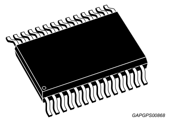
5 band car audio processor

Datasheet - production data



TSSOP28

Features

- Input multiplexer
  - QD1 to QD2: quasi-differential stereo input
  - SE1 to SE3: stereo single-ended input
- InGain
  - 6 dB with 1 dB steps
- Loudness
  - 2^{nd} 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 -79 dB with 1 dB step resolution
  - SoftStep control with programmable blend times
- EQ1
  - 2^{nd} order frequency response
  - Center frequency programmable in 4 steps (63 Hz / 80 Hz/ 100 Hz /125 Hz)
  - Q programmable in 4 steps (1.0/1.25/1.5/2.0)
  - -15 to 15 dB range with 1 dB resolution
- EQ2
  - 2^{nd} order frequency response
  - Center frequency programmable in 4 steps (200 Hz/ 250 Hz/ 315 Hz/ 400 Hz)
  - Q programmable in 4 steps (1.0/1.25/1.5/2.0)
  - -15 to 15 dB range with 1 dB resolution
- EQ3
  - 2^{nd} order frequency response
  - Center frequency programmable in 4 steps (630 Hz/ 800 Hz/ 1 kHz/ 1.25 kHz)
  - Q programmable in 4 steps (0.75/1.0/1.25/2)
  - -15 to 15 dB range with 1 dB resolution
- EQ4
  - 2^{nd} order frequency response
  - Center frequency programmable in 4 steps (2 kHz/ 2.5 kHz/ 3.15 kHz/ 4 kHz)
  - Q programmable in 4 steps (0.75/1.0/1.25/2)
  - -15 to 15 dB range with 1 dB resolution
- EQ5
  - 2^{nd} order frequency response
  - Center frequency programmable in 4 steps (6.3 kHz/ 8 kHz / 10 kHz/ 12.5 kHz)
  - Q programmable in 4 steps (0.75/1.0/1.25/2)
  - -15 to 15 dB range with 1 dB resolution
- Highpass
  - 2^{nd} order frequency response
  - Center frequency programmable in 5 steps (63 Hz / 100 Hz / 120 Hz / 150 Hz/ 180 Hz)
- Subwoofer
  - 2^{nd} order low pass filter
  - Programmable cut off frequency
  - (55 Hz / 85 Hz / 120 Hz / 160 Hz)
- Speaker
  - 6 independent soft step speaker controls
  - +15 dB to -79 dB with 1 dB steps
  - Three selectable output DC level
  - Direct mute
- Mute functions
  - Direct mute
  - Digitally controlled SoftMute 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

Table 1. Device summary

Order code	Package	Packing
TDA7721	TSSOP28	Tube
TDA7721TR	TSSOP28	Tape and reel

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1 Description and block diagram

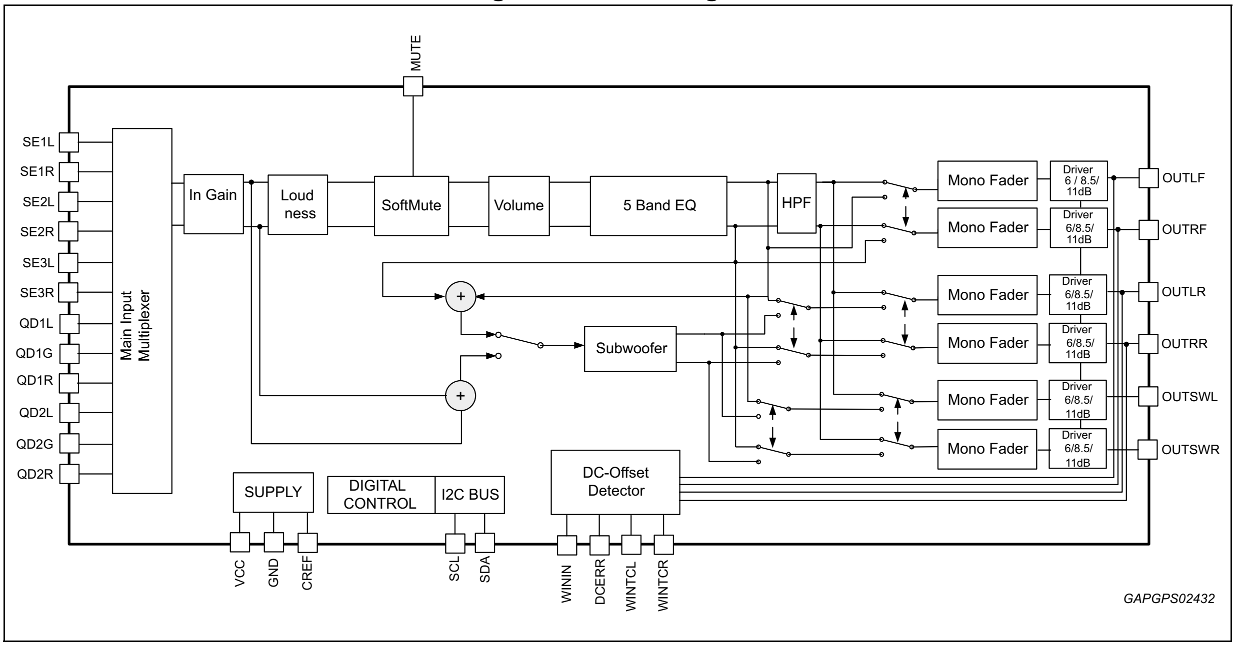
1.1 Description

The TDA7721 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 SoftStep architecture. The digital control allows programming in a wide range of filter characteristics.

