not vary with gain setting – typically 120kΩ Suitable for microphone (low-level) signals only |
| 1 | 1 | Pseudo-Differential | VIN2LP VIN2LN VIN2RP VIN2RN | Input impedance varies with gain setting – minimum 10kΩ Suitable for microphone or line level signals |

Table 11 Port-B Configuration Options

See Figure 8 for examples of the external connections required in each of the supported input configurations.

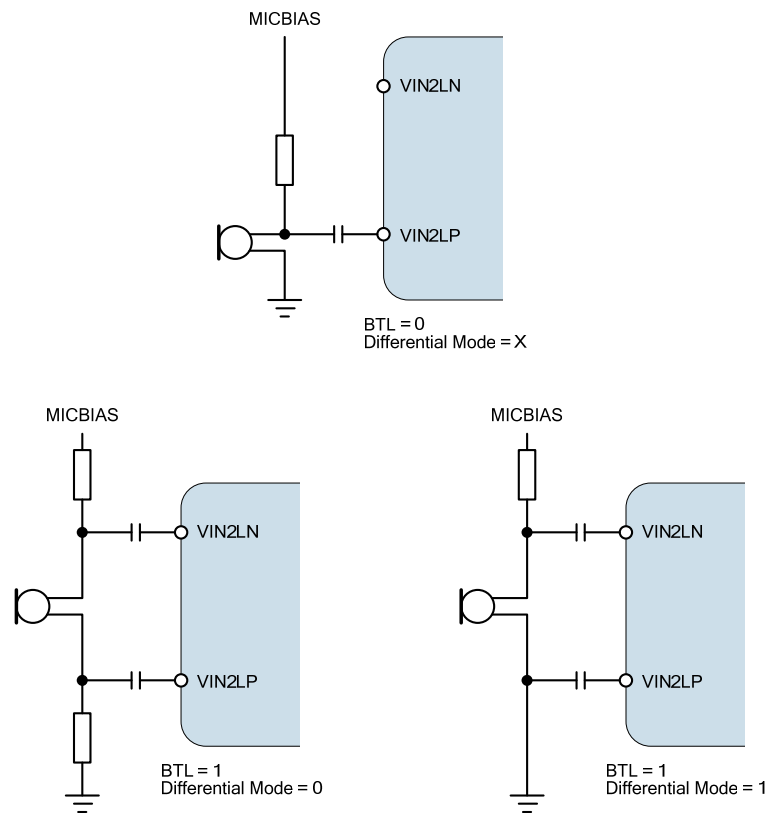


Figure 8 Port-B Example External Connections (one channel shown)

A microphone pre-amplifier is available as part of the Port-B node. This amplifier can be used to boost microphone inputs by +10dB, +20dB or +30dB. Alternatively, the gain of the pre-amplifier can be set to 0dB. It is not possible to use different gain settings for the left and right channels, and the pre-amplifier does not support mute. The microphone pre-amplifier is controlled by the *Amplifier Gain/Mute Verb*.

A low-noise microphone bias generator is provided as part of Port-B, which is suitable for use as a bias supply for analogue microphones. The control of the microphone bias level is via the *Pin Widget Control Verb*.

Port-B supports impedance sensing when using the microphone bias generator; this can be read directly from the *Pin Sense Verb*. Port-B also supports presence detect, using the *Pin Sense Verb*.

If nothing is plugged into Port-B it is possible to use an automute function which will automatically replace the samples in the stream with zeros, thus avoiding any noise being transmitted when there is no input device connected. This function can be enabled using the vendor-specific *Auto-Mute Control Verb*.

| SET VERB | BIT | BITFIELD NAME | DEFAULT | DESCRIPTION |
|----------|-----|---------------|---------|---|
| 7B0h | 0 | PD_ AUTOMUTE | 0h | Auto-Mute Control: 0 = Automute disabled 1 = Automute enabled Note: When PD_AUTOMUTE=1 and Presence Detect (bit 31 in verb F09h)=1 the WM8860 will replace the samples in the stream with zeros |

PGA2 (NID = 0Bh)

Table 12 gives a summary of the PGA2 node:

| NODE SUMMARY INFORMATION | |
|------------------------------|-------------------------------------|
| NID | 0Ch |
| Widget Type | Audio Selector |
| Supported Get Verbs | Bh, F00h, F02h, FB2h |
| Supported Set Verbs | 3h, 7B2h, 7B3h |
| Unsolicited Responses | None |
| Vendor-Specific Verbs | FB2h, 7B2h, 7B3h : PGA Control Verb |

Table 12 PGA2 Node Summary Information

PGA2 provides analogue gain for the inputs to Port-B, allowing the signal level to be adjusted by up to +/-12dB in 0.5dB steps. Gain can be applied to left and right channels independently if required. Additionally, a mute function is available – again this can be applied to separate channels as required. The gain of PGA2 is controlled using the *Amplifier Gain/Mute Verb*.

PGA2 uses an internal zero cross detect circuit to ensure that all gain changes occur while the signal passes through the zero point. This function eliminates any potential DC steps that can occur if gain changes are applied at other times, and therefore the potential for zipper noise is removed. If no zero cross occurs within a specified time after the gain change is requested via a register write a timeout period will elapse and the gain will be changed regardless. This timeout period can be changed using the vendor-specific *PGA Control Verb*:

| SET VERB | BIT | BITFIELD NAME | DEFAULT | DESCRIPTION |
|--------------|------|----------------|---------|---|
| 7B2h 7B3h | 13:0 | Terminal Count | 1FFFh | <p>Set the period of the zero detect timeout clock: 0000h = Timeout disabled 0001h to 03FFh = Reserved 0400h = 1025 x 20.833µs (21.3ms) 0401h = 1026 x 20.833µs (21.4ms) ... 1FFFh = 8192 x 20.833µs (171ms) ... 3FFFh = 16384 x 20.833µs (341ms)</p> <p>Note: The timeout clock uses the SYNC signal from the HDA interface, so the absolute value of the timeout period will depend on the absolute accuracy of the SYNC signal.</p> |

MIC1 MUX (NID = 09h)

Table 13 gives a summary of the MIC1 Mux node:

| NODE SUMMARY INFORMATION | |
|------------------------------|------------------|
| NID | 09h |
| Widget Type | Audio Selector |
| Supported Get Verbs | F00h, F01h, F02h |
| Supported Set Verbs | 701h |
| Unsolicited Responses | None |

Table 13 MIC1 Mux Node Summary Information

MIC1 Mux is used to select the source of the input to the MIC1 node. This can be either from the analogue microphone input path (from PGA2), or from the digital microphone path (from Port-D). When the MIC1 Mux is selecting the digital microphone input (Port-D) the WM8860 is automatically configured to bypass the analogue to digital converter part of the MIC1 node (NID = 03h).

There are no vendor-specific verbs associated with the MIC1 Mux node.

MIC1 (NID = 03H)

Table 14 gives a summary of the MIC1 node:

| NODE SUMMARY INFORMATION | |
|------------------------------|---|
| NID | 02h |
| Widget Type | Audio Input Converter |
| Supported Get Verbs | Ah, F00h, F02h, F03h, F05h, F06h, F08h, <i>F8Eh, FB1h</i> |
| Supported Set Verbs | 2h, 703h, 705h, 706h, 708h, <i>78Eh, 7B1h</i> |
| Unsolicited Responses | Stream Drop |
| Vendor-Specific Verbs | F8Eh, 78Eh : Unsolicited Response Priority Control Verb FB1h, 7B1h : Channel Copy Verb |

Table 14 MIC1 Node Summary Information

MIC1 contains a high performance stereo ADC intended for capture of microphone inputs to the WM8860. MIC1 supports all common sample rates from 8kHz to 48kHz and data widths of 16, 20, 24 and 32-bit (Float-32). The actual processing used by this node is dependant on the type of input received from the MIC1 Mux (NID = 09h), as the input to MIC1 may come from either an analogue or digital microphone.

Regardless of the type of input, the sample rate and word length of the data captured by the MIC1 node is set using the *Stream Format Verb*. Table 15 below shows the required settings for *Base*, *Mult* and *Div* as part of the *Stream Format Verb* to obtain the required sample rate.

When a digital microphone is being used, the DMICCLK output frequency will be set according to the *Stream Format Verb*. See “Digital Microphone Record” for details of the DMICCLK frequency.

| SAMPLE RATE | BASE | MULT[2:0] | DIV[2:0] |
|-------------|------|-----------|----------|
| 8kHz | 0h | 0h | 5h |
| 11.025kHz | 1h | 0h | 3h |
| 16kHz | 0h | 0h | 2h |
| 22.05kHz | 1h | 0h | 1h |
| 32kHz | 0h | 1h | 2h |
| 44.1kHz | 1h | 0h | 0h |
| 48kHz | 0h | 0h | 0h |

Table 15 MIC1 Supported Sample Rate Settings

Note: Other settings of *Base*, *Mult* and *Div* are reserved and should not be set.

The MIC1 output data is by default set to provide the captured waveform from the left channel in Channel 0, and the right channel in Channel 1. It is possible to adjust this mapping using the vendor-specific *Channel Copy Verb*.

| SET VERB | BIT | BITFIELD NAME | DEFAULT | DESCRIPTION |
|----------|-----|---------------|---------|---|
| 7B1h | 1 | CHAN1_SEL | 1 | Channel 1 (right) Mapping Control: 0 = Channel 1 takes data from left audio channel 1 = Channel 1 takes data from right audio channel |
| | 0 | CHAN0_SEL | 0 | Channel 0 (left) Mapping Control: 0 = Channel 0 takes data from left audio channel 1 = Channel 0 takes data from right audio channel |

DIGITAL MICROPHONE RECORD

Digital microphone input is supported using the DMICDAT1, DMICDAT2 and DMICCLK pins; these allow up to four independent digital microphones to be connected through the MIC1 and MIC2 nodes.

The digital microphone interface accepts unfiltered PDM on the DMICDAT1 and DMICDAT2 pins and can recover data from both the high and low periods of the DMICCLK. Two microphone channels are interleaved on DMICDAT1; another two channels are interleaved on DMICDAT2. The timing is illustrated in Figure 9. Each microphone must tri-state its data output when the other microphone is transmitting.

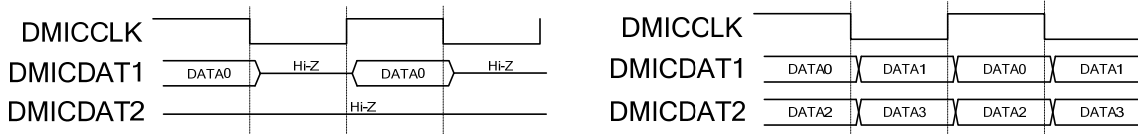


Figure 9 Digital Microphone Interface Protocol for One (left) or Four (right) Microphones

The WM8860 nodes associated with this function are shown in Figure 10.

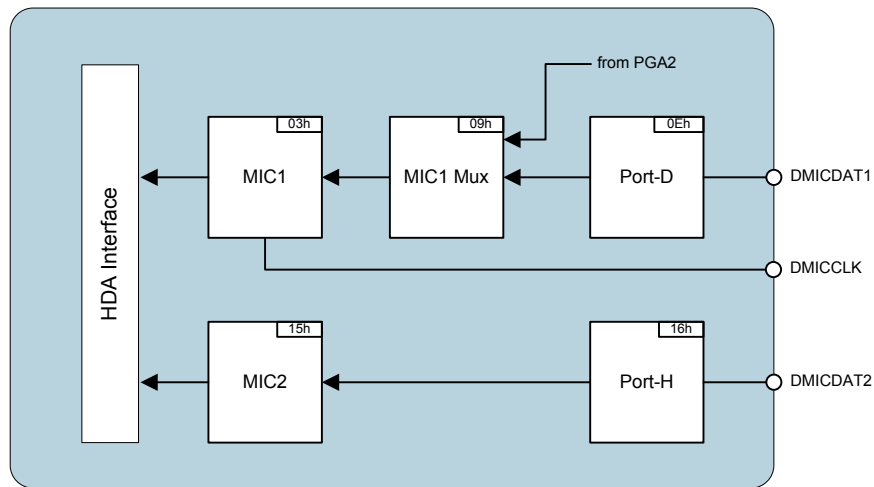


Figure 10 Digital Microphone Record Path

This section provides a summary of the Port-D, Port-H and MIC2 nodes, and describes the vendor-specific verb functions associated with each.

The MIC1 Mux and MIC1 nodes are described in the “Stereo Analogue Microphone Record” section.

PORT-D (NID = 0Eh)

Table 16 gives a summary of the Port-D node:

| NODE SUMMARY INFORMATION | |
|------------------------------|----------------------------------|
| NID | 0Eh |
| Widget Type | Pin Complex |
| Supported Get Verbs | Bh, F00h, F07h, F1Ch |
| Supported Set Verbs | 3h, 707h, 71Ch, 71Dh, 71Eh, 71Fh |
| Unsolicited Responses | None |

Table 16 Port-D Node Summary Information

Port-D provides digital gain for the microphone(s) connected to DMICDAT1, allowing the signal level to be adjusted by up to +32dB to -12dB in 0.5dB steps. Gain can be applied to left and right channels independently if required. Additionally, a mute function is available – again this can be applied to separate channels as required. The gain is controlled using the *Amplifier Gain/Mute Verb*.

There are no vendor-specific verbs associated with the Port-D node.

PORT-H (NID = 16H)

Table 17 gives a summary of the Port-H node:

| NODE SUMMARY INFORMATION | |
|------------------------------|----------------------------------|
| NID | 16h |
| Widget Type | Pin Complex |
| Supported Get Verbs | Bh, F00h, F02h, F07h, F1Ch |
| Supported Set Verbs | 3h, 707h, 71Ch, 71Dh, 71Eh, 71Fh |
| Unsolicited Responses | None |

Table 17 Port-H Node Summary Information

Port-H provides digital gain for the microphone(s) connected to DMICDAT2, allowing the signal level to be adjusted by up to +32dB to -12dB in 0.5dB steps. Gain can be applied to left and right channels independently if required. Additionally, a mute function is available – again this can be applied to separate channels as required. The gain is controlled using the *Amplifier Gain/Mute Verb*.

There are no vendor-specific verbs associated with the Port-H node.

MIC2 (NID = 15h)

Table 18 gives a summary of the MIC2 node:

| NODE SUMMARY INFORMATION | |
|------------------------------|---|
| NID | 15h |
| Widget Type | Audio Input Converter |
| Supported Get Verbs | Ah, F00h, F02h, F03h, F06h, F08h, F8Eh, FB1h |
| Supported Set Verbs | 703h, 706h, 708h, 78Eh, 7B1h |
| Unsolicited Responses | Stream Drop |
| Vendor-Specific Verbs | F8Eh, 78Eh : Unsolicited Response Priority Control Verb FB1h, 7B1h : Channel Copy Verb |

Table 18 MIC2 Node Summary Information

The MIC2 node supports digital audio input at all common sample rates from 8kHz to 48kHz.

Note that the *Stream Format Verb* in the MIC2 widget (NID = 15h) is read-only; the associated parameters will echo the values set in the same verb in the MIC1 widget.

The MIC2 output data is by default set to provide the captured waveform from the left channel in Channel 0, and the right channel in Channel 1. It is possible to adjust this mapping using the vendor-specific *Channel Copy Verb*:

| SET VERB | BIT | BITFIELD NAME | DEFAULT | DESCRIPTION |
|----------|-----|---------------|---------|---|
| 7B1h | 1 | CHAN1_SEL | 1 | Channel 1 (right) Mapping Control: 0 = Channel 1 takes data from left audio channel 1 = Channel 1 takes data from right audio channel |
| | 0 | CHAN0_SEL | 0 | Channel 0 (left) Mapping Control: 0 = Channel 0 takes data from left audio channel 1 = Channel 0 takes data from right audio channel |

DIGITAL MICROPHONE INTERFACE CLOCK RATES

The sample rate of data captured by the digital microphone interface is controlled by the *Stream Format Verb* in the MIC1 widget (NID = 03h). Note that the *Stream Format Verb* in the MIC2 widget (NID = 15h) will echo the values set in the same verb in the MIC1 widget. This is necessary as DMICCLK is shared between the DMICDAT1 and DMICDAT2 pins.

The DMICCLK frequency will output at the rates shown in Table 19, which also contains the required settings for *Base*, *Mult* and *Div* as part of the *Stream Format Verb* of the MIC1 widget to obtain the required sample rate:

| SAMPLE RATE | BASE | MULT[2:0] | DIV[2:0] | DMICCLK FREQUENCY | PROCESSING RATE |
|-------------|------|-----------|----------|-------------------|-----------------|
| 8kHz | 0h | 0h | 5h | 1.024MHz | 128fs |
| 11.025kHz | 1h | 0h | 3h | 1.4112MHz | 128fs |
| 16kHz | 0h | 0h | 2h | 1.024MHz | 64fs |
| 22.05kHz | 1h | 0h | 1h | 1.4112MHz | 64fs |
| 32kHz | 0h | 1h | 2h | 2.048MHz | 64fs |
| 44.1kHz | 1h | 0h | 0h | 2.8224MHz | 64fs |
| 48kHz | 0h | 0h | 0h | 3.072MHz | 64fs |

Table 19 MIC1 Supported Sample Rate Settings for Digital Microphone Interface

Note: Other settings of *Base*, *Mult* and *Div* are reserved and should not be set.

STEREO HEADPHONE PLAYBACK

Stereo headphone playback is supported using the VOUT1L and VOUT1R pins; these provide a ground-referenced stereo output through the DAC1 node. This output is intended for headphones, but can be used as a single-ended line output if required. This path can provide two channels of a multi-channel playback system, operating alongside the other DAC path.

The WM8860 nodes associated with this function are shown in Figure 11.

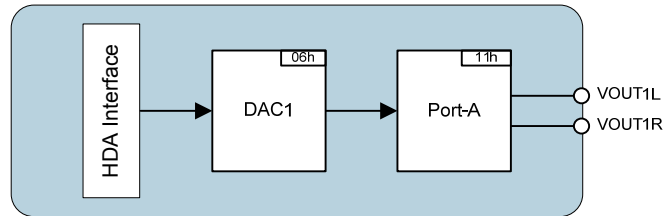


Figure 11 Stereo Headphone Playback Path

This section provides a summary of the DAC1 and Port-A, and describes the vendor-specific verb functions associated with each.

DAC1 (NID = 06H)

Table 20 gives a summary of the DAC1 node:

| NODE SUMMARY INFORMATION | |
|------------------------------|---|
| NID | 06h |
| Widget Type | Audio Converter |
| Supported Get Verbs | Ah, Bh, F00h, F05h, F06h, F08h, F8Eh |
| Supported Set Verbs | 2h, 3h, 705h, 706h, 708h, 78Eh |
| Unsolicited Responses | Stream Error |
| Vendor-Specific Verbs | F8Eh, 78Eh : Unsolicited Response Priority Control Verb |

Table 20 DAC1 Node Summary Information

DAC1 is a high performance stereo DAC that supports all common sample rates from 8kHz to 192kHz and data widths of 16, 20, 24 and 32-bit (Float-32).

The sample rate and word length of the data played back by the DAC1 node is set using the *Stream Format Verb*. Table 9 below shows the required settings for *Base*, *Mult* and *Div* as part of the *Stream Format Verb* to obtain the required sample rate.

| SAMPLE RATE | BASE | MULT | DIV |
|-------------|------|------|-----|
| 8kHz | 0h | 0h | 5h |
| 11.025kHz | 1h | 0h | 3h |
| 16kHz | 0h | 0h | 2h |
| 22.05kHz | 1h | 0h | 1h |
| 24kHz | 0h | 0h | 1h |
| 32kHz | 0h | 1h | 2h |
| 44.1kHz | 1h | 0h | 0h |
| 48kHz | 0h | 0h | 0h |
| 88.2kHz | 1h | 1h | 0h |
| 96kHz | 0h | 1h | 0h |
| 176.4kHz | 1h | 3h | 0h |
| 192kHz | 0h | 3h | 0h |

Table 21 DAC1 Supported Sample Rate Settings

Note: Other settings of *Base*, *Mult* and *Div* are reserved and should not be set.

DAC1 provides digital gain, allowing the signal level to be adjusted between 0dB and -63.5dB in 0.5dB steps. Gain can be applied to left and right channels independently if required. Additionally, a digital softmute function is available – again this can be applied to separate channels as required. The gain of DAC1 is controlled using the *Amplifier Gain/Mute Verb*.

Note: When Port-A is configured to drive headphones (*H-Phn Enable* = 1) the actual gain settings applied will be adjusted by a further -8.0dB. This changes the effective gain range to -71.5dB to -8.0dB.

PORT-A (NID = 11H)

Table 22 gives a summary of the Port-A node:

| NODE SUMMARY INFORMATION | |
|---------------------------------|---|
| NID | 11h |
| Widget Type | Pin Complex |
| Supported Get Verbs | F00h, F02h, F07h, F08h, F09h, F1Ch, <i>F8Eh</i> |
| Supported Set Verbs | 707h, 708h, 709h, 71Ch, 71Dh, 71Eh, 71Fh, <i>78Eh</i> |
| Unsolicited Responses | Presence Detect |
| Vendor-Specific Verbs | F8Eh, 78Eh : Unsolicited Response Priority Control Verb |

Table 22 Port-A Node Summary Information

Port-A contains a ground-referenced headphone driver which negates the requirement for large AC-coupling capacitors commonly required for headphone applications. The headphone driver is powered by an on-board charge pump which generates the required positive and negative supply voltages. Configuration of this block is handled automatically by the WM8860, and the required external components to enable optimum performance of the charge pump are given in the "Applications Information" section.

STEREO LINE PLAYBACK

Stereo line playback is supported using the VOUT2LP, VOUT2LN, VOUT2RP and VOUT2RN pins; these provide a differential stereo output through the DAC2 node. These outputs are intended for line-level loads; the differential configuration provides noise rejection, particularly in the case of lengthy signal tracks. An external differential to single-ended converter should be used for connection to an external stereo jack. This path can provide two channels of a multi-channel playback system, operating alongside the other DAC path.

The WM8860 nodes associated with this function are shown in Figure 12.

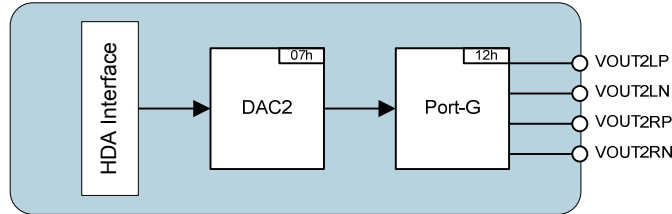


Figure 12 Stereo Differential Line Playback Path

This section provides a summary of the DAC2 and Port-G nodes, and describes the vendor-specific verb functions associated with each.

DAC2 (NID = 07h)

Table 23 gives a summary of the DAC2 node:

| NODE SUMMARY INFORMATION | |
|------------------------------|---|
| NID | 07h |
| Widget Type | Audio Converter |
| Supported Get Verbs | Ah, Bh, F00h, F05h, F06h, F08h, F8Eh |
| Supported Set Verbs | 2h, 3h, 705h, 706h, 708h, 78Eh |
| Unsolicited Responses | Stream Error |
| Vendor-Specific Verbs | F8Eh, 78Eh : Unsolicited Response Priority Control Verb |

Table 23 DAC2 Node Summary Information

DAC2 is a high performance stereo DAC that supports all common sample rates from 8kHz to 192kHz and data widths of 16, 20, 24 and 32-bit (Float-32).

The sample rate and word length of the data played back by the DAC2 node is set using the *Stream Format Verb*. Table 24 below shows the required settings for *Base*, *Mult* and *Div* as part of the *Stream Format Verb* to obtain the required sample rate.

| SAMPLE RATE | BASE | MULT | DIV |
|-------------|------|------|-----|
| 8kHz | 0h | 0h | 5h |
| 11.025kHz | 1h | 0h | 3h |
| 16kHz | 0h | 0h | 2h |
| 22.05kHz | 1h | 0h | 1h |
| 24kHz | 0h | 0h | 1h |
| 32kHz | 0h | 1h | 2h |
| 44.1kHz | 1h | 0h | 0h |
| 48kHz | 0h | 0h | 0h |
| 88.2kHz | 1h | 1h | 0h |
| 96kHz | 0h | 1h | 0h |
| 176.4kHz | 1h | 3h | 0h |
| 192kHz | 0h | 3h | 0h |

Table 24 DAC2 Supported Sample Rate Settings

Note: Other settings of *Base*, *Mult* and *Div* are reserved and should not be set.

DAC2 provides digital gain, allowing the signal level to be adjusted between 0dB and -63.5dB in 0.5dB steps. Gain can be applied to left and right channels independently if required. Additionally, a digital softmute function is available – again this can be applied to separate channels as required. The gain of DAC2 is controlled using the *Amplifier Gain/Mute Verb*.

PORT-G (NID = 12h)

Table 25 gives a summary of the Port-G node:

| NODE SUMMARY INFORMATION | |
|------------------------------|---|
| NID | 12h |
| Widget Type | Pin Complex |
| Supported Get Verbs | F00h, F02h, F07h, F08h, F09h, F1Ch, <i>F8Eh</i> |
| Supported Set Verbs | 707h, 708h, 709h, 71Ch, 71Dh, 71Eh, 71Fh, <i>78Eh</i> |
| Unsolicited Responses | Presence Detect |
| Vendor-Specific Verbs | F8Eh, 78Eh : Unsolicited Response Priority Control Verb |

Table 25 Port-G Node Summary Information

Port-G contains a VMID-referenced differential line driver which requires AC-coupling if driving outputs directly. It is possible to use the output in a single-ended configuration if required; note that this will result in a drop in signal level of 6dB.

If a single-ended output is required, VOUT2LP and VOUT2RP should be used to connect to the load, and VOUT2LN and VOUT2RN should be left unconnected. There is no requirement to change register settings or provide any additional external components to compensate for the unconnected output pins.

S/PDIF TRANSMIT

S/PDIF Transmit functionality is supported using the SPDIFOUT pin; this provides an IEC-60958-3 compatible S/PDIF output through the S/PDIF Tx 1 node.

It is possible to configure the S/PDIF output to select the ADC1, MIC1 or MIC2 nodes as the data source. These signal paths are enabled using vendor-specific verbs, and are illustrated by dotted lines in Figure 13.

The S/PDIF transmitter allows control over the channel status information.

The WM8860 nodes associated with this function are shown in Figure 13.

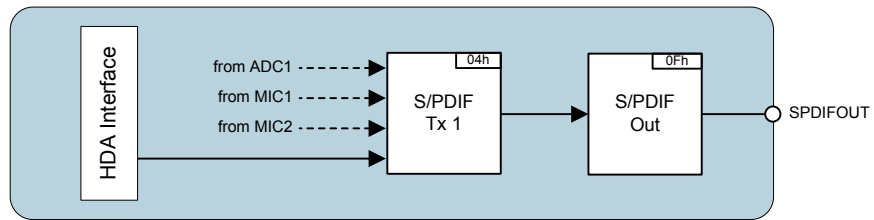


Figure 13 S/PDIF Transmit Paths

This section provides a summary of the S/PDIF Tx 1 and S/PDIF Out nodes, and describes the vendor-specific verb functions associated with each.

S/PDIF TX 1 (NID = 04h)

Table 26 gives a summary of the S/PDIF Tx 1 node:

| NODE SUMMARY INFORMATION | |
|------------------------------|--|
| NID | 04h |
| Widget Type | Audio Output |
| Supported Get Verbs | Ah, F00h, F06h, F08h, F0Dh, F73h, F80h, F81h, F85h, F8Eh |
| Supported Set Verbs | 2h, 706h, 708h, 70Dh, 70Eh, 773h, 780h, 781h, 782h, 783h, 784h, 785h, 78Eh |
| Unsolicited Responses | SRC2 Lock Status Stream Error |
| Vendor-Specific Verbs | F73h, 773h : Internal Path Verb F81h, 781h, 782h, 783h, 784h : Tx Channel Status Control Verb F85h, 785h : Channel Status Data Packing Configuration Verb F8Eh, 78Eh : Unsolicited Response Priority Control Verb |

Table 26 S/PDIF Tx 1 Node Summary Information

The S/PDIF Tx 1 node controls the formatting of the IEC-60958-3 compatible S/PDIF output stream.

Under default conditions, the S/PDIF Tx 1 node will process data received from the HDA interface. In this case, the S/PDIF stream is controlled directly from the Stream Format Verb, as illustrated in Figure 14.

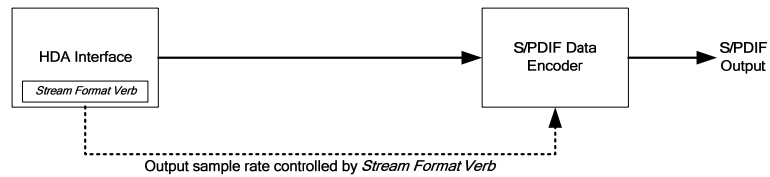


Figure 14 S/PDIF Transmit Function

It is also possible to select ADC1, MIC1 or MIC2 as the data source, using the vendor-specific *Internal Path Verb*.

