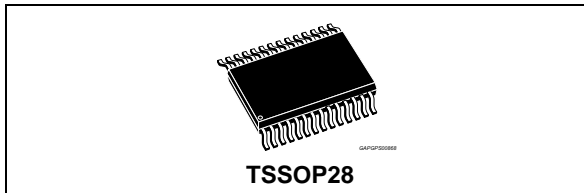


3 band car audio processor

Datasheet - production data



Features

- Input multiplexer
 - QD1: quasi-differential stereo input
 - QD2: quasi-differential stereo input
 - SE1: stereo single-ended input
 - SE2: stereo single-ended input
 - SE3: stereo single-ended 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 -63 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 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 to 15 dB range with 1 dB resolution
- Treble
 - 2nd order frequency response
- Center frequency programmable in 4 steps (10 kHz / 12.5 kHz / 15 kHz / 17.5 kHz)
- -15 to 15 dB range with 1 dB resolution
- High-pass
 - 2nd order frequency response
 - Center frequency programmable in 3 steps (100 Hz / 120 Hz / 150 Hz)
- Subwoofer
 - 2nd order low pass filter
 - 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
- Speaker
 - 6 independent soft-step speaker controls
 - +15 dB to -79 dB with 1 dB steps
 - Two selectable output DC level
 - Direct mute
- 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 TDA7720B is a high performance signal processor specifically designed for car radio applications. The device includes a high performance audio processor 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
TDA7720B	TSSOP28	Tube
TDA7720BTR	TSSOP28	Tape and reel

Contents

- 1 Block circuit diagram 6**

- 2 Pins connection and description 7**
 - 2.1 Pins connection 7
 - 2.2 Pins description 7

- 3 Electrical specifications 9**
 - 3.1 Thermal data 9
 - 3.1.1 Absolute maximum ratings 9
 - 3.2 Electrical characteristics 9

- 4 Description of audioprocessor 14**
 - 4.1 Input stage 14
 - 4.1.1 Single-ended stereo input (SE1, SE2, SE3) 14
 - 4.1.2 Quasi-differential stereo Input (QD1,QD2) 14
 - 4.1.3 Fast charge 14
 - 4.2 Input gain 14
 - 4.3 Loudness 15
 - 4.3.1 Loudness attenuation 15
 - 4.3.2 Peak frequency 15
 - 4.3.3 High frequency boost 16
 - 4.3.4 Flat mode 16
 - 4.4 Soft-mute 16
 - 4.5 Volume 17
 - 4.6 Bass 17
 - 4.6.1 Bass attenuation 17
 - 4.6.2 Center frequency 18
 - 4.6.3 Quality factors 18
 - 4.6.4 DC mode 19
 - 4.7 Middle 19
 - 4.7.1 Middle attenuation 19
 - 4.7.2 Middle center frequency 20
 - 4.7.3 Quality factors 20

4.8	Treble	21
4.8.1	Treble attenuation	21
4.8.2	Center frequency	21
4.9	High-pass filter	22
4.10	Subwoofer filter	22
4.11	Soft-step control	23
4.12	DC offset detector	23
4.13	Output stage	24
4.14	Audioprocessor testing	25
5	I²C bus specification	26
5.1	Interface protocol	26
5.2	I2C bus electrical characteristics	26
5.2.1	Receive mode	27
5.2.2	Transmission mode	27
5.2.3	Reset condition	28
5.3	Data byte specification	29
6	Package information	40
7	Revision history	41

List of tables

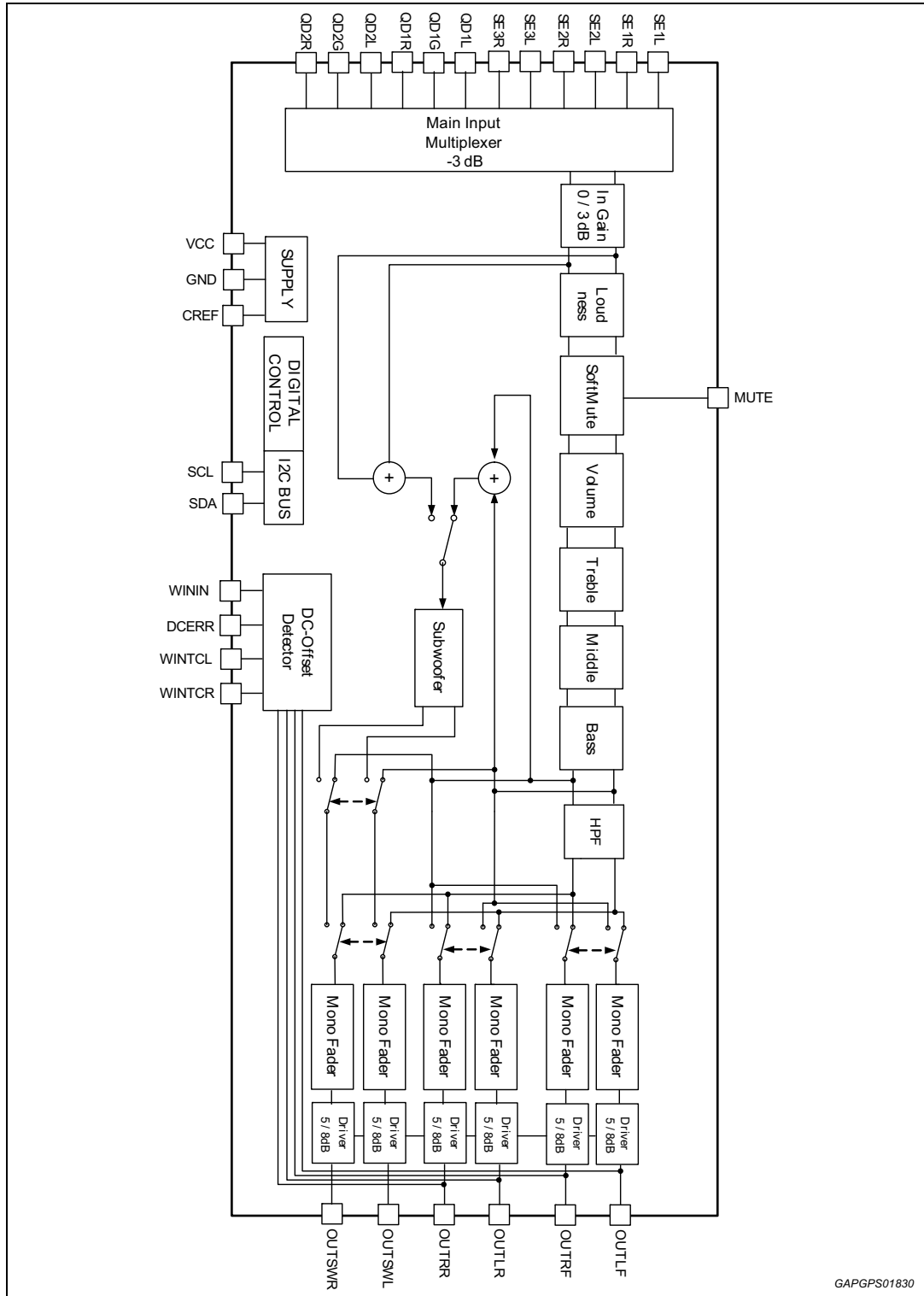
Table 1.	Device summary	1
Table 2.	Pins description	7
Table 3.	Thermal data	9
Table 4.	Absolute maximum ratings	9
Table 5.	Electrical characteristics	9
Table 6.	I ² C bus electrical characteristics	26
Table 7.	Subaddress (receive mode)	28
Table 8.	Main selector (0)	29
Table 9.	Output DC level / highpass (1)	29
Table 10.	Soft-mute / others (4)	30
Table 11.	Soft-step I (5)	31
Table 12.	Soft-step II / DC detector (6)	32
Table 13.	Loudness (7)	33
Table 14.	Volume (8)	34
Table 15.	Treble filter (9)	35
Table 16.	Middle filter (10)	35
Table 17.	Bass filter (11)	36
Table 18.	Subwoofer / middle / bass (12)	36
Table 19.	Speaker attenuation (FL/FR/RL/RR/SWL/SWR) (13-18)	37
Table 20.	Testing audio processor 1 (19)	37
Table 21.	Testing audio processor 2 (20)	38
Table 22.	Testing audio processor 3 (21)	39
Table 23.	Document revision history	41

List of figures

Figure 1.	Block circuit diagram.	6
Figure 2.	Pins connection (top view)	7
Figure 3.	Loudness attenuation @ $f_P = 400$ Hz.	15
Figure 4.	Loudness center frequencies @ attn. = 15 dB	15
Figure 5.	Loudness attenuation, $f_c = 2.4$ kHz	16
Figure 6.	Soft-mute timing	16
Figure 7.	Bass control @ $f_c = 80$ Hz, $Q = 1$	17
Figure 8.	Bass center frequencies @ gain = 14 dB, $Q = 1$	18
Figure 9.	Bass quality factors @ gain = 14 dB, $f_c = 80$ Hz	18
Figure 10.	Bass normal and DC mode @ gain = 14 dB, $f_c = 80$ Hz	19
Figure 11.	Middle control @ $f_c = 1$ kHz, $Q = 1$	19
Figure 12.	Middle center frequency @ gain = 14 dB, $Q = 1$	20
Figure 13.	Middle quality factors @ gain = 14 dB, $f_c = 1$ kHz.	20
Figure 14.	Treble control @ $f_c = 17.5$ kHz	21
Figure 15.	Treble center frequencies @ gain = 14 dB.	21
Figure 16.	High-pass cut frequencies	22
Figure 17.	Subwoofer cut frequencies	22
Figure 18.	DC offset detection circuit (simplified)	24
Figure 19.	Test circuit	25
Figure 20.	I ² C bus interface protocol	26
Figure 21.	I ² C bus data	27
Figure 22.	TSSOP28 mechanical data and package dimensions	40

