

Contents

- 1 Block circuit diagram 6**
- 2 Pin description 7**
 - 2.1 Pin connection 7
 - 2.2 Pin description 7
- 3 Electrical specifications 9**
 - 3.1 Thermal data 9
 - 3.2 Absolute maximum ratings 9
 - 3.3 Electrical characteristics 9
- 4 Description 13**
 - 4.1 Input configuration 13
 - 4.1.1 Front and rear selector 13
 - 4.1.2 Direct path 15
 - 4.2 Mixing 16
 - 4.3 Loudness 17
 - 4.3.1 Loudness attenuation 17
 - 4.3.2 Peak frequency 17
 - 4.3.3 High frequency boost 18
 - 4.3.4 Flat mode 18
 - 4.4 SoftMute 18
 - 4.5 Softstep volume 19
 - 4.6 Bass 19
 - 4.6.1 Bass attenuation 19
 - 4.6.2 Bass center frequency 19
 - 4.6.3 Bass quality factors 20
 - 4.6.4 DC mode 20
 - 4.7 Middle 21
 - 4.7.1 Middle attenuation 21
 - 4.7.2 Middle center frequency 21
 - 4.7.3 Middle quality factors 22
 - 4.8 Treble 22

| | | |
|----------|---|-----------|
| 4.8.1 | Treble attenuation | 22 |
| 4.8.2 | Treble center frequency | 23 |
| 4.9 | Subwoofer Filter | 23 |
| 4.10 | Softstep control | 24 |
| 4.11 | DC offset detector and level meter option | 25 |
| 4.12 | DC offset detector | 25 |
| 4.13 | Level meter | 26 |
| 4.14 | Output gain control | 26 |
| 4.15 | Audioprocessor testing | 26 |
| 4.16 | Test circuit (3 x QD + 1 x FD + DC offset detector) | 27 |
| 5 | I²C bus specification | 28 |
| 5.1 | Interface protocol | 28 |
| 5.1.1 | Receive mode | 29 |
| 5.1.2 | Transmission mode | 29 |
| 5.1.3 | Reset condition | 29 |
| 5.2 | Data byte specification | 31 |
| 6 | Package information | 44 |
| 6.1 | TSSOP28 package information | 44 |
| 7 | Revision history | 46 |

List of tables

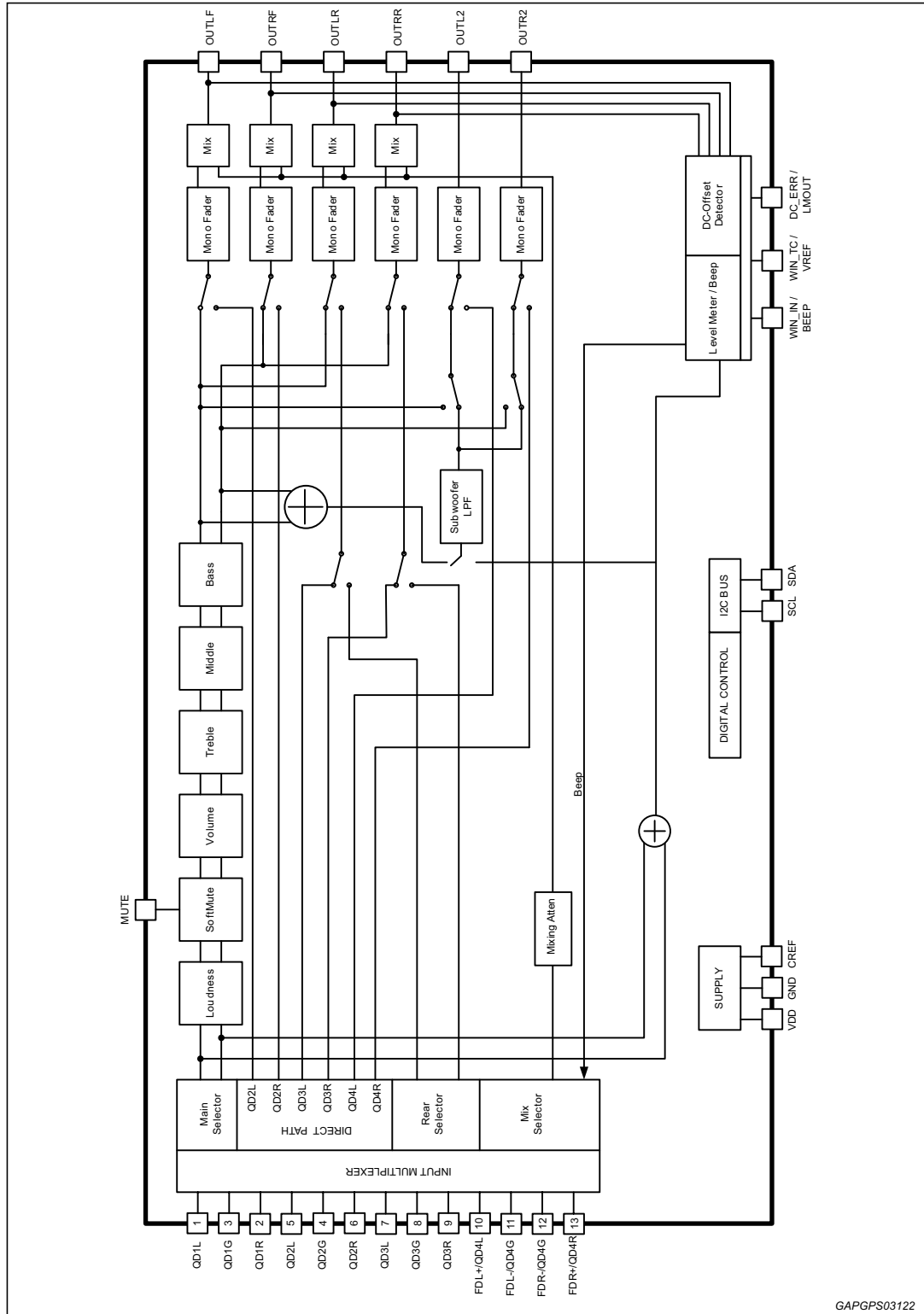
| | | |
|-----------|--|----|
| Table 1. | Device summary | 1 |
| Table 2. | Pin description | 7 |
| Table 3. | Thermal data | 9 |
| Table 4. | Absolute maximum ratings | 9 |
| Table 5. | Electrical characteristics | 9 |
| Table 6. | Input pin configuration | 13 |
| Table 7. | Selector configuration matrix | 14 |
| Table 8. | Available sources for mixing | 16 |
| Table 9. | I ² C bus electrical characteristics | 28 |
| Table 10. | Subaddress (receive mode) | 30 |
| Table 11. | Input configuration / main selector (0) | 31 |
| Table 12. | 2nd Source selector / direct path (1) | 32 |
| Table 13. | Mixing source / mixing gain (2) | 33 |
| Table 14. | Mix control / level meter / dc offset detector configure (3) | 34 |
| Table 15. | Soft mute / others (4) | 35 |
| Table 16. | SoftStep I (5) | 36 |
| Table 17. | SoftStep II / DC detector (6) | 37 |
| Table 18. | Loudness (7) | 38 |
| Table 19. | Volume / output gain (8) | 38 |
| Table 20. | Treble filter (9) | 39 |
| Table 21. | Middle filter (10) | 39 |
| Table 22. | Bass filter (11) | 40 |
| Table 23. | Subwoofer / middle / bass (12) | 40 |
| Table 24. | Speaker attenuation (LF/RF/LR/RR) (13-16) | 41 |
| Table 25. | Subwoofer attenuation (subwoofer L/subwoofer R) (17-18) | 41 |
| Table 26. | Testing audio processor 1 (19) | 42 |
| Table 27. | Testing audio processor 2 (20) | 43 |
| Table 28. | TSSOP28 package mechanical data | 45 |
| Table 29. | Document revision history | 46 |

List of figures

| | | |
|------------|---|----|
| Figure 1. | Block circuit diagram | 6 |
| Figure 2. | Pin connection (top view) | 7 |
| Figure 3. | QD and FD configuration of QD4/FD4 | 15 |
| Figure 4. | Block diagram of mixing stage | 16 |
| Figure 5. | Loudness attenuation @ $f_P = 400$ Hz. | 17 |
| Figure 6. | Loudness center frequencies @ Attn. = 15 dB. | 17 |
| Figure 7. | Loudness attenuation, $f_c = 2.4$ kHz | 18 |
| Figure 8. | SoftMute timing | 18 |
| Figure 9. | Bass Control @ $f_c = 80$ Hz, $Q = 1$ | 19 |
| Figure 10. | Bass center frequencies @ gain = 14 dB, $Q = 1$ | 19 |
| Figure 11. | Bass quality factors @ gain = 14 dB, $f_c = 80$ Hz. | 20 |
| Figure 12. | Bass normal and DC mode @ Gain = 14 dB, $f_c = 80$ Hz | 20 |
| Figure 13. | Middle control @ $f_c = 1$ kHz, $Q = 1$ | 21 |
| Figure 14. | Middle center frequencies @ gain = 14 dB, $Q = 1$ | 21 |
| Figure 15. | Middle quality factors @ gain = 14 dB, $f_c = 1$ kHz | 22 |
| Figure 16. | Treble Control @ $f_c = 17.5$ kHz. | 22 |
| Figure 17. | Treble center frequencies @ gain = 14 dB | 23 |
| Figure 18. | Subwoofer control | 23 |
| Figure 19. | DC offset detection circuit (simplified). | 26 |
| Figure 20. | Test circuit. | 27 |
| Figure 21. | Switching characteristics. | 28 |
| Figure 22. | I ² C timing diagram | 29 |
| Figure 23. | TSSOP28 package outline | 44 |

1 Block circuit diagram

Figure 1. Block circuit diagram

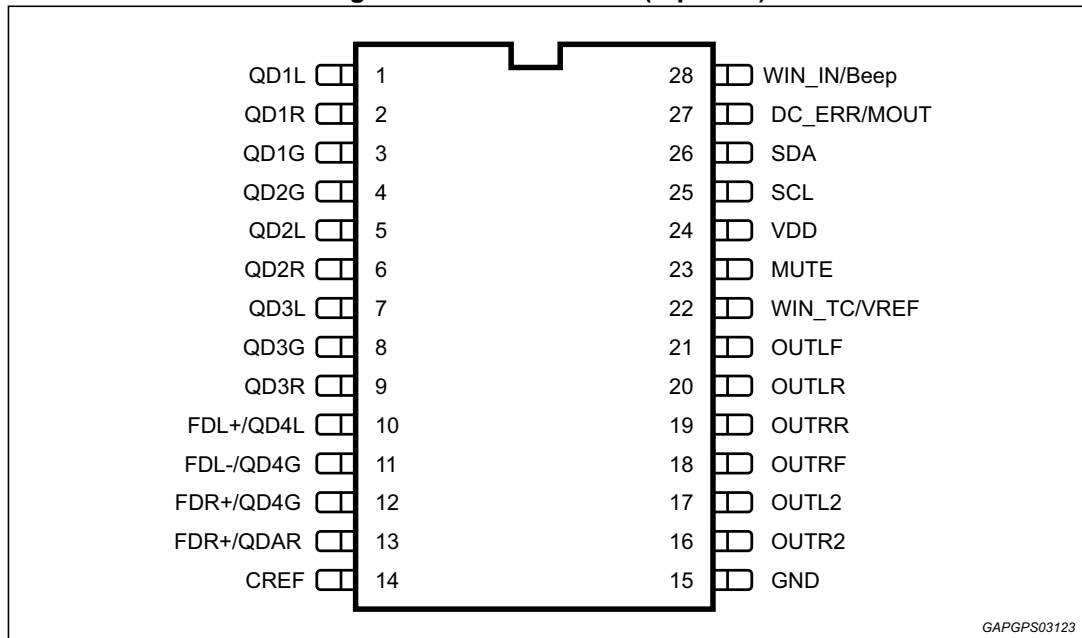


GAPGPS03122

2 Pin description

2.1 Pin connection

Figure 2. Pin connection (top view)



2.2 Pin description

Table 2. Pin description

| No. | Pin name | Description | I/O |
|-----|----------------------------|--|-----|
| 1 | QD1L / SE1L / MD3+ | QD1 left input or SE1 left or MD3 positive input | I/O |
| 2 | QD1R / SE1R / MD3- | QD1 right input or SE1 right input or MD3 negative input | I/O |
| 3 | QD1G / SE2L | QD1 common input or SE2 left input | I/O |
| 4 | QD2G / SE2R | QD2 common input or SE2 right input | I/O |
| 5 | QD2L / SE3L | QD2 left input or SE3 left input | I/O |
| 6 | QD2R / SE3R | QD2 right input or SE3 right input | I/O |
| 7 | QD3L | QD3 left input | I/O |
| 8 | QD3G | QD3 common input | I/O |
| 9 | QD3R | QD3 right input | I/O |
| 10 | QD4L / FD4L+ / SE4L / MD1+ | QD4 left input or FD4L positive input or SE4 left input or MD1 positive input | I/O |
| 11 | QD4G / FD4L- / SE4R / MD1- | QD4 common input or FD4L negative input or SE4 right input or MD1 negative input | I/O |

Table 2. Pin description (continued)

| No. | Pin name | Description | I/O |
|-----|----------------------------|---|-----|
| 12 | QD4G / FD4R- / SE5L / MD2- | QD4 common input or FD4R negative input or SE5 left input or MD2 negative input | I/O |
| 13 | QD4R / FD4R+ / SE5R / MD2+ | QD4 right input or FD4R positive input or SE5 right input or MD2 positive input | I/O |
| 14 | CREF | Reference capacitor | O |
| 15 | GND | Ground | S |
| 16 | OUTR2 | Subwoofer output / 2 nd right output | O |
| 17 | OUTL2 | Subwoofer output / 2 nd left output | O |
| 18 | OUTRF | Front right output | O |
| 19 | OUTRR | Rear right output | O |
| 20 | OUTLR | Rear left output | O |
| 21 | OUTLF | Front left output | O |
| 22 | WinTC / VREF | DC offset detector filter or Vref output | O |
| 23 | MUTE | I ² C bus data | I/O |
| 24 | VDD | Supply | S |
| 25 | SCL | I ² C bus clock | I |
| 26 | SDA | I ² C bus data | I/O |
| 27 | DC_ERR / LMOUT | DC offset detector output or Level meter output | O |
| 28 | WIN_IN / Beep | DC offset detector input or Beep input (Mono Single-Ended input) | I |