1.2 Block diagram

Figure 1. Block diagram



2 Pin connections and description

2.1 Pin connections

Figure 2. Pin connections (top view)

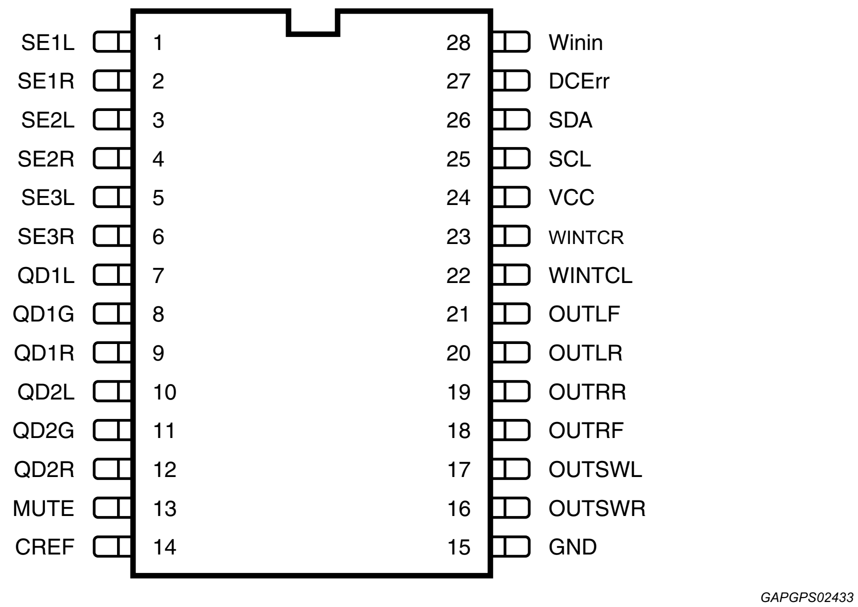


Table 2. Pin description

N#	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
14	CREF	Reference capacitor	O
15	GND	Ground	S

Table 2. Pin description (continued)

N#	Pin name	Description	I/O
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^2C bus clock	I
26	SDA	I^2C bus data	I/O
27	DCERR	DC offset detector output	O
28	WININ	DC offset detector input	I

3 Electrical specifications

3.1 Thermal data

Table 3. Thermal data

Symbol	Description	Value	Unit
$R_{th\text{-}jamb}$	Thermal resistance junction-to-ambient	114	°C/W

3.2 Absolute maximum ratings

Table 4. Absolute maximum ratings

Symbol	Parameter	Value	Unit
V_S	Operating supply voltage	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

3.3 Electrical characteristics

V_s =11.5 V; T_{amb} = 25 °C; R_L = 10 kΩ; all gains = 0 dB; f = 1 kHz; Output gain = 6 dB; Input = SE1; unless otherwise specified

Table 5. Electrical characteristics

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
Supply						
Vs	Supply voltage	-	4.5	8.5	13	V
Is	Supply current	-	33	40	47	mA
Input selector						
R_{in}	Input resistance clipping level	All single ended inputs	70	100	130	kΩ
V_{CL}		Input gain = 0dB, when $V_{CC} \geq 5$ V THD = 1%	0.9	1.06	-	V_{RMS}
		Input gain = 0dB, when V_{CC} = 4.5 V THD = 1%	0.6	0.707		V_{RMS}
S_{IN}	Input separation	-	80	100		dB
V_{ib}	Input bias voltage	All single-ended and differential stereo inputs	2.3	2.5	2.7	V
Differential stereo inputs						
R_{in}	Input resistance	Differential	70	100	-	kΩ

Table 5. Electrical characteristics (continued)

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
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	46	60	-	dB
Loudness control						
A_{MAX}	Max attenuation	-	14	15	16	dB
A_{STEP}	Step resolution	-	0.5	1	1.5	dB
f_{Peak}	Peak frequency(1)	f_{P1}	-	400	-	Hz
		f_{P2}	-	800	-	Hz
		f_{P3}	-	2400	-	Hz
IN gain						
G_{MAX}	Max Gain(2)	-	5	6	7	dB
A_{STEP}	Step resolution	-	0.5	1	1.5	dB
E_T	Tracking error	-			2	dB
V_{DC}	DC steps	Adjacent gain steps	-5	0.5	5	mV
Volume control						
G_{MAX}	Max gain(2)	-	21	23	25	dB
A_{MAX}	Max attenuation	-	-83	-79	-75	dB
A_{STEP}	Step resolution	-	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 -79 dB	-4	0	3	dB
E_T	Tracking error	-			2	dB
V_{DC}	DC steps	Adjacent attenuation steps	-3	0.1	3	mV
		Adjacent gain step from +23dB to +15dB	-15	-	15	mV
		Adjacent gain step From +15dB to 0dB	-5	-	5	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	0.3	7.6	7.9	ms
		T_4	14	15.3	16.8	ms
V_{TH_Low}	Low threshold for MUTE pin(3)	-	-	-	1	V
V_{TH_High}	High threshold for MUTE pin(3)	-	2.5	-	-	V
RPU	Internal pull-up resistor for MUTE pin(3)	-	32	45	58	k

Table 5. Electrical characteristics (continued)

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
VPU	Internal pull-up Voltage for MUTE Pin(3)	-	-	3.3	-	V
EQ1 control						
C_{RANGE}	Control range(2)	-	14	15	16	dB
A_{STEP}	Step resolution	-	0.5	1	1.5	dB
F_c	Center frequency(1)	f_{C1}	-	63	-	Hz
		f_{C2}	-	80	-	Hz
		f_{C3}	-	100	-	Hz
		f_{C4}	-	125	-	Hz
Q1	Quality factor(1)	Q1	-	1.0	-	-
		Q2	-	1.25	-	-
		Q3	-	1.5	-	-
		Q4		2	-	-
EQ2 control						
C_{RANGE}	Control range(2)	-	14	15	16	dB
A_{STEP}	Step resolution	-	0.5	1	1.5	dB
F_c	Center frequency(1)	f_{C1}	-	200	-	Hz
		f_{C2}	-	250	-	Hz
		f_{C3}	-	315	-	Hz
		f_{C4}	-	400	-	Hz
Q2	Quality factor(1)	Q1	-	1.0	-	-
		Q2	-	1.25	-	-
		Q3	-	1.5	-	-
		Q4	-	2	-	-
EQ3 control						
C_{RANGE}	Control range(2)	-	14	15	16	dB
A_{STEP}	Step resolution	-	0.5	1	1.5	dB
F_c	Center frequency(1)	f_{C1}	-	630	-	Hz
		f_{C2}	-	800	-	Hz
		f_{C3}	-	1	-	kHz
		f_{C4}	-	1.25	-	kHz

Table 5. Electrical characteristics (continued)