1 Block circuit diagram

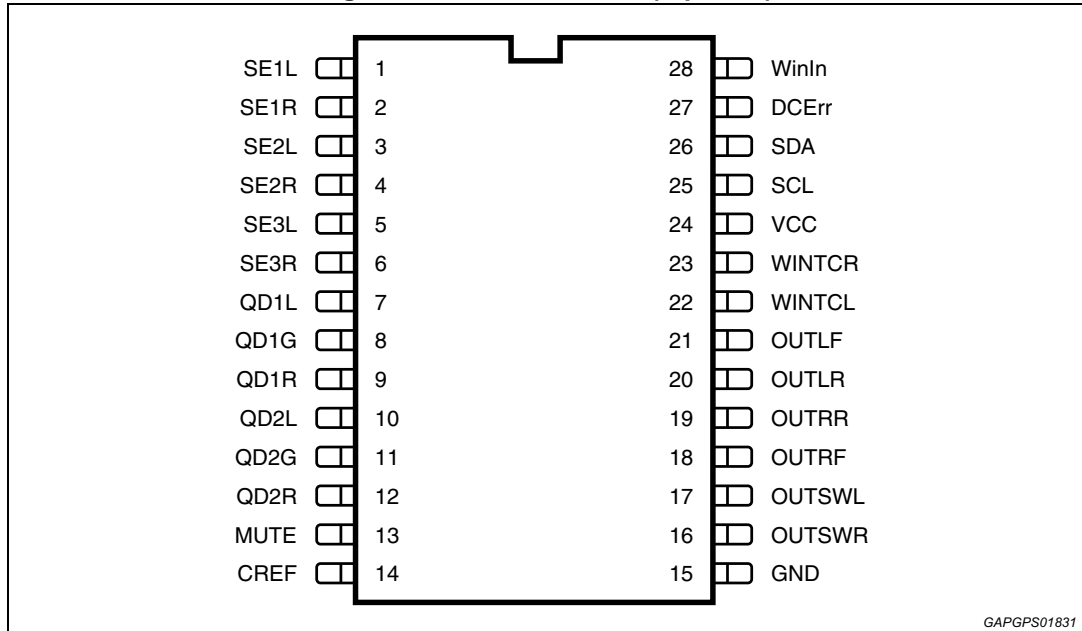
Figure 1. Block circuit diagram



2 Pins connection and description

2.1 Pins connection

Figure 2. Pins connection (top view)



2.2 Pins description

Table 2. Pins description

Pin #	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	QD2L	Quasi-differential stereo inputs left	I
11	QD2G	Quasi-differential stereo inputs common	I
12	QD2R	Quasi-differential stereo inputs right	I
13	MUTE	External mute pin	I

Table 2. Pins description (continued)

Pin #	Pin name	Description	I/O
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	WINTCL	DC offset detector filter output left channel	O
23	WINTCR	DC offset detector filter output right channel	O
24	VCC	Supply	S
25	SCL	I ² C bus clock	I
26	SDA	I ² C bus data	I/O
27	DCERR	DC offset detector output	O
28	WinIn	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
$R_{th-jamb}$	Thermal resistance junction-to-ambient	114	°C/W

3.1.1 Absolute maximum ratings

Table 4. Absolute maximum ratings

Symbol	Parameter	Value	Unit
V_S	Operating supply voltage	13	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
V_{ESD}	ESD withstand voltage:		
	Human body model	$\geq \pm 2000$	V
	Charged device model	$\geq \pm 250$	V

3.2 Electrical characteristics

$V_S = 11.5$ V; $T_{amb} = 25$ °C; $R_L = 10$ k Ω ; all gains = 0 dB; $f = 1$ kHz; Output gain = 5 dB; Input = SE1; unless otherwise specified

Table 5. Electrical characteristics

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
Supply						
V_S	Supply voltage	-	7.5	11.5	12.5	V
I_S	Supply current	-	30	35	39	mA
Input selector						
R_{in}	Input resistance	All single ended inputs	70	100	130	k Ω
V_{CL}	Clipping level	Input gain = 0 dB, THD = 1 %	2	-	-	V_{RMS}
S_{IN}	Input separation	-	80	100	-	dB
Differential stereo inputs						
R_{in}	Input resistance	Differential	70	100	130	k Ω
CMRR	Common mode rejection Ratio for main source	$V_{CM}=1 V_{RMS}$ @ 1 kHz	46	60	-	dB
		$V_{CM}=1 V_{RMS}$ @ 10 kHz ⁽¹⁾	46	60	-	dB

Table 5. Electrical characteristics (continued)

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
Loudness control						
A _{MAX}	Max. attenuation ⁽²⁾	-	14	15	16.5	dB
A _{STEP}	Step resolution ⁽²⁾	-	0.5	1	1.5	dB
f _{Peak}	Peak frequency ⁽³⁾	f _{P1}	-	400	-	Hz
		f _{P2}	-	800	-	Hz
		f _{P3}	-	2400	-	Hz
Volume control						
G _{MAX}	Max. gain ⁽²⁾	-	21	23	25	dB
A _{MAX}	Max. attenuation ⁽²⁾	-	-66	-63	-60	dB
A _{STEP}	Step resolution ⁽²⁾	-	0.5	1	1.5	dB
E _A	Attenuation set error	G = -20 to +23 dB	-0.75	0	0.75	dB
		G = -20 to -63 dB	-4	0	3	dB
E _T	Tracking error	-	-	-	2	dB
V _{DC}	DC steps	Adjacent attenuation steps	-5	0.1	5	mV
		From 0 dB to A _{MAX}	-8	0.5	8	mV
Soft-mute						
A _{MUTE}	Mute attenuation		80	100	-	dB
T _D	Delay time	T ₁	0.36	0.48	0.6	ms
		T ₂	0.84	0.96	1.08	ms
		T ₃	7.3	7.6	8.5	ms
		T ₄	14	15.3	16.8	ms
V _{TH_Low}	Low threshold for MUTE pin	⁽⁴⁾	-	-	0.8	V
V _{TH_High}	High threshold for MUTE pin	⁽⁴⁾	2.5	-	-	V
RPU	Internal pull-up resistor for MUTE pin	-	35	48	63	kΩ
VPU	Internal pull-up voltage for MUTE pin	-	3	3.3	3.6	V
Bass control						
F _c	Center frequency ⁽³⁾	f _{C1}	-	60	-	Hz
		f _{C2}	-	80	-	Hz
		f _{C3}	-	100	-	Hz
		f _{C4}	-	200	-	Hz

Table 5. Electrical characteristics (continued)

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
Q _{BASS}	Quality factor ⁽³⁾	Q ₁	-	1	-	-
		Q ₂	-	1.25	-	-
		Q ₃	-	1.5	-	-
		Q ₄	-	2	-	-
C _{RANGE}	Control range ⁽²⁾	-	14	15	16	dB
A _{STEP}	Step resolution ⁽²⁾	-	0.5	1	1.5	dB
DC _{GAIN}	Bass-DC-gain	DC = off	-1	0	1	dB
		DC = on, Gain = ±14 dB	4	4.4	4.6	dB
Middle control						
C _{RANGE}	Control range ⁽²⁾	-	14	15	16	dB
A _{STEP}	Step resolution ⁽²⁾	-	0.5	1	1.5	dB
Fc	Center frequency ⁽³⁾	f _{C1}	-	500	-	Hz
		f _{C2}	-	1	-	kHz
		f _{C3}	-	1.5	-	kHz
		f _{C4}	-	2.5	-	kHz
Q _{Middle}	Quality factor ⁽³⁾	Q ₁	-	0.75	-	-
		Q ₂	-	1	-	-
		Q ₃	-	1.25	-	-
Treble control						
C _{RANGE}	Clipping level	-	13	15	16	dB
A _{STEP}	Step resolution	-	0.5	1	1.5	dB
Fc	Center frequency ⁽³⁾	f _{C1}	-	10	-	kHz
		f _{C2}	-	12.5	-	kHz
		f _{C3}	-	15	-	kHz
		f _{C4}	-	17.5	-	kHz
Speaker attenuators						
G _{MAX}	Max. gain ⁽²⁾	-	14	15	16	dB
A _{MAX}	Max. attenuation ⁽²⁾	-	-90	-79	-70	dB
A _{STEP}	Step resolution ⁽²⁾	-	0.5	1	1.5	dB
A _{MUTE}	Mute attenuation	-	80	90	-	dB
E _A	Attenuation set error	G = -20 to +15 dB	-0.75	0	0.75	dB
		G = -20 to -79 dB	-10	0	10	dB
V _{DC}	DC steps	Adjacent attenuation steps	-5	0.1	5	mV

Table 5. Electrical characteristics (continued)

