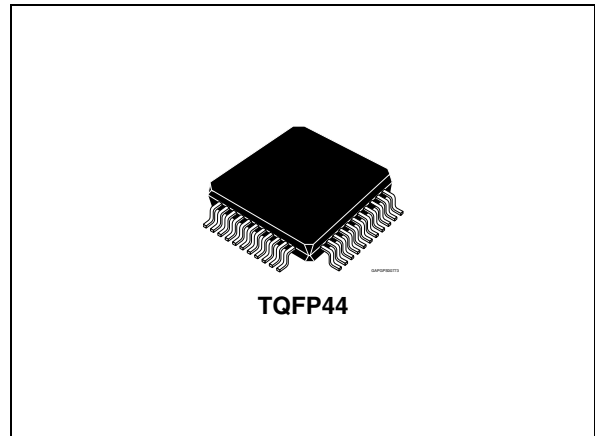


### Features

- 3 stereo inputs
- 1 pseudo differential stereo input
- Volume control
- 7 band equalizer filter control
- High-pass filter for subwoofer application
- Directmute and softmute
- 4 independent speaker outputs
- Soft-step speaker control
- Subwoofer output with soft step
- 7 band spectrum analyzer
- Full mixing capability
- HPF2 with ZeroCross
- I<sup>2</sup>C bus interface



**Table 1. Device summary**

| Order code | Package | Packing |
|------------|---------|---------|
| E-TDA7416  | TQFP44  | Tray    |

### Description

The device includes a high performance audio processor with 7 bands equalizer and spectrum analyzer.

The digital control allows a programming in a wide range of all the filter characteristics.

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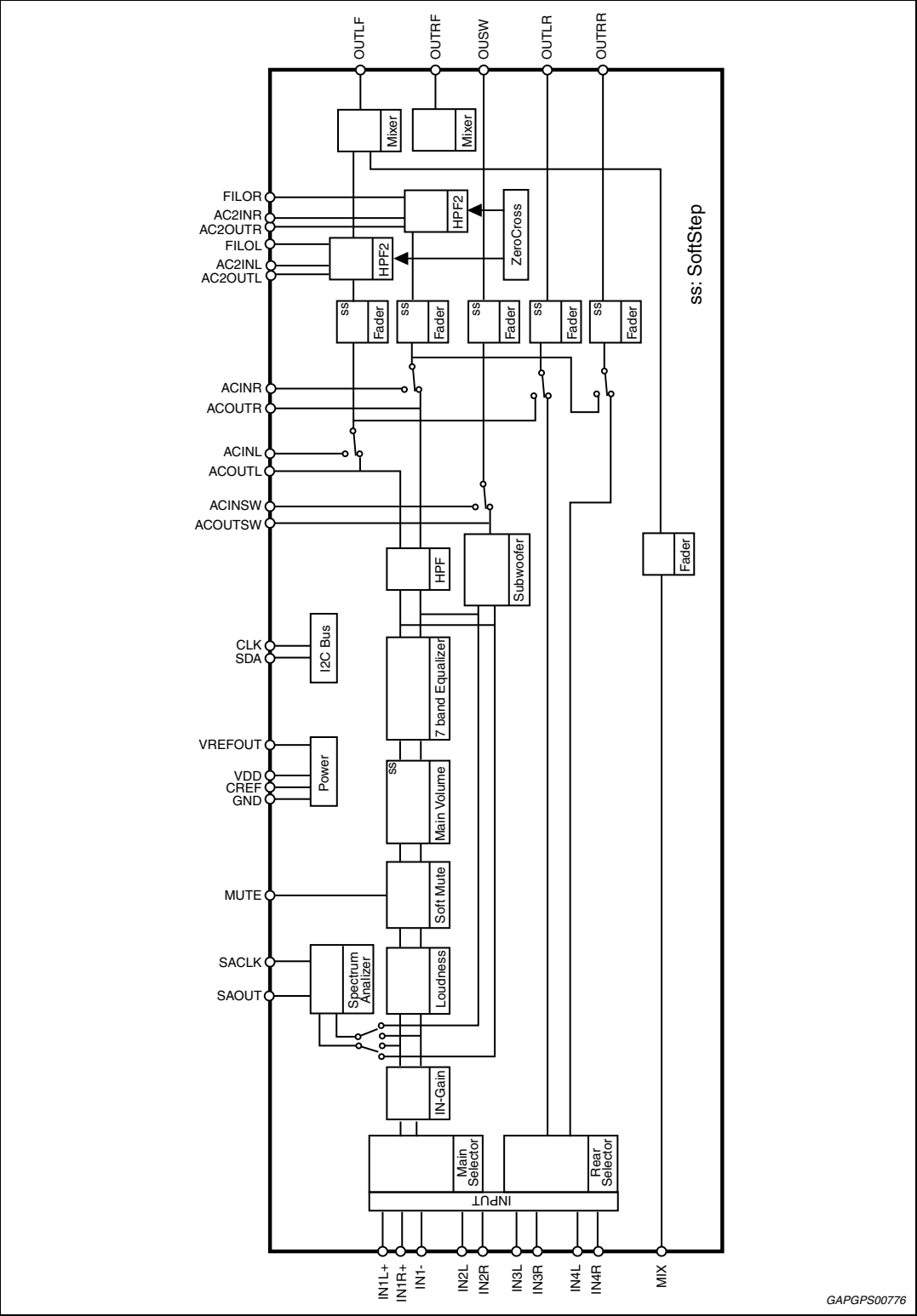
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1 Block diagram

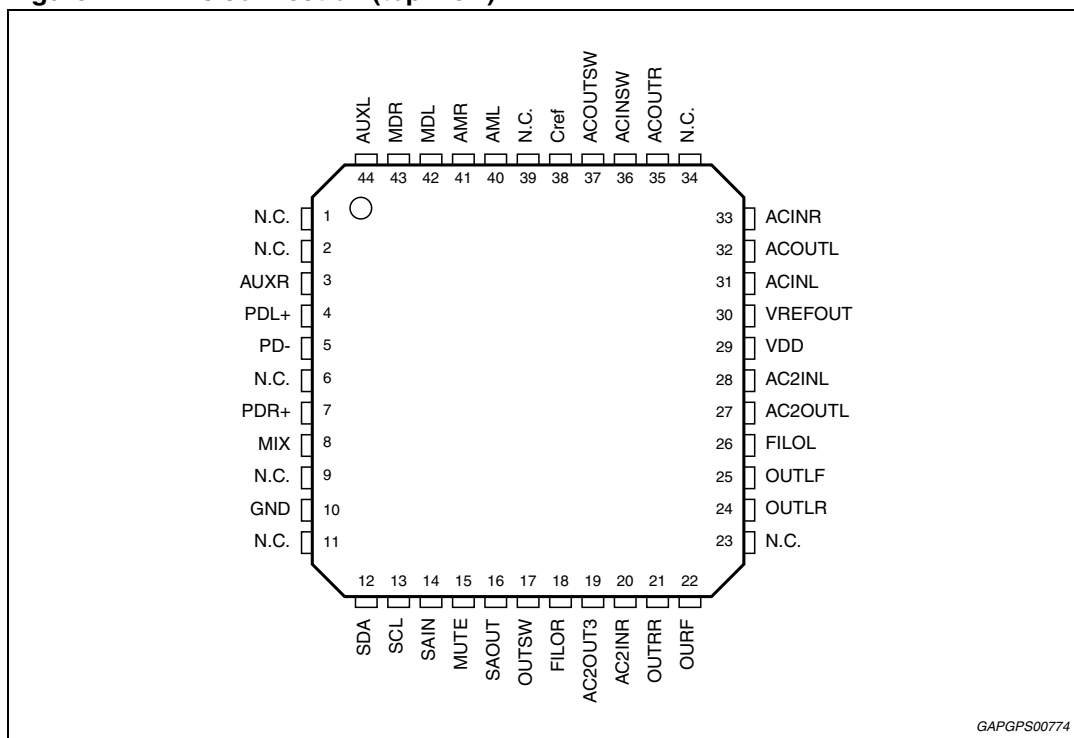
Figure 1. Block diagram



GAPGPS00776

## 2 Pins connection

Figure 2. Pins connection (top view)



## 3 Electrical specifications

### 3.1 Supply

**Table 2. Supply**

| Symbol | Parameter               | Test conditions                    | Min. | Typ. | Max. | Unit |
|--------|-------------------------|------------------------------------|------|------|------|------|
| $V_S$  | Supply voltage          |                                    | 7.5  | 9    | 10   | V    |
| $I_S$  | Supply current          | $V_S = 9\text{ V}$                 | 35   | 45   | 55   | mA   |
| SVRR   | Ripple rejection @ 1kHz | Audio processor (all Filters flat) | -    | 60   | -    | dB   |

### 3.2 Thermal data

**Table 3. Thermal data**

| Symbol           | Description                             | Value | Unit |
|------------------|-----------------------------------------|-------|------|
| $R_{th\ j-pins}$ | Thermal resistance junction-to-pins max | 65    | °C/W |

### 3.3 Absolute maximum ratings

**Table 4. Absolute maximum ratings**

| Symbol    | Parameter                   | Value       | Unit |
|-----------|-----------------------------|-------------|------|
| $V_S$     | Operating supply voltage    | 10.5        | V    |
| $T_{amb}$ | Operating temperature range | -40 to 85   | °C   |
| $T_{stg}$ | Storage temperature range   | -55 to +150 | °C   |

### 3.4 ESD

All pins are protected against ESD according to the MIL883 standard.



### 3.5 Electrical characteristics

$V_S = 9\text{ V}$ ;  $T_{\text{amb}} = 25\text{ °C}$ ;  $R_L = 10\text{ k}\Omega$ ; all gains = 0 dB;  $f = 1\text{ kHz}$ ; unless otherwise specified.

**Table 5. Electrical characteristics**

| Symbol                     | Parameter                               | Test condition                                | Min. | Typ.  | Max. | Unit             |
|----------------------------|-----------------------------------------|-----------------------------------------------|------|-------|------|------------------|
| Input selector             |                                         |                                               |      |       |      |                  |
| R <sub>in</sub>            | Input resistance                        | All single-ended Inputs                       | 70   | 100   | 130  | kΩ               |
| V <sub>CL</sub>            | Clipping level                          | -                                             | 1.8  | 2.2   |      | V <sub>RMS</sub> |
| S <sub>IN</sub>            | Input separation                        | -                                             | 80   | 100   |      | dB               |
| G <sub>IN MIN</sub>        | Min. input gain                         | -                                             | -1   | 0     | 1    | dB               |
| G <sub>IN MAX</sub>        | Max. input gain                         | -                                             | 13   | 15    | 17   | dB               |
| G <sub>STEP</sub>          | Step resolution                         | -                                             | 0.5  | 1     | 1.5  | dB               |
| V <sub>DC</sub>            | DC steps                                | Adjacent gain steps                           | -5   | 1     | 5    | mV               |
|                            |                                         | G <sub>MIN</sub> to G <sub>MAX</sub>          | -10  | 1     | 10   | mV               |
| V <sub>Offset</sub>        | Remaining offset with AutoZero          | -                                             | -    | 0.5   | -    | mV               |
| Differential stereo inputs |                                         |                                               |      |       |      |                  |
| R <sub>in</sub>            | Input resistance (see <i>Figure 3</i> ) | Differential                                  | 70   | 100   | 130  | kΩ               |
| CMRR                       | Common mode rejection ratio             | V <sub>CM</sub> = 1 V <sub>RMS</sub> @ 1 kHz  | 46   | 70    | -    | dB               |
|                            |                                         | V <sub>CM</sub> = 1 V <sub>RMS</sub> @ 10 kHz | 46   | 60    | -    | dB               |
| e <sub>NO</sub>            | Output-noise @ speaker-outputs          | 20Hz - 20kHz, flat; all stages 0dB            | -    | 11    | -    | μV               |
| Mixing control             |                                         |                                               |      |       |      |                  |
| M <sub>LEVEL</sub>         | Mixing ratio                            | Main / mix-source                             | -    | -6/-6 | -    | dB               |
| G <sub>MAX</sub>           | Max. gain                               | -                                             | 13   | 15    | 17   | dB               |
| A <sub>MAX</sub>           | Max. attenuation                        | -                                             | -83  | -79   | -75  | dB               |
| A <sub>STEP</sub>          | Attenuation step                        | -                                             | 0.5  | 1     | 1.5  | dB               |
| Loudness control           |                                         |                                               |      |       |      |                  |
| A <sub>STEP</sub>          | Step resolution                         | -                                             | 0.5  | 1     | 1.5  | dB               |
| A <sub>MAX</sub>           | Max. attenuation                        | -                                             | -21  | -19   | -17  | dB               |
| f <sub>Peak</sub>          | Peak frequency                          | f <sub>P1</sub>                               | 180  | 200   | 220  | Hz               |
|                            |                                         | f <sub>P2</sub>                               | 360  | 400   | 440  | Hz               |
|                            |                                         | f <sub>P3</sub>                               | 540  | 600   | 660  | Hz               |
|                            |                                         | f <sub>P4</sub>                               | 720  | 800   | 880  | Hz               |
| Volume control             |                                         |                                               |      |       |      |                  |
| G <sub>MAX</sub>           | Max. gain                               | -                                             | 18   | 20    | 22   | dB               |
| A <sub>MAX</sub>           | Max. attenuation                        | -                                             | -83  | -79   | -75  | dB               |
| A <sub>STEP</sub>          | Step resolution                         | -                                             | 0    | 0.5   | 1    | dB               |