When ADC1, MIC1 or MIC2 is selected as the input to the S/PDIF Tx 1 node, the *Mult / Base / Div* fields in the *Stream Format Verb* become read-only and are set according to the selected source node.

| SET VERB | BIT | BITFIELD NAME | DEFAULT | DESCRIPTION |
|----------|-----|---------------|---------|---|
| 773h | 7:0 | Path Sel | 00h | Selects the source of the S/PDIF Tx 1 node: 00h = HDA Link 02h = ADC1 03h = MIC1 15h = MIC2 |

The *Digital Converter Verb* is supported by the S/PDIF Tx 1 node, allowing selected channel status information as defined in the HDA Specification to be set. It is also possible to set the remaining bits of channel status data as defined in IEC-60958-3, using the vendor-specific *Tx Channel Status Control Verb*.

| SET VERB | BIT | BITFIELD NAME | DEFAULT | DESCRIPTION |
|----------|-----|------------------------|---------|------------------------------------|
| 784h | 7:4 | Channel Status [39:36] | 0h | Original Sampling Frequency |
| | 3:1 | Channel Status [35:33] | 5h | Sample Word Length |
| | 0 | Channel Status [32] | 1 | Max Word Length |
| 783h | 7:6 | Channel Status [31:30] | 0h | Channel Status [31:30] |
| | 5:4 | Channel Status [29:28] | 0h | Clock Accuracy |
| | 3:0 | Channel Status [27:24] | 1h | Sampling Frequency |
| 782h | 7:4 | Channel Status [23:20] | 0h | Channel Number for Sub-Frame B |
| | 3:0 | Channel Status [23:20] | 0h | Channel Number for Sub-Frame A |
| 781h | 7:4 | Channel Status [19:16] | 0h | Source Number |
| | 3:2 | Channel Status [7:6] | 0h | Channel Status Mode |
| | 1:0 | Channel Status [5:4] | 0h | Additional De-emphasis information |

Notes:

1. See IEC-60958-3 for full definitions of the channel status bits
2. The channel number of Sub-Frame B is uniquely configuration – all other channel status bits in Sub-Frame B have the same value as Sub-Frame A
3. Remaining channel status bits are set using the *Digital Converter Verb* as per the HDA Specification

Under default conditions, the WM8860 will pack the S/PDIF Tx Channel Status Data with the correct values of Sampling Frequency and Sample Word Length automatically, taking into account the various routing options through the chip. This means the Channel Status Data always reflects the same rate as the physical S/PDIF stream.

If required, this behaviour can be disabled using the vendor-specific *Channel Status Data Packing Configuration Verb*. When *CSD_MODE* is set to 0, the S/PDIF Tx Channel Status Data is completely defined using the vendor-specific *Tx Channel Status Control Verb*.

| SET VERB | BIT | BITFIELD NAME | DEFAULT | DESCRIPTION |
|----------|-----|---------------|---------|---|
| 785h | 0 | CSD_MODE | 1 | S/PDIF Transmitter Channel Status Data Packing Mode: 0 = Manual mode: sample rate and data width channel status data packed from data sourced from the <i>Tx Channel Status Control Verb</i> 1 = Automatic mode: sample rate and data width channel status data packed from data sourced from the <i>Stream Verb, S/PDIF Verb</i> |

S/PDIF OUT (NID = 0Fh)

Table 27 gives a summary of the S/PDIF Out node:

| NODE SUMMARY INFORMATION | |
|------------------------------|---|
| NID | 0Fh |
| Widget Type | Pin Complex |
| Supported Get Verbs | F00h, F02h, F07h, F08h, F09h, F1Ch, <i>F8Eh</i> |
| Supported Set Verbs | 707h, 708h, 71Ch, 71Dh, 71Eh, 71Fh, <i>78Eh</i> |
| Unsolicited Responses | Presence Detect |
| Vendor-Specific Verbs | F8Eh, 78Eh : Unsolicited Response Priority Control Verb |

Table 27 S/PDIF Out Node Summary Information

The S/PDIF Out node controls the physical output to the SPDIFOUT pin.

ANCILLARY FUNCTIONS

The WM8860 contains a beep widget suitable for the playback of system beeps to the analogue output widgets.

BEEP (NID = 14h)

Table 28 gives a summary of the Beep node:

| NODE SUMMARY INFORMATION | |
|------------------------------|---------------------------------------|
| NID | 14h |
| Widget Type | Beep Generator |
| Supported Get Verbs | Bh, F00h, F0Ah, F72h |
| Supported Set Verbs | 3h, 70Ah, 772h |
| Unsolicited Responses | Not supported |
| Vendor-Specific Verbs | F72h, 772h : Beep Mask Selection Verb |

Table 28 Beep Node Summary Information

The Beep node controls the system beep sound created by the WM8860. The volume of the beep signal is controlled using the *Amplifier Gain/Mute Verb*. The frequency of the beep signal is controlled using the *Beep Generation Verb*.

The beep signal overrides any sound currently being reproduced in the output path. Under default conditions, the beep is applied to all active outputs simultaneously. It is possible to mask the beep generator output to appear only at specific output nodes using the vendor-specific *Beep Mask Selection Verb*.

| SET VERB | BIT | BITFIELD NAME | DEFAULT | DESCRIPTION |
|----------|-----|------------------|---------|--|
| 772h | 2 | Port-A Beep Mask | 0h | Beep mask enable for Port-A (DAC1) 0h = Beep produced on Port-A 1h = Beep not produced on Port-A |
| | 1 | Port-G Beep Mask | 0h | Beep mask enable for Port-G (DAC2) 0h = Beep produced on Port-G 1h = Beep not produced on Port-G |

AUDIO FUNCTION GROUP (NID = 01h)

Table 29 gives a summary of the Audio Function Group node:

| NODE SUMMARY INFORMATION | |
|------------------------------|---|
| NID | 01h |
| Widget Type | Audio Function Group |
| Supported Get Verbs | F00h, F05h, F08h, F15h, F16h, F17h, F18h, F19h, F1Ah, F20h, F71h, F86h, F8Eh |
| Supported Set Verbs | 7FFh, 705h, 708h, 715h, 716h, 717h, 718h, 719h, 71Ah, 720h, 721h, 722h, 723h, 771h, 786h, 78Eh |
| Unsolicited Responses | GPIO status change |
| Vendor-Specific Verbs | F71h, 771h : VMID Control Verb F86h, 786h : GPIO Automatic Control Verb F8Eh, 78Eh : Unsolicited Response Priority Control Verb |

Table 29 Audio Function Group Node Summary Information

VMID Voltage Reference Control

The analogue circuits in the WM8860 require a mid-rail analogue reference voltage, VMID. This reference is generated from AVDD via a programmable resistor chain. Together with the external VMID decoupling capacitor, the programmable resistor chain determines the charging rate on VMID. The resistor chain is selected using *VMID_SEL*, and can be used to optimise the reference for normal operation, low power standby or for fast start-up.

The VMID charge rate is controlled by *VMID_SEL* and the external VMID capacitor. The *VMID_RATE* field can be used to control the WM8860 power state according to the appropriate VMID conditions. In start-up from power state D4, the WM8860 will not indicate the D3 power state until the time set by *VMID_RATE* has elapsed.

The *VMID_SEL* and *VMID_RATE* fields are part of the *VMID Control Verb*.

| SET VERB | BIT | BITFIELD NAME | DEFAULT | DESCRIPTION |
|----------|-----|---------------|---------|--|
| 771h | 4:2 | VMID_RATE | 2h | Time allocated to charge VMID: 0h = 1024ms 1h = 512ms 2h = 256ms 3h = 128ms 4h = 64ms 5h = 32ms 6h = 16ms 7h = 8ms |
| | 1:0 | VMID_SEL | 2h | VMID String Source Impedance Select: 0h = 12.5kΩ 1h = 75kΩ 2h = 37.5kΩ 3h = 375kΩ Note: These figures give the value of the resistor from AVDD to VMID and from VMID to GND. |

GPIO2 Automatic Control Mode

The *GPIO Automatic Control Verb* controls the behaviour of the GPIO2 pin.

In a system where external speaker amplifiers are connected to the WM8860 the GPIO2 pin may be used to control the enable pin(s) of these amplifiers. For this application, it is possible to automatically configure the GPIO2 pin as an output and to control its logic level as a function of the AFG power state. This function is enabled by setting *GPIO2_AUTO*=1 in the vendor-specific *GPIO Automatic Control Verb*:

| SET VERB | BIT | BITFIELD NAME | DEFAULT | DESCRIPTION |
|----------|-----|---------------|---------|---|
| 786h | 0 | GPIO2_AUTO | 1 | GPIO2 Control Mode: 0 = GPIO2 Manual Mode 1 = GPIO Automatic Control Mode |

The behaviour of GPIO2 when *GPIO2_AUTO*=1 is summarised in Table 30 below. When *GPIO2_AUTO*=0 the behaviour of GPIO2 is as per the standard GPIO verbs.

| AFG PS-Act | GPIO2 Output |
|------------|--------------|
| 0 | Logic 1 |
| 1 | Logic 1 |
| 2 | Logic 0 |
| 3 | Logic 0 |
| 4 | Logic 0 |

Table 30 GPIO2 Automatic Control Mode Summary

Unsolicited Response Priority Control Verb

The *Unsolicited Response Priority Control Verb* is supported by multiple nodes within the WM8860, including the Audio Function Group (AFG) node. This verb allows the Unsolicited Responses associated with each node to be prioritised relative to the other nodes.

The priority level for each node is set using the *Priority* field within the *Unsolicited Response Priority Control Verb*. When more than one Unsolicited Response is awaiting transmission, the node with the lowest *Priority* is placed at the front of the queue. Nodes that have the same *Priority* setting are queued on a 'first to trigger' basis.

Note that the lowest value of *Priority* represents the highest position in the queue.

The *Unsolicited Response Priority Control Verb* is defined as follows.

| SET VERB | BIT | BITFIELD NAME | DEFAULT | DESCRIPTION |
|----------|-----|---------------|---------|---|
| 78Eh | 4:0 | Priority | 00h | Assigns a priority setting for queued Unsolicited Responses. Nodes with the lowest value have the highest priority, and so go to the front of the Unsolicited Response queue. Nodes with the same value for priority are queued on first-to-trigger basis. 00h = Highest priority ... 1Fh = Lowest priority. |

UNSOLICITED RESPONSES

The High Definition Audio Specification provides support for software interrupts to be generated by the CODEC independent of verb commands sent to the CODEC: these are known as Unsolicited Responses. This section defines how the WM8860 creates Unsolicited Responses, explains some of the novel features in the WM8860 to manage them, and what each Unsolicited Response from each node represents. This section assumes familiarity with the High Definition Audio Specification.

GENERATING UNSOLICITED RESPONSES

Unsolicited Responses can only be sent wherever a null response would normally be sent.

Unsolicited Responses are queued on a frame-basis. That is, if an Unsolicited Response is issued in the current frame, it is sent on the next frame containing a null response.

PRIORITY QUEUING

Where more than one Unsolicited Response is awaiting transmission, they are queued such that the Unsolicited Response with the lowest *Priority* value (set using the *Unsolicited Response Priority Control Verb*) is at the front of the queue. Nodes that have the same *Priority* setting are queued on a 'first-to-trigger' basis.

The *Unsolicited Response Priority Control Verb* is described in the "Ancillary Functions" section describing the Audio Function Group node.

IN-QUEUE-UPDATE

The WM8860 stores all flags that trigger an Unsolicited Response. If a node triggers an Unsolicited Response, the Unsolicited Response is queued as described above. Should the same node trigger a second Unsolicited Response (from a different flag within that node) while the first is being queued, the Unsolicited Response is updated to show both flags. This is known as an 'In-Queue-Update'. Should the same node trigger a second Unsolicited Response (from the same flag within the node) while the first is being queued, only one Unsolicited Response is sent for both events.

The concepts of Priority Queuing and In-Queue-Update are illustrated with the example in Figure 15.

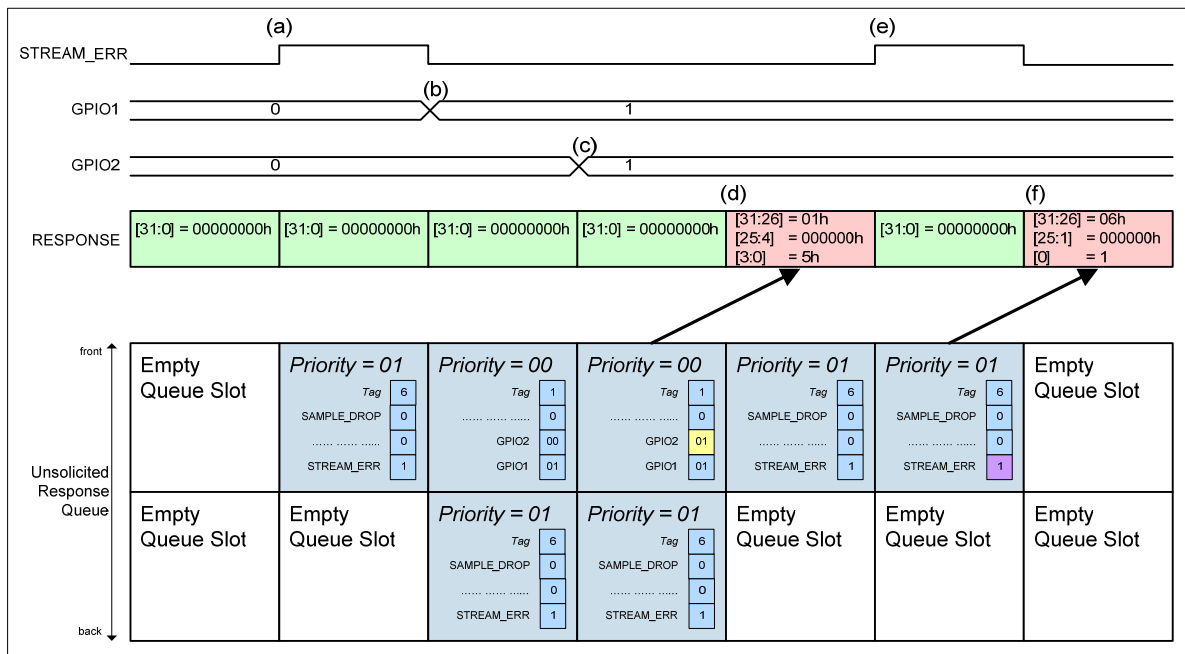


Figure 15 Priority Queuing and In-Queue Updates

- a) STREAM_ERR flag asserts from DAC1 Node (NID = 06h), and an Unsolicited Response (Tag ID = 06h) is queued awaiting a null response slot. STREAM_ERR rescinds at the end of the HDA frame.
- b) GPIO1 input changes to a 1 so the GPIO1 flag (from AFG NID = 01h) asserts and queues an Unsolicited Response (Tag ID = 01h). This Unsolicited Response goes to the front of the queue as its Priority value is lower (indicating higher priority) than the Priority setting of the Unsolicited Response presently at the front of the queue.
- c) GPIO2 input changes to a 1 so the GPIO2 flag asserts. The GPIO2_UPD flag is from the AFG (NID = 01h), and as there is already an Unsolicited Response from this node in the queue, the queued Unsolicited Response is updated to show both events (as highlighted with the yellow box). This is known as an 'In-Queue-Update'.
- d) A slot becomes available for sending an Unsolicited Response, so the AFG Unsolicited Response is transmitted as it is at the front of the queue.
- e) STREAM_ERR asserts from DAC1 Node (NID = 06h). As there is already an Unsolicited Response in the queue from this node, the Unsolicited Response is simply updated (as shown in the purple box). However, the queued Unsolicited Response already shows that there has been a STREAM_ERR flag so the In-Queue-Update does not actually change the Unsolicited Response value.
- f) A slot becomes available for sending an Unsolicited Response, so the Unsolicited Response (Tag ID = 06h) is transmitted.

UNSOLICITED RESPONSE TYPES

There are three types of flags that are returned by the WM8860, prefixed in the register map as follows:

SF = UNSOLICITED RESPONSE STATUS FLAG

Unsolicited Response Status Flags (SF) are used to indicate that there has been a change in flag state, and (where possible) convey what the new state is. A change in state is typically something that will persist for a number of HDA frames. A state change will trigger an Unsolicited Response, but it is possible that a state change can occur more than once while an Unsolicited Response is being queued.

To indicate this, Unsolicited Response Status Flags are 2-bits wide and are encoded as follows:

0h = Flag did not trigger Unsolicited Response.

1h = Rising edge of flag triggered Unsolicited Response.

2h = Falling edge of flag triggered Unsolicited Response.

3h = Rising and falling edges of the flag have been detected while the Unsolicited Response has been queued

When the Unsolicited Response Status Flag is reported as 0h, the user is informed that there has been no change in status. When the Unsolicited Response Status Flag is reported as 1h or 2h, the user is informed that there has been a change in status and what the new status value is. When the Unsolicited Response Status Flag is reported as 3h, the user is informed of a multiple change in status, and the user should read the associated flag's status register to get the current status value of the flag.

UF = UNSOLICITED RESPONSE UPDATE FLAG

Unsolicited Response Update Flags (UF) are used to indicate that there has been one or more changes to the value of some status registers. The status register should be read (through the issue of the appropriate Get command), to see the current register value.

EF = UNSOLICITED RESPONSE EVENT FLAG

Unsolicited Response Event Flags (EF) are used to indicate that an event has occurred during an HDA Frame. The occurrence of an event will trigger an Unsolicited Response.

UNSOLICITED RESPONSE DEFINITIONS

Table 31 gives a summary of the definitions of the Unsolicited Responses from each node in the WM8860. Note that these responses are generated only when the node is set to generate them, using the *Unsolicited Reponse Verb* as defined in the HDA specification.

| NID | NODE NAME | UNSOLICITED RESPONSE | | |
|-----|-----------|----------------------|----------------|---|
| | | BIT | FLAG NAME | DESCRIPTION |
| 01h | AFG | [31:26] | Tag | A software programmable tag value. The default value is equal to the Node ID. Other values can be configured using the Unsolicited Response Verb. |
| | | [25:4] | Rsvd | Reserved |
| | | [3:2] | SF_GPIO2 | Indicates that the value on GPIO2 (configured as an input) has changed, and reports new status value. When the AFG is in power state D0, D1 or D2, a change in GPIO status triggers an Unsolicited Response. When the AFG is in power state D3, a change in GPIO status triggers a power state change request. Note that the status value is also accessible through the <i>Get GPIO Data Verb</i> . |
| | | [1:0] | SF_GPIO1 | Indicates that the value on GPIO1 (configured as an input) has changed, and reports new status value. When the AFG is in power state D0, D1 or D2, a change in GPIO status triggers an Unsolicited Response. When the AFG is in power state D3, a change in GPIO status triggers a power state change request. Note that the status value is also accessible through the <i>Get GPIO Data Verb</i> . |
| 02h | ADC1 | [31:26] | Tag | A software programmable tag value. The default value is equal to the Node ID. Other values can be configured using the Unsolicited Response Verb. |
| | | [25:1] | Rsvd | Reserved |
| | | [0] | EF_STREAM_DROP | Indicates that the stream associated with the ADC1 node has been dropped due to the bandwidth of the SDI line being oversubscribed. Assertion of the flag triggers an Unsolicited Response. The flag is cleared when the <i>Stream ID</i> is written to. |
| 03h | MIC1 | [31:26] | Tag | A software programmable tag value. The default value is equal to the Node ID. Other values can be configured using the Unsolicited Response Verb. |
| | | [25:1] | Rsvd | Reserved |
| | | [0] | EF_STREAM_DROP | Indicates that the stream associated with the MIC1 node has been dropped due to the bandwidth of the SDI line being oversubscribed. Assertion of the flag triggers an Unsolicited Response. The flag is cleared when the <i>Stream ID</i> is written to. |

| NID | NODE NAME | UNSOLICITED RESPONSE | | |
|-----|-------------|----------------------|---------------|--|
| | | BIT | FLAG NAME | DESCRIPTION |
| 04h | S/PDIF TX 1 | [31:26] | Tag | A software programmable tag value. The default value is equal to the Node ID. Other values can be configured using the Unsolicited Response Verb. |
| | | [25:3] | Rsvd | Reserved |
| | | [2] | EF_STREAM_ERR | Indicates that an error has occurred in the transfer of data from the HDA Link to the Stream Manager. Assertion of the flag triggers an Unsolicited Response. The flag rescinds at the end of the present HDA frame. |
| | | [1:0] | SF_SRC2 | Indicates that the lock status of SRC2 has changed, and reports the new lock status. A change in status triggers an Unsolicited Response. The status value is also accessible through the <i>Get SRC Verb</i> . |
| 06h | DAC1 | [31:26] | Tag | A software programmable tag value. The default value is equal to the Node ID. Other values can be configured using the Unsolicited Response Verb. |
| | | [25:1] | Rsvd | Reserved |
| | | [0] | EF_STREAM_ERR | Indicates that an error has occurred in the transfer of data from the HDA Link to the Stream Manager. Assertion of the flag triggers an Unsolicited Response. The flag is cleared at the end of the present HDA frame. |
| 07h | DAC2 | [31:26] | Tag | A software programmable tag value. The default value is equal to the Node ID. Other values can be configured using the Unsolicited Response Verb. |
| | | [25:1] | Rsvd | Reserved |
| | | [0] | EF_STREAM_ERR | Indicates that an error has occurred in the transfer of data from the HDA Link to the Stream Manager. Assertion of the flag triggers an Unsolicited Response. The flag is cleared at the end of the present HDA frame. |

| NID | NODE NAME | UNSOLICITED RESPONSE | | |
|-----|------------|----------------------|-----------|--|
| | | BIT | FLAG NAME | DESCRIPTION |
| 0Ch | Port-E | [31:26] | Tag | A software programmable tag value. The default value is equal to the Node ID. Other values can be configured using the Unsolicited Response Verb. |
| | | [25:2] | Rsvd | Reserved |
| | | [1:0] | SF_PD | Indicates that the Presence Detect value (in the <i>Pin Sense Verb</i>) has changed. A change in status triggers an Unsolicited Response (when the AFG is in power state D0, D1, D2) or it triggers a power state change request (when the AFG is in power state D3). The status value is also accessible through the <i>Get Pin Sense Verb</i> . |
| 0Dh | Port-B | [31:26] | Tag | A software programmable tag value. The default value is equal to the Node ID. Other values can be configured using the Unsolicited Response Verb. |
| | | [25:3] | Rsvd | Reserved |
| | | [2] | EF_IMP | Indicates that the Impedance Sense value is ready. Assertion of the flag triggers an Unsolicited Response. The flag is cleared on an issue of a <i>Get Pin Sense Verb</i> . |
| | | [1:0] | SF_PD | Indicates that the Presence Detect value (in the <i>Pin Sense Verb</i>) has changed. A change in status triggers an Unsolicited Response (when the AFG is in power state D0, D1, D2) or it triggers a power state change request (when the AFG is in power state D3). The status value is also accessible through the <i>Get Pin Sense Verb</i> . |
| 0Fh | S/PDIF Out | [31:26] | Tag | A software programmable tag value. The default value is equal to the Node ID. Other values can be configured using the Unsolicited Response Verb. |
| | | [25:2] | Rsvd | Reserved |
| | | [1:0] | SF_PD | Indicates that the Presence Detect value (in the <i>Pin Sense Verb</i>) has changed. A change in status triggers an Unsolicited Response (when the AFG is in power state D0, D1, D2) or it triggers a power state change request (when the AFG is in power state D3). The status value is also accessible through the <i>Get Pin Sense Verb</i> . |
| 11h | Port-A | [31:26] | Tag | A software programmable tag value. The default value is equal to the Node ID. Other values can be configured using the Unsolicited Response Verb. |
| | | [25:2] | Rsvd | Reserved |
| | | [1:0] | SF_PD | Indicates that the Presence Detect value (in the <i>Pin Sense Verb</i>) has changed. A change in status triggers an Unsolicited Response (when the AFG is in power state D0, D1, D2) or it triggers a power state change request (when the AFG is in power state D3). The status value is also accessible through the <i>Get Pin Sense Verb</i> . |

| NID | NODE NAME | UNSOLICITED RESPONSE | | |
|-----|-----------|----------------------|----------------|--|
| | | BIT | FLAG NAME | DESCRIPTION |
| 12h | Port-G | [31:26] | Tag | A software programmable tag value. The default value is equal to the Node ID. Other values can be configured using the Unsolicited Response Verb. |
| | | [25:2] | Rsvd | Reserved |
| | | [1:0] | SF_PD | Indicates that the Presence Detect value (in the <i>Pin Sense Verb</i>) has changed. A change in status triggers an Unsolicited Response (when the AFG is in power state D0, D1, D2) or it triggers a power state change request (when the AFG is in power state D3). The status value is also accessible through the <i>Get Pin Sense Verb</i> . |
| 15h | MIC2 | [31:26] | Tag | A software programmable tag value. The default value is equal to the Node ID. Other values can be configured using the Unsolicited Response Verb. |
| | | [25:1] | Rsvd | Reserved |
| | | [0] | EF_STREAM_DROP | Indicates that the stream associated with the MIC2 node has been dropped due to the bandwidth of the SDI line being oversubscribed. Assertion of the flag triggers an Unsolicited Response. The flag is cleared when the <i>Stream ID</i> is written to. |

Table 31 Unsolicited Response Summary

DETAILED VERB DESCRIPTIONS

This section provides full verb information on each node in the WM8860. For verbs defined as part of the High Definition Audio Specification Revision 1.0 this is the only information provided. For vendor-specific verbs, more detailed explanation of the function is provided in the main text of the datasheet above.

ROOT NODE (NID = 00H)

| | Verb ID | Payload [7:0] | Response[31:0] |
|-----|---------|--------------------|-----------------|
| Get | F00h | Parameter ID (PID) | Parameter Value |

Vendor ID Response Format (PID = 00h)

| Bit | Bitfield Name | RW | Default | Description |
|---------|---------------|----|---------|--------------------|
| [31:16] | Vendor ID | R | 1AECh | Vendor ID |
| [15:0] | Device ID | R | 8800h | Device ID = WM8800 |

Revision ID Response Format (PID = 02h)

| Bit | Bitfield Name | RW | Default | Description |
|---------|---------------|----|---------|--|
| [31:24] | Rsvd | R | 00h | Reserved |
| [23:20] | MajRev | R | 1h | Major revision number (left of the decimal) of the HDA Specification to which the WM8860 is fully compliant |
| [19:16] | MinRev | R | 0h | Minor revision number (right of the decimal) of the HDA Specification to which the WM8860 is fully compliant |
| [15:8] | Revision ID | R | - | Wolfson's revision number for this device |
| [7:0] | Stepping ID | R | - | Optional stepping number within the Revision ID |

Subordinate Node Count Response Format (PID = 04h)

| Bit | Bitfield Name | RW | Default | Description |
|---------|---------------|----|---------|--|
| [31:24] | Rsvd | R | 00h | Reserved |
| [23:16] | Starting NID | R | 01h | Starting NID of the first function group |
| [15:8] | Rsvd | R | 00h | Reserved |
| [7:0] | Total Nodes | R | 1h | Total number of function group nodes |

AUDIO FUNCTION GROUP (NID = 01H)**FUNCTION RESET VERB**

| | Verb ID | Payload [7:0] | Response[31:0] |
|----------------|---------|---------------|----------------|
| Execute | 7FFh | 00h | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|-------|---------------|----|---------|---|
| [7:0] | Reset | W | 00h | AFG reset. 00h = AFG and all widget nodes associated with the AFG will reset to default values. The WM8860 will issue a response and then be ready to accept commands in the frame following the valid response. Note: The <i>Implementation ID/Subsystem ID Verb</i> and the <i>Configuration Default Verb</i> will not be reset using this verb. |

GET PARAMETER VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|--------------------|-----------------|
| Get | F00h | Parameter ID (PID) | Parameter Value |

Subordinate Node Count Response Format (PID = 04h)

| Bit | Bitfield Name | RW | Default | Description |
|---------|---------------|----|---------|---|
| [31:24] | Rsvd | R | 00h | Reserved |
| [23:16] | Starting NID | R | 02h | Starting NID of the first widget in the AFG |
| [15:8] | Rsvd | R | 00h | Reserved |
| [7:0] | Total Nodes | R | 16h | Total number of widget nodes within the AFG |

Function Group Type Response Format (PID = 05h)

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|---------|---|
| [31:9] | Rsvd | R | 000000h | Reserved |
| [8] | Unsol | R | 1 | The AFG Node is capable of generating Unsolicited Responses |
| [7:0] | Node Type | R | 01h | Node Type is Audio Function Group |

Audio Function Group Capabilities Response Format (PID = 08h)

| Bit | Bitfield Name | RW | Default | Description |
|---------|---------------|----|---------|-----------------------------------|
| [31:17] | Rsvd | R | 0000h | Reserved |
| [16] | Beep Gen | R | 1 | Beep Generator Widget present |
| [15:12] | Rsvd | R | 00h | Reserved |
| [11:8] | Input Delay | R | 8h | Number of samples of input delay |
| [7:4] | Rsvd | R | 00h | Reserved |
| [3:0] | Output Delay | R | 8h | Number of samples of output delay |

Input Amplifier Capabilities Response Format (PID = 0Dh)

| Bit | Bitfield Name | RW | Default | Description |
|---------|---------------|----|---------|--|
| [31] | Mute Capable | R | 0 | Microphone preamplifiers are not capable of muting |
| [30:23] | Rsvd | R | 00h | Reserved |
| [22:16] | Step Size | R | 27h | Gain step size is 10dB |
| [15] | Rsvd | R | 0 | Reserved |
| [14:8] | Num Steps | R | 03h | Number of steps in gain range is 4 (0dB to +30dB) |
| [7] | Rsvd | R | 0 | Reserved |
| [6:0] | Offset | R | 0h | The step number that 0dB corresponds to is 0 |

Output Amplifier Capabilities Response Format (PID = 12h)

| Bit | Bitfield Name | RW | Default | Description |
|---------|---------------|----|---------|---|
| [31] | Mute Capable | R | 1 | DAC Volume control is capable of muting |
| [30:23] | Rsvd | R | 0000h | Reserved |
| [22:16] | Step Size | R | 01h | Gain step size is 0.5dB |
| [15] | Rsvd | R | 0 | Reserved |
| [14:8] | Num Steps | R | 7Fh | Number of steps in gain range is 128 (0dB to -63.5dB) |
| [7] | Rsvd | R | 0 | Reserved |
| [6:0] | Offset | R | 7Fh | The step number that 0dB corresponds to is 7Fh |

Supported Power States Response Format (PID = 0Fh)

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|----------|--|
| [31] | EPSS | R | 0 | EPSS not supported |
| [30] | CLKSTOP | R | 1 | Indicates that the link BCLK can be stopped when the WM8860 is in power state D3. The WM8860 will still perform jack detection and issue a wake the Presence Detect value of a node (in its <i>Pin Sense Verb</i>) has changed. Note: The <i>Power State Verb</i> for the AFG should be queried before actually stopping BCLK to ensure it is acceptable to do so |
| [29:5] | Rsvd | R | 0000000h | Reserved |
| [4] | D4Sup | R | 1 | D4 Power State supported |
| [3] | D3Sup | R | 1 | D3 Power State supported |
| [2] | D2Sup | R | 1 | D2 Power State supported |
| [1] | D1sup | R | 1 | D1 Power State supported |
| [0] | D0Sup | R | 1 | D0 Power State supported |

GPIO Count Response Format (PID = 11h)

| Bit | Bitfield Name | RW | Default | Description |
|---------|---------------|----|---------|---|
| [31] | GPIO Wake | R | 1 | Indicates that a GPIO configured as an input can cause a wake (i.e. generate a Status Change event on the HDA Link) |
| [30] | GPIO Unsol | R | 1 | Indicates that a GPIO configured as an input can cause an Unsolicited Response to be generated |
| [29:24] | Rsvd | R | 00h | Reserved |
| [23:16] | Num GPIs | R | 00h | Device does not support any GPI pins |
| [15:8] | Num GPOs | R | 00h | Device does not support any GPO pins |
| [7:0] | Num GPIOs | R | 02h | Device supports 2 GPIO pins |

POWER STATE VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F05h | 00h | Bits [31:0] in the table below |
| Set | 705h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|---------|---------------|----|---------|---|
| [31:10] | Rsvd | R | 000000h | Reserved |
| [9] | PS-ClkStopOK | R | 0 | Applicable when the AFG is in power state D3: 0 = BCLK must be kept running 1 = It is OK to stop BCLK |
| [8] | Rsvd | R | 0 | Reserved |
| [7:4] | PS-Act | R | 2h | Indicates the actual power state of the AFG node: 0h = D0 1h = D1 2h = D2 3h = D3 4h = D4 The power state of the AFG is controlled by <i>PS-Set</i> below. For the AFG, <i>PS-Act</i> will equal <i>PS-Set</i> (offset by the time required to execute a power state transition). |
| [3:0] | PS-Set | RW | 2h | Sets the power state of the AFG node: 0h = D0 1h = D1 2h = D2 3h = D3 4h = D4 |

Note: If the Link is operational, but the AFG is in power state D4, only Get Commands, Set Power State or AFG Reset commands are executed – all other commands are ignored. In this scenario, the SDI line is inactive and does not transmit responses, tags or data.