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit	
HPF							
F _{HP}	High-pass corner frequency (3)	f _{HP1}	-	100	-	Hz	
		f _{HP2}	-	120	-	Hz	
		f _{HP3}	-	150	-	Hz	
Audio outputs							
V _{CL}	Clipping level	PRE	THD = 0.5% VCC = 8.5V output level/gain = 4V/5 dB	2.5	-	-	V _{RMS}
		FRONT REAR	THD = 0.3% VCC = 8.5V output level/gain = 4V/5dB				
		PRE	THD = 0.5% VCC = 11.5V output level/gain = 5.75V/5dB	3.55	-	-	V _{RMS}
		FRONT REAR	THD = 0.3% VCC = 11.5V output level/gain = 5.75V/5dB				
R _{OUT}	Output impedance	-	-	30	50	Ω	
R _L	Output load resistance	-	2	-	-	kΩ	
C _L	Output load capacitor	-	-	-	10	nF	
V _{DC}	Output DC level	Output level/gain = 4 V / 5 dB	3.8	4.0	4.2	V	
		Output level/gain = 5.75 V / 8 dB	5.5	5.75	6	V	
G _{OUT}	Output gain	Output level/gain = 4 V / 5 dB	4	5	6	dB	
		Output level/gain = 5.75 V / 8 dB	7	8	9	dB	
Subwoofer low-pass							
f _{LP}	Low-pass corner frequency (3)	f _{LP1}	-	55	-	Hz	
		f _{LP2}	-	85	-	Hz	
		f _{LP3}	-	120	-	Hz	
		f _{LP4}	-	160	-	Hz	
DC offset detection circuit							
V _{th}	Zero comp. window size	V ₁	±20	±30	±40	mV	
		V ₂	±30	±45	±55	mV	
		V ₃	±40	±60	±70	mV	
		V ₄	±70	±90	±100	mV	

Table 5. Electrical characteristics (continued)

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit	
τ_{sp}	Max. rejected spike length	T ₁	7	11	25	μs	
		T ₂	14	22	45	μs	
		T ₃	22	33	65	μs	
		T ₄	28	44	80	μs	
I _{CHDCerr}	DCErr charge current	-	3.5	5	6.5	μA	
I _{DISDCerr}	DCErr discharge current	-	3.5	5	8	mA	
V _{OutH}	DCErr high voltage	-	3.1	3.3	3.6	V	
V _{OutL}	DCErr low voltage	-	0	100	300	mV	
V _{TH_Low}	Low Threshold for WinIn pin	(4)	-	-	0.75	V	
V _{TH_High}	High Threshold for WinIn pin	(4)	2.8	-	-	V	
RPU	Internal pull-up resistor for WinIn pin	-	35	50	70	k Ω	
VPU	Internal pull-up voltage for WinIn pin	-	3.1	3.3	3.5	V	
General							
e _{NO}	Output noise	BW = 20 Hz to 20 kHz A-Weighted, all gain = 0dB, HPF=OFF, Input=SE/QD	Output level / gain = 4V / 5dB	-	15	30	μV
			Output level/gain=5.75V/8dB	-	21	35	μV
		BW = 20 Hz to 20 kHz A-Weighted, Output muted	Output level/gain=4V/5dB	-	9	21	μV
			Output level/gain=5.75V/8dB	-	12.5	21	μV
S/N	Signal to noise ratio	all gain = 0 dB, A-weighted; Output level/gain = 4 V / 5 dB; V _o = 2.5 V _{RMS}		98	104	-	dB
		all gain = 0dB, A-weighted; Output level/gain = 5.75 V / 8 dB; V _o = 3.55 V _{RMS}		98	104	-	dB
D	Distortion	VIN=1V _{RMS} ; all gain = 0dB, HPF=OFF	Output level/gain = 4 V / 5 dB	-	0.01	0.05	%
			Output level/gain=5.75V/8dB	-	0.01	0.05	%
S _C	Channel separation left/right	-	75	90	-	dB	

1. Guaranteed by design.
2. Measure performed in DC.
3. Value guaranteed by measuring correlated parameter.
4. Verified only in characterization.

4 Description of audioprocessor

4.1 Input stage

Two quasi-differential stereo input and three single-ended inputs are available.

4.1.1 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.

4.1.2 Quasi-differential stereo Input (QD1,QD2)

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.

4.1.3 Fast charge

Each differential input pin features a "fast-charge" switch allowing to quickly charge any external large coupling capacitors upon power-on of the device. When the device is power-on, the "fast-charge" switches are automatically turn on, for normal operation these switches need to be released by any programming of byte_0. After that, the "fast-charge" switches can be turned on/off by setting "fast charge = on/off".

4.2 Input gain

A 0/3 dB input gain is selectable to compensate the attenuation of input stage.

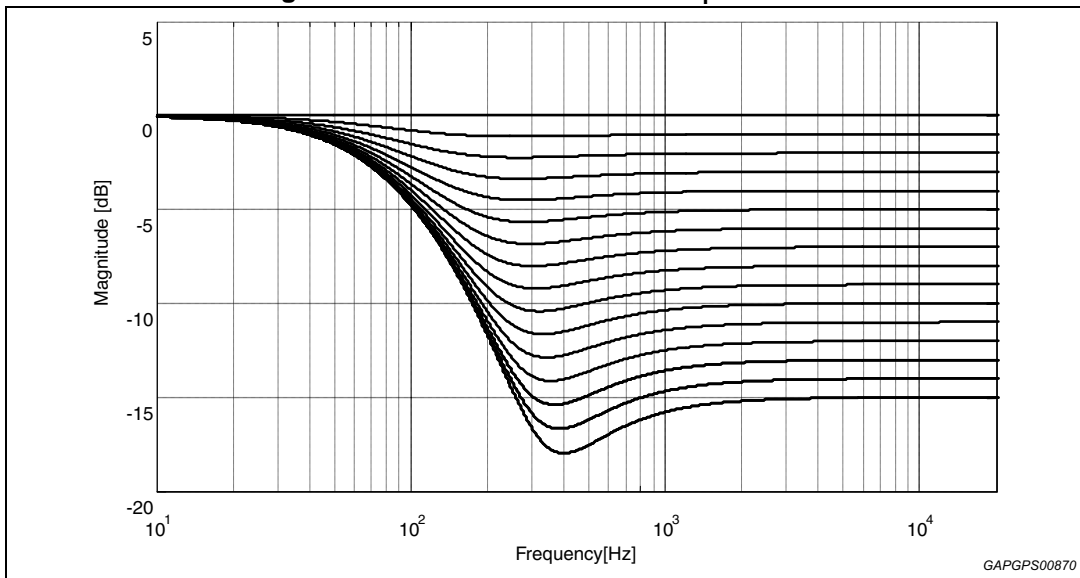
4.3 Loudness

There are four parameters programmable in the loudness stage.

4.3.1 Loudness attenuation

Figure 3 shows the attenuation as a function of frequency at $f_p = 400$ Hz

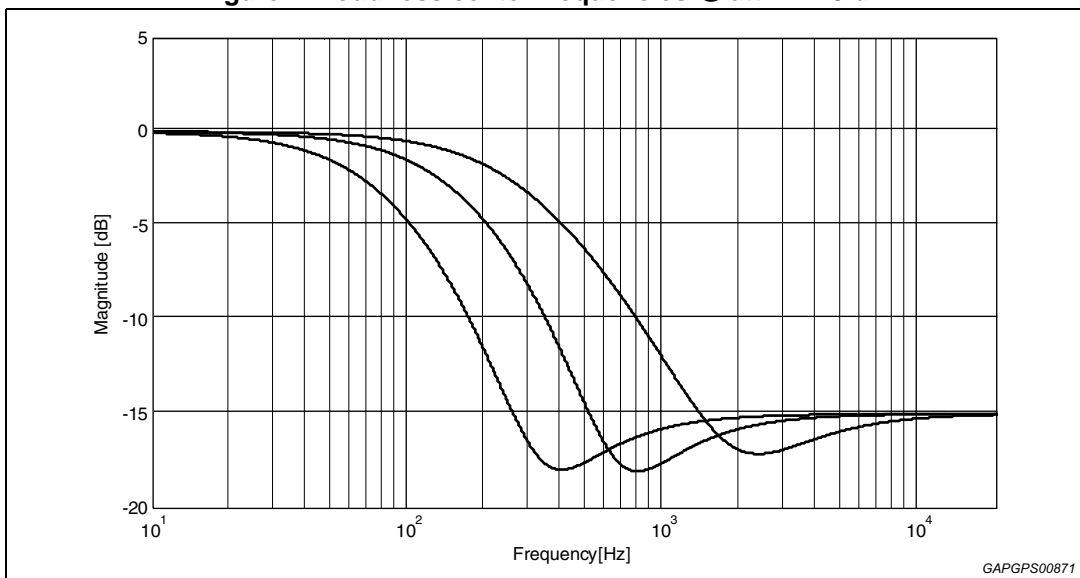
Figure 3. Loudness attenuation @ $f_p = 400$ Hz



4.3.2 Peak frequency

Figure 4 shows the four possible peak-frequencies at 400, 800 and 2400 Hz

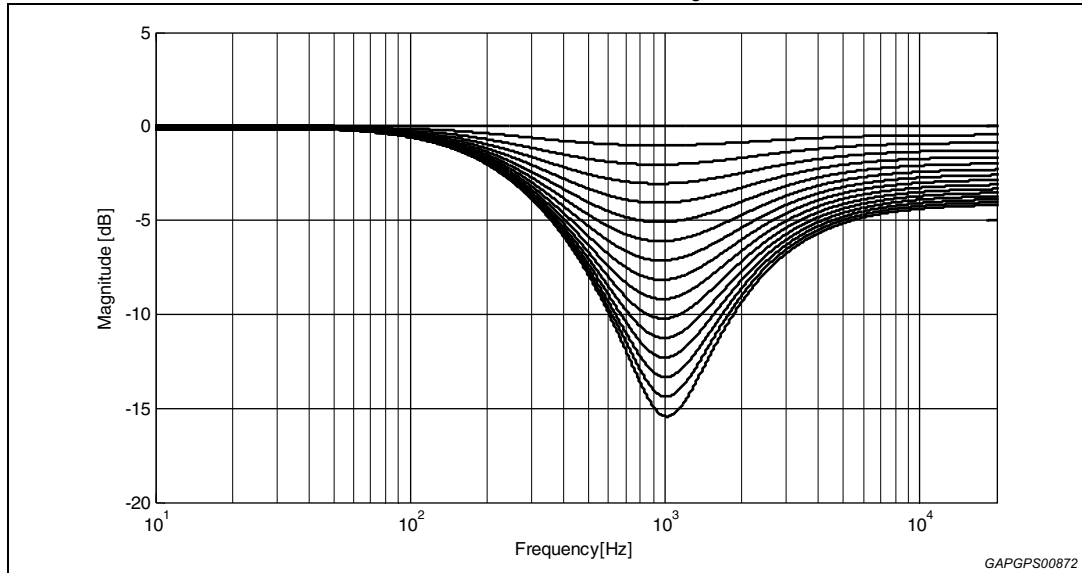
Figure 4. Loudness center frequencies @ attn. = 15 dB



4.3.3 High frequency boost

Figure 5 shows the different loudness shapes in low and high frequency boost.