Table 5. Electrical characteristics (continued)

| Symbol               | Parameter                              | Test condition               | Min.  | Typ. | Max.  | Unit |
|----------------------|----------------------------------------|------------------------------|-------|------|-------|------|
| E <sub>A</sub>       | Attenuation set error                  | G = -20 to +20 dB            | -0.75 | 0    | +0.75 | dB   |
|                      |                                        | G = -80 to -20 dB            | -4    | 0    | 3     | dB   |
| E <sub>T</sub>       | Tracking error                         | -                            | -     | -    | 2     | dB   |
| V <sub>DC</sub>      | DC steps                               | Adjacent attenuation steps   | -     | 0.1  | 3     | mV   |
|                      |                                        | From 0dB to G <sub>MIN</sub> | -     | 0.5  | 5     | mV   |
| Soft-mute            |                                        |                              |       |      |       |      |
| A <sub>MUTE</sub>    | Mute attenuation                       | -                            | 80    | 100  | -     | dB   |
| T <sub>D</sub>       | Delay time                             | T1                           | -     | 0.48 | 1     | ms   |
|                      |                                        | T2                           | -     | 0.96 | 2     | ms   |
|                      |                                        | T3                           | 70    | 123  | 170   | ms   |
| V <sub>TH low</sub>  | Low threshold for SM-Pin <sup>1)</sup> | -                            | -     | -    | 1     | V    |
| V <sub>TH high</sub> | High threshold for SM - Pin            | -                            | 2.5   | -    | -     | V    |
| R <sub>PU</sub>      | Internal pull-up resistor              | -                            | 32    | 45   | 58    | kΩ   |
| V <sub>PU</sub>      | Internal pull-up Voltage               | -                            | -     | 3.3  | -     | V    |
| Equalizer control    |                                        |                              |       |      |       |      |
| C <sub>RANGE</sub>   | Control range                          | -                            | ±14   | ±15  | ±16   | dB   |
| A <sub>STEP</sub>    | Step resolution                        | -                            | 0.5   | 1    | 1.5   | dB   |
| f <sub>C1</sub>      | Center frequency band 1                | f <sub>C1a</sub>             | 55    | 62   | 69    | Hz   |
|                      |                                        | f <sub>C1b</sub>             | 90    | 100  | 110   | Hz   |
| f <sub>C2</sub>      | Center frequency band 2                | f <sub>C2</sub>              | 141   | 157  | 173   | Hz   |
| f <sub>C3</sub>      | Center frequency band 3                | f <sub>C3</sub>              | 365   | 396  | 437   | Hz   |
| f <sub>C4</sub>      | Center frequency band 4                | f <sub>C4</sub>              | 0.9   | 1    | 1.1   | kHz  |
| f <sub>C5</sub>      | Center frequency band 5                | f <sub>C5</sub>              | 2.25  | 2.51 | 2.76  | kHz  |
| f <sub>C6</sub>      | Center frequency band 6                | f <sub>C6a</sub>             | 3.6   | 4    | 4.4   | kHz  |
|                      |                                        | f <sub>C6b</sub>             | 5.70  | 6.34 | 6.98  | kHz  |
| f <sub>C7</sub>      | Center frequency band 7                | f <sub>C7a</sub>             | 13.5  | 15   | 16.5  | kHz  |
|                      |                                        | f <sub>C7b</sub>             | 14.4  | 16   | 17.6  | kHz  |
| Q                    | Quality factor                         | Q <sub>1</sub>               | 0.9   | 1    | 1.1   |      |
|                      |                                        | Q <sub>2</sub>               | 1.26  | 1.4  | 1.54  |      |
|                      |                                        | Q <sub>3</sub>               | 1.62  | 1.8  | 1.98  |      |
|                      |                                        | Q <sub>4</sub>               | 1.98  | 2.2  | 2.44  |      |
| DC <sub>GAIN</sub>   | DC-gain, Band 1                        | DC = off                     | -1    | 0    | +1    | dB   |
|                      |                                        | DC = on, 15dB boost          |       | 4    |       | dB   |

Table 5. Electrical characteristics (continued)

| Symbol                           | Parameter                     | Test condition             | Min. | Typ.     | Max. | Unit      |
|----------------------------------|-------------------------------|----------------------------|------|----------|------|-----------|
| <b>Spectrum analyzer control</b> |                               |                            |      |          |      |           |
| $V_{SAOut}$                      | Output voltage range          | -                          | 0    |          | 3.3  | V         |
| $f_{C1}$                         | Center frequency band 1       | $f_{C1}$                   | 55   | 62       | 69   | Hz        |
| $f_{C2}$                         | Center frequency band 2       | $f_{C2}$                   | 141  | 157      | 173  | Hz        |
| $f_{C3}$                         | Center frequency band 3       | $f_{C3}$                   | 356  | 396      | 436  | Hz        |
| $f_{C4}$                         | Center frequency band 4       | $f_{C4}$                   | 0.9  | 1        | 1.1  | kHz       |
| $f_{C5}$                         | Center frequency band 5       | $f_{C5}$                   | 2.26 | 2.51     | 2.76 | kHz       |
| $f_{C6}$                         | Center frequency band 6       | $f_{C6}$                   | 5.70 | 6.34     | 6.98 | kHz       |
| $f_{C7}$                         | Center frequency band 7       | $f_{C7}$                   | 14.4 | 16       | 17.6 | kHz       |
| Q                                | Quality factor                | $Q_1$                      | 1.62 | 1.8      | 1.98 |           |
|                                  |                               | $Q_2$                      | 3.15 | 3.5      | 3.85 |           |
| $f_{SAClk}$                      | Clock frequency               | -                          | 1    | -        | 100  | kHz       |
| $t_{SAdel}$                      | Analog output delay time      | -                          | 2    | -        | -    | $\mu$ s   |
| $t_{repeat}$                     | Spectrum analyzer repeat time | -                          | 50   | -        | -    | ms        |
| $t_{intres}$                     | Internal reset time           | -                          | -    | 3        | -    | ms        |
| <b>HPF2</b>                      |                               |                            |      |          |      |           |
| $V_{TH}$                         | Zero crossing threshold       | -                          | -    | $\pm 20$ | -    | mV        |
| $E_{MAX}$                        | Max. effect                   | -                          | -    | 22       | -    | dB        |
| $E_{MIN}$                        | Min. effect                   | -                          | -    | 4        | -    | dB        |
| $E_{STEP}$                       | Step resolution               | -                          | 1.5  | 2        | 2.5  | dB        |
| <b>Speaker attenuators</b>       |                               |                            |      |          |      |           |
| $R_{in}$                         | Input Impedance               | -                          | 35   | 50       | 65   | $k\Omega$ |
| $G_{MAX}$                        | Max. gain                     | -                          | 13   | 15       | 17   | dB        |
| $A_{MAX}$                        | Max. attenuation              | -                          | -83  | -79      | -75  | dB        |
| $A_{STEP}$                       | Step resolution               | -                          | 0.5  | 1        | 1.5  | dB        |
| $A_{MUTE}$                       | Output mute attenuation       | -                          | 80   | 90       | -    | dB        |
| $E_E$                            | Attenuation set error         | -                          | -    | -        | 3    | dB        |
| $V_{DC}$                         | DC steps                      | Adjacent Attenuation Steps | -    | 0.5      | 5    | mV        |
| $M_R$                            | Mixing ratio                  | Signal/Mix <sub>IN</sub>   | -    | 50/50    | -    | %         |
| <b>Audio outputs</b>             |                               |                            |      |          |      |           |
| $V_{CLIP}$                       | Clipping level                | Thd=0.3%                   | 1.8  | 2.2      | -    | $V_{RMS}$ |
| $R_L$                            | Output load resistance        | -                          | 2    | -        | -    | $k\Omega$ |
| $C_L$                            | Output load capacitance       | -                          | -    | -        | 10   | nF        |
| $R_{OUT}$                        | Output impedance              | -                          | -    | 30       | 120  | W         |

Table 5. Electrical characteristics (continued)

| Symbol               | Parameter                     | Test condition                                                                     | Min. | Typ. | Max. | Unit     |
|----------------------|-------------------------------|------------------------------------------------------------------------------------|------|------|------|----------|
| V <sub>DC</sub>      | DC voltage level              | -                                                                                  | 4.3  | 4.5  | 4.7  | V        |
| High-pass            |                               |                                                                                    |      |      |      |          |
| f <sub>HP</sub>      | High-pass corner frequency    | f <sub>HP1</sub>                                                                   | 81   | 90   | 99   | Hz       |
|                      |                               | f <sub>HP2</sub>                                                                   | 122  | 135  | 148  | Hz       |
|                      |                               | f <sub>HP3</sub>                                                                   | 162  | 180  | 198  | Hz       |
|                      |                               | f <sub>HP4</sub>                                                                   | 194  | 215  | 236  | Hz       |
| Subwoofer attenuator |                               |                                                                                    |      |      |      |          |
| R <sub>in</sub>      | Input impedance               | -                                                                                  | 35   | 50   | 65   | kΩ       |
| G <sub>MAX</sub>     | Max. gain                     | -                                                                                  | 14   | 15   | 16   | dB       |
| A <sub>ATTN</sub>    | Max. attenuation              | -                                                                                  | -83  | -79  | -75  | dB       |
| A <sub>STEP</sub>    | Step resolution               | -                                                                                  | 0.5  | 1    | 1.5  | dB       |
| A <sub>MUTE</sub>    | Output mute attenuation       | -                                                                                  | 80   | 90   | -    | dB       |
| E <sub>E</sub>       | Attenuation set error         |                                                                                    | -    | -    | 2    | dB       |
| V <sub>DC</sub>      | DC steps                      | Adjacent Attenuation Steps                                                         | -    | 1    | 5    | mV       |
| Subwoofer low-pass   |                               |                                                                                    |      |      |      |          |
| f <sub>LP</sub>      | Low-pass corner frequency     | f <sub>LP1</sub>                                                                   | 72   | 80   | 88   | Hz       |
|                      |                               | f <sub>LP2</sub>                                                                   | 108  | 120  | 132  | Hz       |
|                      |                               | f <sub>LP3</sub>                                                                   | 144  | 160  | 176  | Hz       |
| General              |                               |                                                                                    |      |      |      |          |
| e <sub>NO</sub>      | Output noise                  | BW = 20 Hz - 20 kHz<br>output muted                                                | -    | 3    | 15   | μV       |
|                      |                               | BW = 20 Hz - 20 kHz<br>all gains = 0dB<br>single-ended inputs                      | -    | 15   | 20   | μV<br>μV |
| S/N                  | Signal-to-noise ratio         | all gains = 0 dB<br>flat; V <sub>O</sub> = 2 V <sub>RMS</sub>                      | -    | 103  | -    | dB       |
|                      |                               | All EQ-bands at +12dB; Q = 1.0<br>a-weighted; V <sub>O</sub> = 2.6V <sub>RMS</sub> | -    | 87   | -    | dB       |
| d                    | Distortion                    | V <sub>IN</sub> = 1V <sub>RMS</sub> ; all stages 0dB                               | -    | 0.01 | 0.1  | %        |
|                      |                               | V <sub>OUT</sub> = 1V <sub>RMS</sub> ;<br>Bass & treble = 12dB                     | -    | 0.05 | 0.1  | %        |
| S <sub>C</sub>       | Channel separation left/right | -                                                                                  | 80   | 90   | -    | dB       |