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
Q3	Quality factor(1)	Q1	-	0.75	-	-
		Q2	-	1.0	-	
		Q3	-	1.25	-	-
		Q4	-	2.0	-	-
EQ4 control						
C_{RANGE}	Control range(2)	-	14	15	16	dB
A_{STEP}	Step resolution(1)	-	0.5	1	1.5	dB
F_c	Center frequency(1)	f_{C1}	-	2	-	kHz
		f_{C2}	-	2.5	-	kHz
		f_{C3}	-	3.15	-	kHz
		f_{C4}	-	4	-	kHz
Q_4	Quality factor	Q1	-	0.75	-	-
		Q2	-	1.0	-	-
		Q3	-	1.25	-	-
		Q4	-	2.0	-	-
EQ5 control						
C_{RANGE}	Control range(2)	-	14	15	16	dB
A_{STEP}	Step resolution	-	0.5	1	1.5	dB
F_c	Center frequency(1)	f_{C1}	-	6.3	-	kHz
		f_{C2}	-	8	-	kHz
		f_{C3}	-	10	-	kHz
		f_{C4}	-	12.5	-	kHz
Q_5	Quality factor(1)	Q1	-	0.75	-	-
		Q2	-	1.0	-	-
		Q3	-	1.25	-	-
		Q4	-	2.0	-	-
Speaker attenuators						
G_{MAX}	Max gain(2)	-	14	15	16	dB
A_{MAX}	Max attenuation	-	-83	-79	-75	dB
A_{STEP}	Step resolution	-	0.5	1	1.5	dB
A_{MUTE}	Mute attenuation	-	80	90		dB
E_A	Attenuation set error	G = -20 to +15 dB	-0.75	0	+0.75	dB
		G = -20 to -79 dB	-4	0	3	dB

Table 5. Electrical characteristics (continued)

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
V_{DC}	DC Steps	Adjacent attenuation steps	-5	0.1	5	mV
		Adjacent gain steps	-10	0.5	10	
HPF						
F_{HP}	Highpass corner frequency(1)	f_{HP1}	-	63	-	Hz
		f_{HP2}	-	100	-	Hz
		f_{HP3}	-	120	-	Hz
		f_{HP4}	-	150	-	Hz
		f_{HP5}	-	180	-	Hz
Audio outputs						
V_{CL}	Clipping level	THD = 1%; V_{CC} = 6 V option1	1.9	2.0	-	V_{RMS}
		THD = 1%; V_{CC} = 8.2 V option2	2.5	2.6	-	V_{RMS}
		THD = 1%; V_{CC} = 11.5 V option3	3.3	3.6	-	V_{RMS}
		THD = 1%; V_{CC} = 4.5 V option1	0.8	0.92	-	V_{RMS}
		THD = 1%; V_{CC} = 4.5 V option2	0.15	0.21	-	V_{RMS}
R_{OUT}	Output impedance	-	-	30	100	Ω
R_L	Output load resistance	-	2	-	-	kΩ
C_L	Output load capacitor	-	-	-	10	nF
V_{DC}	Output DC level	Option1: Output level = 3 V	2.85	3	3.15	V
		Option2: Output level = 4 V	3.8	4	2	V
		Option3: Output level = 5.75 V; V_{CC} > 6.5 V	5.5	5.75	6	V
G_{OUT}	Output gain	Option1:Output level/gain = 3 V/6 dB	5	6	7	dB
		Option2: Output level/gain = 4 V/8.5 dB	7.5	8.5	9.5	dB
		Option3: Output level/gain = 5.75V/11dB	10	11	12	dB
Subwoofer lowpass						
f_{LP}	Lowpass corner frequency(1)	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	±15	±30	±45	mV
		V_2	±20	±45	±65	mV
		V_3	±30	±60	±90	mV
		V_4	±60	±90	±120	mV

Table 5. Electrical characteristics (continued)

Symbol	Parameter	Test condition		Min.	Typ.	Max.	Unit
τ_{sp}	Max rejected spike length	-		-	11	-	µs
		-		-	22	-	µs
		-		-	33	-	µs
		-		-	44	-	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	3.5	V
V_{OutH}	DCErr low voltage	-		0	100	300	mV
V_{TH_Low}	Low threshold for WinIn Pin(3)	-		-	-	1	V
V_{TH_High}	High threshold for WinIn Pin(3)	-		2.5	-	-	V
RPU	Internal pull-up resistor for WinIn Pin	-		35	50	65	kΩ
VPU	Internal pull-up voltage for WinIn Pin	-		3.1	3.3	3.5	V
General							
e_{NO}	Output Noise	BW = 20 Hz-20 kHz A-Weighted, all gain = 0 dB, HPF = OFF, Input = SE/QD	Output level/gain = 3 V/6 dB	-	20	25	µV
			Output level/gain = 4 V/8.5 dB	-	27	30	µV
			Output level/gain = 5.75 V/11 dB	-	36	40	µV
		BW = 20 Hz-20kHz A-Weighted, Output muted	Output level/gain = 3 V/6 dB	-	6.6	10	µV
			Output level/gain = 4 V /8.5 dB	-	8	12	µV
			Output level/gain =5.75V/11dB	-	10	15	µV
S/N	Signal to noise ratio	all gain = 0dB, A-weighted;	Output level/gain = 3 V/6 dB	98	100	-	dB
			Output level/gain = 4 V/8.5 dB	98	100	-	dB
			Output level/gain=5.75V/11dB	98	100	-	dB

Table 5. Electrical characteristics (continued)

Symbol	Parameter	Test condition		Min.	Typ.	Max.	Unit
D	Distortion	$VIN=0.5V_{RMS;}$ all gain = 0dB, HPF=OFF	Output level/gain=3V/6dB(5V)	-	0.01	0.1	%
			Output level/gain=4V/8.5dB(6V)	-	0.01	0.1	%
			Output level/gain=5.75V/11dB(8.5V)	-	0.01	0.1	%
S_C	Channel separation left/right	-		75	90	-	dB

1. Value guaranteed by measuring correlated parameter.
2. Measure performed in DC.
3. 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 kΩ.

4.1.2 Quasi-differential stereo Input (QD1,QD2)

The QD input is implemented as a buffered quasi-differential stereo stage with 100 kΩ input-impedance at each input. There is 0 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 powered-on, the "fast-charge" switches are automatically turned on, for normal operations 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 0~6dB input gain is selectable to compensate the different input signal.