3 Electrical specifications

3.1 Thermal data

Table 3. Thermal data

| Symbol | Description | Value | Unit |
|-----------------|--|---------|------|
| $R_{th-j\ amb}$ | Thermal resistance junction to ambient | Max 114 | °C/W |

3.2 Absolute maximum ratings

Table 4. Absolute maximum ratings

| Symbol | Parameter | Value | Unit |
|---------------|---------------------------------------|------------|------|
| V_S | Operating supply voltage | 10.5 | V |
| V_{in_max} | Maximum voltage for signal input pins | 7 | V |
| T_{amb} | Operating ambient temperature | -40 to 85 | °C |
| T_{stg} | Storage temperature range | -55 to 150 | °C |

3.3 Electrical characteristics

$V_S = 8.5\text{ V}$; $T_{amb} = -40\text{ to }85\text{ °C}$; $R_L = 10\text{ k}\Omega$; all gains = 0 dB; $f = 1\text{ kHz}$; unless otherwise specified

Table 5. Electrical characteristics

| Symbol | Parameter | Test condition | Min. | Typ. | Max. | Unit |
|-----------------------------------|--|--|------|------|------|---------------|
| Supply | | | | | | |
| V_s | Supply voltage | - | 7.5 | 8.5 | 10 | V |
| I_s | Supply current | - | - | 35 | - | mA |
| Input selector | | | | | | |
| R_{in} | Input resistance | All single ended inputs ⁽¹⁾ | 70 | 100 | 130 | k Ω |
| V_{CL} | Clipping level | Input gain = 0 dB | - | 2 | - | V_{RMS} |
| S_{IN} | Input separation | - | - | 100 | - | dB |
| Differential stereo inputs | | | | | | |
| R_{in} | Input resistance | Differential | 70 | 100 | 130 | k Ω |
| CMRR1 | Common mode rejection ratio for main source | $V_{CM}=1\text{ VRMS@ }1\text{ kHz}$ | 46 | 60 | - | dB |
| | | $V_{CM}=1\text{ VRMS@ }10\text{ kHz}$ | 46 | 60 | - | dB |
| CMRR2 | Common mode rejection ratio for 2 nd source | $V_{CM}=1\text{ VRMS@ }1\text{ kHz}$ | 46 | 60 | - | dB |
| e_{No} | Output noise @ speaker outputs | 20 Hz-20 kHz, A-weighted; all stages 0dB | - | 12 | - | μV |

Table 5. Electrical characteristics (continued)

| Symbol | Parameter | Test condition | Min. | Typ. | Max. | Unit |
|-------------------------|---------------------------|-----------------------------|----------|-----------|----------|------------|
| Loudness control | | | | | | |
| A_{MAX} | Max attenuation | - | - | 15 | - | dB |
| A_{STEP} | Step resolution | - | - | 1 | - | dB |
| f_{Peak} | Peak frequency | f_{P1} | - | 400 | - | Hz |
| | | f_{P2} | - | 800 | - | Hz |
| | | f_{P3} | - | 2400 | - | Hz |
| Volume control | | | | | | |
| G_{MAX} | Max gain | - | - | 15 | - | dB |
| A_{MAX} | Max attenuation | - | - | -15 | - | dB |
| A_{STEP} | Step resolution | - | 0.5 | 1 | 1.5 | dB |
| E_A | Attenuation set error | - | -0.75 | 0 | +0.75 | dB |
| E_T | Tracking error | - | - | - | 2 | dB |
| V_{DC} | DC steps | Adjacent attenuation steps | - | 0.1 | 3 | mV |
| | | From 0 dB to G_{MIN} | - | 0.5 | 5 | mV |
| Soft mute | | | | | | |
| A_{MUTE} | Mute attenuation | - | 80 | 100 | - | dB |
| T_D | Delay time | T1 | - | 0.48 | - | ms |
| | | T2 | - | 0.96 | - | ms |
| | | T3 | - | 8 | - | ms |
| | | T4 | - | 16 | - | ms |
| $V_{TH\ Low}$ | Low threshold for SM pin | - | - | - | 1 | V |
| $V_{TH\ High}$ | High threshold for SM pin | - | 2.5 | - | - | V |
| R_{PU} | Internal pull-up resistor | - | 32 | 45 | 58 | k Ω |
| V_{PU} | Internal pull-up Voltage | - | - | 3.3 | - | V |
| Bass control | | | | | | |
| F_c | Center frequency | f_{C1} | 54 | 60 | 66 | Hz |
| | | f_{C2} | 72 | 80 | 88 | Hz |
| | | f_{C3} | 90 | 100 | 110 | Hz |
| | | f_{C4} | 180 | 200 | 220 | Hz |
| Q_{BASS} | Quality factor | Q_1 | 0.9 | 1 | 1.1 | - |
| | | Q_2 | 1.1 | 1.25 | 1.4 | - |
| | | Q_3 | 1.3 | 1.5 | 1.7 | - |
| | | Q_4 | 1.8 | 2 | 2.2 | - |
| C_{RANGE} | Control range | - | ± 14 | ± 15 | ± 16 | dB |
| A_{STEP} | Step resolution | - | 0.5 | 1 | 1.5 | dB |
| DC_{GAIN} | Bass-DC-gain | DC = off | -1 | 0 | +1 | dB |
| | | DC = on, Gain = ± 15 dB | - | ± 4.4 | | dB |

Table 5. Electrical characteristics (continued)

| Symbol | Parameter | Test condition | Min. | Typ. | Max. | Unit |
|-----------------------------|------------------------|----------------------------|------|------|------|------------|
| Middle control | | | | | | |
| C_{RANGE} | Control range | - | ±14 | ±15 | ±16 | dB |
| A_{STEP} | Step resolution | - | 0.5 | 1 | 1.5 | dB |
| f_c | Center frequency | f_{C1} | 400 | 500 | 600 | Hz |
| | | f_{C2} | 0.8 | 1 | 1.2 | kHz |
| | | f_{C3} | 1.2 | 1.5 | 1.8 | kHz |
| | | f_{C4} | 2 | 2.5 | 3 | kHz |
| Q_{BASS} | Quality factor | Q_1 | 0.45 | 0.5 | 0.55 | - |
| | | Q_2 | 0.65 | 0.75 | 0.85 | - |
| | | Q_3 | 0.9 | 1 | 1.1 | - |
| | | Q_4 | 1.1 | 1.25 | 1.4 | - |
| Treble control | | | | | | |
| C_{RANGE} | Clipping level | | ±14 | ±15 | ±16 | dB |
| A_{STEP} | Step resolution | | 0.5 | 1 | 1.5 | dB |
| f_c | Center frequency | f_{C1} | 8 | 10 | 12 | kHz |
| | | f_{C2} | 10 | 12.5 | 15 | kHz |
| | | f_{C3} | 12 | 15 | 18 | kHz |
| | | f_{C4} | 14 | 17.5 | 21 | kHz |
| Speaker attenuators | | | | | | |
| A_{MIN} | Min attenuation | - | -1 | 0 | 1 | dB |
| A_{MAX} | Max attenuation | - | -89 | -79 | -69 | dB |
| A_{STEP} | Step resolution | - | 0.5 | 1 | 1.5 | dB |
| A_{MUTE} | Mute attenuation | - | 80 | 90 | | dB |
| E_E | Attenuation set error | - | - | - | 2 | dB |
| V_{DC} | DC steps | Adjacent attenuation steps | - | 0.1 | 5 | mV |
| Audio outputs | | | | | | |
| V_{CL} | Clipping level | $d = 0.3\%$; Byte8_D6=1 | 2 | - | - | V_{RMS} |
| | | $d = 1\%$; Byte8_D6=0 | 2.2 | - | - | V_{RMS} |
| R_{OUT} | Output impedance | - | - | 30 | 100 | Ω |
| R_L | Output load resistance | - | 2 | - | - | k Ω |
| C_L | Output load capacitor | - | - | - | 10 | nF |
| V_{DC} | DC voltage level | - | 3.8 | 4.0 | 4.2 | V |
| Subwoofer attenuator | | | | | | |
| G_{MAX} | Max gain | - | 14 | 15 | 16 | dB |
| A_{MAX} | Max attenuation | - | -83 | -79 | -75 | dB |
| A_{STEP} | Step resolution | - | 0.5 | 1 | 1.5 | dB |
| A_{MUTE} | Mute attenuation | - | 80 | 90 | - | dB |
| E_E | Attenuation set error | - | - | - | 2 | dB |

Table 5. Electrical characteristics (continued)

| Symbol | Parameter | Test condition | Min. | Typ. | Max. | Unit |
|------------------------------------|-------------------------------|---|------|------|------|------|
| V_{DC} | DC steps | Adjacent attenuation steps | - | 0.1 | 5 | mV |
| Subwoofer lowpass | | | | | | |
| f_{LP} | Lowpass corner frequency | f_{LP1} | 72 | 80 | 88 | Hz |
| | | f_{LP2} | 108 | 120 | 132 | Hz |
| | | f_{LP3} | 144 | 160 | 176 | Hz |
| DC offset detection circuit | | | | | | |
| V_{th} | Zero comp window size | V1 | - | ±25 | - | mV |
| | | V2 | - | ±50 | - | mV |
| | | V3 | - | ±75 | - | mV |
| | | V4 | - | ±100 | - | mV |
| t_{sp} | Max rejected spike length | - | - | 11 | - | µs |
| | | - | - | 22 | - | µs |
| | | - | - | 33 | - | µs |
| | | - | - | 44 | - | µs |
| $I_{CHDCerr}$ | DCErr charge current | - | - | 5 | - | µA |
| $I_{DISDCerr}$ | DCErr discharge current | - | - | 5 | - | mA |
| V_{OutH} | DCErr high volotage | - | - | 3.3 | - | V |
| V_{OutL} | DCErr low voltage | - | - | 100 | - | mV |
| Level meter | | | | | | |
| V_{out} | Output voltage range | - | 0 | | 3.3 | V |
| V_{LEVEL} | Output level | $V_{in} = 1 V_{rms}$ | - | 1.6 | - | V |
| | | $V_{in} = AC$ grounded | - | 0 | - | V |
| T_{DEL} | Analog output delay time | - | - | 2 | - | µs |
| General | | | | | | |
| e_{NO} | Output noise | BW = 20 Hz to 20 kHz A-Weighted, all gain = 0 dB | - | 12 | - | µV |
| | | BW = 20 Hz - 20 kHz A-Weighted, output muted | - | 6 | - | µV |
| S/N | Signal to noise ratio | all gain = 0 dB, A-weighted; $V_o = 2 V_{RMS}$ | - | 104 | - | dB |
| D | Distortion | $V_{IN} = 1 V_{RMS}$, all stages 0dB | - | 0.01 | - | % |
| S_C | Channel separation left/right | - | - | 90 | - | dB |

1. When DC offset detector is not used, the impedance of mono single-ended input is 50 kΩ instead of 100 kΩ.

4 Description

4.1 Input configuration

4.1.1 Front and rear selector

The input stage (Main source and 2nd source) is configurable to adapt to different application. There are 7 different configurations which provide different input structure and different number of input sources as shown below.

- 4 x QD,
- 2 x QD + 3 x SE,
- 1 x QD + 5 x SE,
- 1 x QD + 3 x SE + 2 x MD,
- 3 x QD + 1 x FD,
- 3 x QD + 2 x SE,
- 1 x QD + 2 x SE + 1 x FD + 1 x MD,
- 1 x QD + 3 x SE + 1 x FD

Note: QD = Quasi-Differential, SE = Single-ended input, FD = Full Differential, MD = mono Differential

The configuration of the input stage is controlled by 'Input Configuration' bits in I²C control table (Byte0 Bit5~Bit7). The table below shows the configuration of input pins in different configurations.

Table 6. Input pin configuration

| Pin | Pin name | Configuration bits (Byte0 Bit7~Bit5) | | | | | | | | | | | | | | | |
|-----|----------------------|--------------------------------------|------|-------|------|-------|------|-------|------|-------|------|-------|-------|-------|-------|-------|-------|
| | | "000" | | "001" | | "010" | | "011" | | "100" | | "101" | | "110" | | "111" | |
| | | CFG0 | CFG1 | CFG2 | CFG3 | CFG4 | CFG5 | CFG6 | CFG7 | CFG8 | CFG9 | CFG10 | CFG11 | CFG12 | CFG13 | CFG14 | CFG15 |
| 1 | QD1L_SE1L_MD3+ | QD1L | IN0 | SE1L | IN0 | SE1L | IN0 | SE1L | IN0 | QD1L | IN0 | QD1L | IN0 | MD3+ | IN7 | SE1L | IN0 |
| 2 | QD1R_SE1R_MD3- | QD1R | | SE1R | | SE1R | | SE1R | | QD1R | | QD1R | | MD3- | | SE1R | |
| 3 | QD1G_SE2L | QD1G | IN4 | SE2L | IN4 | SE2L | IN4 | SE2L | IN4 | QD1G | IN4 | QD1G | IN4 | SE2L | IN4 | SE2L | IN4 |
| 4 | QD2G_SE2R | QD2G | | SE2R | | SE2R | | SE2R | | QD2G | | QD2G | | SE2R | | SE2R | |
| 5 | QD2L_SE3L | QD2L | IN1 | SE3L | IN1 | SE3L | IN1 | SE3L | IN1 | QD2L | IN1 | QD2L | IN1 | SE3L | IN1 | SE3L | IN1 |
| 6 | QD2R_SE3R | QD2R | | SE3R | | SE3R | | SE3R | | QD2R | | QD2R | | SE3R | | SE3R | |
| 7 | QD3L | QD3L | IN2 | QD3L | IN2 | QD3L | IN2 | QD3L | IN2 | QD3L | IN2 | QD3L | IN2 | QD3L | IN2 | QD3L | IN2 |
| 8 | QD3G | QD3G | | QD3G | | QD3G | | QD3G | | QD3G | | QD3G | | QD3G | | QD3G | |
| 9 | QD3R | QD3R | IN3 | QD3R | IN3 | QD3R | IN3 | QD3R | IN3 | QD3R | IN3 | QD3R | IN3 | QD3R | IN3 | QD3R | IN3 |
| 10 | QD4L_FD4+_SE4L_MD1+ | QD4L | | QD4L | | SE4L | | MD1+ | | FD4L+ | | SE4L | | FD4L+ | | SE4L | |
| 11 | QD4G_FD4L_SE4R_MD1- | QD4G | IN3 | QD4G | IN3 | SE4R | MD1- | FD4L- | IN3 | SE4R | IN3 | FD4L- | IN3 | FD4L- | IN3 | FD4L- | IN3 |
| 12 | QD4G_FD4R_SE5L_MD2- | QD4G | | QD4G | | SE5L | MD2- | FD4R- | | SE5L | | FD4R- | | SE5L | | FD4R- | |
| 13 | QD4R_FD4R+_SE5R_MD2+ | QD4R | IN6 | QD4R | IN6 | SE5R | MD2+ | FD4R+ | IN6 | SE5R | IN6 | FD4R+ | IN6 | FD4R+ | IN6 | FD4R+ | IN6 |
| | | | | | | | | | | | | | | | | | |

With different input configuration, the input source can be selected with input selector (Byte0/1 Bit0~Bit2). The following matrix defines the selector configuration of different input sources dependant on the configuration bits.