UNSOLICITED RESPONSE VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F08h | 00h | Bits [31:0] in the table below |
| Set | 708h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|---------|---|
| [31:8] | Rsvd | R | 000000h | Reserved |
| [7] | Enable | RW | 0 | 0 = Unsolicited Responses disabled for this node 1 = Unsolicited Responses enabled for this node |
| [6] | Rsvd | R | 0 | Reserved |
| [5:0] | Tag | RW | 01h | A software programmable tag value that is returned in the top six bits (31:26) of every Unsolicited Response from this node. The default for <i>Tag</i> is equal to the Node ID. |

Note: The Unsolicited Response for the AFG node is defined in the "Unsolicited Responses" section.

GPIO DATA VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F15h | 00h | Bits [31:0] in the table below |
| Set | 715h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|-----------|---|
| [31:2] | Rsvd | R | 00000000h | Reserved |
| [1] | Data[1] | RW | 0 | Sets and returns data associated with the GPIO2 pin |
| [0] | Data[0] | RW | 0 | Sets and returns data associated with the GPIO1 pin |

GPIO ENABLE MASK VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F16h | 00h | Bits [31:0] in the table below |
| Set | 716h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|-----------|--|
| [31:2] | Rsvd | R | 00000000h | Reserved |
| [1] | Enable[1] | RW | 0 | 0 = GPIO2 pin disabled (Hi-Z) 1 = GPIO2 pin enabled |
| [0] | Enable[0] | RW | 0 | 0 = GPIO1 pin disabled (Hi-Z) 1 = GPIO1 pin enabled |

GPIO DIRECTION VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F17h | 00h | Bits [31:0] in the table below |
| Set | 717h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|-----------|---|
| [31:2] | Rsvd | R | 00000000h | Reserved |
| [1] | Control[1] | RW | 0 | 0 = GPIO2 pin is an input 1 = GPIO2 pin is an output |
| [0] | Control[0] | RW | 0 | 0 = GPIO1 pin is an input 1 = GPIO1 pin is an output |

GPIO WAKE ENABLE MASK VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F18h | 00h | Bits [31:0] in the table below |
| Set | 718h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|-----------|---|
| [31:2] | Rsvd | R | 00000000h | Reserved |
| [1] | Wake[1] | RW | 0 | 0 = GPIO2 wake disabled 1 = GPIO2 wake enabled Note: Applies only if GPIO2 is configured as an input |
| [0] | Wake[0] | RW | 0 | 0 = GPIO1 wake disabled 1 = GPIO1 wake enabled Note: Applies only if GPIO1 is configured as an input |

GPIO UNSOLICITED ENABLE MASK VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F19h | 00h | Bits [31:0] in the table below |
| Set | 719h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|----------------|----|-----------|---|
| [31:2] | Rsvd | R | 00000000h | Reserved |
| [1] | UnsolEnable[1] | RW | 0 | 0 = GPIO2 cannot generate an Unsolicited Response 1 = GPIO2 can generate an Unsolicited Response Note: Applies only if GPIO2 is configured as an input |
| [0] | UnsolEnable[0] | RW | 0 | 0 = GPIO1 cannot generate an Unsolicited Response 1 = GPIO1 can generate an Unsolicited Response Note: Applies only if GPIO1 is configured as an input |

GPIO STICKY MASK VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F1Ah | 00h | Bits [31:0] in the table below |
| Set | 71Ah | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|-----------|---|
| [31:2] | Rsvd | R | 00000000h | Reserved |
| [1] | Data[1] | RW | 0 | 0 = GPIO2 is non-sticky (level sensitive) 1 = GPIO2 is sticky (edge-sensitive) Note: Applies only if GPIO2 is configured as an input |
| [0] | Data[0] | RW | 0 | 0 = GPIO1 is non-sticky (level sensitive) 1 = GPIO1 is sticky (edge-sensitive) Note: Applies only if GPIO1 is configured as an input |

IMPLEMENTATION ID / SUBSYSTEM ID VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|-------------|---------|--------------------------|--------------------------------|
| Get | F20h | 00h | Bits [31:0] in the table below |
| Set1 | 720h | Implementation ID[7:0] | 00h |
| Set2 | 721h | Implementation ID[15:8] | 00h |
| Set3 | 722h | Implementation ID[23:16] | 00h |
| Set4 | 723h | Implementation ID[31:24] | 00h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|-------------------|----|-----------|-------------------|
| [31:0] | Implementation ID | RW | 00000100h | Implementation ID |

Note: The *Implementation ID / Subsystem ID Verb* is not reset to its default value during a reset from any source. The settings are only lost when digital power is removed from the WM8860. When digital power is restored, the System BIOS must restore the settings.

VMID CONTROL VERB (VENDOR SPECIFIC)

| | Verb ID | Payload [7:0] | Response[31:0] |
|-----|---------|-------------------------------|--------------------------------|
| Get | F71h | 00h | Bits [31:0] in the table below |
| Set | 771h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|----------|--|
| [31:6] | Rsvd | R | 0000000h | Reserved |
| [4:2] | VMID_RATE | RW | 2h | Time allocated to charge VMID: 0h = 1024ms 1h = 512ms 2h = 256ms 3h = 128ms 4h = 64ms 5h = 32ms 6h = 16ms 7h = 8ms |
| [1:0] | VMID_SEL | RW | 2h | VMID String Source Impedance Select: 0h = 12.5k Ω 1h = 75k Ω 2h = 37.5k Ω 3h = 375k Ω Note: These figures give the value of the resistor from AVDD to VMID and from VMID to GND. |

GPIO AUTOMATIC CONTROL VERB (VENDOR-SPECIFIC)

| | Verb ID | Payload [7:0] | Response[31:0] |
|-----|---------|-------------------------------|--------------------------------|
| Get | F86h | 00h | Bits [31:0] in the table below |
| Set | 786h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|----------|---|
| [31:1] | Rsvd | R | 0000000h | Reserved |
| [0] | GPIO2_AUTO | RW | 1 | GPIO2 Control Mode: 0 = GPIO2 Manual Mode GPIO2 is controlled manually via the standard AFG verbs 1 = GPIO Automatic Control Mode GPIO2 is always an output and forced high when PS-Act of AFG is D1 or D0. GPIO2 is forced low when PS-Act of AFG is D2, D3 or D4. |

UNSOLICITED RESPONSE PRIORITY CONTROL VERB (VENDOR-SPECIFIC)

| | Verb ID | Payload [7:0] | Response[31:0] |
|-----|---------|-------------------------------|--------------------------------|
| Get | F8Eh | 00h | Bits [31:0] in the table below |
| Set | 78Eh | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|----------|---|
| [31:5] | Rsvd | R | 0000000h | Reserved |
| [4:0] | Priority | RW | 00h | Assigns a priority setting for queued Unsolicited Responses. Nodes with the lowest value have the highest priority, and so go to the front of the Unsolicited Response queue. Nodes with the same value for priority are queued on first-to-trigger basis. 00h = Highest priority ... 1Fh = Lowest priority. |

ADC1 AUDIO INPUT CONVERTER WIDGET (NID = 02H)**STREAM FORMAT VERB**

| | Verb ID | Payload [15:0] | Response[31:0] |
|------------|---------|--------------------------------|--------------------------------|
| Get | Ah | 0000h | Bits [31:0] in the table below |
| Set | 2h | Bits [15:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|---------|---------------|----|---------|---|
| [31:16] | Rsvd | R | 0000h | Reserved |
| [15] | Type | R | 0 | Indicates the widget supports only PCM streams |
| [14] | Base | RW | 0 | Used to set the base rate frequency: 0 = 48 kHz 1 = 44.1 kHz |
| [13:11] | Mult | RW | 0h | Used to set the base rate multiplication factor: 0h = x1 (48kHz, 44.1kHz or less) 1h = x2 (96kHz, 88.2kHz, 32kHz) 2h-7h = Reserved |
| [10:8] | Div | RW | 0h | Used to set the base rate division factor: 0h = divide by 1 (48kHz, 44.1kHz) 1h = divide by 2 (22.05kHz) 2h = divide by 3 (16kHz, 32kHz) 3h = divide by 4 (11.025kHz) 4h = Reserved 5h = divide by 6 (8kHz) 6h = Reserved 7h = Reserved |
| [7] | Rsvd | R | 0 | Reserved |
| [6:4] | Bits | RW | 3h | Bits per Sample: 0h = Reserved 1h = 16 bits 2h = 20 bits 3h = 24 bits 4h = 32 bits (Float 32) 5h-7h = Reserved |
| [3:0] | Chan | RW | 1h | Number of Channels in each frame of the stream: 0h = 1 channel 1h = 2 channels 2h-Fh = reserved |

GET PARAMETER VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|-----|---------|--------------------|-----------------|
| Get | F00h | Parameter ID (PID) | Parameter Value |

Audio Widget Capabilities Parameter (PID = 09h)

| Bit | Bitfield Name | RW | Default | Description |
|---------|------------------------|----|---------|--|
| [31:24] | Rsvd | R | 00h | Reserved |
| [23:20] | Type | R | 1h | Indicates that this is an Audio Input Widget |
| [19:16] | Delay | R | 0h | Latency not reported |
| [15:12] | Rsvd | R | 0h | Reserved |
| [11] | L-R Swap | R | 0 | Left/Right swap capability not supported |
| [10] | PowerCntrl | R | 1 | Indicates that the <i>Power State Verb</i> is supported in this widget |
| [9] | Digital | R | 0 | Indicates that this widget is translating analogue data |
| [8] | Conn List | R | 1 | Indicates that a connection list is present |
| [7] | Unsol Capable | R | 1 | Widget supports Unsolicited Responses |
| [6] | ProcWidget | R | 1 | Widget has processing capabilities (i.e high pass filter) |
| [5] | Stripe | R | 0 | Widget does not support striping |
| [4] | Format Override | R | 1 | Widget has a subset of the supported rates defined for the AFG |
| [3] | Amp Parameter Override | R | 0 | Not applicable as this widget does not have amplifier capabilities |
| [2] | Out Amp Present | R | 0 | Output amplifier not present in this widget |
| [1] | In Amp Present | R | 0 | Input amplifier not present in this widget |
| [0] | Stereo | R | 1 | Indicates that this is a stereo widget |

Supported Rates Parameter (PID = 0Ah)

| Bit | Bitfield Name | RW | Default | Description |
|---------|---------------|----|---------|---|
| [31:21] | Rsvd | R | 000h | Reserved |
| [20] | B32 | R | 1 | ADC1 supports 32-bit audio format |
| [19] | B24 | R | 1 | ADC1 supports 24-bit audio format |
| [18] | B20 | R | 1 | ADC1 supports 20-bit audio format |
| [17] | B16 | R | 1 | ADC1 supports 16-bit audio format |
| [16] | B8 | R | 0 | ADC1 does not support 8-bit audio format |
| [15:12] | Rsvd | R | 0h | Reserved |
| [11] | R12 | R | 0 | ADC1 does not support 384 kHz sample rate |
| [10] | R11 | R | 0 | ADC1 does not support 192 kHz sample rate |
| [9] | R10 | R | 0 | ADC1 does not support 176.4 kHz sample rate |
| [8] | R9 | R | 1 | ADC1 supports 96 kHz sample rate |
| [7] | R8 | R | 1 | ADC1 supports 88.2 kHz sample rate |
| [6] | R7 | R | 1 | ADC1 supports 48 kHz sample rate |
| [5] | R6 | R | 1 | ADC1 supports 44.1 kHz sample rate |
| [4] | R5 | R | 1 | ADC1 supports 32 kHz sample rate |
| [3] | R4 | R | 1 | ADC1 supports 22.05 kHz sample rate |
| [2] | R3 | R | 1 | ADC1 supports 16 kHz sample rate |
| [1] | R2 | R | 1 | ADC1 supports 11.025 kHz sample rate |
| [0] | R1 | R | 1 | ADC1 supports 8 kHz sample rate |

Supported Stream Formats Parameter (PID = 0Bh)

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|-----------|--|
| [31:3] | Rsvd | R | 00000000h | Reserved |
| [2] | AC3 | R | 0 | ADC1 does not support Dolby AC3 formatted data |
| [1] | Float32 | R | 1 | ADC1 supports Float32 formatted data |
| [0] | PCM | R | 1 | ADC1 supports PCM formatted data |

Connection List Length Parameter (PID = 0Eh)

| Bit | Bitfield Name | RW | Default | Description |
|--------|------------------------|----|----------|--|
| [31:8] | Rsvd | R | 0000000h | Reserved |
| [7] | Long Form | R | 0 | Indicates that the connection list items are in short form |
| [6:0] | Connection List Length | R | 01h | Indicates that there is 1 NID entry in the connection list |

Supported Power States Parameter (PID = 0Fh)

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|----------|--------------------------|
| [31:4] | Rsvd | R | 0000000h | Reserved |
| [3] | D3Sup | R | 1 | D3 power state supported |
| [2] | D2Sup | R | 1 | D2 power state supported |
| [1] | D1sup | R | 1 | D1 power state supported |
| [0] | D0Sup | R | 1 | D0 power state supported |

Processing Capabilities Parameter (PID = 10h)

| Bit | Bitfield Name | RW | Default | Description |
|---------|---------------|----|---------|--|
| [31:16] | Rsvd | R | 0000h | Reserved |
| [15:8] | NumCoeff | R | 00h | This widget does not support loadable coefficients |
| [7:1] | Rsvd | R | 00h | Reserved |
| [0] | Benign | R | 0 | The "Processing Benign State" is not supported |

GET CONNECTION LIST ENTRY VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|---------------|--------------------------------|
| Get | F02h | 00h | Bits [31:0] in the table below |

| Bit | Bitfield Name | RW | Default | Description |
|---------|-------------------|----|---------|--|
| [31:24] | Conn List Entry 3 | R | 00h | Unused connection list entry |
| [23:16] | Conn List Entry 2 | R | 00h | Unused connection list entry |
| [15:8] | Conn List Entry 1 | R | 00h | Unused connection list entry |
| [7:0] | Conn List Entry 0 | R | 0Ah | Indicates that the ADC1 widget node connects to the PGA1 widget node (NID = 0Ah) |

PROCESSING STATE VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F03h | 00h | Bits [31:0] in the table below |
| Set | 703h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|------------------|----|---------|---|
| [31:8] | Rsvd | R | 000000h | Reserved |
| [7:0] | Processing State | RW | 01h | The processing block is the high-pass filter (HPF). The processing state is controlled as follows: 00h = Processing Off: HPF disabled 01h = Processing On: HPF enabled 02h = Processing Off: HPF disabled (benign not supported) 03h-7Fh = Reserved 80h-FFh = Vendor Specific – not used |

POWER STATE VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F05h | 00h | Bits [31:0] in the table below |
| Set | 705h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|---------|--|
| [31:8] | Rsvd | R | 000000h | Reserved |
| [7:4] | PS-Act | R | 3h | Indicates the actual power state of the ADC1 widget node: 0h = D0 1h = D1 2h = D2 3h = D3 Note: The power state of the ADC1 widget node is controlled by <i>PS-Set</i> below, however the control may be superseded by the <i>PS-Set</i> of the AFG widget node. |
| [3:0] | PS-Set | RW | 3h | Sets the power state of the ADC1 widget node: 0h = D0 1h = D1 2h = D2 3h = D3 |

CONVERTER STREAM, CHANNEL VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F06h | 00h | Bits [31:0] in the table below |
| Set | 706h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|---------|---|
| [31:8] | Rsvd | R | 000000h | Reserved |
| [7:4] | Stream | RW | 0h | Stream ID used by this widget. Note that Stream ID = 0h is used to indicate an unused stream, and converters will not transfer/receive link data for streams with an ID of 0. |
| [3:0] | Channel | RW | 0h | Lowest channel number used by this widget. Note: as this widget does not support multi-channel capture, only a setting of 0h is applicable. |

UNSOLICITED RESPONSE VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F08h | 00h | Bits [31:0] in the table below |
| Set | 708h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|---------|---|
| [31:8] | Rsvd | R | 000000h | Reserved |
| [7] | Enable | RW | 0 | 0 = Unsolicited Responses disabled for this node 1 = Unsolicited Responses enabled for this node |
| [6] | Rsvd | R | 0 | Reserved |
| [5:0] | Tag | RW | 02h | A software programmable tag value that is returned in the top six bits (31:26) of every Unsolicited Response from this node. The default for <i>Tag</i> is equal to the Node ID. |

Note: The Unsolicited Response for the AFG node is defined in the “Unsolicited Responses” section.

UNSOLICITED RESPONSE PRIORITY CONTROL VERB (VENDOR-SPECIFIC)

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F8Eh | 00h | Bits [31:0] in the table below |
| Set | 78Eh | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|----------|--|
| [31:5] | Rsvd | R | 0000000h | Reserved |
| [4:0] | Priority | RW | 00h | Assigns a priority setting for queued Unsolicited Responses. Nodes with the lowest value have the highest priority, and so go to the front of the Unsolicited Response queue. Nodes with the same value for priority are queued on first-to-trigger basis. 00h = Highest priority ... 1Fh = Lowest priority |

CHANNEL COPY VERB (VENDOR-SPECIFIC)

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | FB1h | 00h | Bits [31:0] in the table below |
| Set | 7B1h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|-----------|---|
| [31:2] | Rsvd | R | 00000000h | Reserved |
| [1] | CHAN1_SEL | RW | 1 | Channel 1 (right) Mapping Control: 0 = Channel 1 takes data from left audio channel 1 = Channel 1 takes data from right audio channel |
| [0] | CHAN0_SEL | RW | 0 | Channel 0 (left) Mapping Control: 0 = Channel 0 takes data from left audio channel 1 = Channel 0 takes data from right audio channel |

MIC1 AUDIO INPUT CONVERTER WIDGET (NID = 03H)**STREAM FORMAT VERB**

| | Verb ID | Payload [15:0] | Response[31:0] |
|------------|---------|--------------------------------|--------------------------------|
| Get | Ah | 0000h | Bits [31:0] in the table below |
| Set | 2h | Bits [15:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|---------|---------------|----|---------|--|
| [31:16] | Rsvd | R | 0000h | Reserved |
| [15] | Type | R | 0 | Indicates the widget supports only PCM streams |
| [14] | Base | RW | 0 | Used to set the base rate frequency: 0 = 48 kHz 1 = 44.1 kHz |
| [13:11] | Mult | RW | 0h | Used to set the base rate multiplication factor: 0h = x1 (48kHz, 44.1kHz or less) 1h = x2 (32kHz) 2h-7h = Reserved |
| [10:8] | Div | RW | 0h | Used to set the base rate division factor: 0h = divide by 1 (48kHz, 44.1kHz) 1h = divide by 2 (24kHz, 22.05kHz) 2h = divide by 3 (16kHz, 32kHz) 3h = divide by 4 (11.025kHz) 4h = Reserved 5h = divide by 6 (8kHz) 6h = Reserved 7h = Reserved |
| [7] | Rsvd | R | 0 | Reserved |
| [6:4] | Bits | RW | 3h | Bits per Sample: 0h = Reserved 1h = 16 bits 2h = 20 bits 3h = 24 bits 4h = 32 bits (Float 32) 5h-7h = Reserved |
| [3:0] | Chan | RW | 1h | Number of Channels in each frame of the stream: 0h = 1 channel 1h = 2 channels 2h = 3 channels 3h = 4 channels 4h-Fh = reserved |

GET PARAMETER VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|-----|---------|--------------------|-----------------|
| Get | F00h | Parameter ID (PID) | Parameter Value |

Audio Widget Capabilities Parameter (PID = 09h)

| Bit | Bitfield Name | RW | Default | Description |
|---------|------------------------|----|---------|--|
| [31:24] | Rsvd | R | 00h | Reserved |
| [23:20] | Type | R | 1h | Indicates that this is an Audio Input widget |
| [19:16] | Delay | R | 0h | Latency not reported |
| [15:12] | Rsvd | R | 0h | Reserved |
| [11] | L-R Swap | R | 0 | Left/Right swap capability not supported |
| [10] | PowerCntrl | R | 1 | Indicates that the <i>Power State Verb</i> is supported in this widget |
| [9] | Digital | R | 0 | Indicates that this widget is translating analogue data |
| [8] | Conn List | R | 1 | Indicates that a connection list is present |
| [7] | Unsol Capable | R | 1 | Widget supports Unsolicited Responses |
| [6] | ProcWidget | R | 1 | Widget has processing capabilities (i.e high pass filter) |
| [5] | Stripe | R | 0 | Widget does not support striping |
| [4] | Format Override | R | 1 | Widget has a subset of the supported rates defined for the AFG |
| [3] | Amp Parameter Override | R | 0 | Not applicable as this widget does not have amplifier capabilities |
| [2] | Out Amp Present | R | 0 | Output amplifier not present in this widget |
| [1] | In Amp Present | R | 0 | Input amplifier not present in this widget |
| [0] | Stereo | R | 1 | Indicates that this is a stereo widget |

Supported Rates Parameter (PID = 0Ah)

| Bit | Bitfield Name | RW | Default | Description |
|---------|---------------|----|---------|---|
| [31:21] | Rsvd | R | 000h | Reserved |
| [20] | B32 | R | 1 | MIC1 supports 32-bit audio format |
| [19] | B24 | R | 1 | MIC1 supports 24-bit audio format |
| [18] | B20 | R | 1 | MIC1 supports 20-bit audio format |
| [17] | B16 | R | 1 | MIC1 supports 16-bit audio format |
| [16] | B8 | R | 0 | MIC1 does not support 8-bit audio format |
| [15:12] | Rsvd | R | 0h | Reserved |
| [11] | R12 | R | 0 | MIC1 does not support 384 kHz sample rate |
| [10] | R11 | R | 0 | MIC1 does not support 192 kHz sample rate |
| [9] | R10 | R | 0 | MIC1 does not support 176.4 kHz sample rate |
| [8] | R9 | R | 0 | MIC1 does not support 96 kHz sample rate |
| [7] | R8 | R | 0 | MIC1 does not support 88.2 kHz sample rate |
| [6] | R7 | R | 1 | MIC1 supports 48 kHz sample rate |
| [5] | R6 | R | 1 | MIC1 supports 44.1 kHz sample rate |
| [4] | R5 | R | 1 | MIC1 supports 32 kHz sample rate |
| [3] | R4 | R | 1 | MIC1 supports 22.05 kHz sample rate |
| [2] | R3 | R | 1 | MIC1 supports 16 kHz sample rate |
| [1] | R2 | R | 1 | MIC1 supports 11.025 kHz sample rate |
| [0] | R1 | R | 1 | MIC1 supports 8 kHz sample rate |

Supported Stream Formats Parameter (PID = 0Bh)

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|-----------|--|
| [31:3] | Rsvd | R | 00000000h | Reserved |
| [2] | AC3 | R | 0 | MIC1 does not support Dolby AC3 formatted data |
| [1] | Float32 | R | 1 | MIC1 supports Float32 formatted data |
| [0] | PCM | R | 1 | MIC1 supports PCM formatted data |

Connection List Length Parameter (PID = 0Eh)

| Bit | Bitfield Name | RW | Default | Description |
|--------|------------------------|----|----------|--|
| [31:8] | Rsvd | R | 0000000h | Reserved |
| [7] | Long Form | R | 0 | Indicates that the connection list items are in short form |
| [6:0] | Connection List Length | R | 01h | Indicates that there is 1 NID entry in the connection list |

Supported Power States Parameter (PID = 0Fh)

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|----------|--------------------------|
| [31:4] | Rsvd | R | 0000000h | Reserved |
| [3] | D3Sup | R | 1 | D3 power state supported |
| [2] | D2Sup | R | 1 | D2 power state supported |
| [1] | D1sup | R | 1 | D1 power state supported |
| [0] | D0Sup | R | 1 | D0 power state supported |

Processing Capabilities Parameter (PID = 10h)

| Bit | Bitfield Name | RW | Default | Description |
|---------|---------------|----|---------|--|
| [31:16] | Rsvd | R | 0000h | Reserved |
| [15:8] | NumCoeff | R | 00h | This widget does not support loadable coefficients |
| [7:1] | Rsvd | R | 00h | Reserved |
| [0] | Benign | R | 0 | The "Processing Benign State" is not supported |

GET CONNECTION LIST ENTRY VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|---------------|--------------------------------|
| Get | F02h | 00h | Bits [31:0] in the table below |

| Bit | Bitfield Name | RW | Default | Description |
|---------|-------------------|----|---------|--|
| [31:24] | Conn List Entry 3 | R | 00h | Unused connection list entry |
| [23:16] | Conn List Entry 2 | R | 00h | Unused connection list entry |
| [15:8] | Conn List Entry 1 | R | 00h | Unused connection list entry |
| [7:0] | Conn List Entry 0 | R | 09h | Indicates that the MIC1 Widget connects to the MIC1 Mux Widget (NID = 09h) |

PROCESSING STATE VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F03h | 00h | Bits [31:0] in the table below |
| Set | 703h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|------------------|----|---------|--|
| [31:8] | Rsvd | R | 000000h | Reserved |
| [7:0] | Processing State | RW | 01h | The processing node is the high-pass filter (HPF). The processing state is controlled as follows: 00h = Processing Off: HPF disabled 01h = Processing On: HPF enabled 02h = Processing Off: HPF disabled (benign not supported) 03h-7Fh = Reserved 80h-FFh = Vendor Specific – not used |

POWER STATE VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F05h | 00h | Bits [31:0] in the table below |
| Set | 705h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|---------|---|
| [31:8] | Rsvd | R | 000000h | Reserved |
| [7:4] | PS-Act | R | 3h | Indicates the actual power state of the MIC1 widget node: 0h = D0 1h = D1 2h = D2 3h = D3 The power state of the MIC1 widget is controlled by <i>PS-Set</i> below, however the control may be superseded by the <i>PS-Set</i> of the AFG node. |
| [3:0] | PS-Set | RW | 3h | Sets the power state of the MIC1 widget node: 0h = D0 1h = D1 2h = D2 3h = D3 |

CONVERTER STREAM, CHANNEL VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F06h | 00h | Bits [31:0] in the table below |
| Set | 706h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|---------|--|
| [31:8] | Rsvd | R | 000000h | Reserved |
| [7:4] | Stream | RW | 0h | Stream ID used by this widget. Note that Stream ID = 0h is used to indicate an unused stream, and converters will not transfer/receive link data for streams with an ID of 0h. For multi-channel capture on MIC1 and MIC2, the <i>Stream</i> value should be the same for both. |
| [3:0] | Channel | RW | 0h | Lowest channel number used by this widget. Note: When MIC1 and MIC2 are setup for multi-channel capture, only a setting of 0h and 2h are applicable. However, the values are mutually exclusive, in that if <i>Channel</i> has been set to 0h for the MIC1 node, it must be set to 2h for the MIC2 node. Both nodes should have <i>Channel</i> set to 0h |

| | | | | |
|--|--|--|--|---|
| | | | | when not in multi-channel capture mode. |
|--|--|--|--|---|

UNSOLICITED RESPONSE VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F08h | 00h | Bits [31:0] in the table below |
| Set | 708h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|----------|---|
| [31:8] | Rsvd | R | 0000000h | Reserved |
| [7] | Enable | RW | 0 | 0 = Unsolicited Responses disabled for this node 1 = Unsolicited Responses enabled for this node |
| [6] | Rsvd | R | 0 | Reserved |
| [5:0] | Tag | RW | 03h | A software programmable tag value that is returned in the top six bits (31:26) of every Unsolicited Response from this node. The default for <i>Tag</i> is equal to the Node ID. |

Note: The Unsolicited Response for the AFG node is defined in the "Unsolicited Responses" section.