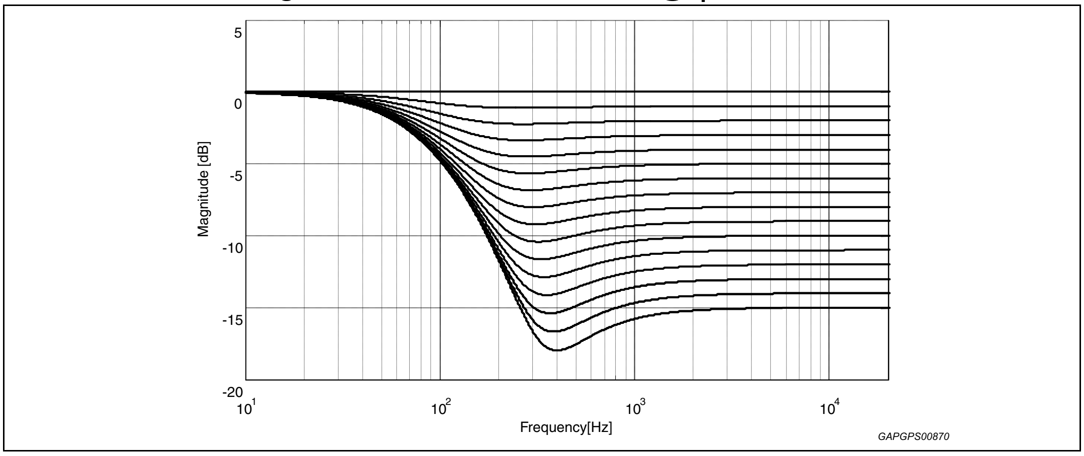
4.3 Loudness

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

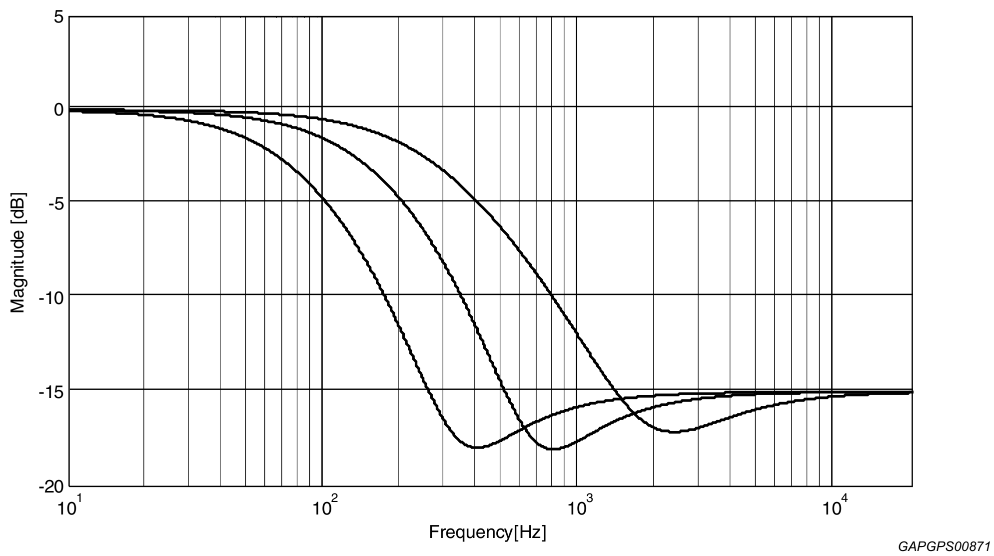
Figure 3. Loudness attenuation @ f_P = 400 Hz



4.3.2 Peak frequency

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

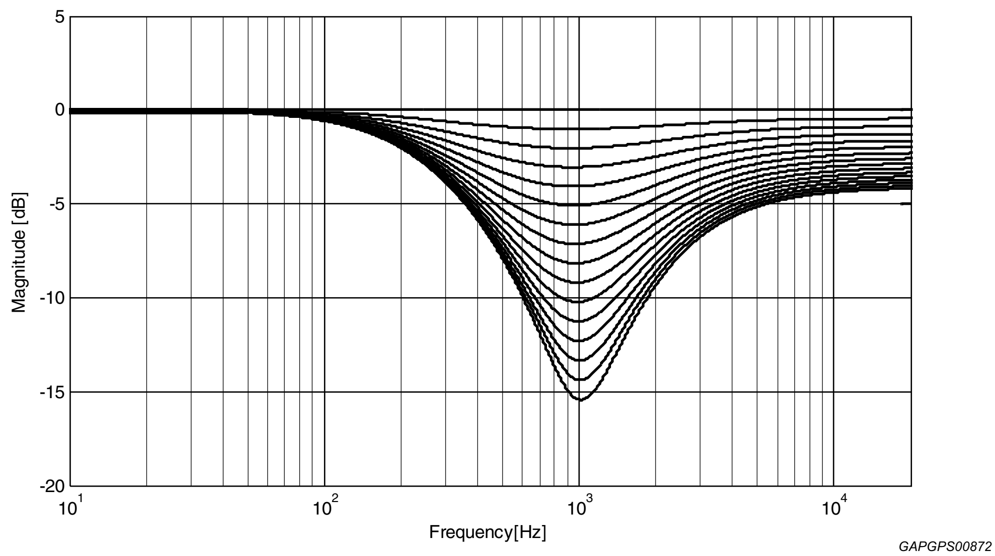
Figure 4. loudness center frequencies @ attn. = 15 dB



4.3.3 High frequency boost

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

Figure 5. Loudness attenuation, f_c = 2.4 kHz



4.3.4 Flat mode

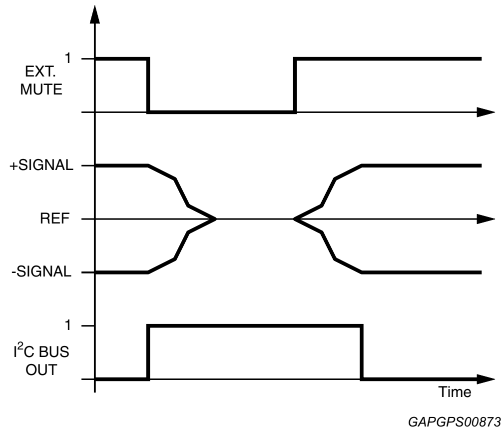
In flat mode the loudness stage works as a 0 dB to -15 dB attenuator.