Table 7. Selector configuration matrix

| Selector Bits (Byte0/1 Bit2~Bit0) | 000 | 001 | 010 | 011 | 100 | 101 | 110 | 111 |
|---|-----|-----|-----|-------|-----|-----|-----|-----|
| | IN0 | IN1 | IN2 | IN3 | IN4 | IN5 | IN6 | IN7 |
| CFG0 | QD1 | QD2 | QD3 | QD4 | NA | NA | NA | NA |
| CFG1 | SE1 | SE3 | QD3 | QD4 | SE2 | NA | NA | NA |
| CFG2 | SE1 | SE3 | QD3 | NA | SE2 | SE4 | SE5 | NA |
| CFG3 | SE1 | SE3 | QD3 | MD1/2 | SE2 | NA | NA | NA |
| CFG4 | QD1 | QD2 | QD3 | FD | NA | NA | NA | NA |
| CFG5 | QD1 | QD2 | QD3 | NA | NA | SE4 | SE5 | NA |
| CFG6 | NA | SE3 | QD3 | FD | SE2 | NA | NA | MD3 |
| CFG7 | SE1 | SE3 | QD3 | FD | SE2 | NA | NA | NA |

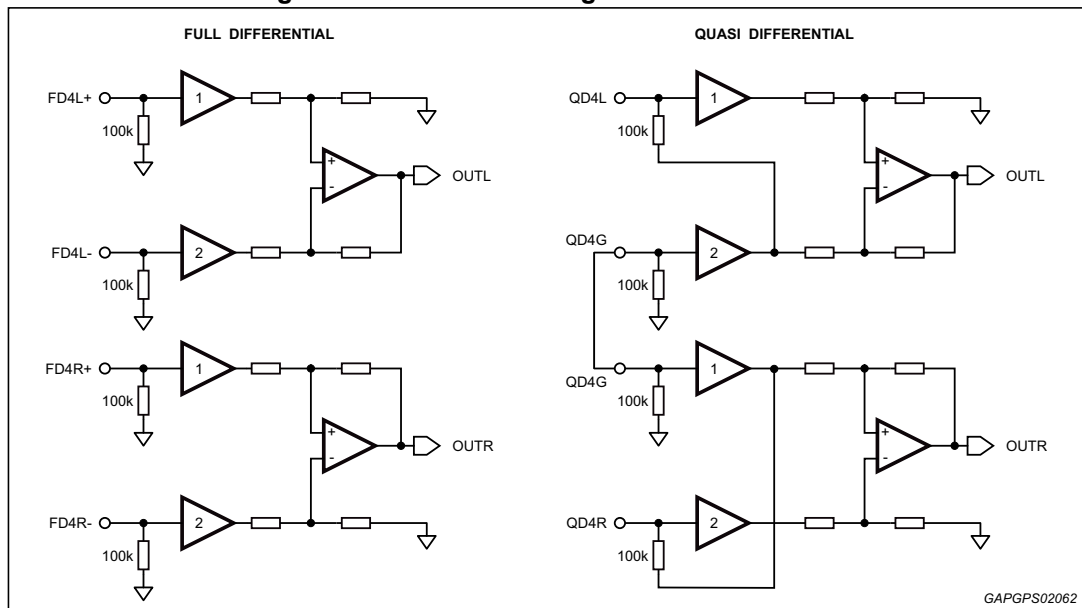
Note: In each configuration, only the light grey cells are allowed. The dark grey cells are not allowed.

MD1/MD2 selection is defined by extra bit – 'MD1/2 selection' in I²C control table (Bit3 of Byte0/1).

The input stage can be configured to 0dB or 3dB gain with I²C bus. The 0dB configuration allows up to 2V_{rms} input signal level, while with 3dB gain, the internal signal will start to clip when input signal level is higher than 1.414V_{rms}.

The Pin10~Pin13 can be configured as full differential input stage or quasi-differential input. When it is configured as quasi-differential input, both Pin11 and Pin12 are used as the QD common input pins. These two pins must be connected together externally in application. In this case the input impedance of QD4 common is reduced to 50kΩ (half of QD4 left and right input). The diagram below shows both QD and FD configuration of QD4/FD4.

Figure 3. QD and FD configuration of QD4/FD4



4.1.2 Direct path

The input pins can be configured as direct path mode by setting Byte1 Bit5~Bit7. In direct path mode the input pins are connected to dedicated mono fader directly, all the filters and volume are bypassed. Below is described the assignment of the input pins and output fader in direct path mode:

Pin5/QD2L --> OUTLF
 Pin6/QD2R --> OUTRF
 Pin7/QD3L --> OUTLR
 Pin9/QD3R --> OUTRR
 Pin10/FDL+_QD4L --> OUTL2
 Pin13/FDR+_QD4R--> OUTR2

Note: *The configurations CFG2, CFG3 and CFG5 are not recommended in direct path mode. Because in these 3 configurations SE4L/MD1+ and SE5R/MD2+ are connected to OUT2_L and OUT2_R fader separately. In this case left and right channel of OUT2 belongs to different input sources.*

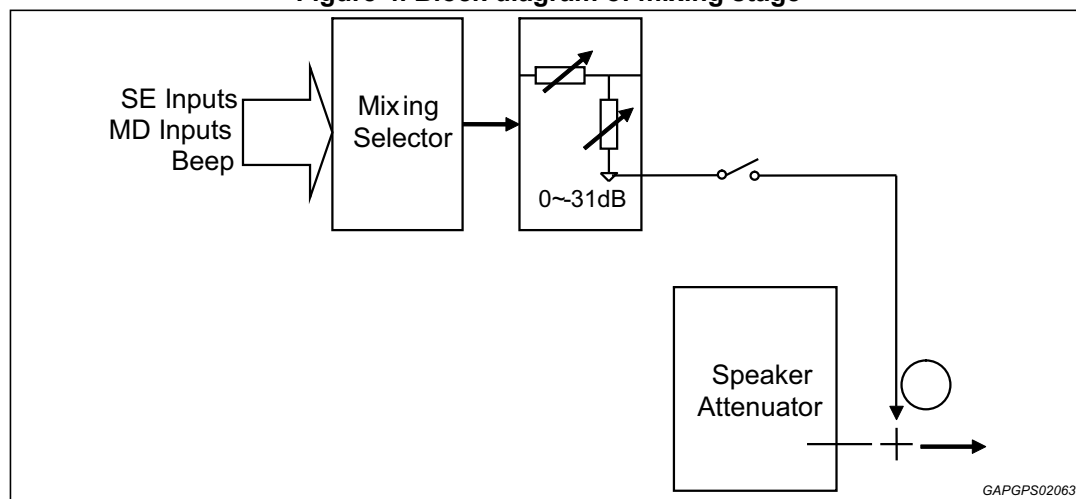
If the direct path is chosen, the input pins have to be used as single ended pins. In case of differential inputs the ground or minus pins must be connect to GND by AC short.

Inputs in direct path mode are also selectable with front and rear selector.

4.2 Mixing

The device provides mixing function which allows the mixing source mixed into front and rear speaker output independently. The mixing source can be any single-ended input, mono-differential input or beep input (Mono single-ended input when DC offset detector is not used). In order to adjust the level of mixing signal, the mixing selector is followed with a 0 dB~31 dB attenuator. The maximum mixing input signal level is 1.6 Vrms for single-ended input and mono-differential input. For beep input, the maximum input signal level is about 1.4 Vrms. The block diagram of the mixing function is shown below.

Figure 4. Block diagram of mixing stage



Since the input stage of this device has different configurations, the corresponding sources for mixing selector are also different according to the configurations. The following table defines the available sources for mixing under different configurations.

Table 8. Available sources for mixing

| Mix selector bits (Byte2 Bit2~Bit0) | 000 | 001 | 010 | 011 | 100 | 101 | 110 | 111 |
|--|--------|--------|--------|--------|--------|--------|--------|--------|
| | MixIN0 | MixIN1 | MixIN2 | MixIN3 | MixIN4 | MixIN5 | MixIN6 | MixIN7 |
| CFG0 | NA | NA | NA | NA | NA | NA | Beep | Mute |
| CFG1 | SE1 | SE2 | SE3 | NA | NA | NA | Beep | Mute |
| CFG2 | SE1 | SE2 | SE3 | SE4 | SE5 | NA | Beep | Mute |
| CFG3 | SE1 | SE2 | SE3 | MD1 | NA | MD2 | Beep | Mute |
| CFG4 | NA | NA | NA | NA | NA | NA | Beep | Mute |
| CFG5 | NA | NA | NA | SE4 | SE5 | NA | Beep | Mute |
| CFG6 | MD3 | SE2 | SE3 | NA | NA | NA | Beep | Mute |
| CFG7 | SE1 | SE2 | SE3 | NA | NA | NA | Beep | Mute |

Note: Only light grey cells are allowed mixing input. The dark grey cells are not allowed. The beep input is available only when DC offset detector function is not used.

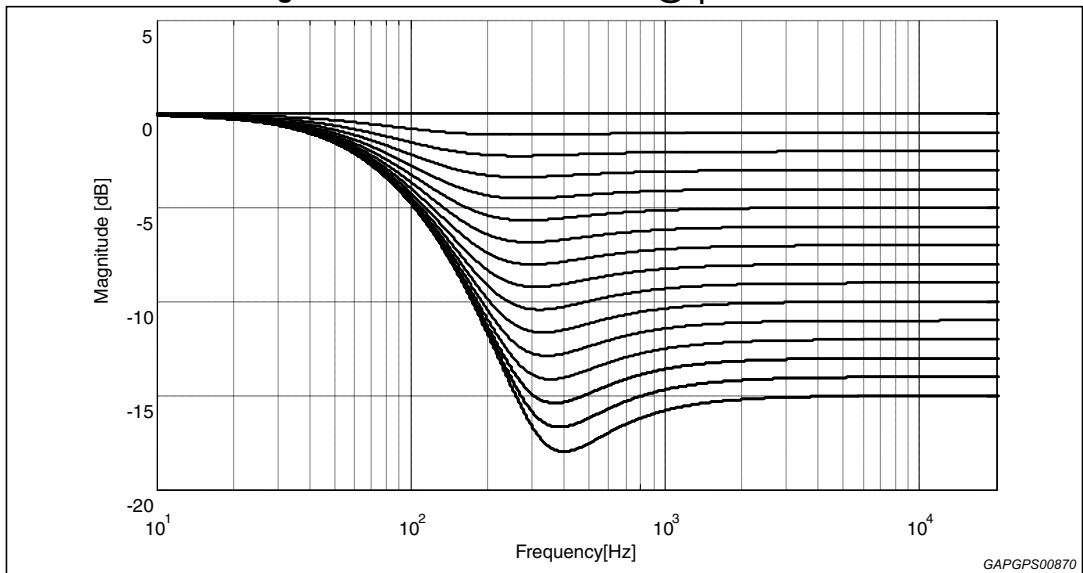
4.3 Loudness

There are four parameters programmable in the loudness stage:

4.3.1 Loudness attenuation

Figure 5 shows the attenuation as a function of frequency at $f_p = 400$ Hz

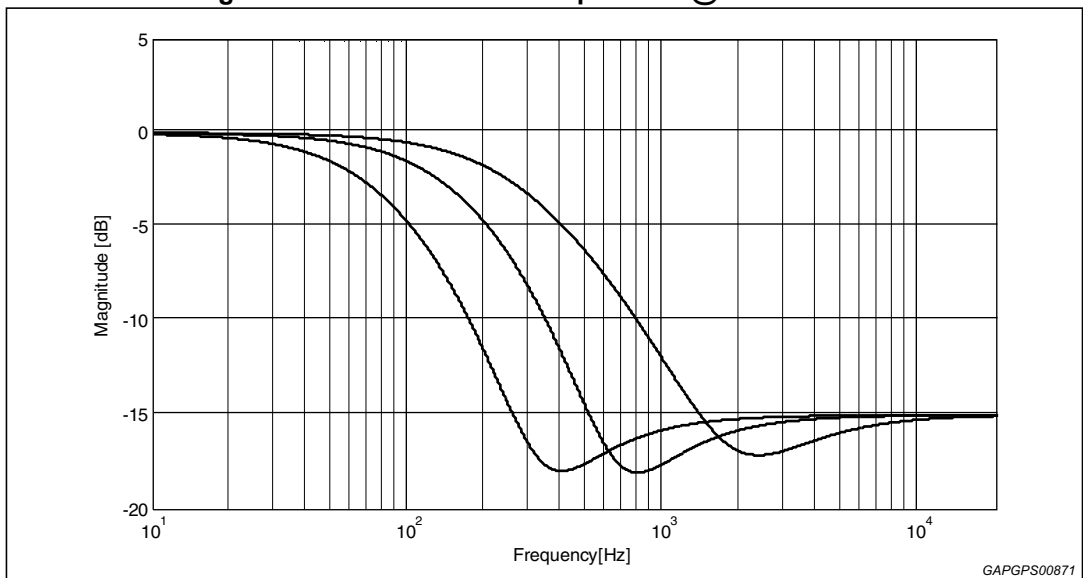
Figure 5. Loudness attenuation @ $f_p = 400$ Hz.