## 4 Description of the audio processor part

### 4.1 Audio processor features

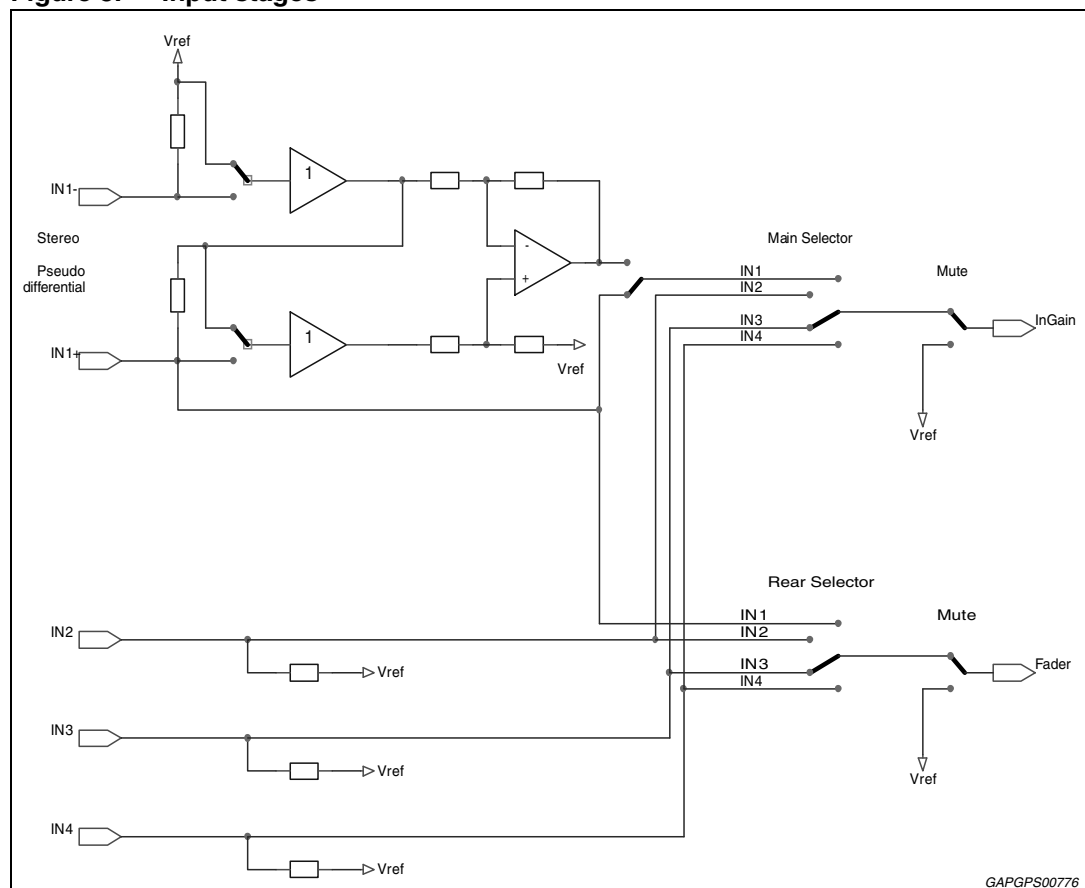
- Input multiplexer
  - 1 pseudo differential CDC stereo input, programmable as single-ended input
  - 3 single-ended stereo inputs
  - Input gain adjust 0 to 15 dB with 1 dB steps
  - direct mute
  - internal offset-cancellation (AutoZero)
- Mixing stage
  - mixable mix input to Front speaker outputs
  - Input controls +15 to -79 dB with 1 dB steps
  - direct mute
  - Loudness
  - programmable center frequency and filter slope
  - 19 dB with 1dB steps
  - selectable flat-mode (constant attenuation)
- Volume
  - +32 to -79.5 dB with 0.5 dB step resolution
  - soft-step control with programmable blend times
  - 100 dB range
- Equalizer
  - seven bands
  - 2<sup>nd</sup> order frequency response
  - center frequency programmable for lowest and highest filter
  - programmable quality factor in four steps for each filter
  - -15 to 15 dB range with 1dB resolution
- Spectrum analyzer
  - seven bandpass filters
  - 2<sup>nd</sup> order frequency response
  - programmable quality factor for different visual appearance
  - analog output
  - controlled by external serial clock
- High-pass
  - 2<sup>nd</sup> order butterworth high-pass with programmable cut-off frequency
  - selectable flat-mode
- Speaker
  - 4 independent soft-step speaker controls, +15 to -79 dB with 1 dB steps
  - mute
  - 4 independent programmable mix inputs with 50% mixing ratio
- Subwoofer

- single-ended monaural output
  - independent soft-step level control +15 to -79 dB with 1 dB steps
- Mute functions**
- direct mute
  - digitally controlled Soft-mute with 3 programmable mute-times
  - Effect
    - Gain effect or high-pass effect fixed external components

## 4.2 Input stages

In the basic configuration one pseudo-differential, three single-ended stereo are available.

**Figure 3. Input stages**



### 4.2.1 Pseudo-differential stereo input (IN1)

The IN1- input is implemented as a buffered pseudo-differential stereo stage with 100 k $\Omega$  input-impedance at each input pin. This input is also configurable as single-ended stereo input. The common input-pin, IN1- features a fast charge switch to speed up the charge time of external capacitors. This switch is released the first time the input-selector data-byte (0) is accessed.

### 4.2.2 Single-ended stereo inputs

All single-ended inputs have an input impedance of 100 k $\Omega$ .

## 4.3 AutoZero

The AutoZero allows a reduction of the number of pins as well as external components by canceling any offset generated by or before the In-Gain-stage (Please notice that externally generated offsets, e.g. generated through the leakage current of the coupling capacitors, are not canceled).

The auto-zeroing is started every time the DATA-BYTE 0 is selected and needs max. 0.3 ms for the alignment. To avoid audible clicks the Audioprocessor have to be muted by soft-mute or hard-mute during this time.

### 4.3.1 AutoZero remain

In some cases, for example if the  $\mu$ P is executing a refresh cycle of the IIC-Bus-programming, it is not useful to start a new AutoZero action because no new source is selected and an undesired mute would appear at the out-puts. For such applications the TDA7416 could be switched in the AutoZero remain-mode (Bit 6(11) of the subaddress-byte). If this bit is set to high, the DATABYTE 0 could be loaded without invoking the AutoZero and the old adjustment-value remains.

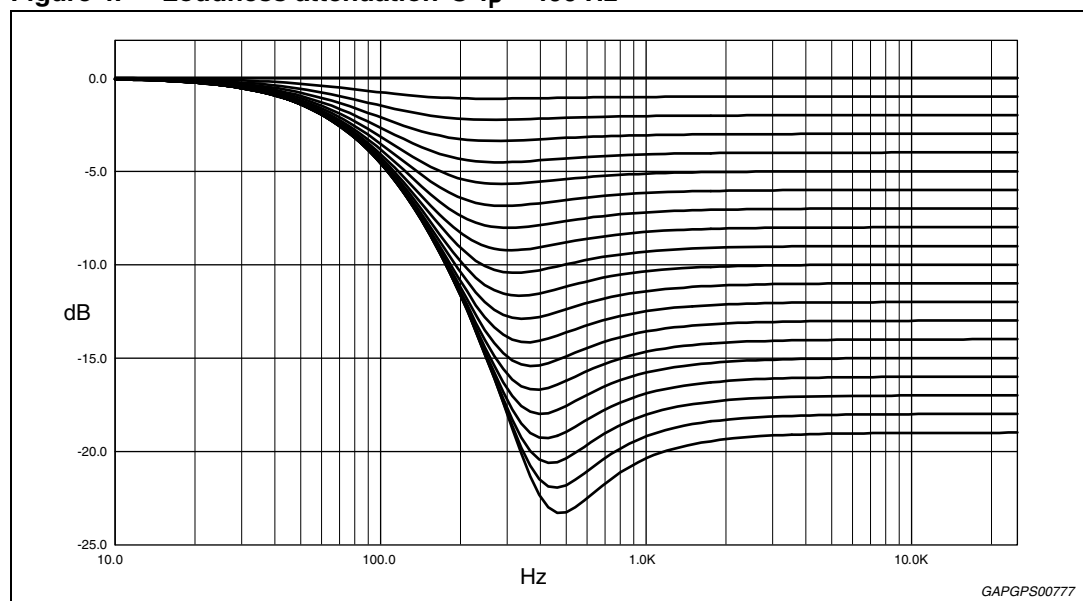
## 4.4 Loudness

There are four parameters programmable in the loudness stage.

### 4.4.1 Attenuation

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

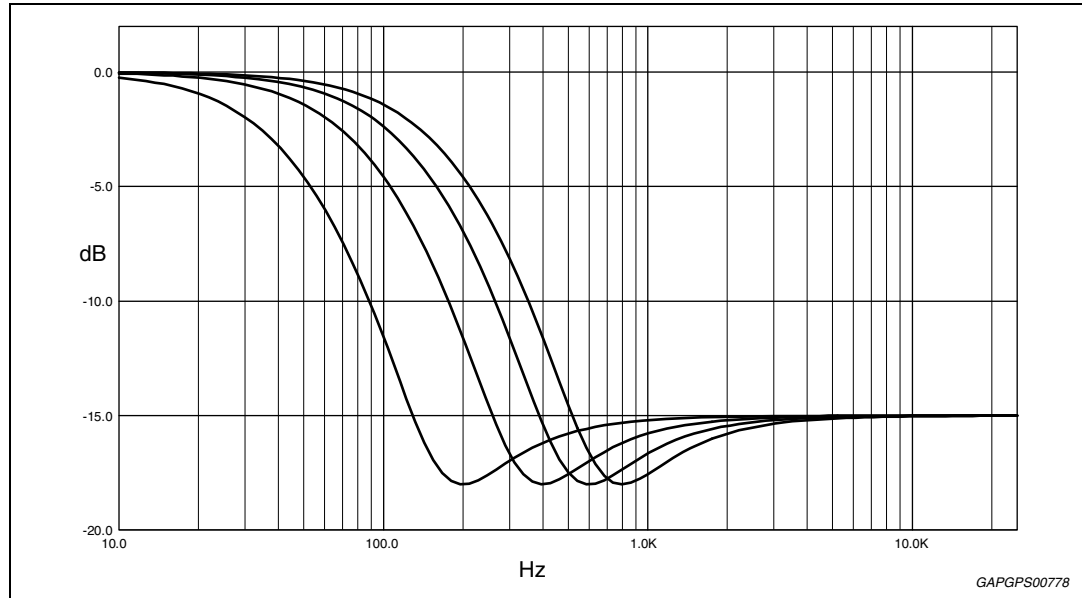
**Figure 4. Loudness attenuation @  $f_p = 400$  Hz**