4.4 SoftMute

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

Figure 6. SoftMute 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 be either a DC-Offset before the volume-stage or the sudden change in the envelope of the audio signal. With the SoftStep-feature both kinds of clicks could be reduced to a minimum and are no more audible. The blend-time from one step to the next is programmable as 5 ms or 10 ms. The SoftStep control is described in detail in Section 4.13.

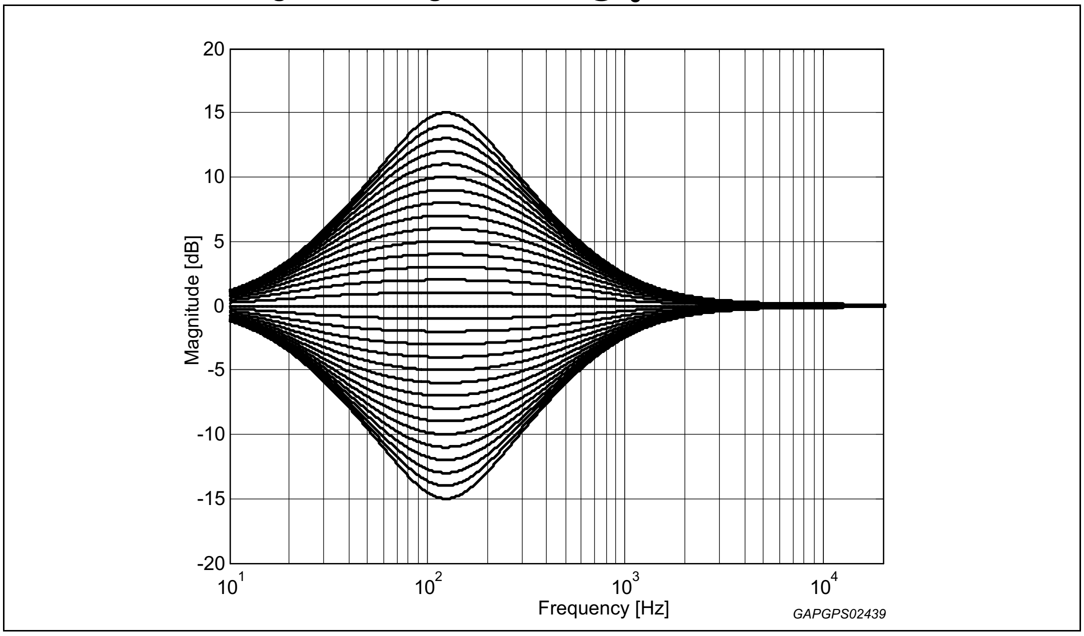
4.6 EQ1

There are three parameters programmable in the EQ1 stage.

4.6.1 EQ1 attenuation

Figure 7 shows the attenuation as a function of frequency at 125 Hz.

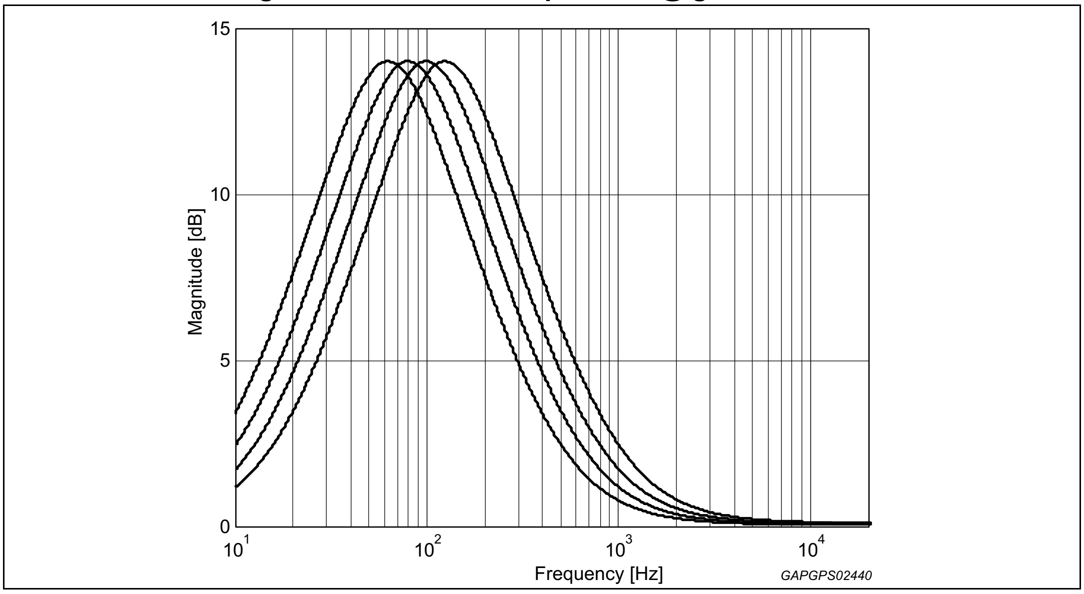
Figure 7. EQ1 gain control @ f_c = 125 Hz, Q = 1



4.6.2 Center frequency

Figure 8 shows the four possible center frequencies 63 Hz/ 80 Hz / 100 Hz/ 125 Hz.