4.3.2 Peak frequency

Figure 6 shows the four possible peak-frequencies at 400, 800 and 2400 Hz

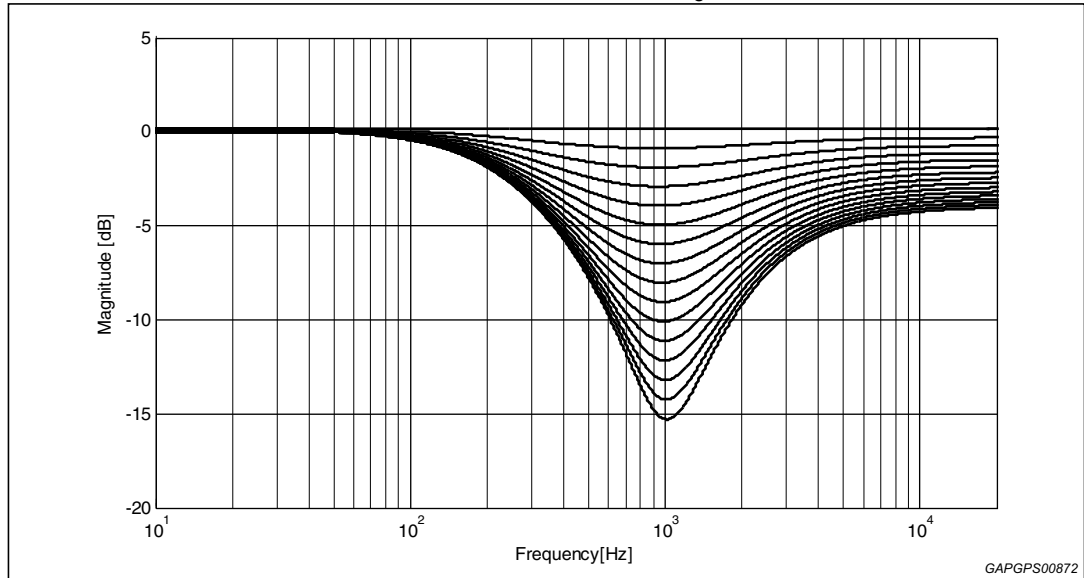
Figure 6. Loudness center frequencies @ Attn. = 15 dB.



4.3.3 High frequency boost

Figure 7 shows the different Loudness shapes in low and high frequency boost.

Figure 7. Loudness attenuation, $f_c = 2.4 \text{ kHz}$



4.3.4 Flat mode

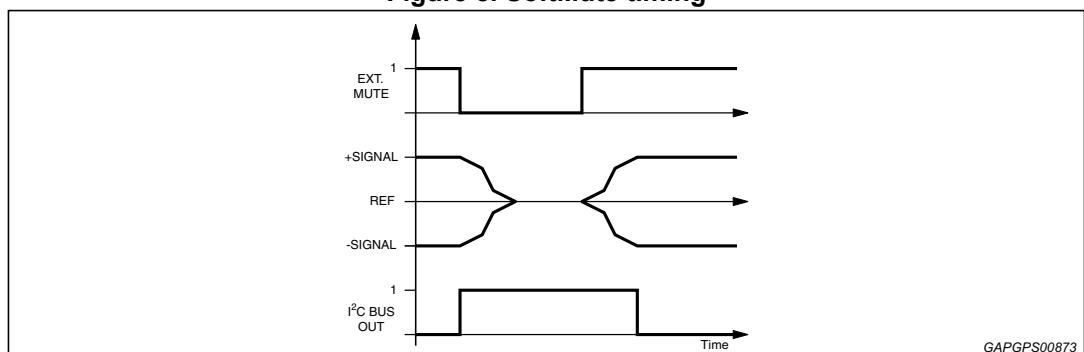
In flat mode the loudness stage works as a 0dB to -15dB attenuator.

4.4 SoftMute

The digitally controlled SoftMute stage allows muting/demuting the signal with a I²C-bus programmable slope. The mute process can either be activated by the SoftMute pin or by the I²C-bus. This slope is realized in a special S-shaped curve to mute slow in the critical regions (see Figure 8).

For timing purposes the Bit0 of the I²C-bus output register is set to 1 from the start of muting until the end of demuting.

Figure 8. SoftMute timing



Note: A started Mute action is always terminated and could not be interrupted by a change of the mute signal.

4.5 Softstep volume

When the volume-level is changed audible clicks could appear at the output. The root cause of those clicks could either be a DC Offset before the volume-stage or the sudden change of the envelope of the audio signal. With the Softstep feature both kinds of clicks could be reduced to a minimum and are no more audible. The blend-time from one step to the next is programmable as 5 ms or 10 ms. The softstep control is described in detail in [Chapter 4.10](#).

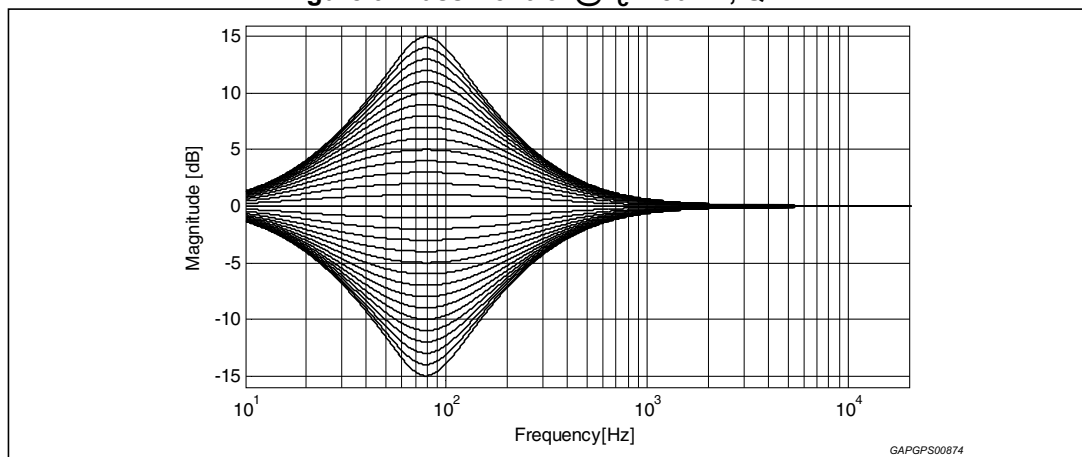
4.6 Bass

There are four parameters programmable in the bass stage:

4.6.1 Bass attenuation

[Figure 9](#) shows the attenuation as a function of frequency at a center frequency of 80 Hz.

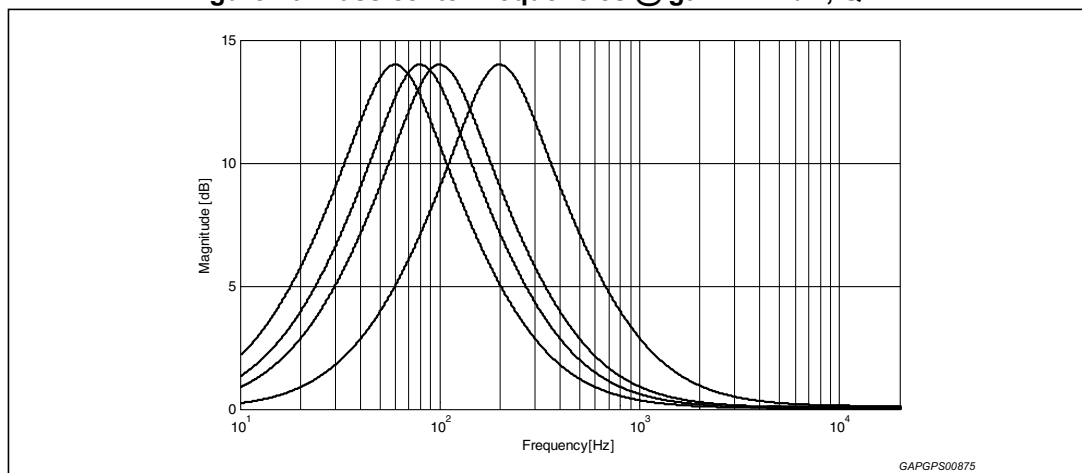
Figure 9. Bass Control @ $f_c = 80$ Hz, $Q = 1$



4.6.2 Bass center frequency

[Figure 10](#) shows the four possible center frequencies 60, 80, 100 and 200 Hz.

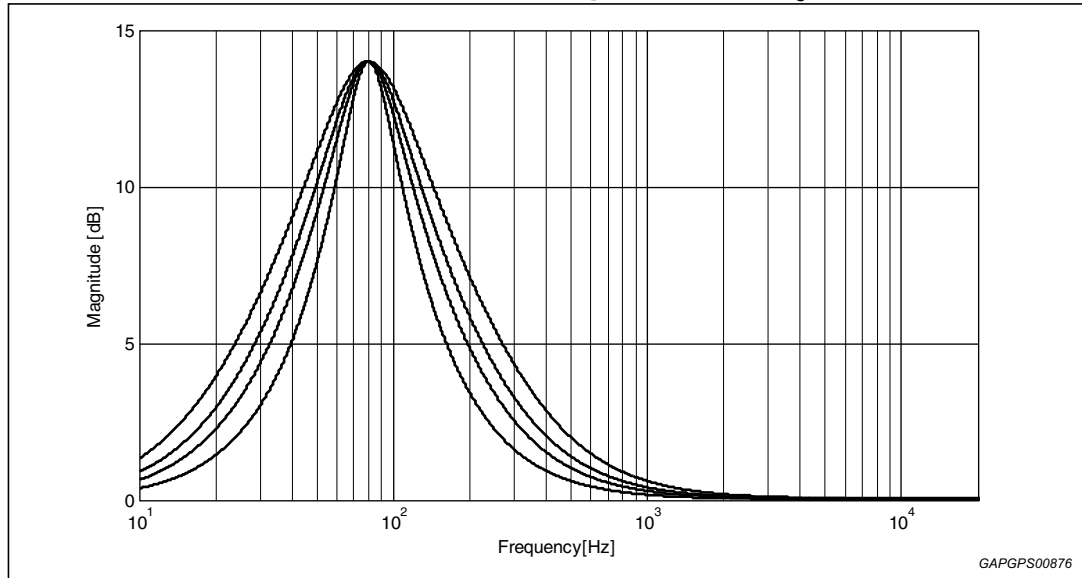
Figure 10. Bass center frequencies @ gain = 14 dB, $Q = 1$



4.6.3 Bass quality factors

Figure 11 shows the four possible quality factors 1, 1.25, 1.5 and 2.

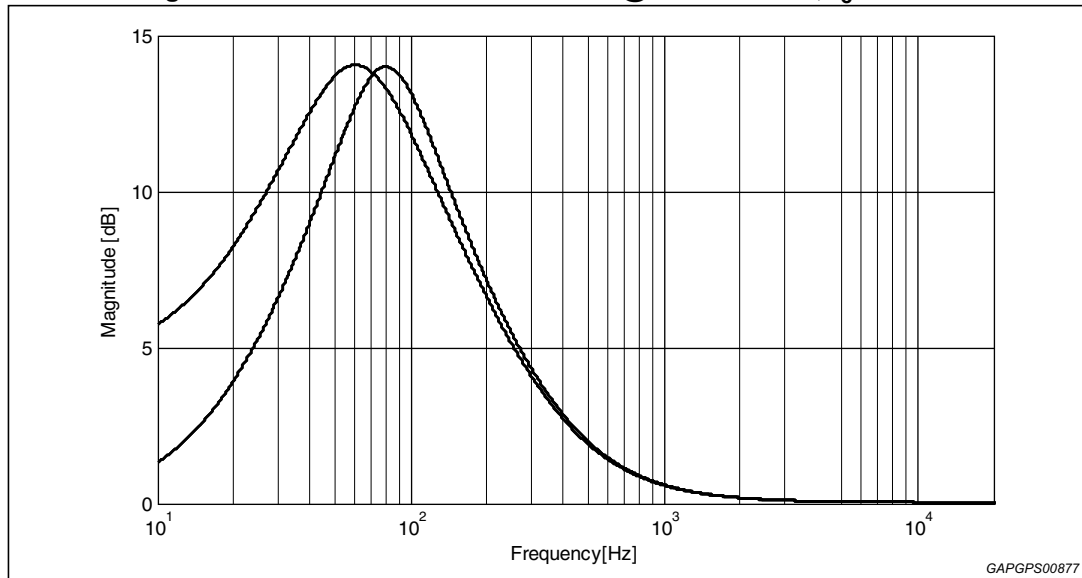
Figure 11. Bass quality factors @ gain = 14 dB, $f_c = 80$ Hz



4.6.4 DC mode

In this mode the DC gain is increased by 4.4 dB. In addition the programmed center frequency and quality factor is decreased by 25 % which can be used to reach alternative center frequencies or quality factors.

Figure 12. Bass normal and DC mode @ Gain = 14 dB, $f_c = 80$ Hz



Note: The center frequency, Q and DC-mode can be set fully independently.