#### 4.4.2 Peak frequency

*Figure 5* shows the four possible peak-frequencies at 200, 400, 600 and 800Hz

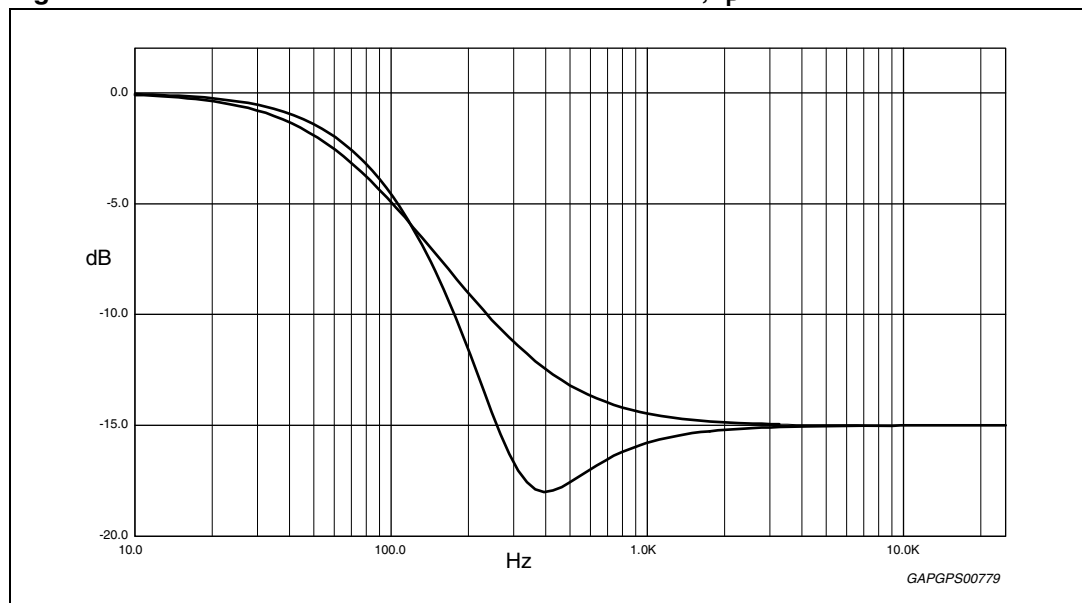
**Figure 5. Loudness center frequencies @ Attn. = 15 dB**



#### 4.4.3 Loudness filter order

Different shapes of 1<sup>st</sup> and 2<sup>nd</sup>-order loudness

**Figure 6. 1<sup>st</sup> and 2<sup>nd</sup> order loudness @ Attn. = 15 dB,  $f_p = 400$  Hz**



#### 4.4.4 Flat mode

In flat mode the loudness stage works as a 0dB to -19dB attenuator.

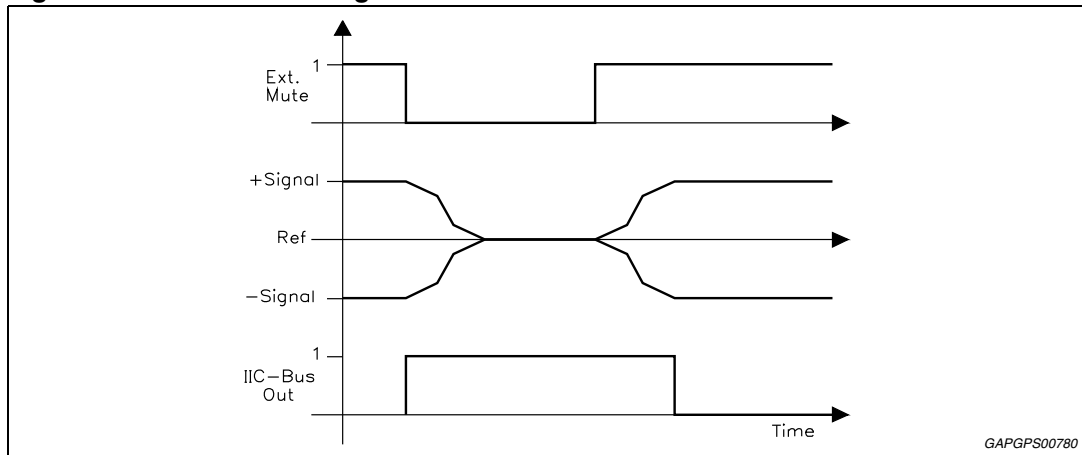


## 4.5 Soft-mute

The digitally controlled soft-mute stage allows muting/demuting the signal with a I<sup>2</sup>C bus programmable slope. The mute process can either be activated by the soft-mute pin or by the I<sup>2</sup>C 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 Bit0 of the I<sup>2</sup>C bus output register is set to 1 from the start of muting until the end of de-muting.

**Figure 7. Soft-mute timing**

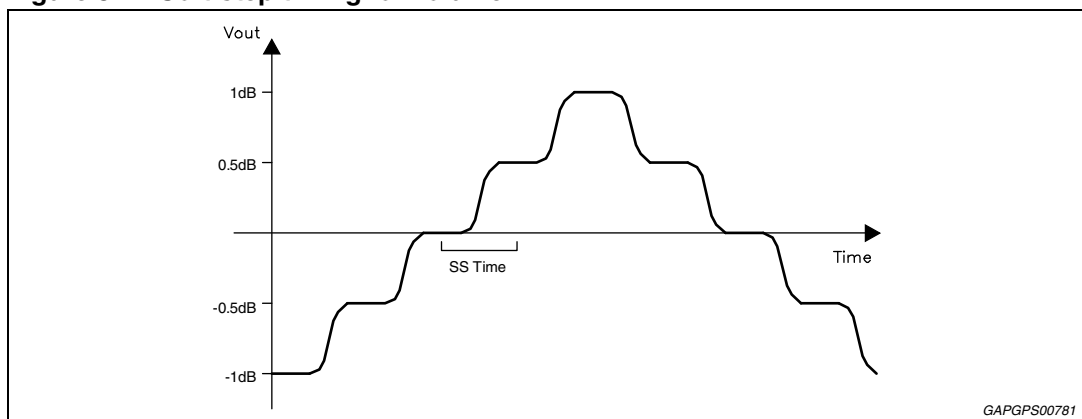


1. Please notice that a started Mute-action is always terminated and could not be interrupted by a change of the mute -signal.

## 4.6 Soft-step volume and speaker

When the speaker-level is changed audible clicks could appear at the output. The root cause of those clicks could either be a DC-Offset before the speaker-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 in four steps.

**Figure 8. Soft-step timing for volume**



1. For steps more than 0.5dB (Volume) or 1dB (Speaker) the soft-step mode should be deactivated because it could generate a hard 1dB step during blending.

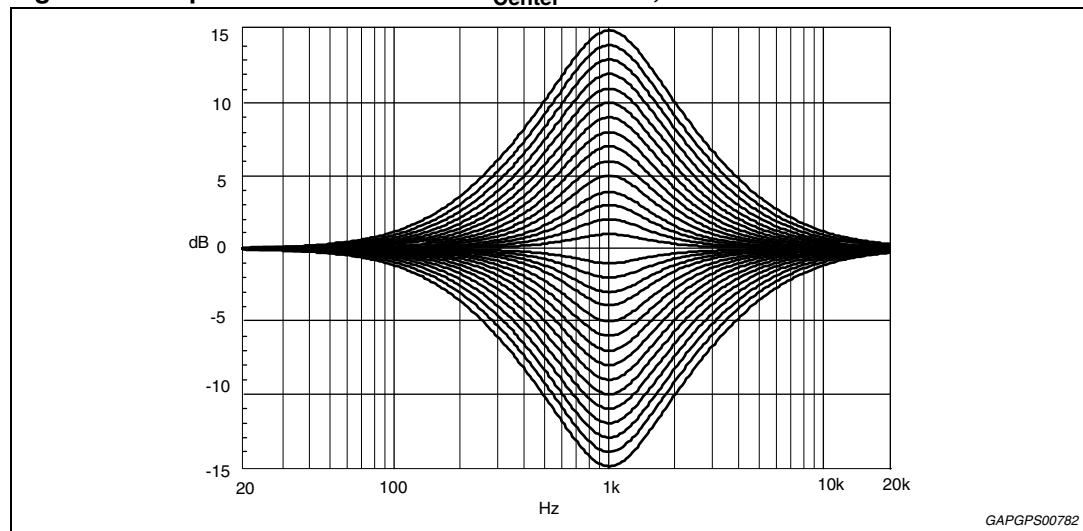
## 4.7 Equalizer filter

There are three parameters programmable in the equalizer filter:

### 4.7.1 Attenuation

*Figure 9* shows the boost and cut response as a function of frequency at a center frequency of 1kHz.

**Figure 9. Equalizer filter control @  $f_{\text{Center}} = 1\text{kHz}$ ,  $Q = 1.0$**

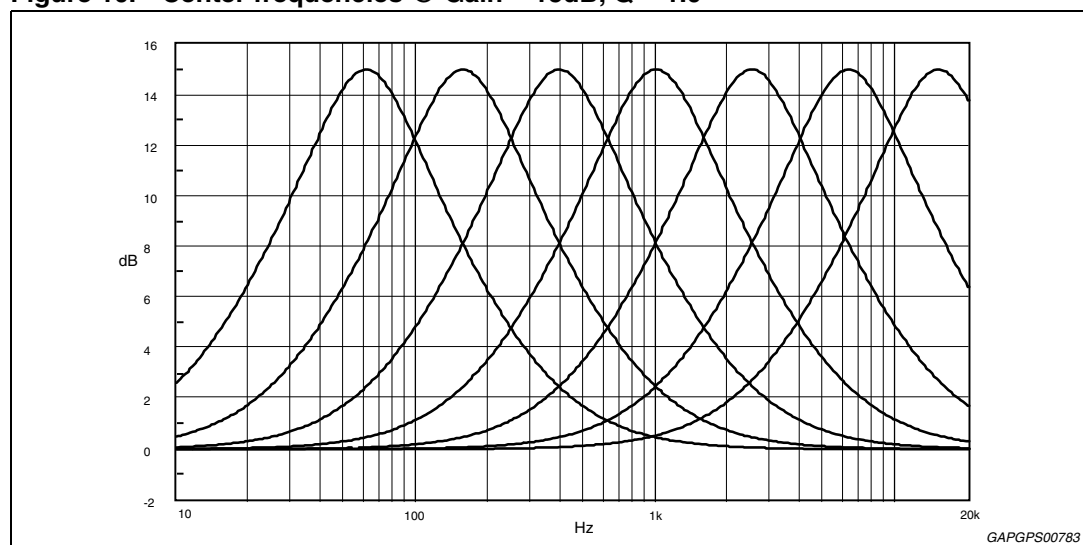


### 4.7.2 Center frequency

This parameter is programmable in the filter stage 1(62/100Hz), 6(4/6.34kHz) and 7(15/16kHz) only.

*Figure 10* shows the center frequencies 62, 156, 396, 1000, 2510, 6340 and 15000 Hz of the 7 equalizer filters.

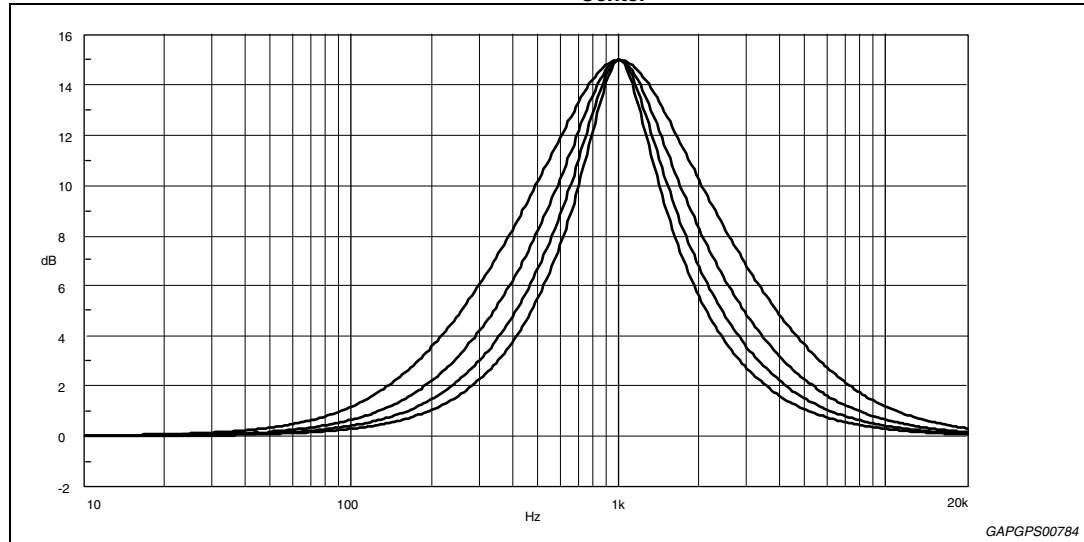
**Figure 10. Center frequencies @ Gain = 15dB,  $Q = 1.0$**