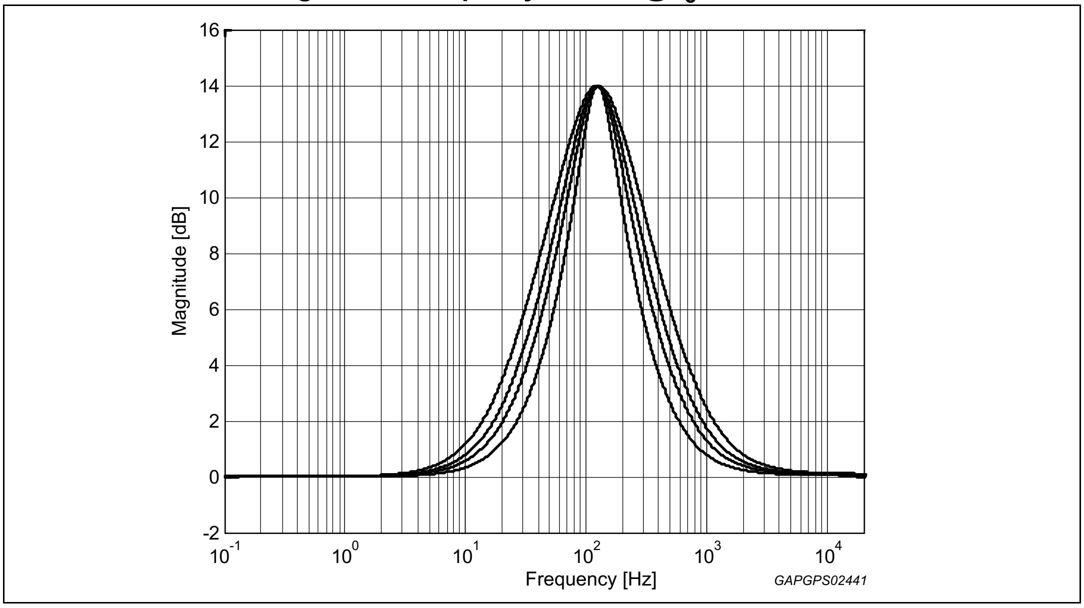
Figure 8. EQ1 center frequencies @ gain = 14 dB



4.6.3 EQ1 quality factor

Figure 9 shows the four possible quality factors (1.0/1.25/1.5/2) when f_c is 125 Hz.

Figure 9. EQ1 quality factors @ f_c = 125 Hz



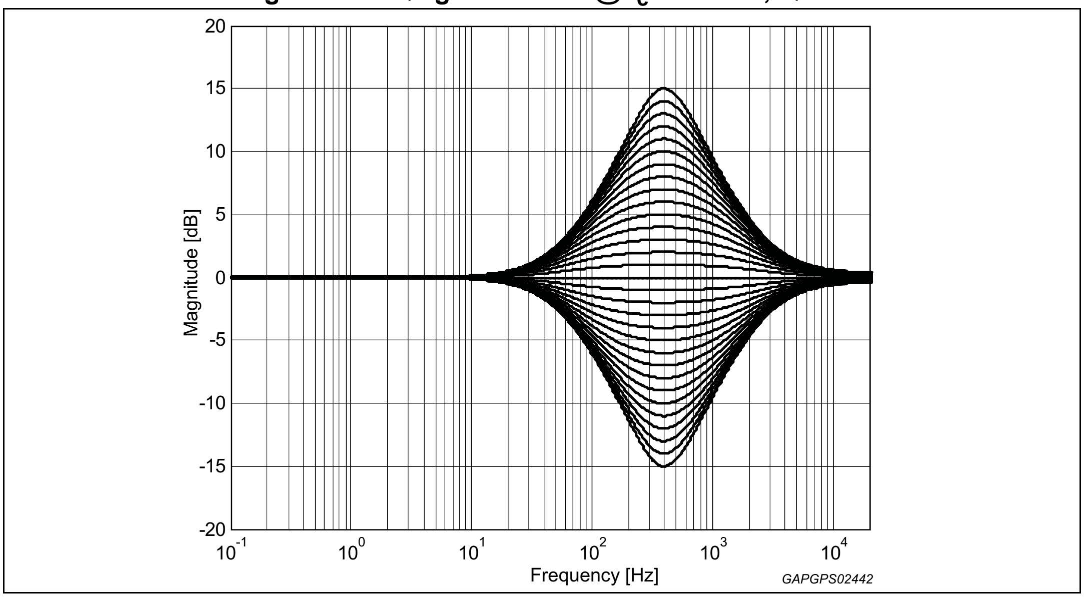
4.7 EQ2

There are three parameters programmable in the EQ2 stage.

4.7.1 EQ2 attenuation

Figure 10 shows the attenuation as a function of frequency at 400 Hz when Q = 1.

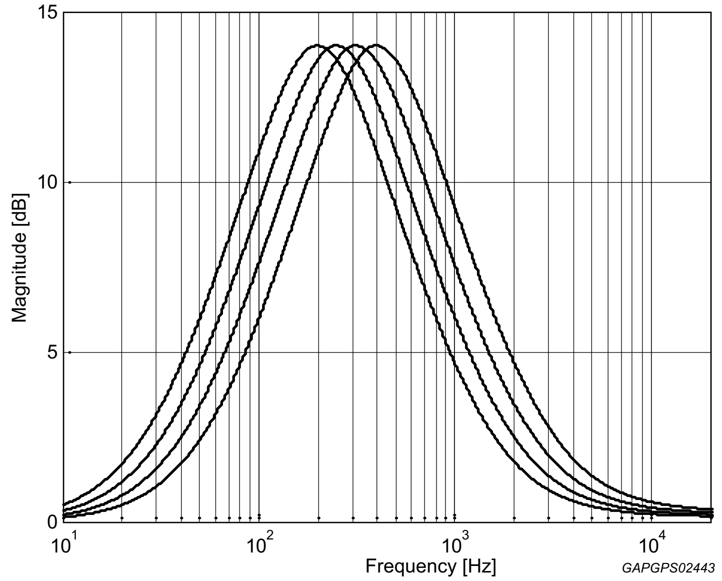
Figure 10. EQ2 gain control @ f_c = 400 Hz, Q = 1



4.7.2 EQ2 center frequency

Figure 11 shows the four possible center frequencies 200/250/315/400 Hz.