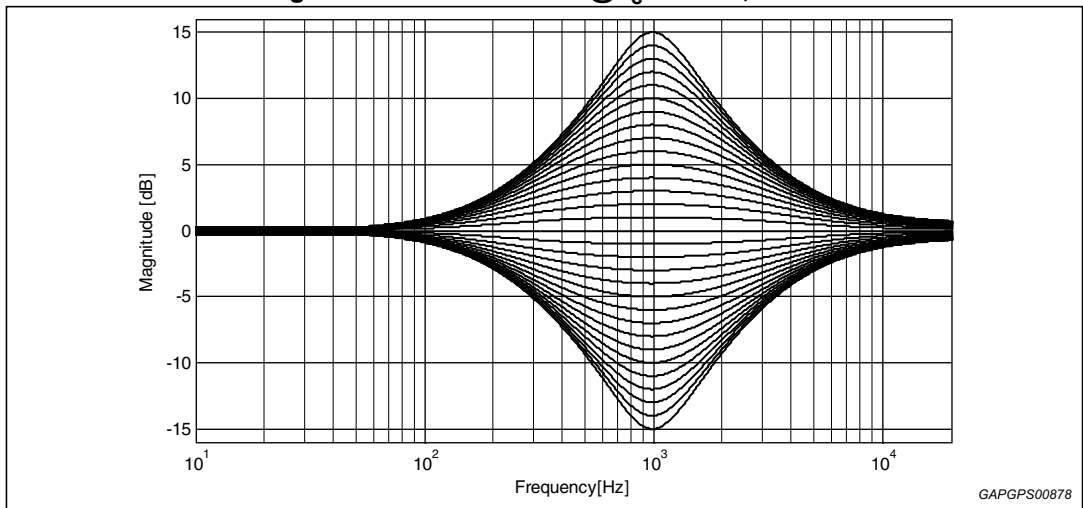
4.7 Middle

There are three parameters programmable in the middle stage:

4.7.1 Middle attenuation

Figure 13 shows the attenuation as a function of frequency at a center frequency of 1 kHz.

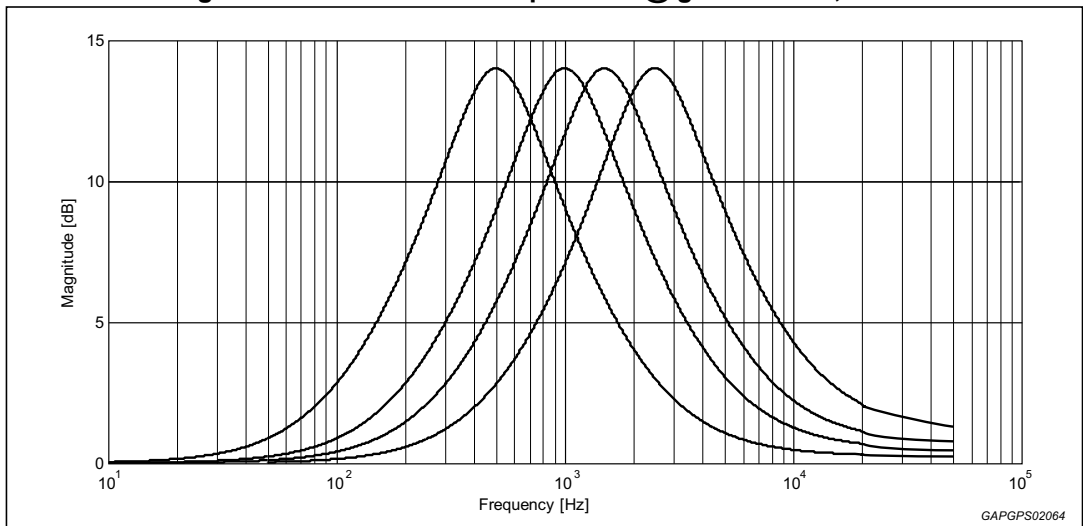
Figure 13. Middle control @ $f_c = 1$ kHz, $Q = 1$



4.7.2 Middle center frequency

Figure 14 shows the four possible center frequencies 500 Hz, 1 kHz, 1.5 kHz and 2.5 kHz.

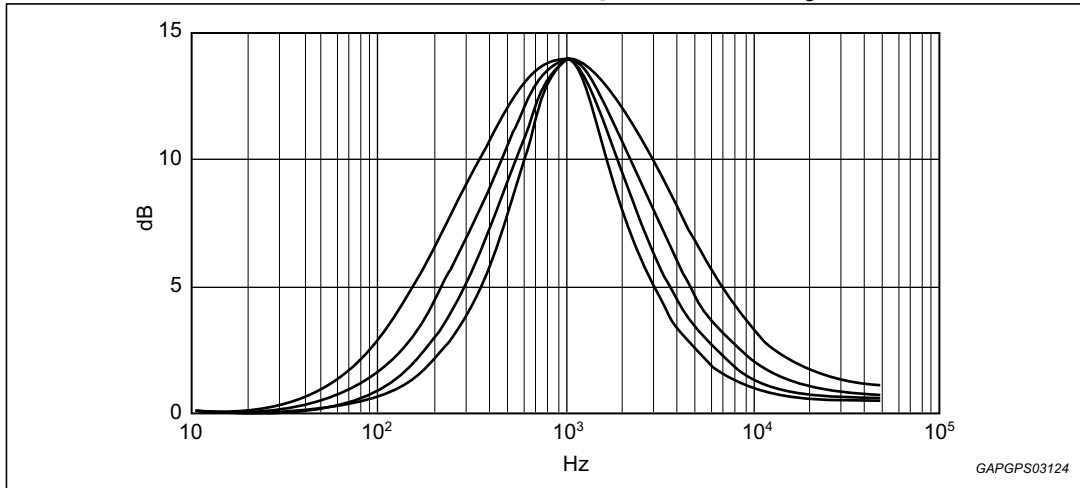
Figure 14. Middle center frequencies @ gain = 14d B, $Q = 1$



4.7.3 Middle quality factors

Figure 15 shows the four possible quality factors 0.5, 0.75, 1 and 1.25.

Figure 15. Middle quality factors @ gain = 14 dB, $f_c = 1$ kHz



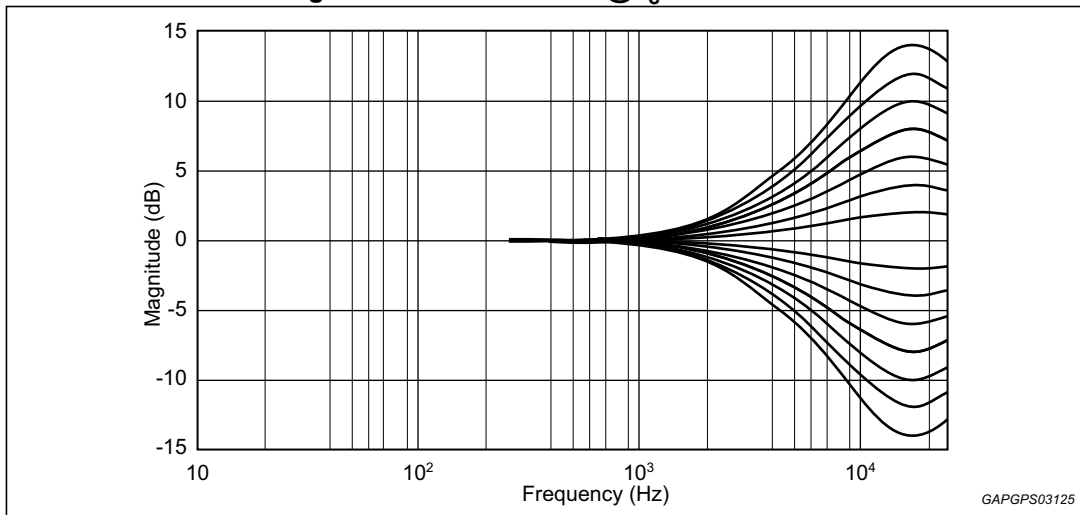
4.8 Treble

There are two parameters programmable in the treble stage:

4.8.1 Treble attenuation

Figure 16 shows the attenuation as a function of frequency at a center frequency of 17.5 kHz.

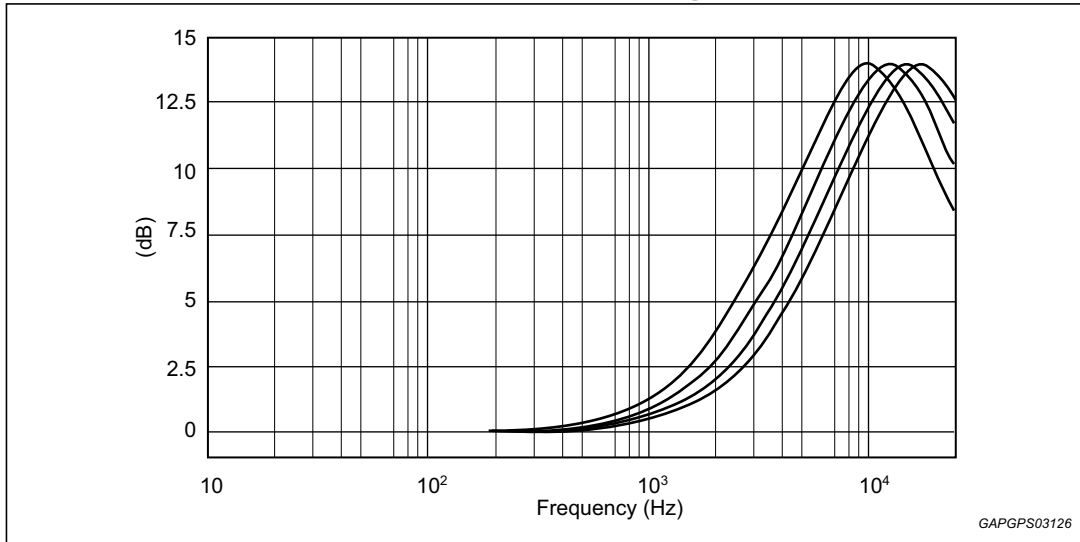
Figure 16. Treble Control @ $f_c = 17.5$ kHz.



4.8.2 Treble center frequency

Figure 17 shows the four possible center frequencies 10 k, 12.5 k, 15 k and 17.5 kHz.

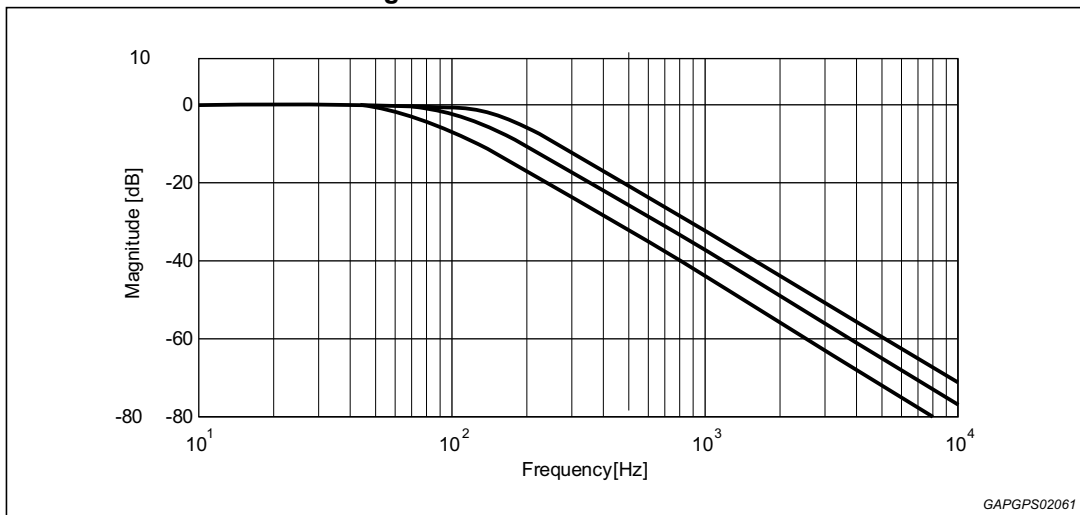
Figure 17. Treble center frequencies @ gain = 14 dB



4.9 Subwoofer Filter

The subwoofer lowpass filter has Butterworth characteristics with programmable cut-off frequency (80 / 120 / 160 Hz). The output phase can be selected between 0 deg and 180 deg. The input of subwoofer takes signal from bass filter output or output of input mux.

Figure 18. Subwoofer control

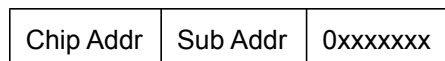


4.10 Softstep control

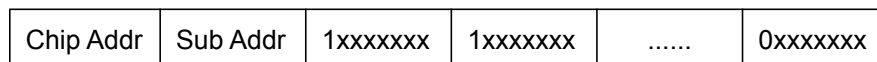
In this device, the softstep function is available for volume, speaker, loudness, treble, middle and bass block. With softstep function, the audible noise of DC offset or the sudden change of signal can be avoided when adjusting gain setting of the block.

For each block, the softstep function is controlled by softstep on/off control bit in the control table. The softstep transient time selection (5 ms or 10 ms) is common for all blocks and it is controlled by softstep time control bit. The softstep operation of all blocks has a common centralized control. In this case, a new softstep operation can not be started before the completion previous softstep.

There are two different modes to activate the softstep operation. The softstep operation can be started right after I²C data sending, or the softstep can be activated in parallel after data sending of several different blocks. The two modes are controlled by the 'act bit' (it is normally bit7 of the byte.) of each byte. When act bit is '0', which means action, the softstep is activated right after the date byte is sent. When the act bit is '1', which means wait, the block goes to wait for softstep status. In this case, the block will wait for some other block to activate the operation. The softstep operation of all blocks in wait status will be done together with the block which activate the softstep. With this mode, all specific blocks can do the softstep in parallel. This avoids waiting when the softstep is operated one by one.



|↑ Softstep start here



|↑ Softstep start here for all

1. It is not allowed to cross 0 dB with softstep directly. From plus gain to minus gain, it must go to +0 dB first, then destination. From minus gain to plus gain, it must go to -0 dB first, and then destination.
2. When one block is in 'wait for softstep' status, it is not allowed to send data to this block again before its softstep is completed.
3. To know if there is a softstep in operation, it is possible to monitor the 'busy' signal by I²C transmission mode ([Section 5.1.2](#)). When softstep is busy (busy=0), it is better to wait before sending new data until it is free (busy=1).

4.11 DC offset detector and level meter option

This device provide DC offset detector function and level meter function option. In one specific application, only one of the function can be used. The configuration of the function is controlled by I²C bus (Byte3 Bit7).