### 4.7.3 Quality Factors

*Figure 11* shows the four possible quality factors 1, 1.4, 1.8 and 2.2

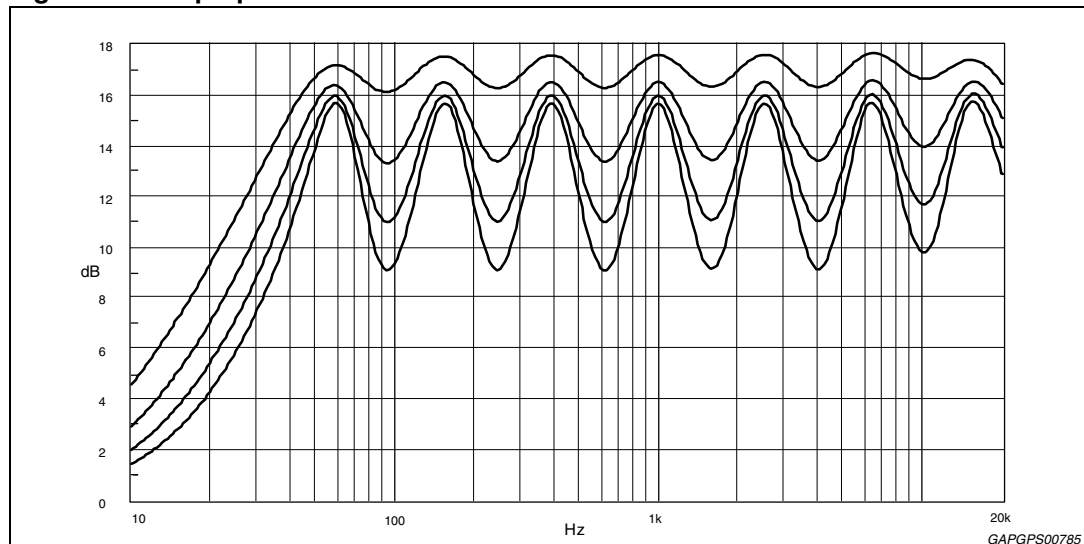
**Figure 11. Quality factors @ boost = 15dB,  $f_{\text{Center}} = 1\text{kHz}$**



### 4.7.4 Superposition of all equalizer filters

*Figure 12* shows the superposition of all equalizer filter curves for different quality factors. The gain for all filters is +15dB.

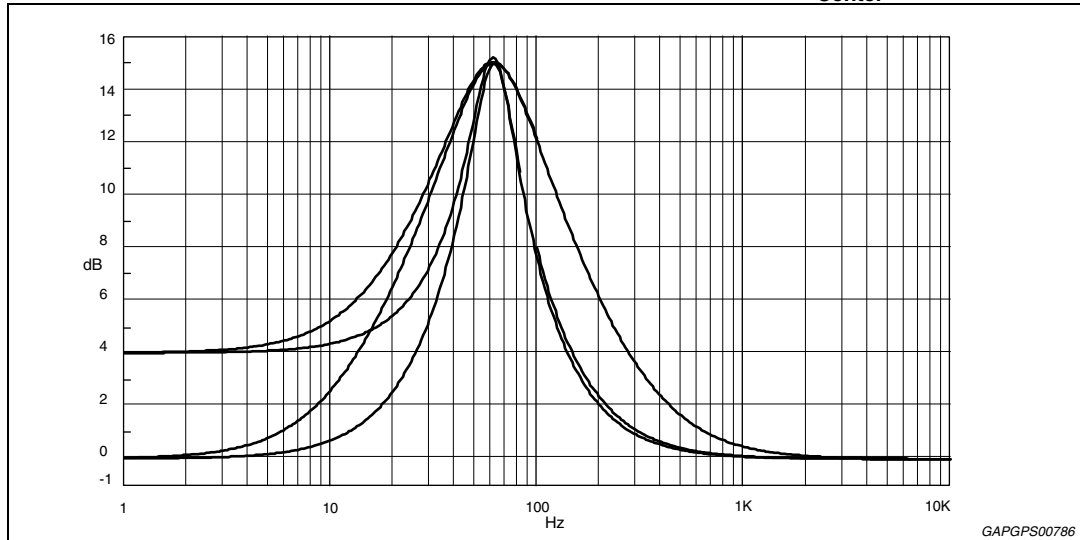
**Figure 12. Superposition of all EQ bands @ boost = 15dB**



#### 4.7.5 DC-mode of equalizer band 1 (62/100 Hz)

In this mode, the DC-gain 4dB when set to 15dB boost.

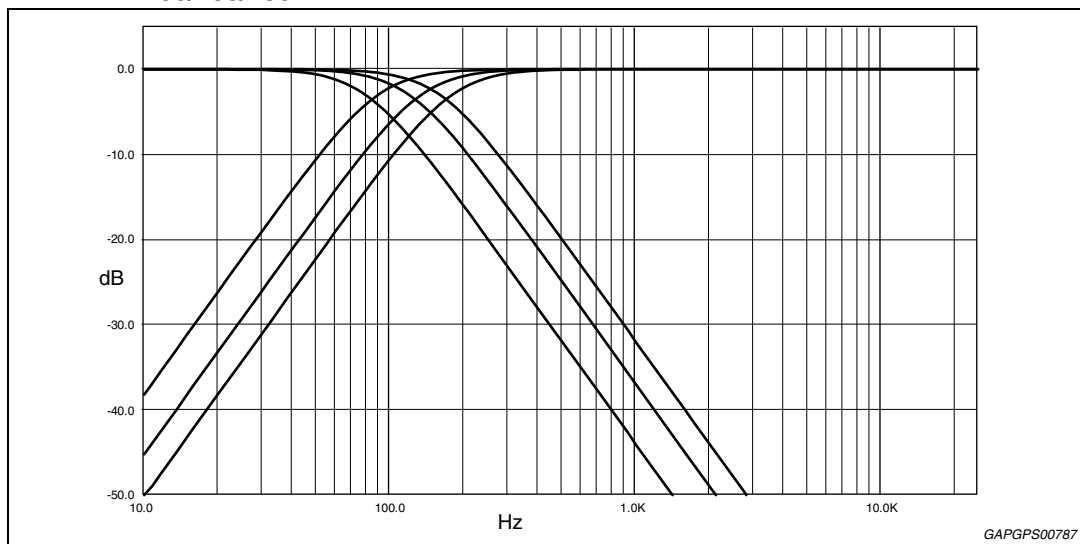
**Figure 13. EQ band1, normal- and DC-mode @ boost = 15 dB,  $f_{\text{Center}} = 62 \text{ Hz}$**



1. The center frequency, Q, DC-mode and boost/cut can be set fully independently for each filter.

#### 4.8 Subwoofer application

**Figure 14. Subwoofer application with low-pass @ 80/120/160Hz and high-pass @ 90/135/180Hz**



Both filters, the low-pass as well as the high-pass filter, have butterworth characteristic so that their cut-off frequencies are not equal but shifted by the factor 1.125 to get a flat frequency response.

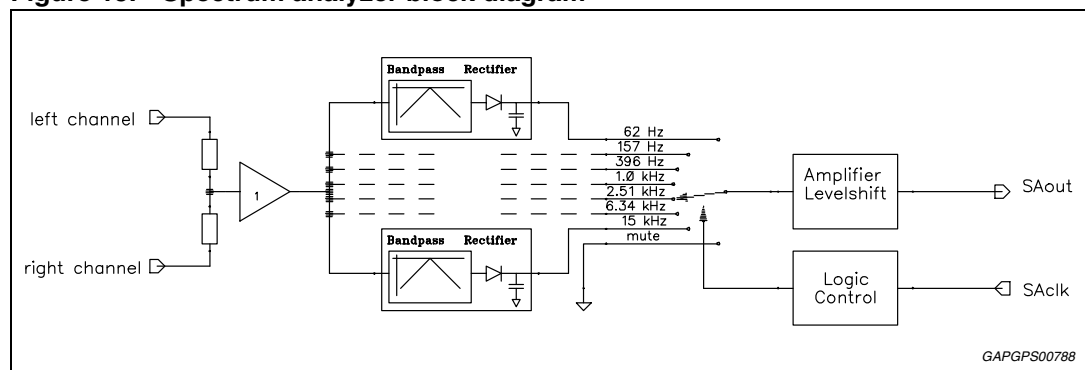
## 4.9 Spectrum analyzer

A fully integrated seven band spectrum analyzer with programmable quality factor is present in the TDA7416 ([Figure 15](#)).

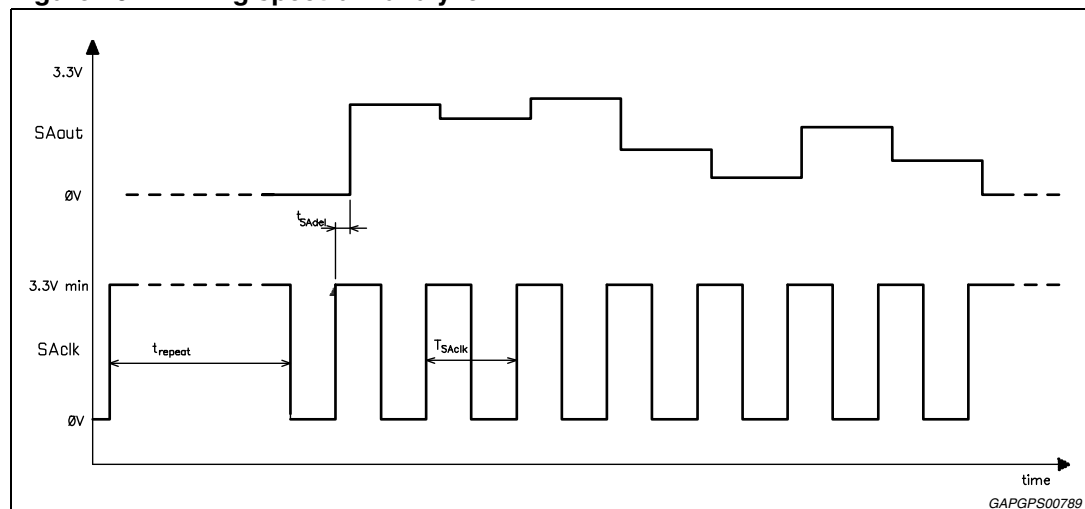
The spectrum analyzer consists of seven band pass filters with rectifier and sample capacitor which stores the maximum peak signal level since the last read cycle. This peak signal level can be read by a microprocessor at the SAout-pin. To allow easy interfacing to an analog port of the microprocessor, the output voltage at this pin is referred to device ground.

The microprocessor starts a read cycle with the negative going clock edge at the SAclock input. On the following positive clock edges, the peak signal level for the band pass filters is subsequently switched to SAout. Each analog output data is valid after the time  $t_{SA\text{del}}$ . A reset of the sample capacitors is induced whenever SAclock remains high for the time  $t_{\text{intres}}$ . Note that a proper reset requires the clock signal SAclock to be held at high potential. [Figure 15](#) shows the block diagram and [Figure 16](#) illustrates the read cycle timing of the spectrum analyzer.

**Figure 15. Spectrum analyzer block diagram**



**Figure 16. Timing spectrum analyzer**



## 4.10 AC coupling

In some applications additional signal manipulations are desired. For this purpose an AC-coupling is placed before the speaker (fader)-attenuators, which can be activated or internally shorted by I<sup>2</sup>C bus. In short condition the input-signal of the speaker-attenuator is available at the AC-outputs. The input-impedance of this AC-inputs is 50k. In addition there are Mix inputs available. With this inputs it is possible to mix an external signal to every speaker with a mixing ratio of 50% (see [Figure 16](#)).