UNSOLICITED RESPONSE PRIORITY CONTROL VERB (VENDOR-SPECIFIC)

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F8Eh | 00h | Bits [31:0] in the table below |
| Set | 78Eh | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|-----------|--|
| [31:5] | Rsvd | R | 00000000h | Reserved |
| [4:0] | Priority | RW | 00h | Assigns a priority setting for queued Unsolicited Responses. Nodes with the lowest value have the highest priority, and so go to the front of the Unsolicited Response queue. Nodes with the same value for priority are queued on first-to-trigger basis. 00h = Highest priority ... 1Fh = Lowest priority |

CHANNEL COPY VERB (VENDOR-SPECIFIC)

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | FB1h | 00h | Bits [31:0] in the table below |
| Set | 7B1h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|-----------|---|
| [31:2] | Rsvd | R | 00000000h | Reserved |
| [1] | CHAN1_SEL | RW | 1 | Channel 1 (right) Mapping Control: 0 = Channel 1 takes data from left audio channel 1 = Channel 1 takes data from right audio channel |
| [0] | CHAN0_SEL | RW | 0 | Channel 0 (left) Mapping Control: 0 = Channel 0 takes data from left audio channel 1 = Channel 0 takes data from right audio channel |

S/PDIF TX 1 AUDIO OUTPUT CONVERTER WIDGET (NID = 04H)**STREAM FORMAT VERB**

| | Verb ID | Payload [15:0] | Response[31:0] |
|------------|---------|--------------------------------|--------------------------------|
| Get | Ah | 0000h | Bits [31:0] in the table below |
| Set | 2h | Bits [15:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|---------|---------------|----|---------|--|
| [31:16] | Rsvd | R | 0000h | Reserved |
| [15] | Type | RW | 0 | Used to set the format of the stream: 0 = PCM 1 = Non-PCM (i.e. AC3 or Software Formatted S/PDIF) |
| [14] | Base | RW | 0 | Used to set the base rate frequency: 0h = 48 kHz 1h = 44.1 kHz |
| [13:11] | Mult | RW | 0h | Used to set the base rate multiplication factor: 0h = x1 (48kHz, 44.1kHz or less) 1h = x2 (96kHz, 88.2kHz, 32kHz) 2h = Reserved 3h = x4 (192kHz, 176.4kHz) 4h-7h = Reserved |
| [10:8] | Div | RW | 0h | Used to set the base rate division factor: 0h = divide by 1 (48kHz, 44.1kHz) 1h =Reserved 2h = divide by 3 (32kHz) 3h-7h = Reserved |
| [7] | Rsvd | R | 0 | Reserved |
| [6:4] | Bits | RW | 4h | Bits per Sample: 0h = Reserved 1h = 16 bits 2h = 20 bits 3h = 24 bits 4h = 32 bits (Software Formatted or Float 32) 5h-7h = Reserved |
| [3:0] | Chan | RW | 1h | Number of Channels in each frame of the stream: 0h = 1 channel 1h = 2 channels 2h-Fh = reserved |

Notes:

- When the internal path (of ADC1 or MIC1 or MIC2) to S/PDIF TX 1 is active, *Mult*, *Base* & *Div* become read only and are programmed by the WM8860 to match the sourced node settings.
- When Software Formatted S/PDIF is selected, and the S/PDIF TX 1 is sourcing the HDA Link, the S/PDIF output is driven low until stream ID is assigned.

GET PARAMETER VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|-----|---------|--------------------|-----------------|
| Get | F00h | Parameter ID (PID) | Parameter Value |

Audio Widget Capabilities Parameter (PID = 09h)

| Bit | Bitfield Name | RW | Default | Description |
|---------|------------------------|----|---------|--|
| [31:24] | Rsvd | R | 00h | Reserved |
| [23:20] | Type | R | 0h | Indicates that this is an Audio Output Widget |
| [19:16] | Delay | R | 0h | Latency not reported |
| [15:12] | Rsvd | R | 0h | Reserved |
| [11] | L-R Swap | R | 0 | Left/Right swap capability not supported |
| [10] | PowerCntrl | R | 0 | Indicates that the <i>Power State Verb</i> is supported in this widget |
| [9] | Digital | R | 1 | Indicates that this widget is translating digital data |
| [8] | Conn List | R | 0 | Indicates that a connection list is not present |
| [7] | Unsol Capable | R | 1 | Widget supports Unsolicited Responses |
| [6] | ProcWidget | R | 1 | Widget has processing capabilities (i.e SRC2) |
| [5] | Stripe | R | 0 | Widget does not support striping |
| [4] | Format Override | R | 1 | Widget has a subset of the supported rates defined for the AFG |
| [3] | Amp Parameter Override | R | 0 | Not applicable as this widget does not have amplifier capabilities |
| [2] | Out Amp Present | R | 0 | Output amplifier not present in this widget |
| [1] | In Amp Present | R | 0 | Input amplifier not present in this widget |
| [0] | Stereo | R | 1 | Indicates that this is a stereo widget |

Supported Rates Parameter (PID = 0Ah)

| Bit | Bitfield Name | RW | Default | Description |
|---------|---------------|----|---------|---|
| [31:21] | Rsvd | R | 000h | Reserved |
| [20] | B32 | R | 1 | Float32 and Software Formatted S/PDIF is supported. |
| [19] | B24 | R | 1 | S/PDIF Tx 1 supports 24-bit audio format |
| [18] | B20 | R | 1 | S/PDIF Tx 1 supports 20-bit audio format |
| [17] | B16 | R | 1 | S/PDIF Tx 1 supports 16-bit audio format |
| [16] | B8 | R | 0 | S/PDIF Tx 1 does not support 8-bit audio format |
| [15:12] | Rsvd | R | 0h | Reserved |
| [11] | R12 | R | 0 | S/PDIF Tx 1 does not support 384 kHz sample rate |
| [10] | R11 | R | 1 | S/PDIF Tx 1 supports 192 kHz sample rate |
| [9] | R10 | R | 1 | S/PDIF Tx 1 supports 176.4 kHz sample rate |
| [8] | R9 | R | 1 | S/PDIF Tx 1 supports 96 kHz sample rate |
| [7] | R8 | R | 1 | S/PDIF Tx 1 supports 88.2 kHz sample rate |
| [6] | R7 | R | 1 | S/PDIF Tx 1 supports 48 kHz sample rate |
| [5] | R6 | R | 1 | S/PDIF Tx 1 supports 44.1 kHz sample rate |
| [4] | R5 | R | 1 | S/PDIF Tx 1 supports 32 kHz sample rate |
| [3] | R4 | R | 0 | S/PDIF Tx 1 does not support 22.05 kHz sample rate |
| [2] | R3 | R | 0 | S/PDIF Tx 1 does not support 16 kHz sample rate |
| [1] | R2 | R | 0 | S/PDIF Tx 1 does not support 11.025 kHz sample rate |
| [0] | R1 | R | 0 | S/PDIF Tx 1 does not support 8 kHz sample rate |

Supported Stream Formats Parameter (PID = 0Bh)

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|-----------|---|
| [31:3] | Rsvd | R | 00000000h | Reserved |
| [2] | AC3 | R | 0 | S/PDIF Tx 1 does not support Dolby AC3 format |
| [1] | Float32 | R | 1 | S/PDIF Tx 1 supports Float32 formatted data |
| [0] | PCM | R | 1 | S/PDIF Tx 1 supports PCM formatted data |

Processing Capabilities Parameter (PID = 10h)

| Bit | Bitfield Name | RW | Default | Description |
|---------|---------------|----|---------|--|
| [31:16] | Rsvd | R | 0000h | Reserved |
| [15:8] | NumCoeff | R | 00h | This widget does not support loadable coefficients |
| [7:1] | Rsvd | R | 00h | Reserved |
| [0] | Benign | R | 0 | The "Processing Benign State" is not supported |

00h
01h
02h
03h
04h
05h
06h
07h
08h
09h
0Ah
0Bh
0Ch
0Dh
0Eh
0Fh
10h
11h
12h
13h
14h
15h
16h
17h

CONVERTER STREAM, CHANNEL VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F06h | 00h | Bits [31:0] in the table below |
| Set | 706h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|---------|---|
| [31:8] | Rsvd | R | 000000h | Reserved |
| [7:4] | Stream | RW | 0h | Stream ID used by this widget. Note that Stream ID = 0h is used to indicate an unused stream, and converters will not transfer/receive link data for streams with an ID of 0. |
| [3:0] | Channel | RW | 0h | Lowest channel number used by this widget. Note: As this widget does not support multi-channel capture, only a setting of 0 is applicable. |

UNSOLICITED RESPONSE VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F08h | 00h | Bits [31:0] in the table below |
| Set | 708h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|---------|---|
| [31:8] | Rsvd | R | 000000h | Reserved |
| [7] | Enable | RW | 0 | 0 = Unsolicited Responses disabled for this node 1 = Unsolicited Responses enabled for this node |
| [6] | Rsvd | R | 0 | Reserved |
| [5:0] | Tag | RW | 04h | A software programmable tag value that is returned in the top six bits (31:26) of every Unsolicited Response from this node. The default for <i>Tag</i> is equal to the Node ID. |

Note: The Unsolicited Response for the AFG node is defined in the "Unsolicited Responses" section.

S/PDIF CONVERTER CONTROL VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|-------------|---------|--------------------------------|--------------------------------|
| Get | F0Dh | 0000h | Bits [31:0] in the table below |
| Set1 | 70Dh | Bits [7:0] in the table below | 00000000h |
| Set2 | 70Eh | Bits [15:8] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|---------|---------------|----|---------|---|
| [31:15] | Rsvd | R | 00000h | Reserved |
| [14:8] | CC | RW | 00h | Category Code. Channel Status bits [14:8] – see IEC 60958-3 for details. |
| [7] | L | RW | 0 | Generation Level, Channel Status bit [15] - see IEC 60958-3 for details. |
| [6] | PRO | RW | 0 | Professional, Channel Status bit[0]: 0 = Consumer Channel Status (40-bits) 1 = Professional Channel Status (192-bits) |
| [5] | /AUDIO | RW | 0 | Non-Audio, Channel Status bit[1]: 0 = PCM formatted data 1 = non-PCM formatted data |
| [4] | COPY | RW | 0 | Copyright, Channel Status bit[2]: 0 = indicates copyright asserted (i.e. S/PDIF Channel Status bit[2] set to 1) 1 = indicates no copyright asserted (i.e. S/PDIF Channel Status bit[2] set to 0) Note: The HDA specification, and the IEC 60958-3 specification are the inverse of each other. To comply with both, the WM8860 inverts the written value. |
| [3] | PRE | RW | 0 | Pre-emphasis, Channel Status bit[3]: 0 = no pre-emphasis 1 = 50/15 us pre-emphasis |
| [2] | VCFG | RW | 0 | Validity Configuration Control - determines what happens to the audio data, should an invalid sample occur (invalid samples occur when SRC2 is in use but not locked, EF_STREAM_ERR is asserted, or the stream ID is 0). 0 = pass data as received by the S/PDIF Tx 1. 1 = overwrite invalid data with all zeros (for the invalid sub frame only). |
| [1] | V | RW | 0 | Validity: 0 = Indicates valid data 1 = Indicates invalid data If V=1, the transmitted <i>validity</i> flag is set to 1. If V=0, the transmitted <i>validity</i> flag is set to 1 if there is an invalid sample being transmitted. Invalid samples may occur when SRC2 is in use but not locked, EF_STREAM_ERR is asserted, or the stream ID is 0. |
| [0] | DigEn | RW | 0 | Digital Enable: 0 = S/PDIF audio path disabled 1 = S/PDIF audio path enabled |

Note: When Software Formatted S/PDIF is selected, verb settings for channel status and validity are not used

INTERNAL PATH VERB (VENDOR-SPECIFIC)

| | Verb ID | Payload [7:0] | Response[31:0] |
|-------------|---------|-------------------------------|--------------------------------|
| Get | F73h | 00h | Bits [31:0] in the table below |
| Set1 | 773h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|----------|---|
| [31:8] | Rsvd | R | 0000000h | Reserved |
| [7:0] | Path Sel | RW | 00h | Selects source of S/PDIF TX 1 node: 00h = HDA Link 02h = ADC1 03h = MIC1 15h = MIC2 All other values of Path Sel are reserved. |

Note: When the internal path (of ADC1 or MIC1 or MIC2) to S/PDIF TX 1 is active, SRC2 is automatically bypassed and *Mult*, *Base & Div* (in the *Stream Format Verb*) become read only and are programmed by the WM8860 to match the sourced node settings.

TX CHANNEL STATUS CONTROL VERB (VENDOR-SPECIFIC)

| | Verb ID | Payload [7:0] | Response[31:0] |
|-------------|---------|---------------------------------|--------------------------------|
| Get | F81h | 00h | Bits [31:0] in the table below |
| Set1 | 781h | Bits [7:0] in the table below | 00000000h |
| Set2 | 782h | Bits [15:8] in the table below | 00000000h |
| Set3 | 783h | Bits [23:16] in the table below | 00000000h |
| Set4 | 784h | Bits [31:24] in the table below | 00000000h |

The bits in the table below are defined in the IEC-60958-3 Specification:

| Bit | Bitfield Name | RW | Default | Description |
|---------|--------------------------|----|---------|------------------------------------|
| [31:28] | Channel Status [39:36] | RW | 0h | Original Sampling Frequency |
| [27:25] | Channel Status [35:33] | RW | 5h | Sample Word Length |
| [24] | Channel Status [32] | RW | 1 | Max Word Length |
| [23:22] | Channel Status [31:30] | RW | 0h | Channel Status [31:30] |
| [21:20] | Channel Status [29:28] | RW | 0h | Clock Accuracy |
| [19:16] | Channel Status [27:24] | RW | 1h | Sampling Frequency |
| [15:12] | Channel Status B [23:20] | RW | 0h | Channel Number for Sub-Frame B |
| [11:8] | Channel Status [23:20] | RW | 0h | Channel Number for Sub-Frame A |
| [7:4] | Channel Status [19:16] | RW | 0h | Source Number |
| [3:2] | Channel Status [7:6] | RW | 0h | Channel Status Mode |
| [1:0] | Channel Status [5:4] | RW | 0h | Additional De-emphasis Information |

Notes:

1. When Software Formatted S/PDIF is selected, verb settings for channel status and validity are not used.
2. The *Channel Number* for Sub-frame B is uniquely configurable – all other Channel status bits have the same value as Sub-frame A.

CHANNEL STATUS DATA PACKING CONFIGURATION VERB (VENDOR-SPECIFIC)

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F85h | 00h | Bits [31:0] in the table below |
| Set | 785h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|----------|---|
| [31:1] | Rsvd | R | 0000000h | Reserved |
| [0] | CSD_MODE | RW | 1 | S/PDIF Transmitter Channel Status Data Packing Mode: 0 = Manual mode: sample rate and data width channel status data packed from data sourced from the <i>Tx Channel Status Control Verb</i> 1 = Automatic mode: sample rate and data width channel status data packed from data sourced from the <i>Stream Verb, S/PDIF Verb</i> |

UNSOLICITED RESPONSE PRIORITY CONTROL VERB (VENDOR-SPECIFIC)

| | Verb ID | Payload [7:0] | Response[31:0] |
|-----|---------|-------------------------------|--------------------------------|
| Get | F8Eh | 00h | Bits [31:0] in the table below |
| Set | 78Eh | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|----------|--|
| [31:5] | Rsvd | R | 0000000h | Reserved |
| [4:0] | Priority | RW | 00h | Assigns a priority setting for queued Unsolicited Responses. Nodes with the lowest value have the highest priority, and so go to the front of the Unsolicited Response queue. Nodes with the same value for priority are queued on first-to-trigger basis. 00h = Highest priority ... 1Fh = Lowest priority |

RESERVED (NID = 05H)

00h
01h
02h
03h
04h
05h
06h
07h
08h
09h
0Ah
0Bh
0Ch
0Dh
0Eh
0Fh
10h
11h
12h
13h
14h
15h
16h
17h

DAC1 AUDIO OUTPUT CONVERTER WIDGET (NID = 06H)**STREAM FORMAT VERB**

| | Verb ID | Payload [15:0] | Response[31:0] |
|------------|---------|--------------------------------|--------------------------------|
| Get | Ah | 0000h | Bits [31:0] in the table below |
| Set | 2h | Bits [15:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|---------|---------------|----|---------|--|
| [31:16] | Rsvd | R | 0000h | Reserved |
| [15] | Type | R | 0h | Indicates the widget supports only PCM streams |
| [14] | Base | RW | 0 | Used to set the base rate frequency: 0 = 48 kHz 1 = 44.1 kHz |
| [13:11] | Mult | RW | 0h | Used to set the base rate multiplication factor: 0h = x1 (48kHz, 44.1kHz or less) 1h = x2 (96kHz, 88.2kHz, 32kHz) 2h = Reserved 3h = x4 (192kHz, 176.4kHz) 4h-7h = Reserved |
| [10:8] | Div | RW | 0h | Used to set the base rate division factor: 0h = divide by 1 (48kHz, 44.1kHz) 1h = divide by 2 (24kHz, 22.05kHz) 2h = divide by 3 (16kHz, 32kHz) 3h = divide by 4 (11.025kHz) 4h = Reserved 5h = divide by 6 (8kHz) 6h = Reserved 7h = Reserved |
| [7] | Rsvd | R | 0 | Reserved |
| [6:4] | Bits | RW | 3h | Bits per Sample: 0h = Reserved 1h = 16 bits 2h = 20 bits 3h = 24 bits 4h = 32 bits (Float 32) 5h-7h = Reserved |
| [3:0] | Chan | RW | 1h | Number of Channels in each frame of the stream: 0h = 1 channel 1h = 2 channels 2h = 3 channels 3h = 4 channels 4h = 5 channels 5h = 6 channels 6h-Fh = reserved |

AMPLIFIER GAIN/MUTE VERB

| | Verb ID | Payload [15:0] | Response[31:0] |
|-----|---------|------------------------------------|---|
| Get | Bh | A000h | Bits [31:0] in the response table below – applies to the left channel only |
| Get | Bh | 8000h | Bits [31:0] in the response table below – applies to the right channel only |
| Set | 3h | Bits [15:0] in the set table below | 00000000h |

Response Table:

| Bit | Bitfield Name | RW | Default | Description |
|--------|----------------|----|---------|---|
| [31:8] | Rsvd | R | 000000h | Reserved |
| [7] | Amplifier Mute | R | 1 | Shows the amplifier mute status of the selected channel: 0 = Normal 1 = Muted |
| [6:0] | Amplifier Gain | R | 7Fh | Shows the amplifier gain setting (step number) for the selected channel. The actual gain applied is determined by <i>the Output Amplifier Capabilities Parameter</i> in the AFG, and is shown below for convenience: 00h = -63.5dB 01h = -63.0dB ... 0.5dB steps 7Eh = -0.5dB 7Fh = 0dB Note: If the <i>H-Phn Enable</i> register in the Port-A (NID=11h) <i>Pin Widget Control Verb</i> is set to 1, the actual gain setting applied has an offset of -8dB from the setting configured by the <i>Gain</i> register. |

Set Table:

| Bit | Bitfield Name | RW | Default | Description |
|--------|----------------|----|---------|---|
| [15] | Set Output Amp | W | 1 | Indicates that the programming refers to the output amplifier on this widget |
| [14] | Set Input Amp | W | 0 | Not applicable to this widget |
| [13] | Set Left Amp | W | 1 | 0 = Left channel amplifier does not accept the values in <i>Mute</i> or <i>Gain</i> fields 1 = Left channel amplifier does accept the values in the <i>Mute</i> and <i>Gain</i> fields |
| [12] | Set Right Amp | W | 1 | 0 = Right channel amplifier does not accept the values in <i>Mute</i> or <i>Gain</i> fields 1 = Right channel amplifier does accept the values in the <i>Mute</i> and <i>Gain</i> fields |
| [11:8] | Index | W | 0h | Not applicable to this widget |
| [7] | Mute | W | 1 | 0 = Normal operation 1 = Mute |
| [6:0] | Gain | W | 7Fh | Step number of the gain – see <i>Amplifier Gain</i> in response table above for details of actual gain values |

GET PARAMETER VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|-----|---------|--------------------|-----------------|
| Get | F00h | Parameter ID (PID) | Parameter Value |

Audio Widget Capabilities Parameter (PID = 09h)

| Bit | Bitfield Name | RW | Default | Description |
|---------|------------------------|----|---------|--|
| [31:24] | Rsvd | R | 00h | Reserved |
| [23:20] | Type | R | 0h | Indicates that this is an Audio Output Widget |
| [19:16] | Delay | R | 0h | Latency not reported |
| [15:12] | Rsvd | R | 0h | Reserved |
| [11] | L-R Swap | R | 0 | Left/Right swap capability not supported |
| [10] | PowerCntrl | R | 1 | Indicates that the <i>Power State Verb</i> is supported in this widget |
| [9] | Digital | R | 0 | Indicates that this widget is translating analogue data |
| [8] | Conn List | R | 0 | Indicates that a connection list is not present |
| [7] | Unsol Capable | R | 1 | Widget supports Unsolicited Responses |
| [6] | ProcWidget | R | 0 | Widget does not have processing capabilities |
| [5] | Stripe | R | 0 | Widget does not support striping |
| [4] | Format Override | R | 1 | Widget has a subset of the supported rates defined for the AFG |
| [3] | Amp Parameter Override | R | 0 | The AFG amplifier parameters are used for this widget |
| [2] | Out Amp Present | R | 1 | Output amplifier is present in this widget |
| [1] | In Amp Present | R | 0 | Input amplifier not present in this widget |
| [0] | Stereo | R | 1 | Indicates that this is a stereo widget |

Supported Rates Parameter (PID = 0Ah)

| Bit | Bitfield Name | RW | Default | Description |
|---------|---------------|----|---------|---|
| [31:21] | Rsvd | R | 000h | Reserved |
| [20] | B32 | R | 1 | DAC1 supports 32-bit audio format |
| [19] | B24 | R | 1 | DAC1 supports 24-bit audio format |
| [18] | B20 | R | 1 | DAC1 supports 20-bit audio format |
| [17] | B16 | R | 1 | DAC1 supports 16-bit audio format |
| [16] | B8 | R | 0 | DAC1 does not support 8-bit audio format |
| [15:12] | Rsvd | R | 0h | Reserved |
| [11] | R12 | R | 0 | DAC1 does not support 384 kHz sample rate |
| [10] | R11 | R | 1 | DAC1 supports 192 kHz sample rate |
| [9] | R10 | R | 1 | DAC1 supports 176.4 kHz sample rate |
| [8] | R9 | R | 1 | DAC1 supports 96 kHz sample rate |
| [7] | R8 | R | 1 | DAC1 supports 88.2 kHz sample rate |
| [6] | R7 | R | 1 | DAC1 supports 48 kHz sample rate |
| [5] | R6 | R | 1 | DAC1 supports 44.1 kHz sample rate |
| [4] | R5 | R | 1 | DAC1 supports 32 kHz sample rate |
| [3] | R4 | R | 1 | DAC1 supports 22.05 kHz sample rate |
| [2] | R3 | R | 1 | DAC1 supports 16 kHz sample rate |
| [1] | R2 | R | 1 | DAC1 supports 11.025 kHz sample rate |
| [0] | R1 | R | 1 | DAC1 supports 8 kHz sample rate |

Supported Stream Formats Parameter (PID = 0Bh)

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|-----------|--|
| [31:3] | Rsvd | R | 00000000h | Reserved |
| [2] | AC3 | R | 0 | DAC1 does not support Dolby AC3 formatted data |
| [1] | Float32 | R | 1 | DAC1 supports Float32 formatted data |
| [0] | PCM | R | 1 | DAC1 supports PCM formatted data |

Supported Power States Parameter (PID = 0Fh)

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|----------|--------------------------|
| [31:4] | Rsvd | R | 0000000h | Reserved |
| [3] | D3Sup | R | 1 | D3 power state supported |
| [2] | D2Sup | R | 1 | D2 power state supported |
| [1] | D1sup | R | 1 | D1 power state supported |
| [0] | D0Sup | R | 1 | D0 power state supported |

POWER STATE VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F05h | 00h | Bits [31:0] in the table below |
| Set | 705h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|---------|---|
| [31:8] | Rsvd | R | 000000h | Reserved |
| [7:4] | PS-Act | R | 3h | Indicates the actual power state of the DAC1 node: 0h = D0 1h = D1 2h = D2 3h = D3 4h-Fh = Reserved Note: The power state of the DAC1 node is controlled by <i>PS-Set</i> below, however the control may be superseded by the <i>PS-Set</i> of the AFG node. |
| [3:0] | PS-Set | RW | 3h | Sets the power state of the DAC1 node: 0h = D0 1h = D1 2h = D2 3h = D3 4h-Fh = Reserved |

CONVERTER STREAM, CHANNEL VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F06h | 00h | Bits [31:0] in the table below |
| Set | 706h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|---------|--|
| [31:8] | Rsvd | R | 000000h | Reserved |
| [7:4] | Stream | RW | 0h | Stream ID used by this widget. Note that Stream ID = 0h is used to indicate an unused stream, and converters will not transfer/receive link data for streams with an ID of 0h. |
| [3:0] | Channel | RW | 0h | Lowest channel number used by this widget. |

UNSOLICITED RESPONSE VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F08h | 00h | Bits [31:0] in the table below |
| Set | 708h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|----------|---|
| [31:8] | Rsvd | R | 0000000h | Reserved |
| [7] | Enable | RW | 0 | 0 = Unsolicited Responses disabled for this node 1 = Unsolicited Responses enabled for this node |
| [6] | Rsvd | R | 0 | Reserved |
| [5:0] | Tag | RW | 06h | A software programmable tag value that is returned in the top six bits (31:26) of every Unsolicited Response from this node. The default for <i>Tag</i> is equal to the Node ID. |

Note: The Unsolicited Response for the AFG node is defined in the "Unsolicited Responses" section.

UNSOLICITED RESPONSE PRIORITY CONTROL VERB (VENDOR-SPECIFIC)

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F8Eh | 00h | Bits [31:0] in the table below |
| Set | 78Eh | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|-----------|--|
| [31:5] | Rsvd | R | 00000000h | Reserved |
| [4:0] | Priority | RW | 00h | Assigns a priority setting for queued Unsolicited Responses. Nodes with the lowest value have the highest priority, and so go to the front of the Unsolicited Response queue. Nodes with the same value for priority are queued on first-to-trigger basis. 00h = Highest priority ... 1Fh = Lowest priority |

DAC2 AUDIO OUTPUT CONVERTER WIDGET (NID = 07H)**STREAM FORMAT VERB**

| | Verb ID | Payload [15:0] | Response[31:0] |
|------------|---------|--------------------------------|--------------------------------|
| Get | Ah | 0000h | Bits [31:0] in the table below |
| Set | 2h | Bits [15:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|---------|---------------|----|---------|--|
| [31:16] | Rsvd | R | 0000h | Reserved |
| [15] | Type | R | 0 | Indicates the widget supports only PCM streams |
| [14] | Base | RW | 0 | Used to set the base rate frequency: 0 = 48 kHz 1 = 44.1 kHz |
| [13:11] | Mult | RW | 0h | Used to set the base rate multiplication factor: 0h = x1 (48kHz, 44.1kHz or less) 1h = x2 (96kHz, 88.2kHz, 32kHz) 2h = Reserved 3h = x4 (192kHz, 176.4kHz) 4h-7h = Reserved |
| [10:8] | Div | RW | 0h | Used to set the base rate division factor: 0h = divide by 1 (48kHz, 44.1kHz) 1h = divide by 2 (24kHz, 22.05kHz) 2h = divide by 3 (16kHz, 32kHz) 3h = divide by 4 (11.025kHz) 4h = Reserved 5h = divide by 6 (8kHz) 6h = Reserved 7h = Reserved |
| [7] | Rsvd | R | 0 | Reserved |
| [6:4] | Bits | RW | 3h | Bits per Sample: 0h = Reserved 1h = 16 bits 2h = 20 bits 3h = 24 bits 4h = 32 bits (Float 32) 5h-7h = Reserved |
| [3:0] | Chan | RW | 1h | Number of Channels in each frame of the stream: 0h = 1 channel 1h = 2 channels 2h = 3 channels 3h = 4 channels 4h = 5 channels 5h = 6 channels 6h-Fh = reserved |

AMPLIFIER GAIN/MUTE VERB

| | Verb ID | Payload [15:0] | Response[31:0] |
|-----|---------|------------------------------------|---|
| Get | Bh | A000h | Bits [31:0] in the response table below – applies to the left channel only |
| Get | Bh | 8000h | Bits [31:0] in the response table below – applies to the right channel only |
| Set | 3h | Bits [15:0] in the set table below | 00000000h |

Response Table:

| Bit | Bitfield Name | RW | Default | Description |
|--------|----------------|----|---------|--|
| [31:8] | Rsvd | R | 000000h | Reserved |
| [7] | Amplifier Mute | R | 1 | Shows the amplifier mute status of the selected channel: 0 = Normal 1 = Muted |
| [6:0] | Amplifier Gain | R | 7Fh | Shows the amplifier gain setting (step number) for the selected channel. The actual gain applied is determined by the <i>Output Amplifier Capabilities Parameter</i> in the AFG (NID = 01h), and is shown below for convenience: 00h = -63.5dB 01h = -63.0dB ... 0.5dB steps 7Eh = -0.5dB 7Fh = 0dB |

Set Table:

| Bit | Bitfield Name | RW | Default | Description |
|--------|----------------|----|---------|---|
| [15] | Set Output Amp | W | 1 | Indicates that the programming refers to the output amplifier on this widget |
| [14] | Set Input Amp | W | 0 | Not applicable to this widget |
| [13] | Set Left Amp | W | 1 | 0 = Left channel amplifier does not accept the values in <i>Mute</i> or <i>Gain</i> fields 1 = Left channel amplifier does accept the values in the <i>Mute</i> and <i>Gain</i> fields |
| [12] | Set Right Amp | W | 1 | 0 = Right channel amplifier does not accept the values in <i>Mute</i> or <i>Gain</i> fields 1 = Right channel amplifier does accept the values in the <i>Mute</i> and <i>Gain</i> fields |
| [11:8] | Index | W | 0h | Not applicable to this widget |
| [7] | Mute | W | 1 | 0 = Normal operation 1 = Mute |
| [6:0] | Gain | W | 7Fh | Step number of the gain – see <i>Amplifier Gain</i> in response table above for details of actual gain values |

GET PARAMETER VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|-----|---------|--------------------|-----------------|
| Get | F00h | Parameter ID (PID) | Parameter Value |