When the device uses DC offset detector function, Pin22, Pin27 and Pin28 are used as WinTC, DCErr and WinIN for DC offset detector. When it is configured as level meter, DCErr becomes level meter output. In the mean time, WinIN is used as beep input (Mono single-ended input for mixing), and WinTC becomes a reference voltage output (4 V external DC voltage or 3.3 V internal reference voltage).

4.12 DC offset detector

Using the DC offset detection circuit ([Figure 19](#)) an offset voltage difference between the audio power amplifier and the TDA7719's Front and Rear outputs can be detected, preventing serious damage to the loudspeakers. The circuit compares whether the signal crosses the zero level inside the audio power at the same time as in the speaker cell. The output of the zero-window-comparator of the power amplifier must be connected with the WinIn-input of the TDA7719. The WinIn-input has an internal pull-up resistor connected to 5.5 V. It is recommended to drive this pin with open-collector outputs only.

To compensate for errors at low frequencies the WinTC-pin are implemented, with external capacitors introducing the same delay $\tau = 7.5\text{k}\Omega * C_{\text{ext}}$ as the AC-coupling between the TDA7719 and the power amplifier introduces. For the zero window comparators, the time constant for spike rejection as well as the threshold are programmable.

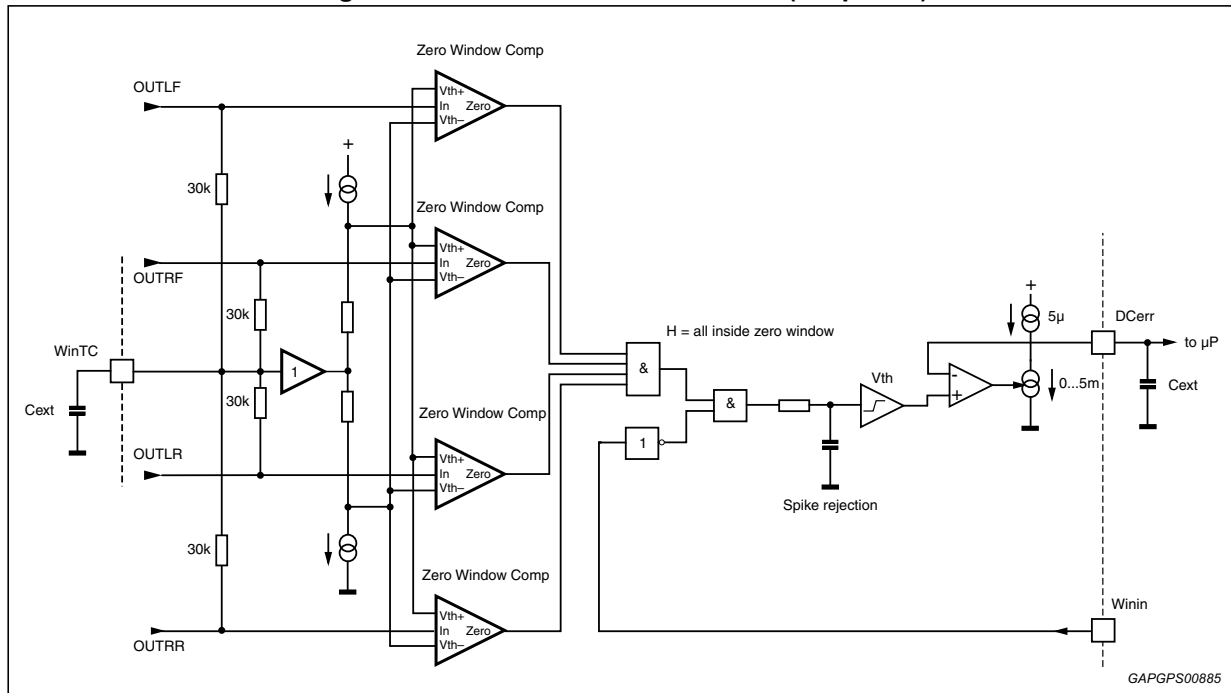
For electrical characteristics see [Chapter 3 on page 9](#).

A low-active DC-offset error signal appears at the DCErr output if the next conditions are both true:

- a) Front and rear outputs are inside zero crossing windows.
- b) The Input voltage VWinIn is logic low whenever at least one output of the power amplifier is outside the zero crossing windows.

After power-on, the external attached capacitor is rapidly charged (fast-charge) to overcome a false indication.

Figure 19. DC offset detection circuit (simplified)



4.13 Level meter

In case of not using DC offset detector, the three pins used for DCO can be configured as other function. Pin27 (DC_Err / LMOUT) becomes the level meter output. The level meter block takes signal after main input selector and mix signal into mono, then rectify the signal and detect the peak of the signal. The output stage of level meter removes the DC voltage of the signal and the output voltage level shows exactly the V_{peak} of signal. Since the discharge time constant of the level meter is quite slow, it is necessary to reset level meter regularly (with I²C bus control Byte3 Bit6) to get correct peak information of the signal.

4.14 Output gain control

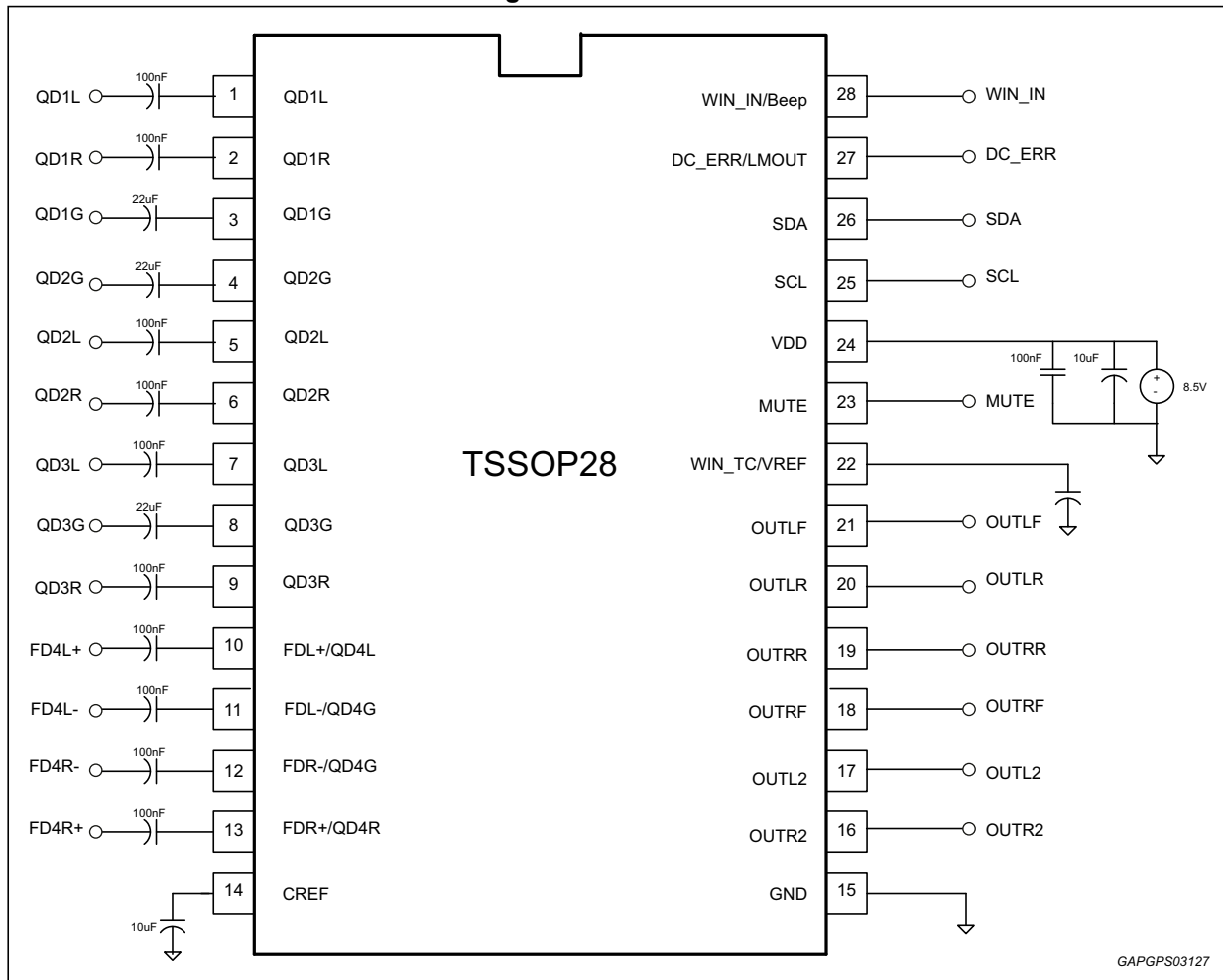
The output stage of the device can provide a option to have additional 1 dB gain in order to boost the maximum output level to 2.2 V_{rms} with maximum 1 % distortion.

4.15 Audioprocessor testing

In the test mode, which can be activated by setting bit D7 of the I²C subaddress byte and bit D0 of the testing-audioprocessor byte, several internal signals are available at the QD1L pin. In this mode, the input resistance of 100 kΩ is disconnected from the pin. Internal signals available for testing are listed in the data-byte specification.

4.16 Test circuit (3 x QD + 1 x FD + DC offset detector)

Figure 20. Test circuit



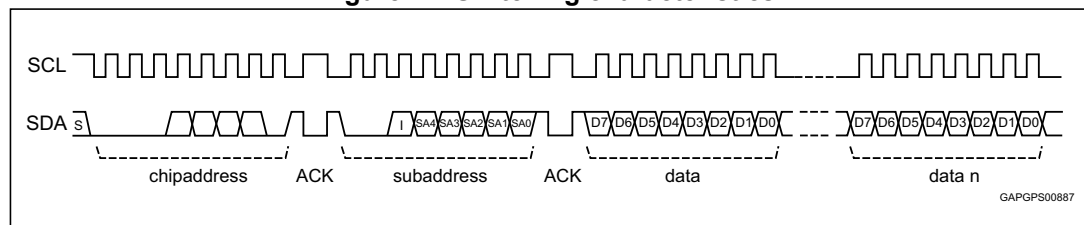
5 I²C bus specification

5.1 Interface protocol

The interface protocol comprises:

- a start condition (S)
- a chip address byte (the LSB determines read/write transmission)
- a subaddress byte
- a sequence of data (N-bytes + acknowledge)
- a stop condition (P)
- the max. clock speed is 400 kbits/s
- 3.3 V logic compatible

Figure 21. Switching characteristics



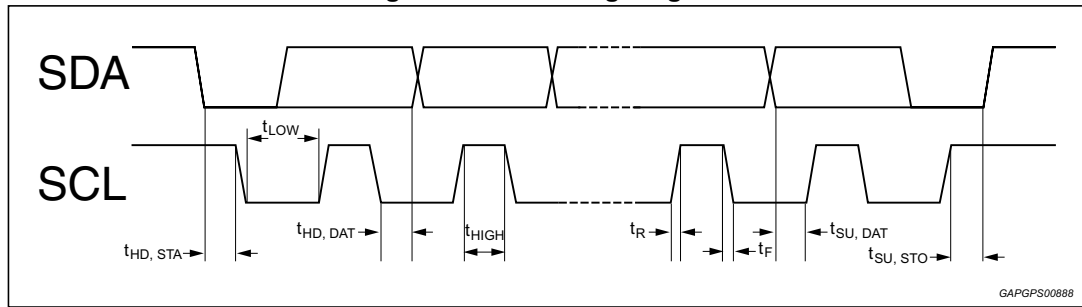
S = Start

ACK = Acknowledge

Table 9. I²C bus electrical characteristics

| Symbol | Parameter | Min | Max | Unit |
|---------------------|---------------------------|-----|-----|------|
| f _{SCL} | SCL clock frequency | - | 400 | kHz |
| V _{IH} | High level input voltage | 2.4 | - | V |
| V _{IL} | Low level input voltage | - | 0.8 | V |
| t _{HD,STA} | Hold time for START | 0.6 | - | µs |
| t _{SU,STO} | Setup time for STOP | 0.6 | - | µs |
| t _{LOW} | Low period for SCL clock | 1.3 | - | µs |
| t _{HIGH} | High period for SCL clock | 0.6 | - | µs |
| t _F | Fall time for SCL/SDA | - | 300 | ns |
| t _R | Rise time for SCL/SDA | - | 300 | ns |
| t _{HD,DAT} | Data hold time | 0 | - | ns |
| t _{SU,DAT} | Data setup time | 100 | - | ns |

Figure 22. I²C timing diagram



5.1.1 Receive mode

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|-----|-----|----|---|----|----|----|----|----|----|-----|------|-----|---|
| S | 1 | 0 | 0 | 0 | 1 | 0 | 0 | R/W | ACK | TS | X | AI | A4 | A3 | A2 | A1 | A0 | ACK | DATA | ACK | P |
|---|---|---|---|---|---|---|---|-----|-----|----|---|----|----|----|----|----|----|-----|------|-----|---|

S = Start

R/W = "0" -> Receive Mode (Chip can be programmed by μP)

"1" -> Transmission Mode (Data could be received by μP)

ACK = Acknowledge

P = Stop

TS = Testing mode

AI = Auto increment

5.1.2 Transmission mode

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|-----|-----|---|---|---|---|---|---|---|----|----|-----|---|
| S | 1 | 0 | 0 | 0 | 1 | 0 | 0 | R/W | ACK | X | X | X | X | X | X | X | BZ | SM | ACK | P |
|---|---|---|---|---|---|---|---|-----|-----|---|---|---|---|---|---|---|----|----|-----|---|

SM = Soft mute activated for main channel

BZ = Softstep Busy ('0' = Busy)

X = Not used

The transmitted data is automatic updated after each ACK. Transmission can be repeated without new chip address.

5.1.3 Reset condition

A Power-On-Reset is invoked if the supply voltage is below than 3.5 V. After that the registers are initialized to the default data written in following tables.