Figure 5. Loudness attenuation, $f_c = 2.4 \text{ kHz}$



4.3.4 Flat mode

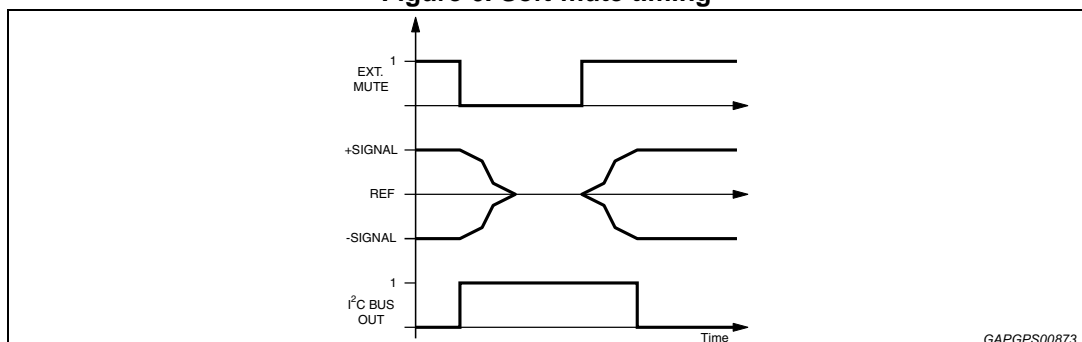
In flat mode the loudness stage works as a 0 dB to -15 dB attenuator.

4.4 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 6).

For timing purposes the bit0 of the I²C bus output register is set to 1 from the start of muting until the end of demuting.

Figure 6. 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.

4.5 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 [Section 4.1.1](#).

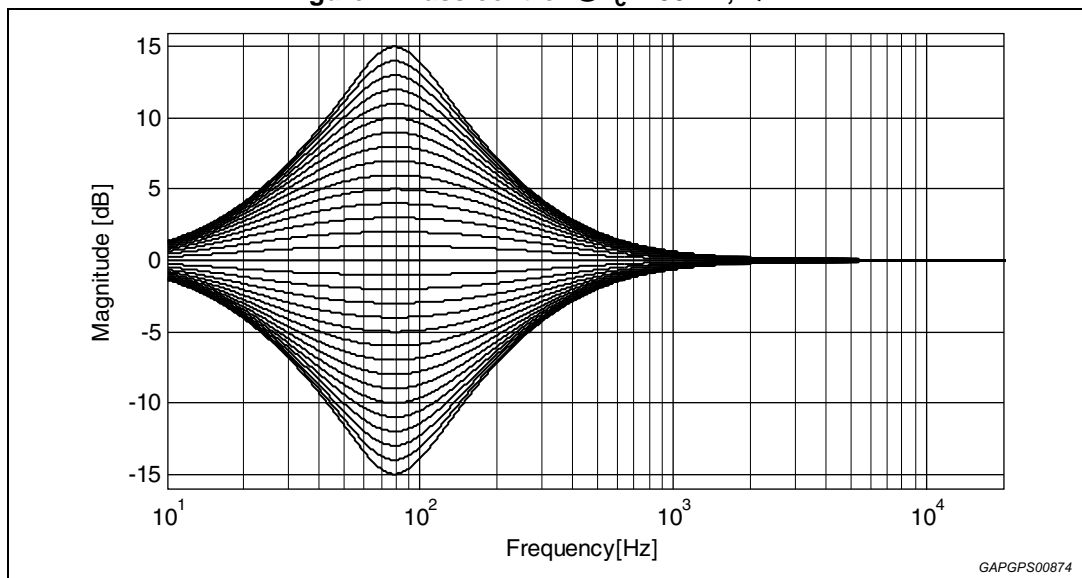
4.6 Bass

There are four parameters programmable in the bass stage.

4.6.1 Bass attenuation

[Figure 7](#) shows the attenuation as a function of frequency at a center frequency of 80 Hz.

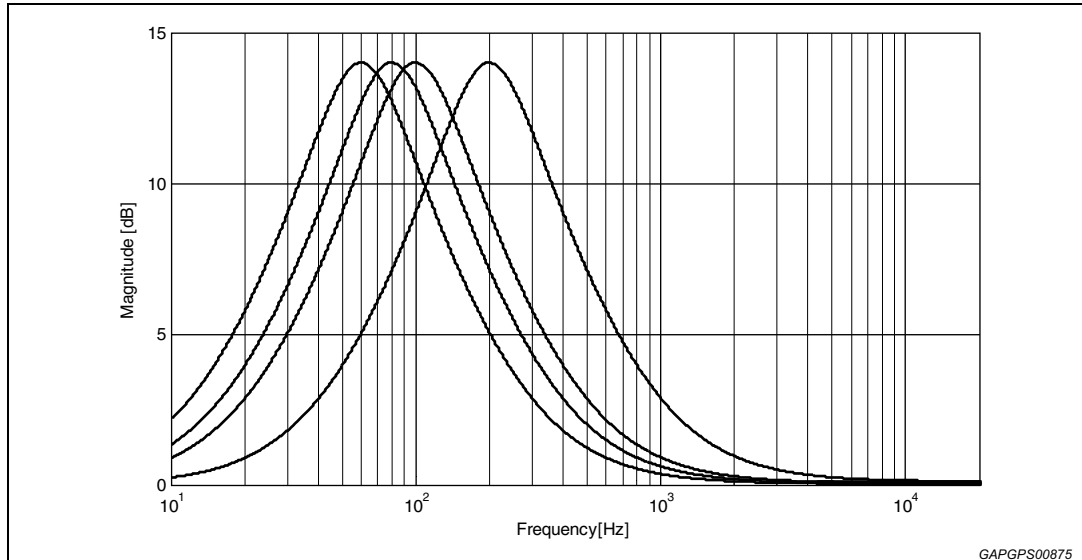
Figure 7. Bass control @ $f_c = 80$ Hz, $Q = 1$



4.6.2 Center frequency

Figure 8 shows the four possible center frequencies 60, 80, 100 and 200 Hz.

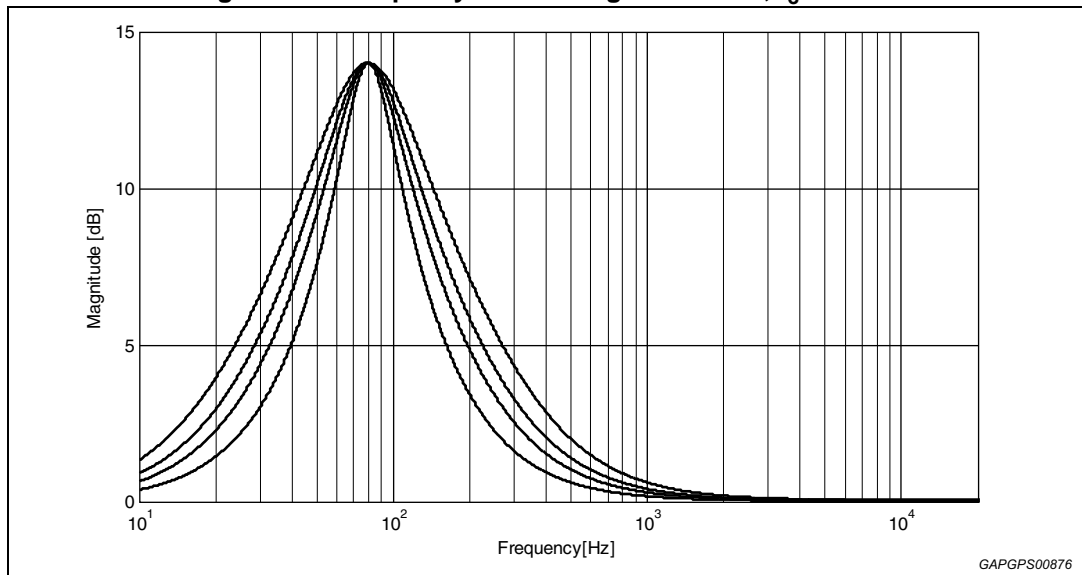
Figure 8. Bass center frequencies @ gain = 14 dB, Q = 1



4.6.3 Quality factors

Figure 9 shows the four possible quality factors 1, 1.25, 1.5 and 2.