Audio Widget Capabilities Parameter (PID = 09h)

| Bit | Bitfield Name | RW | Default | Description |
|---------|------------------------|----|---------|--|
| [31:24] | Rsvd | R | 00h | Reserved |
| [23:20] | Type | R | 0h | Indicates that this is an Audio Output Widget |
| [19:16] | Delay | R | 0h | Latency not reported |
| [15:12] | Rsvd | R | 0h | Reserved |
| [11] | L-R Swap | R | 0 | Left/Right swap capability not supported |
| [10] | PowerCntrl | R | 1 | Indicates that the <i>Power State Verb</i> is supported in this widget |
| [9] | Digital | R | 0 | Indicates that this widget is translating analogue data |
| [8] | Conn List | R | 0 | Indicates that a connection list is not present |
| [7] | Unsol Capable | R | 1 | Widget supports Unsolicited Responses |
| [6] | ProcWidget | R | 0 | Widget does not have processing capabilities |
| [5] | Stripe | R | 0 | Widget does not support striping |
| [4] | Format Override | R | 1 | Widget has a subset of the supported rates defined for the AFG |
| [3] | Amp Parameter Override | R | 0 | The AFG amplifier parameters are used for this widget |
| [2] | Out Amp Present | R | 1 | Output amplifier is present in this widget |
| [1] | In Amp Present | R | 0 | Input amplifier not present in this widget |
| [0] | Stereo | R | 1 | Indicates that this is a stereo widget |

Supported Rates Parameter (PID = 0Ah)

| Bit | Bitfield Name | RW | Default | Description |
|---------|---------------|----|---------|---|
| [31:21] | Rsvd | R | 000h | Reserved |
| [20] | B32 | R | 1 | DAC2 supports 32-bit audio format |
| [19] | B24 | R | 1 | DAC2 supports 24-bit audio format |
| [18] | B20 | R | 1 | DAC2 supports 20-bit audio format |
| [17] | B16 | R | 1 | DAC2 supports 16-bit audio format |
| [16] | B8 | R | 0 | DAC2 does not support 8-bit audio format |
| [15:12] | Rsvd | R | 0h | Reserved |
| [11] | R12 | R | 0 | DAC2 does not support 384 kHz sample rate |
| [10] | R11 | R | 1 | DAC2 supports 192 kHz sample rate |
| [9] | R10 | R | 1 | DAC2 supports 176.4 kHz sample rate |
| [8] | R9 | R | 1 | DAC2 supports 96 kHz sample rate |
| [7] | R8 | R | 1 | DAC2 supports 88.2 kHz sample rate |
| [6] | R7 | R | 1 | DAC2 supports 48 kHz sample rate |
| [5] | R6 | R | 1 | DAC2 supports 44.1 kHz sample rate |
| [4] | R5 | R | 1 | DAC2 supports 32 kHz sample rate |
| [3] | R4 | R | 1 | DAC2 supports 22.05 kHz sample rate |
| [2] | R3 | R | 1 | DAC2 supports 16 kHz sample rate |
| [1] | R2 | R | 1 | DAC2 supports 11.025 kHz sample rate |
| [0] | R1 | R | 1 | DAC2 supports 8 kHz sample rate |

Supported Stream Formats Parameter (PID = 0Bh)

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|-----------|--|
| [31:3] | Rsvd | R | 00000000h | Reserved |
| [2] | AC3 | R | 0 | DAC2 does not support Dolby AC3 formatted data |
| [1] | Float32 | R | 1 | DAC2 supports Float32 formatted data |
| [0] | PCM | R | 1 | DAC2 supports PCM formatted data |

Supported Power States Parameter (PID = 0Fh)

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|----------|--------------------------|
| [31:4] | Rsvd | R | 0000000h | Reserved |
| [3] | D3Sup | R | 1 | D3 power state supported |
| [2] | D2Sup | R | 1 | D2 power state supported |
| [1] | D1sup | R | 1 | D1 power state supported |
| [0] | D0Sup | R | 1 | D0 power state supported |

POWER STATE VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F05h | 00h | Bits [31:0] in the table below |
| Set | 705h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|---------|--|
| [31:8] | Rsvd | R | 000000h | Reserved |
| [7:4] | PS-Act | R | 3h | Indicates the actual power state of the DAC2 node: 0h = D0 1h = D1 2h = D2 3h = D3 4h-Fh = Reserved The power state of the DAC2 node is controlled by <i>PS-Set</i> below, however the control may be superseded by the <i>PS-Set</i> of the AFG node. |
| [3:0] | PS-Set | RW | 3h | Sets the power state of the DAC2 node: 0h = D0 1h = D1 2h = D2 3h = D3 4h-Fh = Reserved |

CONVERTER STREAM, CHANNEL VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F06h | 00h | Bits [31:0] in the table below |
| Set | 706h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|---------|--|
| [31:8] | Rsvd | R | 000000h | Reserved |
| [7:4] | Stream | RW | 0h | Stream ID used by this widget. Note that Stream ID = 0h is used to indicate an unused stream, and converters will not transfer/receive link data for streams with an ID of 0h. |
| [3:0] | Channel | RW | 0h | Lowest channel number used by this widget. |

UNSOLICITED RESPONSE VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F08h | 00h | Bits [31:0] in the table below |
| Set | 708h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|----------|---|
| [31:8] | Rsvd | R | 0000000h | Reserved |
| [7] | Enable | RW | 0 | 0 = Unsolicited Responses disabled for this node 1 = Unsolicited Responses enabled for this node |
| [6] | Rsvd | R | 0 | Reserved |
| [5:0] | Tag | RW | 07h | A software programmable tag value that is returned in the top six bits (31:26) of every Unsolicited Response from this node. The default for <i>Tag</i> is equal to the Node ID. |

Note: The Unsolicited Response for the AFG node is defined in the "Unsolicited Responses" section.

UNSOLICITED RESPONSE PRIORITY CONTROL VERB (VENDOR-SPECIFIC)

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F8Eh | 00h | Bits [31:0] in the table below |
| Set | 78Eh | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|-----------|--|
| [31:5] | Rsvd | R | 00000000h | Reserved |
| [4:0] | Priority | RW | 00h | Assigns a priority setting for queued Unsolicited Responses. Nodes with the lowest value have the highest priority, and so go to the front of the Unsolicited Response queue. Nodes with the same value for priority are queued on first-to-trigger basis. 00h = Highest priority ... 1Fh = Lowest priority |

RESERVED (NID = 08H)

- 00h
- 01h
- 02h
- 03h
- 04h
- 05h
- 06h
- 07h
- 08h**
- 09h
- 0Ah
- 0Bh
- 0Ch
- 0Dh
- 0Eh
- 0Fh
- 10h
- 11h
- 12h
- 13h
- 14h
- 15h
- 16h
- 17h

MIC1 MUX SELECTOR WIDGET (NID = 09H)**GET PARAMETER VERB**

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|--------------------|-----------------|
| Get | F00h | Parameter ID (PID) | Parameter Value |

Audio Widget Capabilities Parameter (PID = 09h)

| Bit | Bitfield Name | RW | Default | Description |
|---------|------------------------|----|---------|--|
| [31:24] | Rsvd | R | 00h | Reserved |
| [23:20] | Type | R | 3h | Indicates that this is an Audio Selector Widget |
| [19:16] | Delay | R | 0h | Latency not reported |
| [15:12] | Rsvd | R | 0h | Reserved |
| [11] | L-R Swap | R | 0 | Left/Right swap capability not supported |
| [10] | PowerCntrl | R | 0 | Indicates that the <i>Power State Verb</i> is not supported in this widget |
| [9] | Digital | R | 0 | Indicates that this widget is translating analogue data |
| [8] | Conn List | R | 1 | Indicates that a connection list is present |
| [7] | Unsol Capable | R | 0 | Widget supports Unsolicited Responses |
| [6] | ProcWidget | R | 0 | Widget does not have processing capabilities |
| [5] | Stripe | R | 0 | Widget does not support striping |
| [4] | Format Override | R | 0 | Widget does not override the format defined for the AFG |
| [3] | Amp Parameter Override | R | 0 | Not applicable as this widget does not have amplifier capabilities |
| [2] | Out Amp Present | R | 0 | Output amplifier is not present in this widget |
| [1] | In Amp Present | R | 0 | Input amplifier not present in this widget |
| [0] | Stereo | R | 1 | Indicates that this is a stereo widget |

Connection List Length Parameter (PID = 0Eh)

| Bit | Bitfield Name | RW | Default | Description |
|--------|------------------------|----|---------|--|
| [31:8] | Rsvd | R | 000000h | Reserved |
| [7] | Long Form | R | 0 | Indicates that the connection list items are in short form |
| [6:0] | Connection List Length | R | 02h | Indicates that there is 2 NID entries in the connection list |

CONNECTION SELECT CONTROL VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F01h | 00h | Bits [31:0] in the table below |
| Set | 701h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|------------------|----|---------|---|
| [31:8] | Rsvd | R | 000000h | Reserved |
| [7:0] | Connection Index | RW | 00h | Connection index currently set: 00h = Connection list entry 0 01h = Connection list entry 1 02h-FFh = Reserved |

GET CONNECTION LIST ENTRY VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|-----|---------|---------------|--------------------------------|
| Get | F02h | 00h | Bits [31:0] in the table below |

| Bit | Bitfield Name | RW | Default | Description |
|---------|-------------------|----|---------|--|
| [31:24] | Conn List Entry 3 | R | 00h | Unused connection list entry |
| [23:16] | Conn List Entry 2 | R | 00h | Unused connection list entry |
| [15:8] | Conn List Entry 1 | R | 0Eh | Indicates that the MIC1 Mux Widget connects to the Port-D Pin Widget (NID = 0Eh) Note: When the MIC1 Widget (NID=03h) is in power state D0, and the MIC1 Mux Widget sources Port-D (Digital Microphone), the analogue circuitry for the ADC, PGA, and MICBIAS is disabled to save power. Also, the DMICCLK is automatically enabled and runs at a rate determined by the MIC1 <i>Stream Format</i> verb. |
| [7:0] | Conn List Entry 0 | R | 0Bh | Indicates that the MIC1 Mux Selector Widget connects to the PGA2 Widget (NID = 0Bh) |

PGA1 SELECTOR WIDGET (NID = 0AH)

AMPLIFIER GAIN/MUTE VERB

| | Verb ID | Payload [15:0] | Response[31:0] |
|-----|---------|------------------------------------|---|
| Get | Bh | A000h | Bits [31:0] in the response table below – applies to the left channel only |
| Get | Bh | 8000h | Bits [31:0] in the response table below – applies to the right channel only |
| Set | 3h | Bits [15:0] in the set table below | 00000000h |

Response Table:

| Bit | Bitfield Name | RW | Default | Description |
|--------|----------------|----|---------|--|
| [31:8] | Rsvd | R | 000000h | Reserved |
| [7] | Amplifier Mute | R | 1 | Shows the amplifier mute status of the selected channel: 0 = Normal 1 = Muted |
| [6:0] | Amplifier Gain | R | 18h | Shows the amplifier gain setting (step number) for the selected channel. The actual gain applied is determined by the <i>Output Amplifier Capabilities Parameter</i> , and is shown below for convenience: 00h = -12dB 01h = -11.5dB ... 0.5dB steps 2Fh = +11.5dB 30h = +12dB Note: If the <i>BTL</i> register in the Port-E Pin Widget (NID=0Ch) <i>EAPD/BTL Verb</i> is set to 0, the input is single-ended and the actual gain setting applied has an offset of -3dB from the setting configured by the <i>Gain</i> register. |

Set Table:

| Bit | Bitfield Name | RW | Default | Description |
|--------|----------------|----|---------|---|
| [15] | Set Output Amp | W | 1 | Indicates that the programming refers to the output amplifier on this widget |
| [14] | Set Input Amp | W | 0 | Not applicable to this widget |
| [13] | Set Left Amp | W | 1 | 0 = Left channel amplifier does not accept the values in <i>Mute</i> or <i>Gain</i> fields 1 = Left channel amplifier does accept the values in the <i>Mute</i> and <i>Gain</i> fields |
| [12] | Set Right Amp | W | 1 | 0 = Right channel amplifier does not accept the values in <i>Mute</i> or <i>Gain</i> fields 1 = Right channel amplifier does accept the values in the <i>Mute</i> and <i>Gain</i> fields |
| [11:8] | Index | W | 0h | Not applicable to this widget |
| [7] | Mute | W | 1 | 0 = Normal operation 1 = Mute Note: When mute is applied to a channel, the data value is overwritten with all zeros. |
| [6:0] | Gain | W | 18h | Step number of the gain – see <i>Amplifier Gain</i> in response table above for details of actual gain values |

GET PARAMETER VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|-----|---------|--------------------|-----------------|
| Get | F00h | Parameter ID (PID) | Parameter Value |

Audio Widget Capabilities Parameter (PID = 09h)

| Bit | Bitfield Name | RW | Default | Description |
|---------|------------------------|----|---------|--|
| [31:24] | Rsvd | R | 00h | Reserved |
| [23:20] | Type | R | 3h | Indicates that this is an Audio Selector Widget |
| [19:16] | Delay | R | 0h | Latency not reported |
| [15:12] | Rsvd | R | 0h | Reserved |
| [11] | L-R Swap | R | 0 | Left/Right swap capability not supported |
| [10] | PowerCntrl | R | 0 | Indicates that the <i>Power State Verb</i> is not supported in this widget |
| [9] | Digital | R | 0 | Indicates that this widget is translating analogue data |
| [8] | Conn List | R | 1 | Indicates that a connection list is present |
| [7] | Unsol Capable | R | 0 | Widget supports Unsolicited Responses |
| [6] | ProcWidget | R | 0 | Widget does not have processing capabilities |
| [5] | Stripe | R | 0 | Widget does not support striping |
| [4] | Format Override | R | 0 | Widget does not override the format defined for the AFG |
| [3] | Amp Parameter Override | R | 1 | The AFG amplifier parameters are overridden for this node |
| [2] | Out Amp Present | R | 1 | Output amplifier is present in this widget |
| [1] | In Amp Present | R | 0 | Input amplifier not present in this widget |
| [0] | Stereo | R | 1 | Indicates that this is a stereo widget |

Connection List Length Parameter (PID = 0Eh)

| Bit | Bitfield Name | RW | Default | Description |
|--------|------------------------|----|---------|--|
| [31:8] | Rsvd | R | 000000h | Reserved |
| [7] | Long Form | R | 0 | Indicates that the connection list items are in short form |
| [6:0] | Connection List Length | R | 01h | Indicates that there is 1 NID entries in the connection list |

Output Amplifier Capabilities Response Format (PID = 12h)

| Bit | Bitfield Name | RW | Default | Description |
|---------|---------------|----|---------|--|
| [31] | Mute Capable | R | 1 | PGA1 is capable of muting |
| [30:23] | Rsvd | R | 0000h | Reserved |
| [22:16] | Step Size | R | 01h | Gain step size is 0.5dB |
| [15] | Rsvd | R | 0 | Reserved |
| [14:8] | Num Steps | R | 30h | Number of steps in gain range is 49 (-12dB to +12dB) |
| [7] | Rsvd | R | 0 | Reserved |
| [6:0] | Offset | R | 18h | The step number that 0dB corresponds to is 18h |

GET CONNECTION LIST ENTRY VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|-----|---------|---------------|--------------------------------|
| Get | F02h | 00h | Bits [31:0] in the table below |

| Bit | Bitfield Name | RW | Default | Description |
|---------|-------------------|----|---------|--|
| [31:24] | Conn List Entry 3 | R | 00h | Unused connection list entry |
| [23:16] | Conn List Entry 2 | R | 00h | Unused connection list entry |
| [15:8] | Conn List Entry 1 | R | 00h | Unused connection list entry |
| [7:0] | Conn List Entry 0 | R | 0Ch | Indicates that the PGA1 Widget connects to the Port-E Pin Widget (NID = 0Ch) |

PGA CONTROL VERB (VENDOR-SPECIFIC)

| | Verb ID | Payload [7:0] | Response[31:0] |
|-------------|---------|--------------------------------|--------------------------------|
| Get | FB2h | 00h | Bits [31:0] in the table below |
| Set1 | 7B2h | Bits [7:0] in the table below | 00000000h |
| Set2 | 7B3h | Bits [15:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|---------|----------------|----|---------|---|
| [31:14] | Rsvd | R | 00000h | Reserved |
| [13:0] | Terminal Count | RW | 1FFFh | <p>Set the period of the zero detect timeout clock:</p> <p>0000h = Timeout disabled</p> <p>0001h to 03FFh = Reserved</p> <p>0400h = 1025 x 20.833µs (21.3ms)</p> <p>0401h = 1026 x 20.833µs (21.4ms)</p> <p>...</p> <p>1FFFh = 8192 x 20.833µs (171ms)</p> <p>...</p> <p>3FFFh = 16384 x 20.833µs (341ms)</p> <p>Note: The timeout clock uses the SYNC signal from the HDA interface, so the absolute value of the timeout period will depend on the absolute accuracy of the SYNC signal.</p> |

PGA2 SELECTOR WIDGET (NID = 0BH)

AMPLIFIER GAIN/MUTE VERB

| | Verb ID | Payload [15:0] | Response[31:0] |
|-----|---------|------------------------------------|---|
| Get | Bh | A000h | Bits [31:0] in the response table below – applies to the left channel only |
| Get | Bh | 8000h | Bits [31:0] in the response table below – applies to the right channel only |
| Set | 3h | Bits [15:0] in the set table below | 00000000h |

Response Table:

| Bit | Bitfield Name | RW | Default | Description |
|--------|----------------|----|---------|---|
| [31:8] | Rsvd | R | 000000h | Reserved |
| [7] | Amplifier Mute | R | 1 | Shows the amplifier mute status of the selected channel: 0 = Normal 1 = Muted |
| [6:0] | Amplifier Gain | R | 18h | Shows the amplifier gain setting (step number) for the selected channel. The actual gain applied is determined by the <i>Output Amplifier Capabilities Parameter</i> , and is shown below for convenience: 00h = -12dB 01h = -11.5dB ... 0.5dB steps 2Fh = +11.5dB 30h = +12dB |

Set Table:

| Bit | Bitfield Name | RW | Default | Description |
|--------|----------------|----|---------|---|
| [15] | Set Output Amp | W | 1 | Indicates that the programming refers to the output amplifier on this widget |
| [14] | Set Input Amp | W | 0 | Not applicable to this widget |
| [13] | Set Left Amp | W | 1 | 0 = Left channel amplifier does not accept the values in <i>Mute</i> or <i>Gain</i> fields 1 = Left channel amplifier does accept the values in the <i>Mute</i> and <i>Gain</i> fields |
| [12] | Set Right Amp | W | 1 | 0 = Right channel amplifier does not accept the values in <i>Mute</i> or <i>Gain</i> fields 1 = Right channel amplifier does accept the values in the <i>Mute</i> and <i>Gain</i> fields |
| [11:8] | Index | W | 0h | Not applicable to this widget |
| [7] | Mute | W | 1 | 0 = Normal operation 1 = Mute Note: When mute is applied to a channel, the data value is overwritten with all zeros. |
| [6:0] | Gain | W | 18h | Step number of the gain – see <i>Amplifier Gain</i> in response table above for details of actual gain values |

GET PARAMETER VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|-----|---------|--------------------|-----------------|
| Get | F00h | Parameter ID (PID) | Parameter Value |

Audio Widget Capabilities Parameter (PID = 09h)

| Bit | Bitfield Name | RW | Default | Description |
|---------|------------------------|----|---------|--|
| [31:24] | Rsvd | R | 00h | Reserved |
| [23:20] | Type | R | 3h | Indicates that this is an Audio Selector Widget |
| [19:16] | Delay | R | 0h | Latency not reported |
| [15:12] | Rsvd | R | 0h | Reserved |
| [11] | L-R Swap | R | 0 | Left/Right swap capability not supported |
| [10] | PowerCntrl | R | 0 | Indicates that the <i>Power State Verb</i> is not supported in this widget |
| [9] | Digital | R | 0 | Indicates that this widget is translating analogue data |
| [8] | Conn List | R | 1 | Indicates that a connection list is present |
| [7] | Unsol Capable | R | 0 | Widget supports Unsolicited Responses |
| [6] | ProcWidget | R | 0 | Widget does not have processing capabilities |
| [5] | Stripe | R | 0 | Widget does not support striping |
| [4] | Format Override | R | 0 | Widget does not override the format defined for the AFG |
| [3] | Amp Parameter Override | R | 1 | The AFG amplifier parameters are overridden for this node |
| [2] | Out Amp Present | R | 1 | Output amplifier is present in this widget |
| [1] | In Amp Present | R | 0 | Input amplifier not present in this widget |
| [0] | Stereo | R | 1 | Indicates that this is a stereo widget |

Connection List Length Parameter (PID = 0Eh)

| Bit | Bitfield Name | RW | Default | Description |
|--------|------------------------|----|---------|--|
| [31:8] | Rsvd | R | 000000h | Reserved |
| [7] | Long Form | R | 0 | Indicates that the connection list items are in short form |
| [6:0] | Connection List Length | R | 01h | Indicates that there is 1 NID entry in the connection list |

Output Amplifier Capabilities Response Format (PID = 12h)

| Bit | Bitfield Name | RW | Default | Description |
|---------|---------------|----|---------|--|
| [31] | Mute Capable | R | 1 | PGA2 is capable of muting |
| [30:23] | Rsvd | R | 0000h | Reserved |
| [22:16] | Step Size | R | 01h | Gain step size is 0.5dB |
| [15] | Rsvd | R | 0 | Reserved |
| [14:8] | Num Steps | R | 30h | Number of steps in gain range is 49 (-12dB to +12dB) |
| [7] | Rsvd | R | 0 | Reserved |
| [6:0] | Offset | R | 18h | The step number that 0dB corresponds to is 18h |

GET CONNECTION LIST ENTRY VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|-----|---------|---------------|--------------------------------|
| Get | F02h | 00h | Bits [31:0] in the table below |

| Bit | Bitfield Name | RW | Default | Description |
|---------|-------------------|----|---------|--|
| [31:24] | Conn List Entry 3 | R | 00h | Unused connection list entry |
| [23:16] | Conn List Entry 2 | R | 00h | Unused connection list entry |
| [15:8] | Conn List Entry 1 | R | 00h | Unused connection list entry |
| [7:0] | Conn List Entry 0 | R | 0Dh | Indicates that the PGA2 Widget connects to the Port-B Pin Widget (NID = 0Dh) |

PGA CONTROL VERB (VENDOR-SPECIFIC)

| | Verb ID | Payload [7:0] | Response[31:0] |
|------|---------|--------------------------------|--------------------------------|
| Get | FB2h | 00h | Bits [31:0] in the table below |
| Set1 | 7B2h | Bits [7:0] in the table below | 00000000h |
| Set2 | 7B3h | Bits [15:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|---------|----------------|----|---------|---|
| [31:14] | Rsvd | R | 00000h | Reserved |
| [13:0] | Terminal Count | RW | 1FFFh | <p>Set the period of the zero detect timeout clock:</p> <p>0000h = Timeout disabled</p> <p>0001h to 03FFh = Reserved</p> <p>0400h = 1025 x 20.833µs (21.3ms)</p> <p>0401h = 1026 x 20.833µs (21.4ms)</p> <p>...</p> <p>1FFFh = 8192 x 20.833µs (171ms)</p> <p>...</p> <p>3FFFh = 16384 x 20.833µs (341ms)</p> <p>Note: The timeout clock uses the SYNC signal from the HDA interface, so the absolute value of the timeout period will depend on the absolute accuracy of the SYNC signal.</p> |

PORT-E PIN COMPLEX WIDGET (NID = 0CH)**GET PARAMETER VERB**

| | Verb ID | Payload [7:0] | Response[31:0] |
|-----|---------|--------------------|-----------------|
| Get | F00h | Parameter ID (PID) | Parameter Value |

Audio Widget Capabilities Parameter (PID = 09h)

| Bit | Bitfield Name | RW | Default | Description |
|---------|------------------------|----|---------|--|
| [31:24] | Rsvd | R | 00h | Reserved |
| [23:20] | Type | R | 4h | Indicates that this is a Pin Complex Widget |
| [19:16] | Delay | R | 0h | Latency not reported |
| [15:12] | Rsvd | R | 0h | Reserved |
| [11] | L-R Swap | R | 0 | Left/Right swap capability not supported |
| [10] | PowerCntrl | R | 0 | Indicates that the <i>Power State Verb</i> is not supported in this widget |
| [9] | Digital | R | 0 | Indicates that this widget is translating analogue data |
| [8] | Conn List | R | 0 | Indicates that a connection list is not present |
| [7] | Unsol Capable | R | 1 | Widget supports Unsolicited Responses |
| [6] | ProcWidget | R | 0 | Widget does not have processing capabilities |
| [5] | Stripe | R | 0 | Widget does not support striping |
| [4] | Format Override | R | 0 | Widget does not override the format defined for the AFG |
| [3] | Amp Parameter Override | R | 0 | Not applicable as this widget does not have amplifier capabilities |
| [2] | Out Amp Present | R | 0 | Output Amplifier not present in this widget |
| [1] | In Amp Present | R | 0 | Input amplifier not present in this widget |
| [0] | Stereo | R | 1 | Indicates that this is a stereo widget |

Pin Capabilities Parameter (PID = 0Ch)

| Bit | Bitfield Name | RW | Default | Description |
|---------|-------------------------|----|---------|--|
| [31:17] | Rsvd | R | 0000h | Reserved |
| [16] | EAPD Capable | R | 0 | Widget does not support an EAPD pin |
| [15:8] | VRef Control | R | 00h | VRef not supported |
| [7] | Rsvd | R | 0 | Reserved |
| [6] | Balanced I/O Pins | R | 1 | Indicates that this widget has balanced pins |
| [5] | Input Capable | R | 1 | Indicates that this widget is input capable |
| [4] | Output Capable | R | 0 | Indicates that this widget is not output capable |
| [3] | Headphone Drive Capable | R | 0 | Not applicable as this is an input port |
| [2] | Presence Detect Capable | R | 1 | Indicates that this widget can perform presence detection via the Pin Sense Verb |
| [1] | Trigger Required | R | 0 | Impedance measurement not supported |
| [0] | Impedance Sense Capable | R | 0 | Impedance measurement not supported |

PIN WIDGET CONTROL VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F07h | 00h | Bits [31:0] in the table below |
| Set | 707h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|---------|---|
| [31:8] | Rsvd | R | 000000h | Reserved |
| [7] | H-Phn Enable | R | 0 | Not applicable as this in an input port |
| [6] | Out Enable | R | 0 | Not applicable as this in an input port |
| [5] | In Enable | RW | 1 | Controls the input path: 0 = Input path is disabled 1 = Input path is enabled |
| [4:3] | Rsvd | R | 0h | Reserved |
| [2:0] | VRefEn | R | 0h | Selectable VRef not supported |

UNSOLICITED RESPONSE VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F08h | 00h | Bits [31:0] in the table below |
| Set | 708h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|---------|---|
| [31:8] | Rsvd | R | 000000h | Reserved |
| [7] | Enable | RW | 0 | 0 = Unsolicited Responses disabled for this node 1 = Unsolicited Responses enabled for this node |
| [6] | Rsvd | R | 0 | Reserved |
| [5:0] | Tag | RW | 0Ch | A software programmable tag value that is returned in the top six bits (31:26) of every Unsolicited Response from this node. The default for <i>Tag</i> is equal to the Node ID. |

Note: The Unsolicited Response for the AFG node is defined in the “Unsolicited Responses” section.

PIN SENSE VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|---------------|--------------------------------|
| Get | F09h | 00h | Bits [31:0] in the table below |

| Bit | Bitfield Name | RW | Default | Description |
|--------|-----------------|----|-----------|--|
| [31] | Presence Detect | R | 0 | 0 = nothing plugged into Port-E 1 = something plugged into Port-E |
| [30:0] | Impedance Sense | R | 00000000h | Impedance sense not supported |

EAPD/BTL VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F0Ch | 00h | Bits [31:0] in the table below |
| Set | 70Ch | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|---------|---|
| [31:1] | Rsvd | R | 000000h | Reserved |
| [0] | BTL | RW | 1 | Controls the configuration of the input pins on Port-E: 0 = Single-ended mode 1 = BTL (balanced) mode |

CONFIGURATION DEFAULT VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|-------------|---------|---------------------------------|--------------------------------|
| Get | F1Ch | 00h | Bits [31:0] in the table below |
| Set1 | 71Ch | Bits [7:0] in the table below | 00000000h |
| Set2 | 71Dh | Bits [15:8] in the table below | 00000000h |
| Set3 | 71Eh | Bits [23:16] in the table below | 00000000h |
| Set4 | 71Fh | Bits [31:24] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|---------|-------------------|----|---------|--|
| [31:30] | Port Connectivity | RW | 0h | Indicates the external connectivity: 0h = Jack 1h = No physical connection 2h = A fixed function device 3h = both a jack and an internal device are connected |
| [29:28] | Location[5:4] | RW | 0h | Gross physical location of the device connected to Port-E: 0h = External on primary chassis 1h = Internal 2h = Separate chassis 3h = Other |
| [27:24] | Location[3:0] | RW | 1h | Geometric location of the device connected to Port-E: 0h = Not applicable 1h = Rear 2h = Front 3h = Left 4h = Right 5h = Top 6h = Bottom 7h = Special 8h = Special 9h = Special Ah-Fh = Reserved |
| [23:20] | Default Device | RW | 8h | Indicates the intended use of Port-E: 0h = Line out 1h = Speaker 2h = Headphone out 3h = CD 4h = S/PDIF out 5h = Digital other out 6h = Modem line side 7h = Modem handset side 8h = Line in 9h = AUX Ah = Mic in Bh = Telephony Ch = S/PDIF in Dh = Digital other in Eh = Reserved Fh = Other |

| Bit | Bitfield Name | RW | Default | Description |
|---------|---------------------|----|---------|--|
| [19:16] | Connection Type | RW | 1h | Indicates the type of physical interface on Port-E: 0h = Unknown 1h = 3.5mm stereo/mono jack 2h = 1/4" stereo/mono jack 3h = ATAPI internal 4h = RCA jack (for analogue audio or coaxial S/PDIF) 5h = Optical 6h = Other digital 7h = Other analogue 8h = Multi-channel analogue (DIN) 9h = XLR/Professional Ah = RJ-11 (modem) Bh = Combination Ch-Eh = Reserved Fh = Other |
| [15:12] | Colour | RW | 3h | Indicates the colour of the physical jack on Port-E: 0h = Unknown 1h = Black 2h = Grey 3h = Blue 4h = Green 5h = Red 6h = Orange 7h = Yellow 8h = Purple 9h = Pink Ah-Dh = Reserved Eh = White Fh = Other |
| [11:8] | Misc | RW | 0h | Presence detection override: 0h = Presence detection indicated by <i>Pin Capabilities Parameter</i> 1h = Presence detection not supported. If the <i>Pin Capabilities Parameter</i> indicates that that presence detection is supported by the node, then this bit is used to override it to indicate the external circuitry is not capable of supporting presence detect All other values are reserved |
| [7:4] | Default Association | RW | Fh | Association number: 0h = Reserved 1h-Eh = Multi Channel or Single Pin Widget Fh = Single Pin Widget Only |
| [3:0] | Sequence | RW | 0h | Sequence number used to define individual channel pairs within a stream. All values (0h-Fh) are available for use. Use a value of 0h for Single Pin Widget. |

Note: The *Configuration Default Verb* is not reset to its default value during a reset from any source. The settings are only lost when digital power is removed from the WM8860. When digital power is restored, the System BIOS must restore the settings.