Table 10. Subaddress (receive mode)

| MSB | | | | | | | | LSB | Function |
|-----|----|--------|----|----|----|----|----|---|----------|
| I2 | I1 | I0 | A4 | A3 | A2 | A1 | A0 | | |
| 0 | | | | | | | | Testing Mode Off On | |
| 1 | x | | | | | | | Not used | |
| | | 0 1 | | | | | | Auto Increment Mode Off On | |
| | | | 0 | 0 | 0 | 0 | 0 | Input Configuration / Main Source Selector | |
| | | | 0 | 0 | 0 | 0 | 1 | 2 nd Source Selector / Direct Path | |
| | | | 0 | 0 | 0 | 1 | 0 | Mixing Source / Mixing Gain | |
| | | | 0 | 0 | 0 | 1 | 1 | Mix Control / Level Meter / DC Offset Detector Config | |
| | | | 0 | 0 | 1 | 0 | 0 | Soft Mute / Others | |
| | | | 0 | 0 | 1 | 0 | 1 | Soft Step I | |
| | | | 0 | 0 | 1 | 1 | 0 | Soft Step II / DC-detector | |
| | | | 0 | 0 | 1 | 1 | 1 | Loudness | |
| | | | 0 | 1 | 0 | 0 | 0 | Volume / Output Gain | |
| | | | 0 | 1 | 0 | 0 | 1 | Treble | |
| | | | 0 | 1 | 0 | 1 | 0 | Middle | |
| | | | 0 | 1 | 0 | 1 | 1 | Bass | |
| | | | 0 | 1 | 1 | 0 | 0 | Subwoofer / Middle / Bass | |
| | | | 0 | 1 | 1 | 0 | 1 | Speaker Attenuator Left Front | |
| | | | 0 | 1 | 1 | 1 | 0 | Speaker Attenuator Right Front | |
| | | | 0 | 1 | 1 | 1 | 1 | Speaker Attenuator Left Rear | |
| | | | 1 | 0 | 0 | 0 | 0 | Speaker Attenuator Right Rear | |
| | | | 1 | 0 | 0 | 0 | 1 | Subwoofer Attenuator Left | |
| | | | 1 | 0 | 0 | 1 | 0 | Subwoofer Attenuator Right | |
| | | | 1 | 0 | 0 | 1 | 1 | Testing Audio Processor 1 | |
| | | | 1 | 0 | 1 | 0 | 0 | Testing Audio Processor 2 | |

5.2 Data byte specification

The default power on status of the registers is written with underline.

Table 11. Input configuration / main selector (0)

| MSB | | | | LSB | | | | Function |
|-----|----|----|----|-----|----|----|----|---|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | |
| | | | | | 0 | 0 | 0 | Main source selector IN0 IN1 <u>IN2</u> IN3 IN4 IN5 IN6 IN7 |
| | | | | | 0 | 0 | 1 | |
| | | | | | 0 | 1 | 0 | |
| | | | | | 0 | 1 | 1 | |
| | | | | | 1 | 0 | 0 | |
| | | | | | 1 | 0 | 1 | |
| | | | | | 1 | 1 | 0 | |
| | | | | | 1 | 1 | 1 | |
| | | | | 0 | | | | MD1/2 configuration for main selector MD1 <u>MD2</u> |
| | | | | 1 | | | | |
| | | | 0 | | | | | Main source input gain select 0dB <u>3dB</u> |
| | | | 1 | | | | | |
| 0 | 0 | 0 | | | | | | Input configuration CFG0 CFG1 CFG2 CFG3 CFG4 CFG5 CFG6 <u>CFG7</u> |
| 0 | 0 | 1 | | | | | | |
| 0 | 1 | 0 | | | | | | |
| 0 | 1 | 1 | | | | | | |
| 1 | 0 | 0 | | | | | | |
| 1 | 0 | 1 | | | | | | |
| 1 | 1 | 0 | | | | | | |
| 1 | 1 | 1 | | | | | | |

Note: For detailed input source and input stage configuration, please refer to [Section 4.1](#).

Table 12. 2nd Source selector / direct path (1)

| MSB | | | | LSB | | | | Function |
|-----|----|----|----|-----|----|----|----|---|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | |
| | | | | | 0 | 0 | 0 | 2nd Source Selector IN0 IN1 IN2 IN3 IN4 IN5 IN6 IN7 |
| | | | | | 0 | 0 | 1 | |
| | | | | | 0 | 1 | 0 | |
| | | | | | 0 | 1 | 1 | |
| | | | | | 1 | 0 | 0 | |
| | | | | | 1 | 0 | 1 | |
| | | | | | 1 | 1 | 0 | |
| | | | | | 1 | 1 | 1 | |
| | | | | 0 | | | | MD1/2 Configuration for 2nd Selector MD1 MD2 |
| | | | | 1 | | | | |
| | | | 0 | | | | | 2nd Source Input Gain Select 0dB 3dB |
| | | | 1 | | | | | |
| | | 0 | | | | | | QD2 Bypass (Front) on Off |
| | | 1 | | | | | | |
| | 0 | | | | | | | QD3 Bypass (Rear) on Off |
| | 1 | | | | | | | |
| 0 | | | | | | | | QD4 Bypass (Subwoofer) on Off |
| 1 | | | | | | | | |

Note: For detailed input source and input stage configuration, please refer to [Section 4.1](#).
To active QD3 Bypass (Rear) function, it needs to set Byte3_D4 to "Direct Path / 2nd Source" also.

Table 13. Mixing source / mixing gain (2)

| MSB | | | | | LSB | | | Function |
|-----|----|----|----|----|-----|----|----|-------------------------------|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | |
| | | | | | 0 | 0 | 0 | Mixing Source Selector |
| | | | | | 0 | 0 | 1 | IN0 |
| | | | | | 0 | 1 | 0 | IN1 |
| | | | | | 0 | 1 | 1 | IN2 |
| | | | | | 1 | 0 | 0 | IN3 |
| | | | | | 1 | 0 | 1 | IN4 |
| | | | | | 1 | 1 | 0 | IN5 |
| | | | | | 1 | 1 | 1 | IN6 |
| | | | | | 1 | 1 | 1 | IN7 |
| | | | | | | | | Mixing Attenuator |
| 0 | 0 | 0 | 0 | 0 | | | | 0dB |
| 0 | 0 | 0 | 0 | 1 | | | | -1dB |
| 0 | 0 | 0 | 1 | 0 | | | | -2dB |
| 0 | 0 | 0 | 1 | 1 | | | | -3dB |
| 0 | 0 | 1 | 0 | 0 | | | | -4dB |
| 0 | 0 | 1 | 0 | 1 | | | | -5dB |
| 0 | 0 | 1 | 1 | 0 | | | | -6dB |
| 0 | 0 | 1 | 1 | 1 | | | | -7dB |
| 0 | 1 | 0 | 0 | 0 | | | | -8dB |
| 0 | 1 | 0 | 0 | 1 | | | | -9dB |
| 0 | 1 | 0 | 1 | 0 | | | | -10dB |
| 0 | 1 | 0 | 1 | 1 | | | | -11dB |
| 0 | 1 | 1 | 0 | 0 | | | | -12dB |
| 0 | 1 | 1 | 0 | 1 | | | | -13dB |
| 0 | 1 | 1 | 1 | 0 | | | | -14dB |
| 0 | 1 | 1 | 1 | 1 | | | | -15dB |
| 1 | 0 | 0 | 0 | 0 | | | | -16dB |
| 1 | 0 | 0 | 0 | 1 | | | | -17dB |
| 1 | 0 | 0 | 1 | 0 | | | | -18dB |
| 1 | 0 | 0 | 1 | 1 | | | | -19dB |
| 1 | 0 | 1 | 0 | 0 | | | | -20dB |
| 1 | 0 | 1 | 0 | 1 | | | | -21dB |
| 1 | 0 | 1 | 1 | 0 | | | | -22dB |
| 1 | 0 | 1 | 1 | 1 | | | | -23dB |
| 1 | 1 | 0 | 0 | 0 | | | | -24dB |
| 1 | 1 | 0 | 0 | 1 | | | | -25dB |
| 1 | 1 | 0 | 1 | 0 | | | | -26dB |
| 1 | 1 | 0 | 1 | 1 | | | | -27dB |
| 1 | 1 | 1 | 0 | 0 | | | | -28dB |
| 1 | 1 | 1 | 0 | 1 | | | | -29dB |
| 1 | 1 | 1 | 1 | 0 | | | | -30dB |
| 1 | 1 | 1 | 1 | 1 | | | | -31dB |

Table 14. Mix control / level meter / dc offset detector configure (3)

| MSB | | | | LSB | | | | Function |
|--------|--------|--------|--------|--------|--------|--------|--------|---|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | |
| | | | | | | | 0 1 | Mix to Front Left On <u>Off</u> |
| | | | | | | 0 1 | | Mix to Front Right On <u>Off</u> |
| | | | | | 0 1 | | | Mix to Rear Left On <u>Off</u> |
| | | | | 0 1 | | | | Mix to Rear Right On <u>Off</u> |
| | | | 0 1 | | | | | Rear Speaker Input Configuration Direct Path / 2 nd Source <u>Main Signal</u> |
| | | 0 1 | | | | | | Reference Output Select Internal Vref (3.3V) <u>External Vref (4V)</u> |
| | 0 1 | | | | | | | Level Meter Reset Normal <u>Reset</u> |
| 0 1 | | | | | | | | DC Offset Detector / Level Meter Config Level Meter <u>DC Offset Detector</u> |

Table 15. Soft mute / others (4)

| MSB | | | | LSB | | | | Function |
|--------|--------|--------|--------|------------------|------------------|--------|--------|---|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | |
| | | | | | | | 0 1 | Soft Mute On <u>Off</u> |
| | | | | | | 0 1 | | Pin Influence for Mute <u>Pin and IIC</u> IIC |
| | | | | 0 0 1 1 | 0 1 0 1 | | | Soft Mute Time 0.48ms 0.96ms 7.68ms 15.36ms |
| | | | 0 1 | | | | | Subwoofer Input Configuration Input Mux <u>Bass Output</u> |
| | | 0 1 | | | | | | Subwoofer Enable (OUTL3 & OUTR3) On <u>Off</u> |
| | 0 1 | | | | | | | Fast Charge On <u>Off</u> |
| 0 1 | | | | | | | | Anti-Alias Filter On <u>Off (bypass)</u> |

Table 16. SoftStep I (5)

| MSB | | | | LSB | | | | Function |
|--------|--------|--------|--------|--------|--------|--------|--------|---|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | |
| | | | | | | | 0 1 | Loudness Soft Step On <u>Off</u> |
| | | | | | | 0 1 | | Volume Soft Step On <u>Off</u> |
| | | | | | 0 1 | | | Treble Soft Step On <u>Off</u> |
| | | | | 0 1 | | | | Middle Soft Step On <u>Off</u> |
| | | | 0 1 | | | | | Bass Soft Step On <u>Off</u> |
| | | 0 1 | | | | | | Speaker LF Soft Step On <u>Off</u> |
| | 0 1 | | | | | | | Speaker RF Soft Step On <u>Off</u> |
| 0 1 | | | | | | | | Speaker LR Soft Step On <u>Off</u> |

Table 17. SoftStep II / DC detector (6)

| MSB | | | | LSB | | | | Function |
|------------------|------------------|-------------|-------------|--------|--------|--------|--------|--|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | |
| | | | | | | | 0 1 | Speaker RR Soft Step on <u>off</u> |
| | | | | | | 0 1 | | Subwoofer Left Soft Step on <u>off</u> |
| | | | | | 0 1 | | | Subwoofer Right Soft Step on <u>off</u> |
| | | | | 0 1 | | | | Soft Step Time 5ms <u>10ms</u> |
| | | 0 0 1 | 0 1 0 | | | | | Zero-comparator Window size ±100mV ±75mV ±50mV |
| 0 0 1 1 | 0 1 0 1 | | | | | | | Spike rejection time constant 11µs 22 µs 33 µs <u>44 µs</u> |

Table 18. Loudness (7)

| MSB | | | | LSB | | | | Function |
|-----|----|----|----|-----|----|----|----|---------------------------------|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | |
| | | | | 0 | 0 | 0 | 0 | Attenuation 0dB |
| | | | | 0 | 0 | 0 | 1 | -1dB |
| | | | | : | : | : | : | : |
| | | | | 1 | 1 | 1 | 0 | <u>-14dB</u> |
| | | | | 1 | 1 | 1 | 1 | -15dB |
| | | 0 | 0 | | | | | Center Frequency Flat |
| | | 0 | 1 | | | | | 400Hz |
| | | 1 | 0 | | | | | 800Hz |
| | | 1 | 1 | | | | | <u>2400Hz</u> |
| | 0 | | | | | | | High Boost on |
| | 1 | | | | | | | off |
| 0 | | | | | | | | Soft Step Action act |
| 1 | | | | | | | | <u>wait</u> |

Table 19. Volume / output gain (8)

| MSB | | | | LSB | | | | Function |
|-----|----|----|----|-----|----|----|----|----------------------------------|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | |
| | | | 0 | 0 | 0 | 0 | 0 | Gain/Attenuation -15dB |
| | | | 0 | 0 | 0 | 0 | 1 | -14dB |
| | | | : | : | : | : | : | : |
| | | | 0 | 1 | 1 | 1 | 0 | -1dB |
| | | | 0 | 1 | 1 | 1 | 1 | 0dB |
| | | | 1 | 1 | 1 | 1 | 1 | 0dB |
| | | | 1 | 1 | 1 | 1 | 0 | <u>+1dB</u> |
| | | | : | : | : | : | : | : |
| | | | 1 | 0 | 0 | 0 | 1 | +14dB |
| | | | 1 | 0 | 0 | 0 | 0 | +15dB |
| | | x | | | | | | Not used |
| | 0 | | | | | | | Output Gain 1dB |
| | 1 | | | | | | | <u>0dB</u> |
| 0 | | | | | | | | Soft Step Action act |
| 1 | | | | | | | | <u>wait</u> |