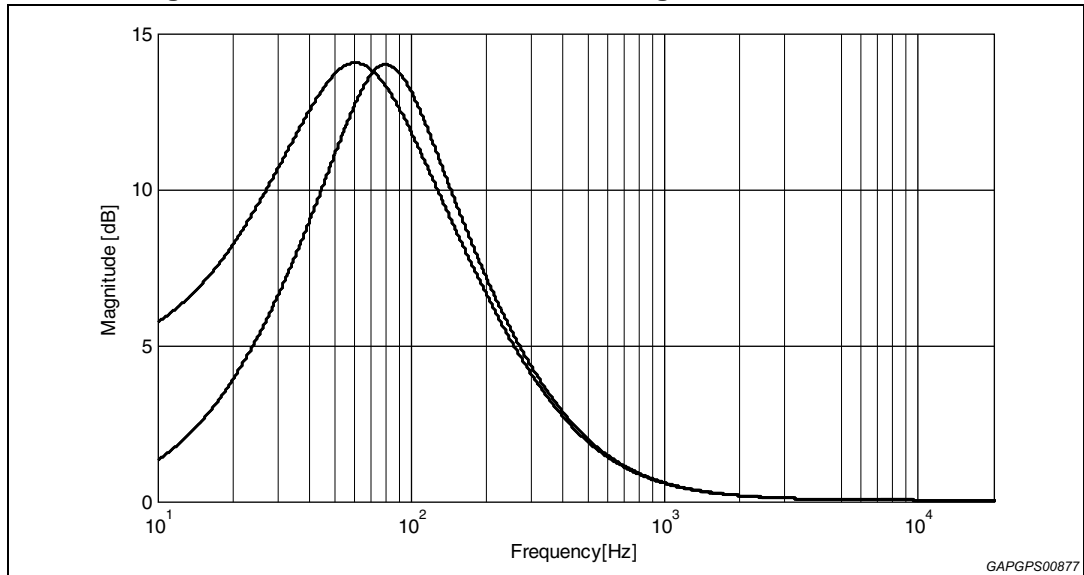
Figure 9. Bass quality factors @ gain = 14 dB, $f_c = 80$ Hz



4.6.4 DC mode

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

Figure 10. Bass normal and DC mode @ gain = 14 dB, $f_c = 80$ Hz



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

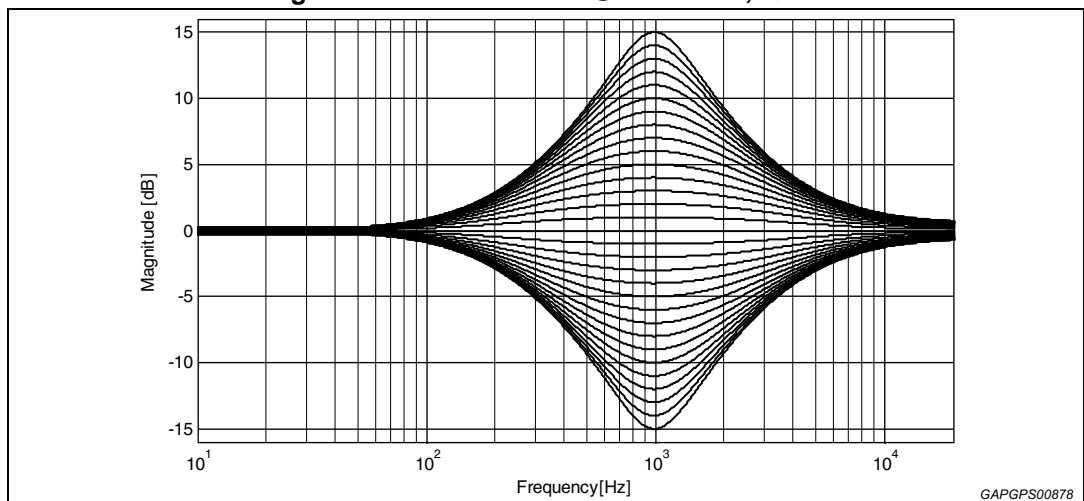
4.7 Middle

There are three parameters programmable in the middle stage.

4.7.1 Middle attenuation

Figure 11 shows the attenuation as a function of frequency at a center frequency of 1 kHz.

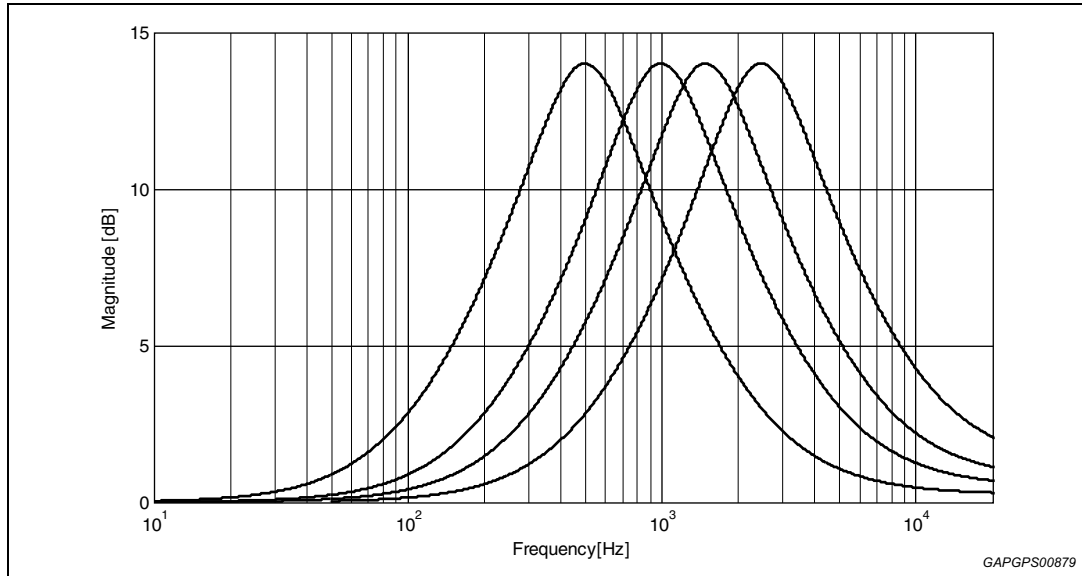
Figure 11. Middle control @ $f_c = 1$ kHz, $Q = 1$



4.7.2 Middle center frequency

Figure 12 shows the four possible center frequencies 500 Hz, 1 kHz, 1.5 kHz and 2.5 kHz.

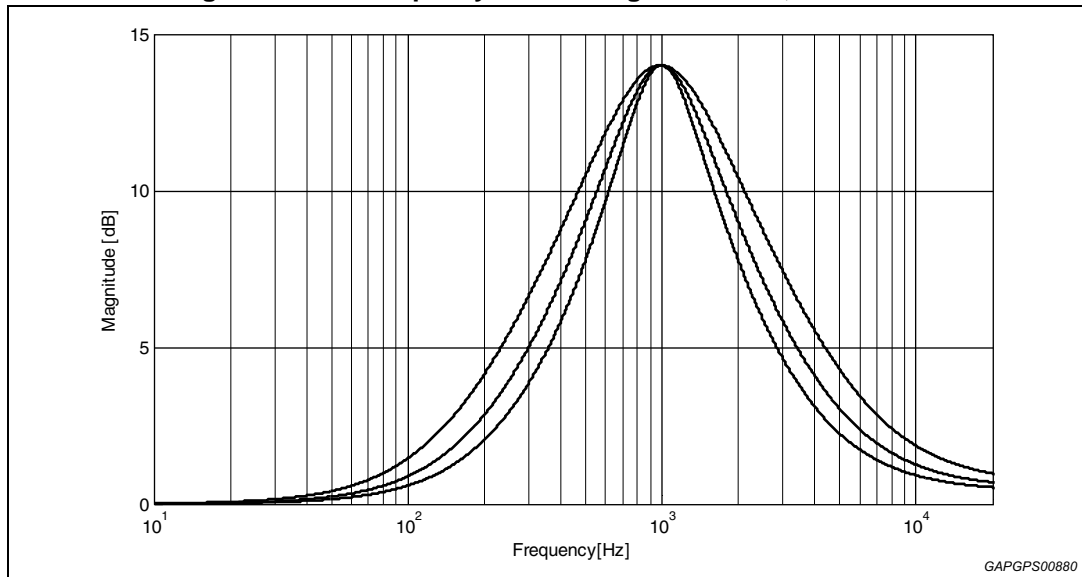
Figure 12. Middle center frequency @ gain = 14 dB, Q = 1



4.7.3 Quality factors

Figure 13 shows the three possible quality factors 0.75, 1 and 1.25.

Figure 13. Middle quality factors @ gain = 14 dB, fc =1 kHz



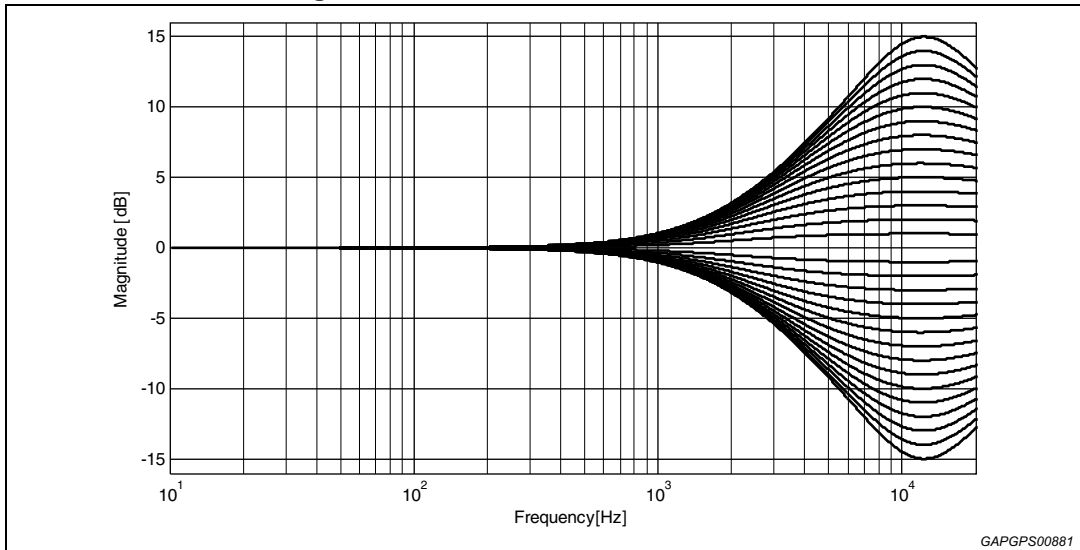
4.8 Treble

There are two parameters programmable in the treble stage.