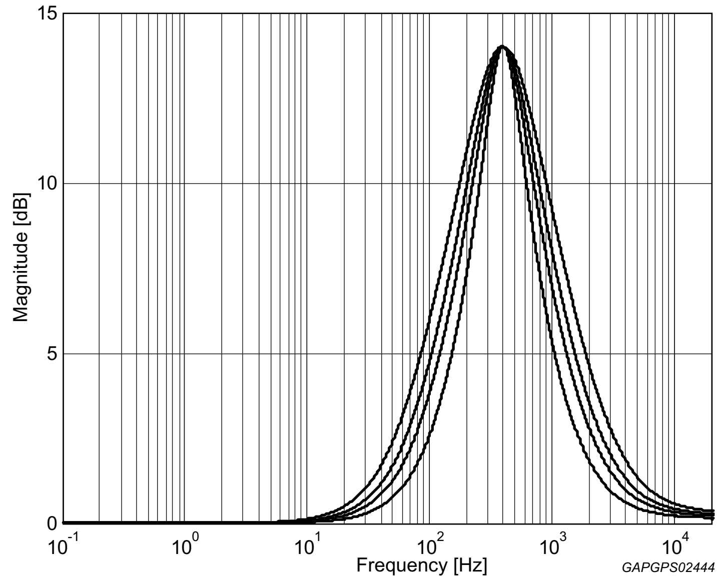
Figure 11. EQ2 center frequency @ gain = 14 dB



4.7.3 EQ2 quality factor

Figure 12 shows the four possible quality factors (1.0/1.25/1.5/2) when f_c is 400 Hz.

Figure 12. EQ2 quality factors @ f_c = 400 Hz



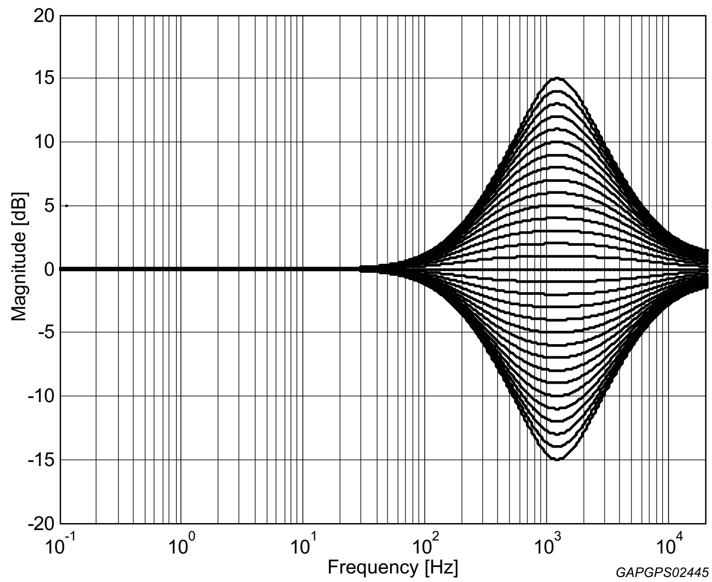
4.8 EQ3

There are three parameters programmable in the EQ3 stage.

4.8.1 EQ3 attenuation

Figure 13 shows the attenuation as a function of frequency at a center frequency of 1.25kHz.

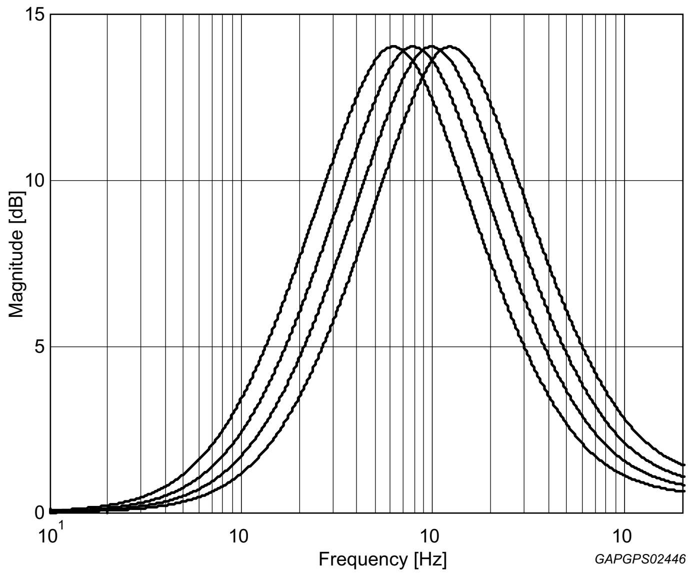
Figure 13. EQ3 gain control @ f_C = 1.25 kHz, Q = 1



4.8.2 Center frequency

Figure 14 shows the four possible center frequencies 630 Hz, 800 Hz, 1 kHz, 1.25 kHz.

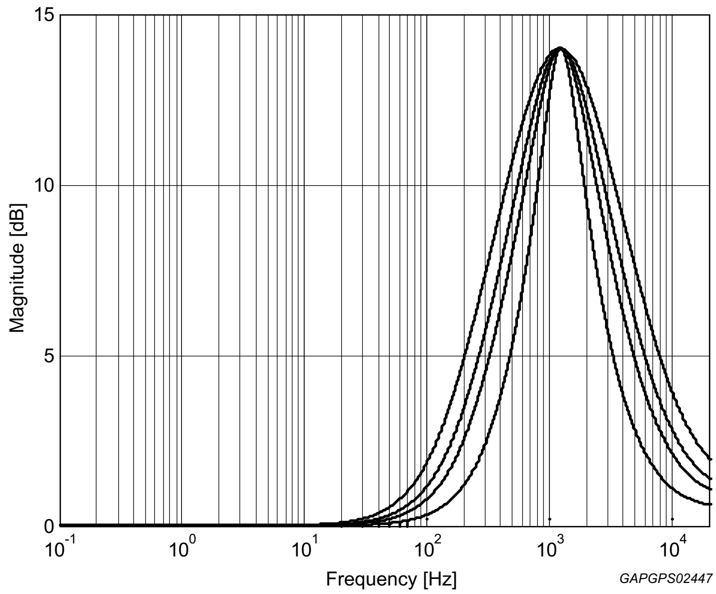
Figure 14. EQ3 center frequencies @ gain = 14 dB



4.8.3 EQ3 quality factor

Figure 15 shows the four possible quality factors (0.75/1.0/1.25/2.0) when f_c is1.25 kHz.