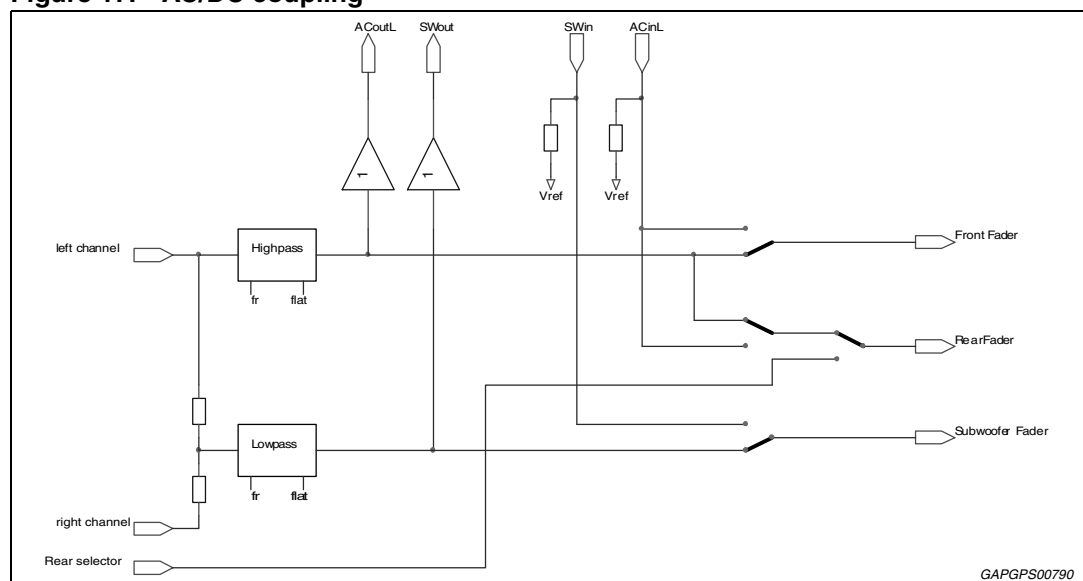
The source of front and rear speaker can be set independently.

As source is choosable:

internal dc coupling (not recommended)

external ac coupling using ACin pins

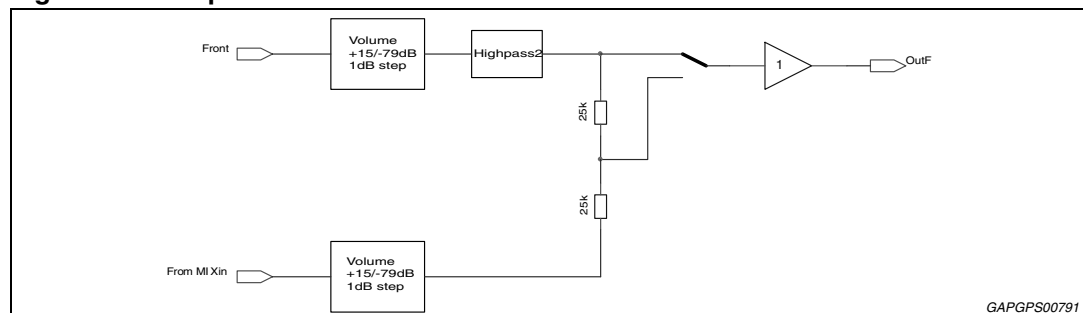
**Figure 17. AC/DC coupling**



## 4.11 Front speaker attenuator and mixing

A Mixing-stage is placed after front speaker-attenuator and can be set independently to mixing-mode. Having a full volume for the Mix-signal the stage offers a wide flexibility to adapt the mixing levels.

**Figure 18. Output selector**

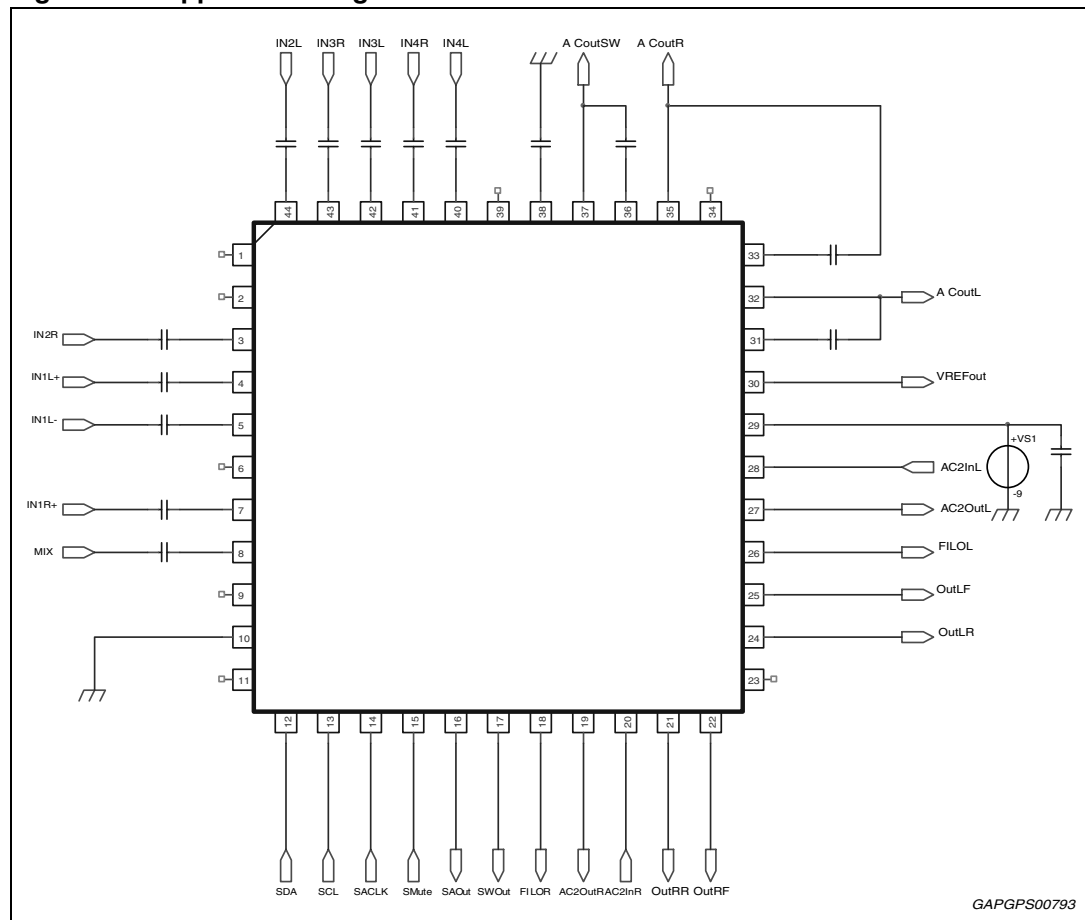


## 4.12 Audio processor testing

During the test mode, which can be activated by setting bit  $I_2$  of the subaddress byte and  $D_0$  of the audioprocessor testing byte, several internal signals are available at the Mix pin. During this mode the input resistance of 100 kOhm is disconnected from the pin. The internal signals available are shown in the Data-byte specification.

## 4.13 Application diagram

Figure 19. Application diagram



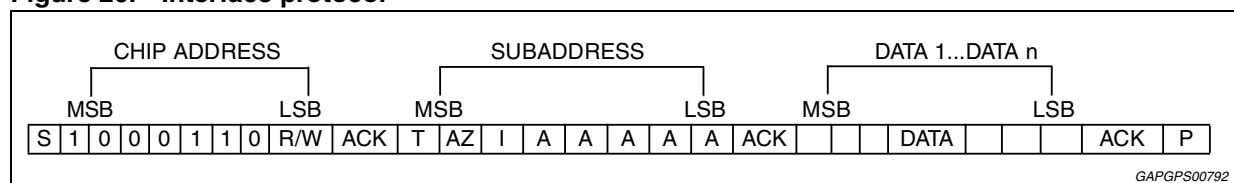
## 5 I<sup>2</sup>C bus interface

### 5.1 Interface protocol

The interface protocol comprises:

- a start condition (S)
- a chip address byte (the LSB bit determines read / write transmission)
- a subaddress byte
- a sequence of data (N-bytes + acknowledge)
- a stop condition (P)

**Figure 20. Interface protocol**



S = Start

R/W = "0" -> Receive-Mode (Chip could be programmed by  $\mu$ P)

"1" -> Transmission-Mode (Data could be received by  $\mu$ P)

ACK = Acknowledge

P = Stop

Max clock speed 500kbits/s

#### 5.1.1 Auto increment

If bit I in the subaddress byte is set to "1", the auto increment of the subaddress is enabled.

#### 5.1.2 Transmitted data (send mode)

| MSB |   |   |   |   |   |   | LSB |
|-----|---|---|---|---|---|---|-----|
| X   | X | X | X | X | X | X | SM  |

SM = Soft-mute activated

X = Not Used

The transmitted data is automatically 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 3.5V. After that, the following data is written automatically into the registers of all subaddresses:

| MSB |   |   |   |   |   |   | LSB |
|-----|---|---|---|---|---|---|-----|
| 1   | 1 | 1 | 1 | 1 | 1 | 1 | 0   |

The programming after POR is marked bold-face / underlined in the programming tables.

With this programming all the outputs are muted to  $V_{REF}$  ( $V_{OUT} = V_{DD}/2$ ).

## 5.2 Subaddress (receive mode)

Table 6. Subaddress (receive mode)

| 1MSB           |                |                |                |                |                |                | LSB            | Function                                  |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|-------------------------------------------|
| I <sub>2</sub> | I <sub>1</sub> | I <sub>0</sub> | A <sub>4</sub> | A <sub>3</sub> | A <sub>2</sub> | A <sub>1</sub> | A <sub>0</sub> |                                           |
| 0              |                |                |                |                |                |                |                | <b>Audio processor Testmode</b>           |
| 1              |                |                |                |                |                |                |                | off<br>on                                 |
|                | 0              |                |                |                |                |                |                | <b>AutoZero remain</b>                    |
|                | 1              |                |                |                |                |                |                | off<br>on                                 |
|                |                | 0              |                |                |                |                |                | <b>Auto-increment mode</b>                |
|                |                | 1              |                |                |                |                |                | off<br>on                                 |
|                |                |                |                |                |                |                |                | <b>Subaddress</b>                         |
|                |                |                | 0              | 0              | 0              | 0              | 0              | Source Selector                           |
|                |                |                | 0              | 0              | 0              | 0              | 1              | Loudness                                  |
|                |                |                | 0              | 0              | 0              | 1              | 0              | Volume                                    |
|                |                |                | 0              | 0              | 0              | 1              | 1              | EQ Filter 1 (62/100Hz)                    |
|                |                |                | 0              | 1              | 1              | 0              | 0              | EQ Filter 2 (157Hz)                       |
|                |                |                | 0              | 0              | 1              | 0              | 1              | EQ Filter 3 (396Hz)                       |
|                |                |                | 0              | 0              | 1              | 1              | 0              | EQ Filter 4 (1kHz)                        |
|                |                |                | 0              | 0              | 1              | 1              | 1              | EQ Filter 5 (2.51kHz)                     |
|                |                |                | 0              | 1              | 0              | 0              | 0              | EQ Filter 6 (4/6.34kHz)                   |
|                |                |                | 0              | 1              | 0              | 0              | 1              | EQ Filter 7 (15/16kHz)                    |
|                |                |                | 0              | 1              | 0              | 1              | 0              | Mixing Programming                        |
|                |                |                | 0              | 1              | 0              | 1              | 1              | Soft-mute                                 |
|                |                |                | 0              | 1              | 1              | 0              | 0              | Subwoofer / Spectrum analyzer / High-pass |
|                |                |                | 0              | 1              | 1              | 0              | 1              | Configuration Audio processor I           |
|                |                |                | 0              | 1              | 1              | 1              | 0              | Mixing Level Control                      |
|                |                |                | 0              | 1              | 1              | 1              | 1              | Speaker attenuator LF                     |
|                |                |                | 1              | 0              | 0              | 0              | 0              | Speaker attenuator RF                     |
|                |                |                | 1              | 0              | 0              | 0              | 1              | Speaker attenuator LR                     |
|                |                |                | 1              | 0              | 0              | 1              | 0              | Speaker attenuator RR                     |
|                |                |                | 1              | 0              | 0              | 1              | 1              | Subwoofer attenuator                      |
|                |                |                | 1              | 0              | 1              | 0              | 0              | Testing Audio processor                   |

## 5.3 Data byte specification

The status after power-on-reset is marked bold-face / underlined in the programming tables.