4.8.1 Treble attenuation

Figure 14 shows the attenuation as a function of frequency at a center frequency of 17.5 kHz.

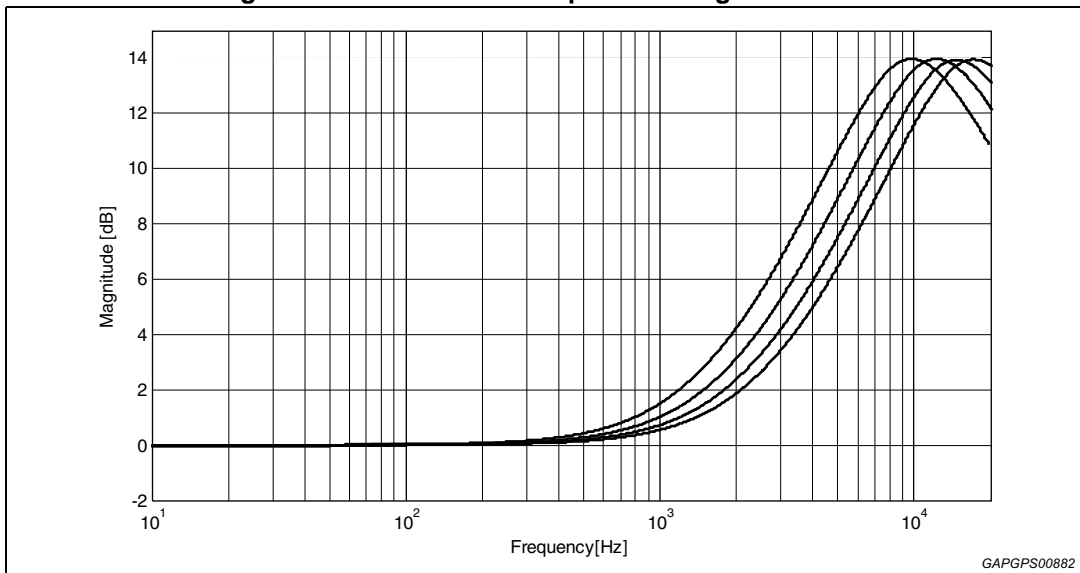
Figure 14. Treble control @ fc = 17.5 kHz



4.8.2 Center frequency

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

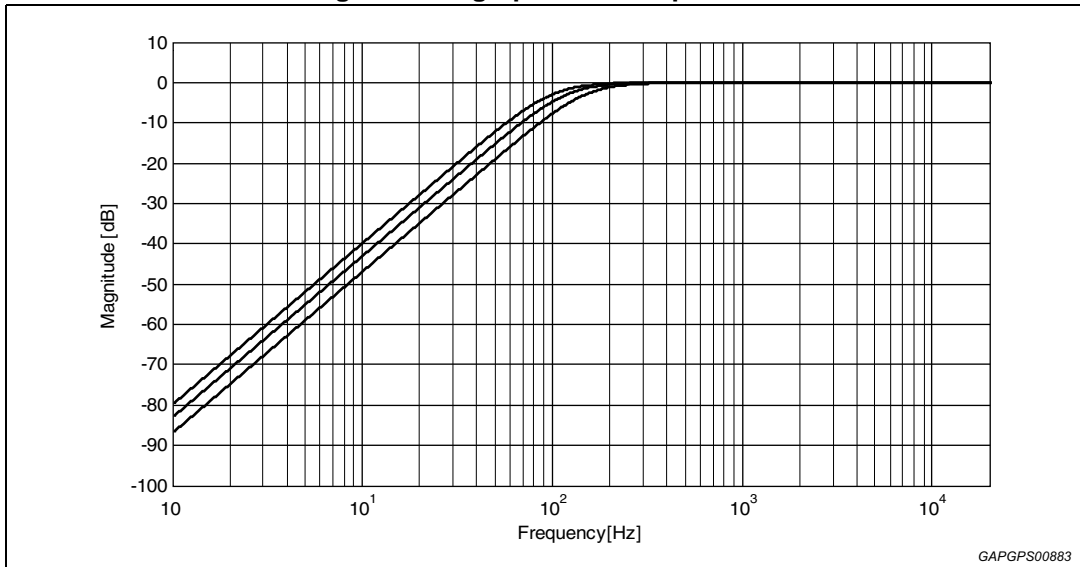
Figure 15. Treble center frequencies @ gain = 14 dB



4.9 High-pass filter

The high-pass filter has 2 order filter characteristics with programmable cut-off frequency (100 / 120 / 150 Hz)

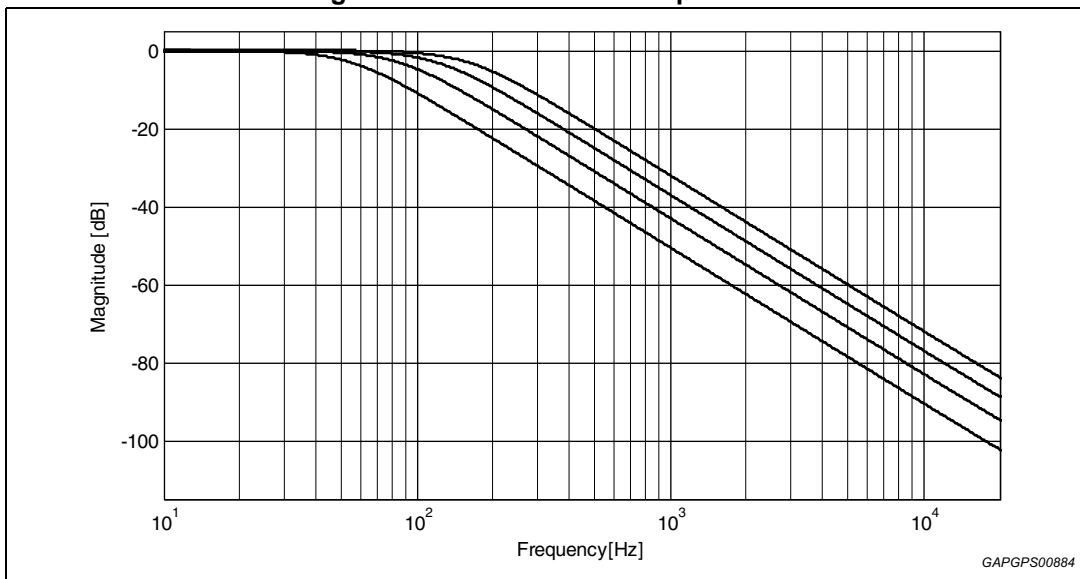
Figure 16. High-pass cut frequencies



4.10 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



4.11 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 will not be started before the completion of 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. Be noticed that if a block is set to 'gain1' with act bit =1, later this block is set to 'gain2' with act bit=0, in this case the block will do a soft-step from present gain to 'gain2' but not from present gain to 'gain1' then to 'gain2'.

Chip Addr	Sub Addr	0xxxxxxx
-----------	----------	----------

← Soft-step start here

Chip Addr	Sub Addr	1xxxxxxx	1xxxxxxx	0xxxxxxx
-----------	----------	----------	----------	-------	----------

← Soft-step start here for all

4.12 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 50 k Ω 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 $\tau = 22.5 \text{ k}\Omega * C_{\text{ext}}$ 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.

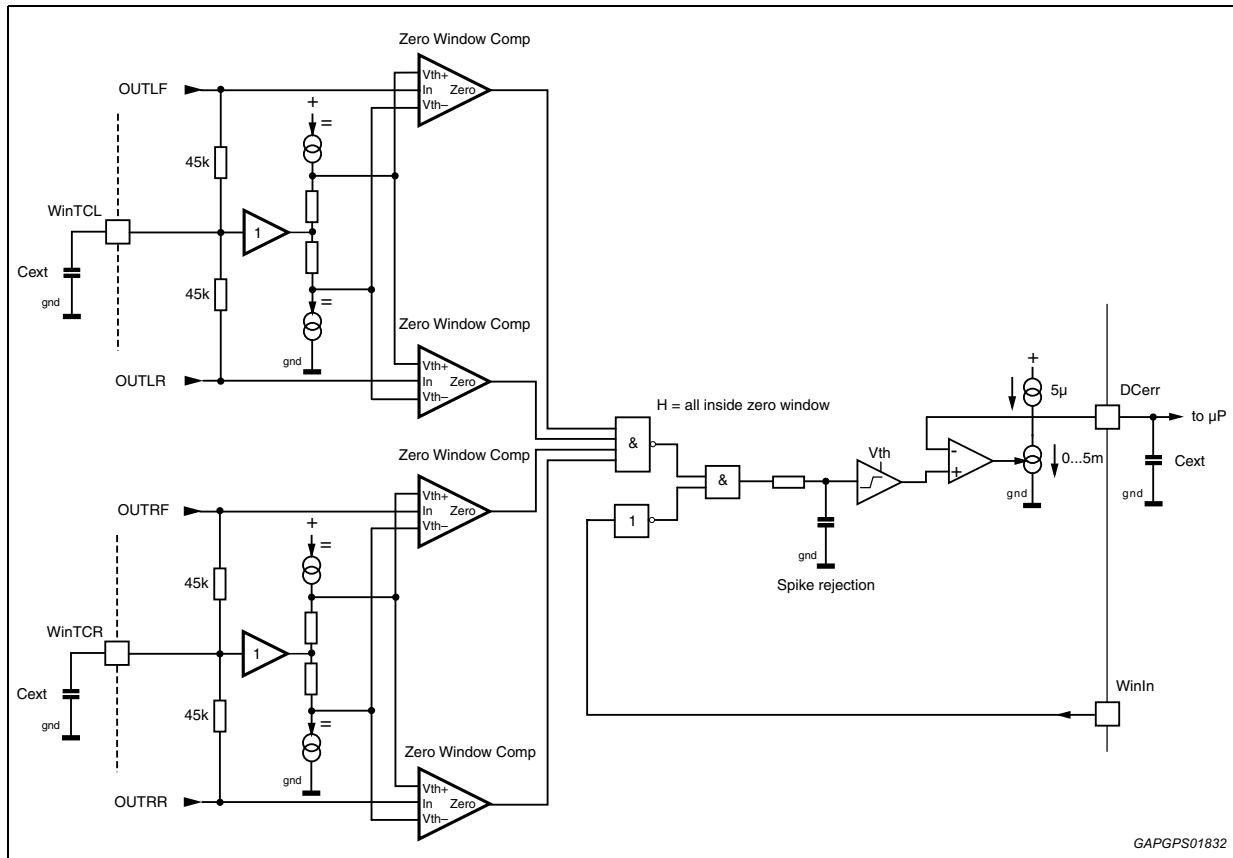
See [Electrical characteristics on page 9](#).