Figure 15. EQ3 quality factors @ f_c = 1.25 kHz



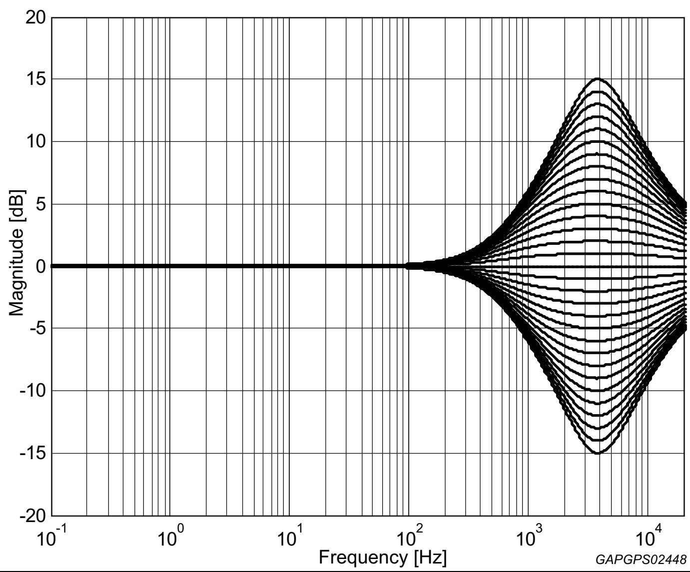
4.9 EQ4

There are three parameters programmable in the EQ4 stage.

4.9.1 EQ4 attenuation

Figure 16 shows the attenuation as a function of frequency at a center frequency of 4 kHz.

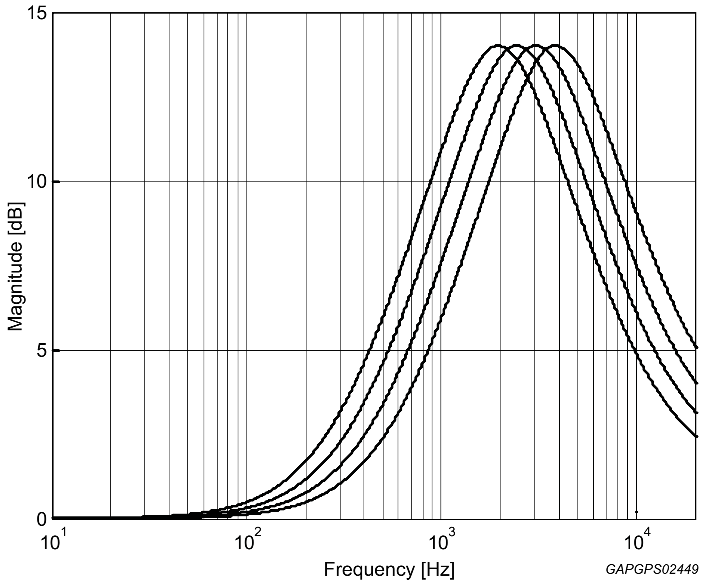
Figure 16. EQ4 gain control @ f_c = 4 kHz, Q = 1



4.9.2 Center frequency

Figure 17 shows the four possible center frequencies 2/2.5/3.15/4kHz.

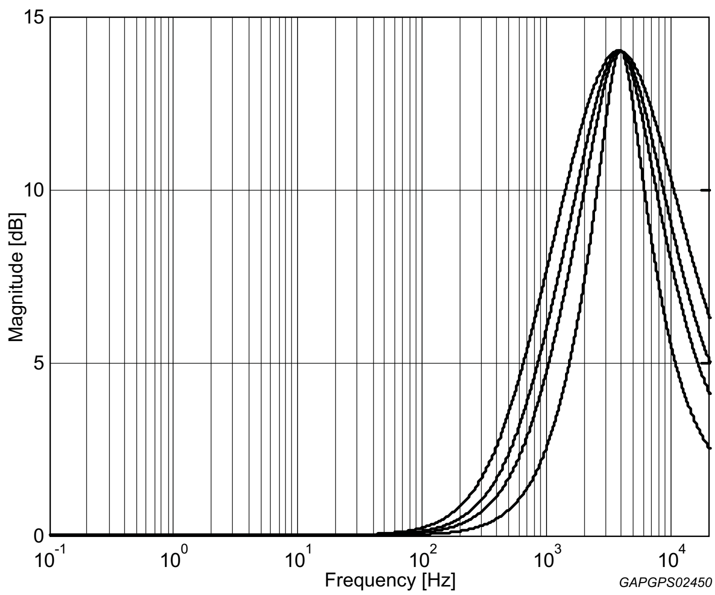
Figure 17. EQ4 center frequencies @ gain = 14 dB



4.9.3 EQ4 quality factor

Figure 18 shows the four possible quality factors(0.75/1.0/1.25/2) when f_c is 4 kHz.

Figure 18. EQ4 quality factors @ f_c = 4 kHz



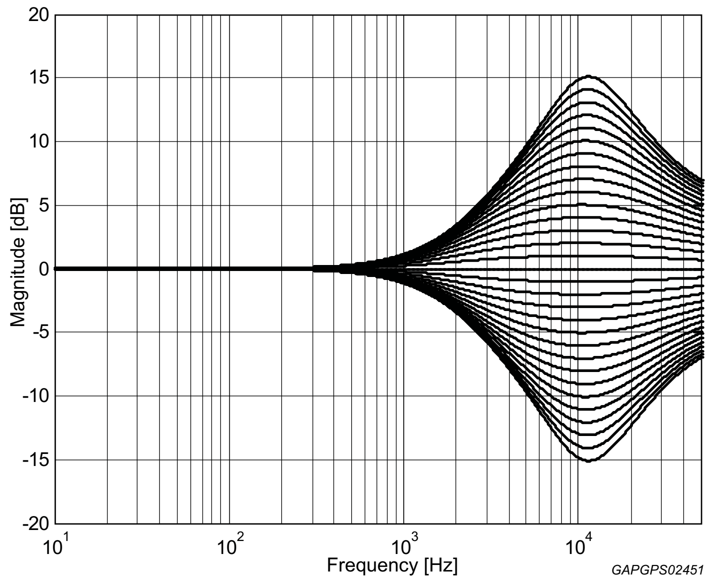
4.10 EQ5

There are three parameters programmable in the EQ5 stage.

4.10.1 EQ5 attenuation

Figure 19 shows the attenuation as a function of frequency at a center frequency of 12.5 kHz.

Figure 19. EQ5 gain control @ f_c = 12.5 kHz



4.10.2 Center frequency

Figure 20 shows the four possible center frequencies 6.3/8/10/12.5 kHz.

Figure 20. EQ5 center frequencies @ gain = 14 dB