Table 20. Treble filter (9)

| MSB | | | | LSB | | | | Function |
|-----|----|----|----|-----|----|----|----|---|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | |
| | | | 0 | 0 | 0 | 0 | 0 | Gain/Attenuation -15dB |
| | | | 0 | 0 | 0 | 0 | 1 | -14dB |
| | | | : | : | : | : | : | : |
| | | | 0 | 1 | 1 | 1 | 0 | -1dB |
| | | | 0 | 1 | 1 | 1 | 1 | 0dB |
| | | | 1 | 1 | 1 | 1 | 1 | 0dB |
| | | | 1 | 1 | 1 | 1 | 0 | <u>+1dB</u> |
| | | | : | : | : | : | : | : |
| | | | 1 | 0 | 0 | 0 | 1 | +14dB |
| | | | 1 | 0 | 0 | 0 | 0 | +15dB |
| | 0 | 0 | | | | | | Treble Center Frequency 10.0kHz |
| | 0 | 1 | | | | | | 12.5kHz |
| | 1 | 0 | | | | | | 15.0kHz |
| | 1 | 1 | | | | | | <u>17.5kHz</u> |
| 0 | | | | | | | | Soft Step Action act |
| 1 | | | | | | | | <u>wait</u> |

Table 21. Middle filter (10)

| MSB | | | | LSB | | | | Function |
|-----|----|----|----|-----|----|----|----|----------------------------------|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | |
| | | | 0 | 0 | 0 | 0 | 0 | Gain/Attenuation -15dB |
| | | | 0 | 0 | 0 | 0 | 1 | -14dB |
| | | | : | : | : | : | : | : |
| | | | 0 | 1 | 1 | 1 | 0 | -1dB |
| | | | 0 | 1 | 1 | 1 | 1 | 0dB |
| | | | 1 | 1 | 1 | 1 | 1 | 0dB |
| | | | 1 | 1 | 1 | 1 | 0 | <u>+1dB</u> |
| | | | : | : | : | : | : | : |
| | | | 1 | 0 | 0 | 0 | 1 | +14dB |
| | | | 1 | 0 | 0 | 0 | 0 | +15dB |
| | 0 | 0 | | | | | | Middle Q Factor 0.5 |
| | 0 | 1 | | | | | | 0.75 |
| | 1 | 0 | | | | | | 1 |
| | 1 | 1 | | | | | | <u>1.25</u> |
| 0 | | | | | | | | Soft Step Action act |
| 1 | | | | | | | | <u>wait</u> |

Table 22. Bass filter (11)

| MSB | | | | LSB | | | | Function |
|-----|----|----|----|-----|----|----|----|---------------------------|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | |
| | | | 0 | 0 | 0 | 0 | 0 | Gain/Attenuation -15dB |
| | | | 0 | 0 | 0 | 0 | 1 | -14dB |
| | | | : | : | : | : | : | : |
| | | | 0 | 1 | 1 | 1 | 0 | -1dB |
| | | | 0 | 1 | 1 | 1 | 1 | 0dB |
| | | | 1 | 1 | 1 | 1 | 1 | 0dB |
| | | | 1 | 1 | 1 | 1 | 0 | +1dB |
| | | | : | : | : | : | : | : |
| | | | 1 | 0 | 0 | 0 | 1 | +14dB |
| | | | 1 | 0 | 0 | 0 | 0 | +15dB |
| | 0 | 0 | | | | | | Bass Q Factor 1.0 |
| | 0 | 1 | | | | | | 1.25 |
| | 1 | 0 | | | | | | 1.5 |
| | 1 | 1 | | | | | | <u>2.0</u> |
| 0 | | | | | | | | Soft Step Action act |
| 1 | | | | | | | | wait |

Table 23. Subwoofer / middle / bass (12)

| MSB | | | | LSB | | | | Function |
|-----|----|----|----|-----|----|----|----|-------------------------------------|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | |
| | | | | | | 0 | 0 | Subwoofer Cut-off Frequency flat |
| | | | | | | 0 | 1 | 80Hz |
| | | | | | | 1 | 0 | <u>120Hz</u> |
| | | | | | | 1 | 1 | 160Hz |
| | | | | | 0 | | | Subwoofer Output Phase 180 deg |
| | | | | | 1 | | | <u>0 deg</u> |
| | | | 0 | 0 | | | | Middle Center Frequency 500Hz |
| | | | 0 | 1 | | | | 1000Hz |
| | | | 1 | 0 | | | | 1500Hz |
| | | | 1 | 1 | | | | <u>2500Hz</u> |
| | 0 | 0 | | | | | | Bass Center Frequency 60Hz |
| | 0 | 1 | | | | | | 80Hz |
| | 1 | 0 | | | | | | 100Hz |
| | 1 | 1 | | | | | | <u>200Hz</u> |
| 0 | | | | | | | | Bass DC Mode on |
| 1 | | | | | | | | <u>off</u> |

Table 24. Speaker attenuation (LF/RF/LR/RR) (13-16)

| MSB | | | | LSB | | | | Function |
|-----|----|----|----|-----|----|----|----|-------------------------|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Gain/Attenuation |
| | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0dB |
| | : | : | : | : | : | : | : | : |
| | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0dB |
| | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0dB |
| | 0 | 0 | 1 | 0 | 0 | 0 | 1 | -1dB |
| | : | : | : | : | : | : | : | : |
| | 1 | 0 | 1 | 1 | 1 | 1 | 0 | -78dB |
| | 1 | 0 | 1 | 1 | 1 | 1 | 1 | -79dB |
| | 1 | 1 | x | x | x | x | x | <u>mute</u> |
| 0 | | | | | | | | Soft Step Action |
| 1 | | | | | | | | act <u>wait</u> |

Table 25. Subwoofer attenuation (subwoofer L/subwoofer R) (17-18)

| MSB | | | | LSB | | | | Function |
|-----|----|----|----|-----|----|----|----|-------------------------|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Gain/Attenuation |
| | 0 | 0 | 0 | 0 | 0 | 0 | 1 | +0dB |
| | : | : | : | : | : | : | : | : |
| | 0 | 0 | 0 | 1 | 1 | 1 | 1 | +15dB |
| | 0 | 0 | 1 | 0 | 0 | 0 | 0 | -0dB |
| | 0 | 0 | 1 | 0 | 0 | 0 | 1 | -1dB |
| | : | : | : | : | : | : | : | : |
| | 1 | 0 | 1 | 1 | 1 | 1 | 0 | -78dB |
| | 1 | 0 | 1 | 1 | 1 | 1 | 1 | -79dB |
| | 1 | 1 | x | x | x | x | x | <u>mute</u> |
| 0 | | | | | | | | Soft Step Action |
| 1 | | | | | | | | act <u>wait</u> |

Table 26. Testing audio processor 1 (19)

| MSB | | | | LSB | | | | Function |
|-----|--------|--------|---|--|--|--|--------|---|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | |
| | | | | | | | 0 1 | Audio Processor Testing Mode off on |
| | | | 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 | 0 0 0 1 1 0 0 0 0 1 0 1 1 1 | 0 0 1 1 0 1 1 0 1 1 0 1 1 1 | 0 1 0 1 0 1 1 0 1 1 0 1 0 1 | | Test Multiplexer at QD1L ⁽¹⁾ DCDet Vth High DCDet Vth Low VolumeoutL IntZeroErr InGainL LoudoutL BassoutL MidoutL Ref5V5 VGB1.26 SMCLK TrebleoutL SSCLK Clock200k REQ SDCLK |
| | | 0 1 | | | | | | Clock Fast Mode ⁽²⁾ on Off |
| | 0 1 | | | | | | | Clock Source ⁽²⁾ external (at mute pin) Internal (200kHz) |
| x | | | | | | | | Not Used |

1. The control bit needs both I2C test mode on & sub-address test mode on.
2. The control bit does not depend on test mode.

Table 27. Testing audio processor 2 (20)

| MSB | | | | LSB | | | | Function |
|-----|----|----|------------------|------------------|--------|--------|--------|--|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | |
| | | | | | | | 0 1 | Test Architecture ⁽¹⁾ <u>normal</u> Split |
| | | | | | | 0 1 | | Oscillator Clock ⁽²⁾ 400kHz 800kHz |
| | | | | | 0 1 | | | Softstep Curve ⁽²⁾ S-Curve <u>Linear Curve</u> |
| | | | 0 0 1 1 | 0 1 0 1 | | | | Manual Set Busy Signal ⁽¹⁾ Auto Auto 0 <u>1</u> |
| | | | 0 0 1 1 | 0 1 0 1 | | | | Request for Clk Generator ⁽¹⁾ Allow Allow Stopped <u>Stopped</u> |
| x | x | x | | | | | | Not Used |

1. The control bit needs sub-address test mode on
2. The control bit does not depend on test mode.

6 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK[®] packages, depending on their level of environmental compliance. ECOPACK[®] specifications, grade definitions and product status are available at: www.st.com.

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6.1 TSSOP28 package information

Figure 23. TSSOP28 package outline

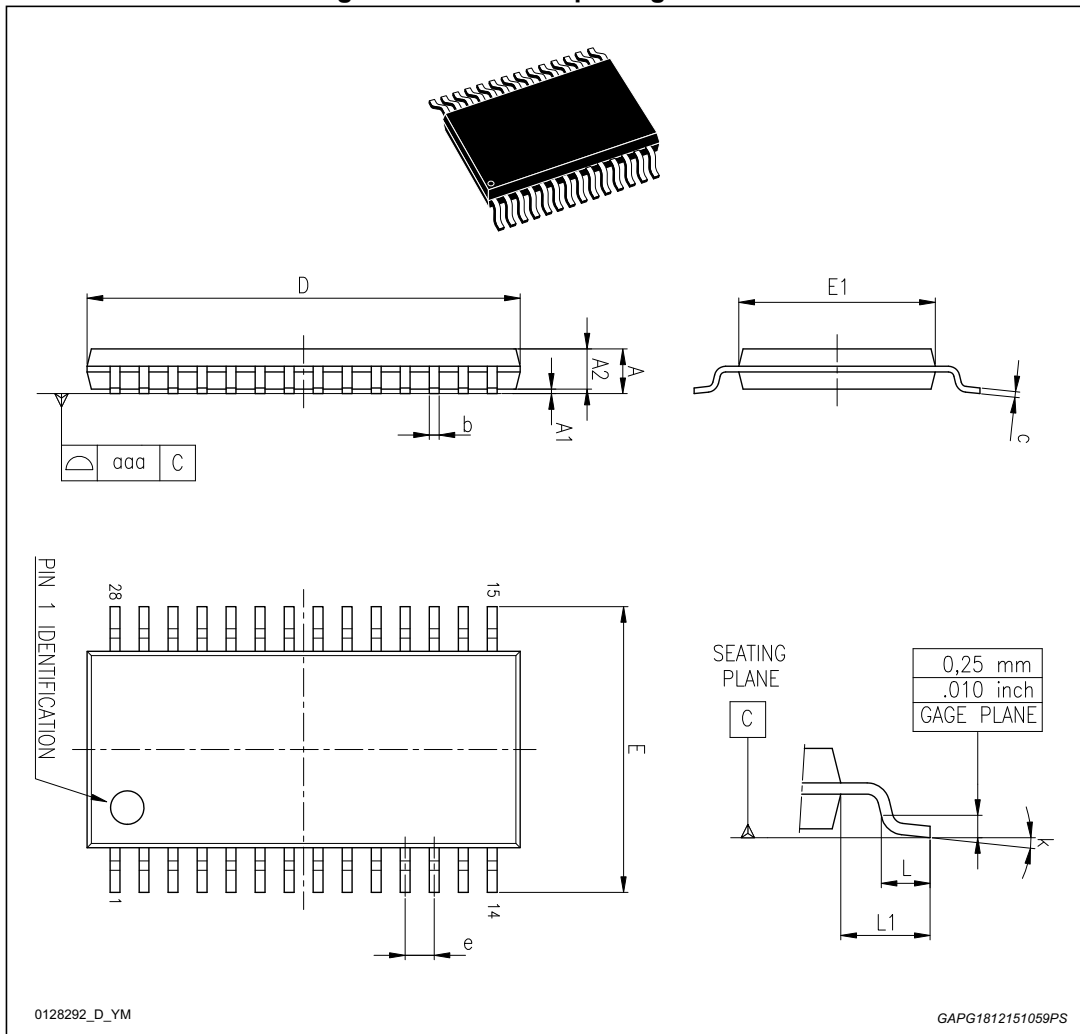


Table 28. TSSOP28 package mechanical data

| Ref | Dimensions in mm | | |
|------------------|----------------------|------|------|
| | Min. | Typ. | Max. |
| A | - | - | 1.20 |
| A1 | 0.05 | - | 0.15 |
| A2 | 0.80 | 1.00 | 1.05 |
| b | 0.190 | - | 0.30 |
| c | 0.09 | - | 0.20 |
| D ⁽¹⁾ | 9.60 | 9.70 | 9.80 |
| E | 6.20 | 6.40 | 6.60 |
| E1 ¹ | 4.30 | 4.40 | 4.50 |
| e | - | 0.65 | - |
| L | 0.45 | 0.60 | 0.75 |
| L1 | - | 1.00 | - |
| k | 0° (min.), 8° (max.) | | |
| aaa | - | - | 0.10 |

1. D and E1 does not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.15 mm (.006inch) per side.

7 Revision history

Table 29. Document revision history

| Date | Revision | Changes |
|-------------|----------|---|
| 16-Jul-2007 | 1 | Initial release. |
| 07-Jan-2007 | 2 | Added and updated the values on the Table 5: Electrical characteristics . Document status promoted from preliminary data to datasheet. |
| 30-Jul-2008 | 3 | Updated Table 5: Electrical characteristics . |
| 23-Apr-2009 | 4 | Updated Figure 1: Block circuit diagram on page 6 . Updated Section 4.1: Input configuration on page 13 . Added Section 4.1.2: Direct path on page 15 . Added Figure 21: Switching characteristics on page 28 , Table 9: I²C bus electrical characteristics on page 28 and Figure 22: I²C timing diagram on page 29 . |
| 17-Sep-2013 | 5 | Updated disclaimer. |
| 01-Dec-2017 | 6 | Added "Automotive " in the title in cover page; Added "AEC-Q100 qualified" as first feature and car icone; Updated Figure 1: Block circuit diagram on page 6 ; Updated Figure 6: Package information on page 44 ; Updated disclaimer. |

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