UNSOLICITED RESPONSE PRIORITY CONTROL VERB (VENDOR-SPECIFIC)

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F8Eh | 00h | Bits [31:0] in the table below |
| Set | 78Eh | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|----------|--|
| [31:5] | Rsvd | R | 0000000h | Reserved |
| [4:0] | Priority | RW | 00h | Assigns a priority setting for queued Unsolicited Responses. Nodes with the lowest value have the highest priority, and so go to the front of the Unsolicited Response queue. Nodes with the same value for priority are queued on first-to-trigger basis. 00h = Highest priority ... 1Fh = Lowest priority |

AUTO-MUTE CONTROL VERB (VENDOR-SPECIFIC)

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | FB0h | 00h | Bits [31:0] in the table below |
| Set | 7B0h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|----------|---|
| [31:1] | Rsvd | R | 0000000h | Reserved |
| [0] | PD_AUTOMUTE | RW | 0 | Controls the WM8860 automute behavior when there is nothing plugged into Port-E: 0 = Automute disabled 1 = Automute enabled Note: When PD_AUTOMUTE=1 and Presence Detect (bit 31 in verb F09h)=1 the WM8860 will replace the samples in the stream with zeros |

PORT-B PIN COMPLEX WIDGET (NID = 0DH)

AMPLIFIER GAIN/MUTE VERB

| | Verb ID | Payload [15:0] | Response[31:0] |
|-----|---------|------------------------------------|---|
| Get | Bh | 2000h | Bits [31:0] in the response table below – applies to the left channel only |
| Get | Bh | 0000h | Bits [31:0] in the response table below – applies to the right channel only |
| Set | 3h | Bits [15:0] in the set table below | 00000000h |

Response Table:

| Bit | Bitfield Name | RW | Default | Description |
|--------|----------------|----|---------|---|
| [31:8] | Rsvd | R | 000000h | Reserved |
| [7] | Amplifier Mute | R | 0 | Mute not supported |
| [6:0] | Amplifier Gain | R | 00h | Shows the amplifier gain setting (step number) for the selected channel. The actual gain applied is determined by the <i>Input Amplifier Capabilities Parameter</i> in the AFG (NID = 01h), and is shown below for convenience: 00h = 0dB 01h = +10dB 02h = +20dB 03h = +30dB |

Set Table:

| Bit | Bitfield Name | RW | Default | Description |
|--------|----------------|----|---------|---|
| [15] | Set Output Amp | R | 0 | Not applicable to this widget |
| [14] | Set Input Amp | W | 1 | Indicates that the programming refers to the input amplifier on this widget |
| [13] | Set Left Amp | W | 1 | 0 = Left channel amplifier does not accept the values in <i>Mute</i> or <i>Gain</i> fields 1 = Left channel amplifier does accept the values in the <i>Mute</i> and <i>Gain</i> fields |
| [12] | Set Right Amp | W | 1 | 0 = Right channel amplifier does not accept the values in <i>Mute</i> or <i>Gain</i> fields 1 = Right channel amplifier does accept the values in the <i>Mute</i> and <i>Gain</i> fields |
| [11:8] | Index | R | 0h | Not applicable to this widget |
| [7] | Mute | R | 0 | Mute not supported |
| [6:0] | Gain | W | 0h | Step number of the gain – see <i>Amplifier Gain</i> in response table above for details of actual gain values Note: Port-B amplifier implements Mic-Boost. The gain setting is always applied to both left and right channels when either (or both) the <i>Set Left Amp</i> or <i>Set Right Amp</i> registers are set. Dedicated boost settings for each channel are not supported. |

GET PARAMETER VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|-----|---------|--------------------|-----------------|
| Get | F00h | Parameter ID (PID) | Parameter Value |

Audio Widget Capabilities Parameter (PID = 09h)

| Bit | Bitfield Name | RW | Default | Description |
|---------|------------------------|----|---------|--|
| [31:24] | Rsvd | R | 00h | Reserved |
| [23:20] | Type | R | 4h | Indicates that this is a Pin Complex Widget |
| [19:16] | Delay | R | 0h | Latency not reported |
| [15:12] | Rsvd | R | 0h | Reserved |
| [11] | L-R Swap | R | 0 | Left/Right swap capability not supported |
| [10] | PowerCntrl | R | 0 | Indicates that the <i>Power State Verb</i> is not supported in this widget |
| [9] | Digital | R | 0 | Indicates that this widget is translating analogue data |
| [8] | Conn List | R | 0 | Indicates that a connection list is not present |
| [7] | Unsol Capable | R | 1 | Widget supports Unsolicited Responses |
| [6] | ProcWidget | R | 0 | Widget does not have processing capabilities |
| [5] | Stripe | R | 0 | Widget does not support striping |
| [4] | Format Override | R | 0 | Widget does not override the format defined for the AFG |
| [3] | Amp Parameter Override | R | 0 | The AFG amplifier parameters are used for this widget |
| [2] | Out Amp Present | R | 0 | Output amplifier not present in this widget |
| [1] | In Amp Present | R | 1 | Input amplifier is present in this widget |
| [0] | Stereo | R | 1 | Indicates that this is a stereo widget |

Pin Capabilities Parameter (PID = 0Ch)

| Bit | Bitfield Name | RW | Default | Description |
|---------|-------------------------|----|---------|--|
| [31:17] | Rsvd | R | 0000h | Reserved |
| [16] | EAPD Capable | R | 0 | Widget does not support an EAPD pin |
| [15:8] | VRef Control | R | 17h | Indicates that the MICBIAS pin supports the following voltage levels: <ul style="list-style-type: none"> • Hi-Z • Ground • AVDD1 * 50% • AVDD1 * 80% |
| [7] | Rsvd | R | 0 | Reserved |
| [6] | Balanced I/O Pins | R | 1 | Indicates that this widget has balanced pins |
| [5] | Input Capable | R | 1 | Indicates that this widget is input capable |
| [4] | Output Capable | R | 0 | Indicates that this widget is not output capable |
| [3] | Headphone Drive Capable | R | 0 | Not applicable as this in an input port |
| [2] | Presence Detect Capable | R | 1 | Indicates that this Widget can perform presence detection |
| [1] | Trigger Required | R | 1 | Indicates that impedance measurement uses the <i>Execute</i> command that is part of the <i>Pin Sense Verb</i> |
| [0] | Impedance Sense Capable | R | 1 | Impedance measurement supported |

PIN WIDGET CONTROL VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F07h | 00h | Bits [31:0] in the table below |
| Set | 707h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|---------|--|
| [31:8] | Rsvd | R | 000000h | Reserved |
| [7] | H-Phn Enable | R | 0 | Not applicable as this in an input port |
| [6] | Out Enable | R | 0 | Not applicable as this in an input port |
| [5] | In Enable | RW | 1 | Controls the input path: 0 = Input path is disabled 1 = Input path is enabled |
| [4:3] | Rsvd | R | 0 | Reserved |
| [2:0] | VRefEn | RW | 0h | MICBIAS control: 0h = Hi-Z 1h = AVDD1 * 50% 2h = Ground (0V) 3h = Reserved 4h = AVDD1 * 80% 5h-7h = Reserved Note: If VRefEn is set to a reserved value, the value programmed will be 0h (Hi-Z) to avoid any potential damage to external components |

UNSOLICITED RESPONSE VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F08h | 00h | Bits [31:0] in the table below |
| Set | 708h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|---------|---|
| [31:8] | Rsvd | R | 000000h | Reserved |
| [7] | Enable | RW | 0 | 0 = Unsolicited Responses disabled for this node 1 = Unsolicited Responses enabled for this node |
| [6] | Rsvd | R | 0 | Reserved |
| [5:0] | Tag | RW | 0Dh | A software programmable tag value that is returned in the top six bits (31:26) of every Unsolicited Response from this node. The default for <i>Tag</i> is equal to the Node ID. |

Note: The Unsolicited Response for the AFG node is defined in the "Unsolicited Responses" section.

PIN SENSE VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|----------------|---------|---------------|--------------------------------|
| Get | F09h | 00h | Bits [31:0] in the table below |
| Execute | 709h | 00h | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|-----------------|----|-----------|--|
| [31] | Presence Detect | R | 0 | 0 = nothing plugged into Port-B 1 = something plugged into Port-B |
| [30:0] | Impedance Sense | R | 7FFFFFFFh | Impedance sense value: 7FFFFFFFh = measurement not ready |

EAPD/BTL VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F0Ch | 00h | Bits [31:0] in the table below |
| Set | 70Ch | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|---------|---|
| [31:1] | Rsvd | R | 000000h | Reserved |
| [0] | BTL | RW | 1 | Controls the configuration of the input pins on Port-B: 0 = Single-ended mode 1 = BTL (balanced) mode |

CONFIGURATION DEFAULT VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|-------------|---------|---------------------------------|--------------------------------|
| Get | F1Ch | 00h | Bits [31:0] in the table below |
| Set1 | 71Ch | Bits [7:0] in the table below | 00000000h |
| Set2 | 71Dh | Bits [15:8] in the table below | 00000000h |
| Set3 | 71Eh | Bits [23:16] in the table below | 00000000h |
| Set4 | 71Fh | Bits [31:24] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|---------|-------------------|----|---------|---|
| [31:30] | Port Connectivity | RW | 0h | Indicates the external connectivity: 0h = Jack 1h = No physical connection 2h = A fixed function device 3h = both a jack and an internal device are connected |
| [29:28] | Location[5:4] | RW | 0h | Gross physical location of the device connected to Port-B: 0h = External on primary chassis 1h = Internal 2h = Separate chassis 3h = Other |
| [27:24] | Location[3:0] | RW | 2h | Geometric location of the device connected to Port-B: 0h = Not applicable 1h = Rear 2h = Front 3h = Left 4h = Right 5h = Top 6h = Bottom 7h = Special 8h = Special 9h = Special Ah-Fh = Reserved |

| Bit | Bitfield Name | RW | Default | Description | |
|---------|-----------------|----|---------|--|--|
| [23:20] | Default Device | RW | Ah | Indicates the intended use of Port-B: 0h = Line out 1h = Speaker 2h = Headphone out 3h = CD 4h = S/PDIF out 5h = Digital other out 6h = Modem line side 7h = Modem handset side 8h = Line in 9h = AUX Ah = Mic in Bh = Telephony Ch = S/PDIF in Dh = Digital other in Eh = Reserved Fh = Other | 00h 01h 02h 03h 04h 05h 06h 07h |
| [19:16] | Connection Type | RW | 1h | Indicates the type of physical interface on Port-B: 0h = Unknown 1h = 3.5mm stereo/mono jack 2h = 1/4" stereo/mono jack 3h = ATAPI internal 4h = RCA jack (for analogue audio or coaxial S/PDIF) 5h = Optical 6h = Other digital 7h = Other analogue 8h = Multi-channel analogue (DIN) 9h = XLR/Professional Ah = RJ-11 (modem) Bh = Combination Ch-Eh = Reserved Fh = Other | 08h 09h 0Ah 0Bh 0Ch 0Dh |
| [15:12] | Colour | RW | 9h | Indicates the colour of the physical jack on Port-B: 0h = Unknown 1h = Black 2h = Grey 3h = Blue 4h = Green 5h = Red 6h = Orange 7h = Yellow 8h = Purple 9h = Pink Ah-Dh = Reserved Eh = White Fh = Other | 0Eh 0Fh 10h 11h 12h 13h |
| [11:8] | Misc | RW | 0h | Presence detection override: 0 = Presence detection indicated by <i>Pin Capabilities Parameter</i> 1 = Presence detection not supported. If the <i>Pin Capabilities Parameter</i> indicates that that presence detection is supported by the node, then this bit is used to override it to indicate the external circuitry is not capable of supporting presence detect All other values are reserved | 14h 15h 16h 17h |

| Bit | Bitfield Name | RW | Default | Description |
|-------|---------------------|----|---------|--|
| [7:4] | Default Association | RW | Fh | Association number: 0h = Reserved 1h-Eh = Multi Channel or Single Pin Widget Fh = Single Pin Widget Only |
| [3:0] | Sequence | RW | 0h | Sequence number used to define individual channel pairs within a stream. All values (0h-Fh) are available for use. Use a value of 0h for Single Pin Widget. |

Note: The *Configuration Default Verb* is not reset to its default value during a reset from any source. The settings are only lost when digital power is removed from the WM8860. When digital power is restored, the System BIOS must restore the settings.

UNSOLICITED RESPONSE PRIORITY CONTROL VERB (VENDOR-SPECIFIC)

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F8Eh | 00h | Bits [31:0] in the table below |
| Set | 78Eh | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|----------|--|
| [31:5] | Rsvd | R | 0000000h | Reserved |
| [4:0] | Priority | RW | 00h | Assigns a priority setting for queued Unsolicited Responses. Nodes with the lowest value have the highest priority, and so go to the front of the Unsolicited Response queue. Nodes with the same value for priority are queued on first-to-trigger basis. 00h = Highest priority ... 1Fh = Lowest priority |

DIFFERENTIAL VERB (VENDOR-SPECIFIC)

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | FA3h | 00h | Bits [31:0] in the table below |
| Set | 7A3h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|-------------------|----|----------|--|
| [31:1] | Rsvd | R | 0000000h | Reserved |
| [0] | Differential Mode | RW | 1 | Differential mode: 0 = Differential (Microphone) 1 = Pseudo-differential |

AUTO-MUTE CONTROL VERB (VENDOR-SPECIFIC)

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | FB0h | 00h | Bits [31:0] in the table below |
| Set | 7B0h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|----------|---|
| [31:1] | Rsvd | R | 0000000h | Reserved |
| [0] | PD_AUTOMUTE | RW | 0 | Controls the WM8860 automute behavior when there is nothing plugged into Port-B: 0 = Automute disabled 1 = Automute enabled Note: When <i>PD_AUTOMUTE=1</i> and <i>Presence Detect=1</i> the WM8860 will replace the samples in the stream with zeros |

PORT-D PIN COMPLEX WIDGET (NID = 0EH)

AMPLIFIER GAIN/MUTE VERB

| | Verb ID | Payload [15:0] | Response[31:0] |
|-----|---------|------------------------------------|---|
| Get | Bh | 2000h | Bits [31:0] in the response table below – applies to the left channel only |
| Get | Bh | 0000h | Bits [31:0] in the response table below – applies to the right channel only |
| Set | 3h | Bits [15:0] in the set table below | 00000000h |

Response Table:

| Bit | Bitfield Name | RW | Default | Description |
|--------|----------------|----|---------|--|
| [31:8] | Rsvd | R | 000000h | Reserved |
| [7] | Amplifier Mute | R | 0 | Shows the amplifier mute status of the selected channel: 0 = Normal 1 = Muted |
| [6:0] | Amplifier Gain | R | 18h | Shows the amplifier gain setting (step number) for the selected channel. The actual gain applied is determined by the <i>Input Amplifier Capabilities Parameter</i> , and is shown below for convenience: 00h = -12dB 01h = -11.5dB ... 0.5dB steps 18h = 0dB ... 0.5dB steps 57h = +31.5dB 58h = +32dB |

Set Table:

| Bit | Bitfield Name | RW | Default | Description |
|--------|----------------|----|---------|---|
| [15] | Set Output Amp | W | 0 | Not applicable to this widget |
| [14] | Set Input Amp | W | 1 | Indicates that the programming refers to the input amplifier on this widget |
| [13] | Set Left Amp | W | 1 | 0 = Left channel amplifier does not accept the values in <i>Mute</i> or <i>Gain</i> fields 1 = Left channel amplifier does accept the values in the <i>Mute</i> and <i>Gain</i> fields |
| [12] | Set Right Amp | W | 1 | 0 = Right channel amplifier does not accept the values in <i>Mute</i> or <i>Gain</i> fields 1 = Right channel amplifier does accept the values in the <i>Mute</i> and <i>Gain</i> fields |
| [11:8] | Index | W | 0h | Not applicable to this widget |
| [7] | Mute | W | 0 | 0 = Normal operation 1 = Mute Note: When mute is applied to a channel, the data value is overwritten with all zeros. |
| [6:0] | Gain | W | 18h | Step number of the gain – see <i>Amplifier Gain</i> in response table above for details of actual gain values |

GET PARAMETER VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|-----|---------|--------------------|-----------------|
| Get | F00h | Parameter ID (PID) | Parameter Value |

Audio Widget Capabilities Parameter (PID = 09h)

| Bit | Bitfield Name | RW | Default | Description |
|---------|------------------------|----|---------|--|
| [31:24] | Rsvd | R | 00h | Reserved |
| [23:20] | Type | R | 4h | Indicates that this is a Pin Complex Widget |
| [19:16] | Delay | R | 0h | Latency not reported |
| [15:12] | Rsvd | R | 0h | Reserved |
| [11] | L-R Swap | R | 0 | Left/Right swap capability not supported |
| [10] | PowerCntrl | R | 0 | Indicates that the <i>Power State Verb</i> is not supported in this widget |
| [9] | Digital | R | 1 | Indicates that this widget is translating digital data |
| [8] | Conn List | R | 0 | Indicates that a connection list is not present |
| [7] | Unsol Capable | R | 0 | Widget does not support Unsolicited Responses |
| [6] | ProcWidget | R | 0 | Widget does not have processing capabilities |
| [5] | Stripe | R | 0 | Widget does not support striping |
| [4] | Format Override | R | 0 | Widget does not override the format defined for the AFG |
| [3] | Amp Parameter Override | R | 1 | The AFG amplifier parameters are overridden for this widget node |
| [2] | Out Amp Present | R | 0 | Output amplifier not present in this widget |
| [1] | In Amp Present | R | 1 | Input amplifier is present in this widget |
| [0] | Stereo | R | 1 | Indicates that this is a stereo widget |

Pin Capabilities Parameter (PID = 0Ch)

| Bit | Bitfield Name | RW | Default | Description |
|---------|-------------------------|----|---------|--|
| [31:17] | Rsvd | R | 0000h | Reserved |
| [16] | EAPD Capable | R | 0 | Widget does not support an EAPD pin |
| [15:8] | VRef Control | R | 00h | VRef not supported for Digital Inputs |
| [7] | Rsvd | R | 0 | Reserved |
| [6] | Balanced I/O Pins | R | 0 | Indicates that this widget does not have balanced pins |
| [5] | Input Capable | R | 1 | Indicates that this widget is input capable |
| [4] | Output Capable | R | 0 | Indicates that this widget is not output capable |
| [3] | Headphone Drive Capable | R | 0 | Not applicable as this is an input port |
| [2] | Presence Detect Capable | R | 0 | Presence detection not supported |
| [1] | Trigger Required | R | 0 | Impedance measurement not supported |
| [0] | Impedance Sense Capable | R | 0 | Impedance measurement not supported |

Input Amplifier Capabilities Response Format (PID = 0Dh)

| Bit | Bitfield Name | RW | Default | Description |
|---------|---------------|----|---------|--|
| [31] | Mute Capable | R | 1 | DMIC amplifiers are capable of hard-mute |
| [30:23] | Rsvd | R | 0000h | Reserved |
| [22:16] | Step Size | R | 01h | Gain step size is 0.5dB |
| [15] | Rsvd | R | 0 | Reserved |
| [14:8] | Num Steps | R | 58h | Number of steps in gain range is 89 (-12dB to +32dB) |
| [7] | Rsvd | R | 0 | Reserved |
| [6:0] | Offset | R | 18h | The step number that 0dB corresponds to is 18h |

PIN WIDGET CONTROL VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F07h | 00h | Bits [31:0] in the table below |
| Set | 707h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|---------|---|
| [31:8] | Rsvd | R | 000000h | Reserved |
| [7] | H-Phn Enable | R | 0 | Not applicable as this in an input port |
| [6] | Out Enable | R | 0 | Not applicable as this in an input port |
| [5] | In Enable | RW | 1 | Controls the input path: 0 = Input path is disabled 1 = Input path is enabled |
| [4:3] | Rsvd | R | 0h | Reserved |
| [2:0] | VRefEn | R | 0h | Selectable VRef not supported |

CONFIGURATION DEFAULT VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|-------------|---------|---------------------------------|--------------------------------|
| Get | F1Ch | 00h | Bits [31:0] in the table below |
| Set1 | 71Ch | Bits [7:0] in the table below | 00000000h |
| Set2 | 71Dh | Bits [15:8] in the table below | 00000000h |
| Set3 | 71Eh | Bits [23:16] in the table below | 00000000h |
| Set4 | 71Fh | Bits [31:24] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|---------|-------------------|----|---------|---|
| [31:30] | Port Connectivity | RW | 0h | Indicates the external connectivity: 0h = Jack 1h = No physical connection 2h = A fixed function device 3h = both a jack and an internal device are connected |
| [29:28] | Location[5:4] | RW | 1h | Gross physical location of the device connected to Port-D: 0h = External on primary chassis 1h = Internal 2h = Separate chassis 3h = Other |
| [27:24] | Location[3:0] | RW | 0h | Geometric location of the device connected to Port-D: 0h = Not applicable 1h = Rear 2h = Front 3h = Left 4h = Right 5h = Top 6h = Bottom 7h = Special 8h = Special 9h = Special Ah-Fh = Reserved |

| Bit | Bitfield Name | RW | Default | Description |
|---------|-----------------|----|---------|--|
| [23:20] | Default Device | RW | Ah | Indicates the intended use of Port-D: 0h = Line out 1h = Speaker 2h = Headphone out 3h = CD 4h = S/PDIF out 5h = Digital other out 6h = Modem line side 7h = Modem handset side 8h = Line in 9h = AUX Ah = Mic in Bh = Telephony Ch = S/PDIF in Dh = Digital other in Eh = Reserved Fh = Other |
| [19:16] | Connection Type | RW | 6h | Indicates the type of physical interface on Port-D: 0h = Unknown 1h = 3.5mm stereo/mono jack 2h = 1/4" stereo/mono jack 3h = ATAPI internal 4h = RCA jack (for analogue audio or coaxial S/PDIF) 5h = Optical 6h = Other digital 7h = Other analogue 8h = Multi-channel analogue (DIN) 9h = XLR/Professional Ah = RJ-11 (modem) Bh = Combination Ch-Eh = Reserved Fh = Other |
| [15:12] | Colour | RW | 0h | Indicates the colour of the physical jack on Port-D: 0h = Unknown 1h = Black 2h = Grey 3h = Blue 4h = Green 5h = Red 6h = Orange 7h = Yellow 8h = Purple 9h = Pink Ah-Dh = Reserved Eh = White Fh = Other |
| [11:8] | Misc | RW | 0h | Presence detection override: 0h = Presence detection indicated by <i>Pin Capabilities Parameter</i> 1h = Presence detection not supported. If the <i>Pin Capabilities Parameter</i> indicates that that presence detection is supported by the node, then this bit is used to override it to indicate the external circuitry is not capable of supporting presence detect All other values are reserved |

| Bit | Bitfield Name | RW | Default | Description |
|-------|---------------------|----|---------|---|
| [7:4] | Default Association | RW | Fh | Association number: 0h = Reserved 1h-Eh = Multi Channel or Single Pin Widget Fh = Single Pin Widget Only |
| [3:0] | Sequence | RW | 0h | Sequence number used to define individual channel pairs within a stream. All values (0h-Fh) are available for use. Use a value of 0 for Single Pin Widget. |

Note: The *Configuration Default Verb* is not reset to its default value during a reset from any source. The settings are only lost when digital power is removed from the WM8860. When digital power is restored, the System BIOS must restore the settings.

00h
01h
02h
03h
04h
05h
06h
07h
08h
09h
0Ah
0Bh
0Ch
0Dh
0Eh
0Fh
10h
11h
12h
13h
14h
15h
16h
17h

S/PDIF OUT PIN COMPLEX WIDGET (NID = 0FH)**GET PARAMETER VERB**

| | Verb ID | Payload [7:0] | Response[31:0] |
|-----|---------|--------------------|-----------------|
| Get | F00h | Parameter ID (PID) | Parameter Value |

Audio Widget Capabilities Parameter (PID = 09h)

| Bit | Bitfield Name | RW | Default | Description |
|---------|------------------------|----|---------|--|
| [31:24] | Rsvd | R | 00h | Reserved |
| [23:20] | Type | R | 4h | Indicates that this is a Pin Complex Widget |
| [19:16] | Delay | R | 0h | Latency not reported |
| [15:12] | Rsvd | R | 0h | Reserved |
| [11] | L-R Swap | R | 0 | Left/Right swap capability not supported |
| [10] | PowerCntrl | R | 0 | Indicates that the <i>Power State Verb</i> is not supported in this widget |
| [9] | Digital | R | 1 | Indicates that this widget is translating digital data |
| [8] | Conn List | R | 1 | Indicates that a connection list is present |
| [7] | Unsol Capable | R | 1 | Widget supports Unsolicited Responses |
| [6] | ProcWidget | R | 0 | Widget does not have processing capabilities |
| [5] | Stripe | R | 0 | Widget does not support striping |
| [4] | Format Override | R | 0 | Widget does not override the format defined for the AFG |
| [3] | Amp Parameter Override | R | 0 | Not applicable as this widget does not have amplifier capabilities |
| [2] | Out Amp Present | R | 0 | Output amplifier not present in this widget |
| [1] | In Amp Present | R | 0 | Input amplifier is present in this widget |
| [0] | Stereo | R | 1 | Indicates that this is a stereo widget |

Pin Capabilities Parameter (PID = 0Ch)

| Bit | Bitfield Name | RW | Default | Description |
|---------|-------------------------|----|---------|---|
| [31:17] | Rsvd | R | 0000h | Reserved |
| [16] | EAPD Capable | R | 0 | Widget does not support an EAPD pin |
| [15:8] | VRef Control | R | 00h | VRef not supported for digital outputs |
| [7] | Rsvd | R | 0 | Reserved |
| [6] | Balanced I/O Pins | R | 0 | Indicates that this widget does not have balanced pins |
| [5] | Input Capable | R | 0 | Indicates that this widget is not input capable |
| [4] | Output Capable | R | 1 | Indicates that this widget is output capable |
| [3] | Headphone Drive Capable | R | 0 | Not applicable as this is an input port |
| [2] | Presence Detect Capable | R | 1 | Indicates that this widget can perform presence detection |
| [1] | Trigger Required | R | 0 | Impedance measurement not supported |
| [0] | Impedance Sense Capable | R | 0 | Impedance measurement not supported |

Connection List Length Parameter (PID = 0Eh)

| Bit | Bitfield Name | RW | Default | Description |
|--------|------------------------|----|---------|--|
| [31:8] | Rsvd | R | 000000h | Reserved |
| [7] | Long Form | R | 0 | Indicates that the connection list items are in short form |
| [6:0] | Connection List Length | R | 01h | Indicates that there is 1 NID entry in the connection list |

GET CONNECTION LIST ENTRY VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|---------------|--------------------------------|
| Get | F02h | 00h | Bits [31:0] in the table below |

| Bit | Bitfield Name | RW | Default | Description |
|---------|-------------------|----|---------|---|
| [31:24] | Conn List Entry 3 | R | 00h | Unused connection list entry |
| [23:16] | Conn List Entry 2 | R | 00h | Unused connection list entry |
| [15:8] | Conn List Entry 1 | R | 00h | Unused connection list entry |
| [7:0] | Conn List Entry 0 | R | 04h | Indicates that the S/PDIF Out Pin Widget connects to the S/PDIF Tx 1 Widget (NID = 04h) |

PIN WIDGET CONTROL VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F07h | 00h | Bits [31:0] in the table below |
| Set | 707h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|---------|--|
| [31:8] | Rsvd | R | 000000h | Reserved |
| [7] | H-Phn Enable | R | 0 | Not applicable for S/PDIF Out |
| [6] | Out Enable | RW | 1 | Controls the output path: 0 = Output path is disabled 1 = Output path is enabled Note: If <i>OutEnable</i> =0, the S/PDIF signal is still transmitted, but the payload of the S/PDIF signal is filled with zeros. In this way, the <i>OutEnable</i> register acts as a S/PDIF Mute. Note: If <i>DigEn</i> =0, the SPDIFOUT pin is held at logic 0. |
| [5] | In Enable | R | 0 | Not applicable for S/PDIF Out |
| [4:3] | Rsvd | R | 0h | Reserved |
| [2:0] | VRefEn | RW | 0h | Selectable VRef not supported |

UNSOLICITED RESPONSE VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F08h | 00h | Bits [31:0] in the table below |
| Set | 708h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|---------|---|
| [31:8] | Rsvd | R | 000000h | Reserved |
| [7] | Enable | RW | 0 | 0 = Unsolicited Responses disabled for this node 1 = Unsolicited Responses enabled for this node |
| [6] | Rsvd | R | 0 | Reserved |
| [5:0] | Tag | RW | 0Fh | A software programmable tag value that is returned in the top six bits (31:26) of every Unsolicited Response from this node. The default for <i>Tag</i> is equal to the Node ID. |

Note: The Unsolicited Response for the AFG node is defined in the "Unsolicited Responses" section.