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 V_{winin} 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)



4.13 Output stage

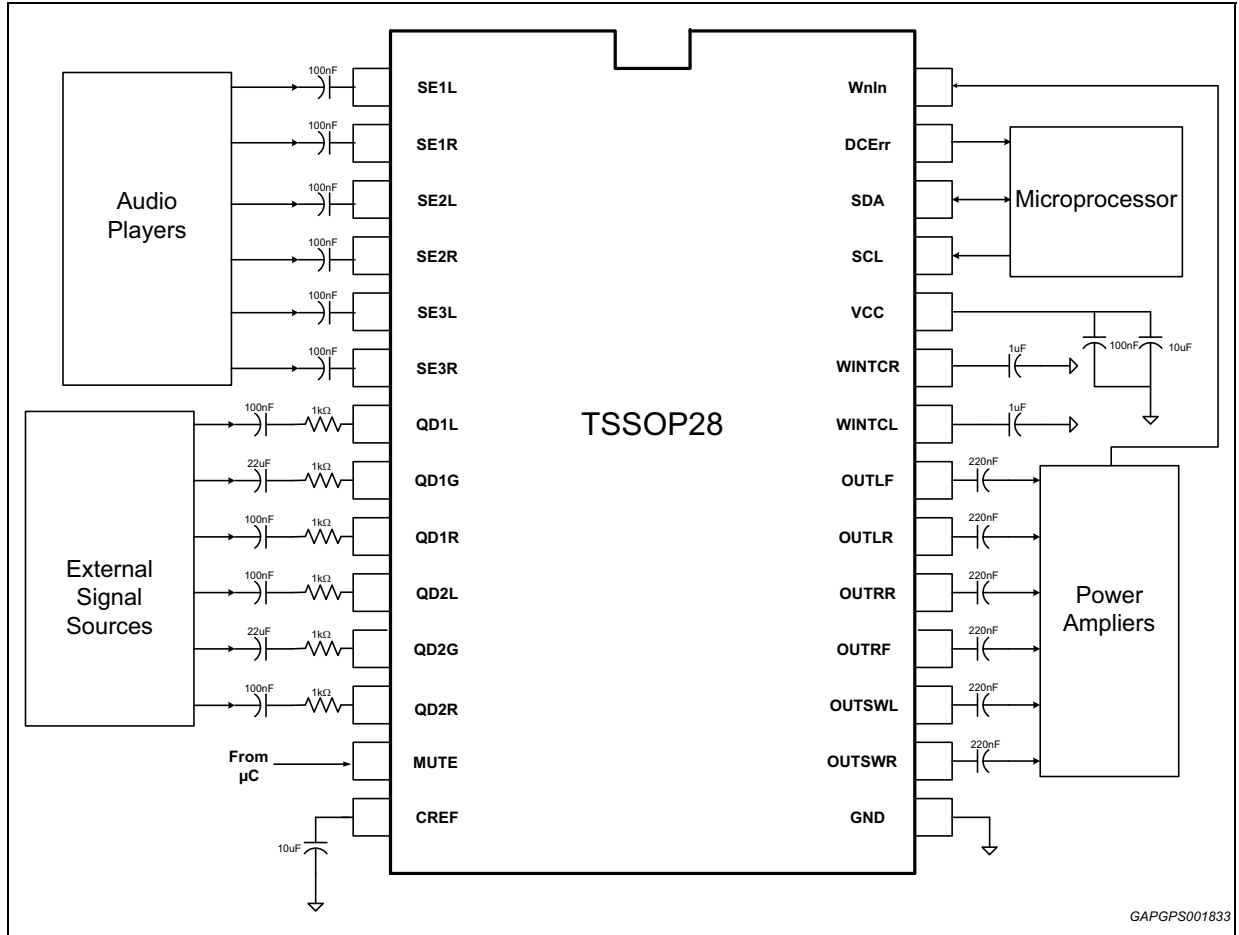
The output gain and output DC voltage is configurable by I²C to fit different application. The configuration is as following:

- AC Gain = 5 dB, DC level = 4 V
- AC Gain = 8 dB, DC level = 5.75 V

4.14 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 QD2G pin. In this mode, the input resistance of 100 kOhm is disconnected from the pin. Internal signals available for testing are listed in the data-byte specification.

Figure 19. Test circuit



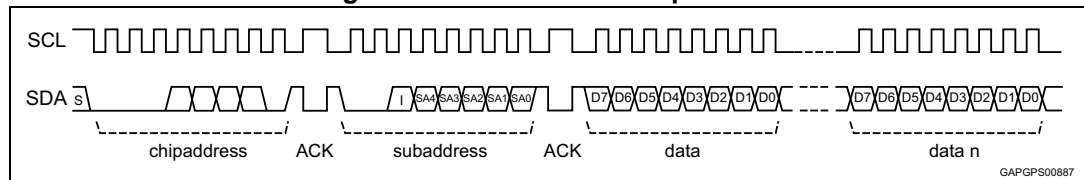
5 I²C bus specification

5.1 Interface protocol

The interface protocol comprises:

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

Figure 20. I²C bus interface protocol



S = Start

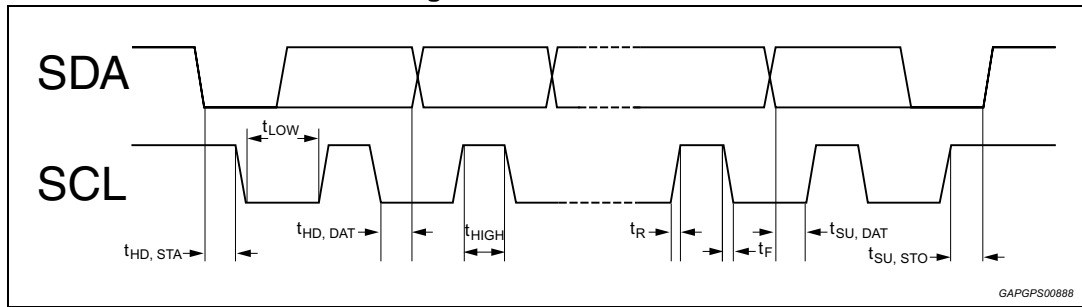
ACK = Acknowledge

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	DAT A	ACK	P
---	---	---	---	---	---	---	---	-----	-----	----	---	----	----	----	----	----	----	-----	-------	-----	---

S = Start

R/W = "0" -> Receive mode (Chip can be programmed by μ P)

"1" -> Transmission mode (Data could be received by μ P)

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 Off	
1	-	-	-	-	-	-	-	On	
-	x	-	-	-	-	-	-	Not used	
-	-	0	-	-	-	-	-	Auto increment mode Off	
-	-	1	-	-	-	-	-	On	
-	-	-	0	0	0	0	0	Main selector	
-	-	-	0	0	0	0	1	Output DC level / highpass	
-	-	-	0	0	0	1	0	Not used	
-	-	-	0	0	0	1	1	Not used	
-	-	-	0	0	1	0	0	Soft-mute / others	
-	-	-	0	0	1	0	1	Soft-step I	
-	-	-	0	0	1	1	0	Soft-step II / DC-detector	
-	-	-	0	0	1	1	1	Loudness	
-	-	-	0	1	0	0	0	Volume / output gain	
-	-	-	0	1	0	0	1	Treble	
-	-	-	0	1	0	1	0	Middle	
-	-	-	0	1	0	1	1	Bass	
-	-	-	0	1	1	0	0	Subwoofer / middle / bass	
-	-	-	0	1	1	0	1	Speaker attenuator left front	
-	-	-	0	1	1	1	0	Speaker attenuator right front	
-	-	-	0	1	1	1	1	Speaker attenuator left rear	
-	-	-	1	0	0	0	0	Speaker attenuator right rear	
-	-	-	1	0	0	0	1	Subwoofer attenuator left	
-	-	-	1	0	0	1	0	Subwoofer attenuator right	
-	-	-	1	0	0	1	1	Testing audio processor 1	
-	-	-	1	0	1	0	0	Testing audio processor 2	
-	-	-	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> 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	
-	-	-	-	x	-	-	-	Not used
-	-	-	0	-	-	-	-	Main source input gain select 0 dB 3 dB
			1					
-	-	0	-	-	-	-	-	Subwoofer flat Off <u>On</u>
		1						
-	0	-	-	-	-	-	-	Subwoofer input source Input mux <u>Bass output</u>
	1							
x	-	-	-	-	-	-	-	Not used

Table 9. Output DC level / highpass (1)