### 5.3.1 Input selector (0)

Table 7. Input selector (0)

| MSB            |                |                |                |                |                |                | LSB            | Function               |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|------------------------|
| D <sub>7</sub> | D <sub>6</sub> | D <sub>5</sub> | D <sub>4</sub> | D <sub>3</sub> | D <sub>2</sub> | D <sub>1</sub> | D <sub>0</sub> |                        |
|                |                |                |                |                | X              | 0              | 0              | <b>Source selector</b> |
|                |                |                |                |                | X              | 0              | 1              | BUS/PD                 |
|                |                |                |                |                | X              | 1              | 0              | AUX                    |
|                |                |                |                |                | X              | 1              | 1              | <u>MD</u>              |
|                |                |                |                |                | X              | 1              | 1              | AM/FM                  |
|                | 0              | 0              | 0              | 0              |                |                |                | <b>Input gain</b>      |
|                | 0              | 0              | 0              | 1              |                |                |                | 0dB                    |
|                | :              | :              | :              | :              |                |                |                | 1dB                    |
|                | 1              | 1              | 1              | 0              |                |                |                | :                      |
|                | 1              | 1              | 1              | 1              |                |                |                | 14dB                   |
|                |                |                |                |                |                |                |                | <u>15dB</u>            |
| 0              |                |                |                |                |                |                |                | <b>Mute</b>            |
| 1              |                |                |                |                |                |                |                | off                    |
|                |                |                |                |                |                |                |                | <u>on</u>              |

### 5.3.2 Loudness (1)

Table 8. Loudness (1)

| MSB            |                |                |                |                |                |                | LSB            | Function                |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|-------------------------|
| D <sub>7</sub> | D <sub>6</sub> | D <sub>5</sub> | D <sub>4</sub> | D <sub>3</sub> | D <sub>2</sub> | D <sub>1</sub> | D <sub>0</sub> |                         |
|                |                |                | 0              | 0              | 0              | 0              | 0              | <b>Attenuation</b>      |
|                |                |                | 0              | 0              | 0              | 0              | 1              | 0 dB                    |
|                |                |                | :              | :              | :              | :              | :              | -1 dB                   |
|                |                |                | 0              | 1              | 1              | 1              | 0              | :                       |
|                |                |                | 0              | 1              | 1              | 1              | 1              | -14 dB                  |
|                |                |                | :              | :              | :              | :              | :              | -15 dB                  |
|                |                |                | 1              | 0              | 0              | 1              | 1              | :                       |
|                |                |                | :              | :              | :              | :              | :              | -19 dB                  |
|                |                |                | :              | :              | :              | :              | :              | not allowed             |
|                | 0              | 0              |                |                |                |                |                | <b>Center frequency</b> |
|                | 0              | 1              |                |                |                |                |                | 200Hz                   |
|                | 1              | 0              |                |                |                |                |                | 400Hz                   |
|                | 1              | 1              |                |                |                |                |                | 600Hz                   |
|                |                |                |                |                |                |                |                | <u>800Hz</u>            |
| 0              |                |                |                |                |                |                |                | <b>Loudness order</b>   |
| 1              |                |                |                |                |                |                |                | First order             |
|                |                |                |                |                |                |                |                | <u>Second order</u>     |

### 5.3.3 Volume (2)

Table 9. Volume (2)

| MSB            |                |                |                |                |                |                | LSB            | Function         |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|------------------|
| D <sub>7</sub> | D <sub>6</sub> | D <sub>5</sub> | D <sub>4</sub> | D <sub>3</sub> | D <sub>2</sub> | D <sub>1</sub> | D <sub>0</sub> |                  |
| 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | Gain/Attenuation |
| 0              | 0              | 0              | 0              | 0              | 0              | 0              | 1              | (+32.0dB)        |
| :              | :              | :              | :              | :              | :              | :              | :              | (+31.5dB)        |
| 0              | 0              | 0              | 1              | 1              | 0              | 0              | 0              | :                |
| 0              | 0              | 0              | 1              | 1              | 0              | 0              | 1              | +20.0dB          |
| 0              | 0              | 0              | 1              | 1              | 0              | 1              | 0              | +19.5dB          |
| 0              | 0              | 0              | 1              | 1              | 0              | 1              | 1              | +19.0dB          |
| :              | :              | :              | :              | :              | :              | :              | :              | :                |
| 0              | 0              | 1              | 1              | 1              | 1              | 1              | 1              | +0.5dB           |
| 0              | 1              | 0              | 0              | 0              | 0              | 0              | 0              | 0.0dB            |
| 0              | 1              | 0              | 0              | 0              | 0              | 0              | 1              | -0.5dB           |
| :              | :              | :              | :              | :              | :              | :              | :              | :                |
| 1              | 1              | X              | 1              | 1              | 1              | 1              | 0              | <u>-79.0dB</u>   |
| 1              | 1              | X              | 1              | 1              | 1              | 1              | 1              | -79.5dB          |

**Note:** *It is not recommended to use a gain more than 20dB for system performance reason. In general, the max. gain should be limited by software to the maximum value, which is needed for the system.*

### 5.3.4 Equalizer (3,4,5,6,7,8,9)

Table 10. Equalizer (3,4,5,6,7,8,9)

| MSB            |                |                |                |                |                |                | LSB            | Function                                                                                               |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|--------------------------------------------------------------------------------------------------------|
| D <sub>7</sub> | D <sub>6</sub> | D <sub>5</sub> | D <sub>4</sub> | D <sub>3</sub> | D <sub>2</sub> | D <sub>1</sub> | D <sub>0</sub> |                                                                                                        |
|                |                |                | 0              | 0              | 0              | 0              | 0              | <b>Equalizer cut/boost level</b><br>-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                                                                                                    |
|                |                |                | <b>1</b>       | <b>1</b>       | <b>1</b>       | <b>1</b>       | <b>0</b>       | <u>+1dB</u>                                                                                            |
|                |                |                | :              | :              | :              | :              | :              | :                                                                                                      |
|                |                |                | 1              | 0              | 0              | 0              | 1              | +14dB                                                                                                  |
|                |                |                | 1              | 0              | 0              | 0              | 0              | +15dB                                                                                                  |
|                | 0              | 0              |                |                |                |                |                | <b>Equalizer Q-Factor</b><br>2.2                                                                       |
|                | 0              | 1              |                |                |                |                |                | 1.8                                                                                                    |
|                | 1              | 0              |                |                |                |                |                | 1.4                                                                                                    |
|                | <b>1</b>       | <b>1</b>       |                |                |                |                |                | <u>1.0</u>                                                                                             |
| 0              |                |                |                |                |                |                |                | <b>Equalizer center frequency (only Subaddresses 3,8,9)</b><br>62Hz(addr 3)/4kHz(addr 8)/15kHz(addr 9) |
| <b>1</b>       |                |                |                |                |                |                |                | <u>100Hz(addr 3)/6.24kHz(addr 8)/16kHz(addr 9)</u>                                                     |
| 0              |                |                |                |                |                |                |                | <b>DC mode EQ Band 1 (62/100 Hz, Subaddress. 4!)</b><br>on                                             |
| <b>1</b>       |                |                |                |                |                |                |                | <u>off</u>                                                                                             |

### 5.3.5 Mixing programming (10)

Table 11. Mixing programming (10)

| MSB            |                |                |                |                |                  |                  | LSB            | Function                                                                                   |
|----------------|----------------|----------------|----------------|----------------|------------------|------------------|----------------|--------------------------------------------------------------------------------------------|
| D <sub>7</sub> | D <sub>6</sub> | D <sub>5</sub> | D <sub>4</sub> | D <sub>3</sub> | D <sub>2</sub>   | D <sub>1</sub>   | D <sub>0</sub> |                                                                                            |
|                |                |                |                |                |                  |                  | 0<br>1         | <b>Mixing Mute</b><br>enable                                                               |
|                |                |                |                |                | 0<br>0<br>1<br>1 | 0<br>1<br>0<br>1 |                | <b>Rear Source Selector</b><br>BUS'(PD)<br>AUX<br>MD<br>AM/FM                              |
|                |                |                | 0<br>1         | 0<br>1         |                  |                  |                | <b>Mixing Target</b><br>Speaker LF off<br>Speaker LF on<br>Speaker RF off<br>Speaker RF on |
|                | 0<br>1         | X<br>X         |                |                |                  |                  |                | <b>ZeroCross on HPF2</b><br>on<br>off                                                      |
| 0<br>1         |                |                |                |                |                  |                  |                | <b>Spectrum Analyzer Detect Point</b><br>After EQ<br>Before EQ                             |

### 5.3.6 Soft-mute and HPF2 (11)

Table 12. Soft-mute and HPF2 (11)

| MSB                                                 |                                                     |                                                     |                                                     |                |                |                | LSB            | Function                                                                                                                                             |
|-----------------------------------------------------|-----------------------------------------------------|-----------------------------------------------------|-----------------------------------------------------|----------------|----------------|----------------|----------------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| D <sub>7</sub>                                      | D <sub>6</sub>                                      | D <sub>5</sub>                                      | D <sub>4</sub>                                      | D <sub>3</sub> | D <sub>2</sub> | D <sub>1</sub> | D <sub>0</sub> |                                                                                                                                                      |
|                                                     |                                                     |                                                     |                                                     |                |                |                | 0<br>1         | <b>Soft-mute</b><br><u>On (Mute)</u><br>Off                                                                                                          |
|                                                     |                                                     |                                                     |                                                     |                | 0<br>0<br>1    | 0<br>1<br>X    |                | <b>Soft-mute time</b><br>Mute time = 0.48ms<br>Mute time = 0.96ms<br>Mute time = 123ms                                                               |
|                                                     |                                                     |                                                     |                                                     | 0<br>1         |                |                |                | <b>Secondary high-pass enable</b><br>Filter available<br><u>No Filter (Gain)</u>                                                                     |
| 0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>1<br>1<br>1 | 0<br>0<br>0<br>0<br>1<br>1<br>1<br>1<br>X<br>X<br>X | 0<br>0<br>1<br>1<br>0<br>0<br>1<br>1<br>X<br>0<br>1 | 0<br>1<br>0<br>1<br>0<br>1<br>1<br>1<br>0<br>1<br>1 |                |                |                |                | <b>Secondary high-pass effect (with ZeroCross)</b><br>4 dB<br>6 dB<br>8 dB<br>10 dB<br>12 dB<br>14 dB<br>16 dB<br>18dB<br>20dB<br>22dB<br><u>0dB</u> |

**Note:** It is recommended to set D3(Filter available or not) during initial mute.

### 5.3.7 Subwoofer configuration / spectrum analyzer / high-pass (12)

Table 13. Subwoofer configuration / spectrum analyzer / high-pass (12)

| MSB              |                  |                |                |                |                |                  | LSB              | Function                                                                     |
|------------------|------------------|----------------|----------------|----------------|----------------|------------------|------------------|------------------------------------------------------------------------------|
| D <sub>7</sub>   | D <sub>6</sub>   | D <sub>5</sub> | D <sub>4</sub> | D <sub>3</sub> | D <sub>2</sub> | D <sub>1</sub>   | D <sub>0</sub>   |                                                                              |
|                  |                  |                |                |                |                | 0<br>0<br>1<br>1 | 0<br>1<br>0<br>1 | <b>Subwoofer Filter</b><br>off<br>80Hz<br><u>120Hz</u><br>160Hz              |
|                  |                  |                |                | X<br><u>X</u>  | 0<br>1         |                  |                  | <b>Subwoofer Coupling</b><br>AC using SW <sub>In</sub> pin<br><u>DC</u>      |
|                  |                  |                | 0<br>1         |                |                |                  |                  | <b>Spectrum Analyzer Q-Factor</b><br>3.5<br><u>1.8</u>                       |
|                  |                  | 0<br>1         |                |                |                |                  |                  | <b>High-pass enable</b><br>Filter off<br><u>Filter on</u>                    |
| 0<br>0<br>1<br>1 | 0<br>1<br>0<br>1 |                |                |                |                |                  |                  | <b>High-pass cut-off frequency</b><br>90Hz<br>135Hz<br>180Hz<br><u>225Hz</u> |