PIN SENSE VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|-----|---------|---------------|--------------------------------|
| Get | F09h | 00h | Bits [31:0] in the table below |

| Bit | Bitfield Name | RW | Default | Description |
|--------|-----------------|----|-----------|--|
| [31] | Presence Detect | R | 0 | 0 = nothing plugged into S/PDIF Out 1 = something plugged into S/PDIF Out |
| [30:0] | Impedance Sense | R | 00000000h | Impedance sense not supported |

CONFIGURATION DEFAULT VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------|---------|---------------------------------|--------------------------------|
| Get | F1Ch | 00h | Bits [31:0] in the table below |
| Set1 | 71Ch | Bits [7:0] in the table below | 00000000h |
| Set2 | 71Dh | Bits [15:8] in the table below | 00000000h |
| Set3 | 71Eh | Bits [23:16] in the table below | 00000000h |
| Set4 | 71Fh | Bits [31:24] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|---------|-------------------|----|---------|---|
| [31:30] | Port Connectivity | RW | 0h | Indicates the external connectivity: 0h = Jack 1h = No physical connection 2h = A fixed function device 3h = both a jack and an internal device are connected |
| [29:28] | Location[5:4] | RW | 0h | Gross physical location of the device connected to S/PDIF Out: 0h = External on primary chassis 1h = Internal 2h = Separate chassis 3h = Other |
| [27:24] | Location[3:0] | RW | 1h | Geometric location of the device connected to S/PDIF Out: 0h = Not applicable 1h = Rear 2h = Front 3h = Left 4h = Right 5h = Top 6h = Bottom 7h = Special 8h = Special 9h = Special Ah-Fh = Reserved |

| Bit | Bitfield Name | RW | Default | Description |
|---------|-----------------|----|---------|--|
| [23:20] | Default Device | RW | 4h | Indicates the intended use of S/PDIF Out: 0h = Line out 1h = Speaker 2h = Headphone out 3h = CD 4h = S/PDIF out 5h = Digital other out 6h = Modem line side 7h = Modem handset side 8h = Line in 9h = AUX Ah = Mic in Bh = Telephony Ch = S/PDIF in Dh = Digital other in Eh = Reserved Fh = Other |
| [19:16] | Connection Type | RW | 5h | Indicates the type of physical interface on S/PDIF Out: 0h = Unknown 1h = 3.5mm stereo/mono jack 2h = 1/4" stereo/mono jack 3h = ATAPI internal 4h = RCA jack (for analogue audio or coaxial S/PDIF) 5h = Optical 6h = Other digital 7h = Other analogue 8h = Multi-channel analogue (DIN) 9h = XLR/Professional Ah = RJ-11 (modem) Bh = Combination Ch-Eh = Reserved Fh = Other |
| [15:12] | Colour | RW | 9h | Indicates the colour of the physical jack on S/PDIF Out: 0h = Unknown 1h = Black 2h = Grey 3h = Blue 4h = Green 5h = Red 6h = Orange 7h = Yellow 8h = Purple 9h = Pink Ah-Dh = Reserved Eh = White Fh = Other |
| [11:8] | Misc | RW | 1h | Presence detection override: 0 = Presence detection indicated by <i>Pin Capabilities Parameter</i> 1 = Presence detection not supported. If the <i>Pin Capabilities Parameter</i> indicates that that presence detection is supported by the node, then this bit is used to override it to indicate the external circuitry is not capable of supporting presence detect All other values are reserved |

| Bit | Bitfield Name | RW | Default | Description |
|-------|---------------------|----|---------|---|
| [7:4] | Default Association | RW | Fh | Association number: 0h = Reserved 1h-Eh = Multi Channel or Single Pin Widget Fh = Single Pin Widget Only |
| [3:0] | Sequence | RW | 0h | Sequence number used to define individual channel pairs within a stream. All values (0h-Fh) are available for use. Use a value of 0 for Single Pin Widget. |

Note: The *Configuration Default Verb* is not reset to its default value during a reset from any source. The settings are only lost when digital power is removed from the WM8860. When digital power is restored, the System BIOS must restore the settings.

UNSOLICITED RESPONSE PRIORITY CONTROL VERB (VENDOR-SPECIFIC)

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F8Eh | 00h | Bits [31:0] in the table below |
| Set | 78Eh | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|----------|--|
| [31:5] | Rsvd | R | 0000000h | Reserved |
| [4:0] | Priority | RW | 00h | Assigns a priority setting for queued Unsolicited Responses. Nodes with the lowest value have the highest priority, and so go to the front of the Unsolicited Response queue. Nodes with the same value for priority are queued on first-to-trigger basis. 00h = Highest priority ... 1Fh = Lowest priority |

RESERVED (NID = 10H)**CONFIGURATION DEFAULT VERB**

| | Verb ID | Payload [7:0] | Response[31:0] |
|-------------|---------|---------------|----------------|
| Get | F1Ch | 00h | 40C000F0h |
| Set1 | 71Ch | 11110000 | 00000000h |
| Set2 | 71Dh | 00000000 | 00000000h |
| Set3 | 71Eh | 11000000 | 00000000h |
| Set4 | 71Fh | 01000000 | 00000000h |

Note: The *Configuration Default Verb* is not fully supported on the WM8860. It is required that the System BIOS issues the Set1, Set2, Set3 and Set4 Verbs as described above.

Note: The *Configuration Default Verb* is not reset to its default value during a reset from any source. The settings are only lost when digital power is removed from the WM8860. When digital power is restored, the System BIOS must restore the settings.

PORT-A PIN COMPLEX WIDGET (NID = 11H)**GET PARAMETER VERB**

| | Verb ID | Payload [7:0] | Response[31:0] |
|-----|---------|--------------------|-----------------|
| Get | F00h | Parameter ID (PID) | Parameter Value |

Audio Widget Capabilities Parameter (PID = 09h)

| Bit | Bitfield Name | RW | Default | Description |
|---------|------------------------|----|---------|--|
| [31:24] | Rsvd | R | 00h | Reserved |
| [23:20] | Type | R | 4h | Indicates that this is a Pin Complex Widget |
| [19:16] | Delay | R | 0h | Latency not reported |
| [15:12] | Rsvd | R | 0h | Reserved |
| [11] | L-R Swap | R | 0 | Left/Right swap capability not supported |
| [10] | PowerCntrl | R | 0 | Indicates that the <i>Power State Verb</i> is not supported in this widget |
| [9] | Digital | R | 0 | Indicates that this widget is translating analogue data |
| [8] | Conn List | R | 1 | Indicates that a connection list is present |
| [7] | Unsol Capable | R | 1 | Widget supports Unsolicited Responses |
| [6] | ProcWidget | R | 0 | Widget does not have processing capabilities |
| [5] | Stripe | R | 0 | Widget does not support striping |
| [4] | Format Override | R | 0 | Widget does not override the format defined for the AFG |
| [3] | Amp Parameter Override | R | 0 | Not applicable as this widget does not have amplifier capabilities |
| [2] | Out Amp Present | R | 0 | Output amplifier not present in this widget |
| [1] | In Amp Present | R | 0 | Input amplifier not present in this widget |
| [0] | Stereo | R | 1 | Indicates that this is a stereo widget |

Pin Capabilities Parameter (PID = 0Ch)

| Bit | Bitfield Name | RW | Default | Description |
|---------|-------------------------|----|---------|---|
| [31:17] | Rsvd | R | 0000h | Reserved |
| [16] | EAPD Capable | R | 0 | Widget does not support an EAPD pin |
| [15:8] | VRef Control | R | 00h | VRef not supported for digital outputs |
| [7] | Rsvd | R | 0 | Reserved |
| [6] | Balanced I/O Pins | R | 0 | Indicates that this widget does not have balanced pins |
| [5] | Input Capable | R | 0 | Indicates that this widget is not input capable |
| [4] | Output Capable | R | 1 | Indicates that this widget is output capable |
| [3] | Headphone Drive Capable | R | 1 | Indicates that this widget has a headphone driver |
| [2] | Presence Detect Capable | R | 1 | Indicates that this widget can perform presence detection |
| [1] | Trigger Required | R | 0 | Impedance measurement not supported |
| [0] | Impedance Sense Capable | R | 0 | Impedance measurement not supported |

Connection List Length Parameter (PID = 0Eh)

| Bit | Bitfield Name | RW | Default | Description |
|--------|------------------------|----|---------|--|
| [31:8] | Rsvd | R | 000000h | Reserved |
| [7] | Long Form | R | 0 | Indicates that the connection list items are in short form |
| [6:0] | Connection List Length | R | 01h | Indicates that there is 1 NID entry in the connection list |

GET CONNECTION LIST ENTRY VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|-----|---------|---------------|--------------------------------|
| Get | F02h | 00h | Bits [31:0] in the table below |

| Bit | Bitfield Name | RW | Default | Description |
|---------|-------------------|----|---------|--|
| [31:24] | Conn List Entry 3 | R | 00h | Unused connection list entry |
| [23:16] | Conn List Entry 2 | R | 00h | Unused connection list entry |
| [15:8] | Conn List Entry 1 | R | 00h | Unused connection list entry |
| [7:0] | Conn List Entry 0 | R | 06h | Indicates that the Port-A Pin Widget connects to the DAC1 Widget (NID = 06h) |

PIN WIDGET CONTROL VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|-----|---------|-------------------------------|--------------------------------|
| Get | F07h | 00h | Bits [31:0] in the table below |
| Set | 707h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|---------|---|
| [31:8] | Rsvd | R | 000000h | Reserved |
| [7] | H-Phn Enable | RW | 0h | Headphone amplifier enable: 0 = Disable 1 = Enable Note: If the <i>H-Phn Enable</i> register is set to 1, the actual gain setting applied has an offset of -8dB from the setting configured by the <i>Gain</i> register in the <i>DAC1 Amplifier Gain/Mute Verb</i> . |
| [6] | Out Enable | RW | 1 | Controls the output path: 0 = Output path is disabled 1 = Output path is enabled |
| [5] | In Enable | R | 0 | Not applicable for Port-A |
| [4:3] | Rsvd | R | 0h | Reserved |
| [2:0] | VRefEn | R | 0h | Selectable VRef not supported |

UNSOLICITED RESPONSE VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|-----|---------|-------------------------------|--------------------------------|
| Get | F08h | 00h | Bits [31:0] in the table below |
| Set | 708h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|---------|---|
| [31:8] | Rsvd | R | 000000h | Reserved |
| [7] | Enable | RW | 0 | 0 = Unsolicited Responses disabled for this node 1 = Unsolicited Responses enabled for this node |
| [6] | Rsvd | R | 0 | Reserved |
| [5:0] | Tag | RW | 11h | A software programmable tag value that is returned in the top six bits (31:26) of every Unsolicited Response from this node. The default for <i>Tag</i> is equal to the Node ID. |

Note: The Unsolicited Response for the AFG node is defined in the "Unsolicited Responses" section.

PIN SENSE VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|---------------|--------------------------------|
| Get | F09h | 00h | Bits [31:0] in the table below |

| Bit | Bitfield Name | RW | Default | Description |
|--------|-----------------|----|-----------|--|
| [31] | Presence Detect | R | 0 | 0 = nothing plugged into Port-A 1 = something plugged into Port-A |
| [30:0] | Impedance Sense | R | 00000000h | Impedance sense not supported |

CONFIGURATION DEFAULT VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|-------------|---------|---------------------------------|--------------------------------|
| Get | F1Ch | 00h | Bits [31:0] in the table below |
| Set1 | 71Ch | Bits [7:0] in the table below | 00000000h |
| Set2 | 71Dh | Bits [15:8] in the table below | 00000000h |
| Set3 | 71Eh | Bits [23:16] in the table below | 00000000h |
| Set4 | 71Fh | Bits [31:24] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|---------|-------------------|----|---------|---|
| [31:30] | Port Connectivity | RW | 0h | Indicates the external connectivity: 0h = Jack 1h = No physical connection 2h = A fixed function device 3h = both a jack and an internal device are connected |
| [29:28] | Location[5:4] | RW | 0h | Gross physical location of the device connected to Port-A: 0h = External on primary chassis 1h = Internal 2h = Separate chassis 3h = Other |
| [27:24] | Location[3:0] | RW | 1h | Geometric location of the device connected to Port-A: 0h = Not applicable 1h = Rear 2h = Front 3h = Left 4h = Right 5h = Top 6h = Bottom 7h = Special 8h = Special 9h = Special Ah-Fh = Reserved |

| Bit | Bitfield Name | RW | Default | Description |
|---------|-----------------|----|---------|--|
| [23:20] | Default Device | RW | 0h | Indicates the intended use of Port-A: 0h = Line out 1h = Speaker 2h = Headphone out 3h = CD 4h = S/PDIF out 5h = Digital other out 6h = Modem line side 7h = Modem handset side 8h = Line in 9h = AUX Ah = Mic in Bh = Telephony Ch = S/PDIF in Dh = Digital other in Eh = Reserved Fh = Other |
| [19:16] | Connection Type | RW | 1h | Indicates the type of physical interface on Port-A: 0h = Unknown 1h = 3.5mm stereo/mono jack 2h = 1/4" stereo/mono jack 3h = ATAPI internal 4h = RCA jack (for analogue audio or coaxial S/PDIF) 5h = Optical 6h = Other digital 7h = Other analogue 8h = Multi-channel analogue (DIN) 9h = XLR/Professional Ah = RJ-11 (modem) Bh = Combination Ch-Eh = Reserved Fh = Other |
| [15:12] | Colour | RW | 4h | Indicates the colour of the physical jack on Port-A: 0h = Unknown 1h = Black 2h = Grey 3h = Blue 4h = Green 5h = Red 6h = Orange 7h = Yellow 8h = Purple 9h = Pink Ah-Dh = Reserved Eh = White Fh = Other |
| [11:8] | Misc | RW | 0h | Presence detection override: 0 = Presence detection indicated by <i>Pin Capabilities Parameter</i> 1 = Presence detection not supported. If the <i>Pin Capabilities Parameter</i> indicates that that presence detection is supported by the node, then this bit is used to override it to indicate the external circuitry is not capable of supporting presence detect All other values are reserved |

| Bit | Bitfield Name | RW | Default | Description |
|-------|---------------------|----|---------|---|
| [7:4] | Default Association | RW | 2h | Association number: 0h = Reserved 1h-Eh = Multi Channel or Single Pin Widget Fh = Single Pin Widget Only |
| [3:0] | Sequence | RW | 0h | Sequence number used to define individual channel pairs within a stream. All values (0h-Fh) are available for use. Use a value of 0 for Single Pin Widget. |

Note: The *Configuration Default Verb* is not reset to its default value during a reset from any source. The settings are only lost when digital power is removed from the WM8860. When digital power is restored, the System BIOS must restore the settings.

UNSOLICITED RESPONSE PRIORITY CONTROL VERB (VENDOR-SPECIFIC)

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F8Eh | 00h | Bits [31:0] in the table below |
| Set | 78Eh | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|----------|--|
| [31:5] | Rsvd | R | 0000000h | Reserved |
| [4:0] | Priority | RW | 00h | Assigns a priority setting for queued Unsolicited Responses. Nodes with the lowest value have the highest priority, and so go to the front of the Unsolicited Response queue. Nodes with the same value for priority are queued on first-to-trigger basis. 00h = Highest priority ... 1Fh = Lowest priority |

PORT-G PIN COMPLEX WIDGET (NID = 12H)**GET PARAMETER VERB**

| | Verb ID | Payload [7:0] | Response[31:0] |
|-----|---------|--------------------|-----------------|
| Get | F00h | Parameter ID (PID) | Parameter Value |

Audio Widget Capabilities Parameter (PID = 09h)

| Bit | Bitfield Name | RW | Default | Description |
|---------|------------------------|----|---------|--|
| [31:24] | Rsvd | R | 00h | Reserved |
| [23:20] | Type | R | 4h | Indicates that this is a Pin Complex Widget |
| [19:16] | Delay | R | 0h | Latency not reported |
| [15:12] | Rsvd | R | 0h | Reserved |
| [11] | L-R Swap | R | 0 | Left/Right swap capability not supported |
| [10] | PowerCntrl | R | 0 | Indicates that the <i>Power State Verb</i> is not supported in this widget |
| [9] | Digital | R | 0 | Indicates that this widget is translating analogue data |
| [8] | Conn List | R | 1 | Indicates that a connection list is present |
| [7] | Unsol Capable | R | 1 | Widget supports Unsolicited Responses |
| [6] | ProcWidget | R | 0 | Widget does not have processing capabilities |
| [5] | Stripe | R | 0 | Widget does not support striping |
| [4] | Format Override | R | 0 | Widget does not override the format defined for the AFG |
| [3] | Amp Parameter Override | R | 0 | Not applicable as this widget does not have amplifier capabilities |
| [2] | Out Amp Present | R | 0 | Output amplifier not present in this widget |
| [1] | In Amp Present | R | 0 | Input amplifier not present in this widget |
| [0] | Stereo | R | 1 | Indicates that this is a stereo widget |

Pin Capabilities Parameter (PID = 0Ch)

| Bit | Bitfield Name | RW | Default | Description |
|---------|-------------------------|----|---------|---|
| [31:17] | Rsvd | R | 0000h | Reserved |
| [16] | EAPD Capable | R | 0 | Widget does not support an EAPD pin |
| [15:8] | VRef Control | R | 00h | VRef not supported for digital outputs |
| [7] | Rsvd | R | 0 | Reserved |
| [6] | Balanced I/O Pins | R | 0 | Indicates that this widget does not have balanced pins |
| [5] | Input Capable | R | 0 | Indicates that this widget is not input capable |
| [4] | Output Capable | R | 1 | Indicates that this widget is output capable |
| [3] | Headphone Drive Capable | R | 0 | Indicates that this widget does not have a headphone driver |
| [2] | Presence Detect Capable | R | 1 | Indicates that this widget can perform presence detection |
| [1] | Trigger Required | R | 0 | Impedance measurement not supported |
| [0] | Impedance Sense Capable | R | 0 | Impedance measurement not supported |

Connection List Length Parameter (PID = 0Eh)

| Bit | Bitfield Name | RW | Default | Description |
|--------|------------------------|----|---------|--|
| [31:8] | Rsvd | R | 000000h | Reserved |
| [7] | Long Form | R | 0 | Indicates that the connection list items are in short form |
| [6:0] | Connection List Length | R | 01h | Indicates that there is 1 NID entry in the connection list |

GET CONNECTION LIST ENTRY VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|---------------|--------------------------------|
| Get | F02h | 00h | Bits [31:0] in the table below |

| Bit | Bitfield Name | RW | Default | Description |
|---------|-------------------|----|---------|--|
| [31:24] | Conn List Entry 3 | R | 00h | Unused connection list entry |
| [23:16] | Conn List Entry 2 | R | 00h | Unused connection list entry |
| [15:8] | Conn List Entry 1 | R | 00h | Unused connection list entry |
| [7:0] | Conn List Entry 0 | R | 07h | Indicates that the Port-G Pin Widget connects to the DAC2 Widget (NID = 07h) |

PIN WIDGET CONTROL VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F07h | 00h | Bits [31:0] in the table below |
| Set | 707h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|---------|--|
| [31:8] | Rsvd | R | 000000h | Reserved |
| [7] | H-Phn Enable | R | 0 | Not applicable for Port-G |
| [6] | Out Enable | RW | 1 | Controls the output path: 0 = Output path is disabled 1 = Output path is enabled |
| [5] | In Enable | R | 0 | Not applicable for Port-G |
| [4:3] | Rsvd | R | 0h | Reserved |
| [2:0] | VRefEn | R | 0h | Selectable VRef not supported |

UNSOLICITED RESPONSE VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F08h | 00h | Bits [31:0] in the table below |
| Set | 708h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|---------|---|
| [31:8] | Rsvd | R | 000000h | Reserved |
| [7] | Enable | RW | 0 | 0 = Unsolicited Responses disabled for this node 1 = Unsolicited Responses enabled for this node |
| [6] | Rsvd | R | 0 | Reserved |
| [5:0] | Tag | RW | 12h | A software programmable tag value that is returned in the top six bits (31:26) of every Unsolicited Response from this node. The default for <i>Tag</i> is equal to the Node ID. |

Note: The Unsolicited Response for the AFG node is defined in the "Unsolicited Responses" section.

PIN SENSE VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|---------------|--------------------------------|
| Get | F09h | 00h | Bits [31:0] in the table below |

| Bit | Bitfield Name | RW | Default | Description |
|--------|-----------------|----|-----------|--|
| [31] | Presence Detect | R | 0 | 0 = nothing plugged into Port-G 1 = something plugged into Port-G |
| [30:0] | Impedance Sense | R | 00000000h | Impedance sense not supported |

CONFIGURATION DEFAULT VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|-------------|---------|---------------------------------|--------------------------------|
| Get | F1Ch | 00h | Bits [31:0] in the table below |
| Set1 | 71Ch | Bits [7:0] in the table below | 00000000h |
| Set2 | 71Dh | Bits [15:8] in the table below | 00000000h |
| Set3 | 71Eh | Bits [23:16] in the table below | 00000000h |
| Set4 | 71Fh | Bits [31:24] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|---------|-------------------|----|---------|--|
| [31:30] | Port Connectivity | RW | 0h | Indicates the external connectivity: 0h = Jack 1h = No physical connection 2h = A fixed function device 3h = both a jack and an internal device are connected |
| [29:28] | Location[5:4] | RW | 0h | Gross physical location of the device connected to Port-G: 0h = External on primary chassis 1h = Internal 2h = Separate chassis 3h = Other |
| [27:24] | Location[3:0] | RW | 1h | Geometric location of the device connected to Port-G: 0h = Not applicable 1h = Rear 2h = Front 3h = Left 4h = Right 5h = Top 6h = Bottom 7h = Special 8h = Special 9h = Special Ah-Fh = Reserved |
| [23:20] | Default Device | RW | 0h | Indicates the intended use of Port-G: 0h = Line out 1h = Speaker 2h = Headphone out 3h = CD 4h = S/PDIF out 5h = Digital other out 6h = Modem line side 7h = Modem handset side 8h = Line in 9h = AUX Ah = Mic in Bh = Telephony Ch = S/PDIF in Dh = Digital other in Eh = Reserved Fh = Other |

| Bit | Bitfield Name | RW | Default | Description |
|---------|---------------------|----|---------|--|
| [19:16] | Connection Type | RW | 1h | Indicates the type of physical interface on Port-G: 0h = Unknown 1h = 3.5mm stereo/mono jack 2h = 1/4" stereo/mono jack 3h = ATAPI internal 4h = RCA jack (for analogue audio or coaxial S/PDIF) 5h = Optical 6h = Other digital 7h = Other analogue 8h = Multi-channel analogue (DIN) 9h = XLR/Professional Ah = RJ-11 (modem) Bh = Combination Ch-Eh = Reserved Fh = Other |
| [15:12] | Colour | RW | 6h | Indicates the colour of the physical jack on Port-G: 0h = Unknown 1h = Black 2h = Grey 3h = Blue 4h = Green 5h = Red 6h = Orange 7h = Yellow 8h = Purple 9h = Pink Ah-Dh = Reserved Eh = White Fh = Other |
| [11:8] | Misc | RW | 0h | Presence detection override: 0 = Presence detection indicated by <i>Pin Capabilities Parameter</i> 1 = Presence detection not supported. If the <i>Pin Capabilities Parameter</i> indicates that that presence detection is supported by the node, then this bit is used to override it to indicate the external circuitry is not capable of supporting presence detect All other values are reserved |
| [7:4] | Default Association | RW | 2h | Association number: 0h = Reserved 1h-Eh = Multi Channel or Single Pin Widget Fh = Single Pin Widget Only |
| [3:0] | Sequence | RW | 1h | Sequence number used to define individual channel pairs within a stream. All values (0h-Fh) are available for use. Use a value of 0h for Single Pin Widget. |

Note: The *Configuration Default Verb* is not reset to its default value during a reset from any source. The settings are only lost when digital power is removed from the WM8860. When digital power is restored, the System BIOS must restore the settings.

UNSOLICITED RESPONSE PRIORITY CONTROL VERB (VENDOR-SPECIFIC)

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F8Eh | 00h | Bits [31:0] in the table below |
| Set | 78Eh | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|----------|--|
| [31:5] | Rsvd | R | 0000000h | Reserved |
| [4:0] | Priority | RW | 00h | Assigns a priority setting for queued Unsolicited Responses. Nodes with the lowest value have the highest priority, and so go to the front of the Unsolicited Response queue. Nodes with the same value for priority are queued on first-to-trigger basis. 00h = Highest priority ... 1Fh = Lowest priority |

00h
01h
02h
03h
04h
05h
06h
07h
08h
09h
0Ah
0Bh
0Ch
0Dh
0Eh
0Fh
10h
11h
12h
13h
14h
15h
16h
17h

RESERVED (NID = 13H)**CONFIGURATION DEFAULT VERB**

| | Verb ID | Payload [7:0] | Response[31:0] |
|-------------|---------|---------------|----------------|
| Get | F1Ch | 00h | 400000F0h |
| Set1 | 71Ch | 11110000 | 00000000h |
| Set2 | 71Dh | 00000000 | 00000000h |
| Set3 | 71Eh | 00000000 | 00000000h |
| Set4 | 71Fh | 01000000 | 00000000h |

Note: The *Configuration Default Verb* is not fully supported on the WM8860. It is required that the System BIOS issues the Set1, Set2, Set3 and Set4 Verbs as described above.

Note: The *Configuration Default Verb* is not reset to its default value during a reset from any source. The settings are only lost when digital power is removed from the WM8860. When digital power is restored, the System BIOS must restore the settings.

BEEP GENERATOR WIDGET (NID = 14H)**AMPLIFIER GAIN/MUTE VERB**

| | Verb ID | Payload [15:0] | Response[31:0] |
|------------|---------|------------------------------------|---|
| Get | Bh | A000h | Bits [31:0] in the response table below – applies to the left channel only |
| Get | Bh | 8000h | Bits [31:0] in the response table below – applies to the right channel only |
| Set | 3h | Bits [15:0] in the set table below | 00000000h |

Response Table:

| Bit | Bitfield Name | RW | Default | Description |
|--------|----------------|----|---------|--|
| [31:7] | Rsvd | R | 000000h | Reserved |
| [6:0] | Amplifier Gain | R | 04h | Shows the amplifier gain setting (step number) for the selected channel. The actual gain applied is determined by the <i>Output Amplifier Capabilities Parameter</i> , and is shown below for convenience: 00h = -24dB 01h = -18dB 02h = -12dB 03h = -6dB 04h = 0dB |

Set Table:

| Bit | Bitfield Name | RW | Default | Description |
|--------|----------------|----|---------|---|
| [15] | Set Output Amp | W | 1 | Indicates that the programming refers to the output amplifier on this widget |
| [14] | Set Input Amp | W | 0 | Not applicable to this widget |
| [13] | Set Left Amp | W | 1 | 0 = Left channel amplifier does not accept the values in <i>Mute</i> or <i>Gain</i> fields 1 = Left channel amplifier does accept the values in the <i>Mute</i> and <i>Gain</i> fields |
| [12] | Set Right Amp | W | 1 | 0 = Right channel amplifier does not accept the values in <i>Mute</i> or <i>Gain</i> fields 1 = Right channel amplifier does accept the values in the <i>Mute</i> and <i>Gain</i> fields |
| [11:8] | Index | W | 0 | Not applicable to this widget |
| [7] | Mute | R | 1 | Mute not supported |
| [6:0] | Gain | W | 4h | Step number of the gain – see <i>Amplifier Gain</i> in response table above for details of actual gain values |

GET PARAMETER VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|-----|---------|--------------------|-----------------|
| Get | F00h | Parameter ID (PID) | Parameter Value |

Audio Widget Capabilities Parameter (PID = 09h)

| Bit | Bitfield Name | RW | Default | Description |
|---------|------------------------|----|---------|---|
| [31:24] | Rsvd | R | 00h | Reserved |
| [23:20] | Type | R | 7h | Indicates that this is a Beep Generator Widget |
| [19:4] | Rsvd | R | 0000h | Reserved |
| [3] | Amp Parameter Override | R | 1 | The AFG amplifier parameters are overridden for this node |
| [2] | Out Amp Present | R | 1 | Output amplifier is present in this widget |
| [1:0] | Rsvd | R | 0h | Reserved |

Output Amplifier Capabilities Response Format (PID = 12h)

| Bit | Bitfield Name | RW | Default | Description |
|---------|---------------|----|---------|---|
| [31] | Mute Capable | R | 0 | Beep amplifier does not support mute |
| [30:23] | Rsvd | R | 0000h | Reserved |
| [22:16] | Step Size | R | 17h | Gain step size is 6dB |
| [15] | Rsvd | R | 0 | Reserved |
| [14:8] | Num Steps | R | 04h | Number of steps in gain range is 5 (0dB to -24dB) |
| [7] | Rsvd | R | 0 | Reserved |
| [6:0] | Offset | R | 04h | The step number that 0dB corresponds to is 04h |

BEEP GENERATION VERB

| | Verb ID | Payload [15:0] | Response[31:0] |
|-----|---------|--------------------------------|--------------------------------|
| Get | F0Ah | 0000h | Bits [31:0] in the table below |
| Set | 70Ah | Bits [15:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|----------------|----|----------|---|
| [31:8] | Rsvd | R | 0000000h | Reserved |
| [7:0] | Terminal Count | RW | 00h | Sets tone divider value. The frequency of the beep tone is given by $f = 48\text{kHz} / (4 * \text{Divider})$: 00h = Beep Generator disabled 01h = 12kHz 02h = 6 kHz FFh = 47.06 Hz Note: for a beep to be generated, the AFG must be in state D0 |

BEEP MASK SELECTION VERB (VENDOR SPECIFIC)

| | Verb ID | Payload [15:0] | Response[31:0] |
|------------|---------|--------------------------------|--------------------------------|
| Get | F72h | 0000h | Bits [31:0] in the table below |
| Set | 772h | Bits [15:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|------------------|----|----------|---|
| [31:3] | Rsvd | R | 0000000h | Reserved |
| [2] | Port-A Beep Mask | RW | 0 | Beep mask enable for Port-A (DAC1): 0 = Beep tone unmasked from output 1 = Beep tone masked from output |
| [1] | Port-G Beep Mask | RW | 0 | Beep mask enable for Port-G (DAC2): 0 = Beep tone unmasked from output 1 = Beep tone masked from output |
| [0] | Rsvd | RW | 0 | Reserved |

MIC2 AUDIO INPUT CONVERTER WIDGET (NID = 15H)

STREAM FORMAT VERB

| | Verb ID | Payload [15:0] | Response[31:0] |
|-----|---------|----------------|--------------------------------|
| Get | Ah | 0000h | Bits [31:0] in the table below |

| Bit | Bitfield Name | RW | Default | Description |
|---------|---------------|----|---------|--|
| [31:16] | Rsvd | R | 0000h | Reserved |
| [15] | Type | R | 0 | Indicates the widget supports only PCM streams |
| [14] | Base | R | 0 | Used to set the base rate frequency: 0 = 48 kHz 1 = 44.1 kHz |
| [13:11] | Mult | R | 0h | Used to set the base rate multiplication factor: 0h = x1 (48kHz, 44.1kHz or less) 1h = x2 (32kHz) 2h-7h = Reserved |
| [10:8] | Div | R | 0h | Used to set the base rate division factor: 0h = divide by 1 (48kHz, 44.1kHz) 1h = divide by 2 (24kHz, 22.05kHz) 2h = divide by 3 (16kHz, 32kHz) 3h = divide by 4 (11.025kHz) 4h = Reserved 5h = divide by 6 (8kHz) 6h = Reserved 7h = Reserved |
| [7] | Rsvd | R | 0 | Reserved |
| [6:4] | Bits | R | 3h | Bits per Sample: 0h = Reserved 1h = 16 bits 2h = 20 bits 3h = 24 bits 4h = 32 bits (Float 32) 5h-7h = Reserved |
| [3:0] | Chan | R | 1h | Number of Channels in each frame of the stream: 0h = 1 channel 1h = 2 channels 2h = 3 channels 3h = 4 channels 4h-Fh = reserved |

Note: Register values are read-only. As MIC2 and MIC1 share the DMICLK, the MIC1 *Stream Format Verb* is used to configure the sample rate for both converters.