MSB				LSB				Function
D7	D6	D5	D4	D3	D2	D1	D0	
-	-	-	-	-	-	-	-	Not used
-	-	-	-	-	-	0	-	Output DC level 4 V (AC Gain = 5 dB) 5.75 V (AC Gain = 8 dB)
						1		
-	-	-	-	0	0	-	-	High-pass frequency 100 Hz 120 Hz <u>150 Hz</u>
				0	1			
				1	x			
-	-	-	0	-	-	-	-	High-pass enable Off (bypass) <u>On</u>
			1					
x	x	x	-	-	-	-	-	Not used

Table 10. Soft-mute / others (4)

MSB				LSB				Function
D7	D6	D5	D4	D3	D2	D1	D0	
-	-	-	-	-	-	-	0 1	Soft-mute <u>On</u> Off
-	-	-	-	-	-	0 1	-	Pin influence for mute <u>Pin and IIC</u> IIC
-	-	-	-	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 0 1 1	0 1 0 1	-	-	-	-	Speaker-Ls/Rs input selection (OUTSWL & OUTSWR) High Pass filter Subwoofer filter High Pass filter <u>Bass filter</u>
-	0 1	-	-	-	-	-	-	Fast charge On <u>Off</u>
0 1	-	-	-	-	-	-	-	Anti-alias filter On <u>Off (bypass)</u>

Table 11. 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 12. 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 <u>±90 mV</u> ±60 mV ±45 mV <u>±30 mV</u>
0 0 1 1	0 1 0 1	-	-	-	-	-	-	Spike rejection time constant 11 μ s 22 μ s 33 μ s <u>44 μs</u>

Table 13. Loudness (7)

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

Table 14. Volume (8)

MSB							LSB		Function
D7	D6	D5	D4	D3	D2	D1	D0		
								Gain/attenuation	
	0	0	0	0	0	0	0	+0 dB	
	0	0	0	0	0	0	1	+1 dB	
	0	:	:	:	:	:	:	:	
	0	0	0	1	1	1	1	+15 dB	
	0	0	1	0	0	0	0	+16 dB	
	0	:	:	:	:	:	:	:	
	0	0	1	0	1	1	1	+23 dB	
	0	0	1	1	0	0	0	Not used	
	0	:	:	:	:	:	:	:	
	0	0	1	1	1	1	1	Not used	
-	0	1	0	0	0	0	0	-0 dB	
	0	:	:	:	:	:	:	:	
	0	1	0	1	1	1	1	-15 dB	
	0	:	:	:	:	:	:	:	
	0	1	1	1	1	1	0	<u>-30 dB</u>	
	0	1	1	1	1	1	1	-31 dB	
	1	0	0	0	0	0	0	-32 dB	
	1	0	0	0	0	0	1	-33 dB	
	1	:	:	:	:	:	:	:	
	1	0	1	1	1	1	1	-63dB	
	1	1	x	x	x	x	x	Not used	
								Soft-step action	
0	-	-	-	-	-	-	-	Act	
1								<u>Wait</u>	

Table 15. 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	1	0	<u>+1 dB</u>
			:	:	:	:	:	:	:	:
			1	0	0	0	0	0	1	+14 dB
			1	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 16. 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	1	0	<u>+1 dB</u>
			:	:	:	:	:	:	:	:
			1	0	0	0	0	0	1	+14 dB
			1	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 17. 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
			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 18. 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 19. 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 1	-	-	-	-	-	-	-	Soft-step action	
								Act	
								<u>Wait</u>	

Table 20. 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 DCSEL ⁽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	0	DCDet Vth Low		
			0	1	0	1	IntZeroErr		
			0	1	1	0	Ref5V5		
			0	1	1	1	VGB1.95		
			1	0	0	0	Clock200k		
			1	0	0	1	SDCLK		
			1	0	1	0	VrefDCO		
1	0	1	1	REQ_TEST					
1	1	x	x	<u>Reserved</u>					
-	-	0	-	-	-	-	-	Clock fast mode ⁽²⁾	
		1						On <u>Off</u>	

Table 20. Testing audio processor 1 (19) (continued)

MSB							LSB	Function
D7	D6	D5	D4	D3	D2	D1	D0	
-	0 1	-	-	-	-	-	-	Clock source ⁽²⁾ External (MUTE Pin) <u>Internal (200 kHz)</u>
0 1	-	-	-	-	-	-	-	Attenuator gain clock control ⁽²⁾ 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 21. Testing audio processor 2 (20)

MSB							LSB	Function
D7	D6	D5	D4	D3	D2	D1	D0	
-	-	-	-	-	-	-	0 1	Test architecture ⁽¹⁾ <u>Normal</u> Split
-	-	-	-	-	-	0 1	-	Oscillator clock ⁽²⁾ 400 kHz <u>800 kHz</u>
-	-	-	-	-	0 1	-	-	Soft-step curve ⁽²⁾ S-Curve <u>Linear curve</u>
-	-	-	0 0 1 1	0 1 0 1	-	-	-	Manual set busy signal ⁽¹⁾ Auto Auto 0 <u>1</u>
-	-	-	0 0 1 1	0 1 0 1	-	-	-	Request for clk generator ⁽¹⁾ Allow Allow Stopped <u>Stopped</u>
-	-	0 1	-	-	-	-	-	No DCO spike rejection ⁽¹⁾ On <u>Off</u>
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 22. Testing audio processor 3 (21)

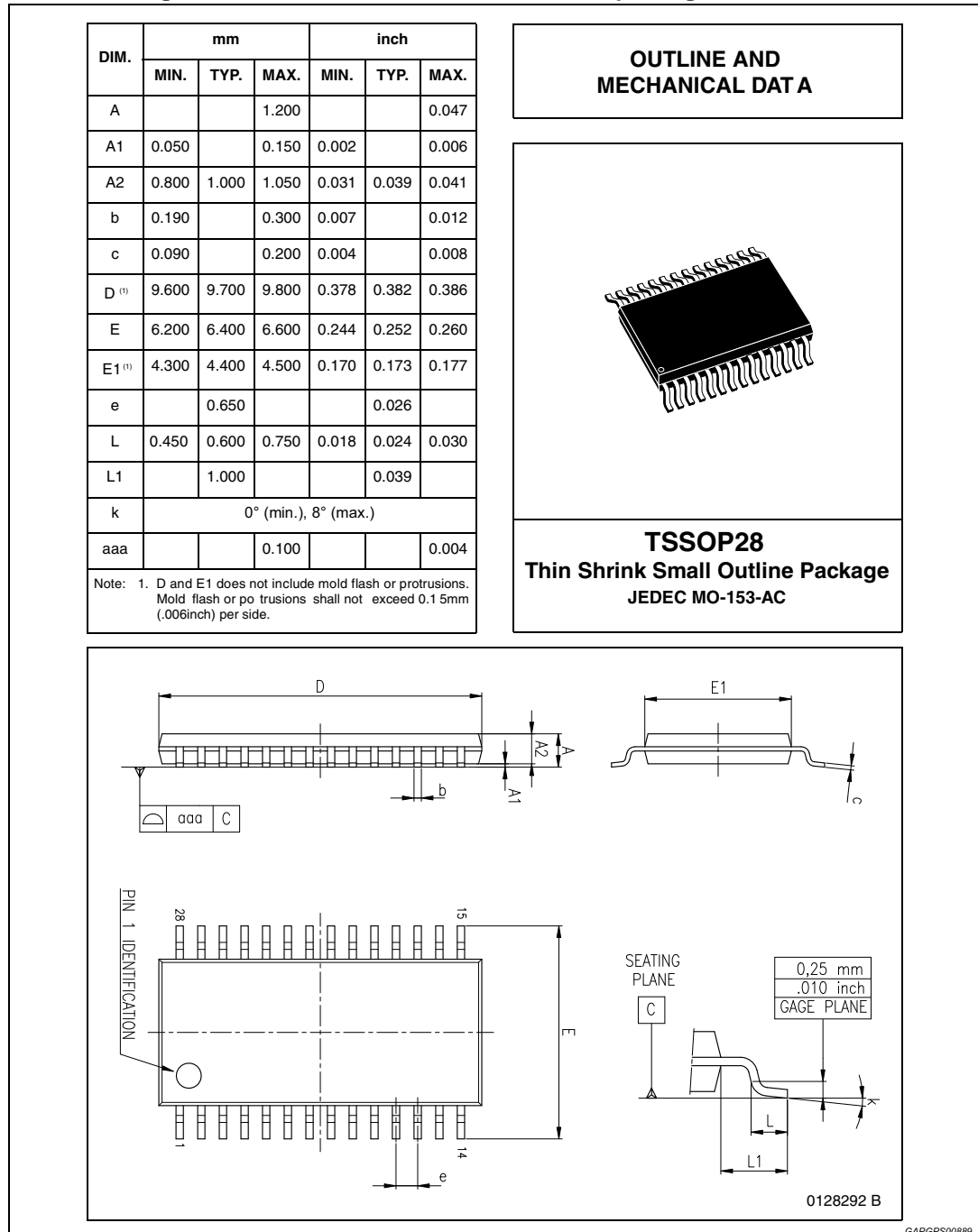
MSB							LSB		Function
D7	D6	D5	D4	D3	D2	D1	D0		
-	-	-	-	-	-	-	0 1	Enable clock for FL/FR/RL/RR/SWL/SWR On <u>Off</u>	
-	-	-	-	-	-	0 1	-	Enable clock for volume On <u>Off</u>	
-	-	-	-	-	0 1	-	-	Enable clock for treble and bass On <u>Off</u>	
-	-	-	-	0 1	-	-	-	Enable clock for loudness and middle On <u>Off</u>	
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 23. Document revision history

Date	Revision	Changes
01-Mar-2013	1	Initial release.
16-Sept-2013	2	Updated Disclaimer

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