### 5.3.8 Configuration audio processor I (13)

Table 14. Configuration audio processor I (13)

| MSB            |                |                |                  |                  |                |                | LSB            | Function                                                            |
|----------------|----------------|----------------|------------------|------------------|----------------|----------------|----------------|---------------------------------------------------------------------|
| D <sub>7</sub> | D <sub>6</sub> | D <sub>5</sub> | D <sub>4</sub>   | D <sub>3</sub>   | D <sub>2</sub> | D <sub>1</sub> | D <sub>0</sub> |                                                                     |
|                |                |                |                  |                  |                |                | 0<br>1         | <b>PD input mode</b><br><u>single ended</u><br>pseudo differential  |
|                |                |                |                  |                  |                | 0<br>1         |                | PD Input Gain<br>-6 dB<br><u>0 dB</u>                               |
|                |                |                |                  |                  | 0<br>1         |                |                | <b>Soft-step volume</b><br>off<br><u>on</u>                         |
|                |                |                | 0<br>0<br>1<br>1 | 0<br>1<br>0<br>1 |                |                |                | <b>Soft-step time</b><br>320μs<br>1.28ms<br>5.12ms<br><u>20.4ms</u> |
|                |                | 0<br>1         |                  |                  |                |                |                | <b>Loudness</b><br>flat<br><u>filter ON</u>                         |
|                | 0<br>1         |                |                  |                  |                |                |                | <b>Front AC speaker</b><br>AC coupling (ACin)<br><u>DC coupling</u> |
| 0<br>1         |                |                |                  |                  |                |                |                | <b>Rear effect</b><br>No effect signal<br><u>Equalizing signal</u>  |



### 5.3.9 Mixer level control (14)

Table 15. Mixer level control (14)

| MSB            |                |                |                | LSB            |                |                |                | Function                |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|-------------------------|
| D <sub>7</sub> | D <sub>6</sub> | D <sub>5</sub> | D <sub>4</sub> | D <sub>3</sub> | D <sub>2</sub> | D <sub>1</sub> | D <sub>0</sub> |                         |
| 1              | 0              | 0              | 0              | 1              | 1              | 1              | 1              | <b>Gain/Attenuation</b> |
|                | :              | :              | :              | :              | :              | :              | :              | +15dB                   |
| 1              | 0              | 0              | 0              | 0              | 0              | 0              | 1              | + 1dB                   |
| 1              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0dB                     |
| 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0dB                     |
| 0              | 0              | 0              | 0              | 0              | 0              | 0              | 1              | - 1dB                   |
| :              | :              | :              | :              | :              | :              | :              | :              | :                       |
| 0              | 0              | 0              | 0              | 1              | 1              | 1              | 1              | -15dB                   |
| 0              | 0              | 0              | 1              | 0              | 0              | 0              | 0              | -16dB                   |
| :              | :              | :              | :              | :              | :              | :              | :              | :                       |
| 0              | 1              | 0              | 0              | 1              | 1              | 1              | 0              | -78dB                   |
| 0              | 1              | 0              | 0              | 1              | 1              | 1              | 1              | -79dB                   |
| X              | 1              | 1              | X              | X              | X              | X              | X              | <u>Mute</u>             |

### 5.3.10 Speaker and subwoofer level control (15,16,17,18,19)

Table 16. Speaker and subwoofer level control (15,16,17,18,19)

| MSB            |                |                |                | LSB            |                |                |                | Function                |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|-------------------------|
| D <sub>7</sub> | D <sub>6</sub> | D <sub>5</sub> | D <sub>4</sub> | D <sub>3</sub> | D <sub>2</sub> | D <sub>1</sub> | D <sub>0</sub> |                         |
|                | 0              | 0              | 0              | 1              | 1              | 1              | 1              | <b>Gain/Attenuation</b> |
|                | :              | :              | :              | :              | :              | :              | :              | +15dB                   |
|                | 0              | 0              | 0              | 0              | 0              | 0              | 1              | + 1dB                   |
|                | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0dB                     |
|                | 0              | 0              | 1              | 0              | 0              | 0              | 0              | 0dB                     |
|                | 0              | 0              | 1              | 0              | 0              | 0              | 1              | - 1dB                   |
|                | :              | :              | :              | :              | :              | :              | :              | :                       |
|                | 0              | 1              | 0              | 0              | 0              | 0              | 0              | -16dB                   |
|                | :              | :              | :              | :              | :              | :              | :              | :                       |
|                | 0              | 1              | 1              | 0              | 0              | 0              | 0              | -32dB                   |
|                | :              | :              | :              | :              | :              | :              | :              | :                       |
|                | 1              | 0              | 0              | 0              | 0              | 0              | 0              | -48dB                   |
|                | :              | :              | :              | :              | :              | :              | :              | :                       |
|                | 1              | 0              | 1              | 0              | 0              | 0              | 0              | -64dB                   |
|                | :              | :              | :              | :              | :              | :              | :              | :                       |
|                | 1              | 0              | 1              | 1              | 1              | 1              | 1              | -79dB                   |
|                | 1              | 1              | X              | X              | X              | X              | X              | <u>Mute</u>             |
| 0              |                |                |                |                |                |                |                | <b>Soft-step on/off</b> |
| 1              |                |                |                |                |                |                |                | On                      |
|                |                |                |                |                |                |                |                | <u>Off</u>              |

### 5.3.11 Testing audio processor (20)

Table 17. Testing audio processor (20)

| MSB            |                |                |                                                          |                                                          |                                                               |                                                               | LSB            | Function                                                                                                                                                                                                                                                                                                                                                                                       |
|----------------|----------------|----------------|----------------------------------------------------------|----------------------------------------------------------|---------------------------------------------------------------|---------------------------------------------------------------|----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| D <sub>7</sub> | D <sub>6</sub> | D <sub>5</sub> | D <sub>4</sub>                                           | D <sub>3</sub>                                           | D <sub>2</sub>                                                | D <sub>1</sub>                                                | D <sub>0</sub> |                                                                                                                                                                                                                                                                                                                                                                                                |
|                |                |                |                                                          |                                                          |                                                               |                                                               | 0<br>1         | <b>Audio processor test-mode</b><br>off<br>on                                                                                                                                                                                                                                                                                                                                                  |
|                |                |                | 0<br>1<br>0<br>1<br>0<br>1<br>X<br>0<br>1<br>X<br>X<br>X | 0<br>0<br>0<br>0<br>0<br>0<br>0<br>1<br>1<br>1<br>1<br>1 | 0<br>0<br>0<br>0<br>1<br>1<br>0<br>0<br>0<br>0<br>1<br>1<br>1 | 0<br>0<br>1<br>1<br>0<br>0<br>1<br>0<br>0<br>1<br>0<br>0<br>1 |                | <b>Test-multiplexer</b><br>Spectrum Analyzer Filter 62Hz<br>Spectrum Analyzer Filter 157Hz<br>Spectrum Analyzer Filter 396Hz<br>Spectrum Analyzer Filter 1kHz<br>Spectrum Analyzer Filter 2.51kHz<br>Spectrum Analyzer Filter 6.34kHz<br>Spectrum Analyzer Filter 16kHz<br>Switch-Ron measurement setup (Level input)<br>not used<br>200kHz Oscillator<br>NB-Hold<br><u>internal reference</u> |
|                |                | 0<br>1         |                                                          |                                                          |                                                               |                                                               |                | <b>Clock</b><br>external<br><u>internal</u>                                                                                                                                                                                                                                                                                                                                                    |
|                | 0<br>1         |                |                                                          |                                                          |                                                               |                                                               |                | <b>AZ function</b><br>off<br><u>on</u>                                                                                                                                                                                                                                                                                                                                                         |
| 0<br>1         |                |                |                                                          |                                                          |                                                               |                                                               |                | <b>SC-Clock</b><br>Fast mode<br><u>Normal mode</u>                                                                                                                                                                                                                                                                                                                                             |

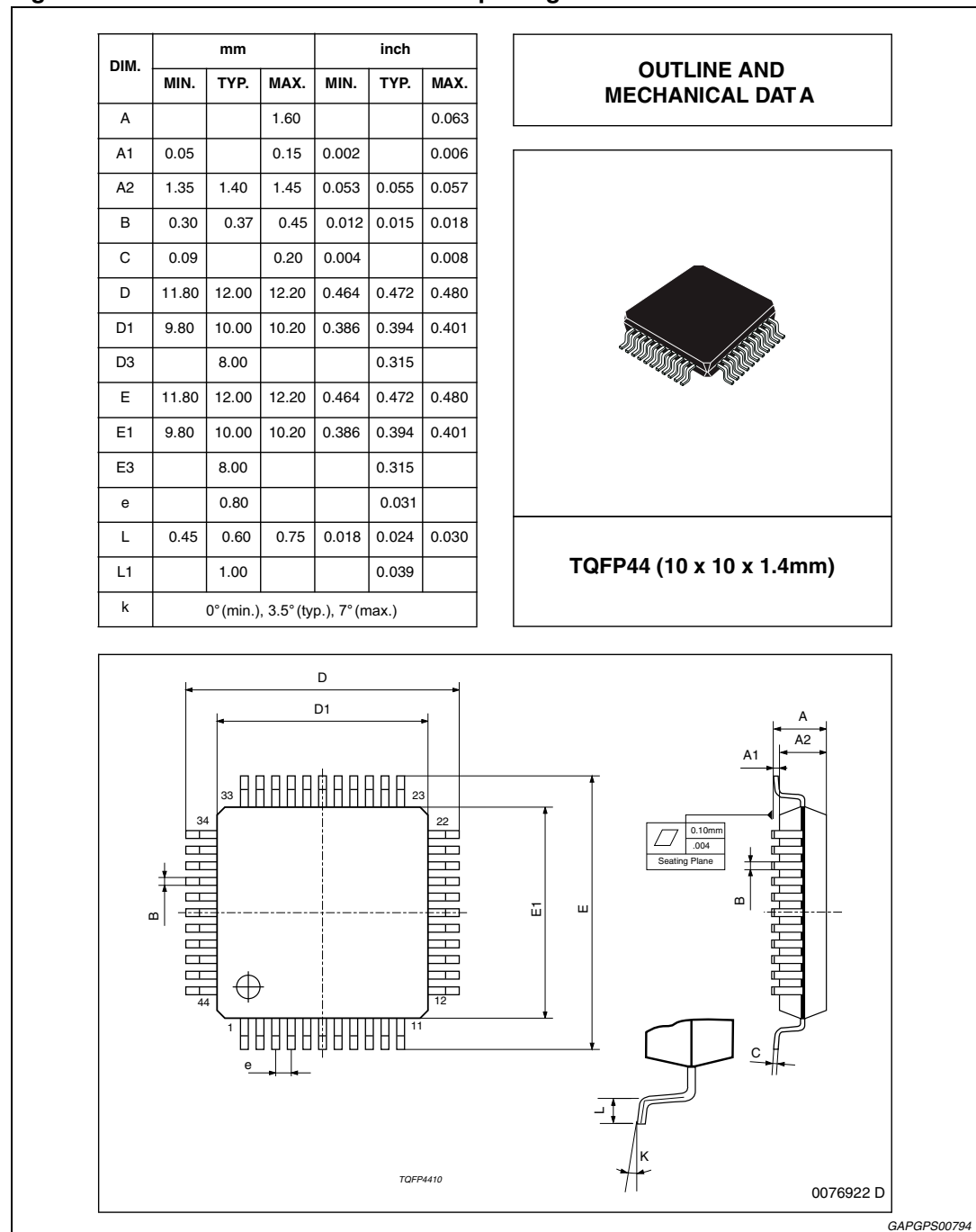
**Note:** This byte is used for testing or evaluation purposes only and must not set to other values than "1111110" in the application!

## 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](http://www.st.com).

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**Figure 21. TQFP44 mechanical data and package dimensions**



## 7 Revision history

**Table 18. Document revision history**

| Date        | Revision | Changes                                                                                                |
|-------------|----------|--------------------------------------------------------------------------------------------------------|
| 20-Sep-2003 | 1        | Initial release.                                                                                       |
| 30-Jun-2011 | 2        | Document reformatted.<br>Updated order code in the <a href="#">Table 1: Device summary on page 1</a> . |
| 24-Sep-2013 | 3        | Updated disclaimer.                                                                                    |

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