GET PARAMETER VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|-----|---------|--------------------|-----------------|
| Get | F00h | Parameter ID (PID) | Parameter Value |

Audio Widget Capabilities Parameter (PID = 09h)

| Bit | Bitfield Name | RW | Default | Description |
|---------|------------------------|----|---------|--|
| [31:24] | Rsvd | R | 00h | Reserved |
| [23:20] | Type | R | 1h | Indicates that this is an Audio Input Widget |
| [19:16] | Delay | R | 0h | Latency not reported |
| [15:12] | Rsvd | R | 0h | Reserved |
| [11] | L-R Swap | R | 0 | Left/Right swap capability not supported |
| [10] | PowerCntrl | R | 0 | Indicates that the <i>Power State Verb</i> is not supported in this widget |
| [9] | Digital | R | 1 | Indicates that this widget is translating digital data |
| [8] | Conn List | R | 1 | Indicates that a connection list is present |
| [7] | Unsol Capable | R | 1 | Widget supports Unsolicited Responses |
| [6] | ProcWidget | R | 1 | Widget has processing capabilities (i.e high pass filter) |
| [5] | Stripe | R | 0 | Widget does not support striping |
| [4] | Format Override | R | 1 | Widget has a subset of the supported rates defined for the AFG |
| [3] | Amp Parameter Override | R | 0 | Not applicable as this widget does not have amplifier capabilities |
| [2] | Out Amp Present | R | 0 | Output amplifier not applicable for this widget |
| [1] | In Amp Present | R | 0 | Input amplifier not present in this widget |
| [0] | Stereo | R | 1 | Indicates that this is a stereo widget |

Supported Rates Parameter (PID = 0Ah)

| Bit | Bitfield Name | RW | Default | Description |
|---------|---------------|----|---------|---|
| [31:21] | Rsvd | R | 000h | Reserved |
| [20] | B32 | R | 1 | MIC1 supports 32-bit audio format |
| [19] | B24 | R | 1 | MIC1 supports 24-bit audio format |
| [18] | B20 | R | 1 | MIC1 supports 20-bit audio format |
| [17] | B16 | R | 1 | MIC1 supports 16-bit audio format |
| [16] | B8 | R | 0 | MIC1 does not support 8-bit audio format |
| [15:12] | Rsvd | R | 0h | Reserved |
| [11] | R12 | R | 0 | MIC1 does not support 384 kHz sample rate |
| [10] | R11 | R | 0 | MIC1 does not support 192 kHz sample rate |
| [9] | R10 | R | 0 | MIC1 does not support 176.4 kHz sample rate |
| [8] | R9 | R | 0 | MIC1 does not support 96 kHz sample rate |
| [7] | R8 | R | 0 | MIC1 does not support 88.2 kHz sample rate |
| [6] | R7 | R | 1 | MIC1 supports 48 kHz sample rate |
| [5] | R6 | R | 1 | MIC1 supports 44.1 kHz sample rate |
| [4] | R5 | R | 1 | MIC1 supports 32 kHz sample rate |
| [3] | R4 | R | 1 | MIC1 supports 22.05 kHz sample rate |
| [2] | R3 | R | 1 | MIC1 supports 16 kHz sample rate |
| [1] | R2 | R | 1 | MIC1 supports 11.025 kHz sample rate |
| [0] | R1 | R | 1 | MIC1 supports 8 kHz sample rate |

Supported Stream Formats Parameter (PID = 0Bh)

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|-----------|--|
| [31:3] | Rsvd | R | 00000000h | Reserved |
| [2] | AC3 | R | 0 | MIC2 does not support Dolby AC3 formatted data |
| [1] | Float32 | R | 1 | MIC2 supports Float32 formatted data |
| [0] | PCM | R | 1 | MIC2 supports PCM formatted data |

Connection List Length Parameter (PID = 0Eh)

| Bit | Bitfield Name | RW | Default | Description |
|--------|------------------------|----|---------|--|
| [31:8] | Rsvd | R | 000000h | Reserved |
| [7] | Long Form | R | 0 | Indicates that the connection list items are in short form |
| [6:0] | Connection List Length | R | 01h | Indicates that there is 1 NID entry in the connection list |

Processing Capabilities Parameter (PID = 10h)

| Bit | Bitfield Name | RW | Default | Description |
|---------|---------------|----|---------|--|
| [31:16] | Rsvd | R | 0000h | Reserved |
| [15:8] | NumCoeff | R | 00h | This widget does not support loadable coefficients |
| [7:1] | Rsvd | R | 00h | Reserved |
| [0] | Benign | R | 0 | The "Processing Benign State" is not supported |

GET CONNECTION LIST ENTRY VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|---------------|--------------------------------|
| Get | F02h | 00h | Bits [31:0] in the table below |

| Bit | Bitfield Name | RW | Default | Description |
|---------|-------------------|----|---------|--|
| [31:24] | Conn List Entry 3 | R | 00h | Unused connection list entry |
| [23:16] | Conn List Entry 2 | R | 00h | Unused connection list entry |
| [15:8] | Conn List Entry 1 | R | 00h | Unused connection list entry |
| [7:0] | Conn List Entry 0 | R | 16h | Indicates that the MIC2 Widget connects to the Port-H Pin Widget (NID = 16h) |

PROCESSING STATE VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F03h | 00h | Bits [31:0] in the table below |
| Set | 703h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|------------------|----|---------|---|
| [31:8] | Rsvd | R | 000000h | Reserved |
| [7:0] | Processing State | RW | 01h | The processing block is the high-pass filter (HPF). The processing state is controlled as follows: 00h = Processing Off: HPF disabled 01h = Processing On: HPF enabled 02h = Processing Off: HPF disabled (benign not supported) 03h-7Fh = Reserved 80h-FFh = Vendor Specific – not used |

CONVERTER STREAM, CHANNEL VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F06h | 00h | Bits [31:0] in the table below |
| Set | 706h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|---------|--|
| [31:8] | Rsvd | R | 000000h | Reserved |
| [7:4] | Stream | RW | 0h | Stream ID used by this widget. Note that Stream ID = 0h is used to indicate an unused stream, and converters will not transfer/receive link data for streams with an ID of 0h. For multi-channel capture on MIC1 and MIC2, the <i>Stream</i> value should be the same for both. |
| [3:0] | Channel | RW | 2h | Lowest channel number used by this widget. Note: When MIC1 and MIC2 are setup for multi-channel capture, only a setting of 0h and 2h are applicable. However, the values are mutually exclusive, in that if <i>Channel</i> has been set to 0h for the MIC1 node, it must be set to 2h for the MIC2 node. Both nodes should have <i>Channel</i> set to 0h when not in multi-channel capture mode. |

UNSOLICITED RESPONSE VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F08h | 00h | Bits [31:0] in the table below |
| Set | 708h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|---------|---|
| [31:8] | Rsvd | R | 000000h | Reserved |
| [7] | Enable | RW | 0h | 0 = Unsolicited Responses disabled for this node 1 = Unsolicited Responses enabled for this node |
| [6] | Rsvd | R | 0h | Reserved |
| [5:0] | Tag | RW | 15h | A software programmable tag value that is returned in the top six bits (31:26) of every Unsolicited Response from this node. The default for <i>Tag</i> is equal to the Node ID. |

Note: The Unsolicited Response for the AFG node is defined in the "Unsolicited Responses" section.

UNSOLICITED RESPONSE PRIORITY CONTROL VERB (VENDOR-SPECIFIC)

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F8Eh | 00h | Bits [31:0] in the table below |
| Set | 78Eh | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|----------|--|
| [31:5] | Rsvd | R | 0000000h | Reserved |
| [4:0] | Priority | RW | 00h | Assigns a priority setting for queued Unsolicited Responses. Nodes with the lowest value have the highest priority, and so go to the front of the Unsolicited Response queue. Nodes with the same value for priority are queued on first-to-trigger basis. 00h = Highest priority ... 1Fh = Lowest priority |

CHANNEL COPY VERB (VENDOR-SPECIFIC)

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | FB1h | 00h | Bits [31:0] in the table below |
| Set | 7B1h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|-----------|---|
| [31:2] | Rsvd | R | 00000000h | Reserved |
| [1] | CHAN1_SEL | RW | 1 | Channel 1 (right) Mapping Control: 0 = Channel takes data from left channel 1 = Channel takes data from right channel |
| [0] | CHAN0_SEL | RW | 0 | Channel 0 (left) Mapping Control: 0 = Channel takes data from left channel 1 = Channel takes data from right channel |

00h
01h
02h
03h
04h
05h
06h
07h
08h
09h
0Ah
0Bh
0Ch
0Dh
0Eh
0Fh
10h
11h
12h
13h
14h
15h
16h
17h

PORT-H PIN COMPLEX WIDGET (NID = 16H)

AMPLIFIER GAIN/MUTE VERB

| | Verb ID | Payload [15:0] | Response[31:0] |
|------------|---------|------------------------------------|---|
| Get | Bh | 2000h | Bits [31:0] in the response table below – applies to the left channel only |
| Get | Bh | 0000h | Bits [31:0] in the response table below – applies to the right channel only |
| Set | 3h | Bits [15:0] in the set table below | 00000000h |

Response Table:

| Bit | Bitfield Name | RW | Default | Description |
|--------|----------------|----|---------|---|
| [31:8] | Rsvd | R | 000000h | Reserved |
| [7] | Amplifier Mute | R | 0 | Shows the amplifier mute status of the selected channel: 0 = Normal 1 = Muted |
| [6:0] | Amplifier Gain | R | 18h | Shows the amplifier gain setting (step number) for the selected channel. The actual gain applied is determined by the <i>Input Amplifier Capabilities Parameter</i> in the AFG (NID = 01h), and is shown below for convenience: 00h = -12dB 01h = -11.5dB ... -0.5dB steps 57h = +31.5dB 58h = +32dB |

Set Table:

| Bit | Bitfield Name | RW | Default | Description |
|--------|----------------|----|---------|---|
| [15] | Set Output Amp | W | 0 | Not applicable to this widget |
| [14] | Set Input Amp | W | 1 | Indicates that the programming refers to the input amplifier on this widget |
| [13] | Set Left Amp | W | 1 | 0 = Left channel amplifier does not accept the values in <i>Mute</i> or <i>Gain</i> fields 1 = Left channel amplifier does accept the values in the <i>Mute</i> and <i>Gain</i> fields |
| [12] | Set Right Amp | W | 1 | 0 = Right channel amplifier does not accept the values in <i>Mute</i> or <i>Gain</i> fields 1 = Right channel amplifier does accept the values in the <i>Mute</i> and <i>Gain</i> fields |
| [11:8] | Index | W | 0h | Not applicable to this widget |
| [7] | Mute | W | 0 | 0 = Normal operation 1 = Mute |
| [6:0] | Gain | W | 18h | Step number of the gain – see <i>Amplifier Gain</i> in response table above for details of actual gain values |

GET PARAMETER VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|-----|---------|--------------------|-----------------|
| Get | F00h | Parameter ID (PID) | Parameter Value |

Audio Widget Capabilities Parameter (PID = 09h)

| Bit | Bitfield Name | RW | Default | Description |
|---------|------------------------|----|---------|--|
| [31:24] | Rsvd | R | 00h | Reserved |
| [23:20] | Type | R | 4h | Indicates that this is a Pin Complex Widget |
| [19:16] | Delay | R | 0h | Latency not reported |
| [15:12] | Rsvd | R | 0h | Reserved |
| [11] | L-R Swap | R | 0 | Left/Right swap capability not supported |
| [10] | PowerCntrl | R | 0 | Indicates that the <i>Power State Verb</i> is not supported in this widget |
| [9] | Digital | R | 1 | Indicates that this widget is translating digital data |
| [8] | Conn List | R | 1 | Indicates that a connection list is present |
| [7] | Unsol Capable | R | 0 | Widget does not support Unsolicited Responses |
| [6] | ProcWidget | R | 0 | Widget does not have processing capabilities |
| [5] | Stripe | R | 0 | Widget does not support striping |
| [4] | Format Override | R | 0 | Widget does not override the format defined for the AFG |
| [3] | Amp Parameter Override | R | 1 | The AFG amplifier parameters are overridden for this node |
| [2] | Out Amp Present | R | 0 | Output amplifier not present in this widget |
| [1] | In Amp Present | R | 1 | Input amplifier is present in this widget |
| [0] | Stereo | R | 1 | Indicates that this is a stereo widget |

Pin Capabilities Parameter (PID = 0Ch)

| Bit | Bitfield Name | RW | Default | Description |
|---------|-------------------------|----|---------|--|
| [31:17] | Rsvd | R | 0000h | Reserved |
| [16] | EAPD Capable | R | 0 | Widget does not support an EAPD pin |
| [15:8] | VRef Control | R | 00h | VRef not supported for digital inputs |
| [7] | Rsvd | R | 0 | Reserved |
| [6] | Balanced I/O Pins | R | 0 | Indicates that this widget does not have balanced pins |
| [5] | Input Capable | R | 1 | Indicates that this widget is input capable |
| [4] | Output Capable | R | 1 | Indicates that this widget is output capable |
| [3] | Headphone Drive Capable | R | 0 | Not applicable as this is an input port |
| [2] | Presence Detect Capable | R | 0 | Presence detection not supported |
| [1] | Trigger Required | R | 0 | Impedance measurement not supported |
| [0] | Impedance Sense Capable | R | 0 | Impedance measurement not supported |

Input Amplifier Capabilities Response Format (PID = 0Dh)

| Bit | Bitfield Name | RW | Default | Description |
|---------|---------------|----|---------|--|
| [31] | Mute Capable | R | 1 | DMIC Amplifiers are capable of hard-mute |
| [30:23] | Rsvd | R | 00h | Reserved |
| [22:16] | Step Size | R | 01h | Gain step size is 0.5dB |
| [15] | Rsvd | R | 0 | Reserved |
| [14:8] | Num Steps | R | 58h | Number of steps in gain range is 89 (-12dB to +32dB) |
| [7] | Rsvd | R | 0 | Reserved |
| [6:0] | Offset | R | 18h | The step number that 0dB corresponds to is 18h |

Connection List Length Parameter (PID = 0Eh)

| Bit | Bitfield Name | RW | Default | Description |
|--------|------------------------|----|---------|--|
| [31:8] | Rsvd | R | 000000h | Reserved |
| [7] | Long Form | R | 0 | Indicates that the connection list items are in short form |
| [6:0] | Connection List Length | R | 01h | Indicates that there is 1 NID entry in the connection list |

GET CONNECTION LIST ENTRY VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|---------------|--------------------------------|
| Get | F02h | 00h | Bits [31:0] in the table below |

| Bit | Bitfield Name | RW | Default | Description |
|---------|-------------------|----|---------|---|
| [31:24] | Conn List Entry 3 | R | 00h | Unused connection list entry |
| [23:16] | Conn List Entry 2 | R | 00h | Unused connection list entry |
| [15:8] | Conn List Entry 1 | R | 00h | Unused connection list entry |
| [7:0] | Conn List Entry 0 | R | 17h | Indicates that the Port-H Pin Widget connects to Node 17h |

PIN WIDGET CONTROL VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|------------|---------|-------------------------------|--------------------------------|
| Get | F07h | 00h | Bits [31:0] in the table below |
| Set | 707h | Bits [7:0] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|--------|---------------|----|---------|--|
| [31:8] | Rsvd | R | 000000h | Reserved |
| [7] | H-Phn Enable | R | 0 | Not applicable as this in an input port |
| [6] | Out Enable | RW | 0 | Controls the output path: 0 = Output path is disabled 1 = Output path is enabled |
| [5] | In Enable | RW | 1 | Controls the input path: 0 = Input path is disabled 1 = Input path is enabled |
| [4:3] | Rsvd | R | 0h | Reserved |
| [2:0] | VRefEn | R | 0h | Selectable VRef not supported |

Note: It is erroneous behaviour for both the *Out Enable* and *In Enable* registers to be set high simultaneously. If both registers are set, Port-H defaults to an input.

CONFIGURATION DEFAULT VERB

| | Verb ID | Payload [7:0] | Response[31:0] |
|-------------|---------|---------------------------------|--------------------------------|
| Get | F1Ch | 00h | Bits [31:0] in the table below |
| Set1 | 71Ch | Bits [7:0] in the table below | 00000000h |
| Set2 | 71Dh | Bits [15:8] in the table below | 00000000h |
| Set3 | 71Eh | Bits [23:16] in the table below | 00000000h |
| Set4 | 71Fh | Bits [31:24] in the table below | 00000000h |

| Bit | Bitfield Name | RW | Default | Description |
|---------|-------------------|----|---------|--|
| [31:30] | Port Connectivity | RW | 0h | Indicates the external connectivity: 0h = Jack 1h = No physical connection 2h = A fixed function device 3h = both a jack and an internal device are connected |
| [29:28] | Location[5:4] | RW | 1h | Gross physical location of the device connected to Port-H: 0h = External on primary chassis 1h = Internal 2h = Separate chassis 3h = Other |
| [27:24] | Location[3:0] | RW | 0h | Geometric location of the device connected to Port-H: 0h = Not applicable 1h = Rear 2h = Front 3h = Left 4h = Right 5h = Top 6h = Bottom 7h = Special 8h = Special 9h = Special Ah-Fh = Reserved |
| [23:20] | Default Device | RW | Ah | Indicates the intended use of Port-H: 0h = Line out 1h = Speaker 2h = Headphone out 3h = CD 4h = S/PDIF out 5h = Digital other out 6h = Modem line side 7h = Modem handset side 8h = Line in 9h = AUX Ah = Mic in Bh = Telephony Ch = S/PDIF in Dh = Digital other in Eh = Reserved Fh = Other |

| Bit | Bitfield Name | RW | Default | Description |
|---------|---------------------|----|---------|--|
| [19:16] | Connection Type | RW | 6h | Indicates the type of physical interface on Port-H: 0h = Unknown 1h = 3.5mm stereo/mono jack 2h = ¼" stereo/mono jack 3h = ATAPI internal 4h = RCA jack (for analogue audio or coaxial S/PDIF) 5h = Optical 6h = Other digital 7h = Other analogue 8h = Multi-channel analogue (DIN) 9h = XLR/Professional Ah = RJ-11 (modem) Bh = Combination Ch-Eh = Reserved Fh = Other |
| [15:12] | Colour | RW | 0h | Indicates the colour of the physical jack on Port-H: 0h = Unknown 1h = Black 2h = Grey 3h = Blue 4h = Green 5h = Red 6h = Orange 7h = Yellow 8h = Purple 9h = Pink Ah-Dh = Reserved Eh = White Fh = Other |
| [11:8] | Misc | RW | 1h | Presence detection override: 0h = Presence detection indicated by <i>Pin Capabilities Parameter</i> 1h = Presence detection not supported. If the <i>Pin Capabilities Parameter</i> indicates that that presence detection is supported by the node, then this bit is used to override it to indicate the external circuitry is not capable of supporting presence detect All other values are reserved |
| [7:4] | Default Association | RW | Fh | Association number: 0h = Reserved 1h-Eh = Multi Channel or Single Pin Widget Fh = Single Pin Widget Only |
| [3:0] | Sequence | RW | 0h | Sequence number used to define individual channel pairs within a stream. All values (0h-Fh) are available for use. Use a value of 0 for Single Pin Widget. |

Note: The *Configuration Default Verb* is not reset to its default value during a reset from any source. The settings are only lost when digital power is removed from the WM8860. When digital power is restored, the System BIOS must restore the settings.

RESERVED (NID = 17H)

- 00h
- 01h
- 02h
- 03h
- 04h
- 05h
- 06h
- 07h
- 08h
- 09h
- 0Ah
- 0Bh
- 0Ch
- 0Dh
- 0Eh
- 0Fh
- 10h
- 11h
- 12h
- 13h
- 14h
- 15h
- 16h
- 17h**

APPLICATIONS INFORMATION

RECOMMENDED EXTERNAL COMPONENTS

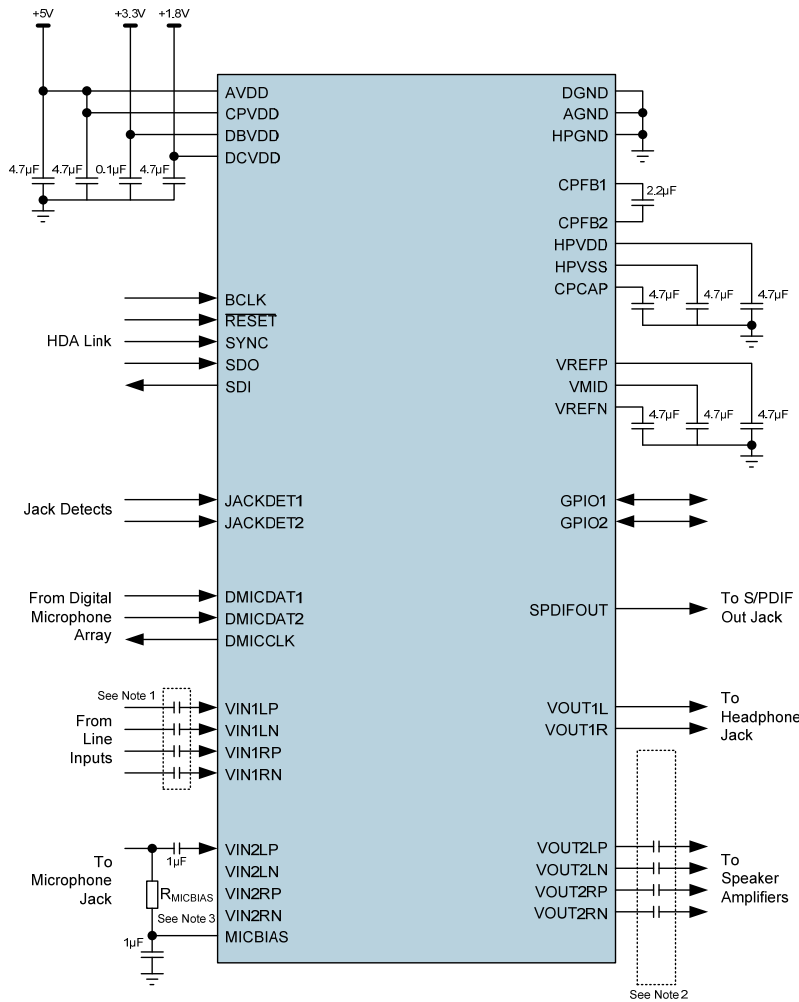


Figure 16 Recommended External Components

Notes:

1. AC-coupling capacitors for inputs may depend on circuitry used prior to WM8860. Typical values between 1µF and 10µF are common – consult any documentation for the exact circuit used
2. AC-coupling capacitors for outputs may depend in circuitry used after WM8860. Typical values between 1µF and 10µF are common – consult any documentation for the exact circuit used
3. A single-ended mono microphone input is shown, but other configurations are equally valid. The value of the microphone bias resistor will vary with the microphone used – a typical value is 2.2kΩ
4. The capacitor between CFB1 and CFB2 must be placed as close as possible to the device pins
5. The decoupling capacitor on CPCAP must also be placed as close as possible to the device pins
6. The decoupling capacitor on CPVDD is next important – it too should be placed as close as possible to the device pins
7. The decoupling capacitors on VREFP, VREFN and VMID are next important, in that order
8. All remaining decoupling capacitors should then be placed as close as possible

REQUIRED JACK DETECT COMPONENTS

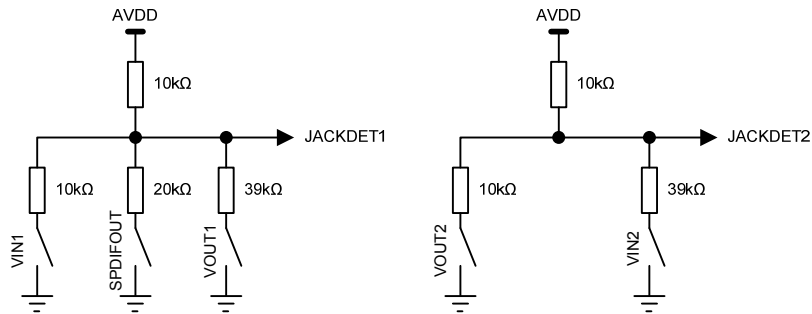
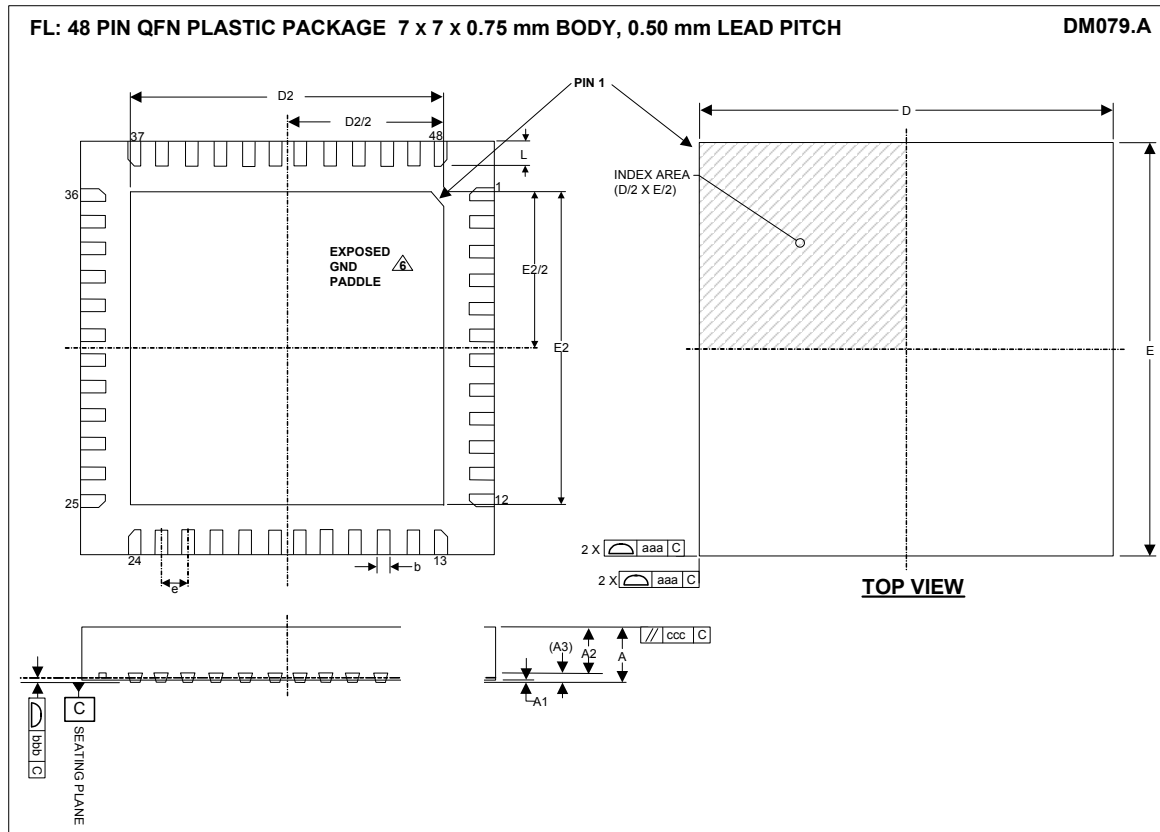


Figure 17 Required Jack Detect Components

The WM8860 supports jack detect on all analogue input and output ports, as well as on the S/PDIF output. This is implemented as per the High Definition Audio Specification Revision 1.0, section 7.4.2 and as such requires the resistor values shown in Figure 17 above. Note that, as per the High Definition Audio Specification, it is a requirement that the tolerance on these resistors is 1% or better.

PACKAGE DIMENSIONS



| Symbols | Dimensions (mm) | | | NOTE |
|--|-----------------|-----------|------|------|
| | MIN | NOM | MAX | |
| A | 0.7 | 0.75 | 0.8 | |
| A1 | 0 | 0.035 | 0.05 | |
| A2 | - | 0.55 | 0.57 | |
| A3 | | 0.203 REF | | |
| b | 0.20 | 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 | | |
| L | 0.35 | 0.4 | 0.45 | |
| Tolerances of Form and Position | | | | |
| aaa | 0.10 | | | |
| bbb | 0.08 | | | |
| ccc | 0.10 | | | |
| REF | JEDEC, MO-220 | | | |

- 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 JESD 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 APPLICATIONS NOTE WAN_0118 FOR FURTHER INFORMATION.

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REVISION HISTORY

| DATE | REV | DESCRIPTION OF CHANGES | PAGE | CHANGED BY |
|-------------|------------|--|-------------|-------------------|
| 04/01/11 | 3.1 | Order Info: updated to show both non tape and reel and tape and reel parts | 8 | JMacD |
| 15/04/11 | 3.2 | AVDD and CPVDD max voltage = 5V+ 5% | 1,10 | JMacD |