

3 band car audio processor

Datasheet - production data



Features

- Input multiplexer
 - QD1: quasi-differential stereo inputs
 - SE1: stereo single-ended input
 - SE2: stereo single-ended input
 - SE3: stereo single-ended input
 - FD full-differential or quasi-differential input
- Loudness
 - 2nd order frequency response
 - Programmable center frequency (400 Hz / 800 Hz / 2400 Hz)
 - 15 dB with 1 dB steps
 - Selectable high frequency boost
 - Selectable flat-mode (constant attenuation)
- Volume
 - +23 dB to -31 dB with 1 dB step resolution
 - Soft-step control with programmable blend times
- Bass
 - 2nd order frequency response
 - Center frequency programmable in 4 steps (60 Hz / 80 Hz / 100 Hz / 200 Hz)
 - Q programmable 1.0/1.25/1.5/2.0
 - DC gain programmable
 - -15 dB to 15 dB range with 1 dB resolution
- Middle
 - 2nd order frequency response
 - Center frequency programmable in 4 steps (500 Hz / 1 kHz / 1.5 kHz / 2.5 kHz)
 - Q programmable 0.75/1.0/1.25
 - -15 dB to 15 dB range with 1 dB resolution
- Treble
 - 2nd order frequency response (10 kHz / 12.5 kHz / 15 kHz / 17.5 kHz)
 - Center frequency programmable in 4 steps (10 kHz / 12.5 kHz / 15 kHz / 17.5 kHz)
 - -15 dB to 15 dB with 1 dB resolution
- Speaker
 - 4 independent soft-step speaker controls
 - +15 dB to -79 dB with 1 dB steps
 - Direct mute
- Subwoofer
 - 2nd order low pass filter with programmable cut off frequency (55 Hz / 85 Hz / 120 Hz / 160 Hz)
 - 2 independent soft-step level control, +15 dB to -79 dB with 1 dB steps
- Mute functions
 - Direct mute
 - Digitally controlled soft-mute with 4 programmable mute-times (0.48 ms/0.96 ms/8 ms/16 ms)
- Offset detection
 - Offset voltage detection circuit for on-board power amplifier failure diagnosis

Description

The TDA7718B is a high performance signal processor specifically designed for car radio applications. The device includes a high performance audioprocessor with fully integrated audio filters and new soft-step architecture. The digital control allows programming in a wide range of filter characteristics.

Table 1. Device summary

| Order code | Package | Packing |
|------------|---------|---------------|
| TDA7718B | TSSOP28 | Tube |
| TDA7718BTR | TSSOP28 | Tape and reel |

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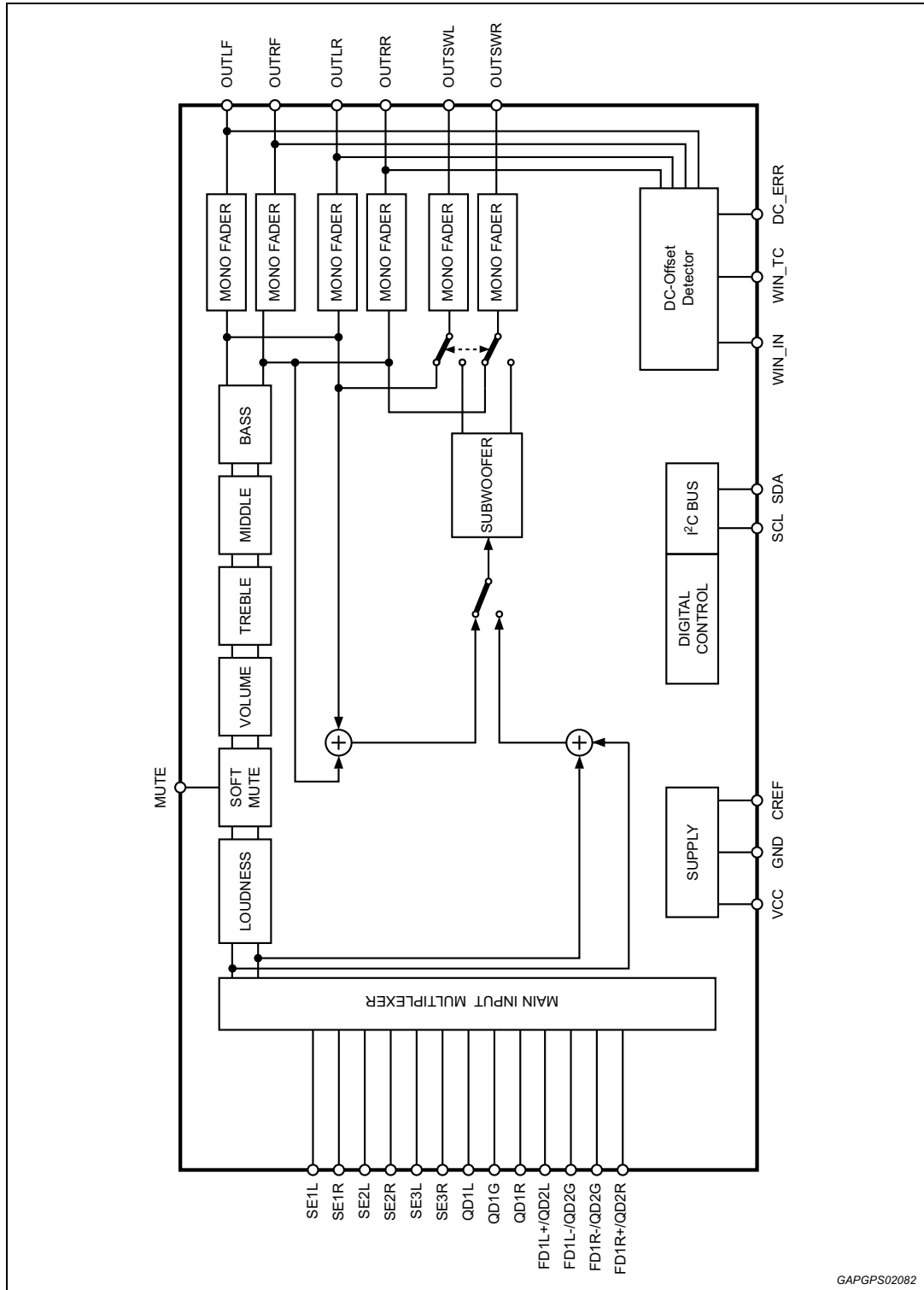
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1 Block circuit diagram

Figure 1. Block circuit diagram

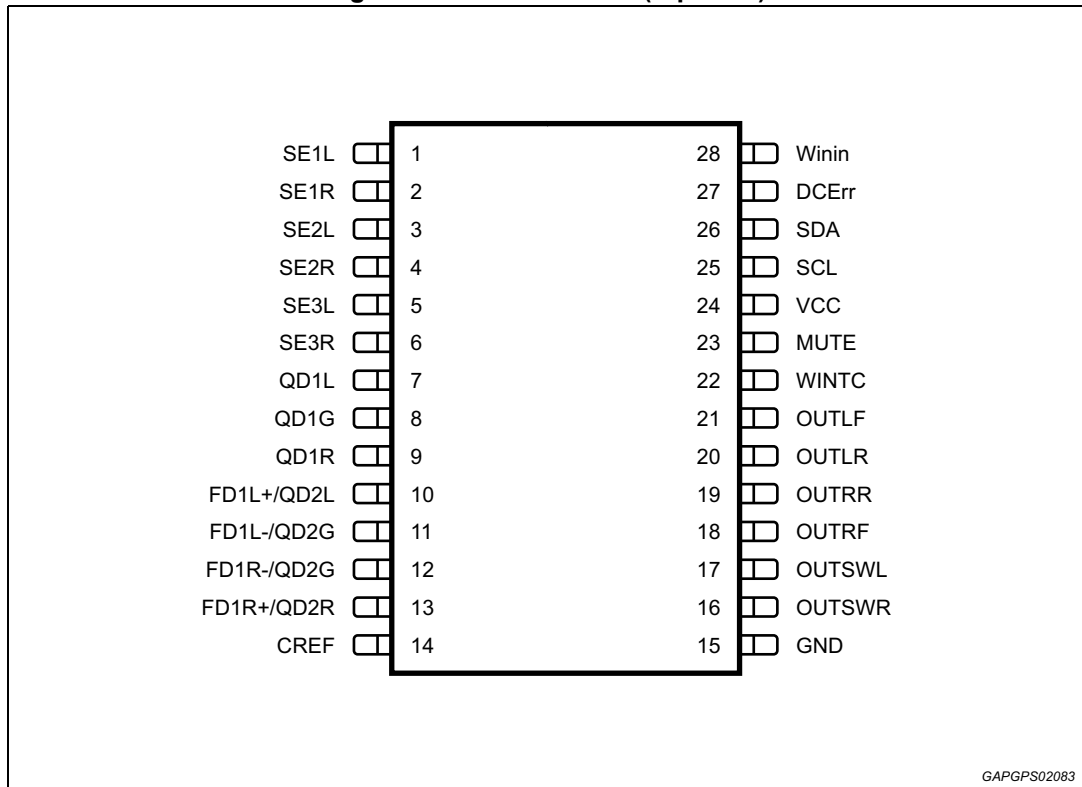


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2 Pin connection and pin description

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 | SE1L | Single-end input left | I |
| 2 | SE1R | Single-end input right | I |
| 3 | SE2L | Single-end input left | I |
| 4 | SE2R | Single-end input right | I |
| 5 | SE3L | Single-end input left | I |
| 6 | SE3R | Single-end input right | I |
| 7 | QD1L | quasi-differential stereo inputs left | I |
| 8 | QD1G | quasi-differential stereo inputs common | I |
| 9 | QD1R | quasi-differential stereo inputs right | I |
| 10 | FD1L+/QD2L | Full differential + input left or quasi-differential left | I |

Table 2. Pin description (continued)

| No. | Pin name | Description | I/O |
|-----|------------|--|-----|
| 11 | FD1L-/QD2G | Full differential - input left or quasi-differential ground | I |
| 12 | FD1R-/QD2G | Full differential - input right or quasi-differential ground | I |
| 13 | FD1R+/QD2R | Full differential + input right or quasi-differential right | I |
| 14 | CREF | Reference capacitor | O |
| 15 | GND | Ground | S |
| 16 | OUTSWR | Subwoofer right output | O |
| 17 | OUTSWL | Subwoofer 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 | DC offset detector filter output | O |
| 23 | MUTE | External mute pin | I |
| 24 | VCC | Supply | S |
| 25 | SCL | I ² C bus clock | I |
| 26 | SDA | I ² C bus data | I/O |
| 27 | DC_ERR | DC offset detector output | O |
| 28 | WIN_IN | DC offset detector input | I |

Note: The L & R channels may be swapped as per the user's wishes making use of proper connections to the device pins, with no impact on electrical performance. Software control has to take into account the external routing and be designed accordingly.

3 Electrical specifications

3.1 Thermal data

Table 3. Thermal data

| Symbol | Description | Value | Unit |
|-----------------|--|-------|------|
| $R_{th-j\ amb}$ | Thermal resistance junction-to-ambient | 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

$V_S = 8.5\text{ V}$; $T_{amb} = 25\text{ °C}$; $R_L = 10\text{ k}\Omega$; 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 | - | 23 | 29 | 35 | mA |
| Input selector | | | | | | |
| R_{in} | Input resistance | All single ended inputs | 70 | 100 | 130 | k Ω |
| V_{CL} | Clipping level | Input gain = 0 dB | 2 | - | - | V_{RMS} |
| S_{IN} | Input separation | - | - | 95 | - | dB |
| Differential stereo inputs | | | | | | |
| R_{in} | Input resistance | Differential | 70 | 100 | - | k Ω |
| CMRR | Common mode rejection ratio for main source | $V_{CM} = 1\text{ V}_{RMS} @ 1\text{ kHz}$ | 44 | 60 | - | dB |
| | | $V_{CM} = 1\text{ V}_{RMS} @ 10\text{ kHz}$ | 44 | 60 | - | dB |
| e_{No} | Output noise @ speaker outputs | 20 Hz - 20 kHz, A-weighted; all stages 0 dB | - | 12 | 22 | μV |

Table 5. Electrical characteristics (continued)

| Symbol | Parameter | Test condition | Min. | Typ. | Max. | Unit |
|-------------------------|---------------------------|-----------------------------|-----------|-----------|-----------|------------|
| Loudness control | | | | | | |
| A_{MAX} | Max attenuation | - | 14 | 15 | 16 | dB |
| A_{STEP} | Step resolution | - | 0.5 | 1 | 1.5 | dB |
| f_{Peak} | Peak frequency | f_{P1} | - | 400 | - | Hz |
| | | f_{P2} | - | 800 | - | Hz |
| | | f_{P3} | - | 2400 | - | Hz |
| Volume control | | | | | | |
| G_{MAX} | Max gain | - | 22 | 23 | 24 | dB |
| A_{MAX} | Max attenuation | - | - | -31 | -30 | 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 | -3 | 0.1 | 3 | mV |
| | | From 0 dB to G_{MIN} | -5 | 0.5 | 5 | mV |
| Soft-mute | | | | | | |
| A_{MUTE} | Mute attenuation | - | 80 | 100 | - | dB |
| T_D | Delay time | T1 | 0.35 | 0.48 | 0.65 | ms |
| | | T2 | 0.7 | 0.96 | 1.3 | ms |
| | | T3 | 5.6 | 7.6 | 9.6 | ms |
| | | T4 | 12.3 | 15.3 | 18.3 | 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 | 3.3 | 3.6 | V |
| Bass control | | | | | | |
| F_c | Center frequency | f_{C1} | - | 60 | - | Hz |
| | | f_{C2} | - | 80 | - | Hz |
| | | f_{C3} | - | 100 | - | Hz |
| | | f_{C4} | - | 200 | - | Hz |
| Q_{BASS} | Quality factor | Q_1 | - | 1 | - | - |
| | | Q_2 | - | 1.25 | - | - |
| | | Q_3 | - | 1.5 | - | - |
| | | Q_4 | - | 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 | ± 4.3 | ± 4.7 | ± 5.1 | 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} | - | 500 | - | Hz |
| | | f_{C2} | - | 1 | - | kHz |
| | | f_{C3} | - | 1.5 | - | kHz |
| | | f_{C4} | - | 2.5 | - | kHz |
| Q_{MIDDLE} | Quality factor | Q_1 | - | 0.75 | - | - |
| | | Q_2 | - | 1 | - | - |
| | | Q_3 | - | 1.25 | - | - |
| 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} | - | 10 | - | kHz |
| | | f_{C2} | - | 12.5 | - | kHz |
| | | f_{C3} | - | 15 | - | kHz |
| | | f_{C4} | - | 17.5 | - | kHz |
| Speaker attenuators | | | | | | |
| G_{MAX} | Max gain | - | 14 | 15 | 16 | dB |
| A_{MAX} | Max attenuation | - | - | -79 | -74 | 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 | - | - | 20 | 100 | W |
| R_L | Output load resistance | - | 2 | - | - | kΩ |
| C_L | Output load capacitor | - | - | - | 10 | nF |
| V_{DC} | DC voltage level | - | 3.8 | 4.0 | 4.2 | V |
| Subwoofer lowpass | | | | | | |
| f_{LP} | Lowpass corner frequency | f_{LP1} | - | 55 | - | Hz |
| | | f_{LP2} | - | 85 | - | Hz |
| | | f_{LP3} | - | 120 | - | Hz |
| | | f_{LP4} | - | 160 | - | Hz |

Table 5. Electrical characteristics (continued)

| Symbol | Parameter | Test condition | Min. | Typ. | Max. | Unit |
|------------------------------------|-------------------------------|--|------|------|------|------|
| DC offset detection circuit | | | | | | |
| V_{th} | Zero comp. window size | V1 | ±10 | ±25 | ±40 | mV |
| | | V2 | ±30 | ±50 | ±70 | mV |
| | | V3 | ±50 | ±75 | ±100 | mV |
| | | V4 | ±70 | ±100 | ±130 | mV |
| t_{sp} | Max rejected spike length | - | 2 | 11 | 30 | µs |
| | | - | 5 | 22 | 50 | µs |
| | | - | 10 | 33 | 70 | µs |
| | | - | 15 | 44 | 90 | µs |
| $I_{CHDCerr}$ | DCErr charge current | - | 2 | 5 | 8 | µA |
| $I_{DISDCerr}$ | DCErr discharge current | - | 4 | 5 | 9 | mA |
| V_{OutH} | DCErr high voltage | - | 3 | 3.3 | 3.6 | V |
| V_{OutL} | DCErr low voltage | - | - | 100 | 300 | mV |
| General | | | | | | |
| e_{NO} | Output noise | BW=20 Hz to 20 kHz A-Weighted, all gain = 0 dB | - | 12 | 22 | µV |
| | | BW=20 Hz - 20 kHz A-Weighted, Output muted | - | 7 | 12 | µV |
| S/N | Signal to noise ratio | all gain = 0 dB, A-weighted; $V_o = 2 V_{RMS}$ | 98 | 104 | - | dB |
| D | Distortion | $V_{IN} = 1 V_{RMS}$; all stages 0 dB | - | 0.01 | 0.1 | % |
| S_C | Channel separation left/right | - | - | 90 | - | dB |

4 Description of the audioprocessor

4.1 Input stages

One quasi-differential stereo input, one full-differential/quasi-differential stereo input and three single-ended inputs are available.

4.1.1 Quasi-differential stereo input (QD1)

The QD input is implemented as a buffered quasi-differential stereo stage with 100 k Ω input-impedance at each input. There is -3 dB attenuation at QD input stage.

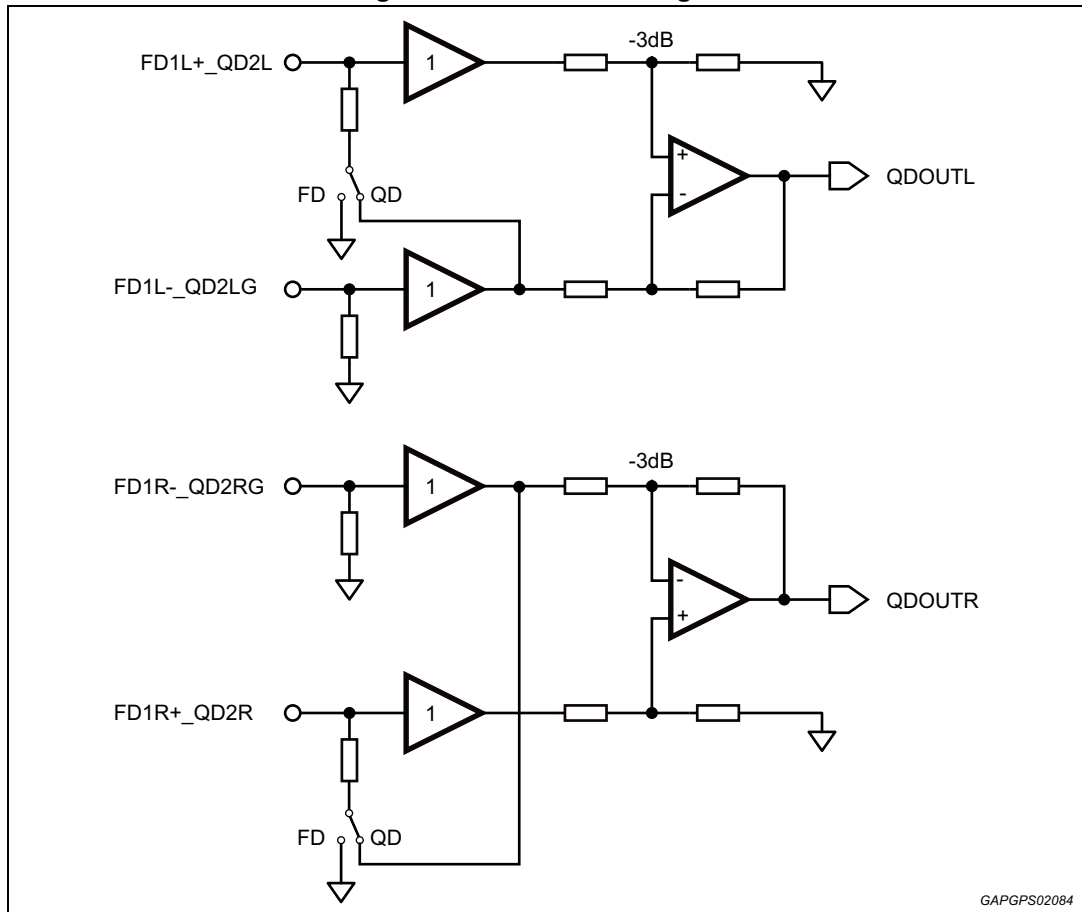
4.1.2 Single-ended stereo input (SE1, SE2, SE3)

The input-impedance at each input is 100 k Ω and the attenuation is fixed to -3 dB for incoming signals.

4.1.3 Full-differential or quasi-differential stereo input (FD/QD2)

This device provides a full-differential stereo input stage (FD) or 2nd quasi-differential stereo input stage. The full differential is a buffered full-differential stereo stage with 100 k Ω input-impedance at each input. When using as QD2 application, it needs to connect the two QD2G pins together from external and the input impedance at QDG becomes 50 k Ω . There is -3 dB attenuation at the input stage. [Figure 3](#) shows the block diagram of this input stage.

Figure 3. FD/QD block diagram



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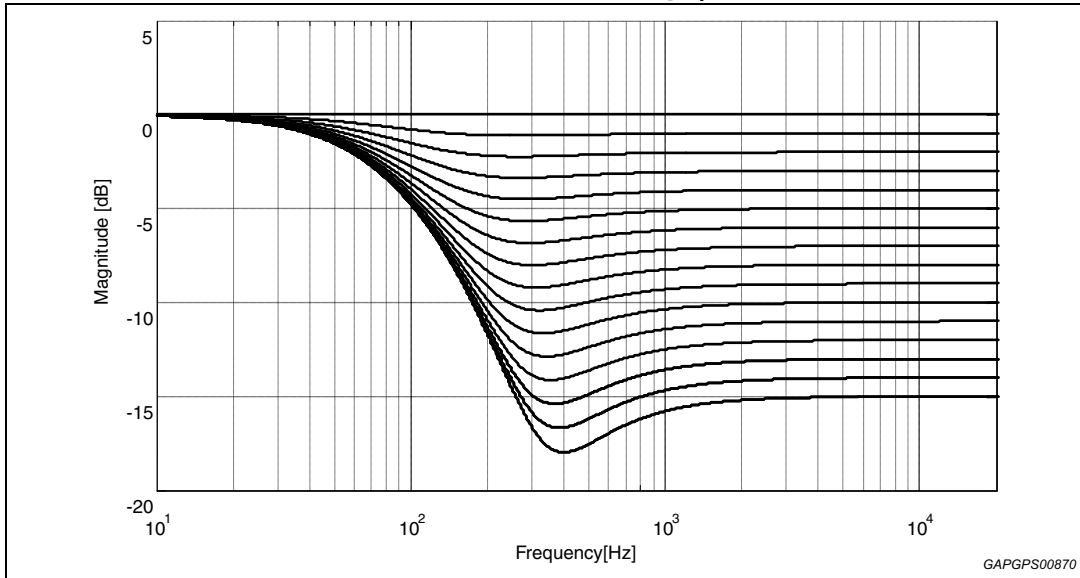
4.2 Loudness

There are four parameters programmable in the loudness stage.

4.2.1 Loudness attenuation

Figure 4 shows the attenuation as a function of frequency at $f_p = 400$ Hz.

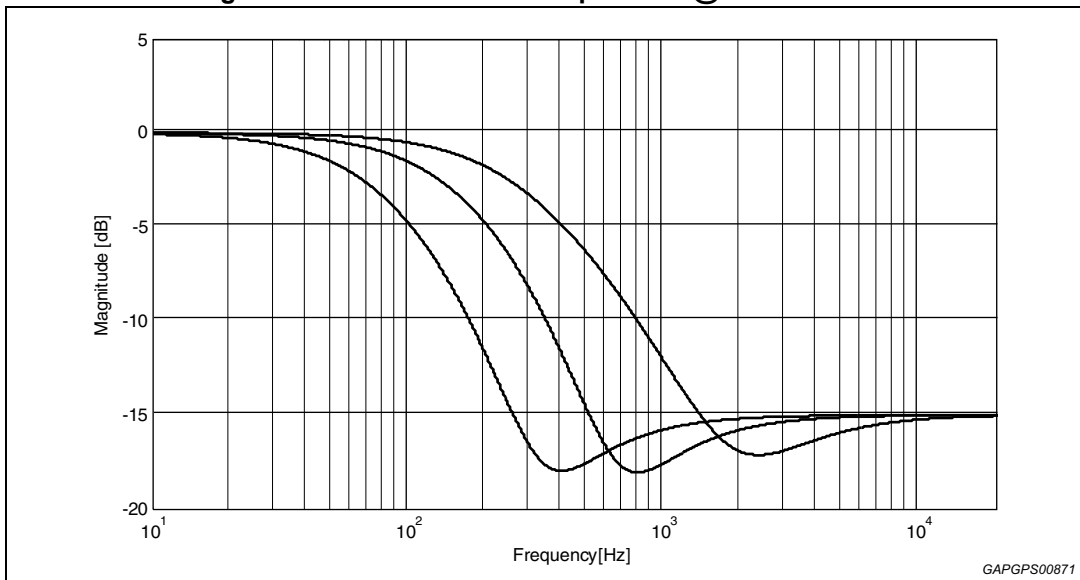
Figure 4. Loudness attenuation @ $f_p = 400$ Hz.



4.2.2 Peak frequency

Figure 5 shows the four possible peak-frequencies at 400, 800 and 2400 Hz.

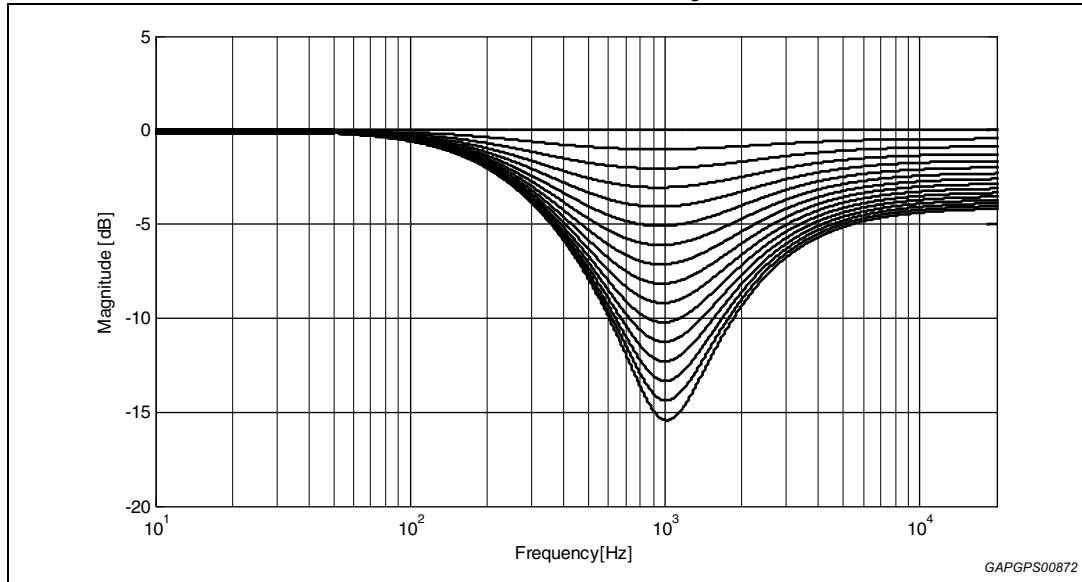
Figure 5. Loudness center frequencies @ attn. = 15 dB.



4.2.3 High frequency boost

Figure 6 shows the different Loudness shapes in low and high frequency boost.

Figure 6. Loudness attenuation, $f_c = 2.4 \text{ kHz}$



4.2.4 Flat mode

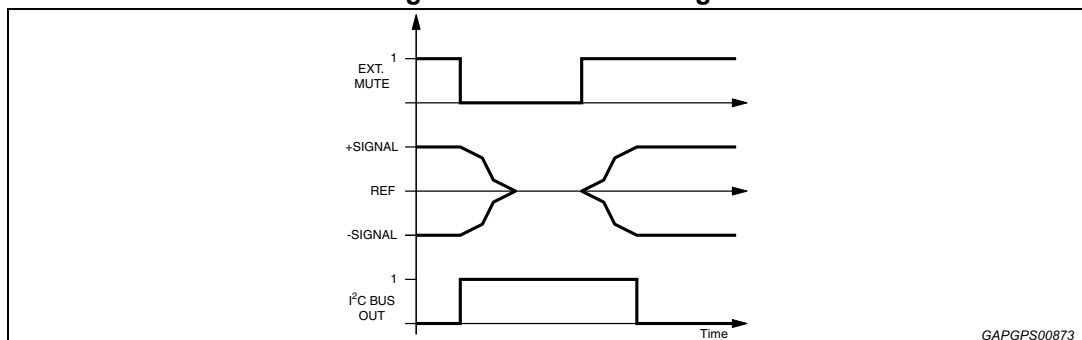
In flat mode the loudness stage works as a 0 dB to -15 dB attenuator.

4.3 Soft-mute

The digitally controlled soft-mute stage allows muting/demuting the signal with a I²C bus programmable slope. The mute process can either be activated by the soft-mute 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 7).

For timing purposes the bit 0 of the I²C bus output register is set to 1 from the start of muting until the end of demuting.

Figure 7. Soft-mute timing



Note: Please notice that a started mute-action is always terminated and could not be interrupted by a change of the mute –signal.

4.4 Soft-step 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 soft-step-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 soft-step control is described in detail in [Chapter 4.9](#).

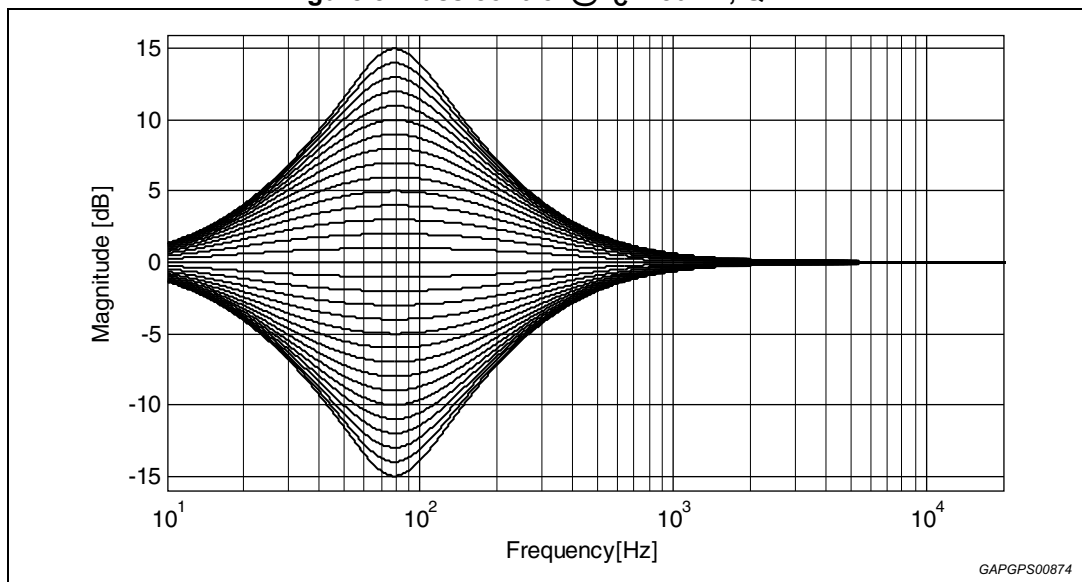
4.5 Bass

There are four parameters programmable in the bass stage:

4.5.1 Bass attenuation

[Figure 8](#) shows the attenuation as a function of frequency at a center frequency of 80 Hz.

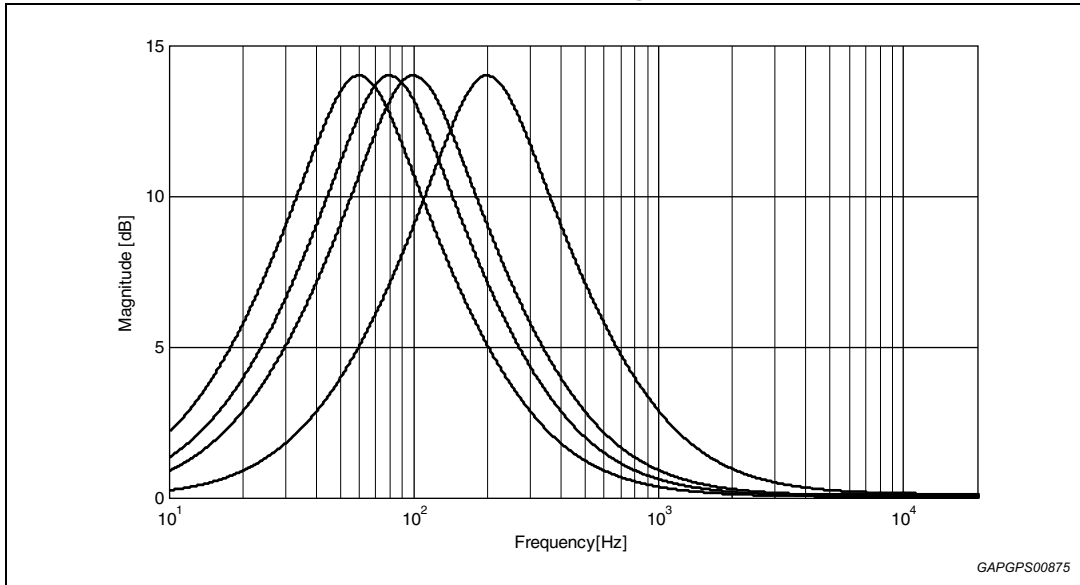
Figure 8. Bass control @ $f_c = 80$ Hz, $Q = 1$



4.5.2 Bass center frequency

Figure 9 shows the four possible center frequencies 60, 80, 100 and 200 Hz.

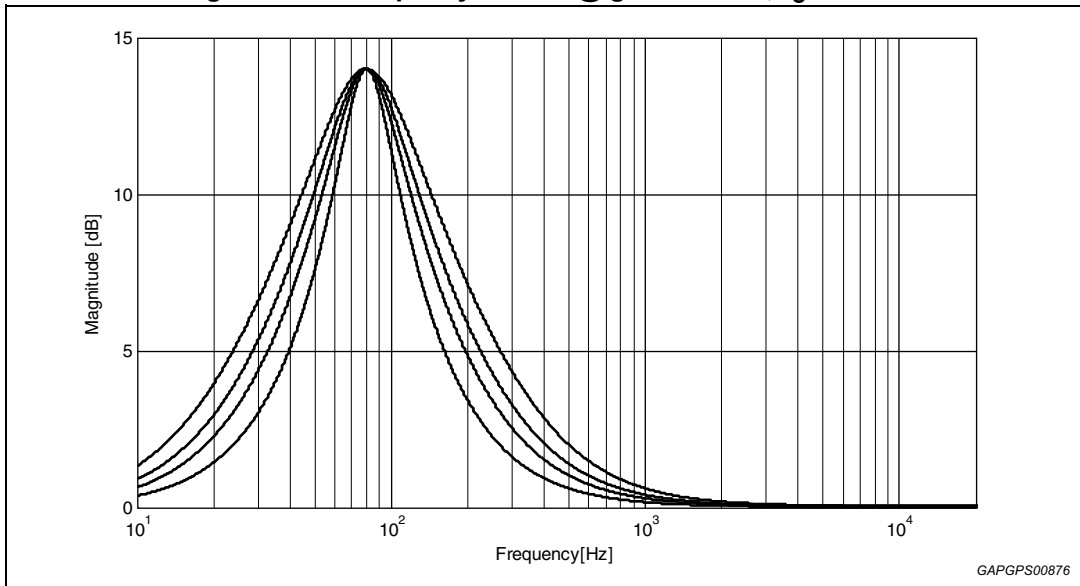
Figure 9. Bass center frequencies @ gain = 14 dB, Q = 1



4.5.3 Quality factors

Figure 10 shows the four possible quality factors 1, 1.25, 1.5 and 2.

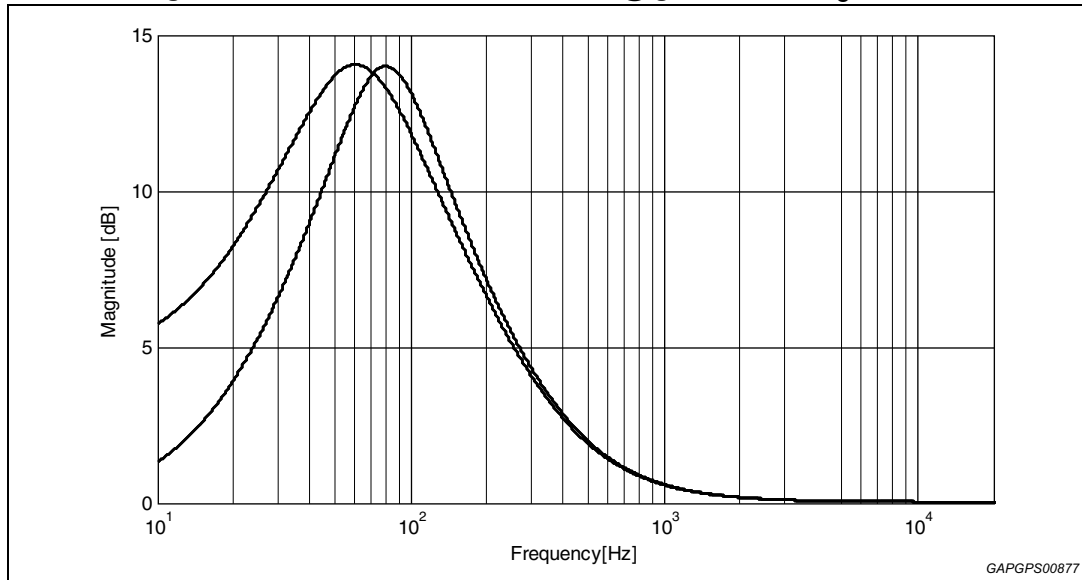
Figure 10. Bass quality factors @ gain = 14 dB, f_C = 80 Hz



4.5.4 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 11. Bass normal and DC mode @ gain = 14 dB, $f_c = 80$ Hz



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

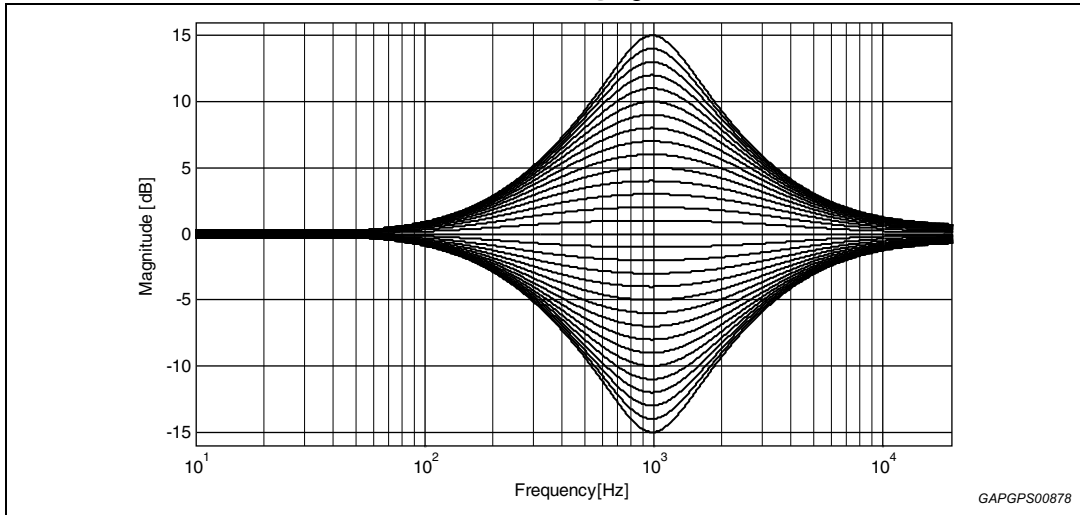
4.6 Middle

There are three parameters programmable in the middle stage:

4.6.1 Middle attenuation

Figure 12 shows the attenuation as a function of frequency at a center frequency of 1 kHz.

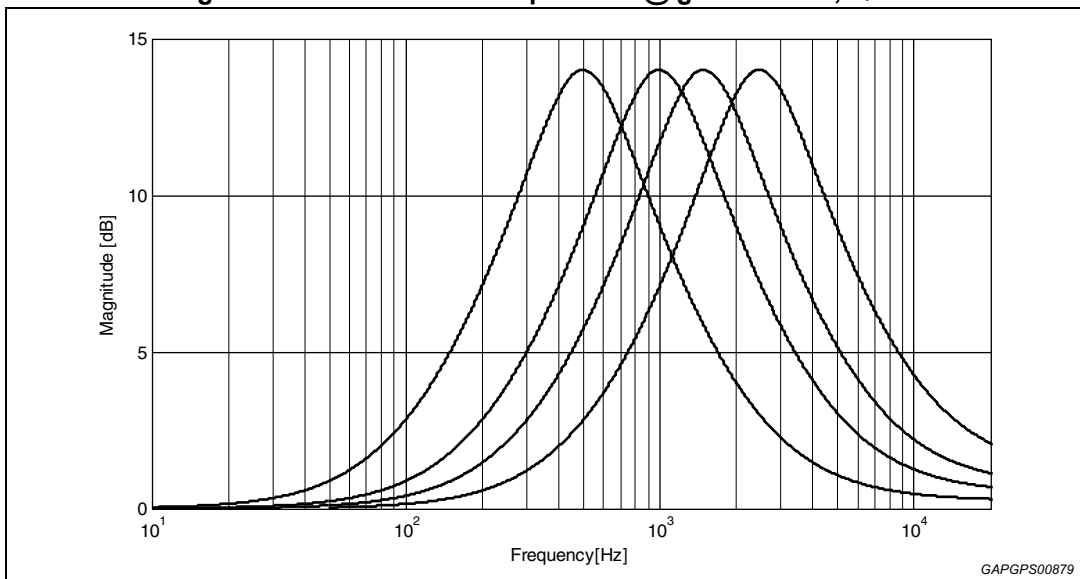
Figure 12. Middle control @ $f_c = 1$ kHz, $Q = 1$



4.6.2 Middle center frequency

Figure 13 shows the four possible center frequencies 500 Hz, 1 kHz, 1.5 kHz and 2.5 kHz.

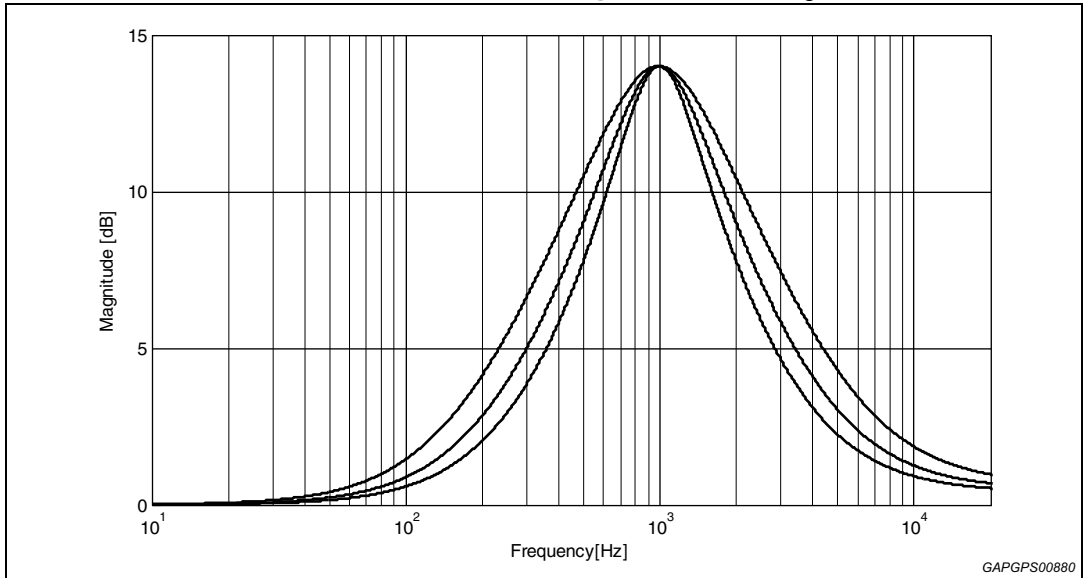
Figure 13. Middle center frequencies @ gain = 14 dB, $Q = 1$



4.6.3 Quality factors

Figure 14 shows the three possible quality factors 0.75, 1 and 1.25.

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



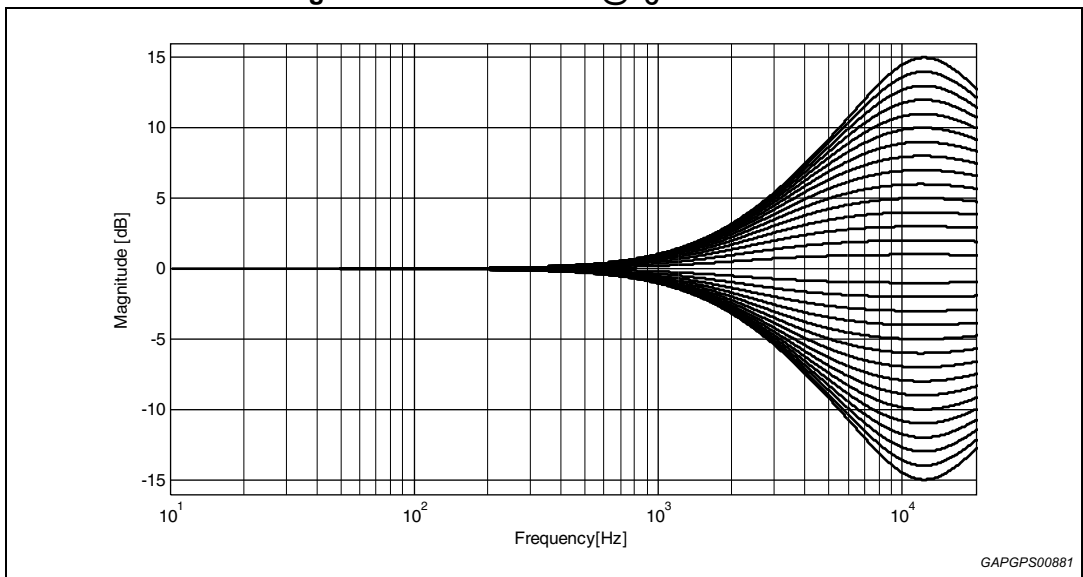
4.7 Treble

There are two parameters programmable in the treble stage:

4.7.1 Treble attenuation

Figure 15 shows the attenuation as a function of frequency at a center frequency of 17.5 kHz.

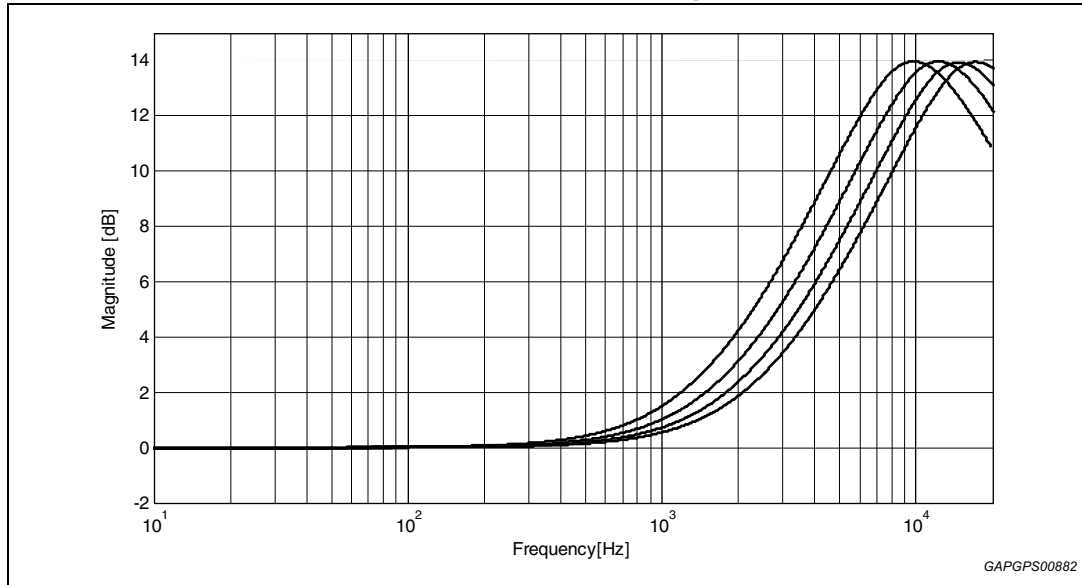
Figure 15. Treble control @ $f_c = 17.5$ kHz.



4.7.2 Center frequency

Figure 16 shows the four possible center frequencies 10 k, 12.5 k, 15 k and 17.5 kHz.

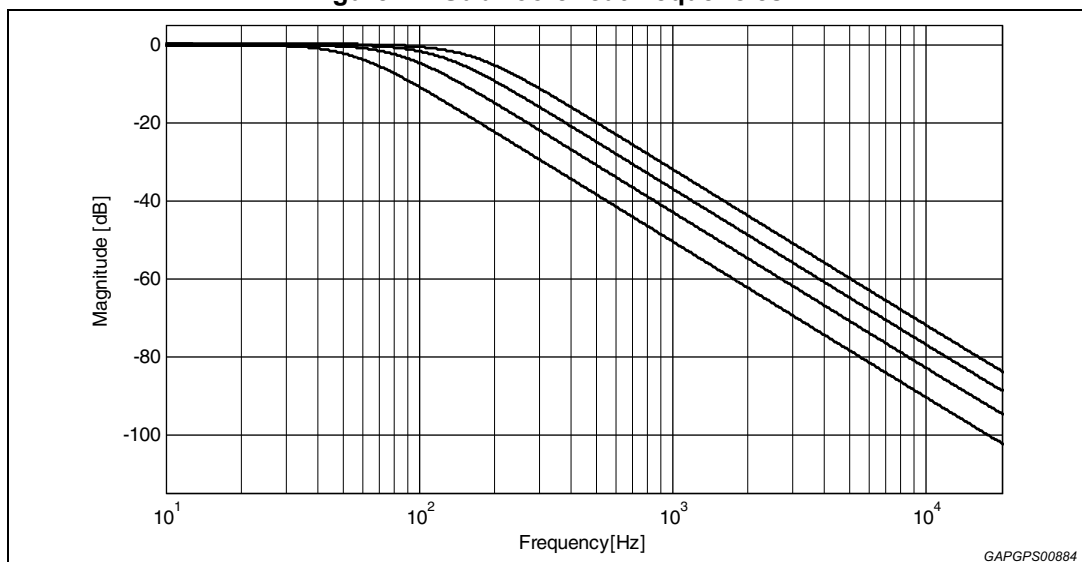
Figure 16. Treble center frequencies @ gain = 14 dB



4.8 Subwoofer filter

The subwoofer lowpass filter has Butterworth characteristics with programmable cut-off frequency (55 Hz / 85 Hz / 120 Hz / 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 17. Subwoofer cut frequencies

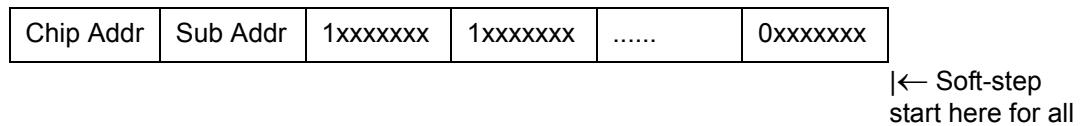
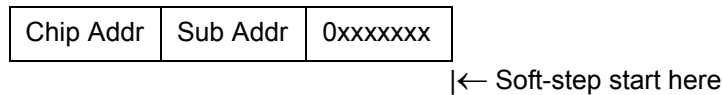


4.9 Soft-step control

In this device, the soft-step function is available for volume, speaker, loudness, treble, middle and bass block. With soft-step 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 soft-step function is controlled by soft-step on/off control bit in the control table. The soft-step transient time selection (5 ms or 10 ms) is common for all blocks and it is controlled by soft-step time control bit. The soft-step operation of all blocks has a common centralized control. In this case, a new soft-step operation can not be started before the completion previous soft-step.

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



4.10 DC offset detector

Using the DC offset detection circuit (Figure 18) an offset voltage difference between the audio power amplifier and the APR'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 APR. The WinIn-input has an 50kΩ internal pull-up resistor connected to 3.3 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 APR and the power amplifier introduces. For the zero window comparators, the time constant for spike rejection as well as the threshold are programmable.

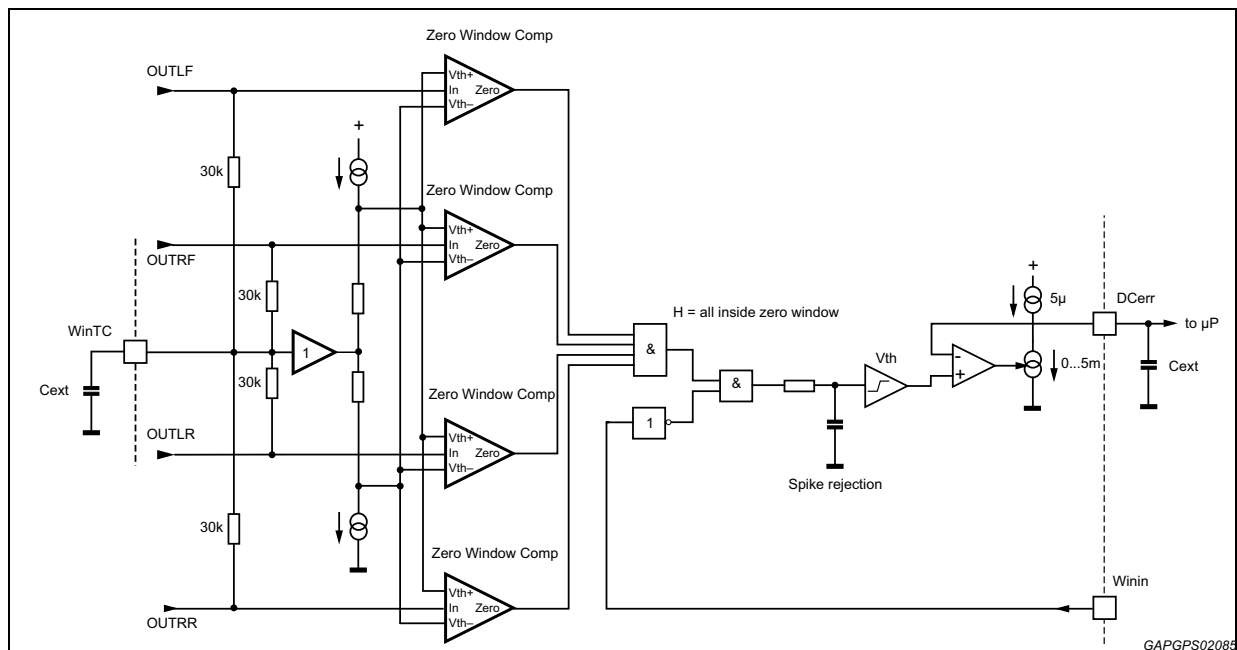
For electrical characteristics see Chapter 3 on page 9.

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.

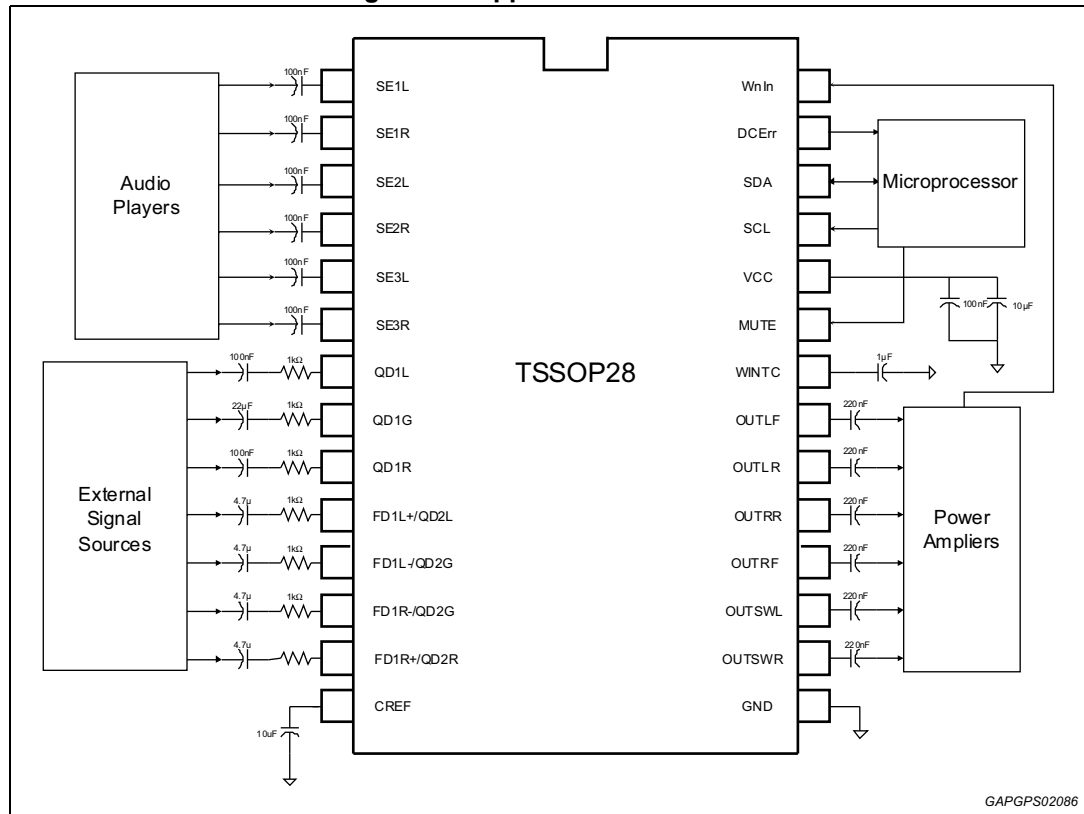
Figure 18. DC offset detection circuit (simplified)



4.11 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 SE1L 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.

Figure 19. Application schematic



4.12 Application note

Above application schematic shows a proposal typical application that QD1 and FD/QD2 is used as external signal sources. To limit the leakage current from signal source a 1 kΩ resistor is recommended to put between de-coupling capacitor and pin if the output impedance of external signal source is less than 1 kΩ.

It's guaranteed that all input pins (pin 1~13) will not be broken even if 2Vrms input signal is applied to the pins when CSP is power off.

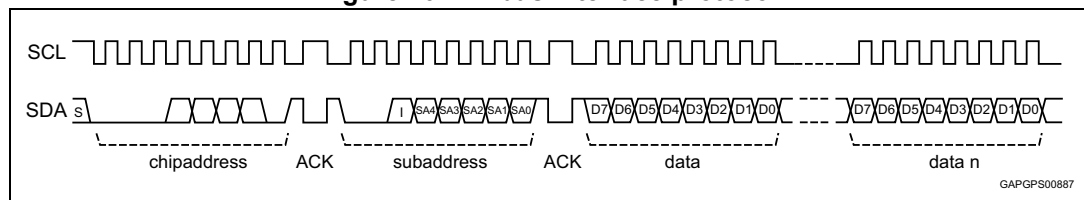
5 I²C bus specification

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 kbit/s
- 3.3 V logic compatible

Figure 20. I²C bus interface protocol



S = Start

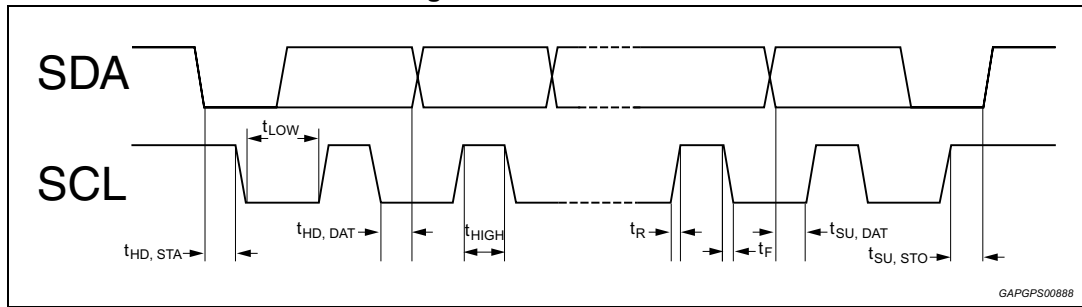
ACK = Acknowledge

5.2 I²C bus electrical characteristics

Table 6. 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 21. I²C bus data



5.2.1 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

5.2.2 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 = Soft-step Busy ('0' = Busy)

X = Not used

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

5.2.3 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 7. Subaddress (receive mode)

| MSB | | | | | | | | LSB | Function |
|-----|----|----|----|----|----|----|----|--------------------------------|----------|
| I2 | I1 | I0 | A4 | A3 | A2 | A1 | A0 | | |
| 0 | - | - | - | - | - | - | - | Testing mode | |
| 1 | - | - | - | - | - | - | - | Off | |
| - | x | - | - | - | - | - | - | On | |
| - | - | 0 | - | - | - | - | - | Not used | |
| - | - | 1 | - | - | - | - | - | Auto increment mode | |
| - | - | - | 0 | 0 | 0 | 0 | 0 | Off | |
| - | - | - | 0 | 0 | 0 | 0 | 1 | On | |
| - | - | - | 0 | 0 | 0 | 1 | 0 | Main selector | |
| - | - | - | 0 | 0 | 0 | 1 | 1 | Not used | |
| - | - | - | 0 | 0 | 1 | 0 | 0 | Not used | |
| - | - | - | 0 | 0 | 1 | 0 | 1 | Soft-mute / others | |
| - | - | - | 0 | 0 | 1 | 1 | 0 | Soft-step I | |
| - | - | - | 0 | 0 | 1 | 1 | 1 | Soft-step II / DC-detector | |
| - | - | - | 0 | 1 | 0 | 0 | 0 | Loudness | |
| - | - | - | 0 | 1 | 0 | 0 | 1 | Volume / output gain | |
| - | - | - | 0 | 1 | 0 | 1 | 0 | Treble | |
| - | - | - | 0 | 1 | 0 | 1 | 1 | Middle | |
| - | - | - | 0 | 1 | 1 | 0 | 0 | Bass | |
| - | - | - | 0 | 1 | 1 | 0 | 1 | Subwoofer / middle / bass | |
| - | - | - | 0 | 1 | 1 | 1 | 0 | Speaker attenuator left front | |
| - | - | - | 0 | 1 | 1 | 1 | 1 | Speaker attenuator right front | |
| - | - | - | 1 | 0 | 0 | 0 | 0 | Speaker attenuator left rear | |
| - | - | - | 1 | 0 | 0 | 0 | 1 | Speaker attenuator right rear | |
| - | - | - | 1 | 0 | 0 | 1 | 0 | Subwoofer attenuator left | |
| - | - | - | 1 | 0 | 0 | 1 | 1 | Subwoofer attenuator right | |
| - | - | - | 1 | 0 | 1 | 0 | 0 | Testing audio processor 1 | |
| - | - | - | 1 | 0 | 1 | 0 | 1 | Testing audio processor 2 | |
| - | - | - | 1 | 0 | 1 | 0 | 1 | Testing audio processor 3 | |

5.3 Data byte specification

Table 8. Main selector (0)

| MSB | | | | LSB | | | | Function |
|-----|----|----|----|-----|----|----|----|---|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | |
| - | - | - | - | - | 0 | 0 | 0 | Main source selector SE1 SE3 <u>QD1</u> FD/ QD2 SE2 Mute Mute Mute |
| | | | | | 0 | 0 | 1 | |
| | | | | | 0 | 1 | 0 | |
| | | | | | 0 | 1 | 1 | |
| | | | | | 1 | 0 | 0 | |
| | | | | | 1 | 0 | 1 | |
| | | | | | 1 | 1 | 0 | |
| | | | | | 1 | 1 | 1 | |
| - | - | - | - | 0 | - | - | - | FD / QD2 selection FD <u>QD2</u> |
| | | | | 1 | | | | |
| - | - | - | 0 | - | - | - | - | Main source input gain select 0 dB <u>3 dB</u> |
| | | | 1 | | | | | |
| - | - | 0 | - | - | - | - | - | Subwoofer flat Off <u>On</u> |
| | | 1 | | | | | | |
| x | x | - | - | - | - | - | - | Not used |

Not used (1-3)

Table 9. Soft-mute / others (4)

| MSB | | | | LSB | | | | Function |
|--------|--------|--------|--------|------------------|------------------|--------|--------|---|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | |
| - | - | - | - | - | - | - | 0 1 | Soft-mute <u>On</u> <u>Off</u> |
| - | - | - | - | - | - | 0 1 | - | Pin influence for mute <u>Pin and IIC</u> <u>IIC</u> |
| - | - | - | - | 0 0 1 1 | 0 1 0 1 | - | - | Soft-mute time 0.48 ms 0.96 ms 7.68 ms <u>15.36 ms</u> |
| - | - | - | 0 1 | - | - | - | - | Subwoofer input source <u>Input mux</u> <u>Bass output</u> |
| - | - | 0 1 | - | - | - | - | - | Subwoofer enable (OUTSWL & OUTSWR) <u>On</u> <u>Off</u> |
| - | 0 1 | - | - | - | - | - | - | Fast charge <u>On</u> <u>Off</u> |
| 0 1 | - | - | - | - | - | - | - | Anti-alias filter <u>On</u> <u>Off (bypass)</u> |

Table 10. Soft-step 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 11. Soft-step 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 5 ms <u>10 ms</u> |
| - | - | 0 0 1 1 | 0 1 0 1 | - | - | - | - | Zero-comparator window size ±100 mV ±75 mV ±50 mV <u>±25 mV</u> |
| 0 0 1 1 | 0 1 0 1 | - | - | - | - | - | - | Spike rejection time constant 11 μs 22 μs 33 μs <u>44 μs</u> |

Table 12. Loudness (7)

| MSB | | | | LSB | | | | Function |
|-----|----|----|----|-----|----|----|----|--------------------------|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | |
| - | - | - | - | 0 | 0 | 0 | 0 | Attenuation 0 dB |
| | | | | 0 | 0 | 0 | 1 | -1 dB |
| | | | | : | : | : | : | : |
| | | | | 1 | 1 | 1 | 0 | -14 dB |
| | | | | 1 | 1 | 1 | 1 | -15 dB |
| - | - | 0 | 0 | - | - | - | - | Center frequency Flat |
| | | 0 | 1 | | | | | 400 Hz |
| | | 1 | 0 | | | | | 800 Hz |
| | | 1 | 1 | | | | | 2400 Hz |
| - | 0 | - | - | - | - | - | - | High boost On |
| | 1 | | | | | | | Off |
| 0 | - | - | - | - | - | - | - | Soft-step action Act |
| 1 | | | | | | | | Wait |

Table 13. Volume / output gain (8)

| MSB | | | | LSB | | | | Function | |
|-----|----|----|----|-----|----|----|----|---------------------------|----------|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | | |
| - | - | 0 | 0 | 0 | 0 | 0 | 0 | Gain/attenuation +0 dB | |
| | | 0 | 0 | 0 | 0 | 0 | 0 | 1 | +1 dB |
| | | : | : | : | : | : | : | : | : |
| | | 0 | 0 | 1 | 1 | 1 | 1 | 1 | +15 dB |
| | | 0 | 1 | 0 | 0 | 0 | 0 | 0 | +16 dB |
| | | : | : | : | : | : | : | : | : |
| | | 0 | 1 | 0 | 1 | 1 | 1 | 1 | +23 dB |
| | | 0 | 1 | 1 | 0 | 0 | 0 | 0 | Not used |
| | | : | : | : | : | : | : | : | : |
| | | 0 | 1 | 1 | 1 | 1 | 1 | 1 | Not used |
| | | 1 | 0 | 0 | 0 | 0 | 0 | 0 | -0 dB |
| | | : | : | : | : | : | : | : | : |
| | | 1 | 0 | 1 | 1 | 1 | 1 | 1 | -15 dB |
| | | : | : | : | : | : | : | : | : |
| | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | -31 dB |
| - | 0 | - | - | - | - | - | - | Output gain 1 dB | |
| | 1 | | | | | | | 0 dB | |
| 0 | - | - | - | - | - | - | - | Soft-step action Act | |
| 1 | | | | | | | | Wait | |

Table 14. Treble filter (9)

| MSB | | | | LSB | | | | Function | | |
|--------|----|----|----|-----|----|----|----|----------|--|--------------|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | | | |
| - | - | - | 0 | 0 | 0 | 0 | 0 | 0 | Gain/attenuation -15 dB | |
| | | | 0 | 0 | 0 | 0 | 0 | 1 | -14 dB | |
| | | | : | : | : | : | : | : | : | : |
| | | | 0 | 1 | 1 | 1 | 1 | 0 | 0 | -1 dB |
| | | | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 dB |
| | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 dB |
| | | | 1 | 1 | 1 | 1 | 1 | 0 | 0 | <u>+1 dB</u> |
| | | | : | : | : | : | : | : | : | : |
| | | | 1 | 0 | 0 | 0 | 0 | 0 | 1 | +14 dB |
| | | | 1 | 0 | 0 | 0 | 0 | 0 | 0 | +15 dB |
| - | 0 | 0 | - | - | - | - | - | - | Treble center frequency 10.0 kHz | |
| | 0 | 1 | | | | | | | 12.5 kHz | |
| | 1 | 0 | | | | | | | 15.0 kHz | |
| | 1 | 1 | | | | | | | <u>17.5 kHz</u> | |
| 0 1 | - | - | - | - | - | - | - | - | Soft-step action Act | |
| | | | | | | | | | Wait | |

Table 15. Middle filter (10)

| MSB | | | | LSB | | | | Function | | |
|--------|----|----|----|-----|----|----|----|----------|-----------------------------------|--------------|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | | | |
| - | - | - | 0 | 0 | 0 | 0 | 0 | 0 | Gain/attenuation -15 dB | |
| | | | 0 | 0 | 0 | 0 | 0 | 1 | -14 dB | |
| | | | : | : | : | : | : | : | : | : |
| | | | 0 | 1 | 1 | 1 | 1 | 0 | 0 | -1 dB |
| | | | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 dB |
| | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 dB |
| | | | 1 | 1 | 1 | 1 | 1 | 0 | 0 | <u>+1 dB</u> |
| | | | : | : | : | : | : | : | : | : |
| | | | 1 | 0 | 0 | 0 | 0 | 0 | 1 | +14 dB |
| | | | 1 | 0 | 0 | 0 | 0 | 0 | 0 | +15 dB |
| - | 0 | 0 | - | - | - | - | - | - | Middle Q factor 0.75 | |
| | 0 | 1 | | | | | | | 1 | |
| | 1 | 0 | | | | | | | <u>1.25</u> | |
| | 1 | 1 | | | | | | | Reserved | |
| 0 1 | - | - | - | - | - | - | - | - | Soft-step action Act | |
| | | | | | | | | | Wait | |

Table 16. Bass filter (11)

| MSB | | | | LSB | | | | Function | |
|-----|----|----|----|-----|----|----|--------|-------------------------|--------|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | | |
| - | - | - | 0 | 0 | 0 | 0 | 0 | -15 dB | |
| | | | 0 | 0 | 0 | 0 | 1 | -14 dB | |
| | | | : | : | : | : | : | : | : |
| | | | 0 | 1 | 1 | 1 | 0 | -1 dB | |
| | | | 0 | 1 | 1 | 1 | 1 | 0 dB | |
| | | | 1 | 1 | 1 | 1 | 1 | 0 dB | |
| | | | 1 | 1 | 1 | 1 | 0 | +1 dB | |
| | | | : | : | : | : | : | : | : |
| | | | 1 | 0 | 0 | 0 | 0 | 1 | +14 dB |
| | | | 1 | 0 | 0 | 0 | +15 dB | | |
| - | 0 | 0 | - | - | - | - | - | Bass Q factor | |
| | 0 | 1 | | | | | | 1.0 | |
| | 1 | 0 | | | | | | 1.25 | |
| | 1 | 1 | | | | | | 1.5 | |
| | | | | | | | | <u>2.0</u> | |
| 0 | - | - | - | - | - | - | - | Soft-step action | |
| 1 | | | | | | | | Act | |
| | | | | | | | | <u>Wait</u> | |

Table 17. Subwoofer / middle / bass (12)

| MSB | | | | LSB | | | | Function |
|-----|----|----|----|-----|----|----|----|------------------------------------|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | |
| - | - | - | - | - | - | 0 | 0 | Subwoofer cut-off frequency |
| | | | | | | 0 | 1 | 55 Hz |
| | | | | | | 1 | 0 | 85 Hz |
| | | | | | | 1 | 1 | <u>120 Hz</u> |
| | | | | | | | | 160 Hz |
| - | - | - | - | - | 0 | - | - | Subwoofer output phase |
| | | | | | 1 | | | 180 deg |
| | | | | | | | | <u>0 deg</u> |
| - | - | - | 0 | 0 | - | - | - | Middle center frequency |
| | | | 0 | 1 | | | | 500 Hz |
| | | | 1 | 0 | | | | 1000 Hz |
| | | | 1 | 1 | | | | 1500 Hz |
| | | | | | | | | <u>2500 Hz</u> |
| - | 0 | 0 | - | - | - | - | - | Bass center frequency |
| | 0 | 1 | | | | | | 60 Hz |
| | 1 | 0 | | | | | | 80 Hz |
| | 1 | 1 | | | | | | 100 Hz |
| | | | | | | | | <u>200 Hz</u> |
| 0 | - | - | - | - | - | - | - | Bass DC mode |
| 1 | | | | | | | | On |
| | | | | | | | | <u>Off</u> |

Table 18. Speaker attenuation (FL/FR/RL/RR/SWL/SWR) (13-18)

| MSB | | | | | | | LSB | | Function |
|-----|----|----|----|----|----|----|-----|-------------------------|----------|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | | |
| - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 dB | |
| | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 dB | |
| | : | : | : | : | : | : | : | : | |
| | 0 | 0 | 0 | 1 | 1 | 1 | 1 | +15 dB | |
| | 0 | 0 | 1 | 0 | 0 | 0 | 0 | -0 dB | |
| | 0 | 0 | 1 | 0 | 0 | 0 | 1 | -1 dB | |
| | : | : | : | : | : | : | : | : | |
| | 1 | 0 | 1 | 1 | 1 | 1 | 1 | -78 dB | |
| | 1 | 0 | 1 | 1 | 1 | 1 | 1 | -79 dB | |
| 1 | 1 | 1 | x | x | x | x | x | <u>mute</u> | |
| 0 | - | - | - | - | - | - | - | Soft-step action | |
| 1 | - | - | - | - | - | - | - | Act <u>Wait</u> | |

Table 19. Testing audio processor 1 (19)

| MSB | | | | | | | LSB | | Function |
|-----|----|----|----|---------|----|----|----------------|---|----------|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | | |
| - | - | - | - | - | - | - | 0 | Audio processor testing mode | |
| | | | | | | | 1 | <u>Off</u> On | |
| - | - | - | 0 | 0 | 0 | 0 | - | Test multiplexer at SE1L ⁽¹⁾ | |
| | | | 0 | 0 | 0 | 1 | SSCLK | | |
| | | | 0 | 0 | 1 | 0 | REQ | | |
| | | | 0 | 0 | 1 | 1 | SMCLK | | |
| | | | 0 | 1 | 0 | 0 | DCDet Vth High | | |
| | | | 0 | 1 | 0 | 1 | DCDet Vth Low | | |
| | | | 0 | 1 | 1 | 0 | IntZeroErr | | |
| | | | 0 | 1 | 1 | 1 | Ref5V5 | | |
| | | | 1 | 0 | 0 | 0 | VGB1.95 | | |
| | | | 1 | 0 | 0 | 1 | Clock200k | | |
| 1 | 0 | 1 | 0 | SDCLK | | | | | |
| 1 | 0 | 1 | 0 | VrefDCO | | | | | |
| - | - | 0 | - | - | - | - | - | Clock fast mode ⁽²⁾ | |
| | | 1 | | | | | | On <u>Off</u> | |
| - | 0 | - | - | - | - | - | - | Clock source ⁽²⁾ | |
| | 1 | | | | | | | External <u>Internal (200 kHz)</u> | |
| 0 | - | - | - | - | - | - | - | Attenuator gain clock control ⁽²⁾ | |
| 1 | - | - | - | - | - | - | - | On <u>Off</u> | |

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 20. Testing audio processor 2 (20)

| MSB | | | | | | | LSB | | Function |
|-----|----|----|----|----|----|----|-----|--|----------|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | | |
| - | - | - | - | - | - | - | 0 | Test architecture ⁽¹⁾ Normal Split | |
| - | - | - | - | - | - | - | 1 | | |
| - | - | - | - | - | - | 0 | - | Oscillator clock ⁽²⁾ 400 kHz 800 kHz | |
| - | - | - | - | - | - | 1 | - | | |
| - | - | - | - | - | 0 | - | - | Soft-step curve ⁽²⁾ S-Curve Linear curve | |
| - | - | - | - | - | 1 | - | - | | |
| - | - | - | 0 | 0 | - | - | - | Manual set busy signal ⁽¹⁾ Auto Auto 0 1 | |
| - | - | - | 0 | 1 | - | - | - | | |
| - | - | - | 1 | 0 | - | - | - | | |
| - | - | - | 1 | 1 | - | - | - | | |
| - | - | - | 0 | 0 | - | - | - | Request for clk generator ⁽¹⁾ Allow Allow Stopped Stopped | |
| - | - | - | 0 | 1 | - | - | - | | |
| - | - | - | 1 | 0 | - | - | - | | |
| - | - | - | 1 | 1 | - | - | - | | |
| - | - | 0 | - | - | - | - | - | No DCO spike rejection ⁽¹⁾ On Off | |
| - | - | 1 | - | - | - | - | - | | |
| x | x | - | - | - | - | - | - | Not used | |

1. The control bit needs sub-address test mode on.

2. The control bit does not depend on test mode.

Table 21. Testing audio processor 3 (21)

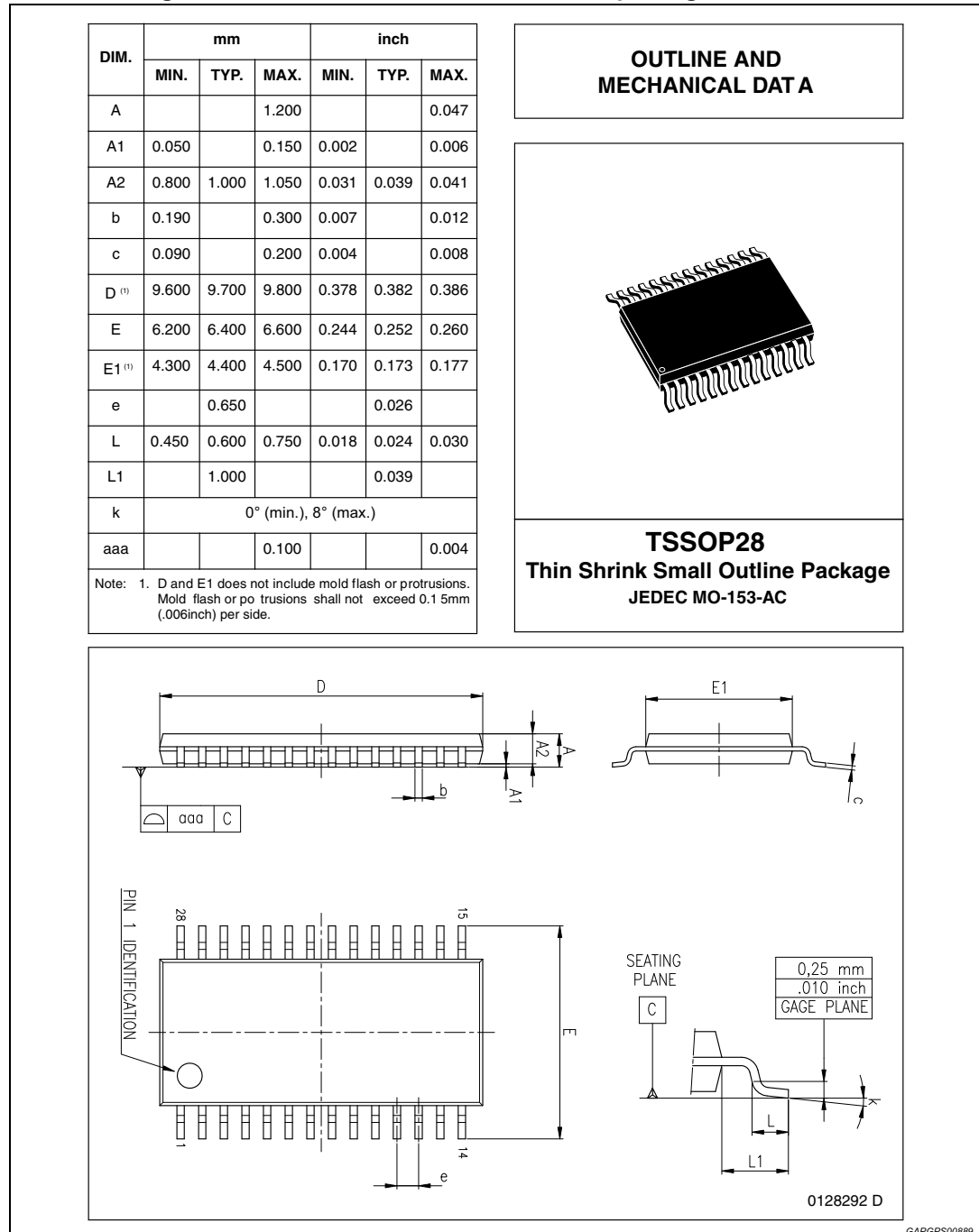
| MSB | | | | | | | LSB | | Function |
|-----|----|----|----|----|----|----|-----|---|----------|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | | |
| - | - | - | - | - | - | - | 0 | Enable clock for FL/FR/RL/RR/SWL/SWR On Off | |
| - | - | - | - | - | - | - | 1 | | |
| - | - | - | - | - | - | 0 | - | Enable clock for volume On Off | |
| - | - | - | - | - | - | 1 | - | | |
| - | - | - | - | - | 0 | - | - | Enable clock for treble and bass On Off | |
| - | - | - | - | - | 1 | - | - | | |
| - | - | - | - | 0 | - | - | - | Enable clock for loudness and middle On Off | |
| - | - | - | - | 1 | - | - | - | | |
| x | x | x | x | - | - | - | - | Not used | |

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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Figure 22. TSSOP28 mechanical data and package dimensions



7 Revision history

Table 22. Document revision history

| Date | Revision | Changes |
|-------------|-----------------|-------------------------|
| 10-Dec-2010 | 1 | Initial release. |
| 26-Feb-2013 | 2 | Added "Note" on page 8. |
| 24-Sep-2013 | 3 | Updated disclaimer